

State-of-Practice of Warranty Contracting in the United States

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Abstract: This paper presents the results of a comprehensive survey on warranty practices in the United States and a summary of the impact of warranty implementation on highway projects, based on questionnaire responses and interviews of State Department of Transportation (DOT) representatives, contractors, and surety companies. According to the results of the survey, the initial bid price increases due to warranty provisions are estimated to be somewhere between 0 and 15%, while the changes in maintenance and project life-cycle costs are expected to be minimal. Warranty provisions increased the quality of the projects and reduced the need for site inspection and record keeping for state DOTs. The study also revealed the unwillingness of surety companies to underwrite small contractors when the project calls for long term warranty durations.

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Introduction

Warranty contracting is one of the latest innovations in the United States highway construction industry. This contracting method has two basic features that differentiate warranty jobs from regular contract jobs: (1) the contractor is held responsible for any maintenance work that may occur over the warranty period and (2) the contractor has the freedom to use the materials and techniques that he or she considers best for the job so long as the state standards are met.

The major underlying objectives of warranty provisions from the perspective of State Department of Transportations (DOTs) include increased quality of the products, lower maintenance and project life-cycle costs, protection against early project failures, and reduction in site inspection. Furthermore, warranty contracting is expected to provide contractors with the necessary freedom and incentives to encourage them to use innovative construction technologies and methods on their projects. However, there are several problems that arise from the use of warranty provisions on state DOT projects such as an increase in the initial bid price as compared to similar but nonwarranty projects, a reduction in the number of small contractors bidding on these projects, the unwill-

ingness of surety companies to issue long term bonds, and the possible increase in contract disputes and litigation.

All the abovementioned pros and cons of warranty provisions need further study to ascertain their impact on cost, quality, construction duration, bonding, contract disputes, and litigation. The study should be broad enough to incorporate the points of view of all concerned parties, state DOTs, sureties, and contractors. It is not certain that the expected benefits from warranties are being realized or that the problems are as severe. Therefore, a comprehensive study was initiated to evaluate warranty provisions on highway construction projects in the United States based on the available knowledge and experience of the parties associated with warranty contracting.

This paper provides valuable up-to-date information on the state-of-practice of warranty contracting and presents the results of the survey that was conducted to address the issues discussed above. The analysis is based on responses from surveyed agencies in the United States including DOTs, contractors, and surety companies. The discussion starts with a brief background of warranty contracting in the United States followed by detailed information on the major issues associated with warranty provisions on highway construction projects. In subsequent sections, the major findings of the survey are highlighted under different categories of concern summarizing the various pros and cons of warranty provisions within the context.

Warranty Contracting

Brief History

In 1988 the Transportation Research Board formed a Task Force to evaluate innovative contracting practices in the United States and abroad. The practices studied under this project included, among others: warranties, design build, lane rental, and cost-plus-time bidding. Upon the recommendation of the Task Force, Federal Highway Administration Special Project Number No. 14 (FHWA SEP-14-Innovative Contracting) was established to evaluate "project specific" innovative contracting practices un-

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dertaken by state highway agencies. Under the SEP-14 program 11 states considered the use of warranties on federal-aid highway projects including Arizona, California, Indiana, Michigan, Missouri, Montana, North Carolina, New Hampshire, Ohio, Washington, and Wisconsin (Hancher 1994).

Warranty contracting was first applied by the State of North Carolina to state highway pavement marking projects in 1987 (Russell et al. 1999). In recent years, there has been a marked increase in the inclusion of warranty provisions in highway construction contracts. By 1999, more than 21 states had used warranty contracting and let about 240 warranted highway construction projects (Russell et al. 1999). It is anticipated that by the end of the year 2003, more than 25 states would have used warranties on highway construction projects. Currently, Michigan, Ohio, and Wisconsin are considered the frontrunners in warranty use in the United States.

Expectations and Issues of Concern

There are many areas of concern in warranty contracting that will have to be addressed. Although long-term performance data in the United States is limited, there is enough information from existing warranted projects to reach conclusions on some of these issues, namely, increase in the bid price, effect on life-cycle costs, anticipated improvements in quality, risks and difficulties involved in bonding, and impact on project duration. These issues will be discussed separately in the following paragraphs.

The unknown impact on cost, especially from a life-cycle cost perspective, is a major concern of warranty use in highway construction. Generally, mandatory warranty bonds, future warranty scope costs, and additional risks of warranty provisions have forced contractors to increase bid prices on warranty projects.

