Long-Term Warranties on Highway Projects

By

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University Transportation Center for Alabama
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16. Abstract

This report documents the state of the art and practice of warranty contracting in the United States. Background information, key elements, benefits and concerns, and lesson learned in other states regarding warranty contracting are presented in the report. Through cases studies, this research evaluates the cost-effectiveness of warranty contracting under risks and uncertainties. Based on a questionnaire survey, this research identifies widespread industrial acceptance of short-term (less than three years) warranties on highway projects in Alabama. There is also a sufficient degree of acceptance for four to five year warranties on pavement projects. However, warranty risks and liabilities, accurate warranty cost estimation, and bonding availability are still major concerns for the local construction industry.

This report also assesses the legal viability of warranty contracting in Alabama. In the current legal environment, short-term warranties (workmanship and material), which are compatible with a competitive low bid system, are permitted in Alabama. However, the state legal environment is not ideal for the introduction of long-term performance warranties where the contractor assumes design responsibility. Recommended practices for successful implementation of warranty contracting are presented in this report.

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Table of Contents

Table of Contents iii
List of Tables v
List of Figures v
Executive Summary vi

1.0 Introduction 1
Problem Statement 1
Research Objectives 1
Research Methodology and Approach 2
Report Organization 3
Research Team 3

2.0 Warranty Contracting: State of Art 4
Background 4
Warranty Contracting 5
Benefits and Concerns 7
Warranty Practices in Other States 9
General Commentary on Applicability of Warranty Provisions 16

3.0 Cost Effectiveness of Warranty Contracting 17
Introduction 17
Cost-Effectiveness Analysis Framework 17
Assessing Cost-Effectiveness: Wisconsin Case Study 20
Assessing Cost-Effectiveness: Indiana Case Study 21
Summary 23

4.0 Evaluation of Warranty Provisions: US 550 Case Study 25
Introduction 25
Warranty Provisions for US 550 25
Discounted Cash Flow Analysis 27
Uncertainty in Warranty Assets 29
Pricing the Expenditure Ceiling Clause 31
Summary and Policy Suggestions 32

5.0 Industry Acceptance of Warranty Contracting 34
Introduction 34
Questionnaire Design 34
Sampling 35

Survey Implementation 36
Industry Acceptance of Warranty Contracting 37
Industry Concerns 38
Contractor's Learning in Warranty Projects 39
Discussion and Summary 40

6.0 Legal Assessment of Warranty Contracting 42
Legal Assessment Framework 42
Initiation of Warranties 42
Statutory Assessment 44
Regulatory Assessment 47
Contractor Liability 48
Summary 49

7.0 Conclusions and Recommendations 50
Warranty Contracting 50
Cost-Effectiveness 50
Industry Acceptance 51
Legal Viability 51
Recommendations 52

References 54

Appendix A: Survey Questionnaire 58
Appendix B: Alabama Statutory Supplement 61
Appendix C: Binomial Model for Pricing Ceiling Clause 62
Appendix D: Warranty Workshop Topics 66

List of Tables

Number Page

2-1 CalTrans I-70 Scheduling Chart 11
2-2 Michigan DOT Warranty Provisions and Durations 13
3-1 Evaluation of Cost-Effectiveness of Warranty versus Traditional Projects 23
5-1 Group Analysis of Bonding Availability 39
5-2 Driver of Industrial Acceptance 40

List of Figures

Number Page

3-1 Initial pavement warranty cost under different warranty periods 19
3-2 Pavement performance: warranty versus standard 22
4-1 US 550 project location 26
4-2 Estimated warranty expenditures over time under best, moderate, and worst scenarios 28
4-3 Net present value versus discount rate 28
4-4 Accumulated cost of warranty work 29
4-5 The US 550 warranty is essentially a combination of a naked warranty and a call option 31
4-6 Net present value versus discount rate with the expenditure ceiling 32
5-1 Profile of responding companies 36
5-2 Industrial acceptance of warranty contracting 38
5-3 Industrial concerns regarding warranty contracting 38
6-1 Legal assessment framework for warranty contracting 43
C-1 A binomial tree for valuing the ceiling clause in the US 550 warranty 64

Executive Summary

In Alabama, there is an increasing demand to explore alternative ways to provide adequate oversight on construction projects. As one of the innovative contracting techniques encouraged by the Federal Highway Administration (FHWA), warranty provisions allow the state department of transportation to shift responsibility for quality control and maintenance to contractors and therefore improve project performance and agency efficiency. However, the successful implementation of warranty provisions would require partnering of many sections of the industry and the Alabama Department of Transportation (ALDOT). The contracting industry needs to have "buy in" and accept the risk and reward of warranty implementation.

This research documents the state of the art and practice of warranty contracting in the United States. Background information, key elements, benefits and concerns, and lesson learned in other states are presented in the report. The report also assesses the cost-effectiveness of warranty contracting in other states. Furthermore, the research team identified the significant impact of specific warranty details on the cost-effectiveness of warranty contracting, especially under risks and uncertainties. Through the NM US 550 case study, this report illustrates how a state agency could improve cost-effectiveness by evaluating and designing a warranty ceiling clause.

This research also investigates the acceptance of warranty contracting by the local construction industry. Based on a questionnaire survey, this research reports widespread industrial acceptance of short-term (less than three years) warranties on highway projects. There is also a substantial degree of acceptance for four to five year warranties on pavements. However, warranty risks and liabilities, accurate warranty estimation, and bonding availability are still major concerns for the local construction industry. It was also found that contractors will learn from warranty projects. As a contractor becomes experienced in warranty projects, he will better understand the risks associated with warranties and that in turn alleviates the concerns about risks and liabilities.

In the current legal environment, short-term warranties (workmanship and materials), which are compatible with a competitive low bid system, are permitted in Alabama. However, Design-build contracting by state agencies is prohibited. The state legal environment is not ideal for the introduction of long-term performance warranties where the contractor assumes design responsibility. It is recommended that the agency consider developing legislation to allow for the use of design-build project delivery and also more lenient bidding laws. Additionally, the agency, along with representatives from the surety industry, might consider changes to bonding legislation that allow the agency to set smaller bond amounts in warranty projects. Other specific recommendations for successful implementation of warranty contracting in Alabama are presented in the recommendations section.

1.0 Introduction

Problem Statement

Due to public expectation of better road performance accompanied by economic development and population growth over the past decades, US highway agencies have been under intense pressure for continuous improvement in the quality and cost-effectiveness of transportation project delivery. Furthermore, workforce shortages, changes in funding resources and downsizing of government agencies pose additional challenges for highway agencies. To meet the recent challenges, state departments of transportation (DOTs) often seek innovative approaches to deliver highway projects including outsourcing some of the agency's functions and shifting maintenance responsibilities to contractors. Many states have implemented alternative contracting methods in project programming and execution to provide lasting and functional roadways at the optimum life-cycle cost to the public. Warranty contracting is one of the innovative practices that have been declared operational by the Federal Highway Administration (FHWA) since 1996.

Warranty provisions were first used in highway projects to protect state DOTs' initial investment by holding contractors accountable for potential maintenance after project completion. Since the early warranty practices under the Special Experiment Project Number 14 (SEP-14) established by the FHWA in 1990, there has been a marked increase in the inclusion of warranty provisions in highway construction. By the end of 2004, more than 30 states had used warranty provisions in delivering transportation projects. The warranty practices in these states indicate that warranty contracting may benefit state DOTs by improving quality, life-cycle cost, and schedule as well as encouraging contractor innovations. On the other hand, the challenges associated with warranties can be substantial, including higher initial costs, a reduction or even elimination of small contractors from the bidding process, and an increase in contract disputes and litigation.

The ALDOT has been interested in alternative ways to provide adequate oversight on construction projects. As one of the innovative solution encouraged by the FHWA, warranty provisions shift responsibility for quality control to the contractor with the State assuring quality after the work is completed. However, the successful development of warranty provisions would require partnering of many sections of the industry and the Alabama Department of Transportation (ALDOT). The contracting industry needs to have "buy in" and accept the risk/reward of the warranty implementation.

Research Objectives

Nationwide practices and states' desires justify a need for comprehensive research to clarify the life-cycle cost of highway warranties and contracting industry perspectives on warranty

provisions. This report presents the results of research that was conducted for this purpose. The main objectives of this research investigation were:

(1) to establish and document the state-of-the-art and state-of-the-practice of highway warranty contracting in the United States,
(2) to investigate the acceptance of warranty contracting by local construction industry, and
(3) to evaluate the legal and economic viability of using warranty provisions in Alabama to shift maintenance responsibilities to the construction industry.

Research Methodology and Approach

The research team investigated the state of the art and state of the practice of warranty contracting on highway construction projects in the United States. As a starting point, an extensive review of all sources of literature was conducted to identify warranty practices in the United States. The literature review also assisted in identifying the pros and cons of warranty provisions currently used by state DOTs and determining the variables that affect industrial perspectives on warranty contracting.

Following the literature review, several warranty projects were identified for detailed case study analysis including the New Mexico 44 project (renamed US 550), Virginia Route 288 project, and Cooper River Bridge Replacement project in South Carolina. Project data was collected via the public record databases in those states. Additional project construction information was also obtained through interviews with contractors and DOT construction engineers. The selected case study involved evaluation of uncertainties in warranty contracting. An analysis of the viability of warranty contracting in US 550 is reported in section 4.

A questionnaire survey was conducted to identify the industrial acceptance of warranty contracting in Alabama. The development of the questionnaire involved close cooperation between the research team and the project advisory committee. A copy of the questionnaire is included in this report (See Appendix A.). The questionnaire survey targeted all highway contractors currently doing business with ALDOT. Collected data were grouped, analyzed, and compared to identify industrial concerns and factors impeding acceptance of warranties.

Simultaneously, the research team evaluated the present legal environment in Alabama for the introduction of performance based warranty contracting. A legal assessment framework for warranty contracting was developed to facilitate this investigation. The legal environment in other states was reviewed and compared with Alabama. Alabama Code and ALDOT regulations were further examined to develop recommendations for creating a more favorable climate for warranty contracting.

As one of the research tasks, the research team implemented technology transfer activities including a workshop and seminars to promote awareness of warranty contracting. A one day workshop was organized on the University of Alabama campus. Over 20 people attended the workshop from the contracting industry, surety firms, and academia. A copy of the workshop agenda is enclosed in Appendix D. All presentation files are also available in MS-PowerPoint

format upon request to the research team. Comments and suggestions from workshop attendees were incorporated in the final report.

Report Organization

This report consists of seven sections. Section 2 is the literature review. The reviewed literature related to the research theme is classified into three categories: journal/conference articles, research reports, specifications and regulations. This section offers a brief review on the background, elements, benefits and concerns, and present practices in warranty contracting. Section 3 documents current research results on the economic viability of warranty contracting. Cost items related to warranty contracting are identified and a life-cycle cost analysis framework is presented. Section 4 extends the discussion of cost effectiveness in warranted projects through the US 550 Project case study. The impact of a warranty clause on the economic viability of warranty contracting is analyzed and presented in this section. Section 5 provides information on industrial acceptance of warranty contracting in Alabama. Survey design, analysis results, and recommendations are described in this section. Section 6 evaluates the present legal environment in Alabama for possible introduction of warranty contracting. Section 7 includes a summary of the research as well as recommendations for ALDOT and contracting industry.

Research Team

The research was conducted under the direction of the project advisory committee that includes representatives from the Alabama Department of Transportation (ALDOT), Alabama Road Builder Association (ARBA), and surety industry. The project advisory committee members involved in this research played a significant role in guiding the research project, developing questionnaire survey, and organizing the warranty workshop on the University of Alabama campus. The authors would like to express their sincere appreciation to all committee members, Don Arkle, Ronald Baldwin, Walter Dowdy, Terry McDuffie, George Norrell, and Terry Robinson. Several undergraduate and graduate students of the University of Alabama assisted in the research project, including Aaron Quick, Brandon Sevedge, Matt Cash, and William Makowski, who supported the literature review and survey, and Lan Wang who assisted in data analysis, and Hao Zhou who helped develop a warranty cost analysis and the estimating model. Their hard work is greatly appreciated.

2.0 Warranty Contracting: State of the Art

Background

Innovative contracting has been utilized effectively in highway pavement projects in several states as well as internationally. This section seeks to define warranties, discuss the origins of warranty contracting in the United States, document the state of practice on warranty contracting, and utilize previous state departments of transportation case studies to form implementation recommendations for ALDOT. Additionally, concerns of both highway paving contractors and public agencies are addressed in order to further define and scope project requirements where warranty clauses may be most effective.

Roads have become increasingly important, especially in the United States, since the turn of the twentieth century. Historically, roadways have been developed to transport military troops and equipment. This is the case for the United States as well with the Eisenhower administration realizing the need after World War II and developed the framework for an interstate highway system. By the early 1990s, the 155,000 mile National Highway System (NHS) was all but completed at a cost of over $300 billion. Several legislative efforts have aided in bringing this roadway system into being, though it was not until 1991 that innovative contracting was brought to the forefront of state and federal agencies. Initial conceptual notions were to shift risk away from public agencies and onto contractors. The bottom line of this thinking was to increase productivity, decrease costs and infringement upon the traveling public, and to create a higher standard of performance – ultimately saving taxpayer dollars.

In 1990 the Federal Highway Administration (FHWA) established *Special Experimental Project No. 14* (SEP-14). This policy outlined and defined the basis for innovative contracting techniques in highway pavement projects. Based on Title 23 of the United States Code, Section 307, it authorized the Secretary of Transportation to conduct research and experimental procedures on all aspects of highway construction. By April 1991, the Office of Chief Council within the FHWA reviewed the design-build concept for compatibility with current Federal laws and regulations. Based on these findings, the Office concluded that Federal-aid funds may be used for design-build contracts when awarded using traditional competitive bidding procedures and were subject to approval by the governing authority. Conceptual approval from the FHWA was necessary for any "experimental" contracting practices including construction projects that utilized other factors in addition to price in the award process (e.g., life cycle cost) and for projects that incorporated both design and construction services in one contract.

Originally, SEP-14 defined four new innovations in highway construction. These include: (1) cost-plus-time bidding, (2) lane-rental, (3) warranty, and (4) design-build. This experimentation allowed states to evaluate these techniques with the potential to reduce life cycle costs and maintain (or hopefully increase) end-product quality. Though highway projects were typically evaluated and let according to design-bid-build contracts, innovative contracting opened the door

to allow for other factors such as time, quality, and further innovation in construction in addition to simply being the "lowest qualified bidder."

Additionally, in 1991 a critical turning point came with passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) through Congress. This landmark legislation not only consolidated all highway classifications into the singular NHS, but also provided greater flexibility to state agencies when allocating Federal funds. This allowed a greater emphasis on public transportation by enabling certain exemptions to FHWA oversight for those highways off the National Highway System. Additional amendments to the legislation in 1995 and 1996 revised the FHWA stance on warranty provisions and dictated that warranty provisions must be applied to specific construction products or features that are within the control of contractors (Yakowenko, 2002). It must be noted, however, that routine maintenance charges remained ineligible for payment utilizing Federal funds.

Warranty Contracting

Definition of Warranty Contracting

A warranty is defined by www.dictionary.com as an official authorization, sanction, or warrant that justifies grounds for an act or course of action. The definition pertains to law and provides an assurance by the seller that the goods or services will be as promised. These are given in the contractual agreement between the contractor and agency in the form of a binding covenant. This document states that the product is reliable and free from known defects with the stipulation that the seller will, without charge, repair or replace defective parts within a given time limit and under certain conditions.

This applies directly into warranty contracting by replacing the "product" mentioned above with "roadway," "seller" with "contractor," and "contractual agreement" with "warranty clause." While this definition is a broad sweep, typically as it pertains to products and consumer goods, highway warranty clauses are classified as performance, or service guarantees. This service is performed according to measurable standards prior to, during, and after construction activities are completed. Additional fiscal liability is also incorporated in the form of a performance bond to cover any expenses that occur. Again, the binding contract dictates and governs the imposed limitations, durations, and other terms of the warranty clause, discussed further in ensuing sections of this report.

Warranty contracting is primarily classified as workmanship and material warranty or as a performance warranty (Aschenbrener and DeDios, 2001). A workmanship and material warranty holds a contractor responsible for correcting deficiencies caused by bad workmanship and material but exempts the contractor from deficiencies caused by design and other reasons beyond the contractor's control. The state highway agencies are still responsible for deficiencies that are design related. The workmanship and material warranty is compatible with the low bid system and usually has a short-term period, from a few months to five years. The contractor is given the responsibility for material selection and undertakes the risk for bad workmanship and early failure of the selected material. In the performance warranty approach, the contractor is

given flexibility to design and even modify contract details, in addition to material selection and workmanship. Thus, he assumes the responsibility for correcting defects that are caused by workmanship and material, as well as design. The contractor may also choose a rehabilitation strategy or undertake preventive maintenance during the warranty period. To provide an adequate protection from design defects, the performance warranty usually has a longer period, from 5 to 20 years, which, under certain conditions may also be a biddable item (Russell, et al., 1999).

History of Warranty Contracting

Warranty contracting on roadway projects has been used successfully in Europe for over forty years (D'Angelo, et al., 2003) and also on non-Federal projects to protect investments from early failure from a performance perspective. The United States, however, prohibited these types of contracts until SEP-14 was implemented. This has limited the amount of information available and data to comprehensively research the finer points of warranty contracting in America.

Traditionally, American highway pavement projects are let according to design-bid-build techniques and come with a one-year material and workmanship warranty, ensuring that the contractor will build the pavement according to owner specifications and acceptance and return to repair any defects resulting from use of improper materials or inferior installation (Hastak, et al., 2004). Also, traditional procurement dictates that contractors are evaluated on a "lowest bidder" basis that stipulates that construction is governed by agency specified parameters and guidelines for both pavement mix design and installation. This contrasts warranty methodology which prescribes a "best value" evaluation that includes safety features, innovation, and environmental impact (Anderson and Russell, 2001).

Implementing Warranty Contracts

When considering warranty usage, the contracting agency (DOT) identifies end result parameters and clearly establishes design criteria minimums. These requirements give a much broader allowance to the contractor as it pertains to optimization of equipment, labor, scheduling, and design resources. In turn, this opens up additional flexibility for innovation and forces the contractor to assume greater responsibility for all phases of the construction process from "cradle to grave." This includes not only the design phase, but also the ensuing maintenance period after construction activities conclude. Based on submitted bid proposals from contractors, DOTs are more able to rate the contracting agencies on factors other than lowest cost which include design quality, timeliness, and management capabilities.

