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Federal Highway Administration

International Technology Exchange Program

Asphalt Pavement Warranties Technology and Practice in Europe

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NOTICE

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16. Abstract

A diverse team of experts, representing the Federal, State, and local government as well as industry and academia, was assembled to research, document, and promote best practices in Europe relating to short- and long-term warranty contracting for asphalt paving projects. Specifically, the team studied methodologies to determine risk assessment for agencies and contractors; administration of warranty contracts; criteria to account for traditional performance indicators; and practices to maintain smoothness and skid resistance.

The team traveled to Denmark, Germany, Spain, Sweden, and the United Kingdom, all of which have long histories with the use of warranty contracting and are facing many of the same political, financial, and resource challenges as the United States.

The report covers key findings and recommendations relating to material and workmanship warranties, performance warranties, best-value procurement, and alternative contracting. The report concludes with recommendations for Federal, State, and local governments as well as the pavement industry.

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SUMMARY REPORT OF THE

Asphalt Pavement Warranties Technology and Practice in Europe

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November 2003

FHWA International Technology Exchange Program

The Federal Highway Administration's (FHWA) Technology Exchange Program accesses and evaluates innovative foreign technologies and practices that could significantly benefit U.S. highway transportation systems. This approach allows for advanced technology to be adapted and put into practice much more efficiently without spending scarce research funds to recreate advances already developed by other countries.

The main channel for accessing foreign innovations is the International Technology Scanning Program. The program is undertaken jointly with the American Association of State Highway and Transportation Officials (AASHTO) and its Special Committee on International Activity Coordination in cooperation with the Transportation Research Board's National Cooperative Highway Research Program Project 20-36 "Highway Research and Technology—International Information Sharing," the private sector, and academia.

FHWA and AASHTO jointly determine priority topics for teams of U.S. experts to study. Teams in the specific areas being investigated are formed and sent to countries where significant advances and innovations have been made in technology, management practices, organizational structure, program delivery, and financing. Scan teams usually include representatives from FHWA, State Departments of Transportation, local governments, transportation trade and research groups, the private sector, and academia.

After a scan is completed, team members evaluate findings and develop comprehensive reports, including recommendations for further research and pilot projects to verify the value of adapting innovations for U.S. use. Scan reports, as well as the results of pilot programs and research, are circulated throughout the country to State and local transportation officials and the private sector. Since 1990, FHWA has organized more than 50 international scans and disseminated findings nationwide on topics such as pavements, bridge construction and maintenance, contracting, intermodal transport, organizational management, winter road maintenance, safety, intelligent transportation systems, planning, and policy.

The International Technology Scanning Program has resulted in significant improvements and savings in road program technologies and practices throughout the United States. In some cases, scan studies have facilitated joint research and technology sharing projects with international counterparts, further conserving resources and advancing the state of the art. Scan studies have also exposed transportation professionals to remarkable advancements and inspired implementation of hundreds of innovations. The result: large savings of research dollars and time, as well as significant improvement in the nation's transportation system.

For a complete list of International Technology Scanning topics and to order free copies of the reports please see the list contained in this publication, as well as: Website: **www.international.fhwa.dot.gov** or Email: **international@fhwa.dot.gov.**

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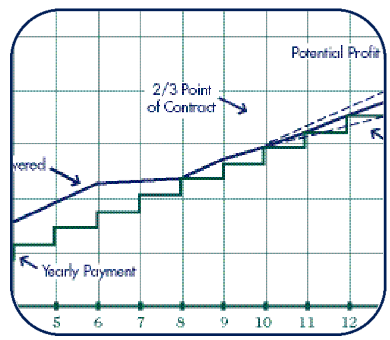
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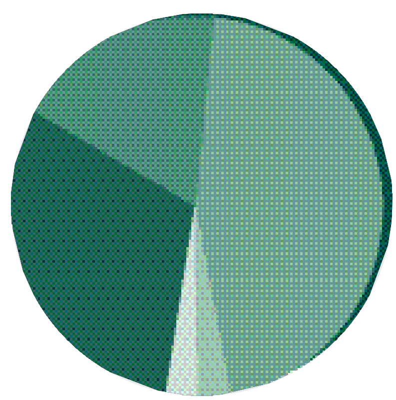

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Abbreviations and Acronyms

AASHTO	American Association of State and Highway Transportation Officials
CQC	Contractor quality control
DBFO	Design-build-finance-operate
DOT	Department of Transportation
EU	European Union
FHWA	Federal Highway Administration
FWD	Falling weight deflectometer
HMA	Hot mix asphalt
IR	International Roughness Index
ISO	International Organization of Standardization
MAC	Managing agent contract
NCHRP	National Cooperative Highway Research Program
PMS	Pavement management system
PPC	Pavement performance contracts
PPP	Public-private partnerships
QA/QC	Quality assurance/quality control
SCRIM	Sideways force coefficient routine investigation machine
STIP	Scan technology implementation plan
TRB	Transportation Research Board

Executive Summary

U.S. highway agencies are discussing and, to some extent, implementing warranty contracts on asphalt paving projects. These highway gencies believe they will receive improved performnce from warranty contracts through a reduction in fe cycle costs and introduction of contractor ingenuy during the design and construction process. In ddition, these agencies see warranty contracting as methodology for dealing with reduced staffing levls and a loss of expertise in the agencies. Concerns ver definitions, roles, responsibilities, and approprite allocation of risk are of major concern among all takeholders. The European highway community has long history with the use of short-term and long-erm warranty contracting. This change toward the se of warranties in the United States, combined with he knowledge of warranties in Europe, led to the ormation of the European Asphalt Pavement Varranties Scan. The goal of the scan was to learn rom European experience to help develop a successul warranty program in the United States.

ackground

warranty is a type of performance-based contract hat guarantees the integrity of a product and the onstructor's responsibility for the repair or replacenent of defects. Traditional U.S. construction conracts typically require the contractor to provide projct warranty for only 1 year after construction is comlete; however, the design life cycle for all types of sphalt pavement is much longer than 1 year. U.S. ighway agencies are increasingly requesting longererm warranty contracts on asphalt paving projects. hese highway agencies believe they will receive nproved performance from warranty contracts and elieve that warranty contracting may reduce life ycle costs by increasing contractor ingenuity during he construction process. Asphalt pavement waranties have the potential to help U.S. highway associations cope with staffing shortages and the loss of experienced staff by potentially reducing project administration and overall construction costs.

Several studies of European asphalt pavement techniques in the early 1990s identified the use of warranties (FHWA 1990; FHWA 1994). Some European highway agencies have been using asphalt pavement warranties for more than 40 years. In recognition of the similarities and benefits that could result from an examination of European warranty practices, a diverse team of experts was assembled to research, document, and promote the implementation of best practices found in Europe that might benefit U.S. practitioners. The Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO) jointly sponsored this study, under the guidance of the FHWA Office of International Programs and the National Cooperative Highway Research Program (NCHRP).

Purpose and Scope

In September 2002, a U.S. panel traveled to Europe to review and document the policies and strategies used in Europe to determine risk assessment and administer warranty contracts. The scan team also reviewed the criteria, programs, and analytical tools used to establish pavement distress criteria for warranting asphalt pavement performance. Specifically, the panel went to Europe to study the following:

- Methodologies used to determine risk assessment for the government agency and contractor.
- Methodologies for administration of warranty contracts.
- Methodologies to select criteria to account for traditional performance indicators of rutting, fatigue cracking, and low temperature cracking.

- Practices to maintain prescribed levels of smoothness and skid resistance.
- Criteria used in successful asphalt pavement warranties.
- Pavement performance prediction tools.

The panel evaluated policies and practices for potential application in the United States. It conducted meetings with representatives of government agencies, academia, and private sector organizations involved with warranties and visited sites where innovative asphalt warranty contracting techniques were being applied. The U.S. participants also shared their viewpoints and experiences in the spirit of mutually beneficial exchanges. The panel visited or met with representatives from Denmark, Germany, Spain, Sweden, and the United Kingdom.

Summary Observations

The following summary observations are provided to set a context for the key findings, conclusions, and recommendations of this study. As noted in the summary observations, the European and U.S. transportation communities are quite similar in terms of the political, financial, and resource challenges that they face. However, the European transportation agencies are better leveraging the innovative management techniques, technical innovations, and financing capabilities that the private sector has to offer. There is a more spirited effort of partnership and collaboration between the public and private sectors in Europe than in the United States. The summary observations listed below are expanded upon throughout this report.

Similar Transportation Needs

- European transportation systems have growing capital project needs as well as a backlog of maintenance requirements.

Long History of Material and W orkmanship Warranties

- Material and workmanship warranties of varying length have been used in the European host countries for 30 to 40 years.

Purchasing Performance in Addition to Materials

- Those countries with a long history of material and workmanship warranties are moving toward pavement performance warranties and other methods of tying the contractor into performance of the pavement over the full life cycle of the product.

Best-Value Procurement

- A focus on quality exhibited by the use of best-value procurement.

Public-Private Partnering

- Strong partnerships between highway agencies anc all sectors of the industry.

Motivation for Alternative Contract Methods

- Motivation for warranties, performance-based contracts, and design-build-finance-operate (DBFO) concessions include:
  - Need for innovation.
  - Need for private sector to finance system upgrades.
  - Desire to improve quality.
  - Desire to improve efficiency.
  - Resource issues.

Balanced Contracting Approach

- Transportation agencies are using a balanced approach in implementing traditional contracting, warranties, performance-based contracts, and DBFO concessions.

Financing

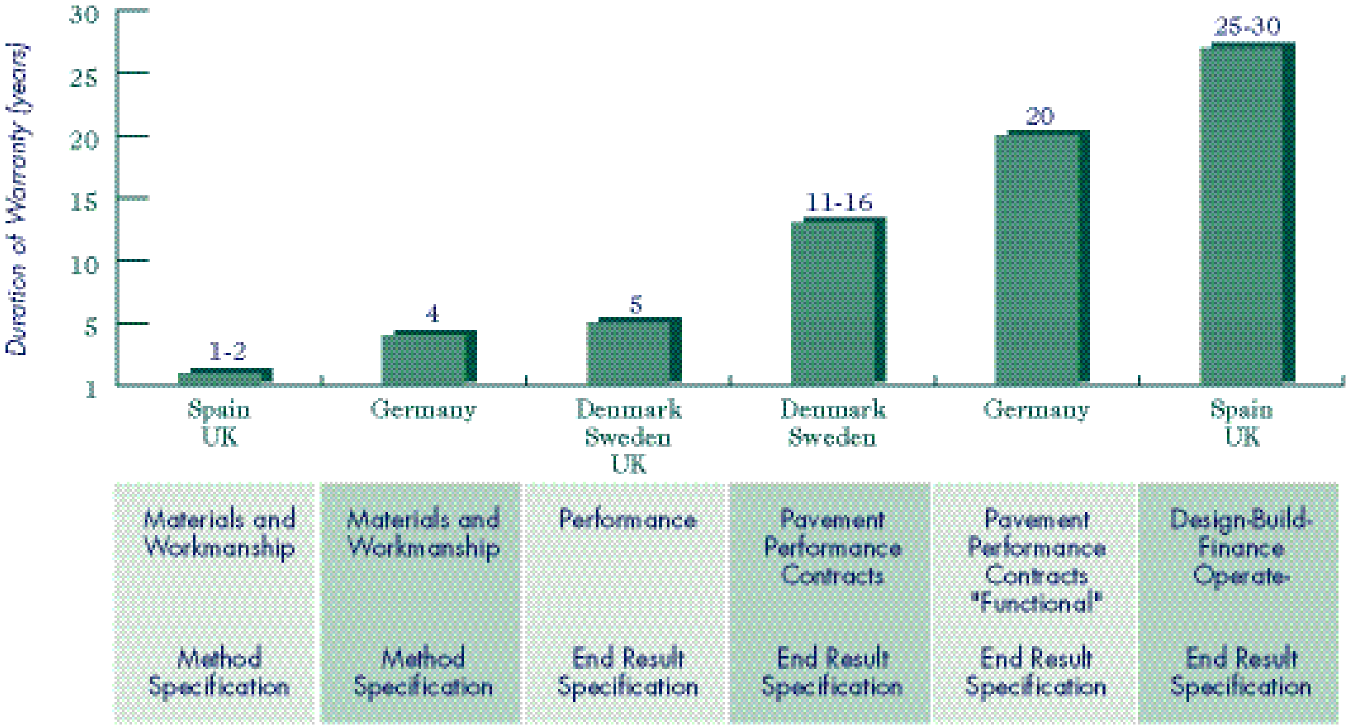
- Available tax dollars is an issue, which is compounded by the new European Union (EU) requirement for less than 3 percent capital debt.

Outsourcing of Maintenance

- Term maintenance contractors from the private sector are used exclusively in some of the host countries, while other countries are also increasing their use of such contractors.

Key Findings

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 Figure E1 provides an overview of the warranty types observed on the scan, the countries that employ them, and their respective durations.



igure E1 Observations on European warranties.

/laterial and Workmanship Warranties
ιt a minimum, all of the host countries use material nd workmanship warranties on their traditional ontracts. These warranties ensure that the contrac-ɔr will build the pavement as specified by the wner and fix any defects resulting from the use of nproper materials or inferior installation. ›epending on the country, the highway agencies ıay seek a remedy of defects from either the prime ontractor or the asphalt contractor, if the prime is ot the asphalt contractor.

Varranty periods vary. On projects designed by the ighway agency, the United Kingdom uses a 1-year ,arranty period, Spain employs a 1-year warranty eriod, and Germany historically uses a 4-year period. hese countries use performance indicators of rut-ng, cracking, and durability on material and work-ıanship warranties.

›erformance Warranties
›enmark and Sweden use performance warranties n their traditional contracts. The United Kingdom mploys performance warranties on its design-build ontracts, which have become their contracting

Figure E2 Material and workmanship warranties.

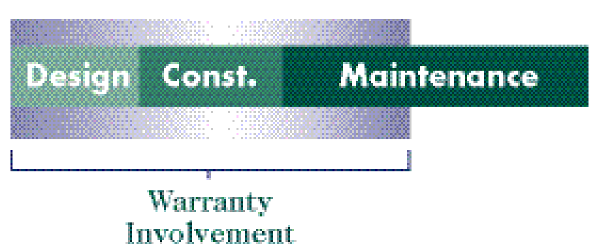


Figure E3 Performance warranties.

method of choice over the past 10 years. 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.

All three countries 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 measure 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.

Best-Value Procurement

All five of the host countries use best-value procurement in lieu of low bid. Best-value procurement involves awarding the contract on technical and/or performance items in addition to cost. Best-value criteria include safety, innovation, and environmental impact. Denmark also includes the bidding of additional years of warranty 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 it 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 contracts (PPCs) and DBFO contracts are extending warranty contracts up to 35 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, which have warranty periods of 11 to 20 years. In Germany, Spain, and the United Kingdom, the highway agencies are promoting PPCs. However, the industry is the catalyst for PPCs in Denmark and Sweden. In all of the countries, the PPC forms are developing with close government and industry collaboration.

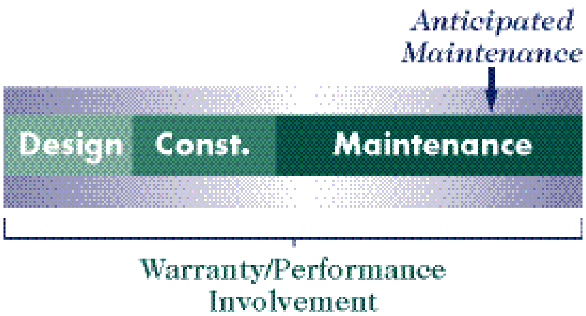
Depending on how the contractor proposes to build the pavement, the maintenance can include a number of items from filling of isolated potholes and minor pavement remarking to a complete mill and overlay of a significant section of pavement. The highway agencies are simply looking to the industry to 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.

Design-Build-Finance-Operate Contracts—In Spain and the United Kingdom, the highway agencies are changing from service providers to owners and managers of the highway system. Both of these countries are turning a small fraction of their highway network over to the private sector for long-term financing, operation, and maintenance. The terms of the DBFO contracts studied on this scan were 25 to 30 years, but other European countries are experimenting 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 delivers a higher quality product and provides benchmarks for public sector performance.

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

Conclusions and Recommendations

The European host countries all believe that their long history of warranty application has improved



igure E4 Pavement performance contracts.

Figure E5 Design-build-finance-operate contracts.

ıe performance of their highway and trunk road sys-ems. Their warranty systems continue to evolve ırough a customer-focused partnership between overnment and industry. Best-value procurement nd prequalification are vital elements of the warran-y system. Material and workmanship warranties are ı use on all short-term warranties. Five-year per-ɔrmance warranties are in use when the contractor ompletes some level of design. The long-term per-ɔrmance warranties include design, construction, nd some type of planned maintenance.
he Europeans hosts use all of these warranties in alanced contracting approaches.

he European Asphalt Pavement Warranties Scan eam included representatives from Federal, State, nd local agencies, industry, and academia. The scan eam offers the following recommendations on the asis of its observations of successful warranty pro-rams in the European host countries.

ederal Government

Warranty requirements: The Federal government should require short-term material and workmanship warranties on all federally funded projects. This should be the first step in moving toward common use of long-term performance warranties in the future.

Enable best-value and prequalification legislation: Assist with enabling legislation to allow contract awards based on technical and quality factors in addition to cost (i.e., best-value and prequalification methods).

Warranty resource center: Create resource center(s) to facilitate and assist in implementing and evaluating warranties. The Federal government should act as a leader for the State, county, and local governments.

State and Local Government

- **Create model warranty documents:** Draft contract documents for warranty implementation with representation from all stakeholders. AASHTO should take the lead in the creation of these documents in collaboration with local governments and industry.

- **Implement material and workmanship warranties:** The State and local highway agencies should develop material and workmanship warranty programs through internal education and industry participation.

- **Implement short-term performance warranties:** State and local highway agencies should implement short-term performance warranties when it is appropriate for the contractor to perform the necessary design.

- **Enable best-value and prequalification procedures:** State and local highway agencies should work to enable legislation allowing contract awards based on technical and quality factors in addition to cost.

Industry

- **Education:** Develop an awareness and understanding of warranty issues and risks.

- **Participation:** Proactively participate in roundtable discussions on warranties.

- **Pilot projects:** Consider proposing on pilot projects.

- **Operation and maintenance competencies:** Consider expanding knowledge of operation and expertise of materials and products for future competitiveness.

Overview

Background

U.S. highway agencies are discussing and, to some extent, implementing warranty contracts on asphalt paving projects. These highway agencies believe they will receive improved performance from warranty contracts through a reduction in life cycle costs and introduction of contractor ingenuity during the design and construction process. In addition, these agencies see warranty contracting as a methodology for dealing with reduced staffing levels and a loss of expertise in the agencies. Concerns over definitions, roles, responsibilities, and appropriate allocation of risk are of major concern among all stakeholders. The European highway community has a long history with the use of short-term and long-term warranty contracting. This change toward the use of warranties in the United States, combined with the knowledge of warranties in Europe, led to the formation of the European Asphalt Pavement Warranties Scan. The goal of the scan was to learn from European experience to help develop a successful warranty program in the United States.

A warranty is a type of performance-based contract that guarantees the integrity of a product and the constructor's responsibility for the repair or replacement of deficiencies. Traditional U.S. construction contracts typically require the contractor to warranty the entire project for only 1 year after the completion of construction, but the design life cycles for all types of asphalt pavement are much longer. U.S. highway agencies must optimize the life cycle of initial construction products because funds are limited for capital construction, and even more limited for maintenance. Currently, driving on roads in need of repair and improvement costs motorists additional vehicle operating costs of US$41.5 billion per year. Warranty contracts provide an opportunity to lower these vehicle operating costs by improving the quality of roads during their design life and minimizing the need for closures for maintenance operations.