Research efforts to date show that the level of increase in the bid price is a function of project type as well as the warranty period. Normally, warranty durations up to 1 year do not increase bid prices as compared to conventional projects. In Michigan, there was no measurable impact of warranty provisions on cost of pavement, bridge deck, and painting projects with warranties of short-term duration. For 3-year warranties, only a 3% increase in the bid price was experienced on two hot bituminous pavement projects in Colorado (Aschenbrener and DeDios 2001). Similarly, Missouri DOT did not experience any significant cost increase as a result of 3-year warranties on pavement preservation jobs of the agency (Webb 1994). Bid prices on asphalt pavement projects in Ohio with 5-year warranties increased by an average of 9% (ODOT 2000). However, Scheel (1996) reported significant cost increases on concrete pavement projects in California, as compared to similar projects without warranties. The increase in cost was estimated to be 36% for concrete pavement projects, 23% for rubberized concrete pavement projects with 3-year warranties, and 62 and 25% with 5-year warranties, respectively.

Warranties are expected to reduce life-cycle costs by spreading the initial investment over the entire warranty period (Russell et al. 1999). However, determining the impact of warranty contracting on the life-cycle cost of highway projects is very difficult, due to limited data on long-term performance trends. Krebs et al. (2001) compared the life-cycle costs of 23 asphalt pavement projects with expired warranties to the life-cycle costs of similar standard contracts in Wisconsin. The maintenance costs beyond the warranty period were excluded from the comparison. Also, conflict resolution, distress survey, and traffic count costs were found to be negligible and, therefore, were not included in the analysis. The results of the study for the period 1995–1999

showed that, excluding state delivery costs, warranty contracts averaged \$24.34/t versus \$27.72/t for standard contracts indicating a 12.19% reduction.

Quality improvement is the major anticipated benefit of warranty use on highway construction projects. Contractors are expected to provide better performance on warranted projects than nonwarranty projects to avoid potential repairs and maintenance over the warranty period (Hancher 1994). However, this is not always the case.

With regard to quality, Indiana DOT was satisfied with the high performance of the I-69 project with 5-year workmanship and material warranty [Federal Highway Administration (FHWA) 2000]. Similarly, there was a measurable improvement in quality and performance on 23 warranted asphalt concrete over flexible base pavement projects in Wisconsin as compared to the historical pavement performance data for surface distress and ride quality (Krebs et al. 2001). On the other hand, Aschenbrener and DeDios (2001) reported that there was no measurable difference in quality of warranted versus traditional DOT controlled projects in Colorado. Also, warranty provisions did not totally eliminate early failures. The state of North Carolina discontinued the use of warranty provisions because of an early failure on an epoxy-pavement marking project. Montana DOT experienced significant failures on a 4-year warranted pavement-marking project. Similarly, Indiana DOT found low performance on two hot mixed asphalt pavements with 5-year warranties (FHWA 2000).

Another important aspect of warranty contracting is bonding. Sureties are not willing to issue warranty bonds because of the associated long-term risks that are inherent in such projects. It is clear that underwriting contractors who do not fulfill contract obligations can cause severe losses to the surety companies regardless of the premium paid by the contractor. In addition, a great deal of effort is required to analyze variables, which affect the level of risk to the surety such as the contractor's financial situation, the size and complexity of the scope of the contract, and the length of the warranty period (Russell 2000). All these additional risks and efforts involved in the warranty underwriting process cause an increase in the premiums for contractors. Krebs et al. (2001) estimated an increase of 5–15% in the premium for a qualified contractor on a 5-year warranty pavement project.

The impact of warranty provisions on construction duration is another important concern. According to Byrd and Grant (1993), mobilization, procurement, and physical construction time have decreased on warranted contracts where the contractor had the freedom of design, material selection, and contracting methods.

Research Approach

As described earlier, the major objective of the study was to analyze the pros and cons of warranty provisions currently used by state DOTs and establish the state-of-practice of warranty contracting in the United States. To achieve these objectives, three specific data collection modes were used including: (1) literature review of academic publications, technical reports, and online resources; (2) questionnaire surveys targeting state DOTs, contractors, and surety companies; and (3) personnel interviews of select parties and individuals.

The literature review assisted the writers in identifying a set of criteria that were important to establish the state-of-practice and the evaluation of warranty use in highway construction. The criteria identified during the literature review included cost, quality, duration, bonding, and contract components of highway projects. Based on the results of the literature review, three types of ques-

tionnaires were prepared for state DOTs, contactors, and surety companies, respectively. Since the questionnaire survey also aimed to get general information about the respondents as well as other issues of concern that were not captured under any of the five criteria mentioned above, the questionnaires included seven major sections: general information, cost issues, quality issues, construction duration issues, bonding issues, contract issues, and unclassified issues. The appropriate questionnaires were sent to 158 agencies in the United States and a total of 63 responses were received from 40 state DOTs, 16 contractors, and seven surety companies, giving a response rate of approximately 40%. The remaining ten states that did not respond do not use warranties on their projects. Of the 63 responses, only 35 were tabulated, because 18 state DOTs had never used warranty provisions and nine state DOTs had limited experience with such contracts. Furthermore, a surety company responded with a general information letter instead of filling out the questionnaire. Therefore, unless stated otherwise (some respondents did not answer all the questions), the results of the questionnaire survey are based on 13 state DOT, 16 contractor, and six surety company responses. There were several questions to which respondents could provide as many answers as were applicable, for example contractor innovations used on warranty projects. The responses to these questions are based on the number of observations instead of number of respondents and, therefore, may not add up to the total number of respondents or 100% when reported as percentages.

