Current Use of Warranties in Highway Construction

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INTRODUCTION

Reduction of resources of State Highway Agencies (SHA) has spurred the evaluation of alternative contracting methods including warranties, Design/Build, and Design/Build/ Operate/Transfer. State Highway Agencies are investigating non-traditional and innovative contracting methods that can reduce cost and time, improve quality and safety, and encourage better long-term performance. Warranty contracting may meet those needs if developed and appropriately implemented. Warranty contracting has several potential advantages when compared to design/bid/build contracting. These advantages include a greater motivation to enhance quality, reduction of required SHA resources, increased contractor innovation and reduced highway maintenance for the SHA during the warranty period.

Under the traditional design/bid/build contracting system, the contractor is not responsible for the long-term performance of the constructed product. Contractors are responsible for workmanship one year after the completion of the project. They do not, however, guarantee the performance of the constructed product. The contractor is obligated to complete the project in accordance with the project plans and specifications.

Warranty contracting adds performance to the process by shifting some post-construction performance risk to the contractor. The completed highway facility is evaluated based on overall system performance and not on individual components meeting separate specifications. The crucial issue with traditional contracting is that quality of individual project elements is evaluated based on meeting a specific standard without any formal understanding of how the quality of project elements relate to one another or impact system performance. This approach also requires extensive inspection by SHA personnel. Warranty contracting has the potential benefit of reducing SHA resources by reducing inspection and testing. Finally, under traditional method-based specifications, the contractor does not have free choice to use innovative materials and/or construction techniques. The likelihood of the SHA approving significant departures from method-based specifications is unlikely and requires the involvement and approval of numerous people. Warranty contracting allows the contractor the opportunity to use new techniques, thus encouraging innovation. The contractor, however, assumes the performance risks associated with any innovations.

This paper offers an assessment of the current status of SHA warranty contracting, issues to consider in drafting a model specification, and development of a framework for implementation of warranty contracting.

PRACTICAL APPLICATIONS

The results presented in this paper will be useful to many organizations involved in the highway contracting industry. For SHAs that have not implemented warranty contracting, it provides a starting point and is a compendium of the necessary components required for a warranty program. First, a SHA should become informed as to the current state of practice regarding warranties. SHAs can then evaluate whether or not they want to begin using

warranties. If they do, this paper can provide information on current practices in other states and important issues to consider in implementing a warranty program. It can also help SHAs identify appropriate project characteristics for application of warranties and additional end products such as bridge decks and traffic signs that may be warranted in the future.

For states that have already implemented warranties, this paper provides an opportunity to compare their warranty specifications to those of other states, helping to improve and expand their warranty specifications and program, including the introduction of new warranted end products. The SHAs may also want to identify alternatives to bonds such as retainage systems.

Contractor Benefits

This paper also provides assistance for contractors. Contractors are just as integral as the SHA when developing a warranty program. A contractor, for example, can evaluate from this paper current practices of SHAs and contractors in other states. They can work with their individual SHA to develop and/or improve warranties in their state. This paper provides contractors with information about specific issues such as bonding requirements, risk allocation, and typical specification requirements, including performance requirements. With this information the contractor can help educate the surety company that the performance requirements are achievable and help them evaluate the risk. If the surety understands risks associated with performance requirements, they will be more likely to underwrite the performance bond. Unless states use a retainage-based system (a form of self-surety for the warranty), sureties will continue to remain an essential partner in the warranty process. Finally, a contractor can also work with their contractor associations to focus discussion on key issues related to warranties, such as the impact of warranty implementation on smaller contractors.

Other Organization Benefits

Smaller government organizations such as cities, municipalities, and counties can also use this paper as a guide to help implement warranty contracting. Many of the end products covered by warranties require maintenance activities. Three-year asphalt, microsurfacing, and chip sealing warranties are initiated by the maintenance division of the Michigan DOT. These types of activities are often the responsibility of county maintenance forces. If their maintenance resources are being reduced, warranties may be a viable option.

This paper is also applicable to private owners. These owners may adapt the warranty specifications for their own use. For example, an owner, such as a developer, could require warranties on parking lot pavement and pavement markings. The owner could also adapt the specifications to have the contractor warrant other end products such as lighting, signs, or mechanical and electrical systems.

EVOLUTION OF SPECIFICATION TYPES FOR HIGHWAY CONSTRUCTION

The first type of specification was the method and material-based, in which the materials, equipment and methods to be used are specified by the SHA. As long as the contractor follows the specifications, they are not held responsible, beyond defective materials or workmanship, for the performance of the end product. Method and material-based specifications tend to inhibit

contractor innovation. Experience with method and material specifications suggests that alternate approaches are needed to monitor contractor performance and reduce the level of SHA inspection, while at the same time increasing the quality of the constructed product.

The first step in the improvement process was the development of Quality Control/ Quality Assurance (QC/QA) specifications. The quality control (QC) portion of the specification provides an outline for contractor strategies and procedures for controlling quality. This can be accomplished using QC/QA specifications based on statistical methods, analysis, and results.

