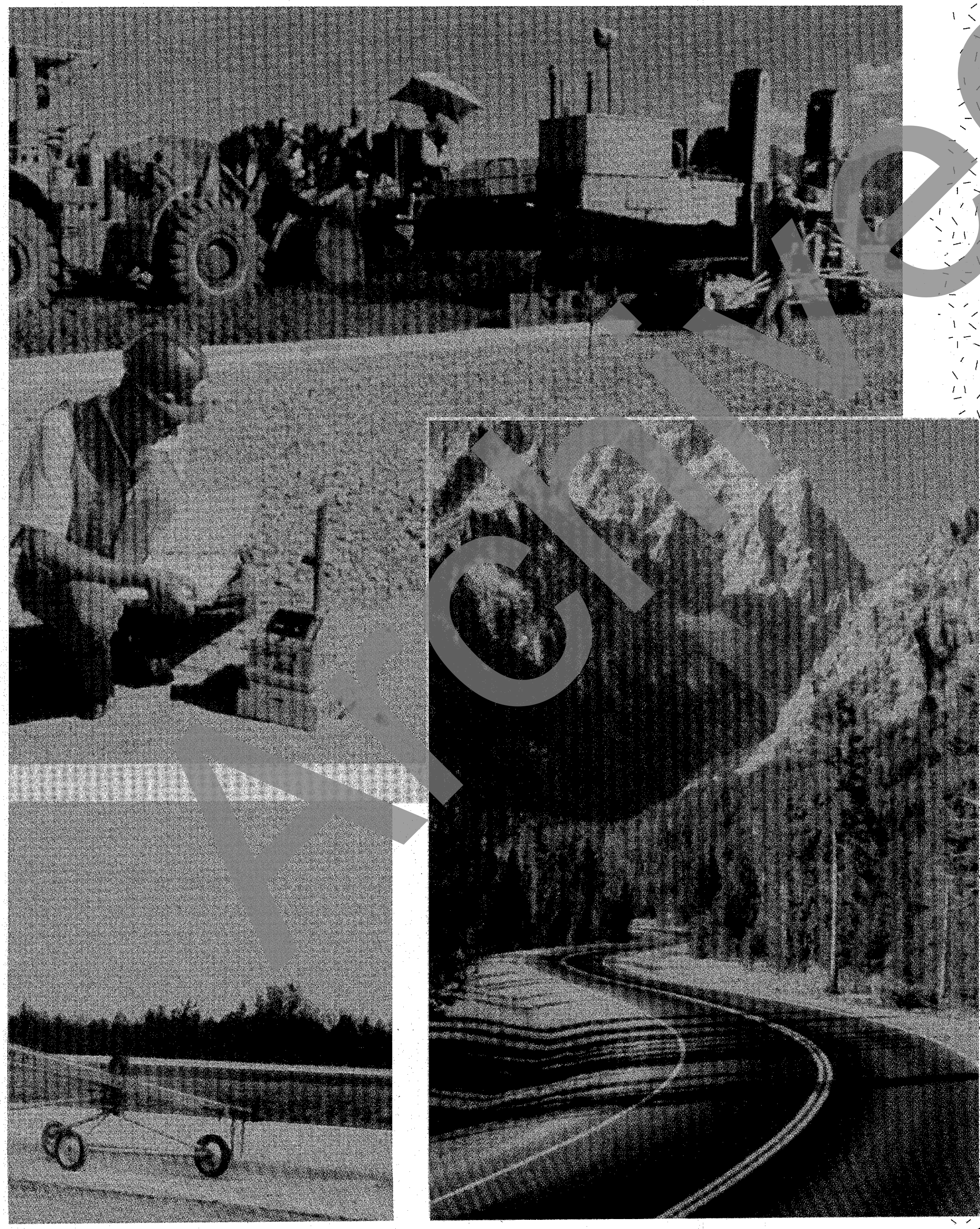
Performance-Related Specifications (PRS)

A Cooperative Effort to Improve Pavement Quality



Providing roadways of the highest possible quality. This has always been the commitment of the highway community to the American public. State Highway Agencies (SHAs), contractors, and suppliers have worked with their industry associations and the Federal Highway Administration (FHWA) to develop highway construction specifications to ensure that the driving public receives long-lasting, high-performing pavements. Naturally, these specifications have evolved as better test methods have become available. Performance-Related Specifications (PRS) are the latest step in the continuing quest to improve the quality of the Nation's roadways.