Additional considerations that should be made when implementing warranty clauses include the additional flexibility to incorporate innovation while forcing contractors to assume greater responsibility. While specific cases of specification comparison have been discussed in earlier research (Hastak, et al., 2004), basic items are presented here in concept only. In order to receive the endpoint benefit of warranty applications, oftentimes extended liability insurance or warranty clauses with a riding surety performance bond are utilized. This fiscal contingency allows for continued supplementation of remediation plans and future warranty maintenance repairs.

It must also be noted that due to the substantial time savings in the design process, a design-build approach to a pavement project is often incorporated along with the warranty clause. By starting construction before all the design details are finalized, significant savings of time and resource allocation can be achieved (i.e. New Mexico 44 completed over 100 miles of roadway in about four years when original plans projected over 27 years). Additionally, because design and construction are performed under the same contract, claims for design errors and omissions or construction delays due to redesign are not allowed (or possible contractor penalties may ensue). Also, the potential for other types of claims and errors is greatly reduced by maintaining one company for both services.

Evaluating Warranty Contract Criteria

In addition to proper scope and delineation of tasks and responsibilities, significant effort must be made in order to properly evaluate contractor performance. This allows a fair and equitable process for the state agencies to quantify and subsequently execute the terms of warranty clauses. These quantitative analyses involve objective criteria which include, but are not necessarily limited to, rutting, bleeding, penetration testing, smoothness, transverse crack spacing, crack widths, potholes, depressions, shoving or heaving, raveling, and delamination.

Benefits and Concerns

As with any innovative and relatively new techniques in contracting, there is inevitably concern from both sides of the aisle including the public agencies letting contracts and the contractors seeking work. This section deals with benefits and concerns to both public agencies and to contractors when considering warranty clause application to new paving contracts. Surety company considerations and concerns will also be discussed as they pertain to long-term warranty clauses.

General Benefits and Concerns

Overall increased performance and reduced life cycle costs are the ultimate objective of warranty contracting as it applies to highway construction projects. Obviously, performance equates to success as it applies to pavement projects. Without continued success of various states and contractors, this methodology would have likely ceased to exist. Along with the inherent performance improvement and lowered costs, a friendlier working environment and relationship can be fostered between contractors and DOTs. By assigning specific tasks to all parties involved, there is a reduction of confusion as to what is expected and how the process evolves throughout each construction phase. These specific responsibilities and other benefits and concerns are addressed further in later portions of this section including discussion of a questionnaire survey.

Additional overall benefits which may not be recognized immediately include rewards for innovation in contracting, construction methods and materials. Some of these may result from a combination of innovative contracting methods, project delivery systems, scheduling, material improvements, and again a more optimal usage of resources available in the future. Through a

comprehensive study of the ever-increasing storehouse of experience and knowledge, further refinement can be made in order to reach stated objectives of warranty usage. These more "nebulous" or "intangible" benefits will continue to make a stronger case for warranty usage in a variety of applications and states.

Outlying concerns can be considered as the antitheses of all the aforementioned benefits. While warranty contracting is still in its relative infancy throughout much of the country, common concerns involve research and development of new materials and application technologies, and the constant challenge of properly and adequately scoping projects. With a relative lack of experience there seems to be a disconnection between working warranty clauses and agencies that are still reluctant to initiate these contracts into their standard operating and letting procedures.

State Highway Agencies

Because warranty contracting was implemented by the FHWA, it is obvious that departments of transportation stand to benefit from their use. This, in turn, leads to a savings for the general traveling and taxpaying public. Agency benefits include a minimization of overall life cycle costs, a reduction of staff (thus a reduction in annual budgeting), an improved probability of good performance for a longer service life, and a less adversarial and confrontational work environment. With additional delineation of tasks and responsibilities for agency personnel, a greater amount of control is enabled as it pertains to structural organization, quantities, time unit costs, and condition surveys.

Inherent to these benefits is a fundamental shift of responsibility and associated risk in the highway pavement project of question. The reduction of agency personnel stems from relinquishing the design burden from the DOT to the contractor, which ultimately requires much less oversight in the initial process and relies more heavily on in-place inspection of the pavement after being installed. This alone greatly reduces the logistical and financial liability associated with typical highway pavement projects as they are currently let and constructed.

Concerns to public agencies include the reluctance to rescind "tried and true" methodologies in pavement specifications. This could be demonstrated by the common adage stating "If it's not broke, don't fix it." While this may have been true thirty or forty years ago, with the advent of new materials and methods it no longer holds true. Though specific specifications may be honed and tuned to cover all situations does not necessarily translate into a "best approach" to highway contracting.

Additional concerns to state DOTs include the relinquishing of contractor oversight while still maintaining the ability to guarantee performance. Without explicit guidelines and rules of conduct, agencies may feel alienated and unsure on how to proceed outside of the stated protocol as provided in what may be out-of-date specifications. This holds especially true when considering out-of-state or poorly performing contractors. As noted above, these concerns and risks may be alleviated by a clear and concise scoping of required work and continuous open communication between the agency and the contractor to ensure that all tasks are performed with the utmost care and appropriate supervision.

Contractors

As expected, contractors hold a very different set of concerns and ideas when it comes to pavement projects as opposed to public agencies. As noted above, a clearly scoped project including design and installation requirements is a necessity for warranty contracting methodology to prove successful. Benefits to contracting agencies include a more proactive involvement to the mix design and installation process. By allowing less DOT oversight into the operations of contractors, it allows contractors to better utilize their own available resources to best handle a project. This results from equipment, labor, scheduling, innovation, and performance criteria as dictated only through "endpoint" requirements as set forth by the letting agency.

By allowing this freedom to contractors, one of the major concerns of contractors in the past is automatically alleviated. With the added benefit of having greater design control and freedom, contractors are allowed a sort of autonomy of process from the design phase through to the final product in place. If DOTs state only an end performance baseline, contractors are able to decide the quickest and most cost effective path on which to meet those requirements. This comes with a "price," however, as contractors become responsible for items such as material usage, mix design, process controls, and remediation plans.

Additional concerns of contracting agencies include payment terms, obviously wanting to be compensated for each ton of asphalt or concrete pavement that is installed. This is in addition to working on their own terms and not being shut down due to seemingly minor "nitpicking" by public agency project engineers. However, with clearly scoped project requirements and continual communication with the DOT along with the endpoint requirements, this is oftentimes alleviated inherently by the process.

Further concerns lie in the shifting of maintenance burdens from state agencies to contractors. Obviously with the added freedom in design and process control, there is some relegation of responsibility to the contractor. This comes in the form of performance requirements as previously noted. By improving quality and contractor accountability from the state perspective, a reduction of major maintenance needs can be observed during the pavement service life. It must be noted, however, that ordinary wear and tear, damage caused by others, and routine maintenance remain the state DOT responsibility. Specific performance requirements and criteria have been discussed in previous sections.

Warranty Practices in Other States

Over 30 states have been involved in warranty contracting since its inception by the FHWA. Of these states, only a few have prepared detailed accounts of their experiences, including executive summaries of the process, plans of action, results of implementation, and recommendations for future projects that may require use of warranty contracting. Sample states will be reviewed, tracing the "cradle-to-grave" concept of warranty contracting. This will, in effect, create a

framework from which to generalize the procedure and provide insight into preparing recommendations for ALDOT.

Colorado Department of Transportation

The Colorado Department of Transportation (CDOT) has successfully implemented warranty contracting on several projects since 1998. Example projects include Interstate 25, South of Fountain (1998); Colorado 470, Santa Fe Drive to Wadsworth Boulevard (1998); United States Route 36, East and West of Superior Interchange (1998); Interstate 70, from Eagle to Avon (2000); Interstate 25, north of Pueblo (2000); United States Route 50, east of Kannah Creek (2001); Colorado 63, south of Atwood (2002); Interstate 25, north of Pueblo (2002); and Colorado 36, east of Byers, (2003). These are just a few of the completed and ongoing projects with which CDOT was involved at the time of this project.

Colorado has been extremely forthcoming with information regarding their program purpose, layout, and implementation. In outlining the purpose of their program when seeking to implement warranties, the primary consideration was to develop a program with a limited number of projects with a comprehensive evaluation plan. Further, they sought to determine if hot bituminous pavement short-term materials and workmanship specifications can improve quality of pavements in a cost-effective manner.

Implementation planning was begun for a six-year time period, with a minimum of two projects and a maximum of four projects for each region. This would allow time for the DOT to comprehensively analyze each project for overall benefit and improvement possibilities. The overall targeted goal for the planned implementation was twelve to fifteen projects. Additional evaluation reports were developed on an annual basis starting in 1997 with the final evaluation completed following the 2003 seasons. It was after this final evaluation that a decision on further implementation could be made.

The CDOT evaluation plan is based on several factors including: performance when compared to similar project scopes without warranties; adequacy of project selection guidelines; adequacy of warranty specifications; costs from initial, life-cycle, and maintenance requirements; and level of competition based on the number of bidders and the spread in the bids. From these relatively simple parameters, the evaluation team then utilized quantifications from the project itself to help define how the warranty performed and how it could be improved in future applications.

A CDOT cost benefit team was assembled to analyze the initial offerings of warranty provisions on projects as noted. Their charge was to gather actual cost data which included initial and maintenance costs of experimental warranty projects and comparable non-warranted projects, used as controls. After comparison and analysis, they presented their conclusions to the State House and Senate Transportation Committees at the end of the warranted period (or earlier as specified by either committee). In these presentations, reports were to include experience gained from these pilot warranty projects and recommendations for the future direction of short-term materials and workmanship hot-bituminous-pavement project warranties by CDOT.

In analyzing these initial projects, the Colorado Department of Transportation Cost Benefit Evaluation Team found several interesting facts. This team found that contractor bidding competition was similar to the control projects, as was contractor performance. Further, there were three warranted projects that had contractor-added experimental features while no such feature was added to the control projects. The bottom line findings were strong enough for the team to recommend that performance evaluations should continue on the warranted projects that ultimately shifted more responsibility to the pavement contractor.

California Department of Transportation

The California Department of Transportation (CalTrans) implemented warranty provisions in 1996. Their first attempt at incorporating this type of control was on Interstate 70 for a hot-mix-asphalt project. The warranty clause was implemented along with the "A + B" technique as well. Thus, the overall contracting method used was actually "A + B + C" bidding, or "Cost + Time + Warranty," with the time being charged as a lane rental fee. These fees were charged differently for peak and non-peak hours at rates of $13,800 per lane per period and $4,600 per lane per period, respectively. Several other factors were also considered here, including an average daily traffic load of 40,000 vehicles, of which 29% were heavy trucks.

In this project, the scheduling issues became paramount as a result of the lane rental fees and charges. In the contractors bid, as a requirement associated with lane rental clauses, the number of contract days was provided as demonstrated below in Table 2-1.

Table 2-1. CalTrans I-70 Scheduling Chart

CONTRACT DAYS BID	CONTRACT DAYS USED	PEAK PERIODS BID	PEAK PERIODS USED	NON-PEAK PERIODS BID	NON-PEAK PERIODS USED
135	84	177	127	277	139

As seen in the table, the contractor was able to complete the job fifty-one days ahead of schedule, while utilizing fifty less peak periods than bid and one hundred thirty-eight less non-peak periods than bid. This resulted in an overall savings to the contractor of $1,352,000 which was essentially passed along to the consumer in a myriad of ways – from less taxpayer money required to a summarily adjusted attitude of the contractor.

Additional innovation from this warranty contracting gave rise to new ideas on how to utilized material transfer vehicles, joint maker and tape, APT and Purwheel testing methodologies, and working double shifts to optimize labor crews. This also gave rise to the contractor attitude adjustment, based on the potential money saved, encouraging better performance from both a productivity and performance standpoint by invoking several innovative contracting techniques. As noted in the CalTrans report on this particular project, there was incorporation of a third roller, ensuring that the trucks were always covered in tarps (for a cleaner, safer roadway with less wastage from spills), and more care was taken in the joints between the paved surfaces. Quality control was also increased as a result of the warranty provision, which encouraged more care with the joints, additional APT and Purwheel testing as noted, and more precise controls and testing performed with nuclear gauges and core samples of in-place materials. Other special products were also incorporated into the design, though specifics were not discussed.

Future considerations by CalTrans resulting from this initial experimental project included usage on high profile projects with heavy traffic and considerable time constraints. The CalTrans evaluation team also noted that until further information could be assimilated on warranty and innovative contracting methods, they should limit their implementation to two or three projects per year. It must also be noted that to date, CalTrans has had nine warranted hot-mix-asphalt pavement contracts under its supervision.

Michigan Department of Transportation

Perhaps one of the most visible and supportive state departments of transportation, Michigan, has helped to lead the way in usage of innovative warranty clauses. While many of these projects are smaller in scope and often geared to maintenance and reconstruction, a wealth of information is available in addition to a relatively strong model of what works and what does not work when addressing these concerns. It must be noted that there will be very few new roads built in the next several years and the importance of resurfacing and rehabilitating, along with a comprehensive preventative maintenance plan will ultimately save these agencies a considerable amount of money.

In summarizing Michigan's warranty provision applications from 1996 to 2002, there have been four hundred seventy-three capital preventive maintenance (CPM) usages and one hundred thirty-one rehabilitation and reconstruction (R&R) clauses implemented. By the end of this period (i.e. 2002), over 90% of the CPM program and over 50% of the R&R program have utilized warranty clauses in some capacity. Typical warranty durations for these projects are provided in Table 2-2 on the next page, including applicable treatments and problems that are addressed by each.

As noted, the Michigan Department of Transportation (MDOT) has a strong and comprehensive model in which to frame warranty components of any contract. This would be expected due to the large number of contracts administered utilizing warranty clauses. The components of the warranty specifications are as follows and will be subsequently discussed:

- Initial Acceptance
- Warranty Bond
- Rights and Responsibilities
- Performance Thresholds
- Corrective Action
- Conflict Resolution Process

The warranty bond simply covers the fiscal responsibilities of the contractor for the warranty period and cost. In the capital preventative maintenance contracts, the bond issued covers 100% of the warranted work, while in restoration and rehabilitation contracts, the bond amount typically covers either five percent of the contracted amount or a fixed dollar amount agreed to by all parties involved (i.e. contracting agency and the department of transportation).

Table 2-2. Michigan DOT Warranty Provisions and Durations

TYPICAL DURATION	TYPE	PROVISIONS
2 Years	CPM	• Chip seals • Micro-Surfacing • Crack Treatment • Concrete Joint Resealing
3 Years	CPM	• Non-Structural HMA Overlays • Cold Mill and HMA Resurfacing • Hot In-place HMA Recycling • Concrete Pavement Repairs
5 Years	R&R	• Multiple Course HMA Overlays on: • Rubblized Concrete • Repaired HMA or Concrete • Crush & Shape Base

As with any contract, the rights and responsibilities must be delineated to all parties entering into a binding agreement. In the case of pavement contracts, these parties are obviously the pavement contractor and the state agency letting the contract. Along with the initial acceptance agreement, this section of the specifications is paramount to the execution of a successful project which relies on warranty provisions.

From the departmental perspective, charged responsibilities are dictated which include approval of materials, methods, and schedule for the corrective work to be performed; routine maintenance of the roadway; third party procurement for emergency repairs; and the notification of the contractor when pavement conditions exceed performance thresholds (thresholds discussed in the next section). This would imply that the departmental responsibilities would also include testing and quality assurance protocol in routine maintenance duties.

From the pavement contractor point of view, a completely different set of responsibilities is required. These delineated duties include a written work plan for corrective actions in each of the potential failure mechanisms; adherence to the transportation agency permitting processes; and prudent completion of all corrective work before the warranty period expires.

Performance thresholds outline the required parameters to which the contracting agency must adhere throughout the duration of the project. By judiciously establishing, maintaining, and requiring compliance with these standards, potential miscommunications can be alleviated and thus reduce the instance of a combative situation in the future. These thresholds are predicated on condition parameters, segment lengths, and the potential for a contractor caused condition. General conditions which govern these thresholds include, but may not be limited to, transverse and longitudinal (also called open joint) cracking, de-bonding, raveling, flushing, rutting, and ride quality.

Inevitably, there will be instances where corrective actions must be taken in order to remedy pavement conditions which have exceeded or otherwise fallen outside the parameters listed under the general conditions of the executed warranty contract. MDOT notes, however, that warranty-related callbacks for capital preventive maintenance projects are less than 5% and generally were handled through either repair work performed by the contractor, or at times through a cash settlement in which case the public agency will repair the roadway. In rehabilitation and restoration projects, warranty callbacks occur less than two percent of the time in which case repair work is utilized exclusively for remedying the situation.

For instances where there is a dispute that arises about responsibilities, MDOT has outlined and implemented a comprehensive conflict resolution process. While this is a rare occurrence given the low callback rates of the warranted projects, generally the repairs are handled as noted above. However, there is a portion of the specifications which requires a five member team composed of two departmental representatives, two from the contractor, and one member mutually selected when the dispute cannot be resolved through the completion of repair work or the cash settlement as described above. As of 2002, there has never been a case where the conflict resolution process has proceeded so far as to invoke the formation of this five member team. It should be noted, however, that while this has not been utilized in the past, there has been considerable forethought by MDOT to plan for the worst and to make the appropriate arrangements to deal with the situation should it arise.

Some of the experiences that MDOT has garnered after the five year period in which this plan was implemented include some of the same issues noted by the Colorado agency. Namely, there was no effect on the bid costs when warranty provisions were included. There is also an inherent and implicit transfer of risk in the process of awarding warranty-laden contracts. Other discoveries included a reduction of costs associated with agency inspections, though "actual" overhead costs became an unknown due to the shifting of manpower and requirements in the DOT itself. Added benefits included an unforeseen improvement in workmanship and productivity from the same contractors that had been used in the past. This ultimately led to an unknown gain in the remaining service life of the pavement itself. While these gains were certainly welcomed, the elimination of premature distress and pavement failure was not abated.

In addition to the experience which MDOT gained, several lessons were derived for future recommendations and improvements in the warranty letting process. Essential to the process for successful implementation of warranty clauses is proper scoping of the project to ensure that a warranty clause is applicable. It was also noted, specifically resulting from the unknown overhead costs, that documentation becomes a more integral part of the project tracking and control measures. This allows for a comprehensive reference book for reference when questions of scheduling, methodology, quality control and inspection, and responsibility arise. Additionally, a need for more stringent pavement contractor pre-qualification standards was necessary to maintain the caliber and quality of work to be performed as well as the viability of the company to perform the task required of them. The implicit shift of risk from the agency to the contractor led to the unforeseen instance of some contractors refusing to bid warranted work altogether. While this may be attributable to smaller contractors that do not have the bonding capabilities of larger firms, it may also be a result of larger contractors feeling "cheated" by the DOT and having their hand forced by requiring this additional innovation in the contract

documents. However, despite these possible inherent shortcomings and difficulties, MDOT has found that warranties are acceptable for the correct projects, inherently valuable, and "here to stay."