Purpose and Scope

In September 2002, a U.S. panel traveled to Europe to review and document the policies and strategies used in Europe to determine risk assessment and administer warranty contracts. The use of warranties in Europe was documented in the 1990 European Asphalt Study Tour (EAST; FHWA 1990) and the 1994 Contract Administration Techniques for Quality Enhancement Study Tour (CATQUEST; FHWA 1994). Although these studies identified the use of warranties in Europe, they did not focus on the documentation and technology transfer of specific lessons learned. This report focuses specifically on the criteria, programs, and analytical tools used to establish pavement distress criteria for warranting asphalt pavement performance. Specifically, the panel went to Europe to study the following:

- Methodologies used to determine risk assessment for the government agency and contractor.
- Methodologies for administration of warranty contracts.
- Methodologies to select criteria to account for traditional performance indicators of rutting, fatigue cracking, and low temperature cracking.
- Practices to maintain prescribed levels of asphalt pavement smoothness and skid resistance.
- Criteria used in successful asphalt pavement warranties.
- Pavement performance prediction tools.

The panel evaluated policies and practices for potential application in the United States. It conducted meetings ranging from 2 to 8 hours in length over 2 weeks with those government agencies, academia, and private sector organizations involved with warranties and visited sites where innovative asphalt warranty contracting techniques were being applied. U.S. participants also shared their viewpoints and experiences in the spirit of mutually beneficial exchanges.

Methodology

The Asphalt Pavement Warranties Scan was selected

U.S. Parallel: Background Information on U.S. W arranties

Figure 1.1 Warren Brothers warranty seal.

Pavement warranties are not new to the United States. From 1890 to 1921, Warren Brothers Paving owned a patent on hot mix asphalt (HMA). Warren Brothers provided a warranty for its products that lasted up to 15 years. The warranties covered both materials and workmanship. After 1921, the Warren Brothers' patent expired. The asphalt market was opened up to competition and its warranty program was discontinued. Figure 1.1 is a brass seal that Warren Brothers used to roll into its pavements to identify its product and its warranty. This particular picture was taken in the New York area from pavement that was in use from 1919 to the early 1960s.

In the 1950s, the U.S. Federal government formalized its participation in the highway construction program. Warranties were not allowed because they were considered to be maintenance, and the Federal government could only participate in construction. In 1988, a Transportation Research Board (TRB) study produced Circular 386 – Innovative Contracting Practices, which described the possible application of warranties to highways. The Federal Highway Administration (FHWA) Special Experimental Project 14 was put into place in 1990 and allowed for the evaluation of warranties and other alternative contracting methods on Federally funded highway projects. In 1995, the FHWA mainstreamed most alternative contracting methods, including warranties, and many other States and local agencies began to evaluate the use of warranties on their own. Figure 1.2 depicts the States in which the FHWA had approved warranty projects in 1999.

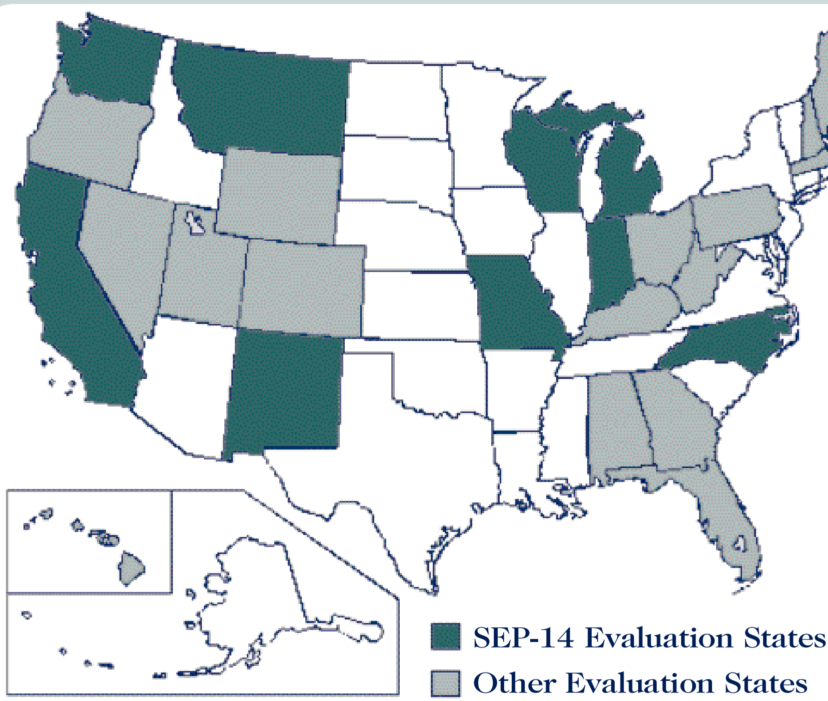


Figure 1.2 Warranty evaluation States.

Developing and administering these new warranty contracts can be a challenge to agencies with little or no experience with them, but several European agencies have been using warranty contracting for decades. U.S. highway representatives documented the use of asphalt warranties in Europe in the early 1990s (European Asphalt Tour 1990; CATQUEST 1994). The vast European experience with warranties creates an opportunity for the United States to learn from their experiences and practices.

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Kent County Road Commission
Representing: National Association of County Engineers

y the TRB's National Cooperative Highway Research rogram's (NCHRP) Panel 20-36 from a number of ompeting proposals for the 2002 funding cycle. Jpon acceptance of the proposal, two co-chairs vere named as representatives for the funding gencies: John D'Angelo, Asphalt Materials Engineer or the FHWA, and Gary Whited, Administrator, Division of Transportation (DOT) Infrastructure Development, Wisconsin State DOT for the merican Association of State and Highway ransportation Officials (AASHTO). They joined rep-esentatives from the public and private sectors to epresent a cross-section of the industry. The team nembers are shown in figure 1.3, and their affilia-ions are listed below. Complete contact information nd biographical sketches for the scan team mem-ers are listed in appendix A.

he next step was to conduct a "desk scan" for ne purpose of selecting the most appropriate ountries for the scan tour to visit. The objective f the study was to maximize the time spent by the anel in reviewing its topics of interest. This desk can employed a three-tier methodology of litera-ure reviews, expert interviews/surveys, and ynthesis. This methodology enabled collection of ata from government agencies, professional rganizations, and experts abroad who are most dvanced in the scan topics. The literature eview uncovered reports that documented use of sphalt pavement warranties in a number of ountries in the late 1980s and early 1990s. It was uggested that a visit to these countries would rovide insights into the long-term performance f warranty programs. The literature review lso revealed activity in the related area of naintenance and concessions contracts. The survey evealed numerous U.S. and European contacts vho provided interviews to help select the inal countries to visit. For a copy of the 2001 Contract Administration Desk Scan, contact ne Office of International Programs at *ttp://www.international.fhwa.dot.gov.*

he desk scan was presented to the U.S. scanning eam, which held a meeting in Washington, D.C. to elect the host countries. The team also finalized a panel overview" document, which was sent ahead o the host countries to prepare them for the U.S. elegation. The panel overview explained the back-round of the study, the scope of the study, the ponsorship, team composition, topics of interest, nd the tentative itinerary.

Before conducting the scan tour, the team prepared a comprehensive list of "amplifying questions" to further define the panel overview and sent the questions ahead to the host countries. The process of assembling the final list of questions took several iterations, with a final team meeting 8 months prior to the scanning tour. Some of the host countries responded to these questions in writing prior to the scanning tour while others used the questions to organize their presentations. An attempt was made to craft the questions precisely enough that the team would not miss any information that it antici-pated, yet open-ended enough that new ideas—not envisioned by the U.S. scan team—could be brought to light by the host countries. Appendix B contains the amplifying questions that were sent to the host countries. Appendix C lists references that are cited within this report, and appendix D contains a list of European host representatives.

The delegation traveled to Europe from September 13-29, 2002. The visit consisted of a combination of meetings with highway agencies and practition-ers, as well as site visits. The scan team visited Madrid, Spain; Koblenz, Germany; Copenhagen, Denmark; Crowthorne, England; Banbury, England; and London, England.

Organization of the Report

The report combines definitions and illustrative case study examples of asphalt warranty techniques in Europe with critical analysis of the applicability of these techniques to U.S. contracting. Whenever pos-sible, U.S. parallel examples are provided to amplify those techniques that are directly applicable. The report is organized into the areas of warranty use in Europe, warranty implementation, warranty evalua-tion, and alternative delivery methods, as shown in figure 1.4 on the following page.

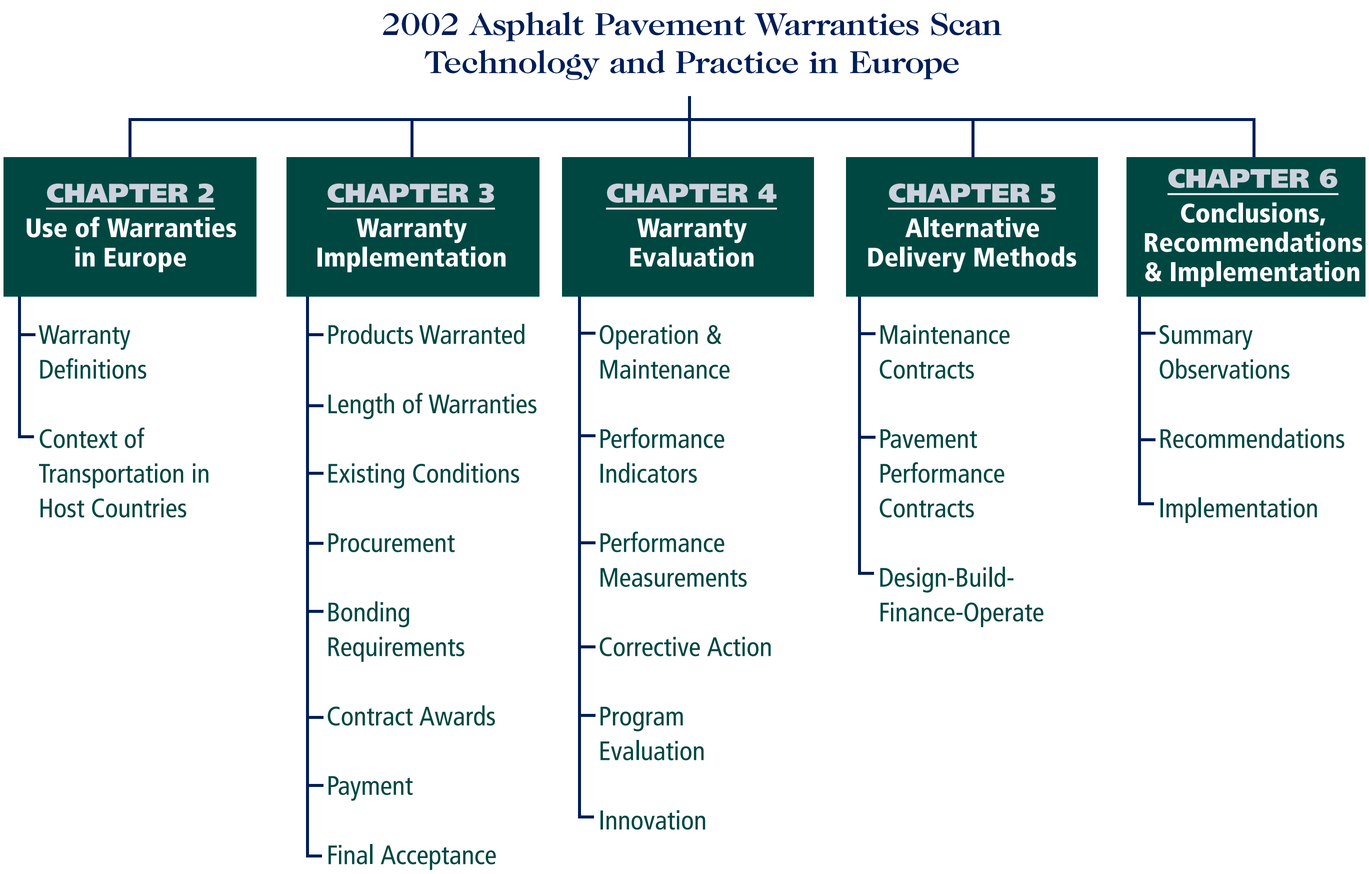


Figure 1.4 Organization of the report.

Use of Warranties in Europe

European highway agencies are not so different from U.S. agencies. European transportation systems have growing capital project needs as well s a backlog of maintenance needs. They face many f the same political, financial, societal, and environnental challenges found here in the United States.)ne major difference, however, is the use of asphalt avement warranties. Asphalt pavement warranties re a fixture of the European highway contracting tructure. In the European countries visited by the can team, warranties of varying lengths have been sed for 10 to 40 years. In fact, many of the European osts, most notably in Germany and Denmark, could ot answer questions concerning the impetus for neir warranty programs because the programs were nitiated before they were born.

his chapter of the report introduces the fundamenal warranty concepts used in Europe and being nplemented in the United States and provides a ontext for the highway industry in Europe. It presnts a set of definitions that are used throughout ne remainder of the report. The context of the ransportation community is then summarized for ach of the counties visited. For better understandng of warranty use, the chapter presents the key spects of how transportation is positioned within ne political, economic, and technological structure. : provides items such as funding, owner structure, narket structure, market competition, contractor ssociations, use of public-private partnerships, and ne roles and responsibilities of the primary stakeolders in the transportation life cycle. Lastly, the characteristics of European asphalt pavement warranties are summarized for reference throughout the remainder of the report.

Warranty Definitions

Numerous different types of warranties have evolved in Europe and the United States. The following definitions describe the general categories of warranties (adapted from Anderson and Russell 1998; Colorado DOT [CDOT] 2001; Hamilton 2001).

Warranty: A type of performance-based contract that guarantees the integrity of a product and assigns responsibility for the repair or replacement of defects to the contractor.

Warranty period: The prespecified time in which the contractor is required to repair defects in the product. Warranty periods vary by type of warranty and type of product. The ideal warranty period should be long enough to provide assurance of pavement performance, but not so long as to unnecessarily inflate contract prices.

Materials and workmanship warranties: The contractor is responsible for correcting defects in work elements within the contractor's control during the warranty period. This includes distresses resulting from defective materials and/or workmanship. The owner is responsible for the pavement structural design. The contractor assumes no responsibility for pavement design or those distresses that result from the design. Some responsibility is shifted from the owner to the contractor for materials selection and workmanship.

Performance warranties: The contractor assumes full responsibility for pavement performance during the warranty period. In effect, the contractor guarantees that the pavement will perform at a desired quality level. The contractor assumes some level of responsibility, depending on the specific project, for the structural pavement or mix decisions.

While the terms warranty and warranty period are used almost universally throughout the world, the specific definitions of warranty types are not as clear. Particular attention must be given to the difference between material and workmanship and performance warranties because the risk allocation, particularly for design liability, varies a great deal between the two warranty types.

Context of Transportation in the Host Countries

The host countries for the scan were Denmark, Germany, Sweden, Spain, and the United Kingdom. The context of the transportation environment in these host countries is surprisingly similar to that of the United States. To better understand the environment in which these countries have implemented their warranty programs, it is useful to summarize the context of their transportation environment and their implementation of warranty programs.

Political, Economic, and Technological Structure

The political, economic, and technological structure of the host countries lends some insight into the successes of their warranty programs. The scan team specifically chose host countries with transportation environments that are similar to that of the United States so that the warranty lessons learned could be implemented more easily. All of the countries have a free market economy. Most have similar federal government structures for funding and planning, and state/local government structures for construction, administration, and maintenance. Table 2.1 summarizes the context of the transportation environment in the host countries.

Although our transportation environments are similar, there are some notable differences between the United States and a number of the host countries. The level at which the federal government participates in the development of specifications and designs varies. Germany probably exhibits the most control over plans and specifications on traditional projects while the Danish Road Directorate may give the most latitude to the industry in this area. In the area of PPPs, the United Kingdom yields much of the design control to the private sector while Germany and Spain maintain tighter control. The current U.S. system varies, but might be most closely related to the German system. The U.S. system is similar to that of the U.K. system prior to the formation of the British Highways Agency resulting from the Private Finance Initiative.

The host countries vary significantly in their use of PPPs to finance and maintain the structures. With the exception of Germany, all of the countries use some form of PPPs on a larger portion of their network than does the United States. The United Kingdom is most aggressively pursuing PPPs to build and maintain its network through the Private Finance Initiative. A portion of the United Kingdom's maintenance operations on major highways is undertaken by the private sector through term contracts. Likewise, much of Spain's and Sweden's maintenance is done through the private sector. The United Kingdom is also pursing an aggressive DBFO program that could make up as much as 25 percent of the new construction program in the next 8 years. Spain has recently begun a more aggressive PPP program. Germany, on the other hand, experimented with PPPs and stopped using the delivery method because they were not seen as a good investment (although there are some stakeholders who would like to open the doors to PPPs in the future again). Sweden and Denmark have used PPP tolls for bridges on a limited basis. All of the countries are employing some form of pavement performance contracts (PPCs) to tie construction, maintenance, and financing together. Denmark, Sweden, and the United Kingdom are more aggressively pursuing PPC programs. PPCs will be discussed in depth later in this report.

The most significant difference between the host countries and the United States is their allocation of maintenance operations to the private sector. Germany and Denmark most closely resemble the United States in that they maintain their highway networks through some portion of the government. Spain, Sweden, and the United Kingdom all rely on the private sector for a significant portion of their highway maintenance. This is accomplished through a series of term maintenance agreements where routine maintenance and repair is done in accordance with performance contracts. However, the warranty contracts in those countries that perform

	Denmark	Germany	Spain	Sweden	United Kingdom
'rimary 'ransportation 'unding	• Motorways:Funding provided by state government • Highways:Funding provided by counties	• Funding provided by central government for 16 states (Länders)	• Funding provided by central government for 17 autonomous regions	• Funding provided by central government for 96% of the traffic • Private funding for the other 4% of rural roads	• Funding provided by central government and private funds through the Private Finance Initiative
)wner Structure	• Democracy with constitutional monarchy • Motorways: The state government administers construction and maintenance activities • Highways: The counties administer construction and maintenance activities	• Central government and states • States administer construction and maintenance activities on behalf of the federal government	• Democracy with constitutional monarchy • The state government administers construction and maintenance activities	• Democracy with constitutional monarchy • Until recently, the state maintained a quasi-private highway construction company, but it has recently opened the market to competition and now administers the construction and maintenance	• Democracy with constitutional monarchy • The central government administers design and construction through the Highways Agency that reports to the Secretary of State for Transport
1arket Structure	• Member of the European Union (EU) • Free market • There are nine main contractors that construct highway projects in Denmark	• Member of the EU • Free market • Healthy competition • There are approximately 3,500 firms with road-construction capabilities	• Member of the EU • Free market • Healthy competition • There are at least six large, multinational firms in addition to smaller contractors	• Member of the EU • Free market • The four major pavement contractors in Sweden are vertically integrated (they own aggregate sources, have asphalt plants, own work site equipment, and have the capacity to do testing and quality control)	• Member of the EU • Free market • Healthy competition • There are 25 to 30 major firms with road-construction capabilities in addition to smaller contractors
Jse of 'ublic-Private 'artnerships PPPs)	• PPPs are only employed on two large bridges and a few local roads • New long-term pavement performance contracts, which incorporate financing, are being used by municipalities	• Minimal use of PPPs because of poor experience with system • Future use of PPPs is possible	• Significant examples of PPPs on new highways • Maintenance is being contracted to the private sector	• There is a long history of PPPs for maintenance contracts • Limited use of PPPs on road networks • Long-term pavement performance contracts, which incorporate financing, have been used for 20 years	• The private sector contracts all maintenance • The Highways Agency began using design-build-finance-operate (DBFO) contracts of long duration 8 years ago • Up to 25% of the new program may be DBFO in the next 8 years
Roles and Responsibilities of he Primary Stakeholders in he Transportation Life Cycle	• The state and county governments finance and own most of the transportation system • The state and county governments set construction specifications and supervise construction • The state and county governments operate and maintain the network with the exception of municipal pavement performance contracts	• The federal government finances and owns the transportation system with the exception of tolls • The states set construction specifications and supervise construction • The states operate and maintain the network with the exception of tolls	• The state government finances and owns most of the transportation system with the exception of tolls and shadow tolls • The federal government sets construction specifications and supervises construction • The state and a series of term contractors operate and maintain the network with the exception of tolls	• The state government finances and owns most of the transportation system • The state government sets construction specifications and supervises • Due to the relatively small number of contractors, the state has begun to own its own materials from which the industry can purchase • The state and a series of term contractors operate and maintain the network	• The federal government finances and owns most of the transportation system with the exception of tolls and shadow tolls • The federal government sets construction specifications and supervises construction with the exception of design-build contracts and PPPs • The private sector maintains the roads through a series of term maintenance contracts and PPPs

able 2.1 Context of transportation in host countries.

their own maintenance are similar to those that rely on the private sector for maintenance. In fact, the performance indicators for maintenance and warranties are based on the same measurements.

