# Use of Performance Based Warranties on Roadway Construction Projects

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**16. Abstract**

The purpose of this report is to provide the reader with an overview of the use of warranty contracting for highway construction projects and to further recommend how the state of Montana might implement this approach for selected demonstration projects. The paper begins with a brief description and discussion of the various elements and issues of warranty based roadway design and construction. The manner in which other states have addressed these issues is then described. Finally, specific suggestions are made about how Montana could proceed with warranty based demonstration projects.

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| English Unit | Metric Unit | English to Metric Conversion Factor |
|---|---|---|
| Mile (mi) | Kilometer (km) | 1.609 |
| Foot (ft) | Meter (m) | 0.305 |
| Inch (in) | Centimeter (cm) | 2.540 |
| In/Mile (in/mi) | Meter/Kilometer (m/km) | 0.016 |
| Miles/Hour (mph) | Kilometers/Hour (kph) | 1.609 |

## EXECUTIVE SUMMARY

In an effort to improve quality and decrease costs, many state departments of transportation are experimenting with incorporating warranties on in-service performance in their roadway construction contracts. Historically, and due to uncertainties regarding: a) the existing conditions upon which a roadway design is based, and b) the demands that a roadway will experience once it is placed into service, the designers and builders of a highway have not been required to guarantee its in-service performance. The engineer prepares his/her best possible design, and the contractor is tasked with building that design according to the engineer's specifications for materials and workmanship. While this approach to roadway construction has been accepted for decades as offering the best value to the public, many states believe it may be time to revisit this issue. Notably, since in-service warranties on performance are common for so many consumer products, their use on roadway construction merits further consideration.

Why could the use of warranties on in-service performance on roadway construction projects lead to improved quality at lower costs? The basic answer to this question is that following this approach, the focus of the construction process shifts from simply meeting material and workmanship requirements stated by the engineer to meeting the expectations of the motorist with respect to how the roadway will fulfill its intended function. Rather than requiring the contractor to simply build the roadway to meet the engineer's specifications, the contractor is also required to guarantee the roadway will meet certain performance criteria once it is placed into service. Thus, the contractor's efforts are expected to focus directly on those activities that result in better performance of a roadway once it is in service.

If a contractor is to guarantee the performance of a roadway, he/she should reasonably expect some input/control on the design. This requirement of the warranty approach is a major departure from current practice in which design and construction are independent functions performed by separate entities. This departure from standard procedure is but one of many changes that will be necessary relative to traditional procedures when a warranty approach is used. Other issues that must be addressed include the length of the warranty, the performance parameters to be used in evaluating warranty compliance, the steps necessary to insure the contractor will meet warranty obligations, the role of the state during project design and construction, etc. The intention of this report is to acquaint the reader with these issues, indicate how other states have addressed them in pilot projects, and present recommendations on how the state of Montana might implement in-service performance warranties in demonstration projects.

In reading this report, it is important to keep in mind that, while promising, the cost-effectiveness of using warranty contracts for roadway construction projects is uncertain. In using this approach, the risk of project failure is effectively transferred from the state to the contractor. In response to assuming this risk, initial contract costs will probably increase. In the long term, any such increases in cost will hopefully be more than offset by increased efficiencies in contractor operations and roadway design. On the other hand, the best value in roadway construction might be realized under the current contracting scheme, in which the public assumes the risk of roadway failure. Thus, as is being done in other states, Montana needs to carefully examine the costs and benefits associated with using warranties on roadway construction projects.

# 1.0 INTRODUCTION

## 1.1 Background

Over the past 10 to 15 years, the use of in-service warranties on roadway construction projects has attracted considerable interest across the United States. Utilizing this approach with highway construction, the contract specifications are related to the expectations that the motoring public has for the performance of the roadway once it is in use. At the very least, these expectations include that the roadway provide a safe and comfortable ride over its design life at a reasonable cost. The contractor is given the responsibility of designing, constructing, and maintaining the roadway so that it meets these expectations.

While performance based warranties are commonplace for many consumer products, their use on highways has been very limited. Unlike many consumer products which are produced in large quantities under identical and controlled conditions, each highway project is unique with respect to things such as soil, pavement, climatic, and traffic conditions. Furthermore, while these factors all affect the performance of the highway after it is placed in service, they often are not well known, and the exact manner in which they factor into the roadway's performance both singly and collectively is not fully understood. Thus, it can be difficult to exactly predict how well a highway will perform after it is designed, built, and placed in service. Therefore, designers and builders of highways (typically engineers and contractors, respectively) have been relieved of the responsibility of explicitly guaranteeing that their work will serve its intended function after it is placed in service. Rather, the engineer is statutorily bound to generate the best possible design with the information available to him/her, and the contractor is contractually bound to build the road designed by the engineer.

Following the standard approach to highway design and construction described above, the financial burden incurred if a roadway is found to be "defective" once it is placed into service is borne by the public (similarly, any financial gain associated with a highway that outperforms design expectations is also accrued by the public). While this approach for providing highway service is almost exclusively used throughout the country across all levels of government, its cost effectiveness relative to other approaches for providing highway service has not generally been evaluated. Notably, since performance based warranties are so prevalent for other consumer products, it seems reasonable to revisit their use for highways, despite the above mentioned problems with their use in this application. Due to the lack of experience with warranties on highway construction projects, these types of projects were administered through Special Experimental Project No. 14 on federal aid highway work prior to 1996 (FHWA, 2002). In 1996, the federal government deemed that warranties on highway projects were no longer "experimental" for the National Highway System (NHS) (FHWA, 2000). Since that time, the number and type of projects contracted using a warranty approach by state transportation agencies across the country has increased substantially. Sufficient interest has been generated by this idea that several state legislatures have mandated that their respective departments of transportation let some demonstration warranty projects for roadway construction.

The potential benefit offered by performance warranties for highways is that equal or better quality roadways can be built at lower costs than are presently being incurred. Following the

warranty approach, the contractor is provided with direct incentives to produce good and useable roadways, rather than being tasked to simply meet prescriptive standards on construction materials and methods. Correspondingly, the focus of transportation officials can be shifted from process related issues such as how well is the contractor compacting the base course of a roadway, to end product related issues, such as how well is the final product serving the motoring public. In this environment, contractors are expected to seek out efficient design approaches and construction methodologies in an effort to maximize their profits. Any cost savings that result from such innovations will eventually be passed onto the motoring public.

Whether or not there will be any cost savings realized using a performance based warranty approach for highway construction is uncertain, due to limited experience in this country with this type of contract for highways. While several states have demonstration warranty projects in-place, these projects typically were built in just the past few years, so only limited results are available on their performance. Wisconsin has reported that in their warranty program, paving costs have actually decreased, while pavement performance (after 5 years) has improved (Wisconsin Department of Transportation (WisDOT), undated). Nonetheless, under the warranty approach, the financial risks inherent in guaranteeing the long-term usability (referred to as serviceability) of a highway are transferred from the public to the contractor. In response to assuming this risk, the initial costs of facilities built under warranty contracts may exceed the cost of the building the same facility using traditional contracting procedures. Indeed, Ohio has reported an increase in the initial cost of warranted pavement projects (Ohio Department of Transportation (ODOT), 2000). Naturally, the subsequent savings realized over the life of the highway due to reduced maintenance requirements, increased service life, etc., would have to outweigh this increase in initial costs for the warranty approach to be viable.

### 1.2 Objectives and Scope

The purpose of this report is to provide the reader with an overview of the use of warranty contracting for highway construction projects and to further recommend how the state of Montana might implement this approach for selected demonstration projects. The paper begins with a brief description and discussion of the various elements and issues of warranty based roadway design and construction. The manner in which other states have addressed these issues is then described. Finally, specific suggestions are made about how Montana could proceed with warranty based demonstration projects. Readers interested in a more detailed treatment of this same topic are directed to an earlier publication on this subject "Use of Warranties on In-Service Performance for Roadway Construction Projects" prepared by Stephens, Johnson, Wangsmo, and Schillings (1998) for the Montana Department of Transportation (MDT). This document includes the results of a survey conducted of highway contractors in the state of Montana regarding their views of warranty based projects. While not offering the depth of discussion included in the earlier effort, this paper is more current than the earlier work, and it is considerably more condensed. Additional information on using warranties in highway work is also available in the references listed at the end of this paper. Notably, a report recently published by the National Cooperative Highway Research Program (NCHRP) titled Guidelines for Warranty, Multiparameter, and Best Value Contracting (Anderson and Russell, 2001) contains a detailed description of the implementation process for roadway warranties generally

following the approach used by the Wisconsin Department of Transportation, which is an advocate and leader in this area of contracting.

This paper focuses specifically on using performance based, warranty contracts for roadway construction. Considerable interest also has been expressed over the past few years with the design-build approach to highway construction. Note that "design-build" and "warranty" contracts are not the same thing. The design-build concept, in which a single entity is responsible for both designing and building a project, does not inherently include an in-service warranty on the performance of the completed facility. A warranty project, on-the-other-hand, typically includes design-build, as it is generally assumed that the contractor will require input/control over the design, if they are to guarantee that the finished product will serve its intended function. Also note that several states (including Montana) are considering or are actively experimenting with performance warranties on a variety of their activities, notably in areas such as pavement marking, bridge painting, etc.

## 2. WARRANTY APPROACH TO HIGHWAY CONSTRUCTION

### 2.1 General Remarks

While simple in concept, several issues need to be addressed and resolved in each step of the warranty contracting process before this approach can be implemented for even a limited number of demonstration projects. These issues include:

Type of project appropriate for demonstration warranty projects
Length of the warranty period
Performance criteria to be used in evaluating warranty compliance
Level of independence allowed to the design/construction team
Basis for bid evaluation and award of contract
Quality control during the construction process
Evaluation of performance during the warranty period
Course of action to be followed if the warranty is invoked
Bonding requirements

Each of these items is briefly discussed below. In Section 3.2 of this paper, the manner in which various states have addressed these issues in demonstration projects is described.

### 2.2 Type of Project Appropriate for Demonstration Projects

The majority of expenditures on the highway system are pavement/roadway related; therefore, the focus of this effort is on using warranty contracts in roadway construction activities. These activities are diverse in nature, and, in the past few years, various states have experimented with warranty contracts across a broad spectrum of roadway construction activities. At one end of this spectrum are relatively inexpensive projects, such as chip seals or overlays, while at the other end of the spectrum are both more expensive and more involved new construction and reconstruction projects. One problem with using warranties on projects such as chip seals and

overlays is that the in-service performance of these treatments is influenced by the condition of the existing pavement, which is not always well characterized. Furthermore, the longevity of a chip seal, for example, is affected by activities such as snow plowing, whose frequency is at the vagaries of Mother Nature. Thus, the contractor is faced with guaranteeing the in-service performance of his/her work while some of this performance is controlled by factors beyond his/her control. While this situation is greatly reduced for new construction or reconstruction, such projects are considerably more involved than a chip seal or overlay. Implementing a warranty approach on these projects may be considerably more complex than it would be for simple chip seals and overlays (with a correspondingly greater financial loss if the approach is a failure). In either case, the intent is to only hold the contractor responsible for performance related to demands and existing conditions included in their design.

### 2.3 Length of the Warranty Period

The required length of the warranty period for roadway construction projects is not definitively known. Various states have used from 2 years to 20 years in their demonstration projects. The length of the warranty on many consumer products is shorter than the design life of the product. In such cases, from the consumer's perspective, the intent of the warranty period is to reasonably establish that the product is free from defects that will interfere with its performance and/or compromise its useful life. One problem in using this approach on roadway construction projects is in establishing exactly how long the warranty period must be for the motoring public to be assured that the roadway will continue to fulfill its function for its entire design life. Is, for example, a 3 to 5 year in-service warranty adequate for a reconstruction project with a 20 year design life? The answer to this question is uncertain. Note that the deterioration of a roadway occurs over time due to environmental effects and traffic. Thus, the warranty may need to be expressed in terms of both the age of the roadway and the amount of traffic it has carried (e.g., five years or 50,000 ESALs[1], whichever comes first).

### 2.4 Performance Criteria to be Used in Evaluating Warranty Compliance

Under a performance based, warranty contract, the parameters used to evaluate compliance with the terms of the contract during the warranty period should be closely related to the in-service performance of the facility. That is, if the roadway is to provide a comfortable and safe ride over a long service life, these parameters should be used in establishing warranty compliance. The performance parameters should be quantitative in nature, to eliminate the arguments that can develop when subjective criteria are used for evaluation purposes. Comfort and safety, for example, can be measured using ride and skid indices, respectively. The contract document should specify minimum allowable values for these indices during the warranty period. Alternatively, the minimum performance values can change over the life of the warranty, as the roadway condition deteriorates over time and with use. In either case, these values should be set by the regulatory agency to be consistent with historical highway performance that has been

[1] An ESAL is a measure of the load demand placed on a pavement by an 18,000 pound axle. The load demands of all the different types of vehicles expected to use a highway can be quantified in terms of the number of 18,000 pound axles that will generate the same total demand on the pavement as the actual traffic.

found to be: a) satisfactory by the motoring public and b) reasonably achievable using conventional design and construction procedures.

If the warranty period is less than the design life of the roadway, it can be difficult to predict if the as-built facility will have the promised service life beyond the end of the warranty period. Typically, remaining service life has to be extrapolated based on some manifestation of accumulated distress, such as rate, extent, and severity of cracking. Thus, some limits should be placed on pavement distress, or some mandatory remedial action required in the event objectionable damage of this kind occurs.

Note that relative to traditional highway contract specifications, no requirements have been given on methods or materials. Rather than requiring a certain level of compaction for the running surface at the time of construction, for example, the warranty specification focuses on the related outcome of interest once the roadway is placed in-service, namely, a smooth ride and a long life. The contractor is left to decide if attaining certain levels of compaction are crucial to producing a finished facility that will perform adequately during the warranty period.

### 2.5 Level of Independence Allowed to the Design/Construction Team

Under a warranty approach, the contractor and his/her engineer are responsible for the design of the roadway. This approach is consistent with subsequently holding the contractor responsible for the in-service performance of the constructed facility. Ideally, the contractor will be free to provide any type of facility, as long as it meets the client's/user's performance criteria (safe, smooth ride, low cost, long life, etc.). Such an approach allows for the greatest innovation and greatest potential cost savings in providing highway service. In reality, particularly in early projects, constraining at least the type of running surface to traditional materials (say, asphalt concrete or Portland cement concrete) may, to some extent, increase all the participants' comfort level with these contracts. Further requirements such as minimum thicknesses for the base and running surface on a reconstruction project, may steer the contractor in the design direction preferred by the contracting agency. Such constraints on the contractors' design options are also attractive with respect to simplifying the subsequent bid evaluation process, as bids from various contractors are for generally similar facilities. This simplification, however, comes at the cost of restricting innovation in the design solution. In placing constraints on the contractor's design, the contracting agency is also assuming some responsibility for the performance of the completed project (commensurate with the level of detail with which they have directed the design).

Note that in all cases, the contracting agency is still free to place constraints on the design/construction team appropriate to the specific circumstances of each project. Such constraints might include restrictions such as when a project must be done, how much construction operations can interfere with traffic flow, etc.

## 2.6 Basis of Bid Evaluation and Award of Contract

As alluded to above, the evaluation of bids on warranty roadway construction projects may not be as simple as it is following the traditional method for contracting highway construction projects. Using the traditional approach, contractors all bid to build an identical facility. Thus, the bid price is the only factor needed to compare the relative value offered by competing contractors. Under the warranty approach, each bidder might propose building a different facility as a result of pursuing different strategies to provide a roadway meeting the same in-service demands. For example, on a simple reconstruction project, contractor "A" may propose a thick base and thin running surface made of a modified asphalt concrete, while contractor "B" may propose a thinner base and a thicker surface made with conventional asphalt concrete. In each case, the contractor may or may not propose to do any annual maintenance over the warranty period. One approach to evaluating these bids would be to simply accept the lowest bid. Under the terms of the warranty contract, the successful bidder is guaranteeing the design, and is therefore obligated to perform remedial work if it becomes necessary after the roadway is placed in-service. This approach is certainly consistent with most standard procurement laws, which mandate the award of projects to the lowest responsible bidder. Alternatively, and in the interest of obtaining the best possible value for the least cost from what may appear to be a comparison of "apples" versus "oranges", it may be appropriate to have a technical panel evaluate each bid according to predetermined criteria that factor in both the quality and cost of the proposed roadway. Bid award could subsequently be made based on the lowest cost per unit of technical quality or a similar parameter. Existing evaluation schemes for requests for design proposals (rather than requests for bids or quotations) may be useful in this regard. Whether or not such approaches to awarding highway construction contracts is allowed by state statute is uncertain.

## 2.7 Quality Control During Construction

Under an in-service warranty system, the contracting agency (e.g., MDT) should not have to engage in extensive oversight/quality control during roadway construction. The contractor will select and use those construction methods and materials that they believe will produce a roadway that meets the warranty requirements on in-service performance. They will further specify and engage in the quality control effort necessary to insure the completed facility performs its intended function. In this manner, design procedures, construction methods, and quality control activities that do not directly contribute to creating quality roads will, under market forces, be eliminated and/or replaced by more efficient processes. Quality control efforts for MDT might well be limited only to documentation of conditions that could impact serviceability at a later date (which might be useful in establishing responsibility for non-compliant performance during the warranty period) .