The next step in the specification evolution was performance-based specifications. Under performance-based specifications, the contractor has more freedom to select materials and methods as long as the resulting performance meets predetermined performance thresholds.

Specifications then shifted toward the warranty. A warranty is a guarantee of the integrity of a product and of the contractor's responsibility for the repair or replacement of deficiencies. A warranty is an absolute liability on the part of the Warrantor, and the contract is void unless it is strictly and literally performed (*1*). A warranty can be a combination of QC/QA and performance-based specifications. Warranty specifications often contain Quality Control requirements. Similar to performance-based specifications, the contractor is responsible for performance of their product. With a warranty, the contractor assumes performance risk both during and after the construction process. Annual inspection of the end product replaces the Quality Assurance portion of the typical QC/QA specification. However, statistically-based QA procedures such as stratified random sampling are often used to monitor the end product. Under the warranty program, contractors have more freedom to select the materials and methods for construction of the end product, and can develop their own QC program.

The final step is the end result specification, defined by TRB as, "Specifications that require the contractor to take the entire responsibility for supplying a product or an item of construction. The highway agency's responsibility is to either accept or reject the final product or apply a price adjustment that compensates for the degree of compliance with the specifications" (*3*). Examples of this type of specification can be found in Design/Build/Operate (DBO) or Design/Build/Operate/Transfer (DBOT) contracting methods, where the contractor has the ability to design, choose materials, and construct the facility. The contractor is then held responsible for an extended period of time, ten to twenty five years, for the performance of the facility, which is longer than the typical warranty specification.

RESEARCH METHODOLOGY

This research was based upon six critical issues related to warranty contracting: (1) selection criteria for the particular contracting practice; (2) approach to risk allocation; (3) reduction of the level of inspection on warranty projects; (4) whether or not warranty contracting stays within the competitive low bid system, since the low bid system is the accepted practice in SHA contracting; (5) bonding requirements; and (6) anticipation that warranty contracting will improve quality because the contractor is the closest to the construction process, and therefore best able to identify cost-effective, quality-improving strategies. These six issues were investigated.

A literature review was performed to obtain relevant information on warranty contracting in the highway construction industry. This review focused on both domestic and foreign publications including recent examples of warranty contracting. The articles and special publications were then analyzed and summarized using the six critical issues mentioned above.

In addition to the literature review, two interview data collection instruments were developed. First, an initial telephone survey was prepared. All fifty states, as well as the District of Columbia, and Puerto Rico were called to determine their current use of warranties. This survey was organized into six areas. The major topic areas for warranty contracting included the Department's actual and planned use of warranties, types of projects using warranties, facility elements covered by warranties, length of warranty, number of projects completed and the status of their warranty period (under construction, completed), and dollar size of projects completed. During this process, the states were asked to provide sample warranty specifications for review.

A comprehensive on-site interview guide was then developed, and used to conduct on-site interviews with nine SHAs. The on-site interview guide consisted of two sections. The first section focused on agency level information including the characteristics of the State Highway Agency, and general issues related to the contracting method. The second section was developed to collect project-specific information dealing with characteristics such as the project description and location, the six critical issues mentioned above, the success or failure of the contract method, and possible improvements that may be recommended for future projects. From these sources of information, the current level of use of warranties was identified. Thirty-two specifications were received during the data collection process for review. Each of the specifications was then analyzed for content, structure, strengths, and weaknesses.

CURRENT STATUS OF WARRANTY CONTRACTING

Warranties have been in use in the highway industry since a 1987 North Carolina DOT pavement marking project. They were used sparingly until the Intermodal Surface Transportation Efficiency Act (ISTEA) was passed in 1991, allowing states the freedom to use warranty contracting on projects located off the National Highway System (4). Since 1991, the number of states using warranties has continued to increase. However, use of warranty contracting is still limited. Twenty-one states have completed warranty projects and Florida and Utah will begin using warranties on construction projects in 1998. Of the 29 agencies not using construction warranties presently or beginning in 1998, eleven (38%) indicated that they are considering the use of warranties on future projects.

Figure 1 shows the number of warranty projects completed in the United States by year. A total of 240 projects have been completed since 1987. This does not include a number of traffic marking projects and irrigation/landscaping items, because an accurate estimate of the number of projects completed could not be given by the SHAs. As seen in Figure 1, the number of warranty projects in 1997 as compared to 1995 has increased by over 1,000 percent.

ANALYSIS OF WARRANTY SPECIFICATIONS

Seventy-eight percent (18) of the twenty-three SHAs either currently using or beginning a warranty program in 1998 forwarded specifications covering a variety of end products for review. A framework was created for compiling and comparing these specifications. The framework was based on the eleven key elements typically found in a warranty specification, as summarized in Table 1.