A Cooperative Effort to Improve Quality

In recent years, the trend among SHAs has been to include statistically based, quality assurance elements within their specifications. These specifications often contain price adjustment schedules that increase or decrease the contractor's pay depending on the results of tests performed during or immediately after construction. To be fair and effective, price adjustment schedules must address two critical issues:

- How do you *measure* quality?
  What tests should be performed to determine the quality of the construction project?

- How do you *reward* quality work?
  How should test results be mathematically linked to price adjustments?

The research that has been performed to develop PRS provides a solid foundation of data to address these two issues. Working together to adopt and further refine PRS, the highway community can improve quality and ensure that quality work is fairly rewarded.

Definition of PRS

Specifications that describe the desired levels of key materials and construction quality characteristics that have been found to correlate with fundamental engineering properties that predict performance. These characteristics (for example, air voids in asphaltic pavements, and strength of concrete cores) are amenable to acceptance testing at the time of construction. True performance-related specifications not only describe the desired levels of these quality characteristics, but also employ the quantified relationships containing the characteristics to predict subsequent pavement performance. They thus provide the basis for rational acceptance and/or price adjustment decisions.

— TRB Circular #457, *Glossary of Highway Quality Assurance Terms*

What Are PRS?

Simply put, PRS are improved quality assurance (QA) specifications. The major distinguishing feature is the use of improved acceptance plans with rationally derived performance-related price adjustments (refer to Figure 1). As in conventional QA specifications, it is the desired product quality rather than the desired product performance that is specified.

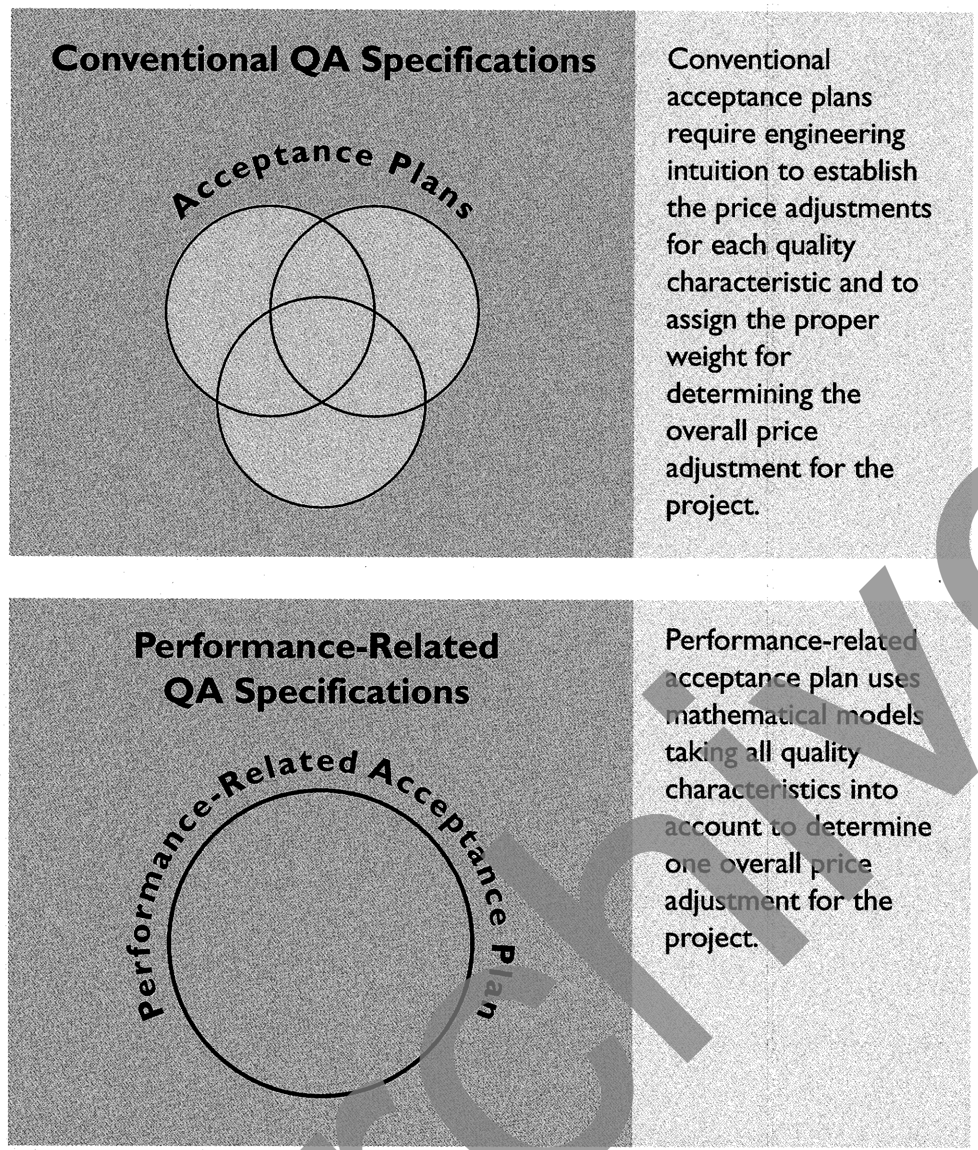
True PRS are based on quantified relationships (i.e., mathematical models) between product performance and certain key materials and construction quality characteristics. The models are based on data and present a much clearer and more realistic picture of what influences a constructed product's performance than can be visualized through engineering judgment and intuition alone. These models are used to establish PRS acceptance plans with price adjustments. Continued use of the models within a highway agency's Pavement Management System can bring about even more significant benefits.

