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**Development of
Warranty Programs
for Hot-Mix Asphalt
Pavements**

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Development of Warranty Programs for Hot-Mix Asphalt Pavements

A synopsis prepared by

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for the
General Issues in Asphalt Technology Committee
and the
Flexible Pavement Construction and Rehabilitation Committee
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PUBLISHER'S NOTE

This circular is a synopsis of current information for the development of warranty programs for hot-mix asphalt pavements prepared by Victor (Lee) Gallivan. The Transportation Research Board committees that reviewed the information in the document agreed that it could be of interest to transportation agencies contemplating the use of warranties for hot-mix asphalt pavements. The opinions and recommendations are those of the author and not the Transportation Research Board or the standing committees sponsoring this document.

Preface

Pavement warranties were first used in the United States in the early 20th century as local agencies began to pave all-weather roads to improve the lives of millions of Americans. Fred Warren, of the Warren Brothers Company, was an entrepreneur of the times. On June 4, 1901, the Warren Brothers Company patented their product called “Warrenite Bitulithic Pavement” and offered 15-year warranties. Warranties remained in use for several years, but as competition increased they were no longer offered. The Warren Brothers Company continued to offer warranties until the early 1920s.

In the 1950s, when Interstate construction expansion began, the use of warranties was explicitly disallowed. The federal government participated in the cost of building highways but maintenance was completely a state function. The Bureau of Public Roads (now the Federal Highway Administration) determined that warranties fell under the category of maintenance activities and therefore not permitted.

For the next 40 years warranties had limited use with states and local agencies, but they surfaced again on highway projects in the 1990s. Federal regulations were revised in 1995 to improve the long-term quality of roadways. Since then, several agencies have used different types of warranties with varying degrees of success. In some states legislative mandates have required the use of warranties. In addition, other state agencies have chosen to use them to achieve a higher quality product.

Warranties are defined as performance specifications that guarantee the integrity of a product and assign responsibility for the repair or replacement of defects to the contractor. A warranty is used to specify desired performance characteristics of a particular product over a specified period of time and to define who is responsible for the product. Six elements are typically included in warranty specifications:

1. Contract administrative requirements,
2. Distress identifiers and applicable thresholds,
3. Distress remediation,
4. Quality programs for binders, aggregate, production, and laydown,
5. Restrictions, traffic monitoring and performance evaluation of the pavement, and
6. Bonding or guarantees.

It is important that practitioners recognize the power of warranties during the development of the specifications and that the “game is played as the rules are written.”

—Victor (Lee) Gallivan
*Federal Highway Administration
Office of Pavement Technology*

Background of Pavement Warranties

Pavement warranties of the 21st century have been under development and refinement since their introduction in 1901 as local agencies began to pave all weather roads to improve the lives of millions of Americans (1, 2). On June 1, 1901, the Warren Brothers Company patented their product called “Warrenite Bitulithic Pavement” and offered a 15-year warranty for its performance. Warranties remained in use for several years, but as competition increased and, after losing patent protection in 1921, the use of warranted pavement diminished to near extinction. Those warranties lead to the birth of method specifications in an attempt to establish uniformity across state boundaries and give the agency maximum control of the production and product (3).

The latest interest in pavement warranties in the United States came about due, in part, to the reported European success of warranties in improving the quality of highways (4). Warranties have been successfully used in the highway industry to protect investments from early or catastrophic failures and to improve the quality of construction activities. The use of warranties in the United States is being driven by a variety of factors including the desire for improved pavement performance and pressures within the agencies to reduce field personnel that oversee the construction program. The warranty program process as provided herein is applicable to both hot-mix asphalt (HMA) and portland cement concrete pavements. The differences in the two products will be primarily related to the pavement performance indicators, thresholds, and remedial actions, but the specifications themselves are typically similar in format within the agency.

In the United States, warranty specifications have been part of a developing process for many years. A specification development continuum, illustrated in Figure 1, began without any specifications or limited maintenance guarantees in the early 1900s. In the 1920s governmental authorities began utilizing method-type specifications, defining each step in the construction process. In the mid-1960s, after noting construction and materials variability from the 1956 AASHO Road Test, agencies and industry leaders together determined that method specifications alone did not sufficiently control the construction process and developed new ways of specifying the product (5). In the early 1980s quality control–quality assurance (QC-QA) specifications, now referred to as quality assurance specifications, were developed to enable

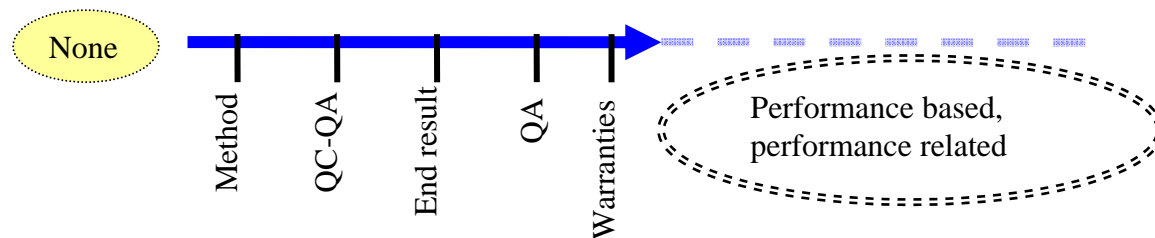


FIGURE 1 Specification development continuum.

the sharing of responsibilities for the construction of pavements. Following that were end-result type specifications that allowed agencies to specify what they wanted the final product to resemble. Warranties reentered the specification arena in the early 1990s to assist states in accelerating quality construction, improving pavement performance, increasing contractor innovation, and responding to reductions in available resources for agency field personnel. As with any developing process, there will be future advances made to meet the needs of the paving community.

Before 1991, FHWA had a policy restricting the use of warranties on federal aid projects. The rationale for the restriction was that FHWA statutes prohibited the use of federal funds in maintenance activities. Many believed that the use of warranties would effectively result in federal aid funds participating in maintenance costs. However, the desire for innovation in highway contracting practices resulted in legislation to encourage the use of warranties by agencies for highway projects.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) offered more independence by enabling the FHWA to delegate many of the project decisions to the states. The new regulations allowed states to utilize their own policies and procedures for federal aid projects located off the National Highway System (NHS). Under these conditions, agencies could use warranty clauses that were developed in accordance with their own procedures. Many agencies were interested in the use of warranties for highway construction projects but were not ready to undertake such a practice without greater FHWA involvement.

In December of 1991, a TRB task force evaluating innovative contracting practices documented its findings in *Transportation Research Circular 386: Innovative Contracting Practices*. Subsequently FHWA responded by initiating Special Experimental Project No. 14 (SEP-14), which includes activities that encouraged a number of highway agencies to use and to evaluate promising innovative contracting practices with the objective of enhancing the quality of highways (5). Included among these innovative practices were the use and the evaluation of warranties by eight states on a variety of federal aid highway projects.

On August 25, 1995, FHWA published an Interim Final Rule (IFR) for warranties for projects on the NHS, eliminating the restriction on the general use of warranties. The IFR states that “warranty provisions shall be for a specific construction product or feature and routine maintenance items are still not eligible.” The IFR also prohibits warranties for items not within the control of contractors. The provisions of the IFR were adopted as a final rule on April 19, 1996. The FHWA’s policy for warranties is codified in 23 CFR 635.413. (6)

The regulations were subsequently updated on December 10, 2002, with the inclusion of requirements for Design-Build projects with warranties. Warranties are permitted if they include the above noted restrictions and are not the sole means of acceptance of the project. Typically the term of the warranty is short and includes the quality of workmanship, materials and other specific tasks identified in the contract (6).

Nearly two-thirds of the states have varying degrees of experience with the use of some form of warranty provisions on federal aid highway projects. The use of warranties may be permitted or prohibited by the state’s statutes or administrative policies. Several states require the use of warranties where appropriate. For example, Michigan enrolled Senate Bill 303 of 1997 to include the following provision for development of warranties on state trunk-line construction projects: “Of the amounts appropriated for state trunk line projects, the department shall, where possible, secure warranties of not less than 5-year full replacement guarantee for contracted construction work” (7).

continually changing to keep pace with advances in technology and contracting methods. The following discussion of terms is provided by the author to serve as a general reference to address the fact that some of these terms are not well understood and their use is subject to a variety of different interpretations.

Warranty

A warranty is defined as performance specifications that guarantee the integrity of a product and assign responsibility for the repair or replacement of defects to the contractor. Warranty contracting places a greater emphasis on the quality of the constructed pavement than traditional contracts and shifts some of the construction risk to the contractor. Under a warranty specification, quality is measured based on the actual product performance of the pavement and not on the properties of construction materials or operations (11). A warranty is used to specify the desired performance characteristics of a particular product over a specified period of time and to define who is responsible for the product. Warranties are typically assigned to the prime contractor but may be passed down to the paving subcontractor as pass-through warranties.