The end products currently being warranted include Asphalt/rubberized asphalt pavement, Bridge Components, Bridge Painting, Chip Sealing, Concrete Pavement Patches, Intelligent Transportation System Components, Landscaping/Irrigation Systems, Microsurfacing, Pavement Marking, and Roofs. Figure 2 shows the distribution of the total number of completed warranty projects per end product. There have been more bridge painting projects completed than any other end product, primarily because the Michigan DOT has required warranties on all bridge painting projects since 1996. There have also been a number of pavement marking and asphalt paving projects completed in the United States. The length of the warranties ranged from one to ten years. Asphalt pavement warranties, specifically, ranged from three to eight years. Finally, every state is awarding contracts with warranties to the lowest responsible bidder whose proposal complies with all the prescribed bidding and contract award requirements.

Most states required a warranty bond to transfer the risk of the work failing to meet the pre-determined performance requirements. The value of the warranty bonds were determined either as a percentage (10%-100%) of the contract value, the maximum cost for replacement or rehabilitation of the warranted work, or a fixed, predetermined amount. Typically, the SHA requires the contractor to provide proof of a bond or combinations of bonds for the entire warranty period before execution of the contract. Several states have also required the bonding companies to have a specific A.M. Best rating to be qualified to issue the bond. States either require a single term bond, allow combinations of single year bonds, or a contract bond and a warranty bond for the warranty period. Some agencies also require a lien bond to cover subcontractors. The alternative to warranty bonds is a retainage system. Michigan and Montana retained a specified percentage of the total contract amount and returned the retainage in specified prorated increments based upon actual performance over the life of the warranty.

Most specifications state that the contractor is responsible for maintenance within fifteen to forty-five days after receiving notice from the state agency when performance indicator threshold values are exceeded. The right to perform, or have performed, routine maintenance or emergency maintenance during the warranty period can be reserved by the SHA for the period of the warranty. The contractor is allowed to monitor the warranted product and propose corrective actions subject to the approval of the state agency.

Ten of the eighteen states that sent specifications required a Conflict Resolution Team (CRT) on their warranty projects. Asphalt and road maintenance applications such as Chip Sealing and Microsurfacing usually have a conflict resolution team, because these types of end products have many possible causes of failure and it can be difficult to determine the precise cause. Other end products that have more easily identifiable causes of failure, such as bridge painting and pavement marking, tend not to have CRTs. The CRT teams typically consist of two

SHA representatives, two contractor representatives, and a third party representative who is mutually agreed upon, and the cost of whom is shared equally by the SHA and the contractor. Variations in the CRT did exist, however. Some states stipulate a three-member team, while some include in their team a private consultant and members of the asphalt paving industry who are not directly involved with the project. Some states require CRT members to have special training or experience.

All the states that sent specifications for asphalt stated that the contractor is responsible for the job mix formula and for quality control. Colorado, Florida, and Wisconsin require the contractor to provide all quality management data to the SHA. Colorado, Florida, Indiana, and Wisconsin require that the contractor submit the quality control plan before paving starts. Generally, the pavement thickness is specified by the state agency. In most cases, the contractor can use non-destructive techniques to evaluate pavement quality. In some cases, the contractor can submit amendments to SHA specifications, select the materials, monitor the pavement, and even determine the necessary remedial actions, with input from the state engineer. Some SHAs require notification before remedial action takes place.

The minimum thickness of asphalt pavement is usually specified by the SHA. Other elements that were specified by some states included the performance grade of the asphalt cement and the mix design for asphaltic concrete friction courses.

Indiana, Maryland, and Michigan all required the contractor to unconditionally warrant the paint system applied to the bridge to be free of defects during the warranty period.

Some agencies handle pavement marking quality issues by addressing contractor qualifications and material quality. These agencies require lists of materials and equipment and personnel resumes, and test reports or manufacturer data for the project. An annual performance report may also be required. Other states make quality control and placement solely the responsibility of the contractor. Some agencies require the manufacturer of the material to warrant the work as well as the material. This may entail training of contractor personnel by the manufacturer, or having a manufacturer's representative present on the job site. The contractor may also be required to furnish a traffic control plan, a striping plan indicating areas and timing of work, a spill recovery plan, and/or a placement, procurement, and handling plan.

The SHA typically inspects the facility annually whether it is an asphalt road or a bridge painting project. The agency then notifies the contractor and/or surety in writing within fifteen to forty-five days of the results and any remedial actions that are necessary. The SHAs are usually responsible for the costs of the inspections.

Generally, if the contractor should fail or refuse to comply with the warranty, the SHA may elect to make any needed repairs itself. The costs are then either reimbursed by the contractor, or are deducted from the moneys due the contractor, depending on the payment system and situation.

Certain performance indicators, such as ride quality, were not used in some specifications because they are affected by too many factors beyond the contractor's control. If the accumulated Equivalent Single Axle Loads (ESAL's) were a certain percentage (often 25-50%) higher than what was used by the SHA to design the pavement, if it was determined that the designed pavement thickness was deficient, or if a deficiency was due to the failure of the base, subgrade, or pre-existing layers for which the contractor was not responsible, some states waived performance requirements. Usually there was a clause in the warranted asphalt pavement

specification that cancels the warranty agreement if damages occur from the result of coring, milling or other destructive procedures not performed by or under the supervision of the contractor.