New Mexico Department of Transportation

The first highway project in the United States requiring a twenty year, long-term warranty was New Mexico State Route 44 (NM 44), now called US Highway 550. Given the seemingly astronomical price tag of this warranty clause at $62 million, there has been a great amount of attention focused on this particular case – specifically in how it may be applicable to other projects throughout the country. While the warranty period is still in effect, there have been several evaluations and studies completed on the validity and effectiveness of this warranty clause.

Because of the nature of this warranty and extended period of duration, there were several overriding conditions levied on the contractual terms. These were three-fold and considered not only the duration of twenty years, but also the equivalent single axle loads (ESALs) along with the spending ceiling of $112 million, effectively placing the contractor at-risk for an additional $50 million over the original price of the warranty itself. While Quick and Cui (2005) contend that the $62 million was a fair cost for the warranty at the time of acceptance, the ceiling expenditure cap adversely affected the warranty provisions due to inherent uncertainties associated with future maintenance costs. Further, it must be noted that the *real* price of the warranty is *not* represented in the $62 million as accepted by the New Mexico State Highway and Transportation Department (NMSHTD) because of the ceiling clause. With the actual cost of the ceiling clause resting at $4.8 million (1998 dollars), this represents additional *revenue* to the contractor, Mesa PDC. Through incorporation of this ceiling clause, Mesa PDC effectively eliminated unfavorable risk while maintaining profitable uncertainty. After further examination into the financing terms and hurdle rate, along with the calculation of *actual* costs, Quick and Cui determined that the warranty provision is not justified due to the high cost of the added ceiling clause (2005).

Based upon this singular examination of the long term warranty on NM 44, it is recommended that other state departments of transportation carefully evaluate ceiling clauses when requiring warranty provisions in the long term. By performing relatively simple sensitivity analyses on the ceiling costs versus the actual warranty costs, agencies can better determine favorable ceilings if they are a part of the provisions. As noted, a ten percent increase in the NM 44 ceiling would have reduced the option price of the ceiling clause by 30%.

These clauses can, however, be instrumental in the execution of the overall warranty when compared to "call" options that provide added flexibility in decision making once additional information becomes available to the agency. This allows the agency to minimize risk while maintaining favorable uncertainties – much as Mesa PDC did in securing the warranty for NM 44 – though it can be utilized by both contractors *and* public agencies. Simply stated, real options for warranty contracting provide potential to delay the warranty decision until the end of the construction period when more performance information is available. This simultaneously allows for future maintenance savings to be estimated more accurately (again based on

contractor performance) while facilitating better decision making on whether or not to purchase a warranty for the project in question.

General Commentary on the Applicability of Warranty Provisions

In reviewing many of the specific points associated with the three brief overviews of existing warranty programs, there are a few points which occurred in each. Warranty provisions are best suited to those projects where performance can be measured, ultimately achieving lower overall life-cycle costs. Further, these projects must exhibit conditions that are well defined for all parties involved. Additionally, while not all projects utilized new technologies in materials, equipment, or construction processes, those that did were afforded a seemingly better return on their investments from both productivity and performance standpoints.

Prior studies have outlined specific requirements that must be available in order to incorporate warranty methodologies into paving projects. First, the state DOT and the contractor must have the appropriate resources available to properly and effectively execute their roles. Essential to the process is a DOT-formulated listing of objectives the project must meet in order to proceed. Further, the DOT must clearly define the objectives that determine which projects may be appropriate for warranty inclusion. A listing of these objectives may include reduction of DOT resources required on the project (i.e. reallocating the burden of risk to the contractor in order to maintain specified performance levels), increase contractor innovation in paving methods, increase the quality of the finished product, and ultimately include a reduction of the overall life-cycle costs of the project – thereby reducing the taxpayer burden for all.

A method for determining and quantifying the distresses within each group of selected projects will help to provide a current state of performance for each roadway design after a specified time lapse (here three to four years). A statistical analysis will guide the warranty requirement development as compared to distresses monitored from projects of similar construction.

Obviously, this is an iterative process that allows continual update based on input from contractors, other state agencies, and ongoing pavement research. Assessing the impact of these newly implemented provisions on highway construction include, but are not limited to the following: quality and performance, contracting practices (quality control, cost, schedule, etc), and prudent DOT practices (cost/benefit analyses, quality assurance, systematic inspection, etc). It is only through the constant and continued vigilance of state DOTs and the cooperation of pavement contractors that innovative contracting will become an integrated part of the construction process.

3.0 Cost Effectiveness of Warranty Contracting

Introduction

Pursuing innovative and cost-effective project delivery is one of the most challenging tasks for most state highway agencies. As one of the innovative contracting practices, warranties shift maintenance burden from the agency to the contractor, and therefore encourage innovation and improve roadway performance and service life. However, initial contract prices and other costs may increase due to contractors' extra effort to ensure quality compliance and performance. Detailed investigation of the cost-effectiveness of warranty contracting versus traditional delivery method must be conducted before a state agency promotes this innovative practice. This section identifies cost items related to warranties and presents earlier findings from section 2 of the life-cycle cost comparison study between warranty projects and their traditional counterparts.

Cost-Effectiveness Analysis Framework

Life-Cycle Cost Analysis

Life-Cycle Cost Analysis (LCCA) is a process for evaluating the overall long-term economic efficiency between competing alternative investments. It incorporates initial and discounted future agency, user, and other relevant costs over the life of alternative investments and attempts to identify the best value for investment expenditures. That is the lowest long-term cost that satisfies the performance objective being sought. LCCA needs only to consider differential costs among alternatives. Costs common to all alternatives are not included in LCCA calculations. For identifying different costs between warranty contracting and traditional method, it is necessary to understand the comprehensive impact of warranties on highway projects.

The previous section has identified some advantages of warranties. Contactors are bound to the projects within the warranty period. Early failure because of the contractor's bad performance will be corrected at the contractors' cost. Furthermore, warranties are believed to increase quality by encouraging contractors to provide better workmanship and material. The use of performance based specifications in highway construction projects would result in the development of contractor-funded, internal innovation. The expected improvement of quality and innovation in construction can improve the deterioration curve thus the performance of pavements. Therefore, the maintenance cost beyond the warranty period could be lower. In addition, warranty requirements release highway agencies from stringent inspection and early maintenance. Therefore, less staffing is needed and project administrative costs are potentially reduced as liabilities and risk shift.

On the other hand, several cost items in transportation projects could significantly increase because of the use of warranties. The initial bid price may increase as liabilities and risks shift to the contractor. When the contractor has little knowledge of possible maintenance liability, he charges greater amounts for the potential risks. Furthermore, surety companies are concerned about long-term bonding liabilities and thus skeptical about issuing long-term warranty bonds. They will possible inflate bonding costs that in turn increase contract costs to the agencies (Bayraktar, et al., 2005). An increase in contract disputes and litigation can also be expected due to the difficulty in identifying the real reason for a failure during the warranty period.

Both the potential increase and saving in cost discussed earlier should be considered to conduct the life-cycle cost analysis. Future cost and benefit streams should be estimated in constant dollars and discounted to the present value using a discount rate. An incremental cost-effectiveness analysis, as showed in equation 3.1, can be used to determine the economies of warranty contracting versus traditional delivery method.

$$LCC = \sum_{k=0}^{m} \Delta C_C * (P/F, i, k) + \sum_{l=0}^{n} (\Delta C_M + \Delta C_O) * (P/F, i, l) \tag{3.1}$$

In the equation above, ΔC_C is increased cost in initial construction contract (or warranty cost) caused by the warranty and ΔC_M is the variation of maintenance cost for the service life of the infrastructure facility. The construction period is defined as m, while n represents service life. These cost items represent incremental costs occurred to the highway agency due to the warranty. ΔC_O indicates all other savings and increases in cost items within the service life of the facility. ΔC_O is negative if cost savings are greater than cost increases. *i* is the discount rate that represents the cost of money. If the project is funded by tax revenue, then the return rate of the risk free treasure bond is a good estimate for the discount rate. (*P/F, i, k*) is the present value interest factor for interest rate *i* and discount period *k*, and calculated as $(P/F, i, k) = \frac{1}{(1+i)^k}$.

Initial Construction Cost

It is understandable that contractors add the warranty cost into the initial bid price to cover the potential liability of repairing future failures. It is known that the initial warranty cost depends on such factors as project type, warranty term, performance indicators and threshold values. With limited experience on warranty projects, an accurate estimate for the assumed risk is still a challenging task for both highway agencies and contractors. Many states use a rule of thumb and add 10 percent to the engineering estimate for warranties. However, contractors foresee the potential liability in a different way. Wisconsin and Colorado highway agencies reported the increase in the initial bids to be negligible on three and five year pavement warranty projects (Krebs, et al., 2001; Aschenbrener and Dedios, 2001), whereas an average increase of 8.5% was observed by Ohio DOT in bid prices due to the use of five year warranties on asphalt pavement projects. With more concern on warranties, contractors in California asked more than 30% for additional liability that made the state highway agency re-evaluate the warranty provisions (Hastak, et al., 2003). For a long term warranty like 15 or 20 years, the initial bid could increase significantly because the warranty period is almost equal to the design life of the project.

Figure 3-1 presents an average increase in initial pavement construction cost under different warranty terms.

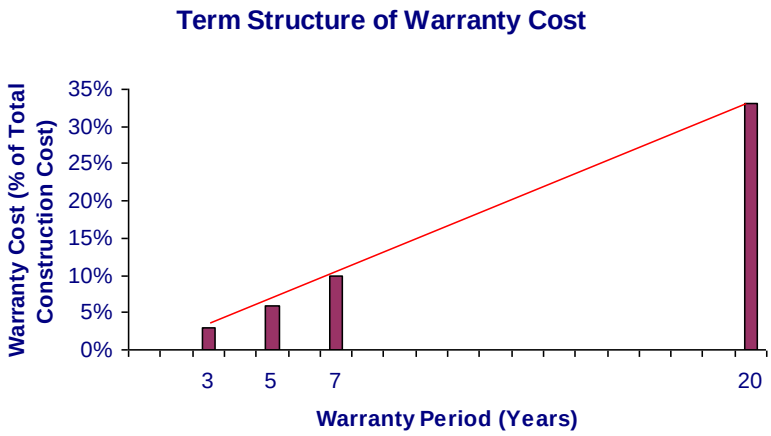

Figure 3-1. Initial pavement warranty cost under different warranty periods

Two conceptual frameworks have been developed recently to quantify the warranty risk cost. Damnianovic and Zhang (2006) applied a structure reliability method to estimate short-term pavement warranty costs. A system analysis methodology was developed for quantifying the risk cost of possible preventive maintenance, but not rehabilitation. The developed methodology considers the characterization of the warranty system and mathematical modeling of the system for the quantitative analysis. Using renewal process, Cui, et al. (2007) developed a cost estimation framework for long-term pavement warranties. This model incorporates performance indicators and threshold values as specified in the warranty specifications and provides warranty cost estimation at a detailed level. The model also considers multiple failures within the warranty period; therefore long-term warranty cost could be estimated.

The large spread of warranty costs indicates that uncertainties exist for future repair costs. From a statistical point of view, most projects go smoothly within the warranty period although major failures will happen in a few projects. Such failures cost a significant amount of money and could make the contractor vulnerable to falling into financial distress. After all, contractors are trying to compensate for failure in the same project rather than spreading the risk throughout all projects. Thus, most bids for warranty costs probably fall into the two extreme ends. One end includes small amount of warranty cost and the other a large amount. Therefore, the LCCA analysis of the expected value of the warranty cost cannot reach a robust result because the result is quite sensitive to the deviation of the warranty cost.

Maintenance Cost

Another major component of warranty life cycle costs is maintenance over the project service life. Maintenance work may be preventive or corrective, or any other structural maintenance work. Because the state agency is still liable for routine or periodic maintenance work, such costs should not be included in the life-cycle cost analysis. Within the warranty period, the contractor bears any cost of maintenance work due to failures resulting from improper materials,

inferior workmanship or defective design for which the contractor is responsible. Any maintenance work incurred within the warranty period would translate to savings to the state agency. It may also include costs of traffic control and lane rental during the remedial action. After the warranty expires, there may be saving in post-warranty maintenance cost due to better roadway performance. These savings are considered as incremental benefits and should be included in the LCCA.

Within the warranty period, the maintenance work depends on the type of required remedial actions when a failure occurs. Most highway agencies require contractors to follow a standard protocol of remedial actions whenever failures happen. The remedial actions on a pavement projects are basically categorized into minor maintenance, major maintenance, rehabilitation, and reconstruction work. Minor maintenance applies to some distress types including isolated potholes, small width cracks, and minor pavement remarking. Remedial actions required during filling potholes and cracks usually involve fewer resources. Major maintenance is used when more serious distress types appear such as rutting, flushing or cracks averaging over one-half inches wide. Most states require contractors to remove and replace the distressed areas or layers. This type of remedial action consumes more labor, material, and equipment when the contractor is required to fix them. In addition, rehabilitation and reconstruction strategies including asphalt overlays need to be considered under long term warranties. Rehabilitation and reconstruction involve a large amount of capital investment and are usually sold as separate contracts in a non-warranty system. Similar to initial construction cost discussed before, the maintenance cost is also characterized by large variance. Although the average annual maintenance cost is low, it can be significantly high in extreme cases. The distribution curve of the failure cost is very flat and the expected value cannot represent the whole picture of the failure cost.

Other Cost Items

In addition to initial construction cost and maintenance cost discussed in the previous sections, other cost items may also change due to the warranty provisions including user cost, project delivery cost, litigation, saving in maintenance staff, and others cost items. The Wisconsin highway agency believes that a saving in project delivery cost should be included although it is difficult to measure (Krebs, et al., 2001). In Michigan, warranty provisions were used to solve a shortage of maintenance staff (Hastak, et al., 2003). With respect to the post-warranty maintenance cost, the recent survey showed that most state highway agencies did not expect any significant change, although the pavement deterioration rate and performance curve could be improved due to the warranty (Bayraktar, et al., 2004). The litigation issue is still a major concern for warranty provisions but no significant changes have been observed yet in those states utilizing warranties. User costs in highway construction are usually measured by queuing delays experienced during the work-zone. Cost are determined by the timing and duration of roadwork, volume of traffic disrupted due to the work zone, and cost rate (Walls and Smith, 1998).

Assessing Cost-Effectiveness: Wisconsin Case Study

The Wisconsin DOT began constructing asphalt pavement with a five-year warranty specification in 1995. By the end of 2000, a total of 24 asphalt warranted pavements had been

built. In 2001, the Wisconsin DOT conducted a progress review on the warranty practice. A cost-effectiveness analysis was made between warranted and standard projects based upon limited performance data. The comparison included all the cost items experienced by Wisconsin DOT and the contractor during the first five years of pavement life (warranty period), in addition to the initial construction cost. However, user costs were not considered. Based on Wisconsin DOT's five-year progress report (Krebs, et al., 2001), the cost items in standard contracts include:

- Mixture bid price
- Asphalt bid price
- Tack coat bid price
- Quality management bid price
- State delivery costs
- State maintenance costs for five years
- Conflict resolution (negligible)
-

Cost items included in warranty contracts were:

- Asphalt pavement warrant bid price
- Costs related conflict resolution team (negligible)
- State delivery cost
- Extra distress survey and reports costs (negligible)
- Extra tests for disputes, traffic counts, etc (negligible)
- Based on cost data from 1995 to 1999, the Wisconsin DOT found out that warranted pavements cost less per ton than standard projects.

  The standard project averaged $28.04 per ton versus $24.34 per ton for the warranted period from 1995 to 1999. It is obvious that warranty project cost $3.70/ton less and therefore warranties are cost-effective on asphalt pavement projects (Krebs, et al., 2001).

Furthermore, warranty projects appear to perform better. The Wisconsin DOT used Pavement Distress Index (PDI) to assess pavement performance, and International Roughness Index (IRI) to quantify rideability. The PDI ranges from zero (perfect condition) to 100 (worst possible condition), while IRI ranges in value from zero (perfect ride) to an indefinite upper-end (four is considered a very rough ride). As shown in Figure 3-2, the average distress performance of the warranted pavements over five years is better than standard pavement performance. The ride values are significantly better than historic performance of standard pavements. This means reduced post-warranty maintenance cost and much longer service life. The analysis also pointed out that "even at an initial cost of up to 7% greater, warranty pavements are still more cost effective than standard pavements" (Krebs, et al., 2001).

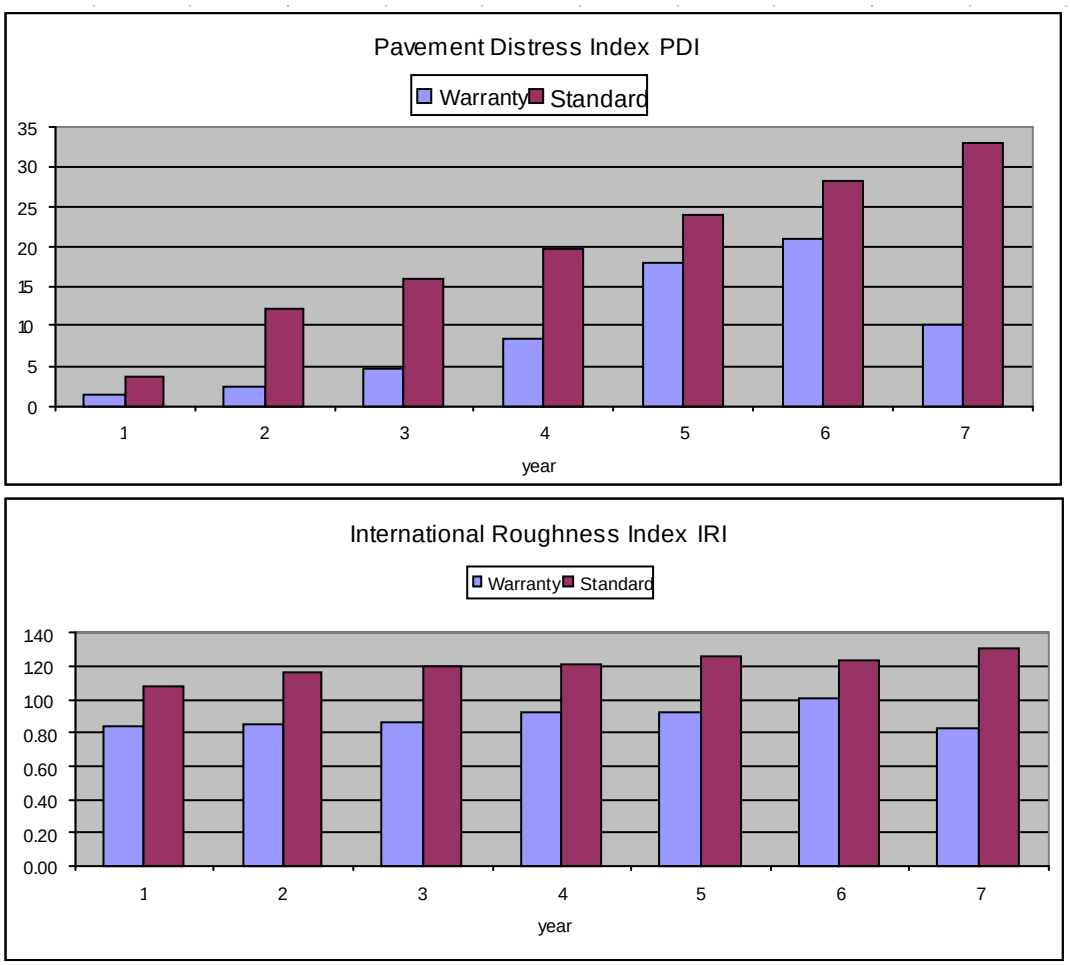

Figure 3-2. Pavement performance: warranty versus standard (Krebs, et al., 2001)

Assessing Cost-Effectiveness: Indiana Case Study

In 1996 the State of Indiana first implemented warranty in the rehabilitation contract of a four mile stretch of I-70 near Greenfield, east of Indianapolis (FHWA, 1996). By the end of 2003 the Indiana DOT had let more than 13 warranty projects covering hot-mix asphalt overlay and rubblized Portland Cement Concrete pavements. Within the required five year warranty period, the contractor is responsible for quality control and roadway performance that is measured by roughness, cracking, rutting, and friction. Based on current warranty practices, a comparison research project had been conducted on warranty cost-effectiveness. Five comparison pairs were established on the basis of their similarity in characteristics such as traffic loading, project type, geographical location, contract length, and construction year.