Warranty Program Background

The scan team was interested in the host countries' original motivation for using warranty programs. A series of questions were asked about how long the countries have been using these warranties, the percentage of the transportation programs that use warranties, the impact of the warranty program on the internal staff, the impact on the private marketplace, the current goals of the warranty program, and the description of internal and external barriers that were encountered in implementing the asphalt pavement warranty program. The host country representatives had difficulty answering these questions about the motivation for their traditional warranty program because the majority of programs had been in use well before the representatives began their employment with the agency. A number of hosts, specifically the Danish Road Directorate, Germany, and the Swedish National Road Association, could not specifically state when the warranty programs started because the warranty programs had been in use for more than 30 years. Table 2.2 provides a summary of the warranty program background, including when the programs started and the current warranty periods.

As seen in table 2.2, traditional material and workmanship warranties have been in use by all the countries for at least 30 to 40 years. However, the warranty programs have evolved in recent years to include performance warranties through the use of design-build, DBFO, and PPCs. All host countries employ at least material and workmanship

	Denmark	Germany	Spain	Sweden	United Kingdom
Duration of Warranty Program	• 1960s or earlier for traditional projects • Late 1990s for PPCs	• 1970s or earlier for traditional projects • 2000 for PPCs	• 1970s or earlier for traditional projects • 1997 for DBFO	• 1960s or earlier for traditional projects • 1980s for PPCs	• 1970s or earlier for traditional projects • Late 1980s for design-build • 1994 for DBFO
Percentage of Projects with Warranties	• All projects employ warranties, but the warranty period varies	• All projects employ warranties, but the warranty period varies	• All projects employ warranties, but the warranty period varies	• All projects employ warranties, but the warranty period varies	• All projects employ warranties, but the warranty period varies
Warranty Period	• 5 years for traditional contracts • 10 years or more for PPCs	• 4 years for traditional contracts • 20 years for PPCs	• 1 year for traditional projects • 30 years for DBFO	• 5 years for traditional contracts • 5-8 years for performance warranty projects	• 2 years for traditional • 5 years for design-build • 30 years or more for DBFO

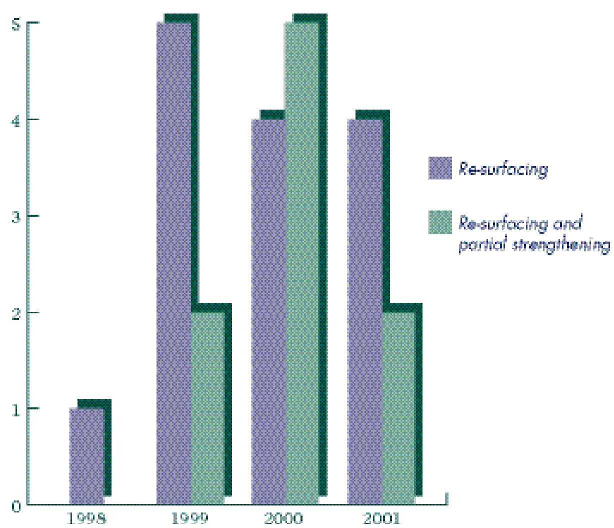
Table 2.2 Background of warranty program.

Type of Contract	Prior to 2002	2002	2007 and Beyond
Design prescribed by owner	100%	90%	75%
Performance based	—	10%	20%
Design, build, operate	—	—	5%
Note: Chart details the history of warranty use and the projected future use of warranties (approximately 250 contracts per year).			

Table 2.3 Evolution of Swedish warranty program (contract type).

Type of Contract	Prior to 2002	2002	2007 and Beyond
Design prescribed by owner	1-2 years	5 years	5 years
Performance based	—	5-8 years	5-12 years
Design, build, operate	—	—	10-15 years

able 2.4 Evolution of Swedish warranty program (warranty period).



igure 2.1 Danish pavement performance contracts ıumber of contracts).

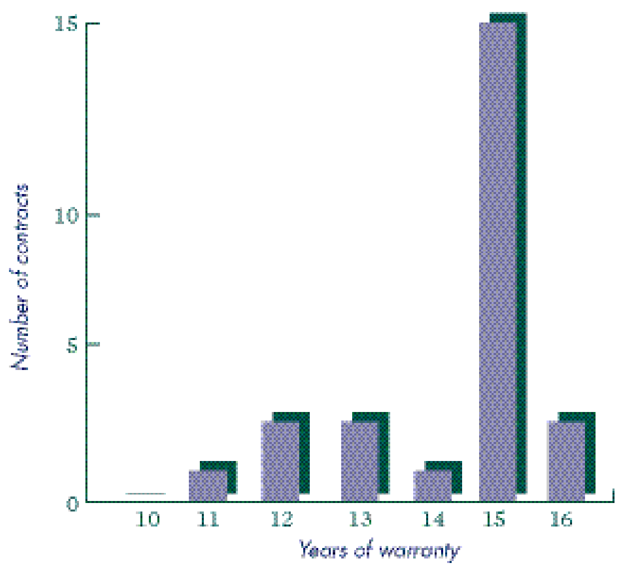


Figure 2.2 Danish pavement performance contracts (warranty periods).

U.S. Parallel: U.S. Warranty Use

In December 2000, the FHWA issued a Briefing on Warranty Clauses in Federal Aid Highway Contracts (FHWA 2000) that outlined the use of warranties in federal-aid highway contracts in the United States. In this briefing, it listed the following States as using pavement-related warranty provisions.

Product	Range of Warranty Periods	States
Asphaltic Concrete/Rubberized Asphalt	3-8 years	AL,CA,CO, FL,IN, ME,MI,MO, MS, OH,NM,UT,WI
Asphaltic Crack Treatment	2 years	MI
Chip Sealing	1-2 years	CA,MI
Microsurfacing	2 years	CO, MI,NV, OH
Pavement Marking	2-6 years	FL,MT, OR, PA,UT, WV

Numerous other States have used warranties since this 2000 FHWA briefing. These States include, but are not limited to, Illinois, Kentucky, Louisiana, Minnesota, Virginia, and Washington. In addition to asphalt paving, some States are also using warranties for concrete paving, bridge painting, and intelligent transportation system components. Although the United States does not have the long history of pavement warranty experience found in Europe, warranties are in use and growing throughout the country.

warranties in the majority, if not all, of their projects. The use of performance warranties varied from country to country. For instance, the British Highways Agency could not provide the scan team with exact figures, but stated that design-build projects with performance warranties is its contracting method of choice. They also are employing an aggressive DBFO initiative and private term maintenance contracts, which include a warranty for performance throughout the life of the contracts (5 to 30 years or more). Germany uses 4-year material and workmanship warranties on all of its projects and has recently let two "functional contracts" that include a warranty of the product for 20 years. The Danish Road Directorate and the Swedish National Road Association were able to provide more specific data on their types of contracts, as seen in tables 2.3 and 2.4 and figures 2.1 and 2.2.

The motivation on the part of host countries for moving toward performance warranties of longer duration is similar to the reasons that we are moving toward warranties in the United States. The host countries stated that the longer-term performance warranties allow them to apply innovative technical and financial solutions to the goal of better performing pavements. Where short-term material and workmanship warranties presented little or no effect on the internal staff and the marketplace, the performance warranties were requiring new thinking on the part of both the highway agencies and the marketplace.

Conclusions

Asphalt pavement warranties are standard practices in all of the host countries and have been for at least 30 to 40 years. All of the countries will continue to use material and workmanship warranties in their standard contracting approaches. The German hosts stated the goals of their material and workmanship warranty program perhaps most succinctly through a description of the duties of an asphalt contractor described under German law.

1. Constructing projects in compliance with government specifications;

2. Constructing roadways that are state of the art, technically; and

3. Constructing roadways that have no defects that decrease their value or usability.

While all host countries generally shared these strict views on contractor duty, there was a sense of partnership and innovation toward the future with the use of performance warranty contracts. All of the host countries are moving toward pavement performance warranties and other method of tying the contractor into the full life cycle of the product. There is a focus on quality and best value for the road user that is being delivered through a closer partnership between the public and private sector. The U.S. highway industry has much to learn from the extremely mature European warranty programs.

Warranty Implementation

European warranty programs evolved independently and therefore have some differences in their implementation. This chapter describes ne technical and management aspects of the ndividual warranty programs in the host countries. : describes in detail the products warranted, length f warranties, scope definition, precontract award, ontract award, payment and final acceptance, and peration and maintenance.

: should be noted that this chapter specifically discusses material and workmanship and short-term (5 ears or less) performance warranties. The general efinition of these warranties is described in chapter , while long-term performance warranties, PPCs, and BFO contracts are discussed in chapter 5.

roducts Warranted

he specific products warranted under asphalt avement warranties varied by country and warranty ype. In standard Danish and Swedish contracts, only ne asphalt layers delivered by the contractor are ubject to warranty. Road markings are also warranted when relevant. Germany warrants hot mix asphalt pavement, subbase aggregate, and subgrade. Germany also places the responsibility for all of these products on the prime contractor. The prime is responsible for all of these items independent of whether it is an earthwork contractor, paving contractor, or other prime. Products warranted in U.K. asphalt pavement warranties vary from the surface treatment material only for maintenance projects to the entire roadway project on design-build projects. Like Germany, the United Kingdom places the responsibility of the warranty on the prime contractor.

Length of Warranties

As briefly discussed in chapter 2, the warranty period of material and workmanship warranties and short-term performance warranties varied between 2 and 5 years in the host countries. The hosts interviewed by the scan team could not comment on the original decision as to the length of the warranty periods, because these decisions evolved long before any of the hosts began working in the programs. Table 3.1 depicts the warranty periods, type of

Country	Warranty Period	Warranty Type	Specification Type
Jnited Kingdom (design-bid-build)	2 years	Material and workmanship	Method
;pain	1 year	Material and workmanship	Method
Germany	4 years	Material and workmanship	Method
Denmark	5 years	Short-term performance	End result
;weden	5 years	Short-term performance	End result
Jnited Kingdom (design-bid)	5 years	Short-term performance	End result

able 3.1 Host country warranty periods.

U.S. Parallel: Warranty Length

Warranty periods in the United States vary on a State-by-State basis. The FHWA and the Michigan DOT conducted a Pavement Warranty Symposium in May 2003 (Pavement Warranty Symposium 2003). As part of this symposium, they conducted a survey of the State transportation agencies that attended. The following table provides the lengths of warranties reported by the States.

Colorado, Florida, Illinois, Indiana, Michigan, Minnesota, and Ohio have all used material and workmanship warranties with lengths of 2 to 7 years. They all provide method specifications on these warranties. The design process on these projects is similar to nonwarranted projects.

Florida, Michigan, Minnesota, and Wisconsin have 5-year performance warranties in which they measure performance and provide end result specifications. For example, Wisconsin provides pavement thickness and type of base, and the contractor is responsible for mix design, material selection, quality control, construction, and maintenance for 5 years. Minnesota and Florida use a similar 5-year performance warranty on their design-build contracts.

State	Warranty Period	Warranty Type	Specification Type
Minnesota	2 years	Materials and workmanship	Method
Colorado	3 years	Materials and workmanship	Method
Florida	3 years	Materials and workmanship	Method
Illinois	5 years	Materials and workmanship	Method
Indiana	5 years	Materials and workmanship	Method
Michigan	5 years	Materials and workmanship	Method
Ohio	7 years	Materials and workmanship	Method
Wisconsin	5 years	Short-term performance	End result
Florida (design-build)	5 years	Short-term performance	End result
Minnesota (design-build)	5 years	Short-term performance	End result
Michigan (performance)	7 years	Short-term performance	End result

The warranty projects described above represent a very small portion of the States' program. At the time of this report, Michigan has employed various types of pavement warranties on more than 400 projects, Wisconsin has used them on more than 45 projects, and Ohio has used them on 34 projects. There were fewer than 50 warranty projects in the other seven States combined at the time of this report. The States listed above are still in the formative stages of their warranty programs. The warranty period, warranty type, and specification type were changing and evolving in all of these States at the time of this report.

arranty, and type of specification for the host ountries. The period listed represents the longest arranty period for the product or performance easure on the entire pavement. Some warranties ave varying lengths on products and performance dicators as described on the following pages.

standard U.K., Spanish, and German contracts, the ost country's highway agency completes the design a method specification fashion. The host coun-ies required material and workmanship warranties these standard contracts. The United Kingdom mployed a 2-year warranty period, Spain employed 1-year period, and Germany employed a 4-year eriod. In the case of agency-supplied design, the ighway agencies are only asking for material and orkmanship warranties.

or short-term performance warranties, the highway gencies provided an end result specification and ave the contractors more flexibility in material hoice and mix design. Standard Danish and Swedish ontracts, as well as U.K. design-build contracts, tilize end result specifications by the agencies. The arranty period for these contracts is 5 years in enmark, Sweden, and the United Kingdom.

he Danish Road Directorate provided us with more etail on the length of the individual performance equirements. The Danish process was summarized in e following seven steps:

Preparation of project and pavement design end result specification.
– Performed by agency or consulting firm.

Preparation of tender documents.
– Performed by agency or consulting firm.

Tender.
– Low bid or economical most feasible bid using best-value system.

Award of contract.

Construction.

Hand over.
– Initial inspection performed by agency and contractor.

Period of warranty.
– Assessment of performance performed by agency.

he Danish system works within established unctional pavement requirements that are orrelated to the end result specification. The high-ay agency has established a set of warranty periods that vary with these functional pavement requirements.

As seen in table 3.2, surface regularity and profile and drainage of surface water are only warranted for the first year of the product. Friction, rutting, instability, and durability are warranted for the full 5 years. The actual performance measures for each of these functional pavement requirements are discussed in the next chapter. The Danish system recognizes that the ideal warranty period should be long enough to provide assurance of pavement performance, but not so long as to unnecessarily inflate contract prices.

Functional Pavement Requirements	Warranty Period
Surface regularity	1 year
Profile and drainage of surface water	1 year
Friction	5 years
Rutting	5 years
Instability	5 years
Durability (raveling, joints, cracking,potholes)	5 years

Table 3.2 Danish functional pavement requirements and warranties.

The Danish system also uses a bidding technique that allows contractors to offer alternate designs with longer life cycles in consideration for a discounted bid. Normally in asphalt pavement warranties, the individual highway agency uses the bidding document to describe the expected design life for the technical solution. However, the Danish system allows contractors to present an alternative solution during the bidding process. If the technical solution is evaluated to have a longer design life, the alternative bid may be accepted by the agency, thus rewarding the contractor through a discounted bid in the evaluation period. Table 3.3 on the following page provides an example from an asphalt paving project in Ribe County, Denmark, from 2002.

The Danish Road Directorate design provided to the contractors in table 3.3 had a design life of 14 years. "Contractor C" provided a design with a design life of 15 years as confirmed by the Directorate. Rather than award the bid on a first cost basis, the Directorate uses an annuity (average yearly value in present worth) to award the contract. Although Contractor C's bid was the highest first cost, it was

Contractor	Tender	Expected Service Life	Added Service Life	Avg. Yearly Cost*
	*DKK***	*Years*	*Years*	*DKK*
A	$1,393,975	14		$140,825
B	$1,371,460	14		$140,825
C	$1,403,205	14	1	$140,825

* The average yearly cost is used to compare individual bids. The average yearly costs are calculated by multiplying the total present value with the factor "K".

$K = r*(1+r)^n / ((1+r)^n – 1)$
r = internal interest rate of 5 percent annually
n = service life in years

**Danish Krone.

Table 3.3 Danish bid evaluation with extended life cycle.

awarded the bid on the basis of its lowest average yearly cost.[1]

The warranty period length varies across the host countries and, in most cases, within the countries. The host countries strive to select the warranty period length that: (1) provides assurance of pavement performance, without unnecessarily inflating contract prices, and (2) provides the optimum opportunity for innovation from the contracting community. Material and workmanship warranties employ method specifications and are shorter term (1 to 4 years). Short-term performance warranties employ end result specifications and have a 5-year warranty period.

Definition of Existing Conditions

The project scope definition process was not absolutely consistent throughout the host countries, but it shared many of the same attributes. Many of the differences stemmed from historical practices within the host countries, as well as the type of specification being used (method or end result).

In all of the host countries, the highway agencies and not the contractors determine the existing traffic loads and climatic conditions for the pavement design, although some of the countries employ consultants for this task. These traffic loads and climatic conditions are used for design purposes and dictate the terms of the warranty. In material and workmanship warranties, as well as short-term performance warranties, the contractors rely on these data for design. The results of inaccurate design data are discussed in the next chapter. It should also be noted that contractors are required to collect their own traffic data and make their own traffic projections in the case of longer-term PPCs and DBFO contracts, as described in chapter 5.

Procurement

The European host countries' procurement award processes vary significantly from that in the United States. All of the host countries allow for past performance and other nonprice factors to be incorporated into the contractor selection. They noted that this process was critical to the success of their warranty programs. The incorporation of past performance and other nonprice factors into the procurement process correlated with both the initial selection of more qualified contractors and more accountability in the enforcement of any corrective action required under the terms of the warranty. The two main methods of incorporating nonprice factors into procurement are project-based prequalification (short listing) and best-value procurement.

Project Prequalification (Short Listing)

U.S. highway agencies are accustomed to using prequalification processes for contractors on an annual basis, but these prequalification processes are usually quite general and the process is not used on a project-by-project basis. Germany, Spain, and the United Kingdom employ a project-based prequalification process, which is commonly referred to as short listing in U.S. public building construction. These European systems are similar to those used in U.S. design-build highway procurement systems.

The United Kingdom employs a strenuous project prequalification process for contractors bidding all project types, but it is even more strict in its design-build procurements. Spain employs a rigorous prequalification process, particularly on its maintenance procurements. The German Federal Ministry of Transport also employs a project short-listing process. Project prequalification criteria vary by country and project, but the following general requirements were noted as short-listing criteria by each country:

[1] The example shown in Table 3.3 is the cost portion of a more comprehensive best-value procurement process. The entire procurement process is shown in Figure 3.2 later in this chapter.

United Kingdom: past experience, performance rating, financial soundness, and quality of the company's human resources procedures.

Spain: minimum staffing and equipment standards of the contract (for example, a professional engineer is required to be on staff; minimum work force and required equipment is available).

Germany: bidder's staffing, financial condition, work experience, and past quality of work being "state of the art."

he Danish Road Directorate and the Swedish lational Road Association do not use a project-based requalification process as a rule given the small numer of contractors in their countries. However, the wedish National Road Association did note short listıg for unique projects on the basis of the availability f special resources on selected projects. Sweden's nnual prequalification process also includes specific lements, such as economic strength, environmental equirements, and safety requirements.

ēest-Value Procurement

his key procurement difference between the United tates and the European hosts involved the use of est-value procurement rather than a reliance on ɔw-bid selection. All of the countries award on a best-value" procurement process. A best-value proꞁurement process is defined as:

> *A procurement process where price and other key factors are considered in the evaluation and selection process to enhance the long-term performance and value of construction.*

All of the host countries pointed to the use of best-value procurement as a critical component in the success of their warranty programs. 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.

The mechanics of the best-value processes varied by country, but all of the processes shared some common characteristics. As shown in figure 3.1, the goal of a best-value selection is to balance cost with noncost factors to achieve long-term performance and value of construction for the public. All of the systems employ a two-envelope bidding (or proposal) system. The contractor submits a price proposal in a separate envelope from the technical (or qualifications) proposal. The technical envelope is always assessed (or scored) prior to the opening of the price proposal. Opening the price proposal occurs only after the assessment of the technical proposal to ensure that the price proposal will not influence the assessment of the technical offer.