There are differences in the ways each product is paid for and the payment systems. Asphalt pavement is paid for by either lump sum, the unit price per ton, or by the cubic meter. Seventy percent of the states used unit price per ton as the basis of payment for asphalt pavement. Ohio was the only state that used cubic meter as the basis for payment. The reason that ODOT pays by the cubic meter is that there are varying aggregate weights in Ohio. Lump sum payment is preferred for Design/Build types of projects. If Design/Build/Warranty projects were paid by the unit price per ton, the contractor could design the thickness of the road to be greater than what it had to be, reducing their risk, and they would still get paid for the extra asphalt pavement.

All the states paid the contractor on a lump sum basis for bridge painting warranty projects. Both of the microsurfacing specifications paid the contractor by the square meter. The pavement marking projects are typically paid for by the linear foot, meter, or mile. A unique, timesaving payment method used in Michigan was payment by the roadbed kilometer.

SHA's have several different systems to pay for performance. The first method pays a bonus for performance above a specified level. Another method is to withhold ten percent of the contract price as a warranty bond replacement. If the contractor meets the performance criteria specified by the SHA, it will be paid a predetermined percentage of the retainage each year. A variation of this method is to retain ten percent of the total contract bid price as security for the fulfillment of the warranty as specified. If the product meets the specified performance criteria, the SHA may then reduce the total amount being retained from payment.

Another variation of this method is to retain five percent of each request for partial payment made by the contractor during the design and construction period. At the completion of work, sixty percent of the additional funds are released. The remaining forty percent of the retainage will be released in equal monthly payments over the two-year warranty period. Any SHA maintenance activities necessitated by contractor non-performance would be deducted from the succeeding monthly retainage payments until reimbursed in full.

GENERAL WARRANTY ISSUES

One major reason states are implementing warranties is to supplement their own workforce and reduce the need for inspection. This is especially true for warranted asphalt pavement projects. Michigan relies on one inspector who visits the project once a day to monitor progress and answer questions. In the past, the inspector was permanently assigned to that project but can now monitor several projects under the warranty program. Wisconsin also mentioned that they have saved money, because they no longer have to perform Quality Assurance testing on the warranty projects. However, an exact cost saving was difficult to determine. Indiana was also able to reduce their inspection staff by two full-time inspectors on their warranty projects. The reduction of inspection resources is not universal, however. Maryland and Michigan still maintain 100 percent inspection on their bridge painting warranty projects.

Warranties can also reduce maintenance staff. According to the Michigan DOT, using the warranty provision provides the department with an easy mechanism to perform initial repairs at the contractor's expense and not have to rely on in-house maintenance forces.

The availability of bonding was the barrier mentioned most often by contractors and SHAs. Both were very concerned that contractors would lose the opportunity to bid projects when their bonding capacity was exceeded. This was a real concern because these contractors are bonding more and more projects, yet the warranty bonds carry over for multiple years.

Many states expressed interest in expanding their warranty programs to include other end products currently warranted by other SHAs. States such as Indiana and Wisconsin will have five-year warranted Portland Cement Concrete pavement projects under construction in 1998.

Length of Warranty Determination

SHAs worked in cooperation with their respective contractors and contractor associations to determine the warranty period for asphalt pavement, chip sealing, microsurfacing, overlays, and crack filling projects. There was an ongoing dialogue between the contractors, SHAs, and bonding companies as to how to write the specifications. One important factor to consider when determining the length of a warranty is the time required for problems with the specific end product to become evident. This is often taken to be the first five years for asphalt and two years for bridge painting.

Maryland has a unique system of determining the length of the warranty. The length of warranty was determined by an "A minus B" system where A is the cost of the project and B is a credit for each additional year of warranty that the contractor bids beyond the required five year period up to a maximum of ten years. This credit was used for bid comparison purposes only, not for payment. The Maryland State Highway Administration determined the amount for the credit by estimating how much it would cost to repaint the bridge, and dividing it over the length of the warranty period.

Costs

One major concern from the SHA perspective was how much more the contractors would charge for the warranty. A number of states felt that their warranty projects would have had lower initial costs if they were bid as traditional contracts.

Costs increases with warranty provisions are not universal, however. Michigan has an ongoing study of their bridge painting warranty projects. They have not found a correlation between higher prices and warranty projects (2). Maryland also stated that the winning contractor did not increase its price on their warranted bridge painting project.

Risk Allocation

Many examples of potential risks to the SHA were identified during the interview process. Some specific examples included: loss of competition; paying an excessive amount for the warranty; potential callbacks; addressing deficiencies; project selection; environmental and subgrade conditions; working with a bonding company; and product lasting its entire design life.

Both SHA and contractor personnel interviewed agreed that, under warranty specifications, risk has been allocated to the party who has most control of the risk. The risk is carried differently on warranted projects as compared to a traditional project, because the

contractor has the risk during the warranty period. SHA inspection is not required to the same extent. The general consensus of those interviewed was that the contractors focus more on the quality of their work when it is warranted.