The cost-effectiveness was measured in terms of (1) additional pavement life per dollar and (2) the area bounded by the performance curve and the threshold line over unit cost. The unit cost includes both agency cost and user cost and is measured by the equivalent uniform annual costs (EUAC) over the analysis period. The cost-effectiveness index represents the user benefits of improved performance over unit cost. Therefore, a higher index suggests more cost-

effectiveness. Table 3-1 summarizes the findings of Singh, et al. (2007) on warranty cost-effectiveness in Indiana. In their research, the performance was measured by IRI. Furthermore, medium-term cost-effectiveness was also conducted using the area bounded by the performance curve per cost.

Table 3-1. Evaluation of Cost-Effectiveness of Warranty versus Traditional Projects (Singh, et al., 2007)

Measure of Cost-Effectiveness	Comparison Sets	Agency cost only		Agency cost + user cost	
		Warranty	Traditional	Warranty	Traditional
Long term	1	0.69	0.50	0.45	0.28
Average service life/EUAC	2	0.54	0.46	0.40	0.30
(year per $1000)	3	0.91	0.52	0.71	0.38
	4	0.98	0.50	0.79	0.30
	5	0.46	0.21	0.30	0.15
Long term	1	78.05	60.60	51.19	34.61
Aver enclosed by the IRI-age	2	84.62	48.64	62.88	31.84
curve/EUAC (IRI-year per $1000)	3	94.52	67.00	74.23	49.38
	4	51.27	46.65	41.42	40.73
	5	82.31	34.91	53.77	24.08
Medium term	1	4.47	6.70	4.43	6.27
Aver enclosed by the IRI-age	2	3.21	5.41	3.14	5.16
curve/EUAC	3	4.87	6.25	4.76	6.05
	4	4.58	4.87	4.51	4.60
	5	1.64	1.58	1.58	1.52

Based on the analysis of five comparison pairs, Singh, et al. (2007) reported that over a relatively short period of five years, the warranty pavements were 27-30% less cost-effective than their traditional counterparts. However, the warranty contracts were approximately 70-90% more cost-effective over the pavement service life based on a long-term analysis. Warranty contracts are much more cost-effective in the long-term when both agency and user cost are used in the analysis rather than only agency cost.

Summary

Warranties encourage quality work and can extend service lives of transportation facilities. The cost-effectiveness evaluation of warranty contracting therefore must incorporate initial and discounted future agency, user, and other relevant costs/benefits over the facility's entire service life. Under current warranty practices, warranty contracting had been identified as a cost-effective method over the entire service life. It is estimated that the warranty contracts represent more than 70% cost-effectiveness over the entire service life when both agency and user costs are used. However, it should be noted that warranty projects could be less cost-effective as compared to their counterparts when a relatively short period of time (e.g. five years) is considered in the analysis. Furthermore, estimating cost/benefit over the service life is a

challenging task, especially under uncertainties. The next section will present the US 550 case study and illustrate how the contract clause influences the cost-effectiveness assessment.

4.0 Evaluation of Warranty Provisions: US 550 Case Study

Introduction

The state of New Mexico was not among the original eight states that initiated the use of warranties under SEP No. 14. However, they have since evaluated the option of warranty contracting and successfully applied it to US 550 (old New Mexico State Route 44), which traverses 118 miles from I-25 at San Ysidro northwest to Bloomfield, near the Four Corners area (See Figure 4-1). When considering the prospect of infiltrating the northwest corner of New Mexico, New Mexico Department of Transportation (NMDOT) determined that the future maintenance and rehabilitation costs of the upgraded 118 miles of roadway would total about $16,000 per lane-mile per year over a service life of twenty years (May, et al., 2003) totaling just over $151 million. Additionally, they determined that the roadbed and surface upgrades would take almost 27 years to complete using normal contracting methods. In an effort to keep the highway in good condition for the long term, NMDOT purchased a 20-year warranty agreement from Mesa PDC who in turn guaranteed the pavement performance during the warranty period.

The US 550 warranty broke new ground in both length and cost. The total cost of the project was $323.82 million which included $46.32 million for project design and construction management, $215 million for construction, and $62 million for the performance warranties. It was the first long-term highway warranty in the United States and the most expensive. Since conception, its economics and applicability to other projects has been a subject of debate. Moreover, the two ceiling clauses in the warranty agreement that limit cumulative traffic volume and maintenance expenditures have been neither examined nor evaluated. This section presents a case study evaluation of the cost effectiveness of warranty clauses in the US 550 project.

Warranty Provisions for US 550

Two primary participants, NMDOT and Mesa Project Development Contractor (PDC), a division of Wichita, Kansas-based Koch Performance Roads, Inc., cooperated on the US 550 project. The NMDOT laid out design criteria, performance requirements, and oversight procedures, and estimated a life-cycle cost to establish the overall present value of the expected maintenance during the twenty-year warranty period. Through team building and open communications, NMDOT was able to monitor performance without responsibility for performance, while Mesa PDC was able to gain insight into the development and award process along with the limitations and constraints that had to be addressed.

To carry a long-term warranty agreement, a Professional Services Contract was introduced. Basic items included delineation of responsibilities and appropriate protocol for repairs, costing, and reimbursement. The final price on the warranty was comprised of $60 million for a 20-year pavement warranty and, $2 million for a 10-year structures warranty to cover bridges, drainage,

Figure 4-1. US 550 project location (May, et al., 2003)

erosion, etc. for a total of $62 million in warranty liability. Mesa PDC also agreed to a 3.5% inflationary risk on future maintenance costs. Based on these numbers, the warranty pricing was $6,400 per lane mile per year, a 60% reduction as compared to the initial evaluation (May, et. al 2003). Additionally, the warranty duration was limited by three ceiling clauses: (1) 20 years of service life; (2) 4,000,000 equivalent single axle loads (ESAL); and (3) $114 million in total expenditures, of which $110 million is the ceiling for the pavement warranty and $4 million is the ceiling for the structure warranty. Thus, in return for $62 million, Mesa PDC agreed to provide up to $114 million in repairs over a period of 20 years or 4 million ESALs. To ensure the fiscal liability was met, the warranty was also backed by a performance bond.

The parties established what constitutes warranted pavement defects based on objective criteria such as smoothness, rutting, transverse crack spacing, crack width, potholes, depressions, bleeding, raveling, and delaminations. Because the warranty provider shoulders the risks associated with performance, they have a strong incentive to assure quality in the design, composition, and construction of the pavement. The parties also developed plans to monitor performance and to perform both preventative and routine maintenance to ensure the highway's health.

Discounted Cash Flow Analysis

In a recent interim report of the US 550 warranty audit, the state of New Mexico challenged the cost-effectiveness of the $62 million warranty (Abbey, 2004). This interim report and its predecessor (Abbey, 1999) provide invaluable cost projections on the US 550 project and the associated warranty. Using these data a cost analysis was conducted based on the information available to the NMDOT when they made the warranty decision in 1998. So for this analysis, all warranty benefits and costs incurred during the construction and warranty period were discounted back to the decision time in 1998, and all costs and payments were assumed to fall at the end of the year. Additionally, only the pavement warranty was considered which was valued at $60 million and explained 96.8% of the total warranty cost. Ignoring the structures warranty, which was valued at only $2 million, reduced ambiguity without any significant impact on the results. Furthermore, Abbey (2004) points out that the structures warranty will expire before the end of the ten year warranty period, while the pavement warranty probably will remain in effect for the entire 20 year term.

Projections of highway maintenance costs by NMDOT project engineers, as represented in Abbey's reports to the State Legislative Finance Committee, were analyzed and discounted back to 1998. These costs, and the inherit uncertainty therein, were assumed by Mesa PDC in return for the warranty payment. The warranty payments to Mesa PDC were distributed over several years predicated on substantial completion of the various sections of the project. For simplicity, these payments were lumped into two installments of $5 million in 2000 and $55 million in 2001 for a total of $60 million. These warranty payments and estimated maintenance costs are illustrated in Figure 4-2. The illustrated "best," "moderate," and "worst" case cash-flow scenarios for maintenance expenditures represent NMDOT life cycle costing estimations of 100% ($146 million), 75% ($110 million), and 50% ($73 million) of the total anticipated maintenance expenditures. These scenarios are based solely on estimations of expenditures associated with maintenance over the twenty year lifetime of the pavement warranty as provided in the financial reports by Abbey in 1999 and 2004, respectively.

The NMDOT financed the project with 4.7% GARVEE bonds (FHWA, 2000). GARVEE bonds, or Grant Anticipation Revenue Vehicles, are new debt instrument financing mechanisms that allow states to leverage project funds with future Federal-aid highway funds. This rate represented the capital (or opportunity) cost of money and was used to discount all warranty payments and projected maintenance costs back to 1998. In this manner, the face value of the warranty, $60 million in 2000/2001 dollars, was reduced to a real cost of $52.5 million in 1998 dollars. A net present value (NPV) sensitivity analysis, as illustrated in Figure 4-3, using the real warranty cost of $52.5 million and the best, moderate and worst case scenarios for maintenance costs yielded hurdle rates of 2%, 4.6%, and 6.4%, respectively. A hurdle rate is the required rate of return in a discounted cash flow analysis, above which an investment makes sense and below which it does not. The 4.6% hurdle rate, for instance, indicates that the estimated moderate maintenance cost stream justifies the $52.5 million cost whenever the cost of money is 4.6% or less. It is interesting to note that the moderate case scenario hurdle rate falls one tenth of a percent below the GARVEE borrow rate. Assuming midyear rather than end-of-year payments and costs yields a hurdle rate of 4.7%, the same rate as GARVEE bonding.

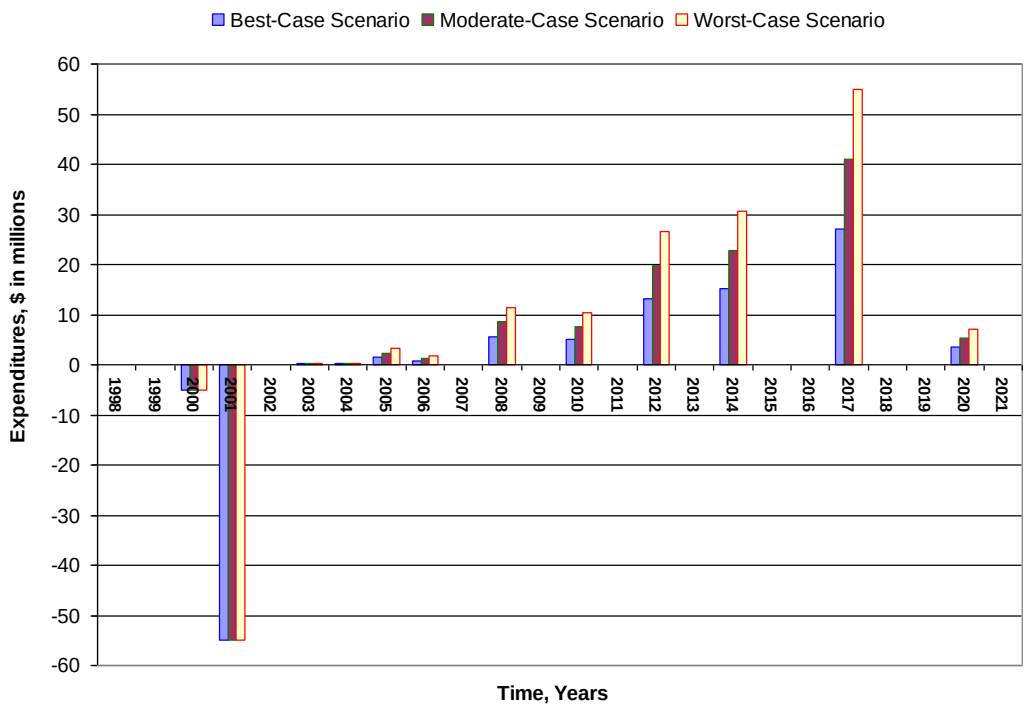

Figure 4-2. Estimated warranty expenditures over time under best, moderate, and worst scenarios (adapted from Abbey, 2004)

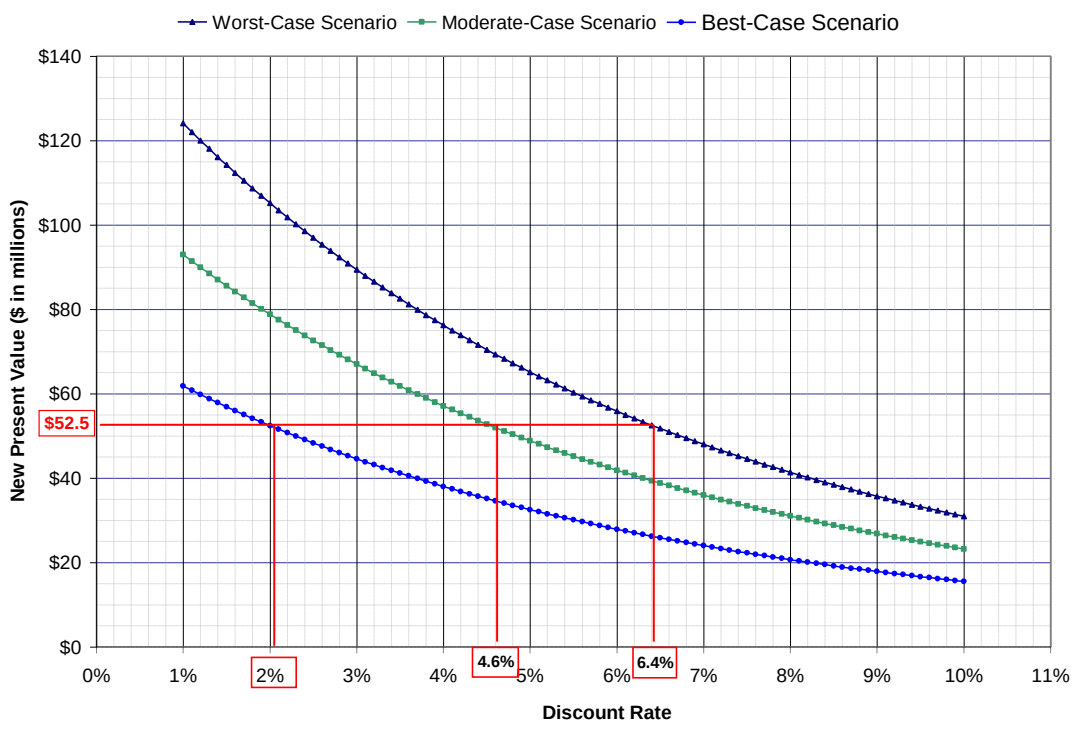

Figure 4-3. Net present value versus discount rate

The hurdle rate calculations do not take into consideration the expenditure ceiling in the warranty provisions. The warranty provisions of the US 550 project contain two ceilings in addition to the 20-year time limit – one for the ESAL and one for the maintenance expenditure costs. Modern financial theory indicates that these ceiling clauses might be costly if the projected maintenance costs are uncertain. Based on the NMDOT current evaluations of ESALs, exercise of the ESAL warranty ceiling is considered unlikely (Abbey, 2004), so it is not evaluated in this research. But based on the NMDOT maintenance cost projections, it is necessary to consider exercise of the cost ceiling provision to be a reasonable possibility. If the maintenance costs occur as in the worst case scenario, then the ceiling clause will be invoked in 2016. (See Figure 4-4.) The expenditure ceiling clause will be discussed and evaluated in the ensuing sections of this section.

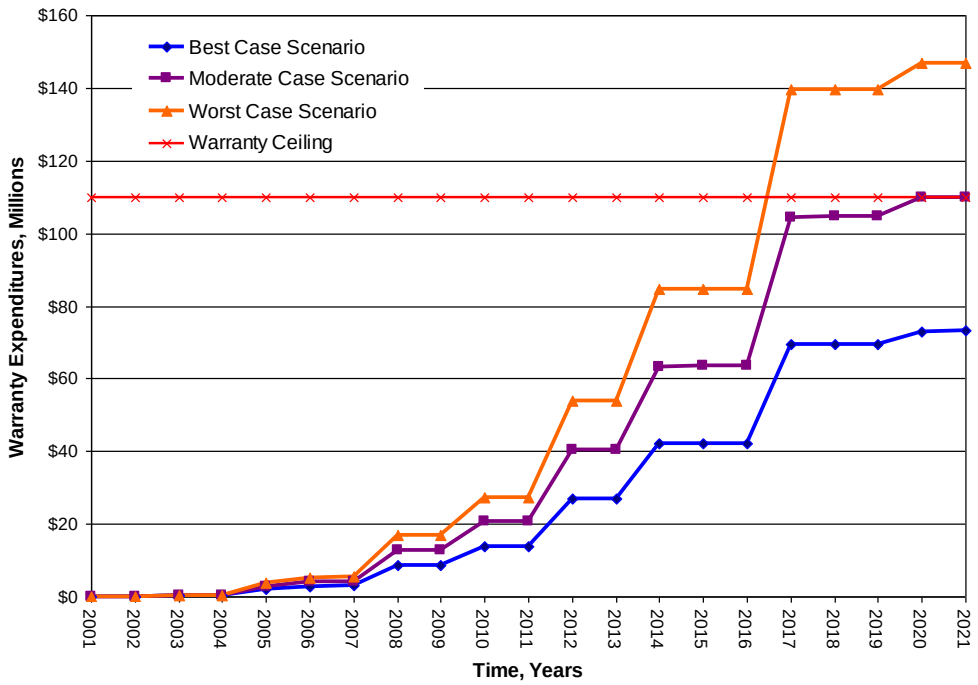

Figure 4-4. Accumulated cost of warranty work

Uncertainty in Warranty Assets

Assets create future cash flow. However, the meaning shifts subtly when applied to warranties. Warranty payments are essentially prepaid credits from the contractor to perform work as needed once the warranty period commences. These credits also represent a reduction of future risk and subsequent liability. This future liability includes uncertainty in both period and value. Period refers to the overall duration of warranted coverage, while value is representative of the yearly expenditures charged to the overall warranty assets. Real options theory provides a means to value an asset under conditions of uncertainty.