The two types of warranties in the highway industry are materials and workmanship warranties and performance warranties. The difference between the two types is focus. Materials and workmanship warranties consider performance but the emphasis shifts more to material properties and workmanship issues that contribute to poor pavement performance. The focus of performance warranties relies on the future performance of the pavement as defined in the warranty with minimal direction on how to achieve the desired performance. There are inherent risks associated with either warranty which can affect the outcome of the agency warranty program.

Warranties are applicable to new construction, rehabilitation, or preventive maintenance type construction projects. Project selection criteria for pavement warranty projects should include the evaluation of the entire pavement structure from the existing subgrade to the surface.

Warranties are not appropriate for addition to contracts after the fact, to address substandard materials, or lower quality operations performed by the contractor. Warranties are intended to increase pavement performance by addressing quality during construction, not as maintenance agreements for covering maintenance costs or activities due to less than desirable execution of the construction contract.

Performance warranties are also not appropriate when simply applied to existing construction specifications.

Warranty Period

The warranty period is the prespecified time for the duration of the warranty and will vary by the type of warranty (Table 1). Based on the European experiences, warranties should be long enough to provide the agency assurance of pavement performance and so the contractor cannot provide inferior products or methods without risking failure. If performance warranty periods are too long, the cost of performance bonds may preclude practical use. This balance between agency risk and contractor risk must be considered. An agency should use pavement performance data from their pavement management system (PMS) to assist in making the determination of an appropriate warranty period.

TABLE 1 Typical Warranty Periods for Each Type of Warranty (12, 13)

Warranty Type		Warranty Period
Materials and Workmanship		2–4 Years
Performance	Short-Term	5–10 Years
	Long-Term	10–20 Years

Materials and Workmanship Warranties

Materials and workmanship type warranties require the contractor to correct defects in the pavement caused by elements within their control and assume no contractor responsibility for the design. The warranties are generally related to preventive maintenance treatments such as crack sealing and chip and seal coats and range from 2 to 4 years in duration, depending on the specific treatment. Materials and workmanship warranties should follow current standard specifications for the specific treatment. It is suggested that acceptance of these warranted projects be in accordance with normal practices.

Materials and workmanship type warranties reportedly have not caused any ascertainable increase of construction costs of the projects. These warranties have not had the reporting that is associated with performance warranties and as such, limited information is known (14–16).

Performance Warranties

Performance warranties require the contractor to assume additional responsibility for the actual pavement performance over a specified length of time. Performance warranties are generally grouped into two classifications of short-term or long-term warranties.

Short-Term Performance Warranties

The warranty period for short-term performance warranties generally ranges from 5 years to 10 years depending on the pavement type and the design of the project. These warranties include specific agency pavement performance criteria to be achieved. Project specifications for short-term warranties include the minimum materials and construction requirements acceptable to the agency.

Typically for short-term warranties for HMA pavements, the agency is responsible for the structural design requirements of the pavement and the contractor is responsible for the mixture design. The warranty program utilizes the contractor's quality control plan (QCP) to address construction details. The agency is responsible for the evaluation of the pavement performance over the warranty period. Final acceptance of short-term warranty projects does not occur until the specified warranty period has been completed.

States such as Wisconsin and Indiana have reported significant successes with short-term performance warranties (15, 16). Successes are being reflected in improved smoothness and lower surface deformation (rutting) values as well as reduced incidents of other types of pavement distresses on HMA pavements. Other states, however, have indicated some issues occurring on warranty projects (i.e., enforceability of the warranty provisions, and warranty evaluations after construction).

Long-Term Performance Warranties

The warranty period for long-term performance warranties generally ranges from 10 to 20 years. For long-term warranties, the contractor has additional responsibility to meet the minimum materials, structural, and mixture design requirements for the pavement. The contractor's QCP and procedures are used to address the construction details. The agency is responsible for the evaluation of the pavement over the warranty period. Final acceptance of long-term warranties does not occur until the specified warranty period has been completed. A limited number of long-term performance warranties have been completed in New Mexico, Colorado, Missouri, Mississippi, Kentucky, and Virginia (2, 17). Long-term warranties are in various stages of performance evaluation, and limited data are available for evaluations.

Design-Build with Warranties

Design-build (DB) contracts are a construction project delivery system where the design and construction aspects are contracted with a single contractor. This system is used to minimize the project risk for an agency and reduce the delivery schedule by overlapping the design phase and construction phase of a project. Pavement performance warranties are applicable to DB projects.

Public-Private Partnership with Warranties

Public-private partnership (PPP) contracting is a construction project delivery system which is funded and operated through a partnership between the agency and a private-sector consortium typically consisting of a construction company, designers, and financing companies. PPP contracts typically include long-term provisions and have been used internationally for a number of years. Pavement warranties are applicable to PPP projects.

ADVANTAGES AND DISADVANTAGES OF WARRANTY CONTRACTING

For agencies to achieve their goals and objectives for warranty contracting there must be an understanding of both the advantages and disadvantages to the contracting method. [Table 2](#), adapted from NCHRP Report 451 (18), is provided as a summary of 14 major issues to be considered.

COMPARISON OF WARRANTIES

[Table 3](#) is intended as a summary of the different aspects of pavement warranties and related issues. The source of the information is from unpublished FHWA documents.

Criteria for materials requirements are dependent on the length of the warranty period. The contractor should have greater control of material selection to compensate for the amount of risk taken.

TABLE 2 Warranty Contracting: Advantages and Disadvantages

Issue	Explanation	Impact
Compatibility with low bid system	Warranty contracting is compatible with low bid system.	The addition of warranties and multiparameter bidding introduces additional risk to the bidder.
Reduction of resources (staffing)	Warranty contracting will reduce the number of agency inspection and testing personnel assigned to the project and will increase the number of contractor's QC personnel depending upon their current operations. Agency staffing and costs for pavement maintenance operations over the life of the warranty is reduced since this is now under the control of the contractor.	Due to the reduction of agency contract-required testing as compared to traditional contracts, an overall increase of contractor's personnel has been shown.
Reduction of cost	Initially, the cost of warranty contracts is typically greater than traditional contracts due to the added costs related to quality control, bonding, and the perceived risk to the contractor. The cost for a warranty contract now includes both the initial cost and the potential maintenance operations over the life of the warranty.	Wisconsin DOT reports that the costs for warranty projects are lower as compared to traditional contracting. Typically, around the country, the warranty costs do come down from the initial highs (~5% to 15%) to nearly even levels once the cost factors and risks are better known by the contractors.
Improvements in the quality of the construction project	Performance warranty contracting has shown an increase in the overall quality of the product which results in longer-life pavements. Contractors do pay more attention to their processes since they now run the risk of repair or replacement of the work if it fails to meet the distress threshold levels in the future. There is a greater incentive to the contractors to construct a higher-quality pavement in the beginning.	Depending on the contractors' existing QC procedures, changes to their operations may or may not be necessary. If the pavement performance indicators meet or exceed the expectations, the contractor will have an opportunity for higher profits since remedial work will not have to be performed. Higher construction quality can be directly related to the long-term performance of the project.

(continued)

TABLE 2 (continued) Warranty Contracting: Advantages and Disadvantages

Issue	Explanation	Impact
Contract completion time (lane rental)	Due to traffic and other issues available time for construction is being reduced without regards to the quality of the project. Multiparameter bidding that includes time combines the intended need for higher quality of construction with shorter construction periods. Warranty projects have introduced added concerns that contractors may need to address such as the stability of the subgrade or subbases prior to placing the subsequent layers.	Contractors need to document all factors during construction that may affect the final performance of their product. The use of subcontractors is typical with the prime contractor still maintaining responsibility for the project. Contractors need to take a proactive posture with their subcontractors to ensure all work is completed in a timely manner and with quality in mind.
Initiation of warranty period	Initiation of the warranty period is suggested at the substantial completion of the last phase. For single-year projects initiation of the warranty period is not an issue but it is an issue for multiple phase (year) projects.	Starting the warranty period after the substantial completion of the entire project means that the initial phase of a multiphase project will have an additional year of trafficking. Agencies have a requirement to have a monitoring program to verify the performance of the pavement. Introduction of multiple phasing on contracts results in a significant impact on the agency.
Shifting of risk from agency to contractor	The agency is shifting some of the post construction performance risk of the pavement with warranties to the contractor. With performance warranties, the contractor is given more freedom to complete the work knowing that they now are responsible for the performance for years into the future.	The contractor assumes more post-construction risk than under a traditional bid-build contract. Typical construction bonding will extend 1 year post-construction for defects, etc. If the paving contractor is not the prime contractor, pass-through warranties are permitted to assign the risk to the responsible party.
Warranty program initiation (data and resources)	The agency needs to allocate dedicated resources in the specification development period beyond traditional contracting methods to collect, collate, and analyze system-wide performance data of pavements. These data are used in setting the warranty distress indicators, thresholds, and remedial actions.	The contractor needs to spend time researching and establishing production variability related to pavement performance. In addition, the contractor may need to conduct research in developing improved quality/process control methods appropriate for warranty contracts.