The questionnaire survey was followed by extensive personnel interviews comprising of select questionnaire survey respondents to further clarify the issues raised in their responses. The interviewed agencies included state DOTs, contractors, and surety companies. A total of 22 interviews were conducted including eight state DOTs, nine contractors, and five surety companies. The titles of the eight state DOT interviewees were Director of Construction (four), Chief Pavement Engineer (one), Construction Division P.E. (one), Traffic Services & Systems Engineer (one), and Quality Assurance Engineer (one). The titles of the nine participants from pavement contractors were President (three), Vice President (five), and Engineer (one). The titles of the five interviewees from surety industry were Executive Vice President (one), Director of Surety (one), and Surety Representative (three).

The interview questions for state DOTs focused on gathering information and comments on major barriers and benefits in implementing the warranty provisions, the best warranty period for different types of projects, the profile of contractors bidding on warranty projects, and possible alternatives to the current warranty provisions. The questions for contractors included issues such as major problems encountered on warranty projects, source of bid price increases, risks associated with innovations, and difficulties in getting warranty bonds. The questions for surety companies mainly covered the risks that bonding companies face with respect to the warranty provisions.

The following sections summarize the results obtained from the questionnaire survey as well as the opinions and viewpoints of the interviewees. However, it should be noted that the findings of the study are based on the information received from state DOTs, contractors, and surety companies that have experience with warranty contracting and, therefore, should not be construed as applying to the whole country. The writers, if contacted, are prepared to provide readers with copies of the survey forms and interview questionnaires.

Table 1. Annual Sales of Warranty Projects of Participating State Department of Transportations

Number	State	Annual sale of warranties		
		\$ Millions	% of total sales	% of number of projects
1	Michigan	100–500	Over 30	Over 30
2	Ohio	100–500	10–20	10–20
3	Florida	100–500	10–20	10–20
4	South Carolina	100–500	10–20	Under 5
5	California	20–100	Under 5	Under 5
6	Wisconsin	5–20	Under 5	5–10
7	Minnesota	5–20	Under 5	Under 5
8	West Virginia	5–20	Under 5	Under 5
9	Colorado	5–20	Under 5	Under 5
10	Mississippi	5–20	Under 5	Under 5
11	Indiana	Under 5	Under 5	Under 5
12	Oregon	Under 5	Under 5	Under 5
13	Pennsylvania	Under 5	Under 5	Under 5

General Information

The objective of this section was to gather general information on the experience of the state DOTs with respect to the agency's expectations, benefits, and problems in warranty implementation, the amount of annual sales of warranty projects, the type of warranted products, the required warranty durations, and the number of bidders on warranty projects.

State Department of Transportations and Warranty Usage

For a majority of the respondents (69%), the annual sales of warranty projects, as a percentage of the agency's total annual projects dollar value, is under 5%, while about 23% of the respondents indicated 10–20%. For very few (8%), the annual sales of warranty projects is over 30%.

A slight change was noticed when the number of warranty projects was compared to the annual total number of projects. A larger number (76%) of the respondents indicated that their annual sales are less than 5%, while the remaining 24% were equally spread among 5–10%, 10–20%, and over 30%. A list of the participating state DOTs with detailed information on their annual sale of warranty projects is given in Table 1.

Warranty Experience of Interviewed State Department of Transportations

This section provides brief information on the warranty experience of the state DOTs who participated in the interview survey. Table 2 is a list of the interviewed states, the typical warranted products, and mandated warranty durations.

As one of the early states implementing warranty contracting, Michigan DOT (MDOT) has currently more than 500 warranty projects in service. Approximately 70% of Michigan DOT projects are sold with warranties. The three reasons indicated by Michigan DOT for applying warranties to DOT projects are to: (1) reduce personnel requirements, (2) encourage contractor innovation, and (3) transfer the risk to the contractor. However, contractor resistance to warranties is still the biggest issue for MDOT in warranty implementation.