The criteria assessed in the technical proposal varied on a project-by-project basis throughout the host countries. Value can be added to projects through two general categories: contractor qualifications or contractor enhancements to the project. Contract qualifications are assessed through criteria such as past experience, past performance, project personnel, management structure, etc. Contractor enhancements vary greatly, but can include time-

igure 3.1 Common attributes of European best-value procurement procedures.

related issues, design enhancements, traffic management plans, safety plans, environmental mitigation, etc. The owners choose these best-value parameters and create evaluation criteria from them on a project-by-project basis.

A key to success in best-value procurement involves the transparency of evaluation plans. Procurement documents must clearly convey how the evaluation criteria will be scored and how the cost and technical proposal will be combined. Transparent criteria and scoring methods convey to the contractors how they will be evaluated and what they should focus on in their proposals. These processes must be transparent to the proposers so that they know how to weight their costs and efforts in their proposals. Procurement documents must clearly convey the owner's project goals if the owner is to receive the best proposals.

The manner in which the tradeoff analysis is conducted between the price and technical proposals varies by country and by project within each country. Some examples only employ two criteria of price and qualifications or past performance. If the lowest price comes from the highest technical rating, then the project is awarded to the lowest bidder. If the lowest bidder does not have the highest technical rating, then the agency performs a tradeoff analysis to determine if the higher technical scores provide the public with better long-term value. If it can be determined that better value is achieved from one of the higher technical offers, then the award is made to a company other than that offering the lowest bid.

Some of the best-value decisions account for more than just price and qualifications. In these cases the tradeoff analysis is more complex and requires more intricate award methods. The Swedish National

Project Description

The best-value procurement method described was used on an asphalt paving project in Ribe County, Denmark, in 2002.

Best-Value Evaluation Criteria

- Technical evaluation
- Inconvenience during construction
- Environment

Best-Value Award Algorithm

Contractor	Tender	Expected Service Life	Added Service Life	Average Yearly Cost	Technical Evaluation	Inconvenience During Construction	Environment	Economical Most Feasible Bid**
	DKK	Years	Years	DKK	Points (E)	Points (U)	Points (M)	DKK
A	1,393,975	14		140,825	4	4	4	125,193
B	1,371,460	14		138,550	5	4	5	120,836
C	1,403,205	14	1	135,188	5	5	4	117,903

* The average yearly cost is used to compare individual bids. The average yearly costs are calculated by multiplying the total present value with the factor "K".

K = r*(1+r)n / ((1+r)n – 1)
r = internal interest rate of 5 percent annually
n = service life in years

** Economical most favorable bid = average yearly cost / F

F = (1 + Points (E)/100) * (1 + Points (U)/100) * (1 + Points (M)/100)

Figure 3.2 Danish best-value example for asphalt paving bids.

oad Association and the Spanish Road Association ffered two examples of best-value methods that nclude evaluation criteria such as past performance, ersonnel, management plans, technical approach, nd alternate bids. Three examples are shown in igures 3.2, 3.3, and 3.4. Figure 3.2 is an extension f table 3.3.

ll of the host countries pointed to prequalification nd best-value selection as a key to the success of neir warranty programs. They stated that the use of onprice factors in the award of future projects moti- ated the contractors toward better construction per- ormance and more amicable negotiations of solu- ons to any problems encountered during the war- anty period.

onding Requirements

he use of warranty bonds is standard practice in the Inited States, but bonds are not found on all proj- cts in Europe. Bonds insure a contractor's financial olvency during the warranty period in case any emedial work is required. The key difference in the ountries that required bonds was in the bond mount. The German Federal Ministry of Transport, ne Danish Road Directorate, and the Swedish lational Road Association required some type of varranty bond while the United Kingdom had no onding requirements. Figure 3.5 depicts the bond- ng requirements of the host countries.

or projects over 250,000 Euros, the German Federal Ainistry of Transport requires a bond equal to 5 ercent of the construction cost through project cceptance (performance bond), and then reduces ne bond to 2 percent throughout the remainder of ne project (warranty bond). The German contracts nay involve several different warranties for differ- nt elements of large jobs, some of which may have ifferent warranty periods and varying portions of ne total project cost.

tandard Danish contracts use a declining bond rate ystem. A performance bond in the amount of 15 ercent of construction costs is required during con- truction. A warranty bond of 10 percent is required uring the first year of the warranty period, but the mount is then reduced to 2 percent for the final our years of the contract. Recall that the standard anish warranty period is 5 years. The Danish Road irectorate thinks that these amounts better repre- ent the risk involved in the construction and warran- y process. A bond of 10 percent could be used

Project Description

The best-value procurement method described was used on all asphalt-resurfacing projects in the Mitt Region of Sweden during 2001.

Best-Value Evaluation Criteria

- Price
- Past performance
- Personnel
- Management plans
- Alternate bids

Best-Value Award Algorithm

The best-value selection system is a weighted criteria method based on a 75-point score for price and a 51-point score for the technical aspects of the proposal as translated below. Award is made to the proposal with the highest point total.

Price Proposal

0-75	Bid amount for main proposal

Points for bid amounts by contractors under consideration are given on a diminishing scale starting at 75 points for the lowest bid to 0 points for twice the amount of the lowest bid.

Technical Proposal

0-4	Main bid and alternative bids/proposals
0-1	The contractor submits a clean bid for the desired product
0-3	The contractor offers interesting/relevant side proposals/side bids
0-12	Offering organization with references
0-5	Main organization (primary project team management plan)
0-5	Additional organization (secondary project team management plan)
0-2	In charge of marking
0-5	Quality (for mass groups)
0-3	Measures
0-2	Control methods
0-5	Quality of pavement operation plans
0-4	Environment – environmentally adjusted work methods

Figure 3.3 Swedish best-value example for asphalt paving bids.

Project Description
The project involves a 5-year performance contract for the maintenance of highways, including asphalt paving, stripping, landscaping, emergency response, etc.

Best-Value Evaluation Criteria
- Price
- Technical approach
- Management plan
- Facilities and equipment

Best-Value Award Algorithm
The best-value selection system is a weighted criteria method. The criteria considered for the award are the quality of the technical solution and the economic offer. The weights used are 70 percent and 30 percent, respectively.

Global Score
The global score (PG) of every offer will be defined as: PG = 0.7(PT) + 0.3(PE)
where, PT: Technical score
PE: Economic score
The bidder with the highest PG will be defined as the apparent winner.

Technical Score
The technical score, PT, has a maximum of 100 points (see evaluation criteria above).

Economic Score
To weigh the economic offer, PE, from the N economic offers, the following algorithm is used.

B1) The calculation is made based on the economic proposals by means of linear interpolation, according to the straight line defined by both points P1 (lowest price, 100) and P2 (estimate of solicitation, minimum score). The method is as follows:

P1: the lowest price is assigned a maximum score equal to 100 points

P2: the corresponding minimum corresponds with the following formula:

Minimum score =
100 x lowest price / solicitation budget.

In the exceptional case, where every economic offer had the same price, every PE (economic score) will be 100 points.

B2) With the N economic offers, it will calculate the average of PE (economic score) defined as BM, and the standard deviation.

Numbering every economic offer from 1 to *n*, defined i as integer from 1 to n, and defined as Of_i, economic offer Of_i. Also, *P.L.* is defined as solicitation budget. Of_i will be the percent respect *P.L.*

$$BO_i = \left[1 - \frac{Of_i}{P.L.} \right] \cdot 100$$

$$BM = \frac{\sum_{i=1}^{n} BO_i}{n}$$

$$\sigma = \left[\frac{\sum_{i=1}^{n} (BO_i)^2 - n \cdot (BM)^2}{n} \right]^{1/2}$$

B3) With the values BM and SD (?), the next step is filtering the economic offer by the next formula:

$$|BO_j - BM| \leq \sigma$$

Now, j is an integer, generic, from 1 to n′ (0 < n′ <= n).

$$BO_j = \left[1 - \frac{Of_j}{P.L.} \right] \cdot 100$$

Figure 3.4 Spanish best-value example for asphalt paving and maintenance bids.

U.S. Parallel: Best-Value Procurement

Best-value procurement is becoming more prevalent in the United States. The NCHRP is sponsoring a project, NCHRP 10-61 Best-Value Procurement for Highway Construction, which will provide guidance for implementation in the United States. The study results are expected to be published in late 2004.

The State of Kentucky tested an alternate pavement design bidding system using warranties on its I-275 project. The alternate pavement designs were based on an equivalent 40-year design.

The Kentucky system can be classified as an "A+B-C" formula where:

A = traditional bid for work;
B = bid for cost of time to complete the project (includes road user costs); and
C = bid for length of warranty (5-year minimum) based on road user costs.

Warranty	Additional Warranty Credit
Year 5 (minimum	$ 0
Year 6	$ 500,00
Year 7	$1,000,00
Year 8	$1,500,00
Year 9	$2,100,00
Year 10	$2,900,00

An additional cost is added to the bid for schedule, creating an incentive for contractors to bid a shorter period of time. A warranty credit is subtracted from the bid for warranties of more than 5 years under the following formula:

In Kentucky's first application of the A+B-C system on the I-275 project, time and warranty length were not a factor in the final award, as seen in the following table, but the State received additional warranty years and a shorter construction schedule.

Contractor	A (Base Bid)	B (Calendar Days)	C (Warranty Years)
1	$23.13 million	380	10
2	$25.58 million	450	10
3	$26.30 million	450	10

All of the contractors bid the maximum 10-year warranty period. This was advantageous for the State because it received a long warranty. Likewise, the schedule was not a factor in award because the contractor with the shortest schedule also provided the lowest bid. In addition to receiving the lowest bid, the State also received a shorter schedule and a longer warranty in this case.

hroughout the process, but the bond would certain- / cost the agency more than the reduced amount in he final 4 years. The Danish Road Directorate ıssumes it will find the major defects in the first year ınd it is willing to pay more for the bond. It does not vish to pay the increased bond costs in years 2 hrough 4 when defects may be less likely to occur.

'he British Highways Agency takes a different view. : stated that its rigorous prequalification process and he existence of a small pool of relatively large contractors negates the need for a bonding process. Ginny Clarke, the British Highways Agency's Chief Highway Engineer, stated that "this is a nice world where we look after everybody." The British Highways Agency relies on its prequalification process to hire only contractors that can and will correct any defects in their work. They do not incur the costs of bonds on their projects.

The philosophy of the British Highways Agency was echoed throughout the host countries. There is a

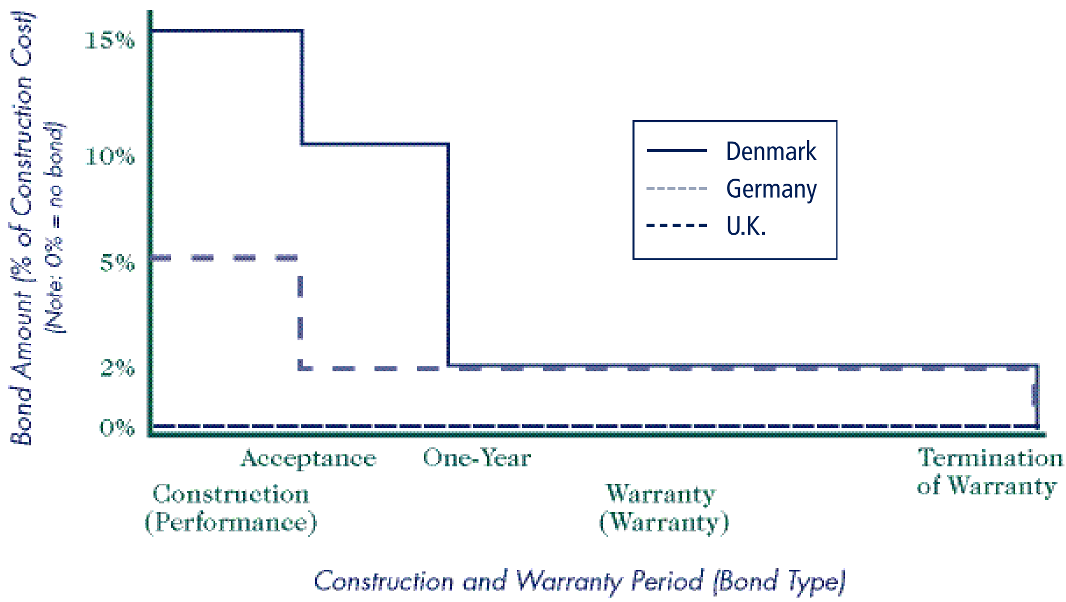


Figure 3.5 Bonding requirements of host countries.

strong feeling from the highway agencies that contractors are making the right decision for the right end result. Moreover, the use of prequalification and/or best-value procurement creates long-term relationships with the contractors. The agencies work strategically with their industry to create a culture of partnership and continuous improvement. The contractors know that they must correct their defects if they wish to be considered for future work. If a warranty bond is called, it will be reflected in their future proposals for a number of years. Likewise, the highway agencies are best served if their contractors succeed and they work closely with them to ensure their success.

Design and Construction Contract Award

Design and construction contract award involves the allocation of responsibilities for design, material selection, and quality assurance/quality control (QA/QC). On projects involving material and workmanship warranties, the design and construction contract award process in the European host countries is similar to that of the United States. However, those projects employing short-term performance warranties require the contractor to perform more of the design. Also, the European host countries use more contractor material selection and QA/QC than found in the United States. A brief discussion of these responsibilities follows.

In all of the host counties, the agency designs the pavement structure. Where short-term, performance-based warranties are being used (Denmark, Sweden, and U.K. design-build contracts) the contractor may select another design from the owner's catalog and the owner must approve selection. The contractor may also select a noncatalog design, but it will be at his or her own risk. In all cases, the contractor performs mix design of bituminous mixtures and submits the job mix formula to the agency for review. The final mix design must be within the limits set by the agency.

With the exception of the Swedish National Road Association and the Danish Road Directorate, material selection is controlled by the agency. Germany, Spain, and the United Kingdom provide preapproved lists of material sources from which the contractor can choose. The use of alternative sources is encouraged, but they require approval from the agency. Sweden and Denmark differ slightly because some of the major contractors own the aggregate sources. These sources are monitored and approved by the agencies.

As stated throughout this report, there is more partnership between the European host counties and the industry than found in the United States. Accordingly the European host countries rely heavily on contractor quality control (CQC). The agency takes an audit role in the QA process. Of the host countries, standard German contracts are the most similar to those in the United States and involve three tests: a suitability test, a self-monitoring test (QC), and an owner

U.S. Parallel: Bonds and Contractor Guarantees

The U.S. highway industry has been concerned with bonding since the inception of warranties. Bonds are required in all of the States using warranties, with the exception of Florida. Bond amounts are calculated in a number of different ways. The table below provides a sample of cases for setting bond amounts.

State	Bond Amount
Wisconsin	Estimated cost for a 1-½ overlay on the mainline pavement.[1]
Colorado	Estimated cost to mill and replace 2" to the nearest $25,000.[1,2]
Michigan	New bituminous pavements – 10 percent of the total warranted bid amount. Bituminous overlays – 100 percent of the total warranted bid amount.[2]
Illinois	New bituminous pavements – 20 percent of mainline cost. Bituminous overlays – 50 percent of mainline surface and binder.[1]
Minnesota	New bituminous pavements – 30 percent of the total warranted bid amount. Bituminous overlays – 20 percent of the total warranted bid amount.[1]

[1] *Pavement Warranty Symposium 2003.*
[2] *FHWA 2000.*

As seen in the table above, bond amounts vary by State. Each of the highway agencies developed their bond amounts in conjunction with the contracting and surety industries in their respective States.

Florida has recently moved away from the use of bonds in lieu of what it has termed a "contractor guarantee." Given Florida's aggressive construction program and an expensive bonding market post 9/11/2001, Florida found the bonds to be too costly. Its contractor guarantee system works on the same principles used in the United Kingdom. In essence, the contractor guarantees that it will fix any defects or it will be removed from the prequalification list on future projects. The following excerpts are from the "Section 5-14: Contractor Guaranteed Project Features" of its design-build contract documents (Florida DOT 2003).

> *"The Contractor shall assume responsibility for all the associated guaranteed work specified in this section for a minimum period of five (5) years … including continued responsibility as to any deficiencies to which notice was provided to the Contractor within such guarantee period until all such pre-existing deficiencies are resolved … Should the Contractor fail to … satisfactorily perform any remedial work within the duration allowed by the Department … the Department shall suspend, revoke or deny the Contractor's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, until the remedial work has been satisfactorily performed or full and complete payment for the remedial work made to the Department. In no case shall the period of suspension, revocation, or denial of the Contractor's certificate of qualification be less than six (6) months."*

At the time of this report, Florida was the only State using the contractor guarantee system for asphalt pavement warranties.

est (QA). The Danish system places more responsibili-
y on the contractor. The contractor performs the QC nd must submit the data to the agency during roduction and construction. No third-party control is equired. However, most Danish contractors are ertified in accordance with ISO 9000. The British lighways Agency relies heavily on CQC for both tandard and design-build contracts. A third party is typically hired by the agency to monitor the contractor's processes, but little testing is done. The agency relies heavily on contractor quality management plans and incorporates their performance into the following procurements through prequalification and best-value selection. The Swedish system is similar to the Danish and U.K. systems in that the contractors do all of their own testing, and the agency inspects

and audits. Contractors or third parties do all tests. In fact, the Swedish National Road Agency does not have its own laboratories.

The Danish Road Directorate employs a unique use of warranties in relation to the QC system. If the QC limits are not met but the contractor believes that the product will perform as desired, the contractor can extend the warranty period in lieu of paying a penalty or correcting the work. This extended warranty places more risk on the contractor but it does give the Directorate confidence in the product. This system has great potential in the United States to create a better relationship between the industry and the public sector.

Payment

Payment for work involves verifying work as complete and distributing payments. Retainage, incentives, and disincentives are common considerations in the final payments. The European host countries' philosophy on payment and retainage is closely related to their bonding philosophy described above. The host countries varied in their use of incentives and disincentives, as described below.

Since significant CQC is used, the European host countries make verification for payment in an audit fashion at the end of the project or in milestones. The German Federal Ministry of Transport uses visual inspection at the completion of construction according to the specifications. In standard Danish contracts, the contractor is paid after the work has been completed and accepted by the agency. On large projects the contractor may be paid on account. The Swedish system pays by unit volume, square meter, or ton, according to milestones. The British Highways Agency pays for work as completed. An inspector for the owner, who is typically a third-party consultant, is present on the projects.

Some countries equate their use of bonds to a retainage system. In Germany, for example, payment is made according to completion, with a 5 percent performance bond and a 2 percent warranty bond withheld depending on project size until the end of the 4-year warranty period. The Spanish system makes payment during construction, and then final payment at the end of the 1-year guarantee period. The Spanish system also delays payment during construction for the verification process. The Swedish system pays for all work except for *one-half* of the bond amount, which is released after completion of the warranty period. The U.K. system is unique in that there is no retainage or bonding system. While there is a performance warranty, there are no retainage or bonding requirements. Again, the British system relies heavily on the prequalification and best-value procurement system to ensure the quality of the work. Retainage systems are not conducive to long-term partnering relationships.

There is little use of incentives in the European host countries. The Spanish, Danish, and U.K. philosophy is to place the responsibility for performance as described in the specifications on the contractor. If the pavement does not comply with specifications or quality is insufficient, the agency can withhold payment until corrective action has been taken. A negotiation process is used in questions of specification compliance, but the warranty is enforced. The German system is similar, but they reserve the right to assess penalties in addition to requiring corrective action. The Swedish system does utilize an incentive/penalty system at project completion and will sometimes use a similar system at the end of the guarantee period.

Final Acceptance

In all host countries, a final acceptance of the project is made at the end of construction to signify the start of the warranty period. The formality of this final acceptance varies according to the level of QA applied by the host agency during construction. The German Federal Ministry of Transport uses perhaps the highest level of QA during construction and its final acceptance consists of a visual inspection done as a drive-though inspection after construction is complete. The British Highways Agency uses an on-the-job consultant throughout construction who verifies payment during construction and provides a final acceptance at the end of the project. The Danish warranty goes into effect at the end of construction independent of the owner's final acceptance. The Swedish system relies heavily on CQC during construction so the final acceptance is very rigorous. The Swedish National Road Association inspects all documents, including test protocols, verifications, and other contract demands. It then performs a visual inspection and a detailed road survey.