(continued on next page)

TABLE 2 (continued) Warranty Contracting: Advantages and Disadvantages

Issue	Explanation	Impact
Contractor innovation	For material and workmanship warranties the short warranty period provides very little opportunity for innovation. For performance warranties, contractors are not restrained as they are on traditional contracts from introducing alternative or other innovative construction methods or techniques. Due to the longer evaluation periods, innovation by the contractors may increase the product quality, increase the pavement performance, and definitely increase the profitability from the contract.	Agency concerns and contract acceptability criteria should be related to the performance of the pavement and not to the method of construction. This opportunity may be especially beneficial to small contractors with innovative ideas that allow them to compete with the larger contractors.
Project applicability	Warranties appear to be most applicable to small or medium-sized projects (i.e., materials and workmanship or short-term performance warranties). Starting a warranty program with a small number of projects with relatively simple scopes allows an agency to learn from previous experiences.	Smaller, less complex projects with warranties will allow for a larger number of bidders.
Dispute resolution	At this point the number of disputes on warranty projects has been limited due to several reasons. First, since the contractors make all operational decisions and know they are responsible for the pavement performance, decisions are made with quality in mind instead of production. On warranty projects, dispute resolution has not been an issue.	Agency and contractor representatives are members of the project conflict resolution team. The team is called together only as needed. For most warranty projects, the conflict resolution team is never called.

(continued)

TABLE 2 (continued) Warranty Contracting: Advantages and Disadvantages

Issue	Explanation	Impact
QA procedures	Warranty projects are an innovative contracting method. For performance warranties, acceptance by the agency will be on the final pavement performance at the warranty period. Traditional agency contract QA procedures are not applicable to short or long-term performance warranties.	Traditional acceptance procedures have been utilized occasionally by the contractors as a crutch to meet quality control requirements of the agency. Performance warranty contracts put the responsibility solely on the contractor. Changes to the agency QA programs are sometimes difficult to accept by both agency and industry representatives alike.
Traffic monitoring	One of the biggest unknowns and a key issue for determining the risk to the contractor is traffic. Escape clauses in performance warranty contracts reduce the risks if and when truck traffic meets certain conditions. The agency is responsible for monitoring and reporting traffic loads during the warranty period.	The contractor does assume more post-construction risk than on traditional contracts. The agency needs to demonstrate a proactive program to monitor the traffic.
Bonding	The agency needs to address bonding with contractors during the development of the specifications. The values of the warranty bonds and level of bonding during the warranty periods can vary, but are directly related to local issues on traditional bonding.	Warranty bonds are additional bonds related to the performance of the project over time. Warranty bonds do impact the cost of the warranty contract. During the development of warranty specification early discussions with surety companies will facilitate program implementation.

INTERNATIONAL SCAN FINDINGS

The 2003 report entitled *Asphalt Pavement Warranties Technology and Practice in Europe* (4) summarizes the observations and findings gleaned from the 2002 European scan. The lessons learned are relevant to this discussion in that the European and U.S. transportation communities are quite similar in terms of the political, financial, and resource challenges that they face.

The European host countries have a long history of warranties on pavement construction. These countries have employed material and workmanship warranties for decades. Although their warranty programs have developed independently through either government specification or industry promotion, all of the countries believe that warranties have improved the quality of their highway systems. However, many European countries work in collaboration with contractors or are even partners, as on the Italian Autostrada. Therefore, direct comparisons to the U.S. process should be made only very generally.

TABLE 3 Aspects of Pavement Warranties

	Warranty Type		
	Materials and Workmanship	Performance	
		Short-Term	Long-Term
Type of specifications	Agency current standard specifications.	Agency-specified minimum materials and construction requirements acceptable for project.	Agency-specified minimum structural design, mixture design, materials, and construction requirements acceptable for project.
Agency responsibility	Design, evaluation.	Structural design, evaluation.	Evaluation.
Contractor responsibility	Correct defects in pavement caused by elements within their control.	Mixture design, QCP, and pavement performance for warranty period.	Structural design, mixture design, QCP, and pavement performance for warranty period.
Acceptance of project	In accordance with agency normal practices.	Initial: construction activities. Final: after specified warranty period is completed.	Initial: construction activities. Final: after specified warranty period is completed.

Materials and Workmanship Warranties

At a minimum, all of the host countries use materials and workmanship warranties on their traditional contracts. These warranties ensure that the contractor will build the pavement as specified by the owner and fix any defects resulting from the use of inferior materials or improper installation. Depending on the country, the highway agencies may seek a remedy of defects from either the prime contractor or the asphalt contractor, if the prime is not the asphalt contractor.

On projects designed by the highway agency, the typical warranty periods vary from 1 to 4 years in duration. Performance indicators including rutting, cracking, and durability are used on materials and workmanship warranties.

Performance Warranties

Performance warranties are used on traditional contracts as well as on DB contracts. A performance warranty includes material and workmanship, but since the contractor is responsible for some or all of the pavement design, it includes performance of the complete asphalt pavement.

The host countries typically use a 5-year warranty period for performance warranties. Although the design life of asphalt pavements is much greater than 5 years, that period provides for adequate performance measurement of the product without unduly burdening the contractor to warranty the product for the entire design life. In addition to rutting, cracking, and durability, performance measures of smoothness and friction are often used.

Performance warranties allow for contractor innovation in mix design and/or material installation. The host countries described varying levels of innovation that stemmed from the use of performance warranties, but all countries described a greater level of innovation than was available through material and workmanship warranties (5).

Best Value Procurement

All the host countries use best value procurement in lieu of low bid. Best value procurement involves awarding the contract on technical or performance items in addition to cost. Best value criteria include safety, innovation, and environmental impact. The bidding of additional years of warranty may also be included as a best-value criterion. In some cases, prequalification was used as a filter in the best-value process. Although the best-value criteria and weights varied, all of the hosts stated that the practice was critical to their warranty program. For warranties to function effectively, highway agencies, and the industry must have a higher level of trust and greater confidence in the contractor's ability to perform. Best-value procurement is one mechanism to promote this trust and confidence.

Alternative Contracting

Similarly to the United States, the European hosts are dealing with growing capital project needs, as well as a backlog of maintenance needs. They are also dealing with a shortage of staff and a changing role of government. All of the host countries are looking at alternative contracting as a mechanism to increase innovation without creating a burden on highway agency staff. Pavement performance contracting (PPCs) and DB–finance–operate (DBFO) contracts are extending warranty contracts up to 30 years and assisting with the growing needs.

Pavement Performance Contracts

PPCs extend performance warranties to include a warranty period that is closer to the design life of the pavement. In a PPC, the contractor is responsible for designing, constructing, and maintaining the performance of the pavement to prespecified levels. All of the host countries are employing or experimenting with some variety of pavement performance warranties with warranty periods of 11 to 20 years. In some instances the highway agencies are promoting PPCs, however in others, the industry is the catalyst. In all of the host countries, the PPCs are developed with close government and industry collaboration.

Depending on how the contractor proposes to build the pavement, the maintenance can include a number of items from filling of isolated potholes and minor pavement re-marking to a complete mill and overlay of a significant section of pavement. The highway agencies are simply looking to the industry to provide a pavement that performs to prespecified standards. The PPCs allow for much more innovation from the industry, however, the industry must be willing to take a substantial risk. The contractors must have design, construction, and maintenance competencies to compete for PPCs.

DBFO Contracts

A couple of highway agencies are changing from service providers to owners and managers of the highway system. A small fraction of the highway network is turned over to the private sector for long-term financing, operation, and maintenance. The terms of the DBFO contracts range from 15 to 30 years, and there are experiments with even longer periods. Drivers for the use of DBFO contracts range from a lack of public funding to a belief that private financing and

maintenance deliver a higher-quality product and provide benchmarks for public-sector performance.

It should be noted that none of the host countries are using PPCs or DBFO contracts as a panacea for transportation needs. Rather, they are taking a balanced contracting approach through the use of a variety of the warranty contracts described in this document.

The World Bank has also provided pavement performance specifications for the procurement of performance-based contracts to over 100 participating countries. Examples are available on service-level criteria for pavements and shoulders that include: cleanliness, cracking, deflection, loose pavement (edges), patching, potholes, raveling, roughness, and rutting (19).