Typically, a distress survey is performed once a year to monitor the performance of the pavement. For asphaltic pavements, the contractor generally has the option to perform SHA approved preventative maintenance.

Warranty contracting also allows the paving contractor to be more innovative with both the mix designs and construction methods and techniques on these projects than would have been possible under the traditional project delivery system.

Agency Resources

One of the major reasons that states are implementing warranties is to supplement their workforce and reduce the need for inspection and quality assurance testing. As discussed previously, states have reduced resources on their warranty projects. Use of warranties can also reduce maintenance personnel requirements over the life of the warranty.

Bidding System

Warranty contracting has had some effect on the number and distribution of bidders. Some states felt that the warranty specifications discouraged some bidders. This is partly because the warranty programs are rather new and some contractors are apprehensive about bidding. Some states have seen a change in the number and distribution of bidders because of the warranty. One SHA believed that as industry gains experience with warranties, contractors will become more comfortable with understanding and pricing the risk associated with warranties.

Quality

Performance indicators for asphalt have typically been determined by the SHA's Pavement Management Section Recommendations, based upon observations from years of monitoring bridge painting projects, and from FHWA guidelines. The most common response was that the indicators were established from in-house records and without assistance from FHWA. Typically the end products are monitored through an annual performance survey.

Michigan has an ongoing study of their bridge painting warranty program in which seven warranty projects are compared with seven traditionally bid projects. The initial conclusion from this study is that a warranty provision does not ensure higher initial quality for bridge painting projects. After a two-year inspection period there was no significant difference in quality between the warranty and control projects. According to the report, deficiencies are not major, but all projects have required some isolated repairs by the original contractor or MDOT maintenance forces (2).

All of Wisconsin's warranted asphalt projects have performed well to-date. One measure of the quality of an asphalt pavement is rideability. After the first two years the ride quality has either matched or been better than non-warranted pavements. Other programs are not far enough into the warranty period to be evaluated at this point.

Level of Success

The general opinion of the state agencies interviewed was that warranties have been a success. The warranty has provided a mechanism to perform initial repairs at the contractor's expense. Warranty projects have proceeded satisfactorily and have been constructed with more care than usual. Workmanship on warranty projects appears to have improved over traditional contracting methods. Agencies also mentioned they were able to reduce resources on projects because of the warranty.

WisDOT stated that all three asphalt projects discussed were successful, in addition to the entire asphalt pavement warranty program. The quality of the pavement has been excellent and there has been no remedial action/preventable maintenance on the three projects thus far. There was only a modest increase in the cost of the asphalt and WisDOT has reduced resources on these projects.

Change Orders and Litigation

Of all the projects interviewed, only California had change orders that were related to the warranty provisions. This project happened to be the only project that had a claim, too. There was no litigation on any of the warranty projects discussed in the interviews.

Possible Improvements

Some improvements that SHAs would like to make include better payment mechanisms for longer warranty periods, setting tighter performance indicator threshold levels, and warranting the entire pavement structure, including the subgrade.

Contractors are exposing themselves to more risk of being sued during the warranty period for third party bodily injury and property damage claims under warranty contracts. SHAs have limits on their liability and indemnification clauses, unlike a contractor. The SHA cannot pass on the indemnification to the contractor due to state laws. Carrying liability insurance may reduce the risk of a third party bodily injury and property damage lawsuit. To this end, the SHA could require in the specifications that the contractor provide proof of liability insurance before awarding the contract. Some SHAs already include this provision.

IMPLEMENTATION STEPS

Figure 3 is a flowchart of steps to implement warranty contracting. With these steps a warranty program should be able to improve and expand successfully.

The first step is to define the motivation to implement warranties and the goals to be accomplished by the program. This results in criteria for evaluating the warranty program. Later on, the SHA will be able to compare the results of the warranty program with the goals set during this step, which could include increased quality, lower life cycle costs, reduced inspection, and reduced contract administration responsibilities.

Once the agency's goals are set, the agency must investigate what other agencies are doing. A thorough literature review is the best way to find out what has been tried, what has

worked, and what has failed. An appropriate start would be to collect similar warranty specifications from other SHAs.

The next step is to determine which end products are suitable for warranties. Products that reduce internal costs and distribute the decision making and risk to the contractors are more likely to be warranted. Ease of implementation can be another criteria for choosing appropriate products. Certain products require more data and initial resources prior to implementation. Concrete and asphalt pavement warranties require data from the Pavement Management System to determine the performance indicators and the proper threshold levels. Other less complex products, such as bridge painting and pavement marking, do not require as much in-depth study by the SHA to determine the proper indicators and threshold levels. These can be obtained from manufacturer's test data. Loss of competition can be an important factor when selecting which end products to warrant. If the number of contractors available to compete for projects is rather limited or the contractors are smaller in annual contract volume, the contractors may not want to bid on warranty projects, or may escalate their bid price. Also, warranties are most applicable to new products that have no effective QA testing during construction, since warranties reduce the need for QA, as well as manufactured products/systems where innovation and flexibility in design, materials, or methods is desirable.