## 2.8 Evaluation of Performance During the Warranty Period

While the contracting agency will no longer be concerned with quality control during construction, they will be involved in monitoring roadway performance for compliance with the terms of the warranty. Thus, any cost savings to the agency resulting from eliminating their involvement in extensive quality control during construction may be offset by the cost of

monitoring performance during the warranty period. Such monitoring may consist of annual inspections to determine ride quality, skid resistance, cracking, rutting, etc.

Note that a contractor could plan to do routine maintenance during the warranty period. If done in a preventive mode, such maintenance could prolong the life of a roadway in a very cost-effective fashion. If such maintenance is necessary simply to get the roadway through the warranty period, the long-term durability of the facility could be questionable. Issues of this kind could potentially be avoided if a proposal based evaluation process was used for contract award.

### 2.9 Course of Action if the Roadway is not in Compliance with the Warranty

In the event that the above mentioned inspections reveal a problem with the roadway, it must be established whether or not the contractor is responsible for performing repairs under the terms of the warranty. As previously stated, the intention of the warranty approach is to only hold the contractor responsible for the occurrence of unacceptable conditions over which he/she has had some control. If, for example, the roadway experienced significantly more traffic than anticipated in its design (which implies traffic demands are being monitored on the warranted roadway), the warranty provisions would be adjusted appropriately. To even move back one step further, if the state discovers a problem with the performance of a warranty project after it is placed in service, the contractor should be given the opportunity to confirm the state's evaluation, before any further action is taken.

In the event that the contractor is deemed to be responsible for a problem observed with the roadway during the warranty period, he/she is also responsible for repairing it. Once again, approaches to remedial work vary from giving the contractor complete freedom in how this work is accomplished to stating in the contract what specific work will be done to remedy each type of warranty distress. Under any approach, some guidelines must be available regarding the timeframe for completing repairs. The contracting agency may also place constraints on the time of day that work may be done, and on the acceptable types of repairs, to protect the motoring public from undue inconvenience. If the problem with the roadway affects safety (e.g., inadequate skid resistance), the state needs the ability to immediately correct the problem if the contractor is unable or unwilling to mobilize quickly enough.

Assigning responsibility for observed problems, arranging for their correction, and reacting to emergency conditions may all involve qualitative judgements and lead to conflict between the contractor and the transportation agency. Some mechanism to allow for expedient and consensual resolution of differences of opinion between these parties will be required. Possibilities might include an arbitration panel with members selected by each party, or a Conflict Resolution Team (CRT) composed of representatives from both sides.

### 2.10 Payment and Bonding Requirements

In a warranty situation, payment for roadway construction can proceed according to traditional practice. That is, the contractor can be paid incrementally for time and materials as construction

is completed. A traditional construction bond can also be used. Additional requirements or consideration must be given, however, to the warranty provisions of the contract.

Some mechanism is necessary to guarantee the contractor's work for the length of the warranty period. Possible mechanisms include withholding payment of a portion of the project costs until the warranty period ends, or requiring the contractor to purchase a warranty bond. The amount of the payment withheld, or how large the bond should be, can be been determined based on the cost of the most expensive remedial action associated with each element of the warranty (e.g., for poor skid resistance, apply a chip seal; for cracking, seal the pavement; for rough ride, mill off the running surface and place a thin overlay, etc.). Alternatively, some states simply set the bond amount at a percentage of the construction cost.

A major concern with warranty based contracts for roadway construction projects is the prolonged nature of the contract agreement. For the agency administering the contract, overhead costs associated with contract administration will be incurred over a relatively long period compared to the present system. For the contractor who was awarded the project or, for his/her bonding company, the possibility of suffering a substantial financial loss will exist throughout the warranty period. Furthermore, outstanding bonds on warranty projects could affect a contractor's ability to secure bonding for new projects.

The surety industry is concerned with their ability to accurately assess their risk (and thus, what they should charge) in guaranteeing that a contractor will meet his/her warranty obligations far into the future (Surety Association of America (SAA), 2001). The surety industry should be more comfortable with warranty contracts if they are shown the relationship between the historic performance of roadways and the threshold values on this performance required during the warranty period. Further, increasingly precise definitions of warranty criteria will make risk quantification more reliable, and therefore more palatable to the surety industry. According to current bonding practices, it is suggested that a premium be charged for each year beyond the first warranty year (SAA, 2001). The surety industry expects that few contractors will be able to qualify for bonds for warranty periods of ten to twenty years, which will limit competition on such projects. In light of this situation, the SAA has recommended that: a) for warranties in excess of 5 years, the bond be successively renewed at 3 to 5 year intervals b) the amount of the bond should be 10 percent of the project cost, and c) the cost to the contractor of meeting the warranty obligation should be listed as a separate line item in the bid, and it should be paid out across the warranty period. Under a standard construction payment schedule, the contractor is paid as work is completed. Thus, if the contractor defaults during construction, the surety company has access to the remaining unspent funds in completing the project. In a similar fashion, SAA recommends that not all of the warranty cost be paid to the contractor at the beginning of the warranty period. If the bonding company finds it necessary to step in and perform some warranty work, they would like to have access to any unspent monies due the contractor for this purpose.

## 3. WORK BY OTHER STATES WITH HIGHWAY WARRANTIES

### 3.1 General Remarks

Starting with just a few states experimenting with alternative design-bid-construct arrangements a few years ago, the number of state transportation departments currently seeking a better way to build highway projects has grown significantly in recent years. Figure 1 shows the states that have introduced legislation just during 2001 or 2002 to permit or revise laws dealing with design-build as a delivery method. As can be seen by the information contained in Figure 1, over half of the states are pursuing new or improved design-build formats for their projects. Several of the unmarked states already permit design-build forms of contracts for public highway projects. While design-build is not synonymous with warranty based contracting methods, it is often a prerequisite for states interested in pursuing warranty based contracting methods.

Figure 2 shows the states that are either actively experimenting with warranty based contracting methods, or have exhibited an interest, but are not actively pursuing any warranty based projects yet. A comparison of Figures 1 and 2 shows a not unexpected correlation between the states interested in design build and those interested in warranties. A brief description of the current status of warranties in many of the active states shown in Figure 2 is presented in the following section.

### 3.2 Demonstration Projects and Typical Contract Provisions

Information was gathered about the current practices of 17 state departments of transportation known to be actively investigating warranty contracting methods. Table 1 presents a summary of the information obtained from one or more representatives of each state's department of transportation. Table 1 is followed by a brief, but expanded, narrative of the work being done in each state. Finally, examples of warranty specifications developed by the Indiana, Minnesota, and Ohio departments of transportation are presented in Appendix A of this report.

In reviewing the work being done by other states, at least two trends are evident in their highway warranty efforts. The first trend observed is that two distinct approaches have been tried with respect to the type of performance to be warranted. Warranties have been written that cover problems with the physical condition of the pavement (e.g., cracking, raveling, rutting, etc.) related to materials and workmanship, and warranties have been written that directly address deficiencies in the use-related performance of the pavement (i.e., safety and ride quality). It appears that the majority of states only use measures of pavement distress in their roadway warranty specifications (e.g., the specifications have thresholds on cracking, raveling, flushing, rutting, etc.). Fewer states include requirements directly on ride quality and surface friction in their warranty specifications. Materials and workmanship warranties appear to apply to a wider range of highway components, to constitute primarily a lengthening of the standard one-year warranty period used on traditional highway projects, and to rarely be coupled with a shift of design responsibility to the contractor. Use-related performance specifications, on the other hand, apply to a more limited range of highway components, require that the state department of

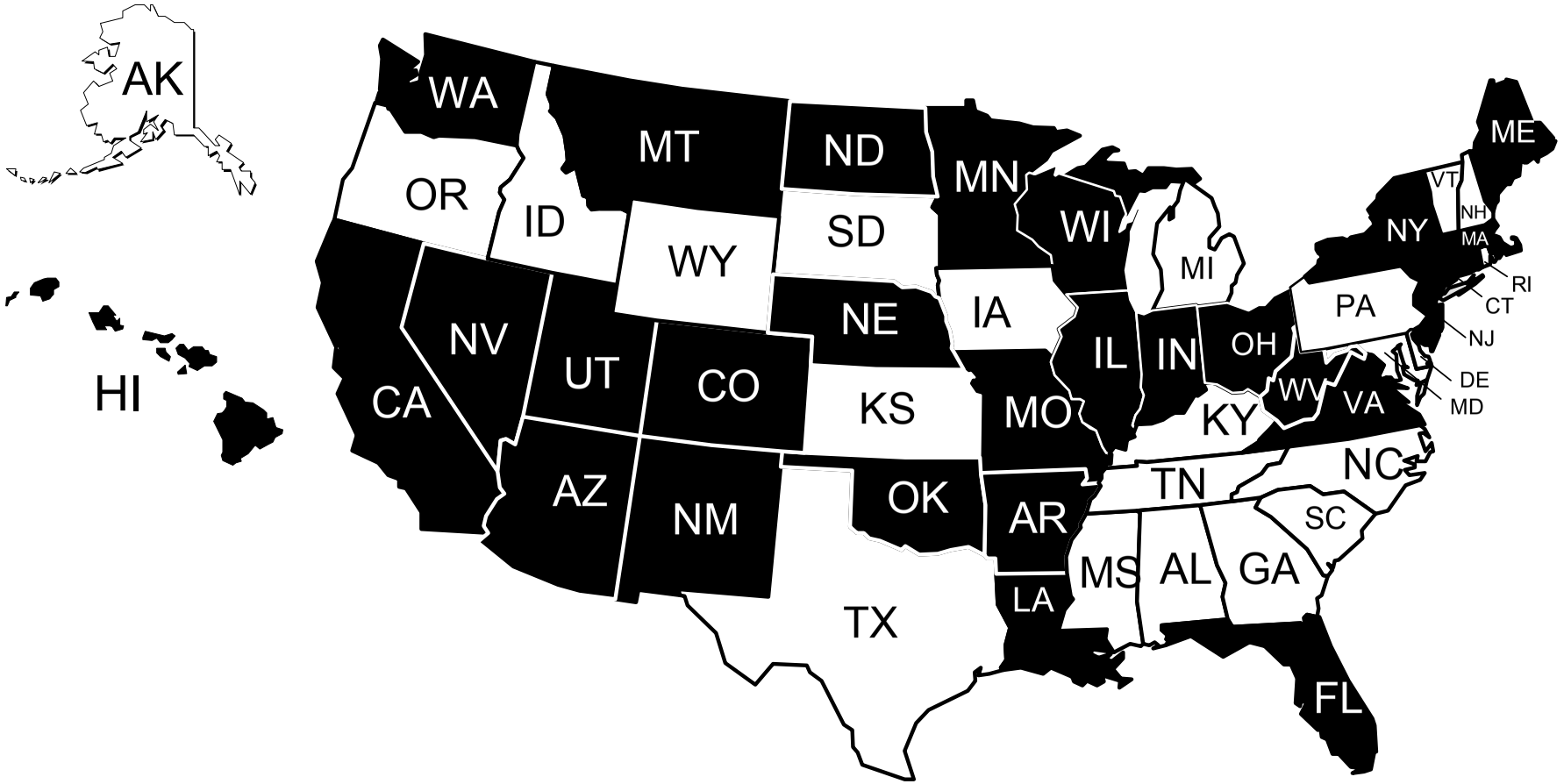


FIGURE 1: States (shown in black) introducing design-build legislation during 2001 or 2002

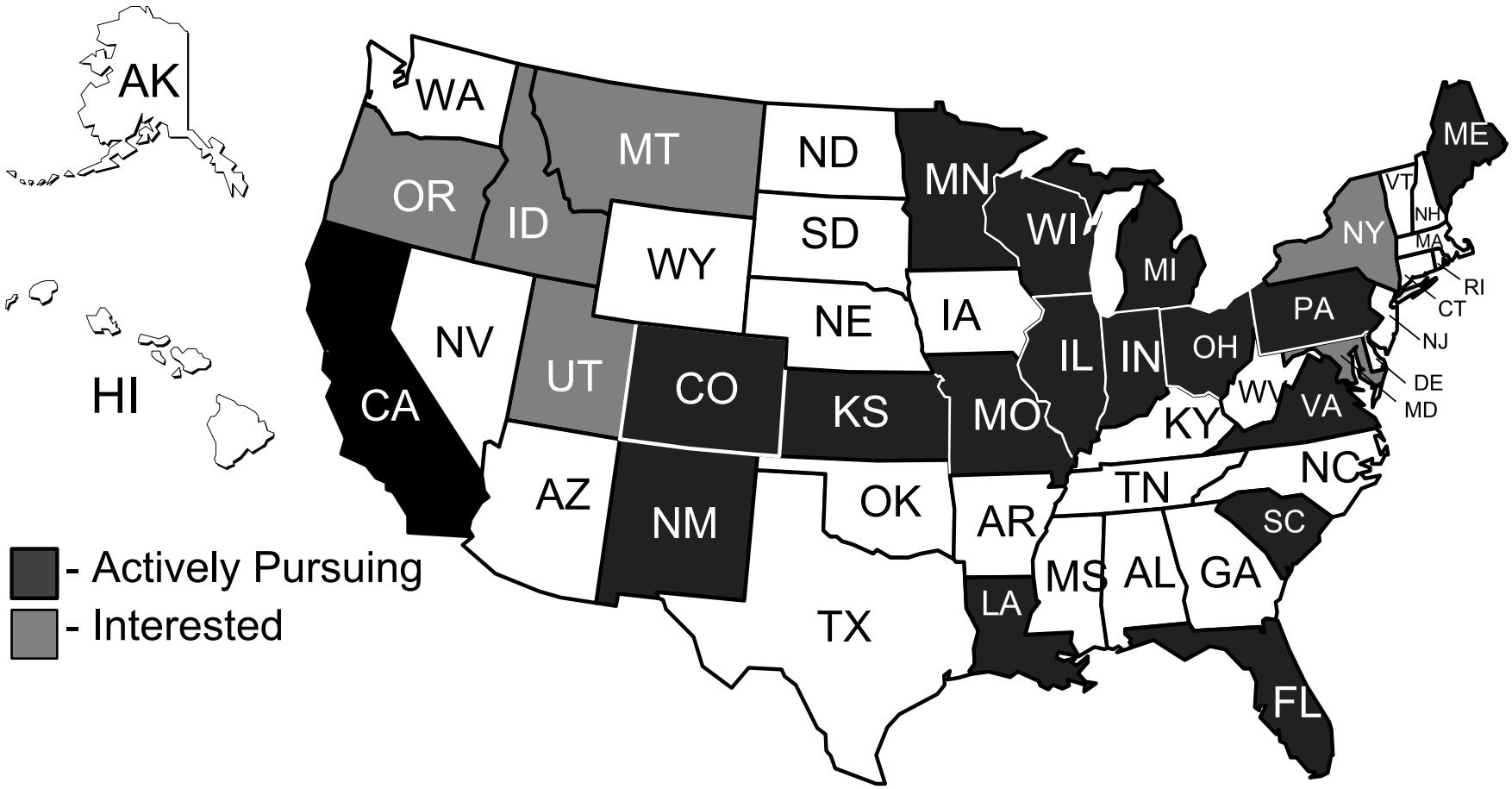


FIGURE 2: States interested in or actively pursuing warranty based contracting methods

TABLE 1: Summary of the Characteristics of Warranty Projects from Selected States

| State | Pilot projects built/underway? How many? | Warranty period | Design responsibility? | Components being warranted | Warranty provision criteria | Completed projects evaluated? How many? Results? | Comments and Notes |
|---|---|---|---|---|---|---|---|
| **California (Caltrans)** | Yes - several | 5 yrs | contractor - mix design | pavement rehabilitation | rutting, raveling, flushing, delamination, cracking, potholes | Yes - none evaluated yet | None |
| **Colorado (CDOT)** | Yes - 4 | 3 yrs & 10 yrs | - - - - - | Pavements | - - - - - | Yes - 3 - inconclusive | 1999 project included design-build for existing pavement rehabilitation |
| **Florida (FDOT)** | - - - - - | 5 yrs | - - - - - | - - - - - | - - - - - | - - - - - | DOT repairs damage from traffic & vandalism; GC has 12 hrs to respond. |
| **Illinois (Illinois DOT)** | No | - - - - - | - - - - - | - - - - - | - - - - - | None | Currently looking at passing legislation authorizing a pilot project based on Wisconsin's program |
| **Indiana (IDOT)** | - - - - - | 5 yrs to 7 yrs | IDOT | asphalt & Portland cement concrete pavements - materials & workmanship only | IRI (International Roughness Index), cracking, flushing, rutting, distortion, friction, disintegration | - - - - - | Complete performance specification is not being considered at this time. |
| **Kansas (KDOT)** | Yes - 1 | 5 yrs | - - - - - | - - - - - | high points, faulting, potholes, delamination, roughness, and cracking | - - - - - | Original 15 yr. warranty period reduced @ insistence of surety |
| **Louisiana (LA DOTD)** | No | 3 yrs | - - - - - | asphalt & Portland cement concrete pavements, traffic markings, protective coatings, structural concrete | currently determining current state of three year old distresses to use as a baseline | None | Warranty based specifications being developed at direction of Legislature |
| **Maine (MDOT)** | Yes - 2 | - - - - - | - - - - - | - - - - - | - - - - - | - - - - - | None |
| **Michigan (MDOT)** | Yes - over 300 | 5 yrs to 7 yrs | primarily MDOT | pavements | construction related failures only | Yes | Warranty is for labor and materials related to construction only |
| **Minnesota (MnDOT)** | - - - - - | 5 yrs | - - - - - | - - - - - | cracking, debonding, raveling, flushing, rutting | - - - - - | Warranty bond set at $1.5 MM |
| **Missouri (MoDOT)** | Yes - 1 | 15 yrs | - - - - - | entire project (23 miles long) | - - - - - | None | Project awarded to Koch Performance Roads, Inc. |
| **New Mexico (NMSHTD)** | Yes – N/A | 20 yrs | contractor | varies | pavement distresses, pavement serviceability rating, rutting, surface friction | - - - - - | Implementing warranties for all new projects; warranty bond amount is 25% of the contract amount |
| **Ohio (ODOT)** | Yes – N/A | 7 yrs minimum | - - - - - | varies | cracking, disintegration, flushing, previous patching, rutting | Yes | Legislature initiated requirement for warranty based projects |
| **Pennsylvania (PENNDOT)** | Yes - 3 | - - - - - | contractor | overlays, pavements | cracking, weathered pavement, flushed pavement areas. | Yes | Each of the 11 divisions are being encouraged to build at least one warranty based project. |
| **South Carolina (SCDOT)** | Yes - 3 | 3, 5, 10, & 15 yrs | contractor | bridge structure, pavement, bridge expansion joints | materials and workmanship, structural integrity | Yes | Warranty periods have varied by project components |
| **Virginia (VDOT)** | Yes - 1 | 10 yrs | contractor | pavement | - - - - - | None | None |
| **Wisconsin (WisDOT)** | Yes - 24 | 5 yrs | contractor, within limits | pavement | cracking, raveling, flushing, distortion, rutting, patching, disintegration | Yes - warranted projects perform significantly better | WisDOT specifies project location, completion schedule, pavement thickness, and type of base material |

transportation be willing and/or able to transfer the responsibility for design to the contractor, and make the contractor responsible for total performance of the warranted item(s) for a specified length of time.