PAVEMENT WARRANTY CONSIDERATIONS

According to NCHRP Report 451, the agency needs to establish their objectives for implementing a warranty program upfront and they need to articulate them to other divisions or units within their agency and to industry to gain support of all parties (18). The following is listed to address some of the issues that need to be taken into consideration when using pavement warranties.

Cost-Effectiveness

The short and long-term cost-effectiveness of warranties is an issue that all agencies have to address. Evaluations of short- and long-term HMA warranties reported by agencies across the country have shown an increase in the initial construction costs of the project by 3% to 15% (10, 20). The increased costs of the warranty are directly related to the increased risk perceived by the contractor. As contractors gain experience in warranties, construction costs may decrease due to a better understanding of risk and the use of innovative construction techniques. Alternatively the price may remain the same or higher resulting in higher margins for those contractors willing to take the risk or who know how to manage the risk. In the low-bid environment the actual cost increase depends on various market forces (10, 14, 15, 21, 22). Cost-effective innovations have been utilized to speed up construction activities without sacrificing quality. Shifting the project-related decisions to the contractor provides freedom to make cost-effective decisions.

There is generally an increase in costs to the agency in the monitoring, verification, and reporting of the operations during the period of the warranty over that of conventional projects. These costs have generally been subsidized by the agencies, but do need to be considered in the overall operation of the warranty program. Reports from several states include discussions on assessing the cost-effectiveness of their warranty programs (14, 15, 20, 21).

Improved Performance

Measurable improvements in performance have been reported by some agencies on projects built with performance warranties, with some other agencies reporting no significant differences (15, 16, 20). Some of these agencies found the performance of HMA short-term warranty projects exceeded that of equivalent nonwarranted projects when evaluating distresses of smoothness and rutting. HMA pavements with fewer defects are safer over a longer period of time, which can be directly related to reducing delays and congestion on the facility and are cost-effective over the

warranty period. The Indiana DOT reported a 9-year increase of pavement life using a performance warranty over that of non-warranty contracting assuming a constant terminal smoothness as illustrated in Figure 3 (16).

Some agencies, such as Colorado and Michigan, have reported less than desirable results for projects where performance warranties were utilized, which caused the reevaluation of the program to address the needs of the agencies (14, 15).

Industry Concerns

Often there is initial resistance from the pavement construction industry when implementing new contracting methods or changes to an existing contracting process. The partial or complete shifting of responsibility for the performance of the roadway to the contractor is viewed as an economic risk. However, accompanying the shift in responsibility, there should also be more freedom for contractor innovation. It is ideal if the warranty program allows the contractor to make decisions about the design and construction that today are made by the agency. Creating the balance of benefits and understanding the newly established responsibilities of the warranty program are facilitated through the buy-in and support of the industry.

Risk

Risk is directly related to industry's knowledge of process, knowledge of materials, and knowledge of how to produce quality work. If the agency warranty specifications are developed with an understanding of the availability of materials and the abilities of industry to provide a quality product, risk is reduced. Risk does become an issue when the existing agency-industry procedures do not include the basic tenets for good quality control systems, design, and project selections.

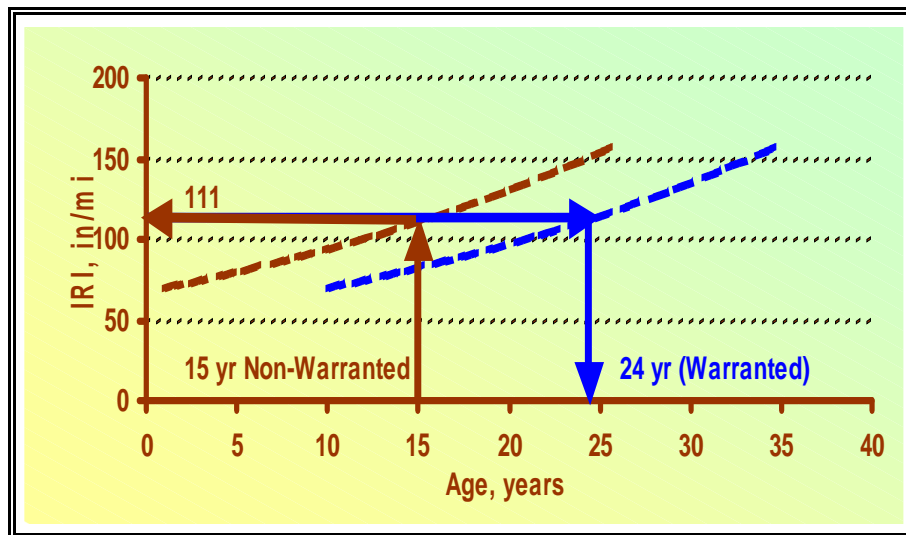


FIGURE 3 Indiana DOT smoothness results (16).

Partnering for Bonding

One integral part to all warranties is the ability of industry to secure the appropriate bonding to accomplish the work and not tie up excessive bonding authority far into the future. This is clearly an area where the industry and agency need to come together in mutual support. Currently agencies vary the methods of bonding on projects that include level, stepped, or straight-line depreciation of liability over the length of the warranty. Another approach is a guarantee program that is tied into the prequalification procedures in lieu of special bonding for the warranty items. Examples of guarantee programs are in Florida and Ohio. No matter which alternative is selected, partnering with the bonding companies is required to ensure their knowledge of the program is commensurate with the agency goals.

Agency Concerns

As with any new program or change to an existing system, there may be a need for an initial realignment of resources within an agency to develop a warranty program. To some extent, concerns that industry may have in terms of risk, culture, and contracting practices could also be reflected within an agency.

Risk

A shift in responsibilities may cause a similar reaction for an agency as with the industry. Agency resistance stems from a perceived lack of control. Current method or prescriptive type specifications lend themselves to the agency engineer having direct control of a project, using the specification book as the baseline authority. Under a warranty specification, the engineer has less ability to control the details of the project. To be effective the agency will need to make adjustments in pavement specifications, field inspections, contract acceptance, and verification procedures.

The risk to the agency is also related to the knowledge of the materials process and knowledge of quality work. If the agency warranty specifications are developed with an understanding of the availability of materials and the abilities of industry to provide a quality product, risk is not an issue. Risk does become an issue when the existing agency–industry procedures do not include the basic tenets for good quality control systems and project selections.

Culture

Moving toward a pavement warranty program is not only an administrative change, but often also a change in culture. The agency can facilitate the change by addressing the concerns and perceptions of engineers and technicians. Some of the resistance could be related to job security and the capability of the personnel to take on different responsibilities. In reality, most agencies are being reduced in size in terms of personnel and resources. In an attempt to supervise larger construction budgets, agencies are stretching personnel to cover more projects leading to the potential for less involvement of personnel than in the past. The shift in responsibilities afforded by a warranty program has the potential for the agency to reallocate resources and personnel to the role of product evaluation and acceptance.

Contracting

For materials and workmanship and short-term performance warranties, contracting will continue to use the low bid method in accordance with the agency procedures. For long-term performance warranties, although low bid contracts have been utilized, agencies may wish to investigate best-value–prequalification-type procedures to ensure the capabilities of industry to construct and to manage the contracts. For some agencies, this may necessitate legislation changes and participation in the SEP-14.

Selection Procedures for Pavement Warranties

The primary question to be asked should be why agencies should consider using warranties? Warranties are one of several innovative contracting methods that states have to advance construction projects. States are all trying to improve the quality of the construction operations and extend the performance of their pavement projects. It has been demonstrated that to improve the performance of a project, quality has to be built into the project which means sharing the responsibility for the performance of the pavement with the contractor. One of the best and most equitable contracting methods to advance the quality and improve the pavement performance may be through a pavement warranty program since it promotes innovation by the contractor.

While there are several choices in the types of warranties that can be used for pavements, the most benefit can be gained through the use of short- and long-term performance warranties. Performance type warranty specifications have been documented to reduce the life-cycle costs of the facility by improving the performance of the pavements (10, 14–16). To continue the trend toward improved pavement performance, it is important to examine and to implement the best practices and lessons learned by agencies in the United States and abroad. The successful use of pavement warranties is dependent upon understanding of the issues as well as the support of all parties involved.

There are a number of issues to be considered when implementing a warranty program. While there are many potential benefits, such as improved performance, there are also adjustments that will need to be made within the highway construction industry and the agency as well as in the bonding requirements. The agency and contractors risk also has to be minimized to achieve a good warranty program.

SPECIFICATION DEVELOPMENT

Pavement warranty projects require specifications that will be substantially different than the specifications most agencies use on most other types of projects. This section will identify issues an agency needs to consider in developing specifications for pavement warranties.

Independent of the type of warranty specification is the need for buy in by both agency and industry representatives. Bringing the representatives together develops a better understanding of the specifications and the meaning behind the specifications. Discussions with the bonding companies upfront may provide critical information as to what the bond includes, the responsibilities of all parties, and the remediation process. Industry and agency concerns need to be discussed fully.