A financial option is defined as the right, but not obligation, to buy (or sell) a financial asset under specified terms, while real options are those that refer to operations imbedded in real operational processes, activities, or investment opportunities. Real options provide the owner

with the flexibility to take favorable actions under different case scenarios. This approach hinges on the pursuit of knowledge before, during, and after construction in order to help manage and mitigate risk as needed. Earlier research efforts define basic real options in capital investment decisions including the option to defer, the option to abandon, the option to switch, the option to grow, the option to expand, and compound options (Trigeorgis, 1996). Several of these basic options have been identified and evaluated in infrastructure construction. Ford, et al. (2002) investigated options in project construction. Zhao and Tseng (2003) identified an option to expand in designing the capacity of an infrastructure under uncertain demands. Ng, et al. (2003) designed a model to value an option to defer a material purchase. Ho and Liu defined a government guarantee on revenue in a Build-Operate-Transfer (BOT) project as an option to lock in the risk. Garvin and Cheah (2004) identified and evaluated options in a toll road project.

Real options, like financial options in the financial markets, have real value. The value of an option depends on the uncertainty of the underlying asset. The more uncertain the underlying asset, the more valuable is the option (Amram and Kulatilaka, 1999). Discounted Cash Flow analysis fails to recognize the value of options and therefore systematically undervalues flexibility in the face of uncertainty. In essence, the ceiling clause in the US 550 warranty provisions provides Mesa PDC with flexibility to declare an early termination of the warranty when actual maintenance cost exceeds the predetermined ceiling. While this is not a true real option since no choice will be made (Mesa PDC would never choose to keep maintaining US 550 after the cost ceiling is reached) real option theory does provide a viable method to value the US 550 ceiling clause. Like real options, the ceiling clause implies a trigger point that is uncertain in time. The warranty savings can be viewed as an asset equal in value to the discounted maintenance costs during the warranty period. These savings, as applicable to the US 550 project, are calculated by discounting maintenance costs back to the initial time (1998). When evaluating the warranty asset with a real options approach, however, additional issues must be considered.

Figure 4-5 shows three separate cases for financing the maintenance costs on US 550. Illustrated in the left-most diagram, a traditional naked warranty provides dollar-for-dollar matching of costs and warranty payoff, a linear relationship irrespective of costs. In the middle figure, an imaginary sale by NMDOT of a call option to Mesa PDC is illustrated. There is no additional expenditure required by NMDOT up to the $110 million ceiling, with the additional $58 million in fiscal risk carried by Mesa PDC as required in the warranty provisions. Any further maintenance costs beyond this $110 million, however, falls squarely on NMDOT, and is represented in the difference between the horizontal axis and the negatively sloped portion of the graph. In the last case, the previous two graphs are combined to demonstrate the real-life warranty parameters associated with US 550 into what is termed a “covered call” option strategy under options theory. Under these circumstances, the unfavorable uncertainty associated with the warranty liability is eliminated from a value standpoint. It must also be clarified that in these cases, the actual maintenance costs to Mesa PDC are assumed to be savings to NMDOT, and that the original $60 million warranty expenditure is considered to be a sunk cost. Thus the ceiling on expenditures can be valuable. In the following section and Appendix C, a lattice-type binomial model will be described to help determine the uncertainties and price the cost ceiling clause.

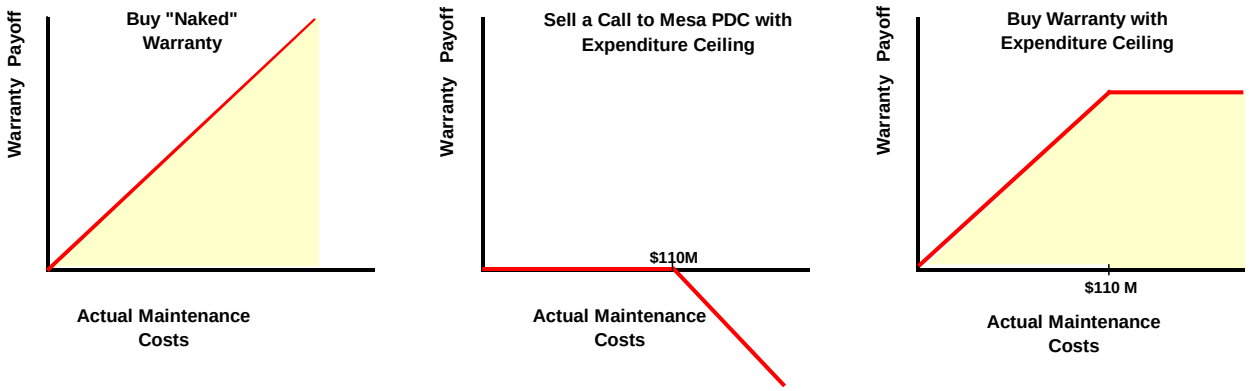

Figure 4-5. The US 550 warranty essentially a combine of a naked warranty and a call option

Pricing the Expenditure Ceiling Clause

Several ways exist to value real options including the Black-Scholes model, the Binomial model, and Monte Carlo simulation. Relying on stochastic differential equations, the Black-Scholes model assumes that volatility is known and constant (Hull, 2000). However, the variation and fluctuation of maintenance expenditures is generally unknown and somewhat difficult to estimate. The Monte Carlo approach is powerful to solve the problem of the curse of dimensionality when several sources of uncertainty exist. As compared to other methods, it is not the best solution for problems with a single source of uncertainty due to its time-consuming nature. This section presents a two-period binomial model to value the uncertainty and flexibility due to the ceiling clause. (See also Appendix C.) The binomial model first presented by Cox, Ross, and Rubinstein (1979) is the special case of a binary tree where nodes represent possible future prices in a recombining manner so that there are *n* possible prices at time *n*. The price of the underlying asset will randomly walk through the path in the binary tree and achieve the future node from the current node. A major assumption in the binomial model is that one does not know whether the asset price will appreciate or depreciate during the next time period, but one does know by how much the value will rise or fall. Pricing an option with the binomial tree is simply a matter of multiplying the values of the option on a late date by the probabilities of each of those prices and discounting back along the paths to the present. These probabilities are referenced to a risk-neutral condition. Risk-neutral means that today's fair price of an asset is equal to the discounted expected value of the future payoff of the same asset. The probability that the value will increase over time above the risk-neutral value is termed the risk-neutral probability of a rise. In the financial market, the risk-neutral represents a state that no risk-free arbitrage exists.

The price of the warranty liability follows the path in the binomial tree and reaches a node from left to right, while pricing the ceiling clause uses a backward algorithm. The backward algorithm in the three-date binomial model includes the following six steps:

(1) defining the nodes on date 3,
(2) determining rise and fall rates and establishing the remaining nodes in the binomial tree,

(3) determining the risk-neutral probabilities,
(4) valuing the ceiling clause as of date 3,
(5) valuing the ceiling clause as of date 2, and
(6) valuing the ceiling clause on date 1.

The three nodal dates are 1998, the date of the original warranty agreement, 2001, the date of the final warranty purchase payment, and 2004, the date of the latest interim audit report. Given the value of the warranty liabilities in 2004, the warranty ceiling clause can be priced at $4.8 million in 1998 dollars by following steps 1 through 6. It is about 9.1% of the total warranty cost. A detailed calculation is included in Appendix C.

Summary and Policy Suggestions

Due to the ceiling clause, the price of the warranty provisions in the US 550 project does not reflect the real cost to the NMDOT. The ceiling clause, valued at 4.8 million per year (1998 dollars) as calculated, represents additional revenue to Mesa besides the $62 million warranty payment from NMDOT. By declaring the ceiling clause, Mesa PDC in fact eliminates unfavorable risk while keeping profitable uncertainty. What Mesa gains is what NMDOT loses since this is a zero-sum game. The actual cost for the warranty provision in the US550 project goes up to 57.3 million year in 1998 dollars. The hurdle rate of a viable warranty provision falls to 4% (Figure 4-6). Considering that the NMDOT had to borrow at a higher interest rate to finance the US 550 project, the warranty provision is not justified because of the high cost of the ceiling clause.

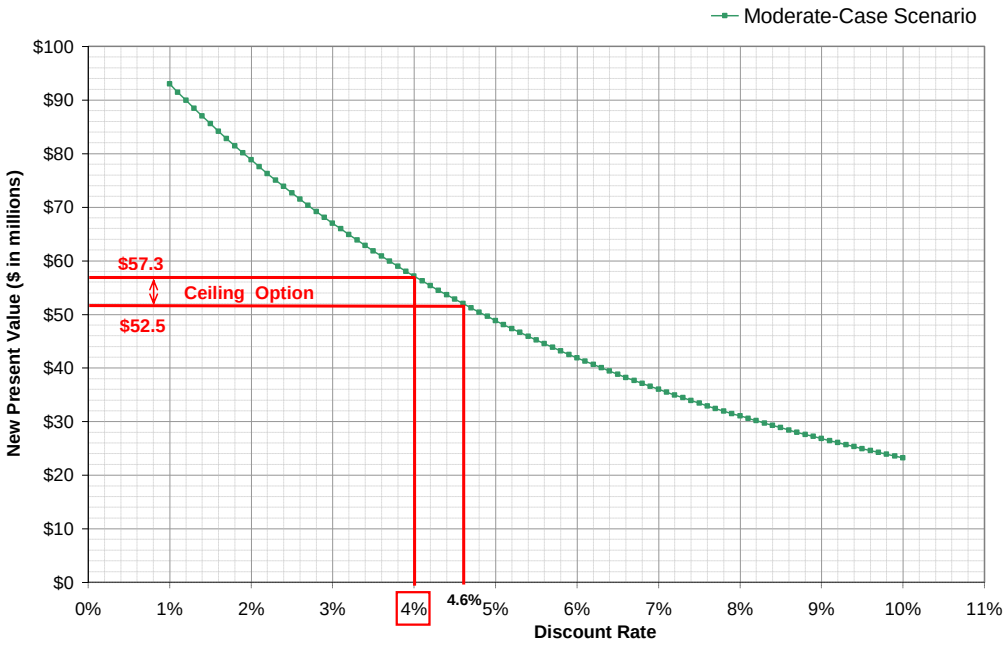

Figure 4-6. Net present value versus discount rate with the expenditure ceiling included

It is suggested that state highway agencies carefully evaluate warranty clauses, especially those with ceiling prices, when requiring warranty services in selling infrastructure projects. Two analyses need to be conducted so a better decision can be made. First, one must realize that the ceiling clause may be costly, especially under uncertainties. The more the uncertainties, the higher the price of ceiling clauses. Second, state agencies should determine a favorable ceiling when including ceiling clauses in the warranty. A sensitivity analysis indicates that the value of the ceiling clause is elastic to the determined ceiling. A 10% increase of the ceiling in the US 550 warranty provisions would reduce the option price of the ceiling clause by 30%. Therefore, careful selection of a ceiling can significantly reduce the impact of the ceiling clause.

5.0 Industry Acceptance of Warranty Contracting

Introduction

In Alabama, there is an increasing demand to explore alternative ways to provide adequate oversight on construction projects. As one of the innovative contracting techniques encouraged by the FHWA, warranty provisions allow the state DOT to shift responsibility for quality control and maintenance to contractors and therefore improve project performance and agency efficiency. However, the successful implementation of warranty provisions would require partnering of many sections of the industry and ALDOT. The ALDOT needs to have "buy in" since warranties would increase quality, reduce failures, and reduce life-cycle cost. The contracting industry also needs to have "buy in" and accept the risk and reward of the warranty implementation. This section reports industrial opinions on warranty contracting in Alabama.

Questionnaire Design

A questionnaire survey was conducted to collect industry opinions on warranty contracting in Alabama. The designed questionnaire was intended to be short and easy to administer in order to encourage wide industry participation. The development of the questionnaire involved a cooperative effort between the research team at the University of Alabama and the project advisory committee, including representatives from ALDOT, Alabama Road Builders Association, and surety companies. Two research meetings were held at ALDOT headquarters in Montgomery to discuss, draft, and finalize the questionnaire. The final questionnaire includes twelve questions covering the background information of the responding company, acceptance of and concerns about warranty contracting, and the expected impact of warranty provisions. A copy of the questionnaire is included as Appendix A.

In addition to questions about the respondent's contact details, four questions were asked regarding company background information, including annual dollar revenue, years in the highway construction business, percentage of revenue in each highway segment, and warranty project experience in other states. These questions could be used to categorize responding companies into several groups according to size, highway construction experience, warranty project experience, etc.

Another four questions were designed to collect contractors' opinions on warranty contracting in Alabama. Respondents were asked what type of warranted highway projects they would consider bidding on, how long a warranty period they would accept, what they would request in return for the warranty, and what were their concerns about warranty work. Additional questions addressed the availability of and length of warranty bonds they could obtain.

A fourth series of questions addressed the expected impact of warranty contracting. Those questions addressed the type of roadway project warranties that would produce benefits in terms of life cycle cost and what measures of roadway performance they would accept. Additional questions, such as the impact of warranties on construction quality and owner-contractor relationships are also covered in the questionnaire.

Sampling

Survey design depends largely upon the sample size and the representativeness of the sample. To obtain a representative sample, the survey population must be defined and examined. In most states, a contractor must be pre-qualified before submitting a bid proposal for highway and bridge construction. In Alabama, ALDOT qualifies a contractor based on the company's financial statement, equipment fleet, and construction experience. There are currently 360 companies on the list of prequalified contractors that are allowed to bid on Alabama transportation projects. Those contractors can be divided into two groups using company size, state residency, or experience in warranty jobs as a criterion. In another words, we can define several dichotomous variables with the value of 0 and 1 to describe the characteristics of any prequalified contractor. For example, residency variable x is defined as the state residency of a responding company. If a responding company takes residency in Alabama x equals to 1, otherwise x equals to 0 for non-Alabama resident companies. The characteristics of the survey population are represented by the group distributions of prequalified companies. However, these distributions are generally unknown.

While sampling from the finite population, the survey requires sufficient responding companies from each group, or a typical sample with statistically indifferent group distributions. Consider a finite population of size N from which a simple random sample of size n is drawn, without replacement. Let $\bar{x}$ be the sample mean and let $\bar{X}$ and $\bar{S}$ be the population mean and variance. If the group variable is dichotomous taking the value of 0 or 1, $\bar{x}$ and $\bar{X}$ will be denoted by p and P, respectively. In this case, $S^2 = \frac{NPQ}{N-1}$, where, $Q = 1 - P$. It is known that

$$Var(\bar{x}) = (\frac{N-n}{Nn})S^2, \tag{5.1}$$

by imposing the restraint $Var(\bar{x}) \le V*$ for a prechosen margin of error $V*$. The required sample size to satisfy this inequity is determined by (Desu and Raghavarao, 1990),

$$n* = \frac{NS^2}{S^2 + NV*} + 1 \tag{5.2}$$

or,

$$n* = \frac{N}{1 + \frac{(N-1)V*}{P(1-P)}} + 1 \tag{5.3}$$

Since P is usually unknown and somewhat difficult to guess, a conservative approach is to take P=0.5. Thus, with N=360 prequalified contractors, the required sample size for $V*= (0.1)^2$ is

$n*$= [360/{1+(359*0.01)/(0.5*0.5)}]+1= 24

If 100 questionnaires are sent, the required sample size represents a 24%response rate. Given an average response rate of 10-20% from construction companies on earlier similar research (Hastak, et al., 2004), the research team decided to send the questionnaire survey to all 360 prequalified contractors and expected a minimal responses rate of 6.7% for a reliable analysis.

Survey Implementation

The list of pre-qualified contractors was obtained from the ALDOT Office of Engineering Bureau. ALDOT also provided a cover letter to the questionnaire which explained the purpose of the research. The questionnaire was sent by mail to all 360 contractors on August 4, 2006. Twenty-eight contractors responded within the required two weeks. Fifteen more questionnaires were received in another two weeks after a reminder was sent out on August 21, 2006. Among the total 43 questionnaires received, three responding companies are specialty contractors for roofing, ITS, etc. and have little expertise in the research area. Another company responded twice with totally conflicting answers. The research team contacted the respondent and confirmed that the latest response reflected the current opinion on warranty contracting. Thus the research team counted 39 effective responses, which represented a 10.8% response rate and satisfied the minimum sample size requirement.

Within the 39 responding contractors, half of them are local companies in Alabama. Another 12 contractors are from southeastern states (Mississippi, Tennessee, Georgia, and Florida). The residency states of the remaining seven contractors were Texas, Minnesota, Indiana, Kentucky, Pennsylvania, Virginia, and Connecticut. After a discussion with ALDOT engineers and the Alabama Asphalt Pavement Association (AAPA), the research team categorized large contractors as those with over $20 million in annual revenue. A small contractor is defined as a firm with less than $5 million in revenue every year. Companies with revenues between $5 to $20 million are medium size contractors. Based on this criterion, 48.7% of the respondents are categorized as large contractors, while 51.3% are in the small and medium size groups. In another dimension, 44% of the responding contractors have done asphalt pavement projects, 23% have done Portland Cement Concrete (PCC) pavement jobs, 41% have done bridge work, and 38% have done pipe work (Figure 5-1).