The second trend to be noted is that while many states are experimenting with warranty specifications, some in a very active manner (notably Michigan, New Mexico, Ohio, and Wisconsin), none thus far have been willing to commit completely to this mode of operation. Most states are letting only a limited number of demonstration warranty projects each year as they develop more experience with this type of contracting. It is reasonable to expect that the lessons learned from the various pilot projects will result in many improvements in contracting procedures. It is also reasonable to expect that the results will not be exactly the same as those anticipated. To determine where the true improvements are, most states are closely evaluating, whenever possible, the overall cost effectiveness of their pilot warranty projects.

**California:**

The California Department of Transportation is currently working on several pilot projects to test warranty specifications for pavement rehabilitation projects. The warranty period for these projects is five years, and the contractor will be given the responsibility of the mix design. The state has developed criteria for the warranty provisions that include rutting, raveling, flushing, de-lamination, cracking (longitudinal, transverse, and alligator), and potholes. No completed warranty projects have been evaluated at this time.

**Colorado:**

The Colorado Department of Transportation (CDOT) began to study the use of warranty based specifications in 1997 when the Colorado Senate passed Bill 97-128 requiring CDOT to apply the experimental technique to a number of paving projects. During the 1998 construction season, CDOT developed three pilot projects meeting the requirements of this bill. A three-year warranty was included in these projects. For the 1999 construction season, only one warranty project was built. This project extended the warranty period to 10 years and included a design-build feature covering rehabilitation of the existing pavement structure.

In 2001, CDOT evaluated the results of the three pilot projects from the 1998 season. Since there were only three projects to evaluate, and the warranty period was so short, the findings were inconclusive.

**Florida:**

The Florida Department of Transportation (FDOT) will soon start using the new Specification 611-5 that requires the contractor to provide a written, five-year warranty starting at the time of final acceptance. FDOT accepts responsibility to repair damage from traffic and vandalism. For other deficiencies, the contractor will be given 12 hours to respond before FDOT may take action to hire a crew for the repair at the contractor's expense.

**Illinois:**

The state of Illinois is considering passage of legislation authorizing a warranty based pilot project modeled after Wisconsin's program. Significant progress by the Illinois Department of Transportation in developing warranty contracts should follow soon thereafter.

**Indiana:**

The Indiana Department of Transportation (IDOT) has applied warranty specifications to both hot mix asphalt and Portland cement concrete pavement projects. Warranty periods of five to seven years have been used. IDOT provides the project design, and the warranty covers only the material and workmanship portions of the project pavement. A true performance specification where the contractor provides the design as well as construction and facility maintenance for the warranty period is not under consideration at this time.

**Kansas:**

The Kansas Department of Transportation (KDOT) has performed only one design-build, warranty project thus far. The project called for either an asphalt or Portland cement concrete pavement that would meet specified performance criteria for high points, faulting, potholes, delamination, roughness, and cracking. However, an initial specification requirement for a 15-year warranty bond to be furnished by the contractor could not be met. Surety representatives contacted KDOT directly to explain that the surety industry could not reasonably furnish an extended warranty for a time period that long. Two major concerns were voiced by the surety representatives regarding such an extended warranty period: 1) there would be no contract funds still available to the surety should a breach occur during the warranty period, and 2) the contract provisions established more of a conditional contract characteristic of an insurance policy than a third party guarantee that is the basis of a bond. KDOT was eventually able to obtain only a 5-year warranty bond for the project. The position taken by KDOT, however, is that the pavement is unlikely to fail during that period, so the state of Kansas may very well realize no benefit from the warranty provided.

**Louisiana:**

The Louisiana Department of Transportation and Development (LA DOTD) has embraced warranty specifications as a result of a directive from the legislative branch of the Louisiana state government. Pursuant to Louisiana House Bill 1698 (1997), LA DOTD has developed a set of warranty based specifications that adhere to House Bill 1698 as well as all applicable federal regulations in place at the time.

So far, LA DOTD has proposed warranty specifications for asphalt and Portland cement concrete pavements, painted traffic striping, painting and protective coatings, plastic pavement markings, raised pavement markings, and structural concrete. The warranty period for these items is three years, during which time LA DOTD plans to undertake a comprehensive research study of the current state of distresses on three-year-old Louisiana highways. Ideally, this study will produce

a bell-shaped curve indicating a normal distribution of distresses that will then be used to establish required performance criteria.

**Maine:**

The Maine Department of Transportation (MDOT) has completed two projects to date. Unfortunately, no information is available at this time about these projects.

**Michigan:**

From 1996 through 2000, the Michigan Department of Transportation (MDOT) awarded over 300 pavement warranty contracts. While the majority of the contracts were for capital preventative maintenance projects, 35 of the contracts were for pavement rehabilitation projects and twelve of the contracts were for reconstruction projects. Currently, MDOT warranties cover only the pavement portion of the project with warranty lengths varying from five to seven years. There appears to be interest in expanding warranty coverage to other project components.

Michigan has employed two different types of warranties: 1) materials and workmanship warranties and 2) performance warranties. A materials and workmanship warranty holds the contractor responsible for correcting defects only under the direct control of the contractor; i.e., materials and workmanship. Because contractors do not have any input into the design process, they cannot be reasonably expected to warranty items outside of his or her control. Under a performance warranty, the contractor does have input in the design process and thus is held responsible for the overall performance of the pavement.

Currently, Michigan is considered a national leader in terms of materials and workmanship warranty specifications. During the 2000 fiscal year, approximately 20-30% of Michigan's trunk line pavement construction projects were let using extended material and workmanship warranty contracts. When a roadway fails, MDOT and the contractor perform a joint field inspection. If, after the joint field inspection, the two parties cannot agree on who is to repair the roadway failure, a conflict resolution team consisting of one representative each from MDOT and the contractor, and a mutually agreed upon third party, is formed. The three-person team then determines whether the failure is primarily one of design or construction. If the failure is design in nature, then MDOT is responsible for the required repair. If the contractor is found to be at fault, the contractor must submit a proposal outlining the resolution of the problem. Due to the nature of the projects, warranty contracts do not specifically address how failures are to be handled, but some guidelines are included in the specifications to give direction to both MDOT and the contractor.

To date, only one of the warranty contracts awarded has been a performance warranty project. Completed in 1997, this contract was for a design-build project that included a five-year warranty provision. As of this time, final evaluation results of this pilot project are not available.

**Minnesota:**

The Minnesota Department of Transportation (MnDOT) has proceeded as far as releasing a memorandum on design-build warranties. MnDOT has established a warranty period of five years beyond final acceptance of the project. The warranty will be guaranteed with a warranty bond in the amount of $1,500,000. The warranty bond will be released at the end of the warranty period or after all warranty work is completed.

**Missouri:**

The Missouri Department of Transportation (MoDOT) is in the process of developing its first warranty specification project. Similar to New Mexico's Corridor 44 Project that used a sole source outside party, MoDOT has selected Koch Performance Roads, Inc. as the contractor and warranty provider. The pilot project is 23 miles long and will have a 15-year warranty period. The MoDOT is having difficulty writing the warranty specification, particularly with regard to the required technical specifications.

**New Mexico:**

The New Mexico State Highway and Transportation Department (NMSHTD) has embraced the concept of warranty specifications. All new projects are expected to have some type of warranty provision for all or part of the project. No standardized method has been developed for all projects, so each warranty contract is handled on a case-by-case basis. Warranty periods are required to be for the design life of the pavement, commonly 20 years, and warranty bonds of 25% of the contract amount are also required. Performance criteria for pavement distresses such as roughness, rutting, and surface friction are included. Threshold levels for these criteria are specified for each distress, and they become less restrictive as the pavement ages. Warranties are also required for bridges and erosion control structures.

An ambitious warranty project awarded to Koch Performance Roads, Inc. by the NMSHTD is the Corridor 44 Project in northwestern New Mexico. This project was 118 miles long, consisted of widening a 2-lane road to 4 lanes, and cost approximately $220 million. In addition to the $220 million construction cost, the NMSHTD purchased a 20-year warranty on the project for $62 million. The state has concluded, when all factors are considered, that the warranty will save an estimated $89 million over the twenty-year period.

A strong believer in long-term warranties, the NMSHTD nevertheless recognizes that there are potential pitfalls. Each project should be carefully evaluated as to the feasibility of using a warranty. In addition, to realize the maximum benefit, projects should be design-build and the contractor should be given the flexibility to try new and innovative methods.

**Ohio:**

The Ohio Department of Transportation (ODOT), like several other state departments of transportation, has adopted warranty based contracting procedures due to requirements laid down by their state legislature. In July 1999, the Ohio Legislature passed House Bill 163 requiring

ODOT to implement warranty specifications. This bill included a provision that at least one-tenth of ODOT's capital construction program must be bid with a pavement warranty specification for a period of two to seven years, depending on the type of paving activity (ranging from preventive maintenance to new construction).

ODOT has completed their first round of construction using warranty contracts and has issued an interim evaluation report on the warranty procedures. As one might expect, bid prices increased as the higher initial costs of warranty specifications were passed on to ODOT. Bid price increases ranged from 3% to 15% with two notable exceptions: bridge painting increased 26% and pavement markings increased 171% over non-warranted bid items. It can be surmised that these notably larger increases make sense when one considers the nature of the work. Bridge painting is a particularly time-consuming and expensive work item, so extra measures would be taken to ensure compliance with a warranty specification, thereby avoiding the possibility of follow-up warranty work. The 171% increase in pavement marking costs appears to be due to the short lifespan in northern climates and the certainty that they will be redone several times during the warranty period.

During the first construction season, ODOT personnel have reported that contractors are more conscientious about performing their work correctly, and are more willing to go the "extra mile" to ensure that subsurface conditions met the requirements to sustain the pavement course. ODOT personnel also concluded that there is not a reduced need for inspections as once thought, since complete and proper documentation of conditions and methods used is necessary should a roadway failure occur during the warranty period.

ODOT is proactively assessing the cost effectiveness of using warranties on highway construction projects. In the case of pavement markings, for example, ODOT has decided not to proceed with a warranty approach. As mentioned above, the costs associated with warranty marking projects were significantly higher than those for non-warranty projects. The observation was made that traditional (non-warranty) projects were offering adequate performance, without the added cost of a warranty.

**Pennsylvania:**

The Pennsylvania Department of Transportation (PENNDOT) has been working with warranty specifications since 1996. Starting with information and examples supplied by the Wisconsin and Indiana Departments of Transportation, PENNDOT has developed its own warranty specification for hot mix asphalt and concrete pavements. Performance criteria based on cracking, weathered pavement, and flushed pavement areas have been established. Thus far, three projects, two pavement overlays and one new construction, have been completed with long-term warranty contracts. As a next step, PENNDOT is attempting to identify at least one project in each of its eleven divisions to utilize a long-term warranty contract. The potential benefits to the motoring public have been recognized, and PENNDOT management believes that most contractors are willing to accept the warranty contract procedures, especially if the contract is in a design-build-warranty format.

**South Carolina:**

The South Carolina Department of Transportation (SCDOT) has not applied warranty specifications across the board, but has performed at least three design-build projects that included warranties. The three design-build projects were: 1) Carolina Bay Parkway, 2) SC 170, and 3) Cooper River Bridge Replacement. The contractor that performed the work for the Carolina Bay Parkway guaranteed their materials and workmanship for three years after final completion. Upon written request from SCDOT, the contractor is obligated to repair any defects or damages not caused by SCDOT at no expense to SCDOT. The warranty of the repaired or replaced component should be the longer of one year from date of completed repair or replacement, or the remainder of the warranty period.

The SC 170 project used a five-year warranty that started on the date of substantial completion. The contractor is required to repair any defective work during the five-year period at no expense to the SCDOT. In addition, the contractor will repair any defective work in the bridge structure, exclusive of bridge joints, bridge bearings, or bridge drainage system, identified within a 10-year period after substantial completion, again at no expense to the SCDOT.

The final project, Cooper River Bridge Replacement, required the contractor to provide three warranties. The first covered the bridge structure, exclusive of expansion joints, for a 10-year period, the second covered the roadway for a five-year period, and the final warranty covered the expansion joints for a 15-year period. The contractor will repair or replace any defective work during the three warranty periods at no cost to the SCDOT.

**Virginia:**

The Virginia Department of Transportation (VDOT) is exploring the use of performance-based specifications to make their projects more results oriented. VDOT currently has its first warranty project, a $175 million design-build highway with a 10-year pavement warranty, underway, and is in the process of investigating the feasibility of using more warranties on future projects.

**Wisconsin:**

The Wisconsin Department of Transportation (WisDOT) has applied warranty specifications to several asphalt concrete pavement projects since 1995. Through the 2000 construction season, a total of 24 asphalt concrete pavement projects have been constructed with each having a warranty period of five years. The warranty required the contractor to perform remedial work if a predetermined distress threshold was exceeded. The threshold levels, established by WisDOT, are considered typical for five-year old asphalt concrete pavements.

WisDOT has found that warranted projects perform better than traditional projects, as evidenced by measured values of two distress parameters, the International Roughness Index (IRI) and the Pavement Distress Index (PDI). When used to evaluate pavement performance, IRI values for warranted projects have averaged 59.5 in/mi as compared to 91.8 in/mi typically measured for five-year old pavements. Similarly, PDI values at five years have averaged 9 for warranted

projects as opposed to 26 for traditionally constructed asphalt concrete pavements. The PDI values indicate that the warranted projects have performed significantly better than the non-warranted projects. Note that PDI and IRI are not used directly as performance parameters in Wisconsin's contracts. Instead, WisDOT contracts use threshold values for individual types of pavement distress.

When comparing costs of warranted and non-warranted projects, WisDOT has found that warranted projects cost less per ton of pavement materials than traditional projects. This conclusion was reached considering all sources of costs including design, maintenance, construction, and project delivery costs. The lower costs appear to be the result of more efficient contractor operations, as well as reduced project delivery costs resulting from less supervision and testing required of WisDOT. Lower costs may also have been partially due to the selection of the first 9 pilot projects based upon their high potential for success. The remaining 15 projects, however, were chosen using a less restrictive set of criteria, and costs have still been less when all sources are considered.

WisDOT has developed a warranty specification that allows contractors to select their own materials, mix design, quality management program, and construction techniques. This approach has allowed contractors more flexibility to find the most efficient and cost effective methods to build a roadway. If a problem arises, the contractor has the ability to evaluate the alternatives and change the process, if needed. As a result, the contactor can make adjustments that save money, increase productivity, and produce higher quality. However, there are still several constraints upon the contactor. WisDOT specifies the location of the project, schedule for completion, pavement thickness, and type of base to be used. The pavement thickness and type of base are specified so that each project can be bid using baseline design information. Using this type of system, projects can still be awarded using lowest bid criteria.