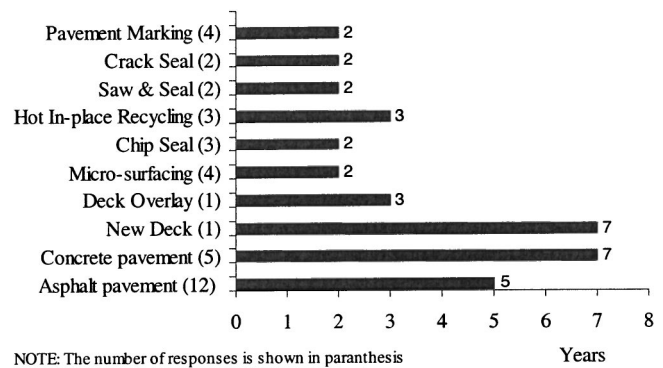
Table 2. List of Interviewed State Department of Transportations with Typical Warranted Products

State	Product(s) warranted	Warranty duration [year(s)]
Wisconsin	Asphalt pavement	5
Minnesota	Asphalt pavement	2–5
	Concrete pavement	5
	Microsurfacing	2
	Hot in-place recycling	2–5
	Saw and seal	2
	Pavement marking	5
Indiana	Asphalt pavement	5
	Concrete pavement	5
Michigan	Asphalt pavement	5 (Material+ workmanship) 7 (Performance)
	Concrete pavement	5 (Material+ workmanship) 7 (Performance)
	Deck overlay	3
	Microsurfacing	2
	Chip seal	2
	Hot in-place recycling	3
	Saw and seal	2
	Crack seal	2
West Virginia	Pavement marking	1–2
Florida	Asphalt pavement	5
South Carolina	Asphalt pavement	3
	Pavement marking	1/2
Oregon	Asphalt pavement	3

Wisconsin DOT requires a 5-year warranty on asphalt pavement projects. Since 1995, the agency has sold 42 asphalt pavement projects. The warranty period of only nine projects has now expired. Wisconsin DOT mentioned that all warranty projects turned out the way they had anticipated, resulting in reduced cost, improved quality, and better documented information. At this point, none of the nine projects with expired warranties has required any remedial or warranty work to be done. Wisconsin DOT plans on expanding the use of warranties on pavement projects in the immediate future.

Minnesota DOT used warranties for the first time in 1995 on saw and seal maintenance contracts with a warranty period of 2 years. In 1999, they went to microsurfacing warranties. Minnesota DOT has let ten such projects with 2-year warranties. In 2001, the agency issued two design–build warranty projects followed by three pilot deck overlay warranty projects in 2002. The warranties for the design–build and deck overlay projects have not yet expired. Minnesota DOT mentioned that the only reason for using the design–build approach on two warranty projects was to get the projects completed in a shorter time. According to Minnesota DOT, warranty provisions helped them in getting more quality conscious contractors without a significant increase in cost.

Indiana DOT has let eight warranty contracts since 1996, all of which are hot-mix asphalt (HMA) pavement projects with 5-year warranties. Only one project has completed its warranty period to date. Indiana DOT mentioned that they have not had any problems with warranty projects. Only minor remediation needed to be done on two projects by the contractor.

**Fig. 1.** Average warranty periods for different types of projects

West Virginia DOT is applying the warranty contracting approach to roadway pavement marking projects. Ten district contracts are issued annually to place pavement markings on roadways, statewide. Additionally, one biannual contract is issued to place a semidurable pavement marking on the interstate and intrastate highway system. Up to and including 2002, West Virginia DOT had let 53 district and three biannual contracts. Of these, 43 district contracts and two biannual contracts have been completed to date. The warranty period for pavement marking projects is only 1 year. West Virginia DOT stated that warranty provisions helped them improve quality on their jobs. Also, related tangible cost increases proved to be insignificant after intangible costs were taken into consideration.

Florida DOT has used warranty contracting on several asphalt pavement and pavement marking projects. However, since it was getting more and more difficult for contractors to provide the agency with a warranty bond, Florida DOT has started to apply a contractor guarantee approach to state DOT construction projects. Under this system, contractors are prequalified for bidding on DOT projects and are made responsible for fixing any failures after project completion, as specified in the contract. Accordingly, any contractor who does not perform is taken off the bidders' list. Because of this approach the State of Florida does not require a warranty bond from contractors anymore.

In South Carolina warranties were applied to two large design–build contracts (>\$100 million). The projects were completed in June of 2000 and in October of 2002, respectively. Both projects have a 3-year warranty. South Carolina DOT mentioned that they are already experiencing failures on the design–build contracts because of problems related to subsurface conditions but not to the construction activities or the quality of construction.

Oregon DOT has been applying warranties to several pavement marking projects. However, the first two asphalt pavement projects with 3-year warranties were sold in 2002 and are still under construction. Due to the short warranty period, Oregon DOT does not expect to have any problems or changes in the process in the future. The reason why they wanted to implement warranties was to make the contractor more responsible for the work being done.

Warranty Period Requirements for Different Types of Projects

The survey showed that the average warranty period required by state DOTs was 5 years for asphalt pavements, 7 years for concrete pavements, and 2 years for preventive maintenance applica-

tions. A detailed summary of the results with the number of the respondents for each project type is shown in Fig. 1.