PRS Models

PRS actually contain two types of models: Performance-prediction models and Maintenance-cost models (refer to Figure 2).

- Performance-prediction models predict when and to what extent a construction element (such as a pavement) will exhibit a given type of distress (such as fatigue cracking or joint spalling).
- Maintenance-cost models estimate a post-construction life-cycle cost (LCC), which is the cost of maintenance and rehabilitation necessary throughout the projected life of the pavement.

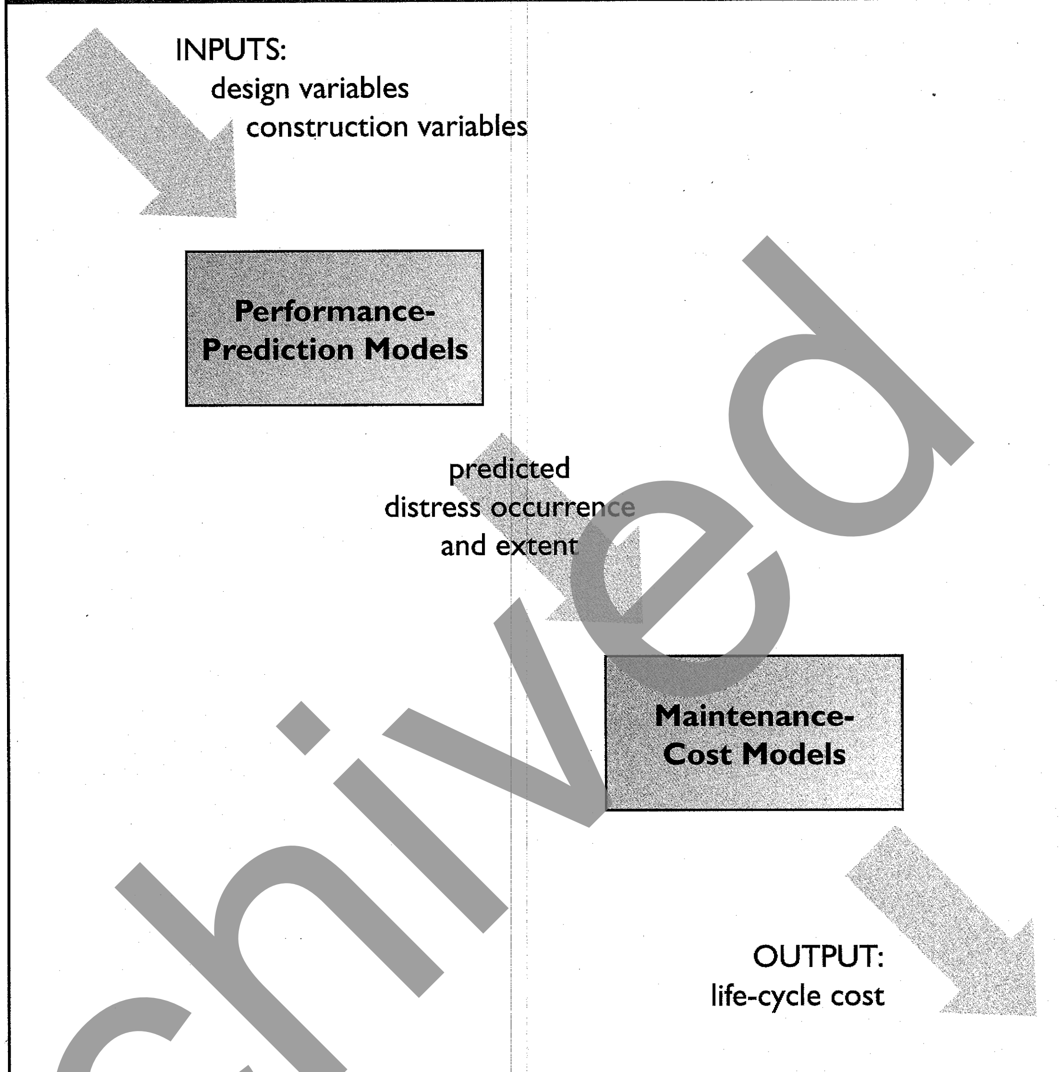
Figure 1: Improved Acceptance Plans



As shown in Figure 2, the inputs are design variables (such as traffic loading, climatic factors, drainage, and roadbed soil factors) and materials and construction quality characteristics (such as asphalt content, concrete strength, and pavement smoothness). The output is an LCC prediction for the construction element.

When the target values of quality characteristics called for in a specification are used as inputs, the output produced is the "as-designed LCC."

Figure 2: Use of models in PRS



When the actual measured values of a construction project's quality characteristics are used as input, the output produced is the estimated "as-constructed LCC." The difference between the as-designed LCC and the as-constructed LCC is the basis for any price adjustment.

This use of quantifiable models is a feature that distinguishes PRS from other highway construction specifications. The models can be an important Pavement Management System tool. Since an agency's construction, design, and maintenance branches are all interested in predicting performance, the common use of the models should assist in the sharing of technical information among the branches.

The models' outputs—the as-designed LCC and the as-constructed LCC—are also new and useful features in specifications. Under PRS, the mathematical models take many quality characteristics into account and produce the LCC—an overall quality characteristic that can be specified and measured (estimated). LCC provides a quantifiable quality standard for the entire highway community. The common goal of minimizing LCC is shared by SHAs and construction contractors.