The bid analysis performed by WisDOT involves a thorough review prior to an award of a contract. A few warranty projects have not been awarded due to the fact that the low bid was substantially higher than the engineer's estimate. For all warranty projects, an inspection of the bid prices have shown consistent differences between the engineer's estimate and the contractor's warranty line item. This difference should decrease as the contractor and WisDOT become more experienced with the pavement warranties.

WisDOT feels that many benefits have been realized from the warranty contracts. They have seen more concern from the contractor for quality workmanship. In some cases, the contractor has exhibited excellent initiative by using a variety of techniques to determine where additional material is needed before the placement of the binder and surface courses. However, WisDOT does require that the contractor notify them should they want to try a new technology or new method. This notification is required so that WisDOT can evaluate the new procedure and determine its potential effectiveness.
Based on their five years of experience, WisDOT has several recommendations concerning future warranty contracts. One of their recommendations is to investigate bidding all projects on a traditional basis with the option of adding a warranty. WisDOT would then award the bid based on the cost for traditional basis, then decide whether or not to add the warranty provision to the contract. They would also like to broaden the use of warranty contracts. For example,

projects with an inadequate subgrade condition might require correction of the deficiency before proceeding with the warranted pavement portion. The state is also looking into either tightening up pavement performance criteria for the same five-year period, or increasing the length of the warranty period.

## 4. RECOMMENDATIONS FOR DEMONSTRATION PROJECTS IN MONTANA

### 4.1 General Remarks

Montana's demonstration warranty projects for roadway construction should include the following basic features:

| | | |
|---|---|---|
| Type of project: | Re-construction, 20 year design life | |
| Item(s) covered by the warranty: | Main roadway | |
| Length of warranty: | Six years or 150 percent of the predicted ESALs | |
| Bid process: | Submit proposal, award based on best value | |
| Measures of warranty performance: | Ride | - IRI |
| | Safety | - Skid resistance |
| | Safety/Ride | - Rut depth |
| | Durability | - Cracking |
| Bonding: | Traditional construction bond, 6 year warranty | |

The division of responsibilities between MDT and the contractor suggested for demonstration warranty projects in Montana is summarized in Table 2. From a philosophical perspective, it is suggested that only minimum constraints be placed on the design solutions and construction processes (e.g., mandate a specific type(s) of running surface, but not its thickness or properties). As previously mentioned, this approach should allow for the most innovation and best possible value to the public in the finished product. In early projects, the warranty should only apply to the primary roadway. That is, shoulders, roadside approaches, bridge approaches, intersections, culverts, side slopes, geometry, etc., should be handled following traditional methods for their design and construction. Although these are all very important elements of the roadway, their performance requirements, pre-construction condition, and level of use can be extremely variable. As more experience is gained with warranties, their use can be expanded to include these elements of the system.

The above recommendations, as well as the further suggestions made below, were arrived at with due consideration of:

1) the issues that must be addressed in implementing warranty contracts in roadway construction projects, as introduced earlier in this report,

2) the information subsequently presented about how other states have addressed these issues, and

| Item | Department of Transportation | Contractor |
|---|---|---|
| Over-all | Prudently use public dollars to provide transportation service at the lowest life-cycle cost without compromising comfort or safety | At a competitive cost, design, build, and warranty a roadway that meets the DOT requirements for performance |
| Project Award | Prepare Bid Documents<br>Qualify bidders | Prepare Bid Response<br>Obtain Construction and Warranty Bonding |
| Design | Determine geometry<br>Determine design traffic loading<br>Determine climatic conditions<br>Handle any right-of-way issues<br>Determine any special requirements on design/construction | Design roadway to meet demands/conditions provided by DOT |
| Construction | Stake centerline<br>Approve contractors traffic control plan<br>Reserve right to observe (but not inspect) construction | Construct roadway<br>Prepare traffic control plan<br>Perform all quality control |
| Warranty period | Monitor traffic loads<br>Perform warranty compliance testing<br>Identify need for remedial action by contractor<br>Identify unsafe situations that require emergency repair | Perform routine maintenance, if programmed into design<br>Reserve right to check warranty testing done by state (if desired)<br>Perform remedial work, if necessary (including restoration of pavement marking, if necessary) |
| Remedial work | Determine any special requirements on remedial work<br>Approve contractor's traffic control plan<br>Reserve right to observe (but not inspect) remedial work<br>Insure safety related work done in timely fashion | Plan and perform remedial work<br>Prepare traffic control plan |

TABLE 2: Responsibilities of MDT and the Contractor Relative to Warranties on Roadway Construction Projects

3) the previous referenced results of a survey of Montana highway contractors regarding the warranty concept that was conducted in 1997 (Stephens, Johnson, Wangsmo, and Schillings, 1998).

With respect to warranty practice in other states, the above suggestions would place Montana philosophically in the middle between states that have maintained considerable control on both design and construction in implementing warranty contracts (e.g., Michigan) and states that have allowed full freedom in both regards on their projects (e.g., New Mexico). With respect to the opinions of contractors in the state regarding warranty contracts for roadway construction projects, the above suggestions are generally consistent with their ideas and thoughts on the subject.

Obviously, the Montana construction industry will be affected by changes in contracting processes for roadways. Before further discussing the above recommendations for warranty projects in Montana, it seems appropriate to briefly summarize the results of the survey mentioned above on this idea that was conducted of the Montana contracting community. Based on the responses received from 21 firms in the state that engage in roadway construction, the industry generally believes that:

1) potential benefits of using in-service warranties are uncertain,

2) contract costs are likely to increase as the responsibility of failed projects shifts from the state to the contractors,

3) the increased cost might not be accompanied by any significant change in the quality of the constructed roadways,

4) small and medium sized firms may have trouble surviving in a warranty market, notably due to bonding problems,

5) the best type of project for warranties is total reconstruction, with the warranty covering cracking, rutting, and ride, and

6) 100 percent payment should be made at the time of construction with some form of bond during the warranty period.

### 4.2 Length of the Warranty Period

The suggested warranty period for demonstration projects is 6 years beyond substantial completion. Note that while the in-service warranty is for 6 years, the roadway itself should be designed for 20 years of service. Early warranty efforts in other states used three-year warranties. Five- to 10-year warranties, however, are becoming increasingly common. A six-year warranty is consistent with this trend, as well as being consistent with the emerging pavement maintenance strategy in Montana. Following this strategy, new pavements generally are expected to require some form of surface treatment at approximately 6 years of age if they are to provide a 20-year life (Dusek, 2002). The warranty period should be expressed in terms of age

and the amount of traffic carried by the facility. The warranty should be voided if the pavement experiences 150 percent of the ESALs predicted for the warranty period.

### 4.3 Performance Criteria for Evaluating Warranty Compliance

Warranty compliance will be evaluated using parameters related to ride quality, safety, and longevity of the roadway. Ride quality will be evaluated using the IRI and rutting. Safety will be evaluated using skid resistance and rutting. Longevity will be inferred from the severity and extent of cracking. Note that fewer warranty performance parameters are being suggested for contract inclusion relative to the number of parameters used by many states. Ride quality, as measured by the IRI, is expected to reasonably reflect the effects of several of their distress parameters.

Rather than having a graduated scale of acceptable performance across the warranty period, it is recommended that a minimum threshold of performance be mandated throughout the warranty period. The performance thresholds should be based on historically accepted levels of performance that can be achieved by standard design and construction practice. Note that other states have set their threshold values such that 90 to 95 percent of past roadway projects would have been judged to have delivered satisfactory performance based on the threshold values. At least initially, use of such liberal thresholds should build confidence in the contractor's ability to provide a roadway capable of meeting the warranty requirements. As familiarity with these contracts grows, consideration should be given to adjusting these thresholds to "up" the performance bar.

MDT already has the necessary equipment to monitor performance during the warranty period using the parameters suggested above.

**IRI Requirements:**

The maximum acceptable IRI value during the warranty period should be 133 in/mi; an IRI of 133 in/mi is considered fair performance in Montana. Note that Indiana used a threshold value for the IRI of 133 in some of their warranty contracts (IDOT, undated). As the name implies, the IRI provides a measurement of roughness of the road as it is traversed by a moving vehicle. The IRI has become the standard scale on which road roughness information is reported both globally and in the United States. The measurement reflects the profile of the road in the direction of travel based on a computer model of what is referred to as *The Golden Car's* response to the measured profile. The IRI can be calculated from the readings of any valid profiler, including the South Dakota Profilometer. The value of the IRI is typically reported in terms of inches per mile (in/mi) in the United States, and in millimeters per kilometer (m/km) internationally. IRI values for various roadways and surface conditions are shown in Figure 3. MDT uses the qualitative scale shown in Figure 4 to correlate quantitative IRI values with descriptive indicators of roadway condition. Values on this scale range from an IRI of 0 in/mi for a flawless ride, to 400 in/mi for a very poor ride (roughly equivalent to a typical gravel road).

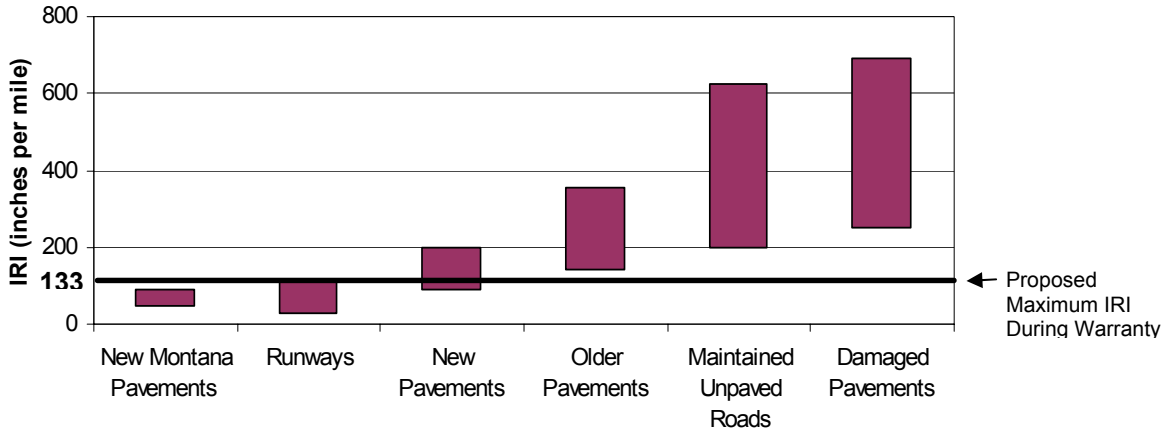


FIGURE 3: Typical IRI values (based on information from Sayers and Karamihas, 1997 and Kovich, 1999).

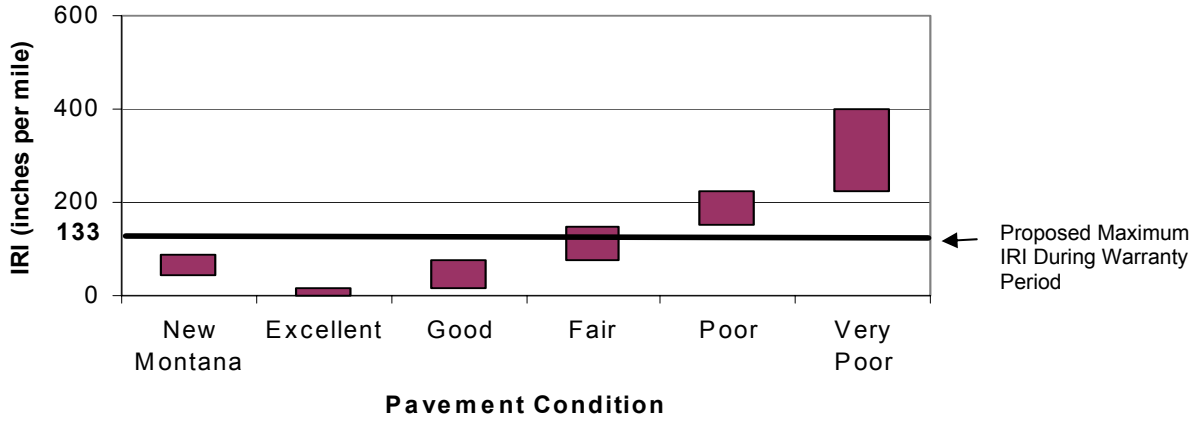


FIGURE 4: Correlation, IRI and pavement condition (based on information from Kovich, 1999).

With respect to establishing an IRI of 133 in/mi as the threshold IRI during the warranty period, recall that the performance requirements during this period need to be set so that the motoring public is satisfied with the roadway's performance. The IRI requirement of 133 in/mi corresponds to a "new" pavement in "fair" condition (see Figures 3 and 4, respectively), which should be an acceptable expectation for a roadway over its first six years of use. Historic pavement performance data can be used to determine whether or not this level of performance can be achieved (and thus the level of risk assumed by the contractor in guaranteeing this level of performance). For example, Figure 5 shows IRI values for National Highway system (NHS) routes in Montana as determined in 2001. Referring to Figure 5, an estimated 92 percent of all NHS lane miles in the state had an IRI below the suggested threshold value of 133. Note that the

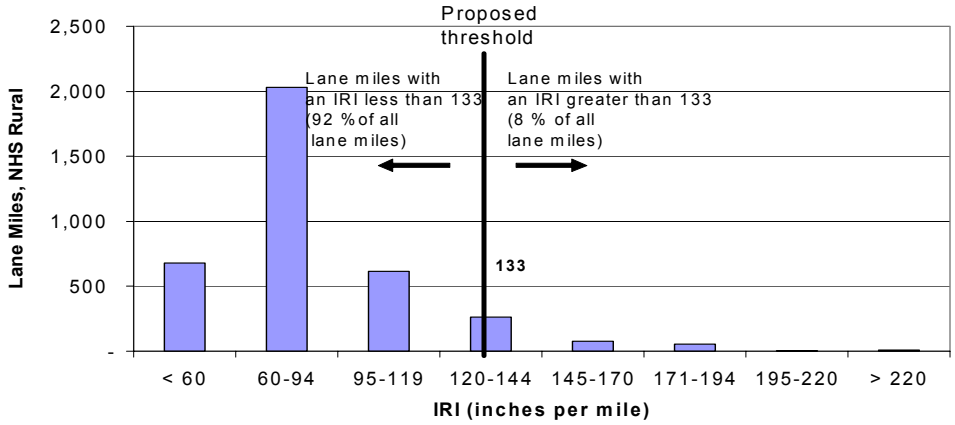


FIGURE 5: Lane miles of rural National Highway System roadway as a function of IRI (based on information from FHWA, 2001).

information presented in Figure 5 includes roadways of all ages. To more exactly estimate the risk associated with guaranteeing a minimum IRI of 133 in/mi during a six-year warranty period, a frequency plot similar to that shown in Figure 5 could be generated solely using historical information on IRI values for pavement projects at 6 years of age. The fraction of pavement projects with IRI values below the threshold of 133 in/mi at 6 years of age would directly reflect the probability of a project satisfying this IRI requirement during the proposed warranty period (presuming it is designed and built using standard practices). As previously mentioned, some states have established their performance thresholds during the warranty period so that 90 to 95 percent of all projects historically would have met them.

The IRI requirement of 133 in/mi should be applied to the main roadway, excluding bridges and their approaches. An IRI value will be obtained for each tenth of a mile of warranted roadway. If any of these values are greater than 133 in/mi, then remedial action will be required of the contractor.

**Permissible Rut Depth:**

The maximum permissible rut depth during the warranty period should be 3/8 inch. Excessive rutting can contribute to both ride and safety problems, as it can interfere with vehicle control on both wet and dry pavements. The degree of rutting on a warranted pavement will be measured by the South Dakota Profilometer. Using a profilometer, rut depth is determined by lasers positioned over the centerline and each wheel path of a lane. The accuracy of the reading from the profilometer can be increased by using an additional laser above the shoulder and an extra laser above the centerline of the highway. It is suggested that these added measurements be used in evaluating rut depths on warranted pavements.

The rut depth averaged over each one tenth mile segment of roadway should not exceed 3/8-inch during the warranty period. This value is less than the value that currently triggers corrective action under MDT's pavement management system. Presently, a 1/2-inch rut corresponds to an index number of 40 according to the MDT pavement management system, which is the threshold

value for corrective action. By using a value that is less than the 1/2-inch, additional in-place densification following the warranty period could occur before reaching the critical value. Moreover, a pavement that is prone to rutting will generally exhibit this behavior early in its life, presumably during the warranty period.

As suggested above for the IRI, an analysis could be done of historical rut depths for 6-year old pavements to determine the percentage of projects that would have met this performance criteria (and thus obtain an estimate of the risk assumed by the contractor in guaranteeing this level of performance for a pavement designed by traditional methods). In the absence of such an analysis, it is useful to note that other states have used rutting as a performance parameter with different allowable depths and means of determining rut depths. Wisconsin allowed the least amount of rutting, accepting only up to a 1/4-inch rut depth (Schober, Whited, and McMullen, 1995). Indiana and California followed, with maximum rut depths before remedial action would be required of 3/8-inch (IDOT, undated) and 1/2-inch (Harvey, Vallerga, and Monismith, 1995), respectively. These states used a California profilograph (Wisconsin), vehicle-mounted lasers (Indiana), and a 12-foot straight edge (California) to determine rut depths.