Next, cooperation and open communication lines must be established between the SHA, the contracting community, contractor associations, and sureties. If there is no education or support for the use of warranties, the necessary commitment will not be available to make the warranty program succeed. Cooperation will be very important to develop the program. By sharing expertise and experiences from many perspectives, the warranty program will have a higher chance of success. All states implementing warranties indicated that cooperation from the contracting industry was essential in the development of their warranty specifications.

Once cooperation and communication are established, the warranty specification should be jointly developed. A SHA must examine its performance requirements and the goals it set to determine which performance indicators are necessary for evaluating the end product. Selecting the appropriate performance indicators and threshold levels is important and can be difficult. First, the distress indicators and levels should be based on established performance records. Typically, these data will come from an Infrastructure Management System. Second, the necessary performance data has to be collected so that an established record of performance can be shown to contractors and surety companies to prove that the thresholds are readily obtainable. If the performance levels are perceived as unachievable, the program will be seen as too risky, so sureties will not provide the necessary warranty bonds and contractors may raise their bid prices.

The new warranty program is then piloted on one or several projects. Risks are typically minimized on the pilot projects so that improvements can be made to the warranty without adversely affecting the entire program. It is advisable to start with a small number of warranty projects. Any lessons learned from the initial pilot program should be documented and incorporated into the program.

The next step is to draft the warranty specifications. Once the specifications are drafted, the contract can be drafted and pilot project(s) selected. Then the project(s) may be let and awarded.

After award of the contract, joint training of the contractor and SHA personnel should begin. Since roles and responsibilities are being changed under the warranty program, it is

important to make sure engineers, inspectors, and contractor personnel all understand their new responsibilities. Contractors may need to know what their new requirements include, such as submitting QC data or establishing correct grades and alignments. As soon as the training and familiarization process is complete, the project may be constructed.

Once the project is constructed, it must be monitored. Test procedures for monitoring the performance of the end product are important. They need to be timely, economical, nondestructive, reliable, and reproducible. Typically, the end product is monitored annually using nondestructive testing procedures. Standardized testing procedures are necessary since the tests are conducted annually. Often times they are based upon accepted inspection procedures from the established Infrastructure Management Systems.

The SHA should then monitor warranty project performance and maintenance expenditures by the contractor. The SHA should also use feedback from contractors and SHA personnel to consider improvements in the warranty specification. By taking this information the SHA can actually determine how much money they are saving by using warranties. This is important for several reasons. First, the SHA should be aware of the areas where its program can be improved. By establishing a feedback loop from the beginning, lessons learned can improve the program. Second, the SHA should be able to justify that the initial higher bid costs of the warranty are offset by the reduction in inspection and maintenance over the life of the project. This information would also be useful in determining whether or not warranties reduce life cycle costs.

Finally actual warranty projects may be implemented with the lessons learned from the initial pilot program. As more projects are completed, a better understanding of the warranty program will be achieved. Through constant feedback from participants, the warranty program should be improved and expanded to include other end products.

FUTURE RESEARCH

Despite its many advantages, warranty contracting is not appropriate for all situations. It is not meant to replace traditional contracting. Therefore, an in-depth study should be conducted to further determine what project characteristics, SHA characteristics, and contractor characteristics are necessary to have a successful warranty project. Since many warranty programs have started in the last three years, many of the projects have not completed their warranty duration. Data must be collected and analyzed on on-going and future projects such that the best practices regarding warranty contracting can be determined.

Next, warranties in the non-highway industry, such as automotive or manufacturing, could also be examined to determine if their contract specifications could help improve the warranty language. More comprehensive implementation guidelines also need to be developed to assist SHAs and other organizations in implementing warranties. Finally, further investigation of companies providing surety bonds is necessary. Their advice will be crucial to extending the length of warranties and expanding warranties to other end products.

SUMMARY

In the future, SHAs will continue to increase the number of projects warranted, increase the length of the warranty, tighten the thresholds on performance indicators, and warrant more end products. Cooperation is very important in the development of a warranty program. The risks and new responsibilities of all the parties involved need to be clearly defined and understood. It is important that goals be established and evaluated. With open communication between the SHA, the contracting community, contractor associates, and the surety companies, the warranty program can be successful.

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Table 1 - Key Elements and Explanations of a Model Warranty Specification