Wisconsin and Indiana DOTs stated that the agencies' 5-year warranty for asphalt pavement projects was a compromise among the state DOT, the contractors, and the surety companies. Having found out that a 5-year warranty is working well, Wisconsin DOT is planning on experimenting with 7-year warranties on asphalt pavement projects in the future. Another reason why Indiana DOT accepted a 5-year warranty is that, according to the agency, any possible construction related problem should show up within the first 5 years after project completion.

Minnesota DOT mentioned that 5-year warranties are still only material and workmanship warranties. According to Minnesota DOT, real performance based warranties should have longer warranty durations. Michigan DOT stated that warranty durations are based on negotiations between the state DOT and the contractors. Their target is to have at least 50% of the design life warranted. Michigan DOT is currently looking at 7-year performance warranties on pavement projects. South Carolina DOT chose a 3-year warranty period for two large design-build contracts, because contractors had a difficult time obtaining a warranty bond for longer periods. For pavement marking projects, however, the agency is currently considering 5-year warranties. Oregon DOT wants to apply warranties to all pavement projects in the future. Hence, they limited the warranty period to 3 years in order not to tie up the bonding capacity of contractors doing business with the agency.

Number of Bidders on Warranty and Nonwarranty Projects

For ten out of 12 state DOTs (84%), the average number of bidders on warranty and nonwarranty projects did not change and remained within a range of 3–7 bidders. Of the respondents, only West Virginia DOT experienced a significant decrease in the number of bidders from more than 30 on nonwarranty to a few on warranty projects. In 1997, West Virginia DOT let three contracts, with only one bidder per contract. In 1998, they let ten contracts, with many of these contracts having sole bidders, and a few contracts with no more than two bids each. According to West Virginia DOT, local contractors are afraid of the related liabilities of warranty projects. All the bidders of the agency are medium size pavement marking contractors, and only one of them is large enough to bid for a district contract.

Wisconsin DOT mentioned that the contractors bidding on warranty and nonwarranty jobs of the agency are usually the same local contractors, who are happy with warranty projects at this point. Minnesota DOT reported that the agency did not see any change in the number and the profile of bidders from nonwarranty to 2-year warranty projects, except in one case where one contractor decided not to bid on warranty jobs for an unknown reason. Minnesota DOT, however, indicated that the agency could experience a reduction in the number of bidders in the case of 5-year warranties because of bonding issues.

Indiana DOT did not experience any decrease in the number of bidders. Since the warranty jobs let are interstate jobs, the competing contractors are medium to large size contractors without the problem of bonding. Similarly, Michigan DOT indicated that warranty provisions did not affect the number of contractors bidding on warranty jobs. With respect to bidders, the most important problem for South Carolina DOT is the small size of in-state contractors. Since the agency applies warranties only to large

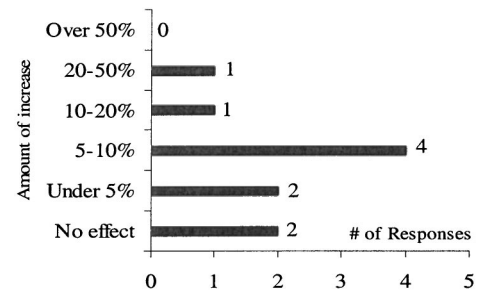


Fig. 2. Average increase in bid prices after warranties

design-build projects, the in-state contractors do not qualify for warranty jobs.

The responses and comments provided by participants in this section indicated that the reason for the decrease in the number of bidders on warranty projects if any is the size of the project rather than the warranty itself.

Cost Issues

The objective of this section was to gather information on cost issues of warranty highway construction projects with respect to changes in bid price, maintenance cost, and project life-cycle cost.

Average Increase in Bid Prices due to Warranty Provisions

As shown in Fig. 2, four out of ten state DOTs indicated a 5–10% increase in bid prices due to warranty provisions, whereas two respondents stated that the increase is less than 5%. No respondent indicated an increase over 50%.

According to Minnesota DOT, the average bid price for projects with 2-year warranties did not change. However, the agency expects some increase on 5-year warranties because of maintenance and bond costs to the contractor. Indiana DOT indicated that the warranted items on warranty projects cost 5% more as compared to nonwarranty projects. In West Virginia, the cost of warranty pavement marking projects decreased incrementally since the first application of warranty provisions in 1997 and is now approximately 10% above regular pavement marking projects. In South Carolina, warranties were applied to two large design-build contracts with a cost of more than \$100 million. However, there is no standard type project of this size that can be used for cost comparison.

A majority (65%) of contractors indicated that the average increase in bid prices due to warranty provisions is 5–15%. About 20% of the respondents reported a 0–5% increase, while the remaining 15% reported a 15–20% increase in bid prices.