The agency typically provides the design year traffic or equivalent single axle loads (ESALs) for all warranty projects and to identify the number of Class 5 and above vehicles for a traffic-level threshold. The contractor needs some maximum volumes to establish the risk. Normally if the number of Class 5 truck ESALs exceeds 150% of the design levels, the contractor is released from the warranty. In order to obtain this type of information accurately, it may be necessary to install automatic vehicle classification (AVC) devices in the vicinity of the warranty project, or rely on a nearby weigh station, for the warranty period. Holding the contractor to unlimited increases of traffic is beyond the contractor's control. Increasing the risk to the contractor will increase the cost of the project.

A key element that needs to be discussed includes the utilization of existing quality assurance procedures used in other non-warranty contracts. Acceptance of materials and construction activities is dependent on the QC-QA procedures. Acceptance of warranty activities is dependent on the field measurement and evaluation procedures to be utilized for the warranty projects. If an agency does not have QC-QA processes in place for a particular warranted program, the use of performance warranties should not be considered. The warranty specifications should include areas as described below.

Materials and Workmanship Warranties

Materials and workmanship type warranties require the contractor to correct defects in the pavement caused by elements within their control and assume no contractor responsibility for the design. Materials and workmanship warranties follow current standard specifications for the specific treatment. Acceptance of these warranted projects is in accordance with normal practices. The only difference is that the contractor carries the additional risk of premature failures and subsequent repairs beyond the normal bonding contract requirements of the agency. The specifications need to be modified to include the pavement criteria to be used for acceptance.

Short-Term and Long-Term Performance Warranties

The development of agency specifications for short-term and long-term performance warranties is dependent on the contracting procedures with the differences being primarily in length of warranty, bonding-guarantees, roadway design requirements, magnitude of the project, risk, and acceptance criteria. The core elements for both types of performance warranties that should be included in the specifications are

1. Description,
2. Warranty bond-guarantee requirements,
3. Conflict resolution team,
4. Permit requirements,
5. Pavement distress indicators, thresholds, and remedial action,
6. Elective-preventive actions,
7. Agency maintenance responsibilities and traffic volume monitoring,
8. Method of measurement,
9. Basis of payment,
10. Quality-process control plans,
11. Verification and evaluation (objective versus subjective), and
12. Final warranty acceptance.

Core Elements of Warranty Specifications

These elements are described in the following sections.

Description

The specification should clearly establish what work is being warranted. Mainline pavement is typically targeted as the warranted item, but if auxiliary lanes, shoulders, or other work (such as subgrade, base, or roadway hardware items) are included it needs to be clearly spelled out. In addition, the date or time when the construction activities end and the warranty period begins should be clearly defined. This is very critical when considering a multiyear contract or multiphased construction as part of the warranty project. Typically, the warranty begins when the construction project is completed and opened up to unrestricted traffic regardless of the phasing or the length of the construction time of the project.

Short-Term Warranties It is ideal for the agency to establish the minimum materials requirements for HMA pavements regarding binders and aggregates.

Long-Term Warranties The contractor is responsible for all QC activities and should be responsible for the minimum materials and pavement and mixture design requirements as applicable.

Warranty Bond–Guarantee Requirements

The bonding requirements to assure the resolution of any noted deficiencies during the warranty period are defined as the warranty bond. Warranty bonds can be developed with various elements such as constant level, straight-line depreciation, stepped depreciation, or a variable depreciation over the length of the warranty. It is critical to include all warranted items into the bond.

Material and Workmanship Warranties Agency bonding requirements for initial construction activities are typically the same as for non-warranty projects, except for the addition of the warranty criteria used for acceptance.

Short-Term Warranties Agency bonding requirements for initial construction activities are typically the same as for non-warranty projects. For HMA, the warranty bond cost includes only the cost of replacing the surfacing materials. If the construction project and the warranty include the subgrade, the warranty bond may include all of the pavement materials (full depth).

Long-Term Warranties Bonding is more difficult because it generally includes the design of the pavement and the paving materials. A bonding-guarantee program in conjunction with prequalification and best value bidding is used in lieu of straight line bonding. The bonding-guarantee issue is critical to both the agency and industry. Discussions with bonding representatives during the development of the warranty specifications usually provide effective results.

Conflict Resolution Team

Disputes on warranty projects are generally fewer than on non-warranty projects due to collaborative attitudes between the parties, but they can occur, therefore a means of resolution is

necessary (10). Projects with warranty specifications generally are not handled as typical agency projects due to the increased responsibilities of the contractor in the project, and therefore the specifications need to include provisions to address potential disputes. A conflict resolution team should be established to address these disputes. Typically the team consists of two representatives selected by the agency, two representatives selected by the contractor, and a fifth independent representative jointly agreed to by both parties. The actual number of team members is not critical, but it does need to be manageable with an uneven number of members. All members of the resolution team need to be knowledgeable of general materials, construction requirements and programs, as well as the terms and conditions of the warranty specifications. The conflict resolution team members need to be identified in writing at the preconstruction meeting to establish project continuity.

The scope of the conflict resolution team responsibilities is included in the warranty specifications and should address issues concerning the warranted pavement relative to material selection, contractor's construction activities and QCP, warranted pavement distress rate, measurement and calculation of pavement distresses, and evaluation and remediation of pavement distresses. Provisions are provided to address impasses within the team. Team decisions are based on consensus or majority votes with the recommendations submitted to the head of the agency for the final decision if required by state laws regarding dispute resolution. Independent of the duties of the team, the specifications need to be clear that the team's function is to review the warranted items during the warranty period as well as the construction activities. Team members may be replaced from either the agency or the contractor due to change of duties or positions during the construction or the warranty performance period.

Caution is needed when establishing conflict resolution teams, in particular to the legality of the team. State laws and agency regulations need to be evaluated and complied with during the development of the specifications. Some agencies require all final decisions to be made by the head of the public agency, or its public designee, rather than a joint agency-contractor team when public monies are involved.

The conflict resolution team is only assembled on an as needed basis and any expenses for the independent representative are typically shared by both the agency and the contractor. Most of the projects to date have indicated that the team has never convened due to the heightened level of partnership at the project level.

Permit Requirements

During the warranty period remedial work may be performed by the contractor at no cost to the agency based on the results of pavement distress surveys. Best results occurs when contractor and the agency make a joint decision on the remedial work to be performed and the specifications and materials to be used. Ideal warranty specifications include procedures for remedial actions that address the needs and responsibilities of both the agency and contractor. Depending on agency requirements, general roadway permits may be necessary to allow the contractor to work on the roadway after the initial construction activities are completed. For example, if the contractor proposes to conduct remedial work in advance of the pavement distress surveys, work permits may need to be obtained from the agency. The agency requirements for roadway permits typically include any specific additional details regarding lane closures, testing protocols, and traffic control requirements. In addition, prior to proceeding with

any remedial actions or monitoring activities, the contractor may also need to obtain other permits from the relevant agencies.

The following are examples of these additional requirements:

- Lane closure periods. Lane closures are the same as lane rentals. For example, if the agency requires a minimum number of mainline lanes to be open to unrestricted traffic during construction closure period requirements need to be included. Specific rates related to dollars for various traffic volumes, mix or time periods will need to be developed by the agency. The values for the closure periods will be the same values used during the warranty performance period for remedial work. These rates and time periods may be defined as in the example below:

Peak hour:	\$2,000.00/lane/hour
Nonpeak hour:	\$400.00/lane/hour

Weekday and weekend peak hours are from 6:00 a.m. to 8:00 p.m., and nonpeak hours are from 8:00 p.m. to 6:00 a.m.

- Testing protocols. During the warranty period the contractor may monitor the warranted pavement using nondestructive procedures. All proposed remedial action should be coordinated with the agency.
- Traffic control. Traffic control in accordance with agency requirements is required to ensure the safety of the traveling public. Agency advance signing and lane closure procedures shall be utilized and coordinated with the agency prior to initiating the activities.
- Pavement evaluation. The contractor, without prior consent of the agency, may not perform coring, milling, grinding, or other destructive procedures to evaluate the pavement. If the contractor elects to conduct any independent testing, both destructive and nondestructive, the equipment shall be calibrated and correlated with the agency equipment. The contractor shall not be responsible for damages to the pavement as a result of coring, milling, or other destructive procedures conducted by the agency.
- Remedial work. The contractor should have the first option to perform remedial work. If, in the opinion of the agency, the problem requires immediate attention for the safety of the traveling public and the contractor cannot perform the remedial work within 24 h, the agency has the option to have the remedial work performed by other forces. The contractor is responsible to pay for all the direct costs incurred. Remedial work performed by other forces will not alter the requirements, responsibilities, or obligations of the warranty.