ELEMENT (1)	EXPLANATION (2)
Description	• Describe what specification covers and work required.
Length	• Establish length of the warranty. Can be fixed or varying using the "A minus B" system.
Bonding Requirements	• Establish the penal value of warranty bonds or retainage system. The penal value should be enough to cover the cost of remedying a worst case scenario. • Establish acceptable bond rating. • Determine acceptable combination of bonds. • Determine bond requirements if surety company falls below specified rating. • Determine requirements if contractor fails to renew warranty bond.
Maintenance	• Establish who is responsible for maintenance activities. • Establish how maintenance activities will be approved.
Conflict Resolution	• Conflict Resolution Team (CRT) could be established especially for items with many causes for failure, such as asphalt and concrete pavement. • Determine the composition of CRT. • Determine when CRT will be used. • Determine length of conflict resolution process.
Contractor Responsibilities	• Warranty the end product for the entire length of warranty. • Remedial action if any threshold levels are met or exceeded. • Selection of materials and construction methods; In some cases design of end product. • Establishment and submission of a Quality Control Plan and QC data. • Elective/preventative action. • Liability Insurance.
Department Responsibilities	• Approve liability insurance and bonds. • Annual inspection of end product. • Determine how the end product will be inspected. • Provide an annual written report to contractor on performance of end product. • Submit report within established time period. • Approve remedial actions and elective/preventative action • Specify special requirements such as Quality Control Plans. • Establish procedures for emergency situations on warranty project and if contractor cannot remedy within prescribed time period. • Establish length of time that contractor can remedy in an emergency situation.
Performance Indicators	• Establish Performance Indicators and threshold levels. Indicators and levels can be determined from Infrastructure Management System, Manufacturer's recommendations, and/or Engineering judgment. • Determine what factors that cause distresses are beyond contractor's control.
Requirements for Corrective Action	• Typically SHA approves corrective action. • Establishment of remedy period. • Establish what types of activities void corrective action by contractor such as destructive testing procedures by the department or utility relocation.
Method of Measurement	• Establish how warranted end product will by measured. For example by the foot, meter, ton, square foot, etc.
Basis of Payment	• Establish how end product will be paid. For example per unit ton, linear foot, lump sum, roadbed kilometer, etc. • Determine if any maximum levels of payment. • Establish amount and payment schedule for performance payment system.