According to the interviewed contractors, future maintenance costs and the cost of the bond are the main sources of the increase in bid price. It was interesting to note that contractors believed that despite the risk of future maintenance costs, the tight market tends to keep prices down, lower than what they would be in a less competitive market. The interview survey also revealed the concerns of small contractors regarding competition. According to small contractors, large contractors have a competitive advantage over smaller contractors, since they can spread out the cost of the warranties among other jobs and reduce the bid price, while carrying less risk than the small contractors. The competition may

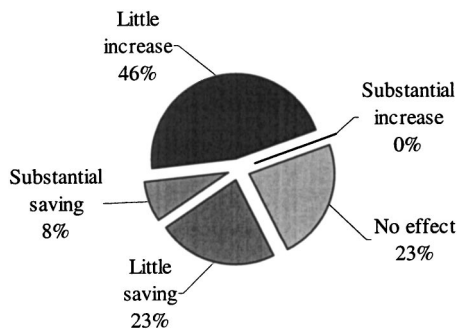


Fig. 3. Expected variation in project life cycle cost

also be decreased due to the small contractors' inability to obtain the required warranty bond, as discussed in the "Bonding Issues" section.

Expected Savings in Maintenance Cost

Eight (8) out of 9 state DOTs (88%) indicated that the expected savings in maintenance costs as compared to nonwarranty projects is under 10%. Only West Virginia DOT expected more than 50% saving in maintenance costs on the agency's pavement marking projects. With warranty contracts, the assumption of the agency is that contractors will perform at a high enough level to keep future maintenance costs very low, or nonexistent.

Indiana DOT mentioned that they did not experience any change in maintenance costs on warranty projects in the first 5 years. It was interesting to note that Oregon DOT expected maintenance costs on two recent pavement projects to be about the same as the agency's highest quality jobs without warranty. The survey also revealed that longer warranty periods and tighter specifications are the major possible methods for state DOTs to reduce future maintenance costs.

Expected Savings in Project Life-Cycle Cost

Very few state DOTs (8%) indicated that they expect a substantial saving in the project life-cycle cost of warranty projects as compared to nonwarranty projects. Most of the respondents (about 46%) reported little increase in the project life-cycle cost of warranty projects. A detailed summary of the results obtained is given in Fig. 3.

Wisconsin DOT mentioned that according to their pavement management data, the agency projects an increase of 5 years in the HMA pavement life due to warranty provisions. Additionally, when all factors such as reduced maintenance and delivery costs are considered, warranty projects are less expensive than regular projects. For example, Wisconsin DOT does not assign a pavement inspector to warranty jobs. According to West Virginia DOT, the cost of regular and warranty pavement projects to the agency are very similar. Although the tangible costs for warranty contracts are somewhat higher (typically within 10% of state force contracts), the intangible costs provide a greater value than the 10% difference. Some of these intangible costs are: better quality, guaranteed performance, shorter contract time frames, and reduced inspection costs.

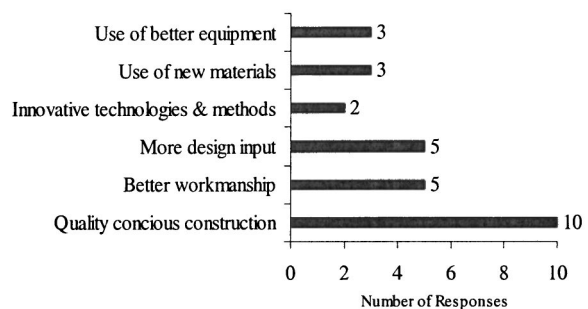


Fig. 4. Contractor innovation on warranty projects

Quality Issues

The objective of this section was to gather information on the impact of warranty provisions on highway construction project quality, site inspection, and record keeping.

Impact of Warranty Provisions on Project Quality

About 46% of the state DOTs indicated that warranty provisions slightly improved project quality, whereas 23% indicated great improvement. On the other hand, 31% of the respondents reported that the impact of warranty provisions on project quality is not yet clear.

Wisconsin DOT stated that warranty projects performed better than regular projects as measured by two performance evaluation indices: performance distress index and international roughness index. Indiana DOT observed that on warranty projects the overall quality seems to be better since the contractors are paying more attention to the quality of the work including nonwarranty items. However, Indiana DOT thinks that the warranty approach is only shifting the risk to the contractor and wants to focus more on straight performance related specifications. Similarly, West Virginia DOT observed that their warranty contracts are worthwhile with respect to quality. The agency has found an improvement in quality on warranty contracts.

About 62% of contractors indicated that warranty provisions encourage them to maintain higher quality. However, the remaining 38% of the respondents indicated that they have not observed any significant change in quality due to warranty requirements. The survey also revealed that contractors have a more conservative attitude when working on warranty projects. Most of the contractors do not innovate but are more quality conscious for fear of carrying additional risk. Fig. 4 is a summary of the most preferred innovations by contractors on warranty projects.