**Skid Resistance:**

A minimum skid number (SN) will be required throughout the duration of the warranty period to insure the pavement has sufficient surface friction for safe vehicle operation. The minimum acceptable skid resistance for a highway is related to the type of roadway and the speed of the vehicles that operate on it. An SN of 37 is the minimum value recommended, for example, for a 40 mph test on a road with an operating speed of 70 mph (Kummer and Meyer, 1967). It may be difficult to review the historical skid performance of Montana's highways, as MDT has only had skid testing capabilities for a few years. Indiana has used an SN requirement of 35 or greater in their warranty contracts, while no single reading can be less than 25 (IDOT, undated). In the first ten years, New Mexico requires an SN of 35 or greater with no single reading less than 30 (NMSHTD, 1977).

Skid testing shall be conducted by pulling a specially designed trailer over the roadway surface to be tested by methods consistent with ASTM E-274 or AASHTO T-242. By these methods, when the specified speed is reached, the trailer's brakes are locked. Using data measured by the trailer, the coefficient of friction between the road surface and the tires of the trailer can be determined.

**Cracking:**

Realizing that cracking affects the useful life of a roadway, it was concluded that any cracks which develop during the warranty period must be sealed. This approach was also used by the states of California, Indiana, and Wisconsin. This requirement should provide an incentive to the builder to provide a quality product, as this is one area in which workmanship (seams) and material selection (asphalt cement) play a key role in the overall product. If cracks develop in the warranty area, they are to be sealed following the standard practices set forth by the MDT. All of the crack sealing within the warranted areas will be the responsibility of the contractor during the warranty period.

### 4.4 Bid Procedure

As mentioned earlier, warranty projects can be awarded based simply on the lowest bid or through a proposal evaluation process. It is difficult to make a definitive recommendation on this issue, in light of the qualitative nature of the advantages and disadvantages offered by each approach. Contract award based on the lowest bid (independent of the facility to be built) is attractive due to its familiarity and established position as an accepted procedure to procure construction services. This approach is certainly consistent with current Montana statutes, which state, in part, that the Highway Commission will award contracts "by competitive bidding to the lowest responsible and responsive bidder (Montana Code Annotated (MCA) 60-2-112, 2001)". At this point in the evolution of warranty roadway contracts, however, this approach can only be comfortably followed if constraints are placed upon the facility to be built. If this approach is used, type of surfacing material, minimum base and pavement thickness, and some requirement on the surfacing mixture (i.e., minimum asphalt content for an bituminous pavement) should be set by MDT in the contract specifications. As previously mentioned, this approach restricts innovation by the contractor and places some of the responsibility for the performance of the facility back on MDT (commensurate with the level of constraints placed on the design).

The second approach to contract award is to use a proposal evaluation process. Using this approach, project award is based on the qualifications of the bidder and on the expected quality of the product proposed by the contractor, as well as on the price. Rather than making the contractor adopt a specific design approach, MDT is tasked with reviewing contractor generated designs and assessing their quality and cost in the proposal evaluation process. State statutes will have to be reviewed to determine if such a procedure for contract award is permissible under existing Montana law. Notably, Section 60-2-112 of the MCA appears to allow some latitude in the basis for awarding contracts, namely, "The commission may let a contract by means other than competitive bidding if it determines that special circumstances so require. The commission shall specify the special circumstances in writing." If use of a proposal evaluation process is deemed to be outside the scope of existing statutes, the project could be awarded simply based on the lowest responsible bid, or efforts could be made to enact a statute to allow demonstration warranty projects to be awarded based on a proposal evaluation process.

Following the proposal evaluation process, the following criteria and the associated percentages of importance should be used:

| | |
|---|---|
| Bid Price | 30 |
| Proposed 20-Year Facility Design | 20 |
| Qualifications of Design and Construction Team | 20 |
| Warranty Service Plan | 20 |
| Project Schedule | 5 |
| Maintenance of Traffic | 5 |
| | 100 |

To avoid the problems associated with requiring contractors to guarantee their Bid Price for a potentially lengthy review period, consideration should be given to utilizing a two step bidding

procedure. The first step would be for the contractor to submit proposed information about all of the criteria listed above, except the Bid Price, for review. Following completion of the review process, and assignment of percentage points, contractors would be given a reasonable, but short, period of time to produce a Bid Price for the project. Further details regarding assignment of percentage points, or even the amount of points allotted to each criterion, will need to be determined during implementation stages. In any event, this evaluation scheme would allow incorporation of the traditional requirements on a project (timeliness of completion, lowest cost, good quality, etc.) without explicitly or rigidly stating in the request for bids how they will be met. Through this mechanism, the public should realize the best over-all value in the contract.

Following either approach, contractors bidding on the project will have to demonstrate that they can obtain the bonding required for the project. Consistent with current practice, the ability to obtain the required bonding will serve to pre-qualify bidders for the project. If the engineering work required to develop a design is estimated to exceed a certain amount, say $15,000, consideration should be given to compensating qualified bidders for some of the work involved in preparing their bid.

### 4.5 Warranty Compliance and Emergency Remedial Action

**Time Frames:**

Warranty compliance testing should be conducted at annual intervals throughout the warranty period. The first tests should be conducted at the completion of construction. This event will signify the start of the warranty period and establish baseline values for warranty criteria. The contractor is responsible for all subsequent remedial actions necessary to keep the pavement in warranty compliance for the warranty period. Annual inspections should be conducted by MDT between May 15 and June 15 of each year so that the testing is done after the frost season, but still in time for the contractor to schedule any necessary remedial work before the return of cold weather in the fall. The annual testing will be done at no cost to the contractor. In an effort to minimize discrepancies associated with testing procedures, all of the tests should be conducted using MDT personnel and equipment. The contractor, however, will be permitted to observe the testing process and to conduct compliance tests in the event any disputes arise concerning the results.

**Testing Locations and Results:**

The IRI and rut depths should be determined for every tenth of a mile of roadway by averaging the continuous readings available from the South Dakota Profilometer. Results from each segment will be compared to the threshold values for their respective parameters in order to determine whether or not remedial action is required. Skid resistance measurements should be taken over a 200-foot segment out of every 2,000 feet of roadway. The segments to be examined should be randomly selected within the 2,000 foot segments. The state should reserve the right to test any localized segment of roadway that appears to be out of compliance with any of the warranty performance parameters.

Test results should be provided to the contractor within 14 calendar days of testing. If the

contractor disputes the data gathered during the inspection, they should provide written notification to MDT within 14 days of receiving the test results. In this notification, the contractor must state the reason why the data is believed to be incorrect. Issues such as these will be handled, as necessary, by the Conflict Resolution Team (CRT), which will be discussed in more detail later in this paper.

**Remedial Action and Emergency Situations:**

The contractor will perform remedial action when the roadway does not meet the warranty parameters set forth in the contract. The contractor should have full freedom to exercise any method of remediation that he/she believes will bring the roadway back into compliance with the warranty, providing such action does not unreasonably compromise the safety or convenience of the motoring public. MDT will evaluate the contractor's proposed remedial actions in this regard. Any disputes about the proposed remediation will be brought to the CRT. Unless a safety problem exists, the roadway should be repaired in the same construction season in which the problem was identified. At their option, MDT can retest the roadway after the remedial work is done to insure the roadway has been restored to the condition required by the warranty.

If the roadway is found to be unsafe in any way at any time, MDT must have the authority to proceed with immediate repairs. If the unsafe condition is related to a warranted attribute of the roadway's performance, the contractor should be given the opportunity to promptly make the required repairs. If this cannot be done, MDT will make other arrangements to fix the unsafe condition and charge the contractor for the cost. Any disputes related to emergency repairs will be resolved by the CRT after the repairs are done.

### 4.6 Conflict Resolution Team

Any differences of opinion between the contractor and MDT related to the warranty provisions of the roadway contract should be referred to the CRT. This group should be especially helpful in handling problems that may arise regarding: a) the inspection results, b) the determination of whether or not the contractor is responsible for any observed non-compliance with the terms of the warranty, and c) the determination if an emergency, safety related situation was properly handled. During the construction phase of the project, the CRT should also be responsible for handling disputes related to issues such as traffic control. The participation of this group may be particularly important in the early contracts used in Montana that follow the warranty approach, as situations may arise that had not been anticipated in the preparation of the contract documents.

The CRT should consist of two members from the design-build team, two MDT representatives, and one independent third party. The independent third party should be jointly agreed upon and compensated by MDT and the design-build team. The ultimate success of the project may be associated with decisions that the CRT makes. Therefore, it is important that knowledgeable people are chosen to represent the interests of the parties involved.

### 4.7 Payment and Bonding

A traditional payment schedule should be used for warranty contracts. That is, payment during construction should be tied to work performed, as measured by quantities placed or percent

complete. Projects should also utilize a standard construction performance bond to assure that construction will be completed and to provide the traditional 1-year warranty on materials and workmanship after completion of the project. A warranty bond should be used for the remaining five years of the warranty. The amount of the bond should be equal to the estimated cost of the remedial work if roadway performance falls below any warranty condition, or 10 percent of the cost of the project, whichever is greater.

## 5. SUMMARY AND RECOMMENDATIONS FOR FURTHER WORK

### 5.1 General Remarks

Performance based warranties are commonplace for consumer products. Generally, such warranties provide the consumer with assurance that a product will perform its intended function for a reasonable period of time. If the product is unable to perform its intended function during the warranty period (and presuming it has not been abused), the manufacturer agrees to repair or replace the product at no additional charge to the user. While highways may not be a typical consumer product, highway users certainly have expectations with regard to highway performance. At the very least, these expectations include that a highway will provide a safe and comfortable ride in a cost effective manner. Traditionally, designers and manufacturers of highways (engineers and contractors, respectively) have not been asked for, nor have they offered, guarantees that the roadways they provide will satisfy these expectations when they are placed in-service. The rational for this approach has been that each highway project is unique, and the uncertainties associated with each project are sufficient that the risk of failure of the facility should be assumed by the public owner, rather than placing it on individual engineers and contractors. The relative cost-effectiveness of this approach of procuring highway service compared to other approaches has not been closely examined under contemporary conditions. Thus, since performance warranties work well in many situations, it is time to consider their use on roadway construction projects.

The potential benefit offered by performance warranties on roadway construction projects is that better highways can be constructed at lower costs than currently are being incurred. This benefit may be realized because transportation agencies and contractors will be focusing their attention on the in-service performance of the roadway, rather than on intermediate steps in the construction process (as is done now). The cost-effectiveness of using performance warranties on roadway construction projects, however, is uncertain. Transportation agencies have only been experimenting with these contracts for the past 10 years; thus, data are available for relatively few projects and only across a short span of time (relative to the 20 design life of a roadway). While many issues related to implementing a warranty approach to roadway construction projects have been addressed by these projects, not all of them have been definitively resolved, nor has

the cost-effectiveness of the approach been definitively established. Thus, if the concept is pursued in Montana, it should first be in the form of selected demonstration projects.

Based on the fundamental issues associated with using a warranty approach to roadway projects,

and the manner in which other states have implemented the approach, the following recommendations are made for demonstration warranty projects in Montana:

| | |
|---|---|
| Type of project: | Re-construction, 20-year design life |
| Item(s) covered by the warranty: | Main roadway |
| Length of warranty: | Six years or 150 percent of the predicted ESALs |
| Bid process: | Submit proposal, award based on best value or lowest bid |
| Warranty performance measures: | Ride - IRI<br>Safety - Skid resistance<br>Safety/Ride - Rutting<br>Durability - Cracking |
| Bonding: | Traditional construction bond, 6-year warranty bond |

Note that these recommendations are not inconsistent with many of the thoughts and ideas expressed by members of the Montana contracting community regarding warranties on roadway construction projects. Furthermore, they generally include warranty ideas actively being experimented with by other states.

### 5.2 Recommendations for Further Work

As mentioned above, use of performance warranties on roadway construction projects is still an emerging approach to highway construction. Therefore, a mechanism should be put into place to formally evaluate the cost-effectiveness of any pilot projects that utilize this approach. The idea that not all projects are appropriate for the warranty approach is repeated throughout the literature on this subject. The state of Wisconsin, for example, which has been an advocate of performance based warranty projects, carefully screens every warranty project using a warranty selection criteria, and it has stepped back from the warranty approach when bids for a project have been substantially higher than they expected them to be. In some situations, it may simply be more cost effective for the risk of project failure to be borne by the owner (in this case, the state of Montana), rather than having the contractor assume this risk.

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## APPENDIX A

Included for the convenience of the reader are examples of warranty specifications developed by the Indiana, Minnesota, and Ohio departments of transportation.

## APPENDIX A.1

Example warranty specifications developed by the Indiana Department of Transportation.

*Proposal*

# *Performance/Warranty Specifications for Hot Mix Asphalt*

*(Special Experimental Project No. 14)*

Rebecca S. McDaniel
Indiana Department of Transportation
Division of Research
1205 Montgomery Street -- P. O. Box 2279
West Lafayette, IN 47906

May 1995

*Introduction*

The Indiana Department of Transportation is letting an asphalt paving contract in 1996 that will require the contractor to provide a five year warranty on the asphalt pavement performance. The contractor will guarantee the performance of the pavement in terms of rutting, frictional resistance, ride quality and longitudinal cracking. This contract will also utilize the so-called *A+B* concept, where the contractor bids a price for the work and materials, as usual, plus a price for time, which represents the increased road user cost. The contractor who can execute the project with the least inconvenience to the motoring public will have an advantage in the bidding process.

Special provisions for the contract have been formulated by a joint INDOT-industry task force. Threshold distress levels have been set that trigger various maintenance or rehabilitation activities to be performed by the contractor to satisfy the terms of the warranty. These threshold levels are established such that the pavement still has approximately ten years of remaining service life at the end of the warranty period.

There are provisions in the contract that void the warranty when specific conditions occur beyond the control of the contractor, such as when the traffic volumes of trucks Class 5 and higher exceed more than 50% over the original estimate. These provisions are included to protect the contractor, who should not be held responsible for traffic-related distresses if traffic is beyond initial design parameters.

This type of innovative contracting will result in numerous changes in the Department's standard operating procedures. For example, INDOT will pull random samples of the mix and perform some density testing to compare with existing QA/QC specifications, but the Department will not directly or indirectly monitor the contractor's warranty work. Acceptance of the materials will be based on the contractor's certifications.

*Objectives*

The overall objective of this research project is to evaluate the effectiveness of the innovative contracting provisions used on one hot mix asphalt paving project. These provisions provide for the alternate bidding process, which includes the time to construct the project, and the warranty on the hot mix asphalt performance. Evaluating these provisions will include assessment of numerous factors, as outlined in the following section.

*Work Plan*

Several items need to be evaluated to provide an overall assessment of the success of this innovative contracting pilot project.

Materials/Placement/Pavement Performance

The ultimate assessment of the performance of the materials as placed will be the service life of the pavement and how much remedial action the contractor has to perform during the warranty period. This performance will be monitored and reported with reference to the factors contained in the warranty contract. The contract will specify the performance criteria (ride quality, rutting, frictional resistance and longitudinal cracking) and threshold distress levels which will trigger remedial action. The project will be inspected annually during the warranty period and distress levels will be documented. Other factors, such as the activities of the conflict resolution team, should also be included in the assessment to help establish if the approach is procedurally sound.

Specifically, the following information will be provided to the Division of Research:

Annual Condition Surveys (Conflict Resolution Team)
Summary of Annual IRI Measurements (Roadway Management)
Summary of Annual Rut Depth Measurements (Roadway Management)
Summary of Annual Average Friction Numbers (Division of Research)
Activities of the Conflict Resolution Team (Conflict Resolution Team)
Remedial Activities Undertaken by the Contractor (Contractor)
Monthly ADT Data (Roadway Management)

Where possible, these items will be compared to conventional projects of a similar nature (i.e. interstate crack and seat projects of similar age). The initial and final reports will also detail the mix design procedures used by the contractor, the contractor's QC plan, the materials selected for use by the contractor, etc.

The Department, through its Independent Assurance (IA) program, will monitor and verify the reliability of the test results. Results of any companion tests run by the IA technician will be used to compare with conventional QA specifications.

Contract Time

To assess how well the contract provisions worked to encourage efficient planning and to reduce user delay, this project will analyze the contract bids and compare the successful low bid to the actual construction time. This work will require the cooperation of the project supervisor/engineer, who will provide information on the actual traffic lane closures. This information is to be reported on the *Weekly Report of Directional Lane Closures and Contract Days*. Any incentives for early completion or disincentives for late completion will also be reported.

The initial bids will be compared, in a confidential manner, to see how much variation there is from contractor to contractor. The bid time frames will also be compared to the contract time limits in similar interstate crack and seat projects. This will help to determine whether the innovative contract time provisions did encourage the contractor to plan and execute the work in a more efficient manner.