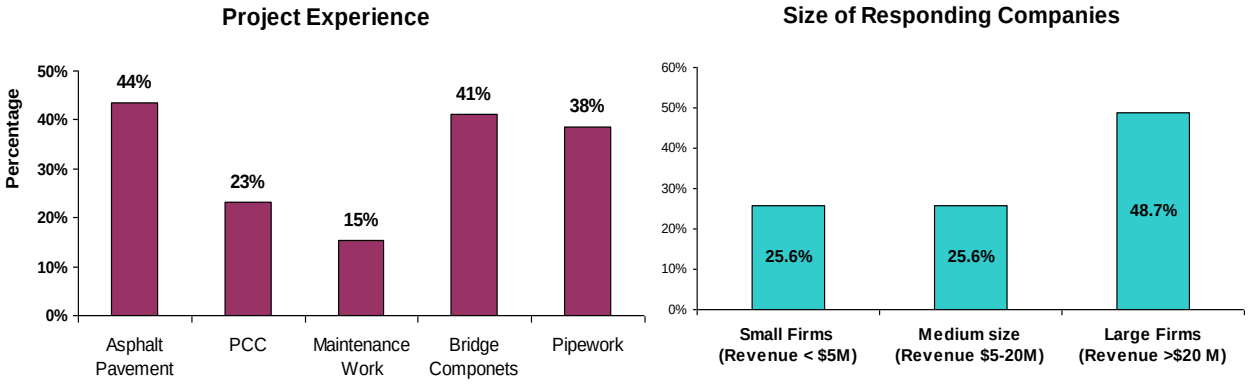

Figure 5-1. Profile of responding companies

Industry Acceptance of Warranty Contracting

The successful implementation of warranty contracting depends on "buy-in" of the local contracting industry. Without cooperation from local contractors, a state DOT would not be able to shift maintenance responsibility. In several states where highway departments intended to let projects with warranties, few contractors would bid on these jobs. A pre-investigation of local industry acceptance of alternative contracting could help state DOTs predict potential backlash from the industry and develop creative solutions. This research shows that a majority of highway contractors in Alabama would bid on highway warranty jobs, but a little more than one-fourth of the responding contractors will not consider biding on warranty projects in Alabama. Within the group accepting warranty contracting, 80% are willing to bid on new construction. There is a significant difference between the acceptance of new construction and resurfacing jobs. The survey shows that contractors are more willing to offer warranties on new construction projects than on resurfacing. This correlates well with earlier findings that contractors would reduce risks on warranty jobs and prefer to warrant design-build contract (Bayraktar, et al., 2004).

Although most contractors would consider bidding on warranty jobs, their decisions also depend upon the term of the warranty period and the type of highway projects. Asphalt pavement and PCC pavement are the top two types of construction projects on which most contractors would offer warranties. Forty-one percent of asphalt paving contractors would bid on asphalt pavement projects with a less than three year warranty. However, when the warranty period goes to four to five years, less than one quarter of contractors would take warranty risks. Only six percent of asphalt paving contractors would try over five years in warranties on asphalt pavement projects. The longest term accepted in an asphalt pavement job is eight years. No contractor in Alabama would bid on an over eight years warranted asphalt project. On PCC projects, the longest accepted warranty period is 10 years. However, as the warranty period goes over three years, a very limited number of contractors would like to bear the risks associated with warranties. Thirty-three percent of PCC contractors would accept a less than three years PCC pavement warranty, will 22% will consider bidding on a four to five year warranty job. There are about 11% of contractors who would bid on a PCC job with a warranty over five years. As for the other types of highway projects, the majority contractors only accept a less than three years warranty (Figure 5-2). In return for the acceptance of a warranty contract, the highway industry would request an increased cost on top of the total installed cost, as well as leniency in the construction specifications.

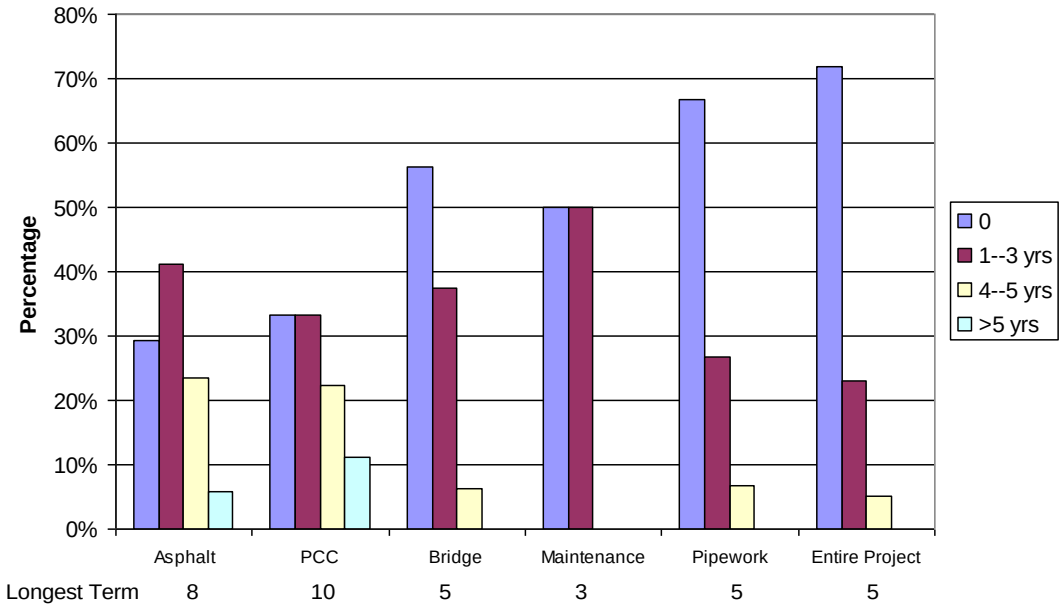

Figure 5-2. Industry acceptance of warranty contracting

Industry Concerns

Earlier research identified state DOTs' major concerns regarding the use of warranties in highway construction (Bayraktar, et al., 2004). This survey reports major industrial concerns as shown in Figure 5-3. The top three concerns are the involved risks and liabilities, availability of warranty bonds, and warranty cost estimating methods. Forty-five percent of respondents rank risks and liabilities as the most important factor in their decision to bid on warranty jobs. The involved risks that contractors are aware of are overloaded traffic and uncertain subground conditions. Furthermore, 24% of the responding companies consider the lack of an estimating

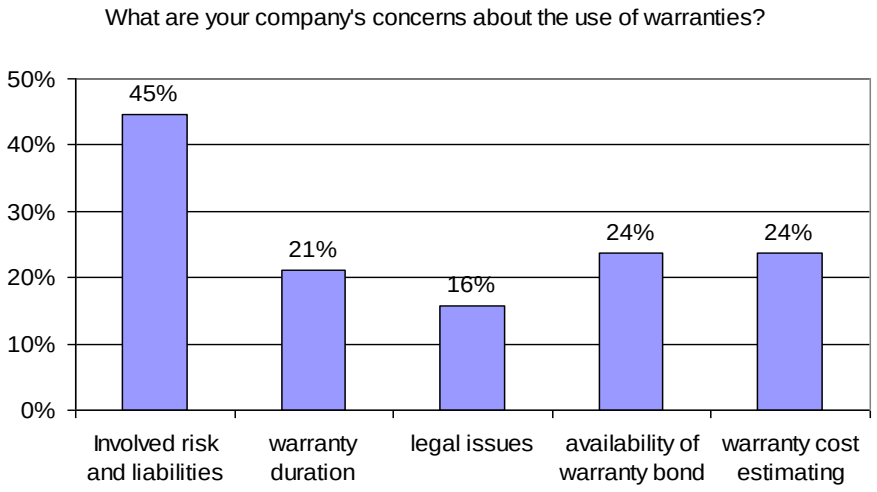

Figure 5-3. Industry concerns regarding warranty contracting

method for warranty cost as a constraint hindering them from bidding on warranty projects. Other concerns include warranty duration and legal issues.

The lack of availability of a warranty bond was especially emphasized in the earlier work. The survey shows that 21 out of 39 responding companies can obtain a warranty bond of three years or less. However, none of them expect a five year or longer warranty bond to be available for them. For the less than three year warranty bond, this research shows a statistically insignificant impact of company size on the availability of warranty bonds. Table 5-1 summarizes the group analysis of bonding availability. An F-test with a value of 0.11 indicates an insignificant difference among the three groups in obtaining a warranty bond. On an average, half of the responding small to medium size contractors would be able to secure a warranty bond. If a warranty bond of more than three years is required, neither large contractors nor small firms are capable of finding a surety firm to bond the warranty projects. Therefore, bonding availability is not a problem in a short term warranty (less than three years) but definitely becomes the most serious obstacle to long term warranty projects (five years or more) in Alabama.

Table 5-1. Group Analysis of Bonding Availability

Groups	*Count*	*Sum*	*Average*	*Variance*
Small Firms	10	5	0.5	0.277778
Medium Size	10	5	0.5	0.277778
Large Firms	19	11	0.578947	0.25731

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	0.060729	2	0.030364	0.113493	0.893029
Within Groups	9.631579	36	0.267544		
Total	9.692308	38			

In return for providing a performance guarantee along with highway construction, most contractors request that a line item be added to the bid schedule and would estimate the warranty cost under a worst case scenario situation. One-third of contractors within the accepting warranties group would request leniency in designing the warranty and specifications. They claim that contractors' control of the specifications will dictate success in warranty projects.

Contractor's Learning in Warranty Projects

A statistical analysis was conducted to identify possible causes that explain the different opinions on warranty contracting. Such factors as company size, state residency, and out-of-state warranty experience were examined. With a lower than 0.05 P-value, out-of-state warranty experience has been found to be statistically significant with regard to the group difference in accepting warranty contracting (Table 5-2). Company size and the state residency, however, do not contribute to the group difference. This finding clarifies an earlier misunderstanding of warranty contracting: If warranties favor large contractors over small firms, then one would expect more large companies to get involved. The survey shows no statistical significance of company size regarding acceptance of warranty contracting. Integrating the finding of the

availability of warranty bond, it is safe to draw a conclusion that warranty contracting would not impede competition in the highway construction market. The use of a warranty contract apparently does not place large contractors in an advantageous competitive position relative to small and medium size contractors.

Table 5-2. Driver of Industrial Acceptance

Variable	Definition	P-Value
X1	Revenue	0.627
X20	Warranty Experience	0.046
X59	State Residency	0.790

This research shows that previous warranty experience can dramatically affect a company's acceptance of warranties in highway construction. A logistic model of the acceptance probability is given by Equation 5.4

$$Log[P/(1-P)] = 0.336 + 2.228\,X_{20} \qquad (5.4)$$

where P is the probability of accepting warranty contracting within the warranty experience group. X_{20} is defined as the warranty experience. The equation shows that the richness of warranty experience significantly increases the acceptance probability of warranty contracting. The increase is partly due to the change in warranty concerns and opinions generated by warranty experience. The survey shows that as a contractor becomes experienced in warranty projects, he/she will better understand the risks associated with warranties, which alleviates the concerns about risks and liabilities but raises concerns about bonding availability, which is beyond his/her control. Furthermore, an experienced contractor would be more likely to request flexibility in design and construction to reduce the warranty costs and risks.

Discussion and Summary

Warranty provisions hold contractors accountable for failures and maintenance after construction completion. Along with the expected benefits, the state DOT needs to evaluate industrial acceptance before implementing the alternative contracting methods. The evaluation should establish a guide for the state DOT to select appropriate projects, warranty term, and specifications. Based on the questionnaire survey, this paper proposes recommendations to both the state DOT and local construction industry.

In Alabama, wide-spread industrial acceptance exists for less than three year short term warranties in highway construction. There is a sufficient degree of acceptance for four to five year warranties in pavement projects. However, the local industry has not been well prepared for warranties over five years. If substantial benefits from warranty contracting are expected, the state DOT is encouraged to consider less than five year warranties for new pavement construction and less than three year warranties for other projects. To achieve a significant level of market acceptance, a better strategy is to implement pilot warranty projects. The pilot projects must be carefully selected to ensure success. They will serve as both a test bed for evaluating the effectiveness of warranty contracting and an educational platform for the local contracting

industry. The development of the pilot projects will strengthen cooperation and partnership among the state DOT, the contracting industry, sureties, and beyond.

Before the state DOT initiates the new program, the state must be ready for possible cost increases. The state DOT should be prepared to allow its contractors more freedom in the selection of materials, construction technologies, inspection methods, or even mix design and structure design. Considerable effort should be devoted to developing detailed specifications and guidelines. The state DOT may have to identify alternative solutions if no surety is willing to provide a bond for pavement projects with five year warranties. Alternative methods used in other states, including renewable bonds (Wisconsin) and letters of guarantee (South Carolina), should be evaluated. Performance indicators should be further examined and carefully selected to insure performance and quality.

Local construction companies may need to adjust their strategies and opinions on warranty contracting. This research highlights the fact that warranty contracting may not be as risky as it appears. Many contractors learn from past experience and are able to control the risks well. When the concept of "Get in, Stay in, Get Out, and Stay Out" as a new objective of the FHWA, the construction industry will see warranties become integral components in more and more transportation projects, especially in design-build projects. To maintain a competitive position, contractors need to consider providing operation and maintenance services. Participation in the policy discussion and cooperation with the state DOT in pilot projects would help improve their competitive advantages in today's changing construction market.

6.0 Legal Assessment of Warranty Contracting

Legal Assessment Framework

As a public sector organization, ALDOT must follow state laws and proper project procurement procedures. State legislation impacting the agency is found in statutes pertaining to public works, highways and roads, government agencies, and special statutes. These statutes define general responsibilities and liabilities of the highway agency, and must be investigated before ALDOT moves to implement any innovative contracting method. Additionally, ALDOT is also bound by regulations it creates outlining the policies and procedures of the agency.

The present legal environment in Alabama is not ideal for the introduction of performance based warranty contracting. This section will examine each necessary legal element as detailed below in Figure 6-1, including the initiation of warranty contracting, statutory assessment, and regulatory assessment. Specific recommendations will be made for creating a more favorable climate for warranty contracting.

Initiation of Warranties

Several states initiated the use of warranties as a result of a legislative mandate. For example, in 1999 the Illinois legislature passed a bill that required twenty of the projects outlined in the Illinois Department of Transportation's Five Year Plan to include five-year performance warranties (IDOT, 2004). Ten of those projects were to be designed to have thirty-year life-cycles (Illinois Compiled Statutes Ch. 605 §5/4-410). Also in 1999 Ohio began using warranties due to a legislative mandate which required a minimum of one-fifth of road construction projects to be bid with a warranty. According to Ohio Revised Code §5525.25, the requirements were later changed on the suggestion of the highway agency to make the minimums into maximums so it could spend more time evaluating what types of projects are best suited for warranties (ODOT, 2000). The warranties were to range from two to seven years, depending on the type of construction. Finally, in a less demanding mandate, the Michigan Compiled Laws §247.661 in a state highway funds appropriation bill included the instruction that, "the Department [of Transportation] shall, where possible, secure warranties of not less than five-year, full replacement guarantee for contracted construction work." These types of mandates generally require the agency to first come up with an outline of how it plans to incorporate these directives into existing procedures and specifications, as well as prepare reports regarding the success of these programs and their cost effectiveness.

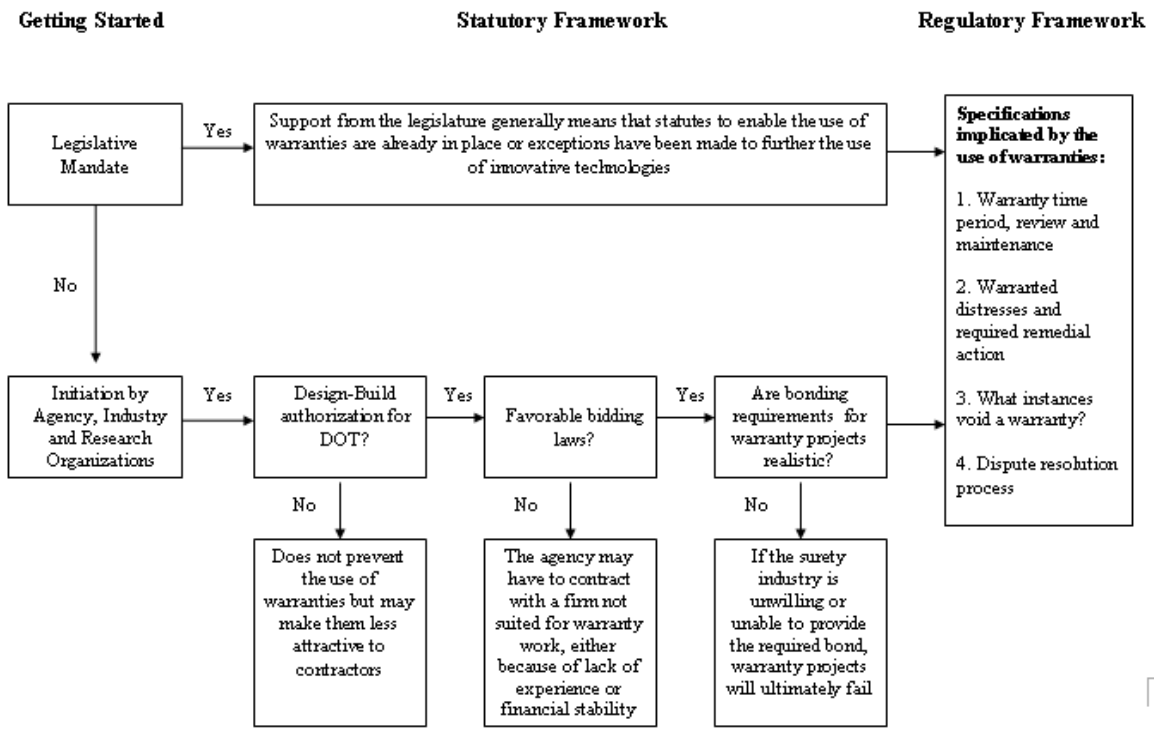

Figure 6-1. Legal assessment framework for warranty contracting

Alternatively, some agencies begin the use of warranties on their own initiative. In Texas, the State Comptroller's Office issued a report on the Department of Transportation's (DOT) operations and strongly recommended the use of more innovative methods, including warranties, to better meet the transportation needs of the state (Strayhorn, 2001). As a result, the Texas Transportation Institute commenced its own investigation of warranties and developed an implementation plan for the Texas DOT (Anderson, et al., 2006). One of the reasons cited for the study was the potential for a future legislative mandate, and the need to research the area before the agency was forced to make use of warranties. Montana acted without any government influence by initiating a bill (Bill Draft No. LC0443), which called for the formation of a committee to study the feasibility of design-build and warranty contracting. This committee was to include members of the House and Senate, Department of Transportation officials, representatives from contractor's associations, and a representative from the general public and would submit a report to the office of Budget and Program Planning. This bill was not enacted but the Department continued their efforts by preparing a report containing specific suggestions as to how Montana could implement warranties on future highway construction projects (Stephen, et al., 2002).

Like Texas and Montana, most states have made their own investigations into the use of performance-based warranties. Generally, state highway agencies have worked with research teams, contractors and industry associations to extensively evaluate the feasibility of warranted projects. Although sometimes a political push may be needed to encourage the use of innovative methods, states which begin researching new ideas on their own may have more time to carefully select the best use for these innovations. As exemplified by Ohio, which found it infeasible to

meet existing legislative mandates, states may have to amend the legislation later, indicating the legislature may not be best suited to make the first move.