Impact of Warranty Provisions on Site Inspection

A majority of state DOTs (77%) indicated that warranty provisions have reduced the need for site inspection, while about 15% indicated no change, and the remaining 8% indicated more inspection by the state DOTs. On the other hand, a majority of contractors (69%) reported no change in site inspection on warranty projects and 25% indicated that warranty provisions increased the need for site inspection by the contractors.

Minnesota DOT did not experience any decrease in its inspection workforce on the 2-year warranty projects, but the agency expects some decrease on projects with 5-year warranties. Florida DOT has reduced its inspection staff on warranty projects. The inspectors in the asphalt plant and on the roadway have been

removed from the process. South Carolina DOT mentioned that they had only three inspectors on large-design-build projects, which resulted in a tremendous reduction in the inspection staff. However, according to the agency, a level of inspection and oversight is still needed to keep everyone honest. So, henceforth, more inspectors will be assigned to new warranty design-build projects. Oregon DOT said that the agency has no plans to change the number of inspection staff on its warranty projects.

Impact of Warranty Provisions on Record Keeping

About 54% of state DOTs reported that warranty provisions resulted in less record keeping, while 31% indicated no change and only 15% indicated more record keeping. However, it was interesting to note that 94% of contractors indicated that warranty provisions have increased the need for record keeping. The contractors mentioned that their documentation and record retention is more important in the case of a future dispute over the warranty.

Construction Duration Issues

The objective of this section was to gather information on the effect of warranty provisions on the construction duration of highway construction projects.

Impact of Warranty Provisions on Construction Duration

State DOTs were asked about the impact of warranty provisions on construction duration. The majority of state DOTs (about 61%) indicated that warranties do not save construction time, while the remaining 39% stated otherwise. On the other hand, about 50% of contractors indicated that warranty provisions may lead to delays because of uncertain conditions or greater emphasis on quality throughout the construction process. The remaining 50% stated that warranty provisions do not affect construction time.

Indiana DOT stated that, unlike A+B contracting or the lane rental technique, warranty provisions do not speed up construction. According to Florida DOT, construction duration and warranties are two separate issues that do not interact with each other. Florida DOT tries to speed up most of the projects by using different tools such as bonuses and incentives. Wisconsin DOT mentioned that they have had no delays on warranty projects since they try to get the uncertainties or problems cleared up before the contractors start paving.

Bonding Issues

The objective of this section was to gather information on bonding problems for small highway contractors and the calculation of the requested face value of the bond.

Small Firms and Warranty Bonding

It was interesting to note that the six bonding companies that responded to the questionnaire were unanimous in their opinion that small firms are very likely to be eliminated from warranty projects. Bonding companies are mostly not interested in supporting smaller companies for a period of 3–7 years without the ability to reunderwrite on a periodic basis, since the contractor's financial situation could change relatively quickly.

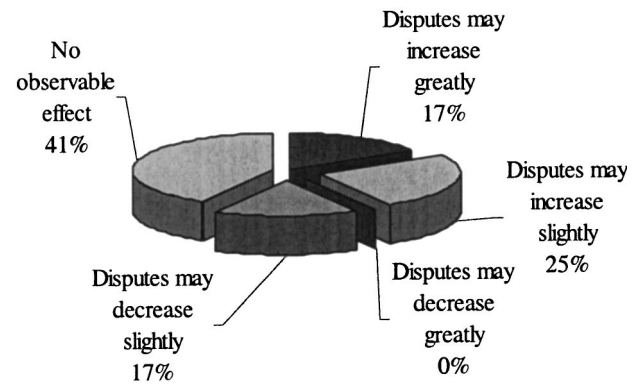


Fig. 5. Impact of warranty contracting on contract disputes and litigation

The interviewees from the surety industry indicated that the underwriters use the same risk evaluation methods for both warranty and nonwarranty projects, but these methods are not adequate for the long-term obligations associated with warranty bonds. Therefore, because of the lack of appropriate risk assessment methods, surety companies prefer larger contractors with relatively larger working capitals to smaller contractors.

Face Value of Warranty Bond

All of the state DOTs indicated that the agency does not decrease the face amount of the bond over time. The survey has also revealed that most agencies require the warranty bond when the contract is signed, while the surety companies prefer to issue the warranty bond after project completion. Seventy five percent of contractors indicated that their bonding capacity does not limit the number of jobs they can bid/undertake, whereas 25% answered in the negative.