Traffic

The warranty provisions regarding rutting and, to some extent, ride quality depend on the accuracy of the initial traffic projections. In both cases, the warranty may be void if the actual accumulated traffic volumes (of trucks Class 5 and higher) exceed 50% more than originally projected. Alternative limiting criteria were discussed, such as basing the limit on Class 9 trucks only or using equivalent single axle loads (ESALs) rather than accumulated traffic. Through this research project, it is possible to evaluate the alternative methods for monitoring traffic and make recommendations regarding which approach is most meaningful for future reference. This project will also develop statistical methods for analyzing the traffic data and accounting for missing data, again for use on future projects.

A Weigh-in-Motion (WIM) site will be installed within the project limits at the location of an existing telemetering site. WIM plates will be installed in each driving lane and classifiers will be installed in the passing lanes. (This is the standard configuration used in Indiana.) Use of WIM will allow daily traffic volumes, classifications and weights to be obtained. The ADT data will be automatically retrieved by Roadway Management and provided on diskette to Research on a monthly basis. This data will then be analyzed by the Division of Research using existing IRD software. The software allows for rapid determination of the breakdown of traffic by classification and the computation of ESALs (given the structural number of the pavement).

The use of ESALs is currently not routine within the Department because it requires a knowledge of the pavement structure, which is often incomplete. In addition, the calculations of ESALs on fractured slabs (crack and seat or rubblized) requires a layer coefficient for the fractured slab, which is not currently available. This project will include a review of the literature to learn what range of values is being used for fractured slabs. Falling Weight Deflectometer (FWD) testing will be performed on this particular site to measure the slab modulus and provide data to be used in determining a layer coefficient. The various layer coefficients reported in the literature will be compared with the FWD measurements obtained in the field to verify that our results are in line with other research. These values will be used to estimate ESALs for this project and develop recommendations on prediction procedures to use in the future.

The data will be analyzed statistically to compare and contrast the options for monitoring traffic (Class 5 and up, Class 9, ESALs). The statistical analysis will also develop procedures to use in the future to estimate traffic (actual accumulated traffic counts or a random sampling and estimating procedure). If summing all the actual traffic is desired, a statistical method to account for lost data will be developed. Data may be lost whenever the WIM station malfunctions. (This work will proceed in coordination with an ongoing study on I-65 which is looking at some of the same issues.)

*Expected Implementation and Benefits*

Use of warranty specifications would allow contractors more flexibility and more control over their projects. This would allow them more freedom to choose the most cost effective materials, methods or practices for individual projects. Because the contractor is also responsible for maintaining the pavement for five years after construction, the contractor should take great pains to ensure that the pavement will perform acceptably, even if it is not constrained by the current specifications.

The contract time provisions included in selecting the lowest bidder will reward the contractor who can plan and execute the work efficiently.. This will benefit the motoring public by resulting in the fewest lane closures and lowest delay times.

The reduced effort of INDOT testing and inspection forces will allow the Department to stretch their limited manpower. The reduced effort should result in lower administrative costs, while the contract provisions will result in lower project costs while maintaining or even improving pavement performance.

*Work Time Schedule*

The work will be accomplished according to the attached work time schedule.

*Cost Estimate*

The costs for this project are expected to be minimal. The Division of Research does not bill for time. Therefore, the only costs to be incurred are for equipment and travel as outlined below.

| | |
|---|---|
| Equipment (WIM) | $40,000 |
| Travel (Out-of-State) | 3,000 |

The Symposium at the 1996 meeting of the Association of Asphalt Paving Technologists in Baltimore, MD, will be on Warranty Contracts. This is one trip that should be funded through this study. A funding level of $3,000 will allow for one additional trip as appropriate later in the warranty period. All out-of-state travel is reviewed and approved by the State following standard procedures.

*Reporting Plan*

Four reports will be published and submitted to the FHWA during the course of this research in addition to the biannual traffic reports.

*Initial report* documenting contractors initial reactions to the bidding documents, problems, and any identifiable effects on the bids. Bid tabulations will be included and comparisons made to conventional QA/QC contracts. This report will be due within three months of the bid letting.

*First Interim report* within six months of the completion of all warranty work. This report will discuss acceptance of materials, production, testing and actual vs. bid construction times. Comparison to conventional QA/QC contracts will be included along with completion date, claims, and other contract administration and/or legal issues.

*Second Interim report* to summarize the results of findings, actions by the contractors and/or Department, and pavement performance. Any recommendations developed to date will be included in this report for wider implementation of this type of innovative contracting procedure. This report will be submitted within six months following the second year's distress survey.

*Final report* to document the overall evaluation of the Performance/Warranty contract criteria at the end of the warranty period. This report will contain suggestions for improvements, recommendations for future use, pitfalls to avoid, etc. The final report will be submitted within six months following the fifth year's distress survey

| Year | 1995 | | | | 1997 | | | | 1998 | | | | 1999 | | | | 2000 | | | | 2001 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Contract Letting | X | | | | | | | | | | | | | | | | | | | | | | | |
| Initial Report | | X | | | | | | | | | | | | | | | | | | | | | | |
| Construction Inspection | | X | X | | | | | | | | | | | | | | | | | | | | | |
| First Interim Report | | | | X | X | | | | | | | | | | | | | | | | | | | |
| Annual Data Collection* | | | | | | X | | | | X | | | | X | | | | X | | | | X | | |
| Second Interim Report | | | | | | | | | | | X | X | | | | | | | | | | | | |
| Final Report | | | | | | | | | | | | | | | | | | | | | | | X | X |
| Internal Report Review | | X | | | X | | | | | | | X | | | | | | | | | | | | X |

*Includes Condition Survey, Friction Survey, Rut Depth Measurements and Ride Quality

## APPENDIX A.2

Example warranty specifications developed by the Minnesota Department of Transportation.

# *DESIGN-BUILD WARRANTIES*

| | |
|---|---|
| **To:** | Paul Huston, P.E., Design-Build Coordinator |
| **From:** | Chuck Gonderinger, HDR Engineering |
| **Date:** | March 20, 2001 |
| **Subject:** | Design-Build Warranty Requirements |
| **Project:** | TH14/218 Design-Build Project, SP 7408-29, Owatonna, MN<br>Minnesota Department of Transportation (the Department) |
| **Copy:** | Richard Augustin, P.E., Project Manager<br>Kevin Anderson, P.E., Bridge Project Manager |

## 1¾ INTRODUCTION

In the design-build procurement process, it is not uncommon to require the design-builder to warranty its work. Long-term warranties for highway projects have been available for projects in which the contractor or operating agency has the "cradle-to-grave" responsibility of not only designing and building the project, but also maintaining and operating it. But insurers have been reluctant to provide long-term warranties on design-build projects because of their uncertainty and newness, and design-build project warranties longer than five years have been difficult and expensive to obtain. Recently, however, some design-build projects have been able to obtain short-term warranties for five- to ten-year periods, and the acceptance of and level of comfort with this longer warranty (by both contractors and the insurance industry) have grown substantially.

Design build contractors have consistently resisted warranting their work. Because of the additional risk that a warranty imposes, contractors are obliged to increase their bid prices to cover this added risk as well as the direct costs of the additional insurance or bonds. Many design-build contractors have requested that warranties be required only for construction items that the contractor has the ability to affect, either through design or workmanship. For example, if an owner has provided a very prescriptive specification on how to construct a certain item and the contractor has constructed it according to specification, the owner should accept responsibility for the construction and the design-builder should accept responsibility for the workmanship and materials.

## 2¾ SUMMARY OF PROJECT WARRANTIES

The design-builder shall warranty the work in accordance with Part I (Scope of Work) of the RFP. In general, the warranties shall remain in effect until five years after the date of final owner acceptance (FOA) or as specified in the following table.

**SUMMARY OF PROJECT WARRANTIES**

| *Section in This Memo* | *General Subject* | *Warranty Period (after FA)* |
|---|---|---|
| 4.1, 4.2 | Flexible Pavements: Cracking | 5 years |
| 4.1, 4.2 | Flexible Pavements: Debonding | 5 years |
| 4.1, 4.2 | Flexible Pavements : Raveling | 5 years |
| 4.1, 4.2 | Flexible Pavements: Flushing | 5 years |
| 4.1, 4.2 | Flexible Pavements: Rutting | 5 years |
| 4.3 | Rigid Pavement: Cracking | 5 years |
| 4.3 | Rigid Pavement: Joint Deficiencies | 5 years |
| 4.3 | Rigid Pavement: Surface Defects | 5 years |
| 4.4 | Structural Concrete | 5 years |
| 4.5 | Bridge: Elastomeric Bearings | 5 years |
| 4.6 | Bridge: Expansion Joints | 5 years |
| 4.7 | Geotechnical: Settlement | 5 years |
| 4.8 | Signing (Permanent) | 5 years |
| 4.9 | Landscape and Turf Establishment: Plantings, Trees, and Grasses | 1 year |

*See also the Warranties section in Part I (Scope of Work) of the RFP.*

# 3¾ WARRANTY REQUIREMENTS

## 3.1 Definitions and Terms

The materials and workmanship warranty warrants the Department against defects in materials and workmanship.

***Final Acceptance (FA):*** The date when the project construction is substantially complete, the project is fully open to traffic without restrictions, and the Department has determined that the project is in compliance with the contract requirements and the scope of work. This date constitutes the start of the warranty period.

***Final Warranty Acceptance (FWA).*** The date that defines the completion of the five-year warranty period, and the date upon which the warranty bond shall be released by the Department. Acceptance will occur as soon as the Department has determined the that the contract requirements have been met for the warranted work.

***Warranty Bond:*** A surety that guarantees that the warranty requirements are met.

***Warranty Work:*** Corrective action taken to bring the warranted work into contract compliance for release of the warranty bond.

## 3.2 Acceptance

The Department and the design-builder shall jointly review all completed warranted work or a portion thereof, as determined by the Department. If the work does not meet the contract requirements, the design-builder shall make all necessary corrections, at its own expense, prior to acceptance. Acceptance will occur as soon as the Department determines that the contract requirements have been met for the warranted work. The date on which acceptance occurs is termed the date of Final Warranty Acceptance (FWA).

***Exclusion for Corrections.*** The Department may accept the work and begin the warranty period, excluding any area needing corrective work, to accommodate seasonal limitations or staged construction.

***Disclaimer.*** Neither the FA nor any prior inspection, acceptance, or approval by the Department diminishes the design-builder's responsibility under this warranty.

***Documentation.*** Acceptance will be documented and executed jointly by the Department and the design-builder on a form furnished by the Department. The Department will send a copy of the form to the design-builder's warranty bond surety agent.

***Material.*** Acceptance of material in penalty under the Department's quality assurance program will not relieve the design-builder from meeting the material and workmanship warranty requirements for the accepted material.

## 3.3 Warranty Bond

***Amount and Term.*** The design-builder shall furnish a single-term warranty bond in the amount of one million, five hundred thousand dollars ($1,500,000). The effective starting date of the warranty bond shall be the date of FA. The warranty bond will be released at the end of the warranty period (at FWA) or after all warranty work has been completed, whichever is latest.

## 3.4 Rights and Responsibilities of the Department

The Department:

- (a) Reserves the right to approve the schedule proposed by the design-builder to perform warranty work.
- (b) Reserves the right to approve all materials and specifications used in the warranty work.
- (c) Reserves the right to determine whether warranty work performed by the design-builder meets the contract specifications.
- (d) Reserves the right to perform, or have performed, routine maintenance during the warranty period, which routine maintenance will not diminish the design-builder's responsibility under the warranty.
- (e) Reserves the right, if the design-builder is unable, to make immediate emergency repairs to the pavement to prevent an unsafe road condition as determined by the Department. The Department will attempt to notify the contractor that action is required to address an unsafe condition. However, should the design-builder be unable to comply with this requirement to the Department's satisfaction and within the time frame required by the Department, the Department will perform, or have performed, any emergency repairs deemed necessary. Any such emergency repairs undertaken will not relieve the design-builder from meeting the warranty requirements. Any costs associated with the emergency repairs will be paid by the design-builder if it is determined to be caused by defective materials and/or workmanship.
- (f) Is responsible for monitoring the pavement throughout the warranty period and will provide the design-builder all written reports on the pavement related to the warranty requirements.
- (g) Is responsible for notifying the design-builder, in writing, of any corrective action required to meet the warranty requirements.

## 3.5 Rights and Responsibilities of the Design-Builder

The design-builder:

- (a) Shall warrant to the Department that the warranted work will be free of defects in materials and workmanship. The warranty bond shall be described on a form furnished by the Department. The completed form shall be submitted to the Department prior to award of the contract.

- (b) Is responsible for performing all temporary or emergency repairs that are necessitated by noncompliance with the warranty requirements, using Department-approved materials and methods.
- (c) Shall notify the Department and submit a written plan for performing the needed warranty work fourteen calendar days before starting warranty work, except in case of emergency repairs as detailed in this section. The submittal must propose a schedule for performing the warranty work and the materials and methods to be used.
- (d) Shall follow a Department-approved traffic control plan (TCP) when performing warranty work.
- (e) Shall schedule warranty work during non-peak-hour traffic.
- (f) Is required to supply to the Department original documentation that all insurance required by the contract is in effect during the period that warranty work is being performed.
- (g) Shall complete all warranty work prior to conclusion of the warranty period, or as otherwise agreed to by the Department.
- (h) Shall be liable during the warranty period in the same manner as contractors currently are liable for their construction-related activities with the Department pursuant to the 2000 *Standard Specifications for Construction*, including, but not limited to, Subsections 1708, 1712, and 1714. This liability shall arise and continue only during the period when the design-builder is performing warranty work. This liability is in addition to the design-builder performing and/or paying for any required warranty work, and shall include liability for injuries and/or damages and any expenses resulting therefrom that are not attributable to normal wear and tear of traffic and weather, but are due to noncompliant materials, faulty workmanship, and the operations of the design-builder.

## 3.6 Evaluation Method

***Segmentation.*** For evaluating pavement, the Department will divide the project into segments. Each individual driving lane and outside shoulder will be divided into 500-foot segments for measuring and quantifying the condition parameters. Evaluation will include use of both the Department's Pavement Management System and/or field pavement condition reviews. This evaluation may be waived in emergency situations.

***POB and POE.*** The beginning point for laying out segments will be the point of beginning (POB) of the project as shown on the base plan. Segments will be laid out consecutively to the point of ending (POE) of the project as shown on the base plan. The original segmentation of the project will be used for all successive reviews throughout the warranty period.

## 3.7 Corrective Action Requirements

***Criteria.*** Warranty work will be required when the following two criteria are met as a result of defect in materials and/or workmanship. If fifty percent or more of the segments in any mile exceed the threshold limits, the entire mile will require corrective action; otherwise, only the affected segments will require corrective action.

***Threshold Limits.*** The specific threshold limits are shown in tables in Section 4 (Material and Workmanship Warranty Specifications).

***Investigations.*** To determine whether the failure to meet the warranty criteria is a result of defects in materials and/or workmanship, a joint field investigation by the Department and the design-builder will be conducted. The Department and/or the design-builder may elect to have a forensic investigation conducted. The decision to undertake a forensic investigation, the scope of it, and the selection of the party to conduct it will be agreed to by the Department and the design-builder. All costs related to the forensic investigation will be shared proportionately based on the determined cause of the condition as related to the materials and workmanship of this contract.

***Nonwarranted Conditions.*** During the warranty period, the design-builder will not be held responsible for pavement distresses that are caused by factors unrelated to materials and workmanship. These include, but are not limited to, chemical and fuel spills, vehicle fires, snowplowing and ice control, and destructive testing done by the Department during the warranty period. Other factors considered to be beyond the control of the design-builder that may contribute to pavement distress will be considered by the Department on a case-by-case basis upon receipt of a written request from the design-builder.

***Time Requirements for Corrective Action.*** The design-builder shall be responsible for taking corrective action within thirty calendar days after notice by the Department. If corrective action work cannot be started within 30 days of notification, due to seasonal limitations, the design-builder shall notify the Department in writing and determine a schedule for completion of the corrective action work. Failure by the design-builder to respond to the Department or take corrective action within the specified period of time shall be cause for the Department to complete the corrective action work and recover the costs of such work from the warranty bond.

## 3.8 Emergency Repairs

If the Department determines that emergency repairs are necessary for public safety, the Department or its agent may take repair action. The District Engineer will authorize emergency repairs. Prior to emergency repairs, the Department will document the basis for the emergency action, and will preserve evidence of the defective condition.

# 4¾ MATERIAL AND WORKMANSHIP WARRANTY SPECIFICATIONS

## 4.1 Flexible Pavement: Hot-Mix Asphalt Overlays

***Application.*** This section is applicable to pavement warranties on hot-mix asphalt (HMA) overlays on flexible pavements. Distress identification shall be according to the "Distress Identification Manual for the Long-Term Pavement Performance Project," SHRP-P-338.

***Limits of Warranted Work.*** The warranted work includes all multiple-course HMA overlays on driving lanes and shoulders within the project limits.

***Warranty Term.*** The warranty term will be *five years* from the date of FA.

***Condition Parameters.*** Condition parameters are used to measure the performance of the HMA overlay during the warranty term. Each condition parameter has a threshold level applied to each segment and a maximum number of defective segments allowed before corrective action (warranty work) is required. A condition survey will be done by the Department each year to determine compliance with the warranty provisions.

***Definitions***

*Transverse Crack*: A crack that is predominantly perpendicular to the pavement centerline, and is not located over Portland cement concrete joints. All transverse cracks will be routed and sealed after four years.