Examples of remedial work areas are typically defined as 150% of the distressed area. Where remedial work is not separated by at least 1,000 ft, the remedial work may be required for the entire area contiguous to the distressed areas, including intermediate areas otherwise requiring no remedial work.

Pavement Distress Indicators, Thresholds, and Remedial Action

When developing a warranty specification, the agency needs to consider several factors to establish pavement distresses, thresholds, and remedial actions. The indicators should be chosen as they affect the road user and the performance of the pavement (18). Then the agency needs to consider the length of the warranty period, the type of project being considered (i.e., new construction, rehabilitation, resurface, or preventive maintenance), the highway system being

considered (i.e., Interstate, two- or four-lane high volume facility, etc.), and the condition of the pavement management data for all the above considerations. Utilizing warranties does not change the agency's responsibility to the public to maintain a high level of pavement condition that is safe to use and to minimize any future delays or congestion due to premature pavement deterioration. Appropriate warranty criteria are based on the properties collected by the agency as part of the PMS and are measured objectively using current technology to the maximum extent possible. Additionally, the frequency of the PMS evaluations needs to be factored into the process, as this will be utilized in the warranty pavement evaluations. The uses of subjective distress evaluations are not ideal. Warranties are best used for mainline, auxiliary lanes, and shoulders. Ramps, turn lanes, and other miscellaneous pavement elements are considered incidental to the mainline pavement and are generally not included in the warranted provisions evaluation even though they may be part of the initial construction project.

Analyzing the PMS project data based on age and highway system will establish a baseline for determining the thresholds. Typically, PMS data systems are based on 1-mi segments, which is not appropriate for warranty projects. It should be noted that a further reduction of the segments to 0.1 mi or less will provide the degree of pavement variations to objectively evaluate the condition of the pavement over the warranty period.

For HMA warranty projects, typical pavement condition indicators include friction, International Roughness Index (IRI), longitudinal cracking, rutting, and transverse cracking (23). These pavement condition indicators are provided based on the assumption that the operations are under the control of the contractor.

Depending upon the completeness of the agency PMS data, additional indicators are included, but only if those objective indicators directly affect the safety of the facility and the performance of the pavement. For example, segregation, fatigue cracking, and block cracking of HMA pavements do affect the long-term performance of the pavement, but these distresses can only be measured subjectively or are related to the structural design. It is not appropriate to include them as pavement indicators for warranty projects. Nonobjectively measured distresses are addressed through indirect, but measureable, performance indicators such as smoothness. The use of subjective indicators increases the risk to the contractor and the cost of the project.

Establishing the threshold criteria for the pavement distresses is dependent on the availability of the data and should be realistic and attainable based on historical PMS data. Setting extreme limits may cause the contracting industry to unbalance the bids to account for unreasonable quality limits for the project. For example, the local rates of rutting in HMA pavements over time are typically known by the agency and there should be a good understanding of the rutting issues. To determine the warranty distress indicators, the agency can use the average rutting experienced on different types of pavements based on age and highway system of the proposed warranty project. Then by calculating the standard deviation of the segments the agency can establish the initial thresholds. The warranty distress indicators for rutting are typically set at two standard deviations from the mean of the segments which represents 95% of the pavement sections would meet the threshold chosen values. The same process can be repeated for smoothness and friction. After the initial thresholds are established, further evaluation of the PMS database can be made to identify outliers in the data and determine their effects on the results. The use of the FHWA Distress Identification Manual (23) is an excellent source to standardize the definitions of the pavement performance indicators.

Remedial actions for addressing pavement distress must be acceptable to the agency. The agency will be assuming liability for the roadway at some point following the initial construction

activities and warranty period, and agency assurance of continued pavement performance is needed.

Using objective methods to establish the pavement warranty distress indicators provides a better understanding of the intent of the warranty specifications to contracting, bonding and industry representatives. The use of subjective indicators should be minimized.

Elective–Preventive Actions

Elective–preventive actions can be performed at the contractor’s option and with agency concurrence. Maintenance operations (by the contractor) to keep the pavement within the limits of the distress indicators are the responsibility and the judgment of the contractor. Typical preventive maintenance operations for HMA pavements include crack sealing, patching, or surface replacement or treatments. For elective–preventive actions closure periods for assessments are not normally charged to the contractor.

Agency Maintenance Responsibilities and Traffic Volume Monitoring

The warranty specifications need to clearly state the roles and the responsibilities of both the contractor and the agency regarding maintenance responsibilities. The contractor is responsible for the performance of the pavement for the warranty period. The agency assumes normal routine maintenance responsibilities during the warranty period for items not related to the warranty such as snow plowing and applying de-icing chemicals, repairs to safety appurtenances, pavement markings, mowing, and sign maintenance. The warranty specifications need to clearly state that during the warranty period, the agency will not perform routine pavement maintenance activities. Contractor and agency responsibilities will vary by the type of warranty. Long-term or pavement performance contracts especially need clarity regarding the pavement maintenance responsibilities and the safety related roadway items such as pavement marking, roadside signs and guardrails, etc.

Method of Measurement

The agency needs to consider various methods to address the measurement and payment for the warranted pavement. Short- or long-term risk for pavement performance is the contractor’s responsibility and it is generally included in the construction costs. Agencies can decide if the cost for the pavement warranty itself will be included in the cost of the bid item (either by the unit measurement or lump sum value) or as a separate lump sum pay item. Warranty expenses generally include the costs for additional bonding for the specified warranty period, additional testing of materials, anticipated preventive maintenance activities, and possible remediation activities. To facilitate the documentation of the costs of warranties, agencies may consider utilizing their standard measurement procedures for the pavement items for the warranted HMA pavements and use a separate lump sum pay item for the pavement warranty cost. The agency is responsible for determining the pay quantities for warranted projects.

Basis of Payment

The basis of payment for construction activities is dependent upon the method of measurement for the warranted pavement. The specifications need to include in the cost of the warranted pavement, full compensation for furnishing, preparing, hauling, mixing and placing all materials. Additionally, the payment will be for the cost of the warranty bond, warranty work, mixture designs, quality control plan and all testing, recordkeeping, sampling and traffic control for remedial or elective–preventive actions.

Typically, warranty projects do not include price adjustments for various pavement construction elements such as the initial smoothness of the pavement or degrees of compliance with the targeted material elements. It is an agency decision to use price adjustments for material costs during construction (i.e., liquid binders, fuel). Some agencies have included incentive payment procedures for significant construction compliance. Including incentives as part of the construction project leads to paying for incentives twice: once for the construction work and the second for the pavement performance work. Incentive provisions for construction compliance are not to be included.

The initial warranty specifications need to include details if incentive payments will be made during the warranty period. For long-term performance warranties, increased payment for construction activities or the warranty is not to be included.

Quality–Process Control Plans

The contractor's QCP is a critical element to the success of a pavement warranty program. A QCP is a project specific written document made up of both of the contractor's QC and process control operations. Quality control includes those QA actions and considerations necessary to assess and adjust production and construction processes so as to control the level of quality produced in the end product (13). Process control includes monitoring the input material properties and processes used to manufacture the final product.

The contractor's QCP should be provided to the agency, maintained in a timely manner, and followed to assure the agency that all materials furnished and placement operations are in accordance with the warranty specifications and the QCP. The QCP is not to be approved by the agency, as this assumes ownership and responsibility of the contents. The agency may disagree with elements in the QCP and has the option to refer comments to the conflict resolution team for disposition. The QCP should note the following as a minimum.

- The procedures to be used for the design of the mixture, sampling, and testing of all materials, and methods and frequency of calibration of all testing equipment.
- Contract-specific details for placement activities and anticipated testing frequencies.
- Names and qualifications of the personnel who will be conducting sampling and testing of materials.
- Mixture design methodologies.
- List of all materials proposed to be used, including specific properties of each and sufficient documentation to demonstrate that all materials meet standard quality requirements for the application. The contractor is responsible for certifying to the agency that all products used during production meet the quality requirements as established by the contractor in the QCP.

- Mixing plant requirements, including the calibration of all meters, scales, and other measuring or recording devices.
- Proposed sampling procedures and size of samples necessary for testing and controlling the HMA mixtures.
- The test methods and minimum frequencies of the QC tests.
- QC charting including the limits for quality control activities to meet agency established thresholds.
- Compliance with the agency-independent assurance program procedures.
- Procedures for documenting all material certifications, production test reports, QC charts, test equipment certifications and calibrations, and any other material or design or production-related records.
- Record-keeping procedures to ensure that all records, either electronic or paper, are maintained in a readily accessible location for access by the agency at any time. Upon completion of the placement and the opening of the warranted HMA pavements to traffic, the contractor is responsible for providing copies of all QC records to the agency.