From Research to Reality: Validating PRS Models

To fully utilize the benefits of PRS, the incorporated performance models must be accurate and effectively applied. Consequently, PRS research has focused on developing and validating appropriate models. Furthermore, a model's use in PRS will lead to its improvement because subsequent actual performance data will show what, if any, adjustments need to be made in the model. For portland cement concrete, the validation of PRS models is being done by collecting and analyzing design, construction, and performance data from in-service pavements.

For hot-mix asphalt, the validation is being done with the help of an accelerated pavement test facility. WesTrack, a specially built, state-of-the-art pavement performance project at the Nevada Automotive Test Center, is gathering 2 years of performance data as automated driverless trucks cruise the 2.9-km track. The scope of this project makes it one of the most significant test track projects since the AASHO Road Test of the 1950s and will provide a solid foundation of data to support PRS for hot-mix asphalt.

Adopting PRS: A Gradual Approach

Each SHA will follow a somewhat different road in adopting PRS, depending on local conditions and its experience with QA specifications. In States that currently use QA specifications, agency and contractor personnel may already be familiar with statistical concepts and procedures. These States

PRS: Benefits for All Involved

The New Jersey Department of Transportation (NJDOT) has been a leader in PRS and has developed an operational version of PRS (as defined in this brochure). Two projects consisting of approximately 10,000 cubic yards of pavement and structural concrete were constructed with the specifications.

"The NJDOT was well satisfied with these [PRS] results because it was believed that more than comparable value was received in terms of extended service lives of the pavements and structures built under this specification. It is presumed that the contractors and producers were also pleased, both with the monetary value of the bonus and with the recognition for having run such well controlled projects."