Currently, the state of Alabama has no statutory directive requiring the use of warranties. Therefore, ALDOT, working with the surety industry, contractors and academics, might develop a plan for the implementation of warranties. In doing so, the agency must look at statutes which may impede the use of warranties.

Statutory Assessment

As indicated before, statutes regarding public works, public transportation, state government, and other related statutes should be evaluated in terms of the legal environment of warranty contracting. Three major types of legislation involved are project delivery, public bidding procedures, and bonding requirements. (See Figure 6-1.)

Legislation Regarding Design-Build Project Delivery

Historically, contractors are told what materials to use and how to use them in the construction project. State personnel oversee the construction and perform continuous quality assurance testing to ensure the contractor is following the specifications.

Legislation may restrict a state to this process, which does not allow for the increased contractor control that use of a warranty may dictate. Legislation may restrict a state to this process, which does not allow for the increased control that might be dictated by a warranty. Several transportation agencies have explicit authorization for design-build contracting methods. For instance, Ohio Revised Code §5517.011 allows for a value-based selection process where technical proposals can be weighted and the bid awarded to the contractor with the lowest adjusted price. These projects may be limited to a specific type of construction such as toll way or bridge projects, or by the dollar amount of design-build contracts that may be awarded annually. Oregon Revised Statute §383.005 allows for toll way contracts to be awarded considering cost, design, quality, structural integrity and experience. And Wisconsin Statute §84.11(5n) allows for certain bridge projects to be bid under design-build after a prequalification process, assessment of a variety of award criteria, and approval by both the federal Department of Transportation and the Governor. In Ohio, the Revised Code §5517.011, however, limits design-build contracts to $250 million biennially.

Other statutes are more general, simply stating that public agencies are permitted to use design-build contracting methods, e.g. Idaho Code §67-2309. In states where design-build contracts are specifically outlawed by statute (e.g. Tenn. Code §4-15-102), the agency has few options. In Texas, where design-build is not allowed, the agency has implemented a rigid, multi-step prequalification process in an effort to factor in advantages one contractor may have over another, while still complying with the traditional design-bid-build laws (Strayhorn, 2001). Design-build and warranties seem to go hand-in-hand, allowing less agency interaction from the beginning of the project and more confidence in the contractor's ability to fulfill the warranty requirements.

However, the proper statutes need to be in place for an agency to utilize this innovative contracting method.

Currently, there are no transportation statutes that allow for design-build in Alabama. When read in context with related statutes, and interpreting the language under the plain meaning rule, design-build contracting by state agencies is prohibited. In the *Anderson v. Fayette Co. Board of Education*, state court has chosen to allow this contract by squeezing it into an exception found in bidding law, such as the "service contract" exception. Additionally, Alabama Attorney General Opinions 84-00262, while not binding in court, have suggested exempting certain types of contracts from the competitive bid law. The agency should push for legislation that specifically allows for design-build contracts. A recent example of legislation that could be copied in Alabama is South Carolina's amendment to its construction contract procedures (Code 1976 §57-5-1625). The statute reads,

> The department may award highway construction contracts using a design-build procedure. A design-build contract means an agreement that provides for the design, right-of-way acquisition, and construction of a project by a single entity. The design-build contract may also provide for the maintenance, operation, or financing of the project. The agreement may be in the form of a design-build contract, a franchise agreement, or any other form of contract approved by the department. Selection criteria shall include the cost of the project and may include contractor qualifications, time of completion, innovation, design and construction quality, design innovation or other technical or quality related criteria.

This type of specificity in defining what constitutes a design-build project and the extensive list of factors that can be considered would ensure for ALDOT the ability to use this project delivery method.

Legislation of Public Bidding Procedures

The use of warranties and other innovative contracting methods may not fit cleanly within existing bidding procedures for public contracts. If the request for proposals details the project in terms of performance based specifications, bidding laws must account for the different methods and materials proposed by bidders. Traditionally, bidding laws require an agency to solicit bids through a competitive, sealed bidding process and award the contract to the "lowest responsible bidder." Exceptions to the lowest bidder rule are sometimes built into statutes, but the more common exceptions only allow an agency to reject all bids if they are all unreasonable or when it is in the interest of the awarding authority to reject all bids, e.g. Alabama Code §39-2-6(c). However, the lowest responsible bidder language presents a way through which a state may avoid contracting with simply the lowest pecuniary bidder, which may better serve the goals of the project.

In Alabama, several statutes must be looked at together to determine the bidding rules. Alabama Code section 23-1-56(a) requires bidders for DOT jobs to prequalify, by furnishing information describing the "past record and experience of both the firm and the personnel of the organization,

together with such other information as the [agency] may deem necessary." This statute will help narrow the pool of potential bidders to those which are best suited for the type of project being let and for warranty contracting in general. Further, when certification to bid is granted to a contractor, section 23-1-56(d) allows the certification to contain a statement limiting such bidder to the submission of bids upon a certain class or classes of work. Finally, section 41-16-57 requires the award be made to the lowest responsible bidder, taking into consideration "the qualities of the commodities proposed to be supplied, their conformity with specifications and the purpose for which required." Fortunately for the agency, Alabama law provides several opportunities to consider factors beyond the lowest monetary value when awarding a bid. The consideration of experience in specific types of projects or with warranties, reputation of the contractor and other factors that may be relevant to the project being awarded will help secure the appropriate contractor for the job, without challenges to the agency for not awarding the contract to the lowest monetary bidder. However, the statutes do not contain any language that allows for best-value bidding or consideration of life cycle costing. In order to better evaluate the proposed bid amount, the agency should propose a catch-all provision that allows the agency to look at the special circumstances of the project when assessing the proposed price and awarding the contract. An example of this type of statutory language can be found in Montana Code §60-2-112, which states that "the commission may award a contract by means other than competitive bidding if it determines that special circumstances so require, so long as the special circumstances are submitted in writing.

Legislation on Bonding

Bonding is one of the most uncertain issues in the use of warranties. Bonding laws commonly require a contractor to secure a bond in the entire amount of the project, for the duration of the project. However, the added cost of a warranty, as well as the length of time the bond would have to be in place, present problems for agencies, contractors and surety companies. The agency must work within the confines of the statutes to find the best solution for security during the warranty period. The Illinois Compiled Statute chapter 30 550/1 requires an agency to require contractors to furnish bond for every project over $5,000. The amount of the bond is set by the agency, based on the amount of materials and labor used in the work for the completion of the project, among other conditions. The statute does not specifically state that the bond must cover 100% of the project cost. This gives the agency some latitude to set a more realistic bond amount. Past projects have required bonds during the warranty period of between 20-50% of the project cost (MDOT, 2003). Michigan Compiled Laws 129.202 also gives the agency discretion in setting the bond amount, so long as it is not less than 25% of the contract amount. In states that do require a bond to cover the full amount of the project, different methods have been used to calculate the total cost of the warranty. Ohio calculates the cost to replace the project on a case by case basis. For hot mix projects, Colorado requires a bond that would cover the estimated cost to mill and replace two inches of the surface, while Wisconsin requires only the estimated cost for a 1½" overlay (Hastak, et al., 2003). Florida is the only state that has completely abandoned using bonds for the warranty period. Instead, they use a guarantee system, which is backed by an extensive prequalification process and strict distress thresholds. Under the guarantee, the contractor is required to fix problems according to specifications during the warranty period or else he will not be allowed to bid on state jobs for a specified period of time, usually six months. This system is allowed, despite Florida law that requires a bond in the full

amount of the project, because specifications state that the remedial work is not an obligation under the contract performance bond (FDOT, 2007). The contract refers to potential warranty work as "value added" in the original contract, which prevents it from having a separate warranty as a pay item. The exclusion of this work from the performance bond allows for release of the bond at the end of the construction, rather than at the end of the five-year warranty period. The Surety Association of America made a recommendation that the amount of a warranty bond should be around 10% of the total contract price, and should be submitted at final acceptance of the construction project to release the contractor from the performance bond. In addition to working within the confines of statutory language, states must confer with surety company representatives to determine the bond value that best fits their situations.

Alabama Code section 39-1-1(a) requires that any person entering into a public contract must execute a performance bond with "a penalty equal to 100% of the amount of the contract price." This poses a potential problem for the agency in that a sufficient number of contractors may not be able to obtain a bond that covers the cost of a project and a warranty of several years. The agency should propose a statute that allows it to set a bond amount on a case by case basis. This proposal will likely be backed by contractors and surety companies. A united front by the highway industry will be further incentive for the legislature to reevaluate the bonding requirements for the DOT, or for public contracts in general.

Once the agency has ensured the proper statutes are in place to implement warranty contracting, special attention should be paid to the specifications and special provisions mentioned above to reduce the likelihood for legal challenges during construction and the warranty period.

Regulatory Assessment

When an agency opts to use construction warranties on a project, special attention should be paid to several types of specifications. Discussed below are suggestions for more clear specifications and additional special provisions that will help an agency avoid excessive litigation and help the contractor better understand the requirements of the project. Many of these suggestions came about through agency and industry cooperation, such as in Ohio, where the agency formed teams that included agency and FHWA officials, as well as industry associations and various contractors, to develop joint specifications for thirteen different types of warranted projects (ODOT, 1999).

Specifications must determine when the warranty comes into effect. The most common benchmarks are at substantial completion, final acceptance by the agency or when the project is open to traffic (Johnson, 2004). After the warranty period begins, there must be procedures in place for inspection of the project. Generally, agency officials joined by the contractor will inspect the project every six months, or annually, to determine if performance requirements are being met. Since agencies are traditionally responsible for all types of road maintenance after construction is finished, it is important to differentiate between the different types of maintenance and clearly allocate responsibility between contractor and agency in the warranty provisions. States vary in the amount of control the contractor has over routine and preventative

maintenance. In New Mexico, Indiana and Virginia, *all* maintenance is the responsibility of the contractor. In Florida and Louisiana, the warranty does not include routine maintenance and in the language in the latter's contract specifies that routine maintenance done by the agency does not void the warranty. With respect to preventative maintenance, in Michigan and Ohio, none is done or expected. In Minnesota and Illinois, it is a contractor option, which in Illinois must be approved by the agency. Nearly all agencies include a provision that allows them to conduct emergency maintenance and later determine who should bear the cost. None of the warranty projects cover litter, snow removal or mowing maintenance.

In addition to determining terms and maintenance responsibilities, the agency should include an exhaustive list of what incidents will void the warranty. If the agency fails to include a distress, it may be responsible for some maintenance, but if an agency fails to outline a specific situation as not voiding the warranty, it may lose years of maintenance and repair by the contractor. The most common events that void a warranty are a significant increase in traffic thresholds, agency maintenance and extreme events, such as unanticipated weather conditions.

Even if extreme care is taken to avoid legal pitfalls in the implementation of an innovative process, disputes are still likely to arise between contractor and agency. It is important that the agency clearly establish a procedure for dispute resolution to minimize costs to both parties and promptly resolve the issue. Most states have opted for a Conflict Resolution Team (CRT) which is assembled for the specific purpose of resolving warranty issues. The teams are usually composed of an agency official, a contractor representative and a third party that both other parties agree on. In Illinois, Michigan and Minnesota, the CRT is responsible for providing a final decision on disputes regarding fulfillment of warranty requirements. In Colorado and Ohio the team functions as a warranty evaluation team and is responsible for the administration of the warranty (Anderson, et al., 2006).

Contractor Liability

One potential effect of warranty contracting is increased contractor liability. Under traditional contracting, the doctrine of sovereign immunity prevents a third party from suing the state highway agency in tort for negligence when the cause of the injury was within the scope of the agency's general functions. As a result, injured parties often choose to sue the contractor responsible for the construction of the roadway itself. In some states, a contractor is protected under the same immunity as the agency if the construction has been completed and accepted by the state and all specifications were followed and satisfied, e.g. Kansas Statute §68-419a. Additionally, some states may abrogate this immunity to expose an agency to liability under certain conditions.

The risk of a lawsuit to contractors is great, given this state immunity, and has led to difficulties in obtaining not only the required level of liability insurance but any extra it needs to obtain. The frame work of warranty contracting only increases this risk. In a warranty contract, the contractor is at risk in more areas that just construction. Under a design-build model, the contractor has full or partial control over the design process and will be exposed to risk where it may not have been under traditional delivery methods. Also, performance based specifications

may be more difficult for the contractor to follow, and may cause confusion as to whether these specifications were fully satisfied and accepted by the agency. Finally, under traditional contracting methods, contractor's liability may be abrogated by agency maintenance that follows completion of construction. With a warranty, not only will the contractor be responsible for injuries caused by defective maintenance, but will also be required to carry liability insurance for a longer period of time on for a specific project.

In Alabama all state agencies are protected by sovereign immunity under Article I, Section 14 of the state constitution. Currently, there are no statutory provisions directed towards the Department of Transportation that limit this immunity. Therefore, the agency is protected against any defects in the design, construction and maintenance of highways that may cause injury, so long as they are done within the normal scope of the agency's business. The *Morgan Hill Paving Co. v. Fonville case* (1930) seems to imply that a contractor who follows completely the instructions given in the contract would be sheltered under state immunity. The *Evans v. Patterson case* (1959) implies that if a project had been accepted by the agency, the liability would have shifted from the contractor to the state. However, no statutory language confirms these notions.

In accepting a warranty contract, contractors may expect consideration for taking on this additional risk. Hold harmless clauses may have to be more limited in scope, shifting some liability back to the state, or removed altogether. Contractors may also want the increased insurance costs passed through to the state, or for the state to provide the extra insurance needed for the project. The final decision on how to best allocate the liability in warranty contracts should be decided between contractors, insurance company representatives and ALDOT.

Summary

State highway agencies, including ALDOT, will continue to face pressure to pursue innovative methods to meet the nation's transportation needs. Among the many considerations for the agency in trying new methods are the legal limitations placed on public contracts. ALDOT could begin to use performance based warranties by partnering with the surety industry, contractors and academics to develop an implementation plan. Legislation that would allow for the use of design-build project delivery and also more lenient bidding laws would allow the agency more flexibility in awarding contracts.

Additionally, bonding legislation to allow the agency to set a smaller bond amount in warranty projects would open the door to a wider range of bidders, particularly for longer-term projects. Finally, before pursuing a warranted project, any state agency must carefully consider its project specifications and add or amend any that may impact a warranty's likelihood of success.

7.0 Conclusions and Recommendations

Warranty Contracting

Warranties hold contractors accountable for the repair or replacement of deficiencies after the project completion for a given period of time. Warranty contracting is primarily classified as workmanship and material warranty, where the contractor is only responsible for correcting deficiencies caused by bad workmanship and material, or as a performance warranty, where the contractor is given flexibility to design and even modify contract details and thus assumes the responsibility for correcting defects that are caused by workmanship and material, as well as design. By the end of 2006, more than thirty-two states have been involved in warranty contracting since its inception by the FHWA in 1991. The warranty program had been implemented in various highway construction projects including asphalt pavement, PCC pavement, bridge components, bridge painting, intelligent transportation system, preventive maintenance jobs, and others, with warranty periods ranging from one year up to twenty years.

Warranty contracting normally contains Performance-Based Specifications, which state the desired operation or function of highway products without specifying construction methods and materials. The contractor has some flexibility to select cost efficient materials and construction methods, or even design and contract details. Some of the key elements in a warranty specification include warranty terms, performance criteria (indicators) and threshold values, bonding requirement, conflict resolution team, control methods and remedial actions, as well as measurement and payment.

The warranty program was initially applied to highway construction to provide the public agency with protection against unexpected earlier failures. Warranty practices in most states also indicated that warranty contracting encouraged quality work and thus would extend service life of transportation facilities. By shifting maintenance responsibility to contractors, it is also expected that warranty contracting would encourage contractor-funded innovation and improve project delivery to the public. On the other hand, the challenges associated with warranties can be substantial, including higher initial costs, a reduction or even elimination of small contractors from the bidding process, and an increase in contract disputes and litigation, in addition to skepticism from contractors and sureties.

Cost-Effectiveness

The cost-effectiveness evaluation of warranty contracting must incorporate initial and discounted agency, user, and other relevant costs/benefits over the facility's entire service life. Under current warranty practices in Wisconsin and Indiana, the warranty approach has been identified as a cost-effective method over the entire service life of transportation facilities. It is reported in Indiana that the warranty contracts represent more than 70%cost-effectiveness over the entire

service life when both agency and user costs are used. However, it should be noted that warranty projects could be less cost-effective as compared to their counterparts when a relatively short period of time (e.g. five years) is considered in the analysis. Furthermore, estimating cost/benefit over the service life is still a challenging task for both agencies and contractors. It is not clear how warranty contracting would influences construction contract cost over a long time period.

This research concluded that specific warranty details may affect cost-effectiveness of warranty contracting. In the US 550 case study, warranty term was determined in three dimensions--calendar years, traffic volume, and expenditure ceiling, whichever comes first. Based on a real option analysis, the ceiling clause was valued at 9.1% of total warranty cost when the construction contract was let. One must realize that the more the uncertainties, the higher the price of ceiling clauses. It is suggested by this case study that state agencies could carefully evaluate and design warranty details, especially under uncertainties, to improve cost-effectiveness of warranty contracting.

Industry Acceptance

There is a good industry acceptance in the state of Alabama for less than three year short term warranties in highway construction. A sufficient degree of acceptance also exists for four to five years warranties on pavement projects. However, the local contracting industry has not been well prepared for warranties longer than five years in highway construction. In return for the acceptance of warranty contracting, the highway industry would request an increased cost on top of the total installed cost, as well as leniency in the construction specifications.

Many contractors are concerned about involved risks and liabilities in warranty contracts. The lack of a cost estimating method for warranty contracts also hinders local contractors from bidding on warranty jobs. This research shows that as a contractor becomes experienced in warranty projects, he will better understand the risks associated with warranties and that in turn alleviates the concerns about risks and liabilities, but raises the concerns about bonding availability, which is beyond his control. Currently, less than three year warranty bonds will be available to both small and large contractors in Alabama. However, bonding availability definitely is the most serious obstacle if the state agency requires a long-term warranty, e.g. five years or more.

Legal Viability

Currently, the State of Alabama has no statutory directive requiring the use of warranties. Alternatively, the highway agency could begin the use of warranties on its own initiative. National-wide warranty practices show that states that began researching new ideas on their own have more time to carefully select the best use for these innovations. ALDOT could work with the surety industry, contractors, and academics in order to develop a comprehensive plan for the implementation of warranties.