At the end of the warranty period, there is an official closeout function where the pavement is inspected and an assessment made as to whether the pavement has performed as expected. Much of this inspection relies on the individual country's avement management system, which is discussed in hapter 4. In general, however, the level of inspecion at the end of the warranty period is similar to nat at the end of construction that was previously escribed. In Germany, there is a drive-through nspection. The agency presents a detailed "punch st" to the contractor. In the case of disputes, a joint nspection may be carried out. The German Federal Ministry of Transport is beginning to measure frición as an acceptance criterion. The Danish Road Directorate uses a third party to conduct a road survey and visual inspection, contract demands, and est protocols. The Swedish National Road ssociation only inspects the pavement at the end f the warranty period if it is required as determined through the pavement management system. f it is required, the agency, or third party, conducts road survey and inspects all documents, including est protocols, verifications, and other contract emands.

onclusions

he use of asphalt pavement warranties is so ntrenched in the European host countries' culture nat few of the hosts could explain the evolution of neir programs. Warranties have simply been in use ince before our hosts started working, and in some ases, before they were born. The warranty system as helped to establish a spirit of partnership and rust between the agencies and their industry. The ontractors know that they are responsible for the uality of their work and that the chances of wining the next project directly relate to the quality of erformance on their current project. Without bestalue selection and project-based prequalification short listing), the warranty programs would not be s effective.

he lengths of warranties vary. As a general rule, naterial and workmanship warranties are shorter (1 o 4 years) and performance warranties are longer 5 years). In all cases of performance warranties, the ontractors have more responsibility for design and QC. The Danish system provides for varying lengths f warranties, depending on the particular assessment criterion.

ll of the bidding processes evaluate more than just rice. Examples of life cycle evaluation criteria are revalent. All counties employ project-based prequalification and/or best-value procurement and point to ne procurement procedures as a critical element of rogram success. Nonprice factors being evaluated can include past experience, performance rating, financial soundness, and quality of the company's human resources procedures, to name only a few. Examples of nonprice factors holding more weight than price factors are not uncommon—particularly on longer-term contracts.

Bonding requirements and payment procedures are closely related and vary from country to country. Only the United Kingdom does not employ bonding or retainage. All of the other host countries employ varying levels of bonding and retainage. Some countries hold retainage until the end of the warranty period.

The European host countries more frequently allocate design, materials, and QC responsibilities than their American counterparts. While the agencies perform existing conditions assessment and pavement structure design in projects using material and workmanship warranties, they perform fewer activities in those projects with performance warranties. In all cases, contractors perform more QC activities than in the United States.

The European hosts strongly believe that contractors are making the right decision for the right end result. Moreover, the use of prequalification and/or best-value procurement creates long-term relationships with the contractors. The agencies work strategically with their industry to create a culture of partnership and continuous improvement. The contractors know that they must correct their defects if they wish to be considered for future work.

Warranty Evaluation

Warranty evaluation occurs during the warranty period of the contract. Critical items that need to be evaluated during the warranty period include allocations of responsibilities for operation and maintenance, criteria and thresholds for performance evaluation, and triggers for corrective action under the terms of the warranty. More globally, agencies must continuously evaluate and improve their warranty programs. This chapter reports on the warranty evaluation process in the European host countries. Although this chapter focuses on material and workmanship and short-term performance warranties, many of the performance evaluation criteria and evaluation techniques are similar to those used in the long-term performance warranties and maintenance contracts described in chapter 5.

Responsibilities for Operation and Maintenance

Historically, warranties have not been allowed in the United States, in part because they can be considered "maintenance," and federal funds could not be used for maintenance as discussed in chapter 1. Since the 1990s, however, U.S. warranty evaluation programs have been allowed to include maintenance in warranty contracts. Table 4.1 provides maintenance definitions for discussion. The definitions have been adapted from NCHRP 451—Guidelines for Warranty, Multi-Parameter, and Best-Value Contracting.

The European host countries all consider preventive maintenance part of the contractor's responsibilities under both material and workmanship warranties and short-term performance warranties. In standard contracts, the warranty contractors are responsible for any maintenance correlating to the correction of defects stemming from material and workmanship related issues or poor performance under normal conditions. A number of important issues must be considered during operation and maintenance of the warranty period, including determination of traffic loads and climatic conditions and emergency repairs.

Unexpected traffic loads or differing climatic conditions are not a major concern in any of the host countries. The German Federal Ministry of Transport makes no adjustments during the 4-year warranty period. It factors its extensive historical climatic and traffic data into the design process. Traffic loads are

Type of Maintenance	Definition
Routine	Such items as signage removal and repair, snow removal, salting/sanding, mowing, and guardrail improvement or repairs
Preventive	Smaller, less serious forms of corrective action performed to prevent a distress from reaching threshold level
Corrective	Repair or replacement of deficient areas, as defined in warranty specifications
Emergency	Any distress or product failure that presents an immediate safety hazard to the traveling public

Table 4.1 Maintenance definitions under warranty specifications.

U.S. Parallel: Preventive and Routine Maintenance

Responsibilities for preventive and routine maintenance are unique to each State, but generally the States are responsible for the routine maintenance, and the contractor has an option to perform preventive maintenance. The following are responses to a survey from a warranty symposium asking the question how routine and preventive maintenance are handled during the warranty period of the contract (Pavement Warranty Symposium 2003).

Florida DOT Routine maintenance is not included; however, the Contractor has maintenance responsibility for the work associated with the Contract for the full warranty period. Remedial work must be performed to Department standards.

Indiana DOT The DOT is responsible for snow plowing, letter removal, etc. Pothole patching, etc. is the contractor's responsibility and must be corrected in accordance with the specifications.

Illinois DOT Routine maintenance (snow removal, pavement marking, mowing, etc.) by IDOT is allowed during warranty period, and does not relieve contractor from meeting the warranty requirements. Preventive maintenance by contractor is allowed, with prior approval by IDOT. Examples would be joint and crack sealing and bump grinding.

Wisconsin DOT The contractor is required to seal all cracks at the end of the 3rd year. However, the contractor can do other corrective action if they feel that it would be beneficial to them. This has to be coordinated through the associated Transportation District.

Additionally, a recent survey for the Texas DOT found that Minnesota, Michigan, and Washington perform preventive maintenance under the States' DOT responsibilities during the warranty period.

Source: Stewart Anderson, Presentation to the Texas DOT, March 5, 2003.

rojected for the life of the pavement and not djusted for in the warranty period. The Danish and wedish philosophies are less stringent and include a egotiation phase with the warranty contractor if the ounts are outside of the limits set on traffic and oads. The same negotiation philosophy is used if climatic conditions vary. In all host countries, Acts of iod are a responsibility of the owner.

mergency maintenance or repairs are typically performed by the warranty contractor in order to minimize coordination of future warranties on the repair vork, but the emergency repairs may be contracted o a separate entity depending on the country and he specifics of the contract. Costs for maintenance temming from an accident are charged to the owner f the vehicle causing the accident. Charging the wner or his/her insurance company is common practice throughout the European host countries.

erformance Indicators and Thresholds

lear and equitable performance indicators and hresholds are a primary key to success in European and U.S. warranty systems. The European host countries rely on their pavement management systems (PMS) to measure the warranted project and use the historic PMS data to determine the thresholds. Therefore, the indicators used to measure warranty project performance are the same indicators that are collected on pavements regularly throughout the country. The majority of indicators are consistent from country to country, with some exceptions because of the particular measurement instruments employed and the types of deterioration problems commonly encountered within each country. The thresholds are somewhat less consistent from country to country. They vary primarily depending on the climatic conditions, the materials available in each country, and the types of deterioration commonly encountered within each country. For example, Sweden does not measure friction on the majority of its roads because the use of studded snow tires maintains a high coefficient of friction on the asphalt. However, rutting is a common problem because of these same studded tires.

	Spain	Germany	Denmark	Sweden	U.K.
Deterioration (longitudinal, transverse and alligator cracking, and potholes)	X	X	X	X	X
Durability (raveling, joints)	X	X	X	X	X
Friction	X	X	X		X
International Roughness Index (IRI)	X		X	X	
Longitudinal evenness			X		X
Transverse profile and drainage of surface water			X		X
Rutting			X	X	X
Instability/structural	X		X		
Crossfall			X	X	
Texture					X

Table 4.2 Performance indicators.

Table 4.2 summarizes the performance indicators specifically mentioned by the European host countries. The research team attempted to collect data for both the types of performance indicators and their corresponding thresholds from each of the host countries. However, complete data collection was not possible given the short time of the research, the language barriers, and the varying nature of indicators and thresholds within the countries.

As seen in table 4.1, all of the host countries use durability and deterioration as performance measures. The definitions of these two measures vary slightly, but all note a visual inspection for conditions of longitudinal cracking, transverse cracking, and/or alligator cracking, potholes, raveling, and joint separation. With the exception of Sweden as previously noted, all of the host counties use friction as a performance indicator. Since the German Ministry of Transport uses prescriptive designs with materials and workmanship warranties, it does believe that it needs to use other performance indicators. Denmark, Sweden, and the United Kingdom are using short-term performance warranties and allow more innovation in the final design, and therefore employ additional indicators that correlate to design performance. IRI, rutting, and texture are all measures that incorporate design performance with material and workmanship performance. Denmark and Sweden use the greatest number of performance indicators in their systems. As these owners move toward longer warranty periods, they are using a greater number of performance indicators and measuring more frequently, as discussed in chapter 5.

Performance Measurements

All of the European host countries rely almost exclusively on their PMS to evaluate the performance of warranted products. For example, the U.K. PMS involves annual inspections, and the Spanish PMS includes surface inspections every 6 months with bearing capacity inspections annually. The German Federal Ministry of Transport also uses a local visual inspection on a weekly basis for normal roads, thrice weekly for Auto Bahns. Regarding specific performance measurements for warranties, all of the countries conduct at least a visual inspection at the end of the construction period. The German Federal Ministry of Transport uses an additional visual inspection at the end of the warranty period. The Danish Road Directorate typically performs an initial inspection at the end of construction, a 1-year inspection, and a 5-year inspection. The Danish Road Directorate also reserves the right to perform inspections whenever necessary.

The European host countries use a similar array of reference guides and equipment as

U.S. Parallel: Performance Indicators

The United States uses many of the same performance indicators found in Europe. The variation of performance indicator is a function of the types of deterioration problems commonly encountered, the particular measurement instruments employed, and the evolution of the warranty program within each State. The table below is a summary of performance indicators reported by the FHWA in 2000 (FHWA 2000).

	AL	CA	CO	FL	IN	ME	MI	MO	OH	WI	Total
Alligator Cracking	X	X	X	X		X	X			X	**7**
Bleeding/Flushing	X	X				X	X		X	X	**7**
Block Cracking	X	X				X	X			X	**6**
Delamination									X		**2**
Disintegrated Areas	X		X	X		X	X			X	**6**
Edge Cracking	X	X	X	X						X	**5**
Edge Raveling										X	**1**
Longitudinal Cracking	X	X	X	X	X			X	X	X	**8**
Longitudinal Distortion	X									X	**2**
Patching						X	X		X	X	**4**
Potholes	X		X	X		X	X	X			**6**
Ride Quality	X		X	X	X		X				**5**
Rutting	X	X	X	X	X	X	X	X	X	X	**10**
Scabbing	X										**1**
Shoving/Slippage Areas	X		X	X		X					**4**
Skid Resistance	X				X						**2**
Spalling								X			**1**
Surface Raveling	X	X	X					X	X	X	**6**
Transverse Cracking	X	X	X	X	X	X	X	X		X	**9**
	15	**8**	**13**	**9**	**5**	**9**	**9**	**6**	**6**	**12**	

In general, the U.S. highway agencies use more performance indicators than do the European host countries. Alabama, Colorado, and Wisconsin all use more than 10 performance indicators to measure warranty performance. Indiana, Missouri, and Ohio use six or less. These indicators can change on a project-by-project basis and may evolve into composite indices as the State warranty programs continue to develop.

Performance Indicator	Measurements
Deterioration (longitudinal, transverse and alligator cracking, and potholes)	• Visual distress surveys • Photo-logging
Durability (raveling, joints)	• Visual distress surveys • Photo-logging
Friction	• Sideways force coefficient routine investigation machine (SCRIM) Pendulum • Photo-logging
International Roughness Index (IRI)	• Noncontact laser profilometers
Longitudinal evenness	• Noncontact laser profilometers
Transverse profile and drainage of surface water	• Noncontact laser profilometers • Visual observations
Rutting	• High-speed monitoring vehicle with rut bar • Noncontact laser profilometers
Instability/ structural	• Falling weight deflectometer (FWD)
Crossfall	• High-speed monitoring vehicle
Texture (stone loss)	• Visual distress surveys • Photo-logging

Table 4.3 European host countries' measurement guides and equipment.

found in the United States, which is displayed in table 4.3.

The host countries employ varying lengths of inspection. Table 4.4 describes the varying lengths of inspection for a selected number of inspections. The length of pavement evaluation varied somewhat from project to project, but table 4.4 describes the length that the host countries most commonly use.

Corrective Action

There may be instances when corrective actions are required under terms of the warranty. For example, the German Federal Ministry of Transport noted that 1 percent to 2 percent of the projects require significant corrective action that invokes the warranty and about 25 percent of the projects require some preventive maintenance, but the work is minor. The owner must then consider the communication of the corrective action to the contractor, the consequences of noncompliance, the conditions that might void the warranty, owner participation in corrective action, and dispute resolution.

The communication of defective items varies slightly from country to country. In Germany, the Ministry of Transport deals with only the prime contractor. The Spanish Road Association uses separate maintenance contractors during the warranty period. These maintenance contractors must repair defects and seek recovery from the warranty contractor. In this manner, the Spanish government is shielded from defects covered under the warranty. The Danish Road Directorate suggests the corrective action in accordance with traditional measures. In some cases, the actual measures will be subject to negotiation, but the agency has a strong position. The British Highways Agency relies on the county representative to initiate the action, but there does not appear to be a fixed procedure.

All countries have stringent penalties for noncompliance with required corrective actions. As previously noted, all countries have the ability to consider the failure to correct defective items in future procurements through project-based prequalification and/or best-value selection. All of the host countries point to this procurement latitude as a primary factor in the success of their programs. Spain, Germany, and the United Kingdom reserve the right to completely debar the contractors from bidding on future work. The German Federal Ministry of Transport requires both construction and

Country	Length of Measurements (meters)
Spain	1000
Germany	100
Denmark	100
United Kingdom	100
Sweden	20

able 4.4 Length of pavement evaluation sections.

varranty period bonds. The German Federal Ministry of Transport will call either bond if necesary and can invoke penalties or withhold payments uring construction. These actions do not affect the varranty performance requirements. The Danish onsequences vary with the nature of the noncompliance. As a general rule, the cost of the measures easonably relates to the actual importance of the oncompliance issue. During construction, they typially use levels of (1) warning, (2) extended warran/ period, (3) remedy action or deduction in payent, and (4) rejection of product. During operaions, they rely on the warranty bond and the impliations on future performance. The United Kingdom elies solely on future qualification for additional ontract work and does not use bonds, as discussed chapter 3.

onditions to void warranties are rare and are negoated in Europe when they are encountered. Acts of iod and accidents are the only cases that were noted s a cause for voiding a warranty in all of the uropean host countries. Before a warranty becomes ompletely void, the European hosts are likely to parcipate in the corrective action as described below. here is a much greater sense of community, shared esponsibility, and negotiation than what is found in ne U.S. industry.

Owner participation in corrective action varies with ne European host countries. The Spanish Road ssociation and the British Highways Agency typically nly participate if the repairs are forced by Acts of iod. The Swedish National Road Association will parcipate if "non-normal" conditions arise. The German ederal Ministry of Transport participates if the epairs are caused by Acts of God or if the owner aused the problem through (1) defective specification, (2) errant special instructions, (3) defective owner-provided materials, or (4) the problems are caused by a previous contractor.

The Danish philosophy for participation in corrective action is unique. In effect, they prorate the repairs on the pavement. If a pavement failure occurs within the 5-year warranty period, they give the contractor credit for the useful life they have already received. However, all repairs have a new 5-year warranty. Also, if it can be justified that the traffic load is higher than the designed technical solution, both parties are supposed to be responsible for the failure to some degree. The contractor is assumed to have some foresight in the problem given the expertise upon which it was selected. The remedial action and related cost are settled by negotiations. The Danish tradition is that the owner and the contractor can split the difference if it was shared responsibility. An example was provided where the contractor paid 7/11th of the costs and the owner paid the other 4/11th for the cost of the remedial action.

Negotiation is the most common mechanism to resolve disputes. There seems to be a long tradition of resolving disputes without taking legal action. However, the agencies are in a strong negotiating position because of the implications to the contractor for future work. The Swedish and Danish rely almost exclusively on negotiations. The German system provides for arbitration. The U.K. system provides for adjudication (use of outside experts, panels, etc.), and ultimately legal action, but this is rarely invoked.

Program Performance Evaluation and Industry Input

The U.S. research team was interested in how the European host countries evaluate and continuously improve their warranty programs. The hosts were asked to provide comparisons for performance of asphalt warranted pavements to that of nonwarranted pavements. However, none of the hosts had such data available since all of their projects have warranties and their warranty programs have been in existence for so long that they do not have data for comparison. It turns out that the host countries rely on their private sector partners to indirectly measure the program performance and assist in continuous improvement.

As discussed throughout this report, there is a great sense of partnership and collaboration among the European highway agencies and the private sector.

U.S. Parallel: Program Performance Evaluation

The U.S. highways agencies have been evaluating the performance of their warranty projects through the use of pilot projects. While much of this has been done informally, Colorado and Wisconsin have published two excellent reports on their program evaluation. Both of these reports are available on the DOT's research websites.

Aschenbrener, T., and DeDios, R. (2001). "Materials and Workmanship Warranties for Hot Bituminous Pavement: A Cost-Benefit Evaluation." Report No. 2001-18, Colorado Department of Transportation, Denver, Colorado.

Krebs, S. (2001). "Asphalt Pavement Warranties – Five-Year Progress Report." Wisconsin State Department of Transportation, Madison,Wisconsin.

The reports offer an interesting contrast.Wisconsin has found a significant cost-benefit savings, while Colorado's experience was not as positive. These findings relate to warranty and project selection processes developed in each State. When viewed together, the reports offer an excellent database of lessons learned.

There is also a culture of continuous improvement that has been fostered by the move toward International Organization of Standardization (ISO) quality systems. Each host country provides opportunities for industry input into the warranty programs, and the agencies use this input to improve their practices. In Spain, there is opportunity for the industry to negotiate with the Spanish Road Association on different aspects of large contracts after they are first advertised and before bids are accepted. The German Federal Ministry of Transport uses a board composed of the agency, industry, and academia to establish test procedures and standards. It operates in a similar fashion to the TRB except that in addition to research, the group also develops and maintains specifications. The Danish Road Directorate uses a standards board composed of agency, industry, and consultants, and addresses issues annually. Similarly, the Swedish National Road Association employs agency, industry, and consultant input, but in a less formal manner. In the United Kingdom, the contractors can comment or propose changes annually. There is a working group composed of consultants, contractors, and the agency. All of these methods provide valuable input into continuous improvement of the host countries' warranty programs.

Innovation in Products and Processes

Contractor innovation is difficult to achieve in standard material and workmanship warranties and in short-term performance warranties. The German system of material and workmanship warranties allows for virtually no flexibility or opportunity for innovation. Standard Danish warranty contracts specify materials and pavement thickness, leaving little incentive for innovation. Even in the Danish example of offering extended service life for a lower average annual cost provided in chapter 3, the contractors must propose preapproved pavement designs. These designs must also go through a rigorous approval process with the Danish Road Directorate. The contracting environment in Spain does not allow the contractor flexibility to innovate at will. If a contractor identifies an innovative material or technology, the idea is submitted to the Spanish Road Association for approval.