Verification and Evaluation

The agency is responsible for routine evaluations of the warranted pavement during the warranty period. The agency needs to clearly indicate how the pavement condition will be verified for each of the warranted pavement indicators and who will be conducting the evaluation during the warranty period. The agency will evaluate the findings from the field verification and will report the conditions to the contractor annually, biannually, etc., and at the end of the warranty period. During the warranty period, the contractor has the right, with the agency concurrence, to independently review the condition of the warranted pavements for their use and information. At a minimum, the agency is to verify the condition of the project at the completion of the warranty period. Intermediate evaluations can be included at the discretion of the agency, but the frequency needs to be identified in the specifications.

To minimize discussions regarding the accuracy of the evaluations, the agency needs to make the evaluation process as objective as possible. The agency Highway Performance Monitoring System (HPMS) and PMS programs typically are objective and repeatable, and therefore are ideal for evaluating the warranted pavement distresses. Pavement indicators such as friction that are not part of the HPMS program can still be objectively evaluated by utilizing the agency's existing pavement friction evaluation program.

During the course of the evaluations the agency should also note any general pavement distresses. Most of the pavement indicators are not reviewed continuously throughout the warranted project and are typically only in the driving lane. If any values exceed the thresholds, more detailed testing and inspection may be conducted to determine the extent and limits of the distresses. Any area showing deficiencies outside the tested lanes or sample sections may also be tested and used to determine the pavement warranty acceptability and to verify the uniformity of the quality of the project.

Roughness measurements may be used to monitor the performance of the pavement in lieu of distress surveys. Pavement distresses such as cracking, corrugations, or distortions are not measured or rated directly, but they may affect the ride measurement and may need correction to provide satisfactory warranty values. The ride measurement by itself does not indicate why the ride may be unsatisfactory. Detailed inspection and testing to examine individual distress

mechanisms will be required to determine the remediation to provide the quality necessary for the expected service life of the pavement.

Objective field evaluations cannot be omitted based on subjective observations that the pavement is in good condition.

Final Warranty Acceptance

The agency needs to specify what will constitute final warranty acceptance. As a minimum, this section in the specifications needs to consist of a field evaluation that addresses each of the warranted pavement indicators and written documentation that transfers pavement maintenance responsibilities back to the agency.

BONDING REQUIREMENTS OR GUARANTEE ISSUES

The purpose of bonding or guarantee is to provide the agency the assurance that any noted deficiencies will be resolved during the warranty period. Most agencies currently require a construction bond that covers the actual construction period, which typically includes one additional year beyond construction for general workmanship issues.

Warranty bond alternatives have been developed using various methods to reduce the outstanding bonding requirements for contractors, including a constant level, straight-line depreciation, stepped depreciation, or a variable depreciation over the length of the warranty. The Florida DOT has moved away from bonding altogether, replacing it with a contractor's prequalification program that is heavily weighted towards performance. Florida DOT limits the bidders on warranted pavement performance projects to only those that have a high performance rating.

Materials and workmanship warranties typically utilize the constant level bonding method for the warranty period. The bonding is typically just an extension of the initial construction bond.

Performance warranties are dependent on which type of warranty is being developed since short-term and long-term warranties have significantly different requirements.

- Short-term warranties: typically utilize the constant level or straight-line depreciation methods. With the warranty periods less than 10 years, the agency's options are generally limited.
- Long-term warranties: agencies have more options to address the contractor's responsibilities and liabilities. Discussions with the local bonding representatives early in the development of the warranty programs are critical to establish knowledge of the programs. Experience has shown that in agencies with multiple warranty projects, the bonding costs have been reduced over time. Initial resistance by bonding representatives can be addressed with clarity in the warranty specifications, knowledge of the contractors completing the warranty work, and knowledge of the agency warranty program.

There are several bonding requirements related to the implementation of warranties that include the length of the warranty period, the mitigation plan for observed distresses, and the timeframe for repairs, in addition to the contractor's experience and qualifications to perform the

work. Various agencies have utilized alternate methods to determine the value of the pavement warranty bond and accompanying payment procedures. Regardless of how the agency determines the program, the bonding requirements need to be clearly detailed in the specifications. The following is a sampling of methods for determining the bonding level for warranted projects (Table 4).

PROJECT SELECTION

As the lessons learned from our European counterparts indicate, not all projects lend themselves to the use of pavement performance warranties. There are other contracting mechanisms that may be more appropriate to consider. This section describes how to select the type of warranty to meet project conditions. Warranties are just one innovative contracting alternative to select from to meet project and agency requirements.

Project selection for warranties is just as critical as the development of the specifications and, depending on the type of warranty, only certain types of projects will be good candidates for warranties. Key points in the selection process include:

- Material and workmanship warranties are typically limited only to preventive maintenance surface treatments, making project selection generally easier. Exceptions to this are microsurfacing. Care has to be taken not to select a facility that has excessive surface deteriorations that are beyond the ability of the microsurfacing to address in one application, or

TABLE 4 Sample Bonding Levels (18)

State	Product	Payment Methods or Bond
Alabama	HMA	Bond for specified percent of contract amount; also retainage of 10% of contract paid over 8 years
California	Rubberized HMA	Bond for 10% of contract amount; also retainage of 10% of contract paid over 5 years
Colorado	HMA	Bond to cover cost of 2.0-in. overlay, restriping, traffic control, rounded up to the nearest \$25,000
Florida	HMA	Bond to cover cost of 1.0-in. overlay
Indiana	HMA	Bond to cover surface overlay
	Microsurfacing	Bond for 100% of contract amount
Michigan	HMA	Bond for 10% of contract amount
	HMA overlay	Bond for 100% of contract amount
	Chip seal/microsurfacing/ track treatment	Bond for 100% of contract amount
Ohio	HMA	Bond for cost of removal and overlay at 5 years considering inflation. Included traffic control, markings, etc.
	Microsurfacing	Bond for 75% of contract amount
Wisconsin	HMA	Bond to cover cost of replacement overlay, regrade shoulders, rounded to next \$100,000

in the case of minor rutting, two applications. Material and workmanship warranties (3 years) have also been applied successfully to HMA thin resurfacing or mill and fill projects.

- Short-term performance warranties are adaptable to rehabilitation or HMA resurface type projects, and they are also applicable to new construction. For rehabilitation type projects, the contractor is only responsible for the new overlay and cannot be responsible for the roadway subbase. New construction takes into account the entire roadway pavement and shoulders and typically includes the subgrade.
- Long-term performance warranties are typically limited to major new construction projects that are significant in nature and will include the pavement, shoulder, and subgrades, and may also include other roadway items as a complete package.

In selecting projects, the PMS data need to be evaluated to consider any particular project. For example, if PMS data show a particular project has a high degree of surface defects, it is normally not a good project for a preventive maintenance single overlay since more work is needed to rehabilitate the facility. The same holds true with warranties, since the contractor cannot be held responsible for elements of the pavement that were not under their control. This does not mean that only very good projects can be selected for warranties, but it should rule out very poor projects if minor resurfacing is proposed. Coordinating the selection of projects with the PMS program is preferred, in consideration of the type of project (rehabilitation, reconstruction, etc.).

ACCEPTANCE PROCEDURES FOR WARRANTY PROJECTS

Acceptance procedures for warranty projects have to incorporate not only the construction activities, but also the verification process. An agency warranty verification process differs depending upon the type of warranties.

- Materials and workmanship warranties. Acceptance of the construction activities is in accordance with agency standard specifications. The agency is also responsible for reviewing the completed project following the completion of the warranty period to document the condition of the pavement. In most cases the agency then prepares documentation that formally releases the contractor from further responsibilities under the contract.
- Short-term performance warranties. Acceptance of the roadway and other elements of the project is important to ensure that the basic scope of the work was completed in accordance with the plans. Material acceptance of the pavement items is through the verification process. The agency is responsible for reviewing the project during and following the completion of the warranty period to document the condition of the pavement. After this, the agency then prepares documentation that formally releases the contractor from further responsibilities under the contract. Verification of the warranted pavement condition is ideally tied to the same PMS program to objectively rate the condition of the pavement. Depending on the length of the warranty, the pavement may be reviewed annually or biannually up to the end of the warranty period when a final condition survey is completed. The pavement ratings need to document each of the warranted distresses throughout the life of the warranty. If any distress exceeds the limits as stated in the specifications, the contractor is responsible for providing a remedy to bring the pavement back into acceptable levels.

- Long-term performance warranties are similar to short-term warranties in that the initial construction activities have to be reviewed and the pavement condition is verified over the life of the warranty period. The pavement condition verification reviews by the agency are less frequent than short-term performance warranties. An initial, or baseline, evaluation is completed following construction and intermediate evaluations may be completed during the warranty period. A final evaluation is completed following the completion of the warranty period.