Workmanship and material warranties are compatible with competitive low bid procedures and are permitted in Alabama. However, the state legal environment is not ideal for the introduction of long-term warranties where the contractor assumes design responsibility. Design-build contracting by state agencies is prohibited. And the statutes do not contain any language that allows for best-value bidding or consideration of life cycle costing. Fortunately for the public agency, Alabama law provides several opportunities to consider factors beyond the lowest monetary value when awarding a bid. The consideration of experience in specific types of projects or with warranties, reputation of the contractor and other factors that may be relevant to the project being awarded will help secure the appropriate contractor for the job, without challenges to the agency for not awarding the contract to the lowest monetary bidder. However, in order to better evaluate the proposed bid amount, the agency could request a catch-all provision that allows the agency to look at the special circumstances of the project when assessing the proposed price and awarding the contract.

One potential effect of warranty contracting is increased contractor liability. In Alabama, all state agencies are protected by sovereign immunity. This means that ALDOT is protected against any defects in the design, construction and maintenance of highways that may cause injury, so long as they are done within the normal scope of the agency's business. Given this state immunity, injured parties often choose to sue the contractor responsible for the construction of the roadway itself. Contractors may expect consideration for taking on this additional risk in warranty projects. Hold harmless clauses may have to be more limited in scope, shifting some liability back to the state, or removed altogether. Contractors may also want the increased insurance costs passed through to the state, or for the state to provide the extra insurance needed for the project.

Recommendations

Given substantial benefits from warranty contracting in other states, it is recommended that ALDOT consider this innovative contracting method to meet growing transportation needs in Alabama. ALDOT is encouraged to implement warranties of less than five years for new pavement construction and less than three years for other highway projects. The warranty should provide ALDOT with a protection from early failures caused by bad workmanship and material.

To achieve a significant level of market acceptance, this research suggests implementing pilot warranty projects in Alabama. The pilot projects must be carefully selected to ensure success. They will serve as both a test bed for evaluating the effectiveness of warranty contracting and an educational platform for the local contracting industry. The development of the pilot projects should strengthen cooperation and partnership among the state DOT, the contracting industry, sureties, and beyond.

Warranty projects often incur larger up-front costs, and the state DOT should consider allowing its contractors more freedom in the selection of materials, construction technologies, inspection methods, or even mix design and structure design in order to reduce these costs. Considerable effort should be devoted to developing detailed specifications and guidelines. The state DOT may have to identify alternative solutions if no surety is willing to provide a bond in pavement

projects with five year warranties. Alternative methods used in other states, including renewable bonds (Wisconsin) and letters of guarantee (South Carolina), should be evaluated. Performance indicators should be further examined and carefully selected to insure performance and quality. Specific warranty details must be carefully examined and evaluated under a risk-based approach in order to ensure cost-effective implementation of warranty contracting.

Legislation that would allow for the use of design-build project delivery and also more lenient bidding laws would allow ALDOT to consider a variety of factors in awarding a contract. Additionally, bonding legislation to allow the agency to set a smaller bond amount in warranty projects would open the door to a wider range of bidders, particularly for longer-term projects.

It is also recommended that local construction companies should adjust their strategies and opinions on warranty contracting. This research highlights the fact that warranty contracting may not be as risky as it appears. Many contractors learn from past experience and are able to control the risks well. Now that the concept of "Get in, Stay in, Get Out, and Stay Out" is now an objective of the FHWA, the construction industry will see warranties become integral components in more and more transportation projects, especially in design-build projects. To maintain a competitive position, contractors need to consider providing operation and maintenance services. Participation in the policy discussion and cooperation with the state DOT in pilot projects would help improve their competitive advantages in today's changing construction market.

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Appendix A: Survey Questionnaire

Respondent: _____ ***Designation:*** _____
Address: _____

Telephone: _____***Fax:***_____ ***Email:***_____

(Please note that your company name will not be used in the final report)

1. What is your company's estimated total dollar revenue in highway work annually?
   ☐ Less than $ 5 million ☐ $5 - $ 10 million
   ☐ $10 - $20 million ☐ More than $20 million

2. How many years has your company worked in highway construction?
   ☐ < 5 years ☐ 5 to 15 years ☐ More than 15 years

3. About what percent of your business' yearly revenue is in the following areas:
   ☐ Asphalt Pavement_____ ☐ Concrete Pavement_____
   ☐ Asphaltic Crack Treatment_____ ☐ Bridge Components_____
   ☐ Micro-Surfacing_____ ☐ Chip Sealing_____
   ☐ Pipe work _____ ☐ Others_____

   How long would you recommend a performance warranty last in those areas?
   ☐ Asphalt Pavement_____ ☐ Concrete Pavement_____
   ☐ Asphaltic Crack Treatment_____ ☐ Bridget Components_____
   ☐ Micro-Surfacing_____ ☐ Chip Sealing_____
   ☐ Pipe work _____ ☐ Entire Project _____
   ☐ Others_____

4. Do you have warranty experience out of state?
   ☐ Yes ☐ No

5. What type of highway warranty project in Alabama would you consider bidding on? Please check all that apply.
   ☐ New construction ☐ Resurfacing ☐ Maintenance ☐ Design-build
   ☐ None

6. What would your company like in return for the application of a performance warranty in highway construction? Please check all that apply.
   - ☐ Nothing
   - ☐ Funds Added to Initial Contract
   - ☐ Leniency in Preconstruction Specs
   - ☐ Other, please elaborate:

   _____

   _____

   _____

7. What are your company's concerns about the use of warranties? (If multiple selections are made, rank numerically, beginning with "1" as most concerned.)
   - ☐ Involved risk and liabilities _____
   - ☐ Legal issues _____
   - ☐ Warranty cost estimating _____
   - ☐ Warranty duration _____
   - ☐ Availability of warranty bond _____
   - ☐ Other, please elaborate: _____

   _____

   _____

8. Would your insurance company provide bonds for the warranty project?
   ☐ Yes ☐ No
   If yes, what length of the warranty bond could be acceptable?
   ☐ 5 years ☐ 7 years ☐ 10 years ☐ 20 years ☐ Other, _____

9. What type of roadway construction projects do you think warranty contracts may be viable in term of project life-cycle cost? (if multiple selections are made, rank numerically, beginning with '1' as best)
   - ☐ Asphalt Pavement_____
   - ☐ Asphaltic Crack Treatment_____
   - ☐ Micro-Surfacing_____
   - ☐ Pipe work _____
   - ☐ Others_____
   - ☐ Concrete Pavement_____
   - ☐ Bridge Components_____
   - ☐ Chip Sealing_____
   - ☐ Entire project _____

10. What measures of roadway performance do you feel would be acceptable to evaluate contract compliance during the warranty period? Please check all that apply.
    - ☐ Cracking
    - ☐ Skid resistance
    - ☐ Bleeding
    - ☐ Rutting & shoving
    - ☐ Potholes
    - ☐ Delamination
    - ☐ Roughness/Ride
    - ☐ Raveling
    - ☐ Other, please elaborate:

    _____

11. What effects would the use of warranty-based contracts in highway construction have on the quality of the job done?

☐ Positive ☐ Negative ☐ None

Comments: _____

_____

12. What would be the effect of the use of warranty on the relationship between the owner (the motoring public, as represented by ALDOT) and the contractor?

☐ Positive ☐ Negative ☐ None

Comments: _____

_____

Thank you for your valuable contribution. Please kindly return the completed questionnaire before Sept 15th, 2006, either (a).by mail to Dr. Qingbin Cui, the University of Alabama, Box 870205, Tuscaloosa, AL 35487-0205 or (b) by fax to 205-348-0783

Appendix B: Alabama Statutory Supplement

Design-Build

There are no statutes that address design-build contracts for public contracts.

Bidding Procedures

§23-1-56 (a)–Prequalification of Contractors
Department of Transportation shall require all bidders to furnish a statement under oath…of detailed information with respect to their financial resources, equipment**, past record and experience of both the firm and the personnel of the organization, together with such other information as the State Department of Transportation may deem necessary.**

§23-1-56(d) – Prerequisites to Award of Certificate
In the discretion of the State Department of Transportation, the certification **may contain a statement limiting such bidder to the submission of bids upon a certain class or classes of work**.

§39-2-6(a) – Award of Contract
The contract shall be awarded to the **lowest responsible and responsive bidder**, unless the awarding authority finds that all the bids are unreasonable or that it is not to the interest of the awarding authority to accept any of the bids. A **responsible bidder** is one who, among other qualities determined necessary for performance, is competent, experienced, and financial able to perform the contract. A **responsive bidder** is one who submits a bid that complies with the terms and conditions of the invitation for bids.

§41-16-57 – Awarding of Contracts Generally
When purchases are required to be made through competitive bidding, awards shall be made to **the lowest responsible bidder** taking into consideration the qualities of the commodities proposed to be supplied, their conformity with specifications, the purpose for which required, the terms of delivery, transportation charges and the dates of delivery.

Bonding Requirements

§39-1-1(a) – Bonds Required of Persons Contracting for Public Work
Any person entering into a contract with an awarding authority in this state for the prosecution of any public works shall, before commencing the work, execute a performance bond, **with penalty equal to 100 percent of the amount of the contract price**.

Appendix C: Binomial Model for Pricing Ceiling Clause

It has been discussed that the warranty expenditure ceiling clause is essentially a combine of a naked warranty and a call option. To evaluate the ceiling clause in the US550 project, a binomial tree model has been presented in section 4. The model uses a backward algorithm and includes six steps:

Step 1: *Defining the nodes on date 3*
Step 2: *Determining rise and fall rates and establishing the remaining nodes in the binomial tree*
Step 3: *Determining the risk-neutral probabilities*
Step 4: *Valuing the ceiling clause as of date 3*
Step 5: *Valuing the ceiling clause as of date 2*
Step 6: *Valuing the ceiling clause on date 1*

Step 1: Defining the nodes on date 3

In 2004 the NMDOT published three maintenance cost scenarios that can be identify as the best, moderate, and worst cases representing total pavement warranty liabilities of value of $73 million, $110 million, and $146 million respectively. These numbers are accumulated values at the end of the 20-year warranty period and need to be discounted back to 2004 dollars for the current analysis. The discounted values are $47.0 million, $70.6 million, and $94.2 million. If substantial maintenance expenditures had occurred before 2004 they would have to be appreciated forward in order to have the correct 2004 values. The worst and the best scenarios define the cap and floor on the warranty asset price. $70.6 million, the year 2004 dollar value under the moderate case scenario is the striking price or the threshold value above which the ceiling clause would be activated. On date 3 the ceiling clause is only valuable when the warranty liability exceeds this striking price.

Step 2: Determining rise and fall rate

In a three-date binomial tree, the price of the underlying asset reaches the highest price on date 3 after two successive rises and the lowest value on date 3 at two successive falls. Both rises and falls follow the same rates. Therefore, the prices of the underlying asset on date 2 can be determined as

$$S_u = \sqrt{S_0 * S_{u^2}} \qquad \text{(C-1)}$$

$$S_d = \sqrt{S_0 * S_{d^2}} \qquad \text{(C-2)}$$

Where S_u is the price of the underlying asset on date 2 when the price goes up on date 2, S_0 is the price of the underlying asset on date 1, and S_{u^2} is the price of the underlying asset on date 3 when the price follows an up-up path, i.e. the warranty liability under the worst case scenario. S_d is the price of the underlying asset on date 2 when the price goes down on date 2, S_{d^2} is the price of the underlying asset on date 3 when the price follows a down-down path, i.e. it is the

warranty liability under the best case scenario. The rise rate *u* and fall rate *d* can be calculated as follows:

$$u = \sqrt{\frac{S_{u^2}}{S_0}} \qquad \text{(C-3)}$$

$$d = \sqrt{\frac{S_{d^2}}{S_0}} \qquad \text{(C-4)}$$

As discussed previously, the highest price on date 3, S_{u^2}, and the lowest price, S_{d^2}, are $94.2 million and $47 million, respectively. The price of the warranty liability on date 1 (1998) is $52.5 million. The rise rate and fall rate would be 1.340 and 0.946. And the prices on date 2 (2001) are calculated to be $70.3 million and $49.7 million, as shown in Figure C-1 (nodes B and C). The price of the warranty liabilities on node E can be determined with equation C-5 and would be $66.5 million.

$$S_{ud} = S_{du} = S_u * d = S_d * u \qquad \text{(C-5)}$$

Step 3: Determining the risk-neutral probability

The risk-neutral probability is the probability of a price rise such that the expected return on the warranty provisions exactly equals the risk-free rate. Assuming the GARVEE interest rate at 4.7% annually as the risk-free rate, this implies a rate of 14.8% over the three year period (date 1 to date 2 or date 2 to date 3). The risk-neutral probability can be solved as:

$$14.8\% = p * (u-1) + (1-p) * (d-1) \qquad \text{(C-6)}$$

Here, *p* represents the risk-neutral probability of a rise. Solving the equation, the risk-neutral probability of a rise is approximately 51.3%, implying the probability of a fall is 48.7%.

Step 4: Valuing the ceiling clause on date 3

As indicates previously, the striking price of the warranty liability is $70.6 million, the discount value on date 3 under the moderate scenario. When the warranty liabilities are over the striking price of as in the worst case ($94.2 million in 2004 dollars), Mesa PDC would activate the ceiling clause and be liable for only $70.6 million in year 2004 dollars. If there is no ceiling clause, Mesa would lose an additional $23.6 million ($94.2M-$70.6M). In other words, the ceiling clause saves Mesa $23.6 million (or is worth $23.6 million) if the actual warranty liability is $94.2 million. However, if the warranty liability is below the striking price, Mesa would not declare the ceiling clause. The ceiling clause generates neither profit and loss and is worthless in the moderate and best-case scenarios. Therefore, the ceiling clause value on date 3 can be determined with the following equations, where *X* represents the striking price or the ceiling amount.

$$C_{u^2} = Max(0, S_{u^2} - X) \qquad \text{(C-7)}$$

$$C_{d^2} = Max(0, S_{d^2} - X) \qquad \text{(C-8)}$$

$$C_{ud} = Max(0, S_{du} - X) \qquad \text{(C-9)}$$

Step 5: Valuing the ceiling clause as of date 2

As indicated in Figure C-1, the ceiling clause will be worth $23.6 million in 2004 if the warranty liability has risen to $94.2 million. That means that by invoking the ceiling clause Mesa can take responsibility for only $70.6 million in maintenance rather than the total $94.2 million maintenance liability. The ceiling clause will be worthless in 2004 if the warranty liability is either $66.5 million or $47 million. Using the risk-neutral probability, the value of the ceiling clause in 2001 (date 2) can be calculated as follows when the warranty liability is $70.3 million at that time:

$$C_u = (51.3\% * 23.6 + 48.7\% * 0) /(1+14.8\%) = \$10.55 \text{ million} \qquad \text{(C-10)}$$

If the warranty liability in 2001 is $49.7 million, the value of the ceiling clause on node C is clearly zero, as indicated by calculation:

$$C_d = (51.3\% * 0 + 48.7\% * 0)/ (1+14.8\%) = 0 \qquad \text{(C-11)}$$

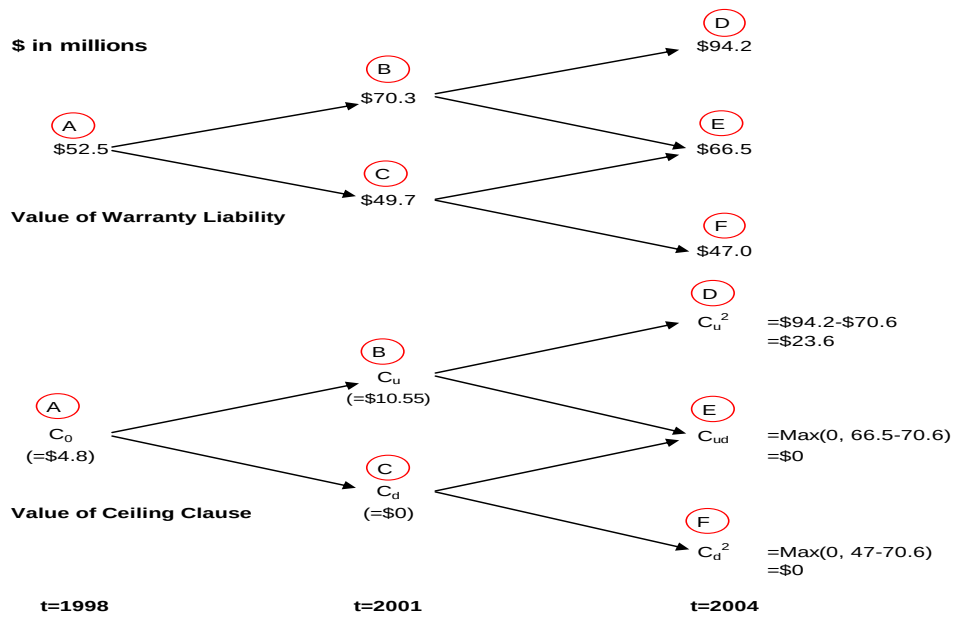

Figure C-1. A binomial tree for valuing the ceiling clause in the US 550 warranty

Step 6: Valuing the ceiling clause on date 1

The calculation in this step is completely analogous to the calculation of the value of ceiling clause in the previous step. Given the values of the ceiling clause on date 2 are $10.55 million and $0, the value of the ceiling on date 1 is determined using the same risk-neutral probability

$$C_0 = (51.3\% * 10.55+ 48.7\% * 0) / (1+14.8\%) = \$4.8 \text{ million} \qquad \text{(C-12)}$$

Therefore the ceiling clause in the US550 warranty is valued at $4.8 million1998 dollars, which is about 9.1% of the total warranty cost.

Appendix D: Highway Warranty Workshop Topics

Highway Warranty Workshop

Tuesday, December 05, 2006
253/275 HM Comer Hall, University of Alabama

Time	Topic	Speaker
8:30-8:45	Welcome	
8:45-9:45	Warranty Contracting: State of Practice	Dr. Makarand Hastak (Purdue University)
9:45-10:00	Break	
10:00-10:30	Warranty Specifications	Mr. Matt Cash
10:30-11:00	Legal Aspect of Alternative Contracting	Ms. Elizabeth Sees
11:00-12:00	Acceptance of Warranty Contracting in AL: Finding from Survey	Dr. Qingbin Cui
12:00-1:00	Lunch (keynote speaker)	Dr. Ken Fridley
1:00-1:30	Bonding in Warranted Projects	Dr. Mehmet Bayraktar (Florida International U)
1:30-2:00	Evaluation of Warranty Ceiling Provisions	Dr. Philip Johnson
2:00-2:30	Warranty Cost Estimating	Mr. Hao Zhou
2:30-3:00	Predicting Contractor's Financial Distress	Ms. Lan Wang
3:00-3:30	Discussion/Q&A	Dr. Philip Johnson
3:30-4:00	Summarize/Path Forward	Dr. Qingbin Cui
4:00 PM	Adjourn	