*Longitudinal Crack or Open Join:* A crack that is predominantly parallel to the pavement centerline. All longitudinal cracks will be routed and sealed after five years.

*Block Cracking:* A pattern of cracks that divide the pavement into approximately rectangular pieces. Rectangular block sizes range from approximately 1 square foot (sq. ft.) to 100 sq. ft.

*Fatigue Cracking:* A series of interconnected cracks in the early stages of development, developing into many-sided, sharp-angled pieces, usually less than one foot on the longest side, with a characteristic chicken-wire or alligator pattern.

*Debonding:* A physical separation of the new pavement surface from the underlying pavement surface. Debonding will be visually identified as shoving, or the loss of new surface course. Surface potholes, regardless of depth, will be classified as debonding, to the extent that the condition was derived from the debonding of the new surface course.

*Raveling:* Wearing away of the hot-mix asphalt pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.

*Flushing:* Excess bituminous binder occurring on the pavement surface, which may cause a shiny, glass-like, reflective surface that may be tacky to the touch; usually found in the wheel paths.

*Rutting:* A longitudinal surface depression in the wheel path. It may have associated transverse displacement.

***Threshold Limits.*** The following table lists the allowable threshold limit for each condition parameter within each segment and the maximum number of allowable segments for each condition parameter. If any of the threshold limits is exceeded as a result of a defect in materials and/or workmanship, corrective action (warranty work) is required. The defective segments for surface distress do not have to be contiguous to necessitate corrective action. The maximum allowable number of defective segments for each condition parameter applies to each driving lane and shoulder in each direction. Each driving lane and shoulder shall be evaluated independently. Any pavement surface requiring removal or replacement to correct deficiencies for any condition parameter shall be placed full-width across the driving lane or shoulder.

**ALLOWABLE THRESHOLD LIMITS—HOT-MIX ASPHALT OVERLAYS**

| *Condition Parameter* | *Segment Threshold Limits* |
|---|---|
| Transverse Cracking | Five cracks per segment, each greater than 6-feet long and 1/8" wide. In addition, all transverse cracks will be routed and sealed after four years. |
| Longitudinal Cracking | 5% of the segment length. In addition, all longitudinal cracks will be routed and sealed after four years |
| Block Cracking | 5% of the segment length |
| Fatigue Cracking | 1% of the segment length |
| Debonding | None allowed |
| Raveling | 1% of the segment area |
| Flushing | 1% of the segment length |
| Rutting | Average rut depth of 0.25 inches |

***Corrective Actions***. The following corrective actions are suggested to illustrate acceptable treatments for the various condition parameters. The Department will accept the listed corrective action if the action addresses the cause of the distress. The design-builder may use the Department-suggested corrective action or an alternative action, subject to Department approval. If fifty percent or more of segments in any mile exceed the threshold limits, the entire mile will require corrective action; otherwise, only the segment will require corrective action.

**CORRECTIVE ACTIONS—**
**HOT-MIX ASPHALT OVERLAYS**

| *Condition Parameter* | *Recommended Action* |
|---|---|
| Transverse Cracks | Rout and seal. |
| Longitudinal Cracks | Rout and seal. |
| Block Cracking | Mill and resurface |
| Fatigue Cracking | Mill and resurface. |
| Debonding | Mill and resurface. |
| Raveling | Mill and resurface |
| Flushing | Mill and resurface. |
| Rutting | Microsurface or mill and resurface. [1] |

*1. Recommended action is dependent on the depth of the rut.*

## 4.2 Flexible Pavement: New Constructed Hot-Mix Asphalt

***Application.*** This section applies to pavement warranties on new and reconstructed hot-mix asphalt (HMA) pavement placed on an unbound or stabilized aggregate base. Distress identification shall be according to the "Distress Identification Manual for the Long-Term Pavement Performance Project," SHRP-P-338.

***Limits of Warranted Work.*** The warranted work includes all hot-mix asphalt on driving lanes and shoulders within the project limits.

***Warranty Term.*** The warranty term will be *five years* from the date of FA.

***Condition Parameters.*** Condition parameters are used to measure the performance of the HMA pavement during the warranty term. Each condition parameter has a threshold level applied to each segment and a maximum number of defective segments allowed before corrective action (warranty work) is required.

***Definitions***

*Transverse Crack:* A crack that is predominantly perpendicular to the pavement. All transverse cracks will be routed and sealed after four years.

*Longitudinal Crack or Open Joint:* A crack that is predominantly parallel to the pavement centerline. All longitudinal cracks will be routed and sealed after four years.

*Block Cracking:* A pattern of cracks that divide the pavement into approximately rectangular areas that range in size from approximately 1 sq. ft to 100 sq. ft.

*Fatigue Cracking:* A series of interconnected cracks in the early stages of development, evolving into many-sided, sharp-angled pieces, usually less than 1-foot on the longest side, with a characteristic chicken-wire or alligator pattern.

*Debonding:* A physical separation of the new pavement surface from the underlying pavement surface. Debonding will be visually identified by shoving or the loss of new surface course. Surface potholes, regardless of depth, will be classified as debonding, to the extent that the condition is derived from the debonding of the new surface course.

*Raveling:* Wearing away of the hot-mix asphalt pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.

*Flushing:* Excess bituminous binder on the pavement surface, which may cause a shiny glasslike reflective surface that may be tacky to the touch; usually found in the wheel paths.

*Rutting:* A longitudinal surface depression in the wheel path. It may have associated transverse displacement.

***Threshold Limits.*** The following table lists the allowable threshold limit and the maximum number of allowable segments for each condition parameter within each segment. If any of the threshold limits is exceeded as a result of a defect in materials and/or workmanship, corrective action (warranty work) is required. The defective segments for surface distress do not have to be contiguous to necessitate corrective action. The maximum allowable number of defective segments for each condition parameter applies to each driving lane and shoulder in each direction. Each driving lane and shoulder shall be evaluated independently. Any pavement surface requiring removal or replacement to correct deficiencies for any condition parameter shall be placed full-width across the driving lane or shoulder.

**ALLOWABLE THRESHOLD LIMITS—**
**NEW CONSTRUCTED HOT-MIX ASPHALT**

| *Condition Parameter* | *Segment Threshold Limits* |
|---|---|
| Transverse Cracking | Five cracks per segment, each greater than 6-feet long and 1/8” wide. In addition, all transverse cracks will be routed and sealed after four years. |
| Longitudinal Cracking | 10% of the segment length. In addition, all longitudinal cracks will be routed and sealed after four years. |
| Block Cracking | 10% of surface area |
| Fatigue Cracking | 1% of segment area |
| Debonding | None allowed |
| Raveling | 1% of the segment area |
| Flushing | 1% of the segment length |
| Rutting | Average rut depth of 0.25 inch |

***Corrective Actions.*** The following corrective actions are suggested to illustrate acceptable treatments for the various condition parameters. The Department will accept the listed corrective action if the action addresses the cause of the distress. The design-builder may use the Department-suggested corrective action or an alternative, subject to Department approval.

If fifty percent of more of segments in any mile exceed the threshold limits, the entire mile will require corrective action; otherwise, only the segment will require corrective action.

**CORRECTIVE ACTIONS?**
**NEW CONSTRUCTED HOT-MIX ASPHALT**

| *Condition Parameter* | *Recommended Action* |
|---|---|
| Transverse Cracking | Rout and seal. |
| Longitudinal Cracking | Rout and seal. |
| Block Cracking | Mill and resurface or surface treatment (chip seal or microsurface). [1] |
| Fatigue Cracking | Repair to full depth and resurface. |
| Debonding | Mill and resurface. |
| Raveling | Mill and resurface or surface treatment (chip seal or microsurface). [1] |
| Flushing | Mill and resurface. |
| Rutting | Microsurface or mill and resurface. [2] |

*1. Recommended action is dependent on extent and severity of cracking.*
*2. Recommended action is dependent on the depth of the rut.*

## 4.3 Rigid Pavement: New or Reconstructed Jointed Plain Concrete

***Application.*** This section applies to pavement warranties on new and reconstructed jointed plain concrete pavement placed on an unbound or stabilized aggregate base course. Distress identification shall be according to the "Distress Identification Manual for the Long-Term Pavement Performance Project," SHRP-P-338.

***Limits of Warranted Work.*** The warranted work includes all jointed plain concrete pavement on driving lanes within the project limits.

***Warranty Term.*** The warranty term will be *five years* from the date of FA.

***Condition Parameters.*** Condition parameters are used to measure the performance of the concrete pavement during the warranty term. Each condition parameter has a threshold level applied to each segment and a maximum number of defective segments allowed before corrective action (warranty work) is required.

**Definitions**

*Crack:* A visible fissure or surface discontinuity that may or may not exceed through the entire slab. Cracks may be singular or in multiple patterns. Crack types are:

*Transverse:* Cracks that are predominantly perpendicular to the pavement centerline.

*Longitudinal:* Cracks that are predominantly parallel to the pavement centerline.

*Corner:* A portion of the panel separated by a crack that intersects the adjacent transverse and longitudinal joints, describing approximately a 45-degree angle with the direction of traffic. The length of the sides ranges from one foot to one-half the width of the panel on each side of the corner.

*Map:* A series of cracks that extend only into the upper surface of the slab. Frequently, larger cracks are oriented in the longitudinal direction of the pavement and are interconnected by finer transverse or random cracks.

*Shrinkage:* Partial depth drying and plastic shrinkage cracks resulting from tensile stresses.

*Joint Spalling:* Cracking, breaking, chipping, or fraying of the panel edges within two feet of the transverse or longitudinal joint.

*Joint Sealant Damage:* Any condition that enables incompressible materials or a significant amount of water to infiltrate the joint from the surface. Typical types of joint sealant damage are extrusion, hardening, adhesive failure (debonding), cohesive failure (splitting), and complete loss of sealant.

*Shattered Slab:* A pavement slab broken into four or more sections by full-depth cracks.

*Scaling:* Deterioration of the upper concrete slab surface, normally 0.125 inch to 0.5 inch; may occur anywhere on the pavement.

*Popouts:* Small pieces of pavement broken loose from the surface greater than ¼ inch in diameter.

*Nonfunctioning Joints:* Transverse panel joints with misaligned dowel bars or dowel bars that do not function as designed.

***Threshold Limits.*** The following table lists the allowable threshold limit for each condition parameter within each segment and the maximum number of allowable segments for each condition parameter. If any of the threshold limits is exceeded as a result of a defect in materials and/or workmanship, corrective action (warranty work) is required. The defective segments for surface distress do not have to be contiguous to necessitate corrective action. The maximum allowable number of defective segments for each condition parameter applies to each driving lane and shoulder in each direction. Each driving lane and shoulder shall be evaluated independently. Any pavement surface requiring removal or replacement to correct

deficiencies for any condition parameter shall be placed full-width across the driving lane or shoulder.

**ALLOWABLE THRESHOLD LIMITS—
NEW OR RECONSTRUCTED
JOINTED PLAIN CONCRETE PAVEMENT**

| *Condition Parameter* | *Segment Threshold Limits* |
|---|---|
| Transverse Cracking | None allowed |
| Longitudinal Cracking | 5% of the segment length |
| Corner Cracking | One per segment |
| Map Cracking | None allowed |
| Shrinkage Cracking | Three panels per segment |
| Joint Spalling | Twelve lineal feet per segment |
| Joint Sealant Failure | Twelve lineal feet per segment |
| Shattered Slab | None allowed |
| Nonfunctioning Joint | None allowed |
| Popouts | Fifteen per square yard |
| Scaling | 1% of the segment area |

***Corrective Actions.*** The following corrective actions are suggested to illustrate acceptable treatments for the various condition parameters. The Department will accept the listed corrective action if the action addresses the cause of the distress. The design-builder may use the Department-suggested corrective action or an alternative, subject to Department approval.

**CORRECTIVE ACTIONS?
NEW OR RECONSTRUCTED JOINTED PLAIN CONCRETE PAVEMENT**

| *Condition Parameter* | *Recommended Action* |
|---|---|
| Longitudinal Cracking<br>Transverse Cracking<br>Corner Cracking<br>Map Cracking<br>Shrinkage Cracking<br>Spalling<br>Joint Sealant Failure<br>Shattered Slab<br>Nonfunctioning Joint<br>Popouts<br>Scaling | For all condition parameters, refer to the current editions of the Mn/DOT Concrete Repair Guidelines and Concrete Pavement Rehabilitation Standards |

## 4.4 Structural Concrete

***Application.*** This section applies to structural concrete and concrete paving associated with bridge construction. This warranty applies to concrete bridge rail, bridge approach slabs, and bridge deck paving.

***Warranty Term.*** The warranty term will be *five years* from the date of FA.

***Condition Parameters.*** Condition parameters are used to measure the performance of the concrete pavement during the warranty term. The following condition parameters shall apply:

- *Map Cracking:* A series of cracks that extend only into the upper surface of the slab. Frequently, larger cracks are oriented in the longitudinal direction of the pavement and are interconnected by finer transverse or random cracks.
- *Scaling:* Deterioration of the upper concrete slab surface, normally 0.125 inch to 0.5 inch and may occur anywhere on the pavement.
- *Popouts:* Small pieces of pavement broken loose from the surface greater than ¼ inch in diameter.

***Threshold Limits and Corrective Actions.*** The Department has not defined specific threshold limits for the above condition parameters. The Mn/DOT Office of Bridge Design shall be the final authority on determination of the necessity for corrective action work with respect to the listed condition parameters.

## 4.5 Bridge Elastomeric Bearings

***Application.*** This section is applicable to warranties on the bridge elastomeric bearings.

***Limits of Warranted Work.*** The warranted work includes all elastomeric bearings on the bridge.

***Warranty Term.*** The warranty term will be *five years* from the date of FA.

***Condition Parameters.*** Condition parameters are used to measure the performance of the elastomeric bearings during the warranty term. Each condition parameter has a threshold level before corrective action (warranty work) is required.

***Definitions***

*Horizontal Deformation:* The top surface of the bearing is misaligned with the bottom surface of the bearing such that the vertical surfaces are not plumb.

*Tearing:* A physical separation of the laminate material in the bearing.

***Threshold Limits.*** The following table lists the allowable threshold limit for each condition parameter. If any of the threshold limits is exceeded as a result of a defect in materials and/or workmanship, corrective action (warranty work) is required.

**ALLOWABLE THRESHOLD LIMITS?**
**BRIDGE ELASTOMERIC BEARINGS**

| *Condition Parameter* | *Threshold Limits* |
|---|---|
| Horizontal Deformation | Greater than 1" out of plumb |
| Tearing | Any tear of the laminate material |

***Corrective Actions***. The following corrective actions are suggested to illustrate acceptable treatments for the various condition parameters. The Department will accept the listed corrective action if the action addresses the cause of the distress. The design-builder may use the Department-suggested corrective action or an alternative action, subject to Department approval.

**CORRECTIVE ACTIONS? BRIDGE ELASTOMERIC BEARINGS**

| *Condition Parameter* | *Recommended Action* |
|---|---|
| Horizontal Deformation | Jack bridge and reset bearing pad. |
| Tearing | Replace bearing pad. |

## 4.6 Bridge Expansion Joints

***Application.*** This section is applicable to warranties on the bridge waterproof expansion joints.

***Limits of Warranted Work.*** The warranted work includes all the waterproof expansion joints on the bridge.

***Warranty Term.*** The warranty term will be *five years* from the date of FA.

***Condition Parameters.*** Condition parameters are used to measure the performance of the waterproof expansion joints during the warranty term. Each condition parameter has a threshold level before corrective action (warranty work) is required.

***Definitions***

*Tearing:* Any tear completely through the gland that will allow water to pass through the joint.

*Pullout:* A separation of the gland from the extrusion.

*Broken or Missing Plow Fingers:* Plow fingers that are broken, cracked, or have been completely removed.

***Threshold Limits.*** The following table lists the allowable threshold limit for each condition parameter. If any of the threshold limits is exceeded as a result of a defect in materials and/or workmanship, corrective action (warranty work) is required.

**THRESHOLD LIMITS? BRIDGE WATERPROOF EXPANSION JOINTS**

| *Condition Parameter* | *Threshold Limits* |
|---|---|
| Tearing | Any tear that will allow water to pass through the gland[1] |
| Pullout | Any portion of the gland that has separated from the extrusion. |
| Broken or Missing Plow Fingers | Any broken, cracked, or missing plow finger |

*1. The complete expansion joint installation shall be watertight at all points and shall be so tested by filling the joint opening, or portions thereof, as designated by the Engineer, with water and observing the results for not less than one hour.*

***Corrective Actions.*** The following corrective actions are suggested to illustrate acceptable treatments for the various condition parameters. The Department will accept the listed corrective action if the action addresses the cause of the distress. The design-builder may use the Department-suggested corrective action or an alternative, subject to Department approval.