For warranted HMA pavements, distress indicators should use PMS data to determine threshold values. The threshold values are provided in [Table 5](#) as a baseline to consider in the development process.

WARRANTY EVALUATIONS

Agencies evaluate the data collected from the warranty projects to determine the effectiveness of the warranty programs. The data can also be utilized in the evaluation and establishment of subsequent warranty project thresholds.

WARRANTY EXPERIENCES

Reports of warranty experiences throughout the country have produced mixed results on the use of pavement warranties and the type of the warranty. Colorado DOT reported that the material and workmanship warranty program was not successful due to the lack of contractual controls in the specifications (10). The Michigan DOT, which utilizes material and workmanship warranties for a significant portion of their warranty program, also reports very little change in the quality of the initial construction by the contractors (10). If developed correctly, individual preventive maintenance programs utilizing material and workmanship warranties such as chip seals, etc., can benefit from warranties due to the emphasis on the operations.

Wisconsin and Indiana DOTs have reported successes with short-term warranties in terms of pavement performance and cost effectiveness (15, 16). Wisconsin utilizes warranties on all types of roadways, including entire pavement replacements. They found that when the contractor is responsible for the subgrade as well as the pavement structure, more attention was focused on all the pavement layers (15). Indiana DOT reported on the use of warranties

TABLE 5 HMA Pavement Performance Indicators

Indicators	Evaluation Section	Threshold Values*
Friction number	Three consecutive sections Entire contract per lane	< 25 < 35 average of all tests
IRI	520 ft (0.1 mi)	75 in./mi
Longitudinal cracking	520 ft (0.1 mi)	0.0 ft
Rut depth	520 ft (0.1 mi)	0.25 in.
Transverse cracking	520 ft (0.1 mi)	0.0 ft

NOTE: * based on 520 ft (0.1 mi) evaluation sections

on high-volume Interstates utilizing single-lay (surface course) preventive maintenance type projects, rehabilitation of existing roadways, and new full-depth pavements. Data from Indiana show that the HMA warranty program extends the life of the pavement an additional 9 years when considering rutting and smoothness elements (16).

Long-term performance warranties in the United States are limited and benefits are still being evaluated. European experiences in long-term pavement warranties have shown positive results (24).

Management of Pavement Warranties

While there are several choices in the types of warranties that can be used for pavements, the most benefit can be gained through the use of short- or long-term performance warranties. Performance type warranty specifications have been documented to reduce the life-cycle costs of the facility by improving the performance of the pavements. To continue the trend toward improved pavement performance it is important to examine and to implement the best practices and lessons learned by agencies in the United States and abroad. The successful use of pavement warranties is dependent upon the understanding of the contracting requirements as well as the support of all parties involved. While there are many potential benefits, such as improved performance, there are also adjustments that will need to be made within the highway construction industry, the agency, and in the bonding programs in the agencies. There are a number of issues that need to be considered as part of the management of a pavement warranty program. The first is an understanding that the acceptance of a warranty project consists not only of the specific construction activities as required by the project, but also the verification of performance during the warranty period.

Management of pavement warranty programs includes the actions by the agency to address not only the initial development of the specifications, but also the coordination with various departments and field divisions within the agencies to verify the performance of the warranted pavement during the warranty period. Management responsibilities also include the establishment of responsibilities within the agencies to address the overall warranty program to coordinate review of, and the updating of, the construction specifications and the verification processes. Management begins at the central office and then disperses throughout the agency in multiple areas including development, pavement management, operations, construction, and materials.

PARTNERING

One of the key elements during the development of the warranty specifications is partnering. Partnering is an element that is critical in the initial decisions regarding warranties within the agency and with industry throughout the warranty periods of the various projects.

Successful pavement warranty programs include pavement warranty management committees (PWMC). This committee includes members from the agency's management, research, pavement management, construction, operations, and materials divisions, as well as industry representatives and federal representatives as applicable. The PWMC establishes warranty task forces to address the details of the warranty program(s) and report back to the committee for approvals.

The PWMC initially considers either materials and workmanship warranties or performance warranties to be utilized. Subsequent decisions may be made regarding the evaluation of the pavement management data in the establishment of the warranty distresses, thresholds, and remediation, together with coordinating the projects evaluation with the rest of the agency's program partnering activities.

Management of the program has to include all the same elements that were initially utilized and has to evaluate the program.

NUMBER AND TYPES OF WARRANTIES

The management of the program will differ if the agency has a single or limited number of warranties, as compared to hundreds of warranties. Michigan DOT, for example, uses a large number of materials and workmanship warranties and has established a central office clearinghouse for the data, but has delegated the verification of warranty projects to the field. Colorado DOT and Indiana DOT are maintaining the programs in their central offices. In the case of Indiana, the monitoring of the program is combined with the pavement management program which minimizes the duplication of the pavement evaluations. The pavement friction program reports separately to the construction division, which has overall responsibility. The construction project cannot be accepted until the warranty verification is completed, even if it takes three or more years. Wisconsin DOT has established a pavement research and warranty engineer in the central office to coordinate the program.

WARRANTY DATA

The pavement data collected during the life of the warranty projects is critical in monitoring the program as this updated information will be incorporated into subsequent warranty projects. Warranty specifications themselves should be reviewed on a yearly basis. The establishment of the initial threshold data would be set based on data from projects built several years prior. Due to construction and materials program changes over the years, pavement performance indicators have to change as well. The agency decision regarding the initial thresholds may need to be revised based on further experience. For example, for short-term performance warranties on HMA pavements, if the initial rutting threshold was established as 0.25 in. for 5 years and the performance data now suggest that it should be less than that, the changes will be incorporated into subsequent pavement warranty projects.

FIELD VERIFICATION PROCESS

Field verification can include visual inspection to identify areas that may need closer inspection. The frequency of inspections depends on the type of warranty. As a minimum, all warranty projects need to have a final acceptance inspection conducted at the end of the warranty period that includes objective evaluations of the warranty distresses. For performance warranties, periodic verifications could be coordinated with the pavement management evaluation program to acquire comprehensive data, while visual inspections that occur more frequently serve to supplement the data or trigger closer inspection. The PWMC will need to develop a process within the agency to complete the acceptance process of the warranty projects. Results from this process not only complete the requirements for past warranty projects, but also generate the data for subsequent revisions in the program or the specifications.

Summary

Pavement warranties are considered to be one of the most successful programs that can protect the agency from early failure of the pavement. At the same time they enhance industry stature by giving them additional responsibilities for performance, opportunities for innovation, and profitability. The process has been widely used in Europe to enhance the quality of pavements and to reduce the life-cycle cost of pavements. Furthermore, the process has been used in the United States and has been very successful. Potential benefits to both the agency and industry of implementing a pavement warranty include decreased construction oversight, enhanced pavement quality, and flexibility in pavement type and material selection. In addition, the agency and industry can be more productive by shifting from a passive to an active attitude toward quality (25).

While there are several choices in the types of warranties that can be used for pavements, many experts feel that the most benefit can be gained through the use of short- and long-term performance warranties. In order to continue the trend toward improved pavement performance it is important to examine and implement the best practices and lessons learned by other agencies in the United States and abroad. It has been found that the successful use of pavement warranties is dependent upon the understanding of contracting methods and risk and the quality of the specifications, as well as the support of the parties involved.

The development of the contract specifications is critical to understanding the risk by both the agency and the contractor which directly relates to the benefit-cost of the program. The development of the specifications includes six building blocks:

1. Contract administrative requirements,
2. Distress indicators and applicable thresholds,
3. Distress remediation,
4. Quality programs for binders, aggregates, production and laydown operations for HMA and aggregates,
5. Restrictions, traffic monitoring, and evaluation of the pavement or project, and
6. Bonding—guarantees.

Contact any one of the following states, highlighted in [Figure 4](#), for specific information regarding their warranty use: California, Colorado, Florida, Illinois, Indiana, Michigan, Minnesota, Mississippi, Ohio, and Wisconsin.

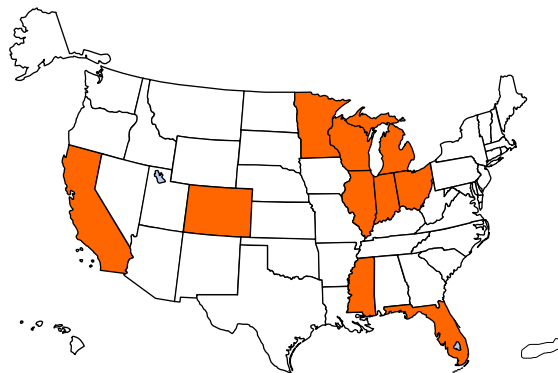


FIGURE 4 Principal users of pavement warranties in the United States (2).

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