The Swedish system provides for a little more innovation. The agency designs a cross-section and recommends mixtures to be used. At the time of bidding, the contractor can propose an alternate cross-section and alternate mixtures. For a completely unknown approach, the agency may ask for an extended warranty of 1 or 2 years. The U.K. short-term performance warranty system using design-build contracts perhaps allows for the most innovation, but there is still little incentive for the design-builder to take such risks. In U.K. design-build contracts, the contractor is required to use standard specifications for the design and construction. The contractor can propose an alternate solution but the British Highways Agency is cautious about accepting any unproven material. The contractor must apply to the Highways Agency for a deviation. The Highways Agency reviews the proposal and data provided and then agrees or disallows the proposed eviation. The typical evaluation of deviations takes to 6 months.

ll of the material and workmanship warranties and hort-term performance warranty programs provide ttle incentive for innovation, and therefore all of he countries are experimenting with alternative con-racting methods to increase program performance. hapter 5 describes alternative contracting methods, articularly PPCs and long-term performance war-anties, in detail.

onclusions

ransparent warranty evaluation processes are a key o any warranty program's success. The longevity of he European host countries' warranty programs has llowed for a large amount of industry input over he years. As discussed throughout this report, there a great sense of partnership and collaboration mong the European highway agencies and the pri-ate sector. This partnership is evident in the entire varranty evaluation process from the allocation of esponsibilities for maintenance to the resolution of isputes.

ll of the European host countries allocate preven-ive maintenance to the contractors. Standard war-anty contracts do not allocate routine maintenance o the contractor, but this is done in alternative con-racting methods as discussed in chapter 5. nexpected traffic loads or climatic conditions are ot a major concern of the highway agencies, but hey will negotiate warranty terms in cases of xtreme conditions. The warranty contractor typical-y performs emergency maintenance required dur-ng the warranty period.

he European host countries determine the perform-nce indicators and thresholds from historical data in heir PMS. The PMS is employed to measure perform-nce indicators in each of the host countries. Since nonitoring occurs on all of the warranted pave-nents in conjunction with the entire network, there little additional effort required to implement the varranty evaluation. Deterioration, durability, fric-on, IRI, profile, and rutting are among the most ommon performance indicators. The thresholds vary rom country to country and project to project, but hey are all consistent with historic expectations rom their PMS. Common measurement tools include isual distress surveys, photo-logging, SCRIM, high-peed monitoring vehicles with rut bars, and noncon-act laser profilometers.

Requirements for corrective actions are typically done through the prime contractor and may employ a negotiation phase. All countries had stringent penalties for noncompliance with required corrective actions. They all note the failure to correct defective items in future procurements through project-based prequalification and/or best-value selection, and they consider this to be a primary element for warranty program success. Owners may participate in costs for corrective action if the defect is not the fault of the contractor; however, there are few instances that would justify owner participation. The agencies are in a very strong negotiating position in these instances. There is a long tradition of resolving disputes without taking legal action, but arbitration or adjudication can be used if negotiations are unsuccessful.

Innovation stemming from the standard warranty programs is not widespread in standard warranty contracts. At a minimum, the agencies design a cross-section and recommend a mixture. Contractors can suggest alternatives, but these alternatives must be approved by the agencies, and they may request extended warranties on unusual requests. To enhance innovation, the agencies are turning to alternative delivery methods, as described in chapter 5.

Alternative Delivery Methods

Introduction

Chapters 3 and 4 of this report describe both material and workmanship and short-term (5 years or less) performance warranties in Europe. The long history of success with these short-term performance solutions has recently evolved toward longer-term guarantees of performance through the use of maintenance contracts, PPCs, and DBFO contracts. Similarly to the United States, the European hosts are dealing with growing capital project needs, as well as backlogged 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 delivery methods as a mechanism to increase innovation without creating a burden on highway agency staff. While these long-term performance contracts were not the focus of the scan, all of the host countries viewed them as a natural evolution of their warranty program and spent a significant amount of time presenting them to the scan team during the visit.

The alternative delivery methods use many of the same mechanisms discussed in the short-term warranties. For example, the previous discussions of existing conditions definitions, final acceptance, performance indicators and thresholds, performance measurements, and corrective action are all very similar in the long-term performance warranties. The primary differences involve the products warranted, the lengths of warranties, procurement methods, bonding requirements or financial guarantees, design and construction contract award, payment, and responsibilities for operation and maintenance.

This chapter presents three categories of long-term performance warranties: maintenance contracts, PPCs, and DBFO contracts (see figure 5.1). The discussion focuses on those items that are significantly different from short-term warranties. All of the long-term performance contracts include both a warranty and maintenance activities. The first group only includes maintenance and is generally shorter in term (5 years). The pavement performance warranties include the maintenance necessary to warrant the project for approximately the design life of the pavement. The DBFO contracts include maintenance over the life of the project, and the term can span over multiple pavement rehabilitations.

The reader should be aware that these alternative delivery methods are a relatively new mechanism in

Material and Workmanship Warranties	Short-Term Performance Warranties	Maintenance Contracts	Pavement Performance Contracts	Design-Build-Operate-Finance

- Method specifications
- 1- to 5-year warranties
- Government financing
- Lower contractor risk
- Traditional delivery

- End results specifications
- 5- to 35-year warranties
- Contractor financing
- Higher contractor risk
- Alternative delivery

Figure 5.1 Warranty evolution continuum.

urope. As noted in chapter 2, significant use of long-erm performance warranties has only been in effect nce the 1990s in the majority of host countries, and ney are still widely considered to be an alternative orm of contracting in these countries. There is not et the documented success and core knowledge ound with the short-term warranties. However, the uropean host countries are placing a lot of faith in nese contracts to deliver performance by tying the ontractor into the full life cycle of the product.

/laintenance Contracts

he majority of short-term warranties does not nclude routine and preventive maintenance in the ontract, but rather include corrective maintenance nrough the performance measurement terms of the ontract. Spain and the United Kingdom provided the can team with examples of maintenance contracts nat place the responsibility for routine and preven-ve maintenance on the contractor. In addition to naintaining pavement at a predescribed level of per-ormance, these maintenance contracts also include ems such as smaller, less serious forms of corrective ction performed to prevent a distress from reaching nreshold levels, signage removal and repair, snow emoval, salting/sanding, mowing, and guardrail nprovement or repairs.

hese maintenance contracts are not necessarily tied o the original construction contract, but they are still natural evolution of warranties as they move from nort-term to long-term performance warranties. Vhere material and workmanship and short-term erformance warranties need only examine the pave-nent performance after 1 to 5 years as a prediction f future performance, they do not typically warrant avements into the preventive maintenance cycle. lowever, long-term performance warranties continu-usly examine the pavement performance well into nis preventive maintenance cycle, and it follows that ne contractor will perform that maintenance so that nere is a clear delineation of responsibility. The con-ractor may also want to control the routine mainte-ance to ensure that drainage and other critical ele-nents of the roadway performance are met.

pain provided an excellent maintenance contract ase study for the research team. In the 1980s the first panish national highways were constructed, and the naintenance of the highways was contracted exter-ally through bids. Prior to that time the Spanish gov-rnment was in charge of the maintenance. In 1987, ne Spanish government awarded the first contract for the maintenance of the M30 loop around Madrid. As of September 2002, there were more than 120 contracts to manage over 3000 km of highways in the national region. Fifty-sixty companies managed these contracts, and the government still managed about 20 percent of the system. The municipalities have similar contracts for cities and urban areas.

The Spanish maintenance contracts were originally awarded on a 4-year term, but the term has recently been switched to a 2-year award with two 1-year options. The contracts are typically for 100 km of highway, but they are often shorter for rural roads. The maintenance contacts are divided into three groups:

- **Group 1** keeps the roads open from incidents, snow, obstacles, etc. A full team has crews that work 24 hours a day/365 days a year with a lead engineer. They must patrol the road at least three times a day. The team takes care of normal repairs during regular business hours, but has full-time shifts that take care of incidents 24 hours a day. The contractors receive a fixed fee monthly and work on a cost-reimbursable basis for the materials they install. The staffing is clearly specified in the contract.
- **Group 2** takes care of routine maintenance such as cutting grass, painting pavement markings, replacing signs, and small paving projects, etc. They are paid on a unit-cost basis rather than a lump-sum basis.
- **Group 3** takes care of unexpected events such as flooding and works under a top set amount for the contract period. If their services are not needed, the money reverts to Group 2. This group will repair the road in cases of a tanker accident, a damaged bridge, etc.

The cost breakout for the entire network is approximately 30 percent to 40 percent for Group 1, 50 percent to 60 percent for Group 2, and 10 percent to 20 percent for Group 3. The Ministry of Transport maintains the system-wide pavement management database. Group 1 collects the data (using a subcontractor with the laboratory), but the Ministry makes the decisions when to repair the road. These data are made available to the maintenance contractor, but are maintained by the Ministry. If maintenance is required on a systemwide basis, the project is let as a large bid. If the work is less than 1 or 2 km, the maintenance contractor may do it. Typical perform-

U.S. Parallel: Asset Management Contracts

The Virginia DOT embarked on a 5½ year, fixed-price maintenance agreement for more than 1,000 lane miles on I-77, I-81, I-95, and I-381. The work includes all required restorative work, such as roadway resurfacing and bridge deck replacement (Garza and Voster, 2000).

ance indices include IRI, deflection, cracking indices, wearing, and friction.

The United Kingdom uses managing agent contracts (MAC) for term maintenance of its motorway and trunk road system. The United Kingdom started with 3-year maintenance contracts for a limited scope of work. Currently, the term is 5+1+1 (5 years as a base plus two 1-year options) if the provider, the contractor, is achieving the performance indicators successfully. The scope of work has also expanded from the initial concept. Emphasis is being placed on integrated supply chain management. The selection process includes evaluation of the plan to provide goods/services, also risk allocation within the contractor team. Maintenance includes routine matters and limited reconstruction work—if reconstruction costs are above a specified level, the job is separately procured.

As previously stated, these maintenance contracts are somewhat outside the scope of this warranty scan, but they are a natural evolution of warranties as they move from short-term performance to long-term performance. As contractors move into the longer-term pavement performance warranties described in the next two sections, they may need to acquire these maintenance competencies in order to deliver the scope of services being required by the government.

Pavement Performance Contracts

Various forms of PPCs were observed in all countries on the tour. Denmark had awarded close to 20 contracts at the time of this scan. Sweden was using PPCs for about 10 percent of its pavements at the time of this scan and is hoping to double the number by 2007. The exact number of Danish PPCs and the type of surfacing is shown in figures 5.2 and 5.3. Germany refers to these contracts as "functional contracts," and they had awarded only two at the time of the scan. The United Kingdom uses a form of PPC though its "framework contract." The term PPC will be used to describe all of these contracts for clarity in this report.

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. The advantages to the owner are readily apparent. Table 5.1 offers a comparison of the lengths of warranties on standard Danish contracts and PPCs. As displayed, the owner is assured of performance over a period of 11 to 16 years in the PPCs, rather than just 1 to 5 years as seen in traditional contracts. Additionally, impenetrability of surface water and load-bearing

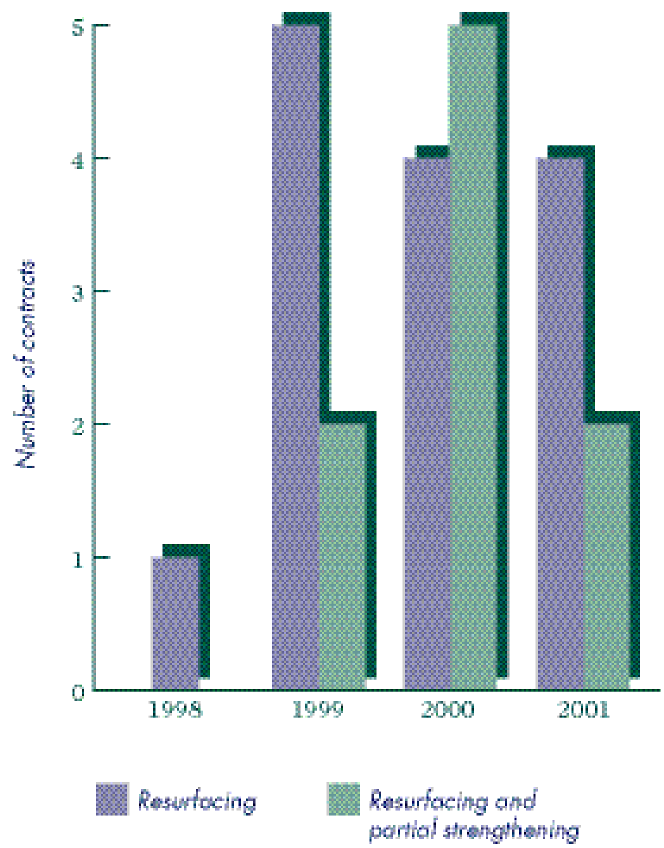


Figure 5.2 Danish pavement performance contracts (number of contracts).

apacity are warranted in the PPCs, but not in the tandard contracts.

ı Spain, Germany, and the United Kingdom, the ighway agencies are promoting the contracts. lowever, the industry is the catalyst for PPCs in enmark and Sweden. In all of the countries, the PPC orms are developing with close government and ıdustry collaboration.

epending on how the contractor proposes to build ıe pavement, the maintenance can include a number of items from filling of isolated potholes and ıinor pavement remarking to a complete mill and verlay of a significant section of pavement. The ighway agencies are simply looking to the industry o provide a pavement that performs to prespecified tandards. The PPCs allow for much more innovation rom the industry. However, there is a substantial isk that the industry must be willing to take. The ontractors must have design, construction, and ıaintenance competencies to compete for a PPC.

he advantages of PPC include that the contract is irectly related to pavement performance; there is reater involvement of the contractors and contractor innovation in the process; agency demands on esign oversight, supervision, and quality control re minimized; and there is an improved control of ontract economy and reduced risk of exceeding the udget for the owner. Likewise, the contractor can plan its work in a long-term fashion rather than a reactive fashion upon successful award of short-term contracts. The disadvantages stem from dedicating money for a potential large network to one contractor for a long period, increased liability for the contractors, and changing environmental, political, and societal issues that are difficult to tie into long-term contracts. Unfortunately, these advantages and disadvantages are speculative given that PPCs are relatively untested by the industry.

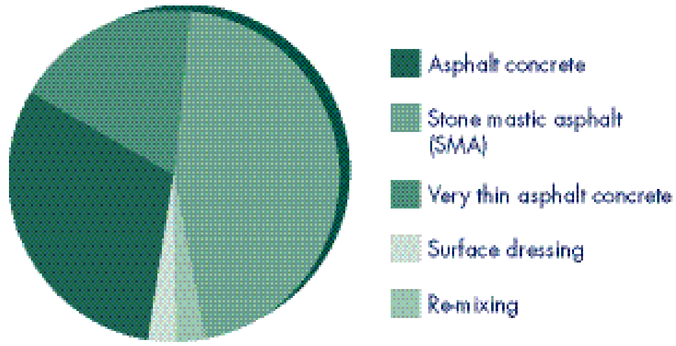


Figure 5.3 Danish pavement performance contracts (type of surfacing).

Length of Contracts

The lengths of PPCs varied. The length of the contract is loosely tied to design life of the pavement, but type of pavement, existing road conditions, and

Performance Indicator	Standard Contracts	Performance Contracts
riction	5 years	Throughout contract
urface regularity	1 year	Throughout contract
rofile and drainage of surface water	1 year	Throughout contract
utting	5 years	Throughout contract
nstability	5 years	Throughout contract
urability (raveling, joints, cracking, potholes)	5 years	Throughout contract
mpermeability of surface layers	None	Throughout contract
oad-bearing capacity	None	Throughout contract
oad marking (friction, reflection, color)	3 years	Throughout contract

able 5.1 Length of warranty and pavement performance contracts in Denmark.

	Germany	Denmark	Sweden
Number of contracts through 2002	2	17	23
Length of contracts (years)	20	11-16	5-12

* *Germany stated that it would increase the length of the contracts to 25 years in its next set of pilot projects.*

Table 5.2 Length and number of PPC contracts.

financing approach all play a role in the length of PPCs. Table 5.2 summarizes the various lengths of PPCS in host countries where the information was available, and figure 5.4 provides the lengths for Denmark's initial PPCs.

In Germany's first PPC, the Federal Ministry of Transport allowed for alternate bids between concrete and asphalt. It chose a period of 20 years and based the award on a life cycle cost evaluation. Concrete was selected as the most economical material for a period of 20 years. Our hosts stated that the next set of contracts would be let with a

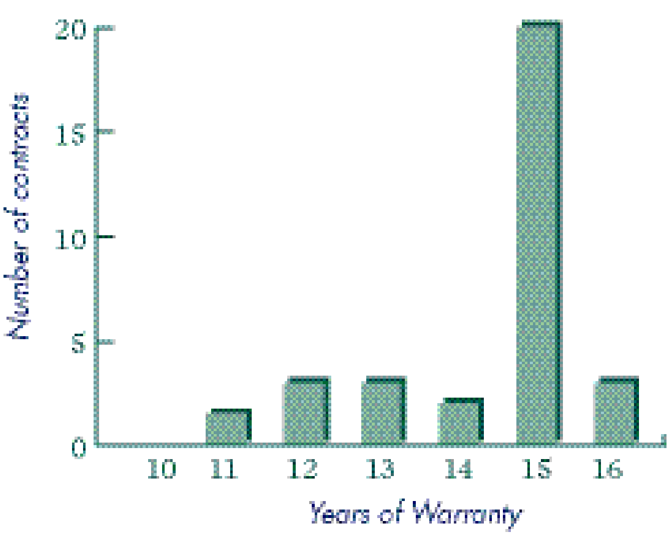


Figure 5.4 Danish pavement performance contracts (warranty periods).

period of 25 years and that they expected that asphalt would be the more economical choice given the expense to repair concrete joints after a 20-year period.

Denmark and Sweden have begun to more aggressively employ PPCs. In Denmark, the municipalities are the sole users of the contracts and they are choosing 11- to 16-year contract lengths. Their motivation for these lengths seems to be tied to the cash flow and financing aspects of the contracts, which is explained in more detail in the following pages of this report. Swedish PPCs currently vary in length between 5 and 12 years. The main motivation for the use of these contracts in Sweden is the outsourcing of administration to the private sector. The length is tied to the current risk appetite of the industry, and the future may see longer contracts.

The length of contract will also have a large bearing on the procurement, bonding requirements, and financing/payments of the PPC. These issues are discussed in detail in the following sections.

Procurement

The best-value process, as described in chapter 3, is the procurement method of choice for PPCs. A key aspect of the best-value procedure is the application of engineering economy to the procurement—particularly equivalent annual value (please refer to figure 3.2). PPCs extend the best-value example presented in figure 3.2 because the contracts can involve a number of planned construction and maintenance cycles throughout the life of the project. The Danish Road Directorate provided the scan team with an example plan of activities and payments, which is shown in table 5.3.[2]

Different contractors may have alternative construction activity strategies. For example, one contractor may choose to conduct major construction in the first year to minimize the maintenance costs throughout the life of the project, while a second contractor may choose to keep the existing pavement performing at acceptable levels through minimal repairs and defer the major construction until later in the contract. As seen in figure 5.5, the contractor chose to delay milling and strengthening until year three of the contract. This will delay its major investment, but it will need to conduct any necessary pavement repair in

[2] Simonsen, P., and Thau, M. (2002). "Pavement Performance Contracts: The Alternative Contractual Relationship," *Roads, PIARC, World Road Association,* No. 315, pp. 45-56. This example was subsequently published in the journal *Roads*. Examples from this article are used for reference throughout the remainder of this section.

U.S. Parallel: Pavement Performance Contracts

The following is a quote from *"Performance-Based Contracting for the Highway Construction Industry"* by Carpenter, Fekpe, and Gopalakrishna, 2003.

> Koch Performance Roads, Inc. is providing performance-based warranties on roads in O'Fallon,Missouri, and Aspen, Colorado. The Aspen project involved rehabilitating 30 percent of Aspen's city streets. The work in O'Fallon consisted of constructing streets in Winghaven Research Park. Both projects used a design-build-warranty approach to finish in a timely manner. The pavement used is warranted against cracking potholes, rutting, and ravelling for 15 years.

ears one and two to maintain the pavement at the ›vel of performance specified in the contract. The verage annual value for each of the strategies can e determined and used in the best-value procure- ıent described in figure 3.2.