**CORRECTIVE ACTIONS?**
**BRIDGE WATERPROOF EXPANSION JOINTS**

| *Condition Parameter* | *Recommended Action* |
|---|---|
| Tearing | Completely replace the gland.[1] |
| Pull-Out | Completely replace the gland.[1] |
| Broken or Missing Plow Fingers | Replace the plow finger. |

*1. Partial replacement or patching of the gland will not be permitted.*

## 4.7 Settlement of New Roadway Grade (Including Bridge Fills)

***Application:*** This section applies to settlement warranties on all new westbound roadway subgrades constructed within the project limits. (This section does not apply to eastbound subgrade work constructed under this project.)

***Limits of Warranted Work:*** The warranted work includes all subgrade excavation, embankment, and aggregate base placed on the westbound roadway below the concrete pavements, including bridge approach panels and concrete pavement over culverts.

***Warranty Term.*** The warranty term will be *five years* from the date of FA.

***Condition Parameter:*** The parameter used to measure settlement is surface differential settlement in the wheel path measured on the surface of the concrete pavement placed within the limits of this project. The differential settlement will be measured by a 25-foot California profilograph or by the Department's Pavement Management distress van (analyzing the van data to emulate the profilograph measurement).

***Threshold Limits.*** The following table lists the allowable threshold limit within each segment. If the threshold limit is exceeded as a result of a defect in materials and/or workmanship, corrective action (warranty work) is required. The defective segments for surface distress do not have to be contiguous to necessitate corrective action. Any pavement surface requiring removal or replacement to correct deficiencies for any condition parameter shall be placed full-width across the driving lane or shoulder.

**ALLOWABLE THRESHOLD LIMIT—**
**SETTLEMENT OF NEW ROADWAY GRADE**

| *Condition Parameter* | *Segment Threshold Limit* |
|---|---|
| Concrete Surface Differential Settlement | 0.50 inches in 25 feet |

***Corrective Action:*** The following corrective action is suggested to illustrate acceptable treatment for the condition parameter. The Department will accept the listed corrective actions. Design Builds may use the Department suggested corrective action or an alternate action, subject to Department approval.

**CORRECTIVE ACTION—**
**SETTLEMENT OF NEW ROADWAY GRADE**

| *Condition Parameter* | *Recommended Action* |
|---|---|
| Concrete Surface Differential Settlement | Remove and replace concrete pavement. |

## 4.8 (Permanent) Signing

***Application.*** This section applies to all permanent signing furnished and installed by the Design-Builder.

***Limits of Warranted Work.*** The warranted work includes all permanent signing materials and hardware installed by the design-builder. Signs damaged by forces beyond the control of the design-builder. such as maintenance activities, accidents, or acts of nature, will relieve the design-builder of any further warranty requirements.

***Warranty Term.*** The warranty term will be *five years* from the date of FA.

## 4.9 Landscaping and Turf Establishment (Plantings, Trees, and Grasses)

***Application.*** This section applies to turf establishment warranties on all disturbed areas within the project limits.

***Limits of Warranted Work.*** The warranted work includes all seeding, fertilizing, and mulching necessary to reestablish turf within the project limits.

***Warranty Term.*** The warranty term will be *one year* from the date of FA.

***Warranty Requirements.*** The design-builder shall be required to provide a minimum level of landscaping or turf reestablishment as outlined in the RFP for a period of one year after final completion of the project. At the end of the one-year warranty period, the design-builder and a representative from the Department will perform an inspection of all the areas that were seeded to ensure that all plant matter is alive and that plant coverage is acceptable to prevent erosion. The design-builder will reestablish areas where the plant matter is dead or coverage is inadequate. Once inspected areas have been reestablished by the design-builder, the Department shall notify the design-builder that the terms of the warranty period have been met and that the warranty period is complete.

## APPENDIX A.3

Example warranty specifications developed by the Ohio Department of Transportation.

**STATE OF OHIO**
**DEPARTMENT OF TRANSPORTATION**

# SUPPLEMENTAL SPECIFICATION 880

# ASPHALT CONCRETE WITH WARRANTY

**November 7, 2000**



**880.01 General.** This work shall consist of constructing one or more courses of asphalt concrete mixed in a central plant and spread and compacted on a prepared surface in accordance with these specifications and in reasonably close conformity with the lines, grades and typical sections shown on the plans or established by the Engineer. The Contractor shall warrant the asphalt concrete for the number of years specified.

**880.02 Maintenance Bond.** When the successful Bidder provides the Department with the performance and payment bonds specified in 103.05, the successful Bidder shall also furnish a maintenance bond for the period of years specified in the pay item in an amount equal to the following percent of the total amount bid for Item 880:

| **Course Thickness** | **Percent** |
|---|---|
| 2.0 inches (50 mm) or less | 90 |
| 2.1 to 4.0 inches (51 to 100 mm) | 60 |
| 4.1 inches (101 mm) or more | 30 |

The Surety that underwrites the maintenance bond is required to have an A.M. Best rating of “A -” or better. The cost of the maintenance bond shall be included in the pay item for the premium for the contract performance and payment bonds.

The effective date of the maintenance bond is the date the Department’s Form C-85 (Partial or Final) is issued for the pavement. The issuance of Form C-85 for a section of pavement shall occur within 30 days after either:

1. all of the pavement items, including all safety items, are completed and the pavement is open to traffic; or

2. the pavement is completed up to, but not including, the surface course, including all safety items, and the pavement is going to be open to traffic over the winter.

After the Form C-85 for a section of pavement is issued, the Department will notify the Surety. After the Final Form C-85 is issued, the Department will also establish all final quantities for the project and the project will be finalized using standard procedures. The maintenance bond expires after the period of years specified in the pay item from the issuance of Form C-85.

The Contractor shall maintain the liability insurance specified in 107.14, insuring against Contractor or Contractor authorized operations negligently performed during the warranty period. This insurance shall be in effect throughout the warranty period. A copy of the Certificate of Insurance shall be sent to the District each year.

**880.03 Warranty Items and Remedial Actions.** Warranty items and Remedial Actions are specified in Table A. The warranty applies only to the mainline pavement lanes and ramps. All shoulders shall be constructed using the same asphalt concrete mixture and construction procedures as the mainline and ramps. The warranty does not apply to structural problems below the pavement placed as part of this project, provided the structural problem is not the fault of the Contractor. The Threshold Levels are based on the 0.1 mile (160 m) Segments described in 880.04.

Meeting the minimum requirements and guidelines of this specification are not to be construed as a warranty, expressed or implied, as to the materials properties and workmanship efforts required to meet the performance criteria set forth in Table A.

The Design Designation in the plan is an indication of the level of traffic expected on this project. Design information, criteria, and calculations are on file in the District office. The warranty requirements of a Section will be waived if the cumulative number of Equivalent 18,000 pound Single Axle Loads (ESAL's), calculated using current information and established Department procedures, exceeds the design calculated ESAL's, prorated for the period of years specified in the pay item, by 20 percent or more.

The intent of this contract is for the Contractor to provide a maintenance free pavement. The Contractor may perform routine maintenance during the warranty period, but this routine maintenance is limited to routing and sealing the pavement with Type 1 crack seal in accordance with Supplemental Specification 825 or other repairs authorized by the Department.

The Contractor's construction traffic control for performing any work required or allowed by this specification during the warranty period shall be in accordance with current Department policy, the Ohio Manual of Uniform Traffic Control Devices for Streets and Highways, and subject to Department approval of the time the work will be performed. Any major change in Department construction traffic control policy will be considered a changed condition.

Asphalt concrete used for Remedial Action work or replacement of sampled areas (See Table A Note 5) shall be approved by the Engineer. The Engineer will take into account the Department's design criteria for the pavement type. The depth of a repair area may

be increased by the Engineer to allow for the size of aggregate in the asphalt concrete. For Remedial Action work, the Engineer may approve alternatives to the extent or type of specified Remedial Action.

Any pavement markings or raised pavement markers (RPM) removed or obliterated while performing a Remedial Action shall be replaced with pavement markings or RPMs equal to or better than the original products at the Contractor's cost.

All Remedial Actions, except crack sealing, shall be performed on or before September 30. Crack sealing shall be performed between October 1 and November 15. If an appeal process uses the arbitration method, the District may revise the date for the completion of the Remedial Action for the appealed item. Prior to performing a Remedial Action, the Contractor shall submit a Remedial Action plan to the Engineer for approval. This plan shall state when and how the Remedial Action will be done, what material will be used, and how traffic will be controlled while the Contractor is performing the Remedial Action.

Emergency work, repairing pavement distresses which are hazardous to the traveling public, will be performed by the Department. If the emergency work is extensive, the Department may authorize the Contractor to do the repairs. The District Construction Engineer (DCE) will determine if the distress is or is not the fault of the Contractor. If the DCE determines the distress is the fault of the Contractor, the cost of this emergency work, no matter who does the emergency work, including construction traffic control, will be paid by the Contractor. The Contractor is not responsible for pavement damage beyond the Contractor's control (i.e., car fire, oil spill, etc.). The Contractor may appeal the DCE's determination in accordance with 880.05.

**880.04 Annual Review**. The project shall be divided into 1 mile (1600 m) Sections. The width of each Section will be the width of a single lane. Each Section shall be divided into 0.1 mile (160 m) Segments.

Each year, between March 1 and April 30, the project will be reviewed by a District Review Team (DRT). The DRT shall notify the Contractor of the scheduled review. The Contractor or any other interested party may attend the annual review, for observation only. Any comments by the Contractor or other interested party will be recorded by the DRT. The DRT will pick at least two Segments in each Section to review, but may review the entire Section. Within 15 days after the completion of the review, the results will be issued in writing to the Contractor.

The District Deputy Director may waive this yearly review for all or part of the project based on the results of a preliminary review by a member of the DRT. This waiver will be in writing to the Contractor.

**880.05 Appeal Process.** The Contractor may appeal a finding of the DRT. Any appeal shall be submitted to the DCE, in writing, within 15 days after the written results of the DRT are given to the Contractor. If the results include Rutting beyond the Threshold Level, the submission time limit is changed to 15 days after removing the slabs (See Table A Note 5) for a dispute over Rutting only.

The DCE will evaluate the Contractor's appeal. This evaluation will include reviewing the disputed area in the field and consulting with the Construction Section of the Office of Highway Management. The evaluation may also include reviewing test data, obtaining samples, or interviewing Department (District or Central Office) or Contractor employees. The DCE's determination will be issued in writing to the Contractor within 45 days after the DCE receives the appeal.

If the Contractor disagrees with the DCE's determination, the Contractor may appeal the determination using an arbitration method acceptable to the Department. The Department will agree, in all cases, to arbitration in the manner in which those methods are practiced by the Department. If the Contractor selects arbitration, written notice of this approach must be made to the DCE within 15 days of receipt of the DCE's determination. After written notice has been provided, the parties shall agree in writing to the Arbitrator and agree to share equally the fees of the Arbitrator.

After the Arbitrator is given notice to proceed, the Arbitrator shall conduct an investigation and issue a determination within 45 days. The Arbitrator's determination will be limited to determining whether or not the pavement distress is or is not the fault of the Contractor.

**880.06 Mix Design and Materials.** The mix design and materials shall meet the following minimum requirements:

1. Virgin aggregate used in the top 3.0 inches (75 mm) shall meet or exceed the quality requirements of 703.05. All virgin aggregate below the top 3.0 inches (75 mm) shall meet or exceed the quality requirements of 703.04.

2. If the Design Designation indicates the current year's trucks to be greater than or equal to 1500, then in the surface course the maximum recycled asphalt pavement that may be used is 10 percent. Below the surface course to 3.0 inches (75 mm), a maximum of 30 percent recycled pavement may be used in the mix provided the virgin binder content is not less than 3.4 percent.

   If the Design Designation indicates the current year trucks are less than 1500, then in the top 3.0 inches (38 mm) the maximum recycled asphalt pavement that may be used is 30 percent provided the virgin binder content is not less than 3.4 percent.

   Below 3.0 inches (75 mm), a maximum of 50 percent recycled asphalt pavement may be used in the mix.

   Recycled asphalt pavement shall be limited to reclaimed asphalt concrete pavement or reclaimed bituminous aggregate base pavement obtained from either a Department or Ohio Turnpike Commission project.

3. Asphalt binders used in the top 3 inches (75 mm) of the pavement shall meet or exceed the PG 70-22M requirements of Supplemental Specification 908 , unless the Design Designation indicates the current year trucks are less than 1500, then the asphalt binder used shall meet or exceed the PG 64-22 requirements of Supplemental Specification 908. The Contractor is responsible for other considerations, such as high stress areas.

4. If the specified thickness for Item 880 is equal to or greater than 8.0 inches (200 mm), all of the material placed below the top 4.0 inches (100 mm) shall meet or exceed the aggregate and mineral filler requirements of 703.04 and 703.07 and meet one of the following mix requirements:

    a. The mix shall meet the requirements of 302.02: or

    b. The mix shall meet or exceed the material requirements of 301.02 and 301.031, be designed in accordance with the Supplement 1044, and meet the mix properties of 302.02.

The Laboratory shall verify that the mix design and materials meet the above minimum requirements. Before the start of production, the Contractor shall submit their material quality control plans and job mix formula (JMF) to the District Engineer of Tests and Laboratory. During production, any changes in the JMF shall also be submitted. The JMF submittal, at a minimum, shall include volumetric data of mix components. There are no minimum requirements for the material quality control plans, other than it must be submitted. These submittals are for establishing the conversion factor used in 880.10 and verification of the above minimum requirements.

**880.07 Tack Coat.** The Contractor is responsible for determining the need and type of tack coat to use on the existing pavement or between pavement layers. The cost of any tack coat shall be included in the cost for this item.

**880.08 Surface Tolerances.** The completed surface course shall meet 404.16, unless the surface tolerance requirements for asphalt concrete is modified elsewhere in the contract documents for this project.

**880.09 Notification.** The Contractor shall notify the Engineer a minimum of 24 hours prior to paving. If the Contractor does not pave for one week, the Engineer shall be notified a minimum of 24 hours prior to resuming paving.

**880.10 Basis of Payment.** The requirements of 401.16 and 401.17 shall apply. The Laboratory shall establish the conversion factor. Payment for accepted quantities completed in place, including any tack coat, will be made at the contract price for:

| Item | Unit | Description |
|---|---|---|
| 880 | Cubic yard (cubic meter) | Asphalt concrete (5 year warranty) |
| 880 | Cubic yard (cubic meter) | Asphalt concrete (7 year warranty) |

**TABLE A – WARRANTY ITEMS AND REMEDIAL ACTIONS**

| **Distress Type** | **Threshold Level** (per Segment) | **Remedial Action** |
|---|---|---|
| **Cracking** (1) | 500 feet (150 m) of cracks which average over 0.25 inch (6 mm) width | (6) |
| **Disintegrated Area** (2) | None | (7) |
| **Flushing** | 125 square feet (12 $m^2$) | (8) |
| **Previous Patching** (3) | 300 square feet (28 $m^2$) | (9) |
| **Rutting** (4) (5) | 0.250 inch (6.0 mm) - mainline (5 year warranty)<br>0.375 inch (9.5 mm) - mainline (7 year warranty) | (7) |

(1) This Distress Type applies only to 7 year warranties. This applies to all cracks, except longitudinal cracks above the interface of a rigid base pavement and a flexible pavement. The width of multiple cracks in a 1 foot (300 mm) width area is totaled to determine the width of the crack.

(2) This includes all types of disintegration, including, but not limited to, mix delamination, potholes, and raveling. This includes any type of disintegration that occurs at a joint or crack.

(3) An area of multiple patches is calculated as the width of the lane times the length of the patched area. These patches consist of Remedial Actions made by the Contractor or patches made by the Department in distressed areas that have been determined to be the Contractor's fault.

(4) For ramps the Threshold Level is 0.375 inch (9.5 mm), unless the pavement depth tapers down to an exit ramp terminus, then the 200 feet (60 meters) before the exit ramp terminus is waived.

(5) Measure the wheel path with a 4 foot (1.2 m) straight edge at 6 locations in a Segment. If one measurement exceeds the Threshold Level, the entire Segment will be measured at 50 foot (15 m) intervals for each wheel path. Remedial Action is required if six or more measurements exceed the Threshold Level.
To determine the depth of the distressed area, the Contractor shall cut a 1 foot (0.3 m) by 4 foot (1.2 m) slab to a depth necessary to determine the depth of the distress at a maximum of three locations determined by the DRT. The slabs shall be retained for possible use in any appeal process. Cost of this slab removal and replacement, including construction traffic control, is paid by the Contractor, unless it is determined the rutting is not the Contractor's fault. Slabs shall be removed within 30 days after receiving the results of the yearly review.

(6) For cracks less than or equal to 0.75 inches (19mm), rout out and seal all the cracks in the Section with Type 1 crack seal in accordance with Supplemental Specification 825. For cracks greater than 0.75 inches (19 mm) wide or multiple cracks in a 1 foot (300 mm) width area, the Remedial Action shall be Note 7. If there are more than 1000 feet (300 m) of cracks or routed and sealed cracks, the Remedial Action shall be Note 8.

(7) Remove and replace the distressed area to the depth needed to repair the distressed area.

(8) Remove and replace the lane width of the distressed area to a depth of 1.5 inches (38 mm).

(9) Remove and replace the surface in this Segment's lane to a minimum depth of 1.5 inches (38 mm), from the end of the first down station Segment with no patches to the beginning of the first up station Segment with no patches.