Wisconsin DOT mentioned that their contractors have not had any problem securing a warranty bond. On pavement projects, Wisconsin DOT excludes the first year after completion from the warranty period and requires either one single term bond or two 2-year renewable bonds from the contractor for the 4-year warranty period. Although Wisconsin DOT allows negotiations on the face value of the warranty bond, it generally requires that the amount for small projects be equal to the total cost of the project and for larger pavement projects 25% of the warranted bid item. Minnesota DOT requires a single term warranty bond from the contractor after project completion. The face value of the bond is based on 20% of the warranted work for overlay projects and on the cost of total replacement of the pavement for design-build projects. Indiana DOT bases the face value of the warranty bond on the estimate of what the cost would be to repair or remediate the worst possible failure, which is generally 20–40% of the warranted item. The warranty bond is usually provided along with the bid as a single term bond for 5 years.

Contract Issues

The objective of this section was to gather information on the effect of warranty provisions on contract disputes and litigation.

Five (5) out of 12 state DOTs (41%) indicated that warranty provisions do not have an observable effect on contract disputes and litigation, while three respondents (25%) said that disputes and litigation may increase slightly (Fig. 5). On the other hand,

the interviewees from the surety industry indicated that an extended duration complicates the sorting out of responsibility which, in turn, may greatly increase disputes on contracts. The interviewees also indicated that contract disputes are expected to occur more frequently in the future as the relatively young warranty programs of many states in the United States begin to mature and contractors are called upon to maintain the pavements.

Unclassified Issues

The objective of this section was to get the opinion of the participants on additional aspects of warranty contracting.

About 54% of state DOTs indicated that warranty contracting is a better method than conventional contracting for achieving goals such as better quality and lower life-cycle cost, while 23% of the respondents did not favor warranty provisions. The remaining 23% of the respondents did not have an opinion at the time of the survey. The majority of the 14 contractors stated that the lack of design-build projects (86%), long warranty durations (79%), and limited bond availability (43%) are the major factors that prevent them from bidding on warranty projects.

Conclusions and Recommendations

Warranty contracting applied to highway construction projects by state DOTs was evaluated through a comprehensive study including questionnaires and interview surveys. The surveyed agencies included state DOTs, contractors, and surety companies. The survey results were based on a total of 35 questionnaire responses and 22 interviews. The survey findings were categorized under seven major sections including general information, cost issues, quality issues, construction duration issues, bonding issues, contract disputes and litigation issues, and unclassified issues.

The study revealed that warranty contracting is currently being utilized by 32 state DOTs in the United States. However, for the majority of the 13 state DOTs included in the analysis (76%), the number of warranty projects was less than 5% of the total annual number of projects awarded by the agency.

According to the results of the study, the initial bid price increases due to warranty provisions are estimated to be somewhere between 0 and 15%, while the changes in maintenance and project life-cycle costs are expected to be minimal. The potential impact of longer warranty durations on the cost of the project is currently unknown due to the unavailability of concrete historical data. On the other hand, warranty provisions slightly increase the quality of the projects as compared to the quality on similar but conventional projects. However, innovative technologies and methods, new materials, or better equipment, which could lead to significant improvements in the quality of warranty projects, are not favored by contractors because of the associated risks. Therefore, it can be concluded that the current practice of warranty provisions is worthwhile if its role is considered mainly as an insurance mechanism against the unexpected and a protection from early contractor defaults. Although this is essential for state DOTs in certain situations, it is not necessary on most projects where the agency has had good previous experience with the contractor. Additionally, with some modifications to the current practice, warranty provisions could be used much more effectively to help state DOTs in achieving better results with respect to the major objectives of warranty contracting including contractor-funded innovation, major quality increases, and re-

duced life-cycle costs. However, these modifications require further study before they can be effectively and safely applied to warranty contracting.

In this regard, the first recommendation of the writers is optional warranty, where the decision to exercise the option to buy the warranty is delayed until the end of construction when more information is available on project performance. In this scenario, the contractor is required to provide a price for the warranty while bidding on a project. The state DOT will then decide on the need for a warranty after construction is completed and would buy a warranty only for projects with a high probability of failure. This method is based on an important analogy to financial options and is a good candidate for further research.

The second alternative approach is the integration of warranty provisions with other contractual methods that proved to be successful in terms of expected benefits. For example, the incentive/disincentive (I/D) approach could be used with warranty provisions under the same contract to motivate contractors to improve the quality or at least to insure that the DOTs get what they pay for. Additionally, bidding on cost/time combined with the I/D approach for quality assurance could be used together with warranty provisions to get the construction completed in a shorter period of time with the expected quality as well as the optional protection of warranty provisions.

While this study has presented several important results on the pros and cons of warranty provisions in highway construction projects, the conclusions were primarily drawn from the limited experience of state DOTs, contractors, and surety companies. Since most warranty programs were only set up in the past 5 years, many completed projects are still under warranty. In addition, pilot projects were intentionally selected for their high probability of success and contractors as well as surety companies are still learning from these limited projects and trying to evaluate the risks associated with warranty provisions. Therefore, it is also very important for state DOTs to keep track of warranty projects over their entire life to gather adequate data so that a conclusive evaluation based on completed projects and warranty periods could be made in the future.

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