Vhile this procurement process has been successful n a number of projects in the host countries, the :an team noted that it could be quite sensitive to oth the period of analysis and the discount rate pecified by the owner. The formulas used to calcu- ıte average annual value are, after all, just a model f the actual costs that will be realized throughout ıe life of the project. As the length of this analysis ıcreases, the models are potentially less accurate. he owners must also take care in choosing appropri- te discount rates, which is not a simple task. ıappropriate analysis periods or discount rates yield ıaccurate results.

Bonding Requirements

onding on PPCs is even more critical than bonding n standard warranty projects because the contrac- ›rs assume a larger investment over a much longer eriod of time. PPCs create a burden on both the ontractor and the surety industry. Ideally, a large erformance bond (5 percent or more) could be vritten for the life of the contract. In 1999,)enmark experimented with several different mod- ls for setting up performance bonds. One of these omprised a 5 percent bond based on the total con- ·act sum for the life of the contract. In addition, a ıinimum of 15 percent of the total contract sum ıould not be paid before two-thirds of the dura- tion of the contract. Another model called for a bond of 10 percent throughout the contract. But as Denmark later discovered, bonds of this size and duration are not maintainable within the policies of the surety firms. Since 2000, Denmark has settled on a 5 percent bond for 5 years and is working on other innovative payment mechanisms to ensure the solvency of the contractors.

Year	Plan of Payments Total Price (DKK)*	Plan of Activities
2001	100,000	Pavement repair
2002	200,000	Pavement repair
2003	3,650,000	Milling, strengthening, temp. road marking
2004	2,000,000	Wearing course, road marking
2005	8,000	Maintenance
2006	8,000	Maintenance
2007	8,000	Maintenance
2008	8,000	Maintenance
2009	250,000	Road marking
2010	8,000	Maintenance
2011	8,000	Maintenance
2012	8,000	Maintenance
2013	8,000	Maintenance
2014	500,000	Pavement repair
2015	50,000	Pavement repair
2016	300,000	Pavement repair
TOTAL	7,114,000	Pavement repair
Total present value: 5,876,443 DKK		
Average yearly cost: 566,150 DKK		

*All in 2001 prices.

The average yearly cost is used to compare individual bids. The average yearly costs are calculated by multiplying the total present value with the factor "K".

K = r*(1+r)n / ((1+r)n - 1)
r = internal real interest 5% per annum
n = service life in years

Table 5.3 Example plan of activities and payments.

Payments

Payment mechanisms for PPCs have the potential to be attractive for both the owner and the contractor. Multiple payment models were shown to the scan team, but they all involved much more standard payment sums than that found in traditional planning and bidding. The government or municipality has the option to offer an equal annual sum payment for the contract, which allows it to plan its budget. The contractor can expect an even cash flow, which allows it to plan its work and equipment investment. However, the contractor may need to finance some of the construction costs, as work will be completed before the payment is received from the government. PPCs ofter require the contractor to partner with a financial institute. The financial institutes are likely to see this type of contract as a good risk because the government is the source of revenue for the contractor. The graph in figure 5.5 is based on the payment mechanism for a PPC in Ronnede, Denmark.

Figure 5.5 is only one model for payment, and it car create a large financial burden for the contractor. Other models do not pay on a stipulated annual

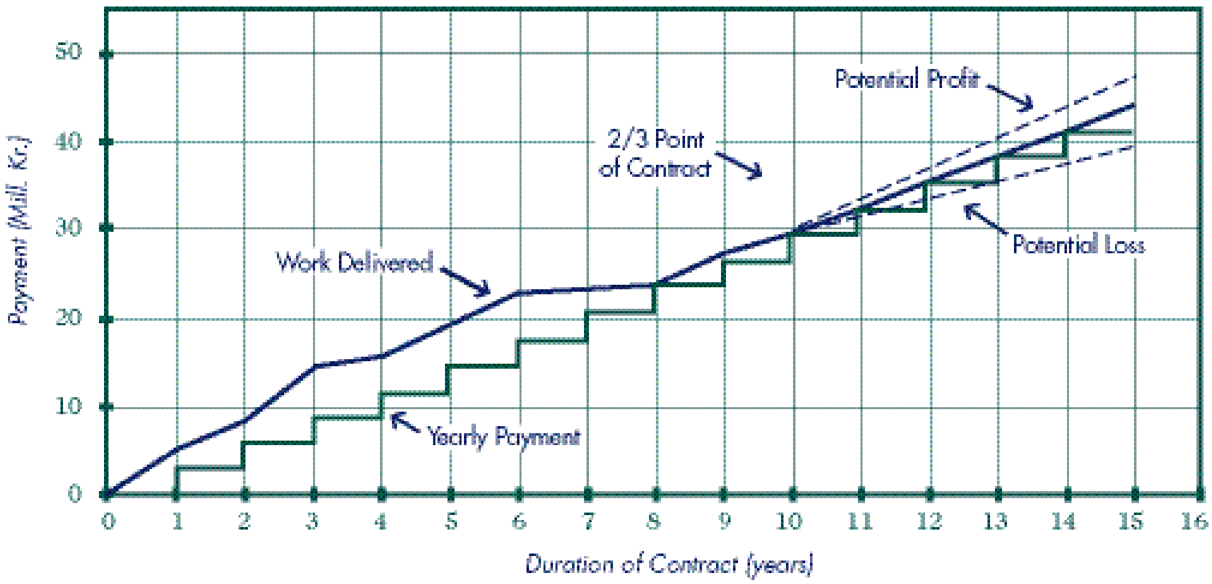


Figure 5.5 Payment model example.

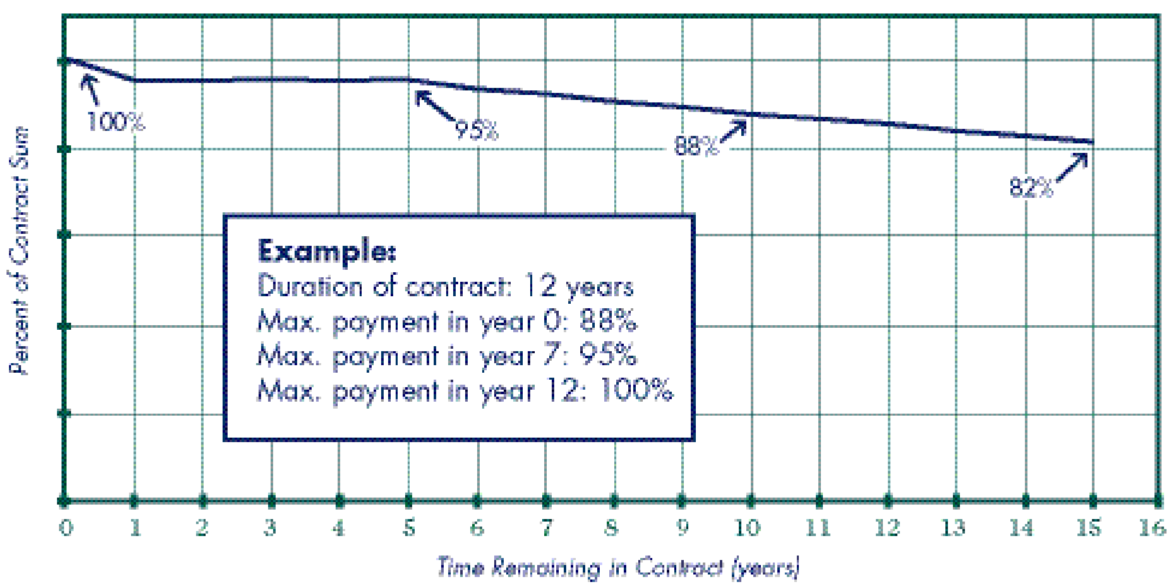


Figure 5.6 Maximum accumulated payment as percentage of contract sum.

asis, but rather pay as a percentage of work ompleted for the first two-thirds of the contract. he contractor is only paid for work accomplished, ntil two-thirds of the warranty period has assed, whereupon it is paid according to the chedule whether work is required or not. This will llow the contractor to make a profit in the same nanner as described in figure 5.5, but it will not reate such a significant financial burden. However, ne government is at greater risk of having the ontractor default in the last 5 years of the contract. he Danish Draft Pavement Performance pecification recommends a payment schedule with ignificant retainage for completed work to protect gainst such a default. Figure 5.6 displays the ecommended retainage schedule from the raft Specification.

iiven the payment schedule in figure 5.6, the con- ractor will not be paid for 100 percent of the work ntil the final year of the contract. For example, if ne work is completed in year 1 of a 16-year PPC, ne government will pay only 88 percent of the con- truction cost. This retainage is lower as the contract noves forward. In years 10 to 15 of the contract, nis retainage remains constant at 5 percent, and ull payment is made in the final year. This payment ystem obviously protects the government in case of ontractor default, and although the retainage cre- tes a financial burden for the contractor, the long- erm assurance of work allows for better planning f resources and equipment. The contractor also has ne same incentive to keep the pavement at peak erformance in the last years because it is paid the tipulated annual sum regardless of whether it is erforming work or not.

dditional payment incentives and penalties are pplicable to this system. In cases of noncompliance vith the stated pavement specifications, PPCs often nclude a penalty system. These penalties may include o payment until the performance conditions are net or a monetary penalty in addition to not eceiving the payment. Bonuses may include a nonetary incentive or a contract extension. The hosts ll mentioned penalty clauses, but none discussed the pecific application of bonuses.

erformance Indicators, Thresholds, and Aeasurements

he performance indicators, thresholds, and measure- nents in PPCs are similar to those found in short-term erformance warranties as discussed in chapter 4. The main difference is the frequency of inspection for these items. Table 5.4 provides an example of the method of measurement and evaluation of compliance with the pavement specification. If the pavement specifications are not fulfilled, the pavement distress will be subject to remedial action. PPCs used in Denmark specify a selection of remedial methods that can be accepted (Simonsen and Thau, 2002).

As seen in table 5.4, the performance indicators are quite comprehensive. They require a comprehensive pavement management system to measure, verify, and store the data. These data are critical because they will correlate to the conditions of the roads for the users and also the contractor's profits or losses. Note that a combination of visual and equipment-based measurements are conducted. These are described in more detail in chapter 4. Note also that the time of year for the measurements is given. Many performance attributes vary in the course of time, e.g., seasonal variations affect smoothness. It is important that specifications are clear on when and where measurements are to be made.

Data collection for the performance indicators shown in table 5.4 is the first part of the PMS. Once the data are collected they must be analyzed for decisions to be made. The following example was provided to the scan team for the PMS in Ronnede, Denmark. The PMS data are collected by means similar to those described in table 5.4. The data are then cataloged in a computer program such as the one shown in figure 5.7.

The data from PMS are then aggregated into a "condition index." The condition index is an aggregate of the measurements shown in the severity column above. The thresholds for the condition index are set at the beginning of the contract and correlate to the maintenance levels of each street segment, as follows: type 1 is a traffic road with bus routes, prime network streets; type 2 is a local road with bus routes; type 3 is a local road without bus routes; and type 4 is all other streets. A condition index is generated for the network as shown in table 5.5.

A survey is done on one-third of the network each year. The mean condition index must not be exceeded or corrective action will be required. The percentage of patches can be used for aesthetics. As the conditions change, the contractor may change its work plans, but the overall performance measure will remain.

Innovation in Products and Processes

Although PPCs represent only a small portion of the road network in Europe, their use is expected to rise. The contracting industry is helping to initiate this change with the goal of being allowed to introduce innovations in contracting methods and materials. The municipalities are more willing to allow innovation because the contractor is at risk for these innovations throughout the life cycle of the product. The owners are also lacking expertise to evaluate these innovations, and PPCs offer a mechanism for quicker improvement to network condition. The owners think that they are benefiting through better prices and better quality because the contractors have an incentive to provide quality products early in the process to gain profit in the end. Owners see a benefit to the public through higher-quality roadways for the duration of the warranty period (15 years).

Performance indicator	Method of measurement	Period of Measurement	Frequency	Responsibility (1)
Friction	ROAR	Fall	(2)	Agency
Longitudinal evenness	Laser	Fall	(3)	Agency
Transversal profile and drainage of surface water	Visual inspection		Acute	Agency
Rutting	Laser	Fall	(3)	Agency
Instability	Visual inspection	Fall	Annual	Contractor
Durability				
Raveling	Visual inspection	Fall	Annual	Contractor
Joints	Visual inspection	Fall	Annual	Contractor
Deterioration:				
Longitudinal cracks	Visual inspection	Fall	Annual	Contractor
Transversal cracks	Visual inspection	Fall	Annual	Contractor
Alligator cracking	Visual inspection	Fall	Annual	Contractor
Potholes	Visual inspection	Fall	Annual	Contractor
Light reflection	Beta value	During construction	During construction	Contractor
Noise emission	Method not decided			
Road marking:				
Reflection	Reflectometer	1/5 - 15/10	Annual	Contractor
Friction	Pendulum	Fall	By request	Agency

(1) Responsible for the execution of the measurements. The Employer reserves the right to supplementary measurements.
(2) First and fifth year, then every 5 years.
(3) First and second year, then every 2 years.

Table 5.4 Example evaluation of pavement specifications.

he PPCs have mainly seen innovation to date in rocesses rather than products. Work is often done ı April through November in a number of uropean countries. By planning their work ahead, ontractors can get early starts and attract better vorkers. They can also have a better workflow or eveling for their staff. This level workflow also llows for time to do research and innovate. inally, there is a "value chain effect" through etter supplier relations that is created by he consistent workflow.

esign-Build-Finance-Operate Contracts

Vhere PPCs have extended the warranty oncept to approximately the equivalent of one esign life cycle, DBFO contracts are extending the oncept through multiple pavement maintenance ycles. DBFO contracts are used for both construc-ion and maintenance of European motorways. rivers for the use of DBFO contracts range from ack of public funding to a belief that private inancing and maintenance delivers a higher quality roduct and provides benchmarks for public ector performance.

The United Kingdom and Spain provided the team with examples of DBFO contracts. DBFO periods vary, but were commonly found to be 30 years. Both public agencies and DBFO companies commonly obtain long-term warranties from their contractors, but the team observed the use of maintenance contracts in lieu of warranties. The German, Danish, and Swedish hosts noted limited use of toll projects, but they did not share specific examples from these projects, and it was not clear if these were true DBFO projects. However, other examples of DBFO contracts throughout Europe found on other scanning tours will be discussed in this section.

DBFO contracts, commonly referred to as concession contracts, can take many forms, and the definition of a concession contract can vary slightly from agency to agency. The French have perhaps the longest history of concessions in Europe. A definition of a concession contract is found in A Draft Typology of Public-Private Partnerships as written by Rémy Prud'homme for the French Ministry of Public Works, Transport and Housing (Perrot and Chatelus, 2000):

Road Id.	From st.	To st.	Name
515-9408-0	0,000	0,155	Virkelystvej

recent Conditions Index 3,5

o. Observation	Severity	Cat.	%	Abs.
Alligator cracks	3 Large > ½ m2	A	7	56 m²
Longitudinal cracks 0-1 m from edge	1 Width < ½ cm	C	70	217 m
Longitudinal cracks > 1 m from edge and tr	1 Width < ½ cm	C	70	217 m
Ravelling	2 Fine particles dislodged	B	35	282 m²
Spalls or potholes	2 Medium < ½ m²	A	7	56m²
Depriessions Settlemants	1 0-2 cm	B	35	282 m²
10 Patshes	1 Sporadically	A	7	56m²
18 Kerb	3 < 7 cm elevation	B	35	108 m
19 Crossfall	2 Along gutter	C	70	217 m
21 Footway	2 Reasonable	B	5	189 m

igure 5.7 Pavement management system for Danish pavement performance contract.

Maintenance Level	Mean Condition Index	Maximum Condition Index	Maximum Percentage of Patches
1	1.5	3	20
2	2.5	4.5	40
3	3.5	5.5	60

Table 5.5 Example pavement performance contract condition index.

"The concessionaire carries out all of the capital investment, operates the resulting service and is remunerated through service fees paid by users. The facilities are to be handed over to the oversight public authority at the end of the contract period." From this definition, it can be seen that DBFO contracts are an extension of warranties, maintenance contracts, and PPCs as discussed previously in this report. However, the primary difference lies in the private sector financing mechanism and the length of the contract, which is often double that of a PPC.

The United Kingdom began its DBFO program in the late 1990s as an outcome of its Private Finance Initiative. The motivation for the contracting method has many similarities to the motivation for the use of warranties. The objectives of this program are explained in the report "DBFO – Value in Roads: A Case Study of the First Eight DBFO Road Contracts and Their Development" (British Highways Agency 1997) as follows:

To ensure that the project is designed, maintained and operated safely and satisfactorily so as to minimize any adverse impact on the environment and maximize benefit to road users;

- To transfer the appropriate level of risk to the private sector;
- To promote innovation, not only in technical and operational matters, but also in financial and commercial arrangements;
- To foster the development of a private sector road-operating industry in the UK; and
- To minimize the financial contribution required from the public sector.

The final performance results will not be known until the end of the contract. However, some selected lessons learned on the first eight DBFO projects completed in the United Kingdom are listed in the report as follows:

DBFO contracts have accelerated the introduction of cost efficiencies, innovative techniques and whole-life cost analysis into the design and construction of road schemes and the operation of roads (although the Agency had started to review these possibilities in the context of traditional methods of procurement).

- The full potential of efficiencies, innovation and whole-life cost analysis inherent in the Private Finance Initiative is likely to be fully unlocked only when the private sector is involved in the outline design of the road scheme, which they are then obliged to construct, operate and maintain under a DBFO contract. This requires the private sector to assume some planning risk. Some of the DBFO projects announced introduce the concept of planning risk and will test the proposition that this will deliver better value for money.

- The risk allocation on DBFO contracts has been encouraging. Two areas where transfer of risk to the private sector has delivered good value for money are protestor action and latent defect risk. The Agency will continue to look for risk transfer to ensure that the DBFO contracts remain off-balance sheet.

- DBFO contracts have delivered value for money. Cost savings (compared with the public sector comparator) have ranged from marginal to substantial; for Tranche I and 1A DBFO contracts, the average cost saving is 15%.

- With eight contracts let and expressions of interest received for further projects, it is clear that a road-operating industry is developing. The same consortia (with a few changes in composition) have appeared as bidders on projects within each group.

Durations of concessions in Europe can be found from less than 5 years to more than 75 years, but the majority are under contract for 15 to 30 years. Many of the contracts also contain windows of profitability for determining the end of the contract given that traffic forecasts for 30 years in the future are quesionable. If traffic forecasts are wrong, there are only wo options for equitable compensation for the project: change the rate of tolls (or payments) or change ne duration of the contract. Political and financial iability typically limit changes in the rates charged. ossible solutions to problems caused by inaccurate raffic forecasts are to provide some mechanism for hanging toll rates and, if necessary, changing the otal duration of a concession to provide an equitable ompensation to the concessionaire.

he hosts discussed a number of financing and ayment options for funding DBFO projects. The Inited States typically employs a user-based toll aid directly by the user. Both the United Kingdom nd Spain described the use of "shadow tolls" for neir DBFO projects. Shadow tolls are an alternative inancing payment mechanism in which the overnment pays a private sector partner (DBFO or oncessionaire) for a project on the basis of the umber of vehicles that use the facility. Traditional ampling methods and high-tech real count mechaisms are in use to count the vehicles for the hadow toll payments. The government receives the nitial project financing from the private sector artner, and the partner takes the risk/reward for ne number of vehicles that use the road. In addiion, the operational nature/characteristics of the hadow toll payments may assist the government in nore effectively managing its debt. This is because hadow toll payments are determined and made on periodic basis—most commonly on an annual asis. Accordingly, the government and investment ommunity may properly consider these shadow toll ayments to be an item of operating expense; and, s an operating rather than capital expense, it enerally need not be included in calculating debt atios or debt capacity. Such an operating definition nereby provides the government with debtnanagement flexibility in the event that its evenues fall below expectations or if its cash-flow osition deteriorates for some other reason.

s previously described, the role of a concessionaire oes far beyond simply warranting a project. Not nly do the concessionaires have to maintain precribed quality for the government, but also they ow must prove to their financial lenders and shareolders that they are delivering and maintaining a uality product. From what the host concessionaires escribed on the scan tour, these lenders and shareolders are sometimes more demanding than the ighway agencies have ever been.