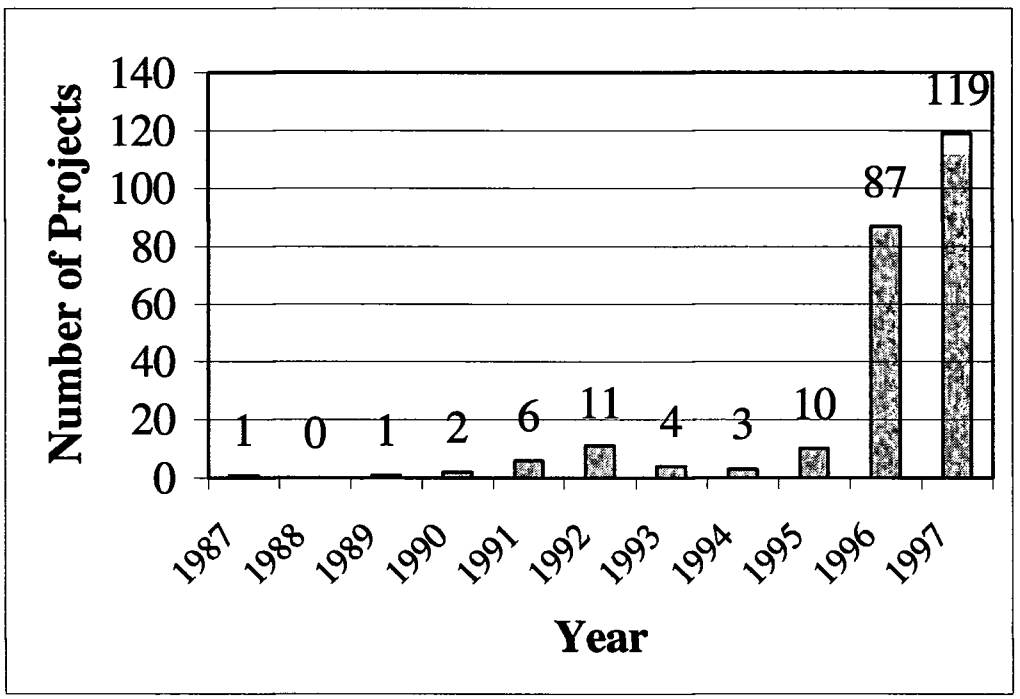

Figure 1 - Number of Warranty Projects Completed Per Year

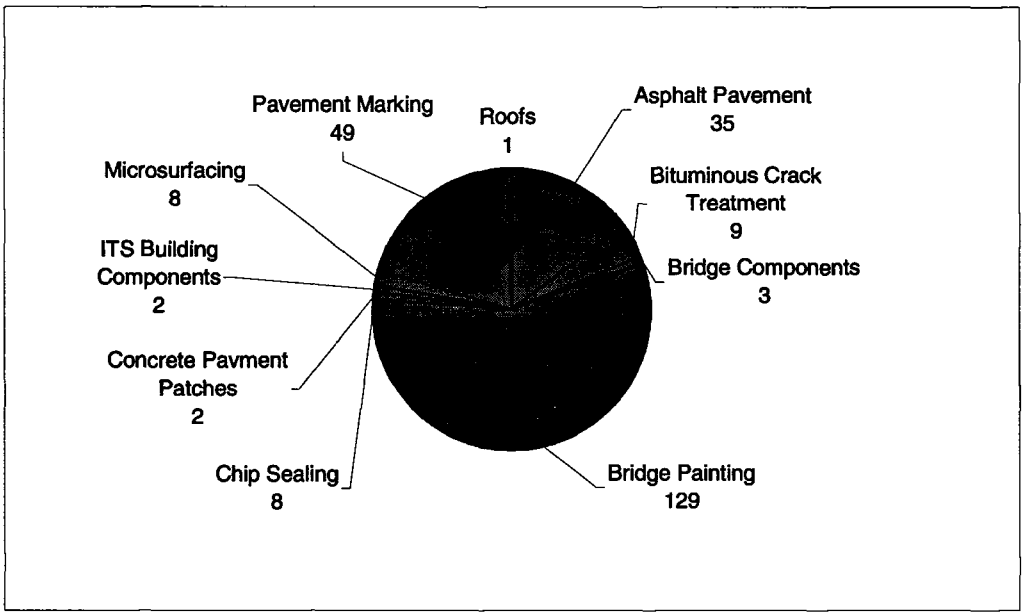

Figure 2 – Distribution of Completed Warranty Projects (1987-1997)

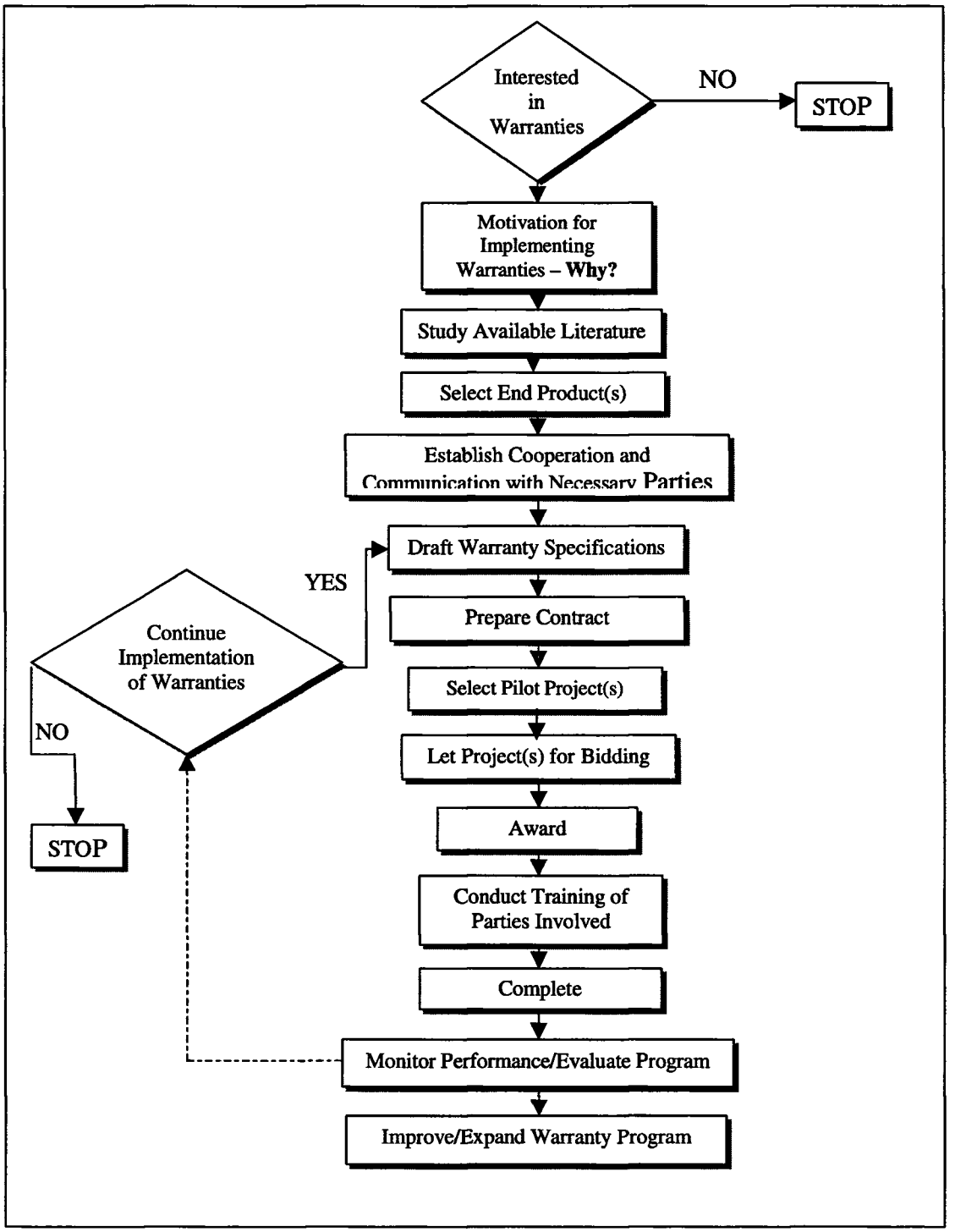

Figure 3 – Implementation Flowchart