Unfortunately, the European hosts on this Asphalt Pavement Warranty Scan did not provide the performance terms of the DBFO contracts. However, the performance terms of a similar DBFO project were provided from Portugal for the 2002 Contract Administration Scanning Tour (FHWA, 2002). The performance terms of that contract include:

- The Concessionaire must keep Motorways in very good conservation and perfect condition of utilization, carrying out all the necessary works in order to permanently satisfy the Motorways purposes.

- The Concessionaire is responsible for the high standards of conservation and functioning of environmental monitoring equipment, environmental conservation and preservation systems and noise protection system.

- The Concessionaire must respect minimum quality standards, such as pavement bond and smoothness, conservation of signaling, clients assistance and safety equipment.

- Specific performance tests include:
  - Tests with FWD every 100m, including visual inspections
  - Longitudinal irregularities determination
  - Pavement depression due to heavy traffic measures
  - Friction measures
  - Pavement degradation report

- They have four separate performance contracts:

  - Contract 1
    - Vegetation (shrubs and plants) Maintenance
    - Cleaning and Sweeping
    - Fencing repairing and maintenance

  - Contract 2
    - Safety equipment repairing and conservation
    - Traffic sign, road sign and safety guards

  - Contract 3
    - Civil Engineering works Conservation and Maintenance
    - Drainage
    - Sloping Banks
    - Pavements
    - Concrete Structures

  - Contract 4
    - Engineering Structures Maintenance

U.S. Parallel: Public-Private Partnerships

U.S. PPPs most closely resemble the European DBFO models described in this chapter. The following is an excerpt from the American Association of Transportation Official's Primer on Contracting for the Twenty-First Century:A Report of the Contract Administration Task Force of the AASHTO Subcommittee on Construction, which describes the use of PPPs in the United States. (AASHTO, 2001).

> "A 'public-private partnership' is a broad term used to describe a contract between a public owner and a private entity who have agreed to certain financial and contractual responsibilities. In such contracts, a private entity finances or invests in a transportation project by developing, designing,building and/or maintaining a roadway or bridge for a specified duration in return for monetary compensation, toll revenues or development rights. Many of the first U.S. roadways were privately financed by associations, users and the automotive industry. In some countries, concessionaires are used to allow corporations with mixed capital structure or privately owned corporations to finance, design, build and operate toll roads."

Examples of PPPs in the United States

CA Build Operate Transfer (transfer after construction); SR-91 Express Lanes, US$126 million

CO E-470 46-mile beltway along the eastern edge of the Denver metro area, US$1.2 billion

MO Build Operate Transfer, Lake of the Ozarks Bridge, US$23.6 million

VA Build Operate Transfer, Dulles Greenway, US$325 million

VA Rt. 895 Connector, DB/F, via the VA Public-Private-Transportation Act, US$323 million

VA Route 288 via the VA Public-Private-Transportation Act, US$236 million

VA Coalfields Expressway via the VA Public-Private-Transportation Act, US$1.1 billion

TX Texas Turnpike Authority 122-mile contiguous tollway, US$3.22 billion

As demonstrated above, the performance terms of the DBFO contract are based on many of the same performance measurements being used for warranty contracts. Because the overall goals of ensuring performance for the traveling public are similar, the DBFO contracts can be viewed as an extension of warranty contracts. However, DBFO contracts transfer much more of the risk for financing and performance to the private sector. DBFO contracts constitute a major departure from traditional highway delivery in the United States, but if the evolution of performance contracting in the United States follows that of Europe, there may be more DBFO contracts on the not-so-distant horizon.

Conclusions

This chapter provided an overview of the evolution of short-term material and workmanship warranties to performance warranties, maintenance contracts, PPCs, and DBFO contracts. The long history of success with these short-term performance solutions has provided incentives for the European hosts to experiment with these alternative delivery methods. All of the host countries are looking at alternative delivery methods as a mechanism to increase innovation without creating a burden on highway agency staff. The contracts described in this chapter are new and somewhat untested when compared with the warranty methods described in previous chapters, but the hosts were confident that these approaches could be applied in a balanced contracting program to deliver value to the public.

The alternative delivery methods use many of the same mechanisms discussed in the description of short-term warranties found in chapters 3 and 4. Performance indicators, thresholds, and measurement are perhaps the most similar in nature. The primary differences involve the lengths of warranties, financing, and responsibilities for operation and maintenance.

The United States may well benefit from the alternative delivery methods described in this chapter. PPCs in particular may hold great benefit for counties and municipalities throughout the United States, and could gain acceptance relatively quickly. The continued application of pavement warranties will help the United States gain an understanding of performance contracting, which is critical for successful application of these alternative delivery methods. It is difficult to say if the United States will follow the same path as the Europeans in the application of alternative delivery methods, but a similar evolution may be forthcoming.

Observations Recommendations and Implementation

This scan team reviewed and documented the policies and strategies used in Europe to determine risk assessment and administer warranty ontracts. The European hosts prepared formal preentations and written documents for technology ransfer to the United States. In addition, the hosts rovided the team with candid insights regarding the uccesses and challenges that they face with their varranty programs. Throughout the study, team nembers discussed their observations and critically valuated which of the techniques and strategies sed in the host countries could be practically and uccessfully implemented in the United States. Team nembers met at the end of the study to review their ndings and developed the following summary bservations, recommendations, and implementation trategies. These observations, recommendations, and nplementation strategies are those of the scan team nd not FHWA.

ummary Observations

he European and U.S. transportation communities are uite similar in terms of the political, financial, and esource challenges that they face. However, the uropean transportation agencies are better leverag- ng the innovative management techniques, technical nnovations, and financing capabilities of the private ector. There is a more spirited effort of partnership nd collaboration between the public and private secors in Europe than in the United States. The summary bservations are listed below to provide a context for ne recommendations and implementation strategies.

imilar Transportation Needs

European transportation systems have growing capital project needs as well as a backlog of maintenance requirements, not unlike the United States.

Long History of Material and W orkmanship Warranties

- Material and workmanship warranties of varying length have been used in the European host countries for 30 to 40 years.

Purchasing Performance in Addition to Materials

- Those countries with long material and workmanship warranties histories are moving toward pavement performance warranties and other methods of tying the contractor into the full life cycle of the product.

Best-Value Procurement

- A focus on quality exhibited by the use of best-value procurement.

Public-Private Partnering

- Strong partnerships between agency and all sectors of the industry.

Motivation for Alternative Contract Methods

- Motivation for warranties, performance-based contracts, and DBFO concessions include:
  - Need for innovation
  - Need for private sector to finance system upgrades
  - Desire to improve quality
  - Desire to improve efficiency
  - Resource issues

Balanced Contracting Approach

- Transportation agencies are using a balanced approach in implementing traditional contracting, warranties, performance-based contracts, and DBFO concessions.

Financing

- Available tax dollars is an issue, which is compounded by the new EU requirement for less than 3 percent capital debt. Many of the European countries are exploring innovative financing mechanisms and incorporating private financing into their highway networks.

Outsourcing of Maintenance

- Term maintenance contractors from the private sector are used exclusively in some of the host countries, and the other countries are also increasing their use of such contractors. This knowledge of maintenance in the private sector is resulting in more integrated life cycle solutions for highway network needs.

Recommendations

The European host countries all believe that their long history of warranty application has improved the performance of their highway and trunk road systems. Their warranty systems continue to evolve through a customer-focused partnership between government and industry. Best-value procurement and prequalification are vital elements of the warranty system. Material and workmanship warranties are in use on all short-term warranties. Five-year performance warranties are in use when the contractor completes some level of design. The long-term performance warranties include design, construction, and some type of planned maintenance. The Europeans hosts use all of these warranties in balanced contracting approaches.

This scan team, which was composed of members from Federal, State, and local agencies, industry, and academia, offers the following recommendations on the basis of its observations of successful warranty programs in Europe:

Federal Government

- **Warranty requirements:** The Federal government should require short-term material and workmanship warranties on all federally funded projects. This should be the first step in moving toward common use of long-term performance warranties in the future.
- **Enable best-value and prequalification legislation:** Assist with enabling legislation to allow contract awards based on technical and quality factors in addition to cost (i.e., best-value and prequalification methods).
- **Warranty resource center:** Create resource center(s) to facilitate and assist in implementing and evaluating warranties. The Federal government should act as a leader for the State, county, and local governments.

State and Local Government

- **Create model warranty documents:** Draft contract documents for warranty implementation with representation from all stakeholders. AASHTO should take the lead in the creation of these documents in collaboration with local governments and industry.
- **Implement material and workmanship warranties:** The State and local highway agencies should develop material and workmanship warranty programs through internal education and industry participation
- **Implement short-term performance warranties:** State and local highway agencies should implement short-term performance warranties when it is appropriate for the contractor to perform the necessary design.
- **Enable best-value and prequalification procedures** State and local highway agencies should work to enable legislation allowing contract awards that are based on technical and quality factors in addition to cost.

Industry

- **Education:** Develop an awareness and understanding of warranty issues and risks.
- **Participation:** Proactively participate in roundtable discussions on warranties.
- **Pilot projects:** Consider proposing on pilot projects.
- **Operation and maintenance competencies:** Consider expanding knowledge of operation and expertise of materials and products for future competitiveness.

Implementation

The scan team formed a small group to develop a scan technology implementation plan (STIP). The plan outlines a series of activities to disseminate, test, assess, and implement the techniques and strategies discovered on the study. These activities focus on awareness, understanding, commitment, and action. The STIP Team includes Monte Symons, FHWA; Steve Bower, Michigan DOT; Gerald Huber, Heritage Research Group; and Jim Wood, City of Dallas.

STIP Observations

The STIP Team developed the following list of observations relevant to the implementation plan:

1. Each country has a long history of involvement in asphalt warranties, and all believe that warranties have improved the quality of the system.

. All five countries use a best-value system in lieu of the low bid only to determine contractors on warranty contracts.

. There is a direct relationship between contractor involvement in construction and materials specifications and length of warranty period. Short-term warranty periods (1-2 years) have limited contractor involvement, and in the longest warranty periods the contractors are allowed to use most of their own specifications materials.

. Pavement condition and performance criteria have been established from historical records.

. Contract responsibilities are specific and generally hold contractors responsibility for only those items that are under their control.

. Contractor responsibility for pavement maintenance is a part of all warranty contracts if pavement performance criteria are not achieved or maintained.

. The relationships and cooperation between owner agencies and warranty contractors is significantly different than in the United States.

TIP Recommendations

he STIP Team believes that substantial change in xisting contracting processes in the United States is equired to implement ideas and concepts identified uring the Asphalt Pavement Warranty Scan. To ccomplish these changes, the STIP Team has identiied a change model that consists of activities associted with (1) awareness and understanding of the can findings, (2) commitment of agencies and ndustry to some underlying warranty contract priniples, and (3) specific actions that will facilitate nore widespread and common use of asphalt waranties. The following tasks and subtasks are proosed to implement the findings:

ask 1.0 – Widespread Distribution of Scan Findings

.1 Provide support for members to make presentations on the scan findings to targeted audiences, such as industry associations, key industry/owner technical working groups, agency technical and management groups (estimated 15 to 20 presentations).

.2 Develop and distribute glossy brochure summarizing findings and recommendations.

.3 Develop a detailed implementation plan that provides documentation of benefits based on sound business principles from both the owner and contractor perspectives.

Task 2.0 – Trial Use and Evaluation of Asphalt Pavement Warranty Contracts

2.1 Establish an executive national TRB committee to overview implementation and evaluate results of trial asphalt pavement warranty contracts.

2.2 Establish subgroups to develop guidelines that address specific broad issues, such as arbitration standards, bonding requirements, prequalifications, and contract award issues.

Task 3.0 – Specific Actions for Implementation

3.1 Provide uniform pavement performance evaluation of trial and innovative contracts that use asphalt pavement warranty concepts.

3.2 Document and distribute cost-benefit information on trial contracts.

3.3 Prepare and distribute asphalt pavement warranty guidelines.

3.4 Prepare policy guidance documents for justification of asphalt pavement warranty contracts for Federal, State, and local projects, with examples.

Conclusions

U.S. highways agencies are continuously striving to improve the performance of their pavements while reducing life cycle costs through the use of appropriate technologies and contracting mechanisms. These agencies are striving for these improvements in an environment of diminishing agency personnel and increasing traffic demands. The scan team believes that these agencies will realize benefits from the use of warranty contracting, but they will need to develop new roles and responsibilities alongside the private sector in an environment that appropriately allocates risk.

The scan team members strongly recommend that the innovative ideas described in this report be considered and evaluated for use in the United States, because they could improve the performance of our pavements and create an environment of long-term partnership between the public and private sectors. The true value of this information will only be realized when these recommendations are shared, evaluated, and, as appropriate, put into place. The challenge ahead is to find champions to test these ideas and disseminate the results in the hopes that the U.S. highway industry can benefit from the experiences of its peers in Europe.

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ames J. Steele is a Senior Management Official for he FHWA in the Michigan Division Office in Lansing, Michigan. Mr. Steele is currently responsible for the delivery of the Federal-aid highway program to the State of Michigan. He is currently working with the Michigan DOT (MDOT) in developing process and requirements for performance pavement warranties. Prior to moving to Michigan in 1996, he served as the Assistant Division Administrator in the state of Ohio and with the FHWA regional office in Chicago where he was the Regional Environmental Program Manager. Mr. Steele is a graduate of the Indiana Institute of Technology and holds a Master's of Civil Engineering in Transportation from Clemson University. He is a licensed professional engineer in Washington, D.C. and is presently serving on an International Border Working Group to develop a new U.S.-Canada border crossing.

Monte G. Symons is the Team Leader of the Infrastructure Unit in the Midwestern Resource Center (MRC) of the FHWA, Olympia Fields, Illinois. Mr. Symons currently leads efforts for FHWA in the midwestern United States to implement innovative highway construction contracting methods and procedures. He has been involved in highway materials, pavement design, evaluation, and research for over 28 years. Recently, he has been involved in the Long Term Pavement Performance (LTPP) research project and the development of a new 2002 pavement design procedure. Mr. Symons is a graduate of the University of Illinois and holds both Bachelor of Science and Master of Science degrees. He is a licensed professional engineer in Washington and serves on committees for the ASCE, NCHRP, and National Academy of Sciences.

James M. Wood is Director of the Street Services Department for the city of Dallas, Texas. Mr. Wood currently is responsible for the maintenance of more than 14,000 lane miles of streets and alleys and directs the pavement management program that monitors the conditions of streets and alleys and determines appropriate preventive maintenance, repair, or capital construction needs. Recently, he has been involved in efforts to implement a citywide project management system to monitor construction from inception through warranty. Prior to joining the Street Services Department in 1998, Mr. Wood spent 3 years in the city of Dallas Department of Public Works. Mr. Wood received a Bachelors of Arts and a Master's degree in Public Administration from Texas Tech University. He is a member of the APWA and the Texas Public Works Association.

Amplifying Questions

I. General

A. Context of Transportation in Country

1. Describe the key aspects of how transportation is positioned within the political, economic, and technological structure of your country. Please comment on items such as funding, owner structure, market structure, market competition, contractor associations, use of public-private partnerships, and the roles and responsibilities of the primary stakeholders in the transportation life cycle.

B. Warranty Program Background

1. Describe the evolution of your country's asphalt pavement warranty program. Consider the original motivation for implementation, how long has your country been using these warranties, the percent of your transportation program that uses warranties, the impact of the warranty program on your internal staff, the impact on the private marketplace, the current goals of your warranty program, and describe any internal and external barriers that you have encountered in implementing your asphalt pavement warranty program.
2. Does your country use warranties on items other than asphalt pavement? If applicable, please state the other major items that are warranted.

II. Implementation

A. Program Specific Issues

1. What criteria are used to designate projects for use of asphalt pavement warranties?
2. What products are specifically warranted on asphalt pavement projects?
3. What are the standard lengths of warranty periods? How does warranty length relate to the expected pavement service life? If multiple warranty lengths are used for different projects, how are these lengths determined?
4. Do warranties cover workmanship, product performance, and/or other items?

B. Project Scope Definition

1. Who determines existing traffic loads and climatic conditions for the pavement design?
2. Do contractors rely on public agency pavement performance data to assess their risk in a warranty situation or do they use other measures? Do you have tools for predicting pavement life that the contractors can use when assessing the risk of providing a warranty?
3. How are interactions between warranted product (asphalt) and other products (such as subgrade) assessed and incorporated into the design?
4. Is a life cycle cost analysis performed for asphalt pavement warranty projects? If so, is it only for the life of the pavement warranty or beyond?
5. Are user delay costs evaluated in warranty projects? For example, is disruption to traffic for construction or future treatments of maintenance or corrections considered?

C. Pre-Contract Award

1. Is there a prequalification process for warranty contractors? If applicable, what are the prequalification criteria?
2. What type of bond or financial assurance is required to support the contractor warranty effort? If applicable, how are the values determined?

D. Contract Award (Design and Construction)

1. Who designs the pavement structure under a typical asphalt pavement warranty contract? If the design is not done by the agency, does the agency review and approve the design?
2. Who selects the project specific materials under a typical asphalt pavement warranty contract? If the material is not selected by the agency, does the agency review and approve the selection?
3. Describe the testing and verification of materials during construction. Does the owner, provider, or a third party test or verify the materials?

. Describe the inspection of construction processes. Does the owner, provider or a third party inspect the construction processes?

. Payment

. How is work verified as complete and how is payment distributed on an asphalt warranty project? If you use pay equations for warranty projects, could you provide us with examples?
. Are retainage systems (monies held by the owner until final inspection) used during or after construction?
. Are incentives paid or penalties assessed for performance during construction or during maintenance of the product?
. What is the distribution in costs for administration in typical asphalt pavement warranty projects?

. Final Acceptance

. Is there a final inspection of the product before the warranty process begins? For example, after final acceptance for payment and before beginning of warranty period?
. At the end of the warranty period, is there an official closeout function where the pavement is inspected and an assessment made as to whether the pavement has performed as expected?

. Operation and Maintenance

. How are traffic loads and climatic conditions accounted for during the warranty period?
. Is the warranty provider or the owner responsible for routine/emergency maintenance during the warranty period?
. When the warranty provisions are enforced, how is the contractor requested to repair/fix the problem?
. Are there times when the owner must also participate in the repair?
. What is the frequency of inspections during the warranty period?

I. Corrective Action

. What are the consequences of noncompliance issues during the construction phase and during the operation period?
. Do you have provisions that allow the warranty to be voided? For example, higher traffic volumes or loadings than initially anticipated.
. How are disputes resolved between the owner and provider during the construction phase and during the operational period? Is this dispute resolution process different from nonwarranted projects?

III. Program and Project Evaluation

A. Program Performance

1. Are any comparisons available for performance of asphalt warranted pavements to that of nonwarranted pavements? Specifically, discuss long-term quality/performance measures, bid costs vs. engineering estimates, and warranted vs. nonwarranted asphalt pavement project costs in the area of unit bid costs, life cycle costs, and percent of pavement requiring repair.
2. Warranty contracting often allows for considerable innovation on the part of the contractor. Have innovations been realized from the use of asphalt pavement warranties? How do you analyze innovation prior to bids and/or after award of contract?

B. Project Performance

1. The United States uses surface distress, ride quality, friction measures, composite pavement condition index, engineering properties, delamination, cracking, debonding, and other performance indicators as assessment tools throughout the life cycle of the product.
2. What are the criteria that your country uses to measure asphalt pavement warranty performance on individual projects?
3. How are performance thresholds determined?
4. How do your testing methods account for the aging that has occurred in the asphalt?
5. What tools or equations have been developed to predict performance as it relates to the warranty requirements?
6. What reference guide and/or equipment are used to determine the conditions and measure the performance?
7. How long are the pavement evaluation sections within the project?
8. How is industry input solicited and incorporated into warranty specifications? (Industry - materials suppliers, contractors, fiduciary, trade associations, transportation facility owners, or all of the above)?

C. Case Studies and Contract Examples

1. Can you provide a case history of a "typical" asphalt pavement warranty project? Examples of "successes" and "failures" would also be helpful.
2. Can you provide example contracts and/or contract language from successful warranty contracts?

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