— *Managing Quality: Time for a National Policy*, NJDOT report

may also have conducted considerable research in establishing typical statewide materials and construction variabilities.

For States that do not have QA specifications, a longer timeframe must be built to implement PRS. The State, however, can adopt a simplified PRS as a first QA specification.

To smooth the transition to PRS, FHWA has established two PRS implementation levels. PRS level 1 is the basic PRS entry level. It provides the State with experience in specifying and establishing LCCs while permitting the use of the SHA's current tests. PRS level 2 is more sophisticated and can offer greater advantages. It employs in situ testing and permits project-specific price adjustments. Under PRS level 2, one overall price adjustment is calculated, which reflects the interactions among quality characteristics. FHWA recommends that States gain experience with level 1 before moving to level 2.

Creating a PRS Implementation Plan

The full implementation of PRS, like any other QA specifications, requires an orderly plan. The general steps for PRS implementation are similar to those that many States have followed in implementing QA specifications. These steps apply even if a State already has conventional QA specifications.

1. Open communication lines among SHA, the contractor community, industry associations, and FHWA.
2. Jointly develop PRS.

THE TRANSITION TO PRS:
Key Differences Between PRS Level 1 and Level 2

	LEVEL 1	LEVEL 2
Primary Method of Acceptance Testing	current acceptance tests used by SHA	*in situ* acceptance testing
Number of Acceptance Quality Characteristics	current number used by SHA	current number used by SHA, plus any other desired performance-related quality characteristics
Price Adjustments	a performance-related price adjustment for each quality characteristic	one overall price adjustment which reflects true interactions among the quality characteristics
	for each quality characteristic, individual price adjustment schedules based on an as-constructed LCC estimate (This assumes other quality characteristics are held constant at their target values.)	overall price adjustment based on an as-constructed LCC estimate calculated from all quality characteristics
	individual price adjustment schedules apply to categories of projects (e.g., high ADT interstate)	price adjustment is project-specific

3. Conduct joint training.
4. Obtain technician certifications and laboratory accreditations.
5. Conduct PRS simulation projects (governed under current specifications).
6. Conduct pilot projects (governed under experimental PRS).
7. Conduct PRS projects (no longer on an experimental basis).
8. Monitor project performance and maintenance expenditures, using feedback to adjust or fine-tune PRS models.
9. Improve and expand PRS (e.g., incorporate better tests or additional distress types).

Criteria for PRS Elements

In developing an effective PRS structure, it is vital that an SHA work with all of its partners—contractors, suppliers, industry associations, FHWA, and other SHAs. Sharing expertise and experiences from many perspectives will greatly facilitate the development of PRS for a particular State.

Distress Types

An SHA must examine its performance needs and ask: What are the distress types to be controlled through PRS? Not all distress types can be controlled through PRS. Those that are not controllable should continue to be addressed through conventional QA. A distress type is a candidate for control through PRS only if it meets all three of the following criteria:

- It is under the contractor's control.
- It can be predicted through an engineering-based model that is either currently available or can readily be developed.
- It impacts pavement life and required maintenance and rehabilitation.

Quality Characteristics

After identifying controllable distress types, the next issue becomes: What are the materials and construction quality characteristics that influence each controllable distress type? Not all are appropriate for use as PRS acceptance quality characteristics. Those that are not appropriate may cause their associated distress type to be dropped from consideration for PRS. An acceptance quality characteristic is a candidate for use in PRS only if it meets all three of the following criteria:

- It is under the contractor's control.
- It is measurable (ideally, *in situ*).
- It correlates strongly with the distress.

Test Procedures

Finally, any test procedure selected to measure the quality characteristic should, if possible, be:

- Timely
- Economical
- Nondestructive
- Reliable
- Reproducible

Once the PRS structure has been defined, the SHA will need to closely examine the PRS models recommended through FHWA's research. Where appropriate, models can be adjusted to better meet local conditions and demands. Some laboratory or field testing may be required to add new models or modify existing ones.

Laboratory or field testing may also be required if the agency intends to use a new test to measure a given quality characteristic. This should help in establishing or adjusting the suggested materials and construction variability values (i.e., standard deviations) associated with the quality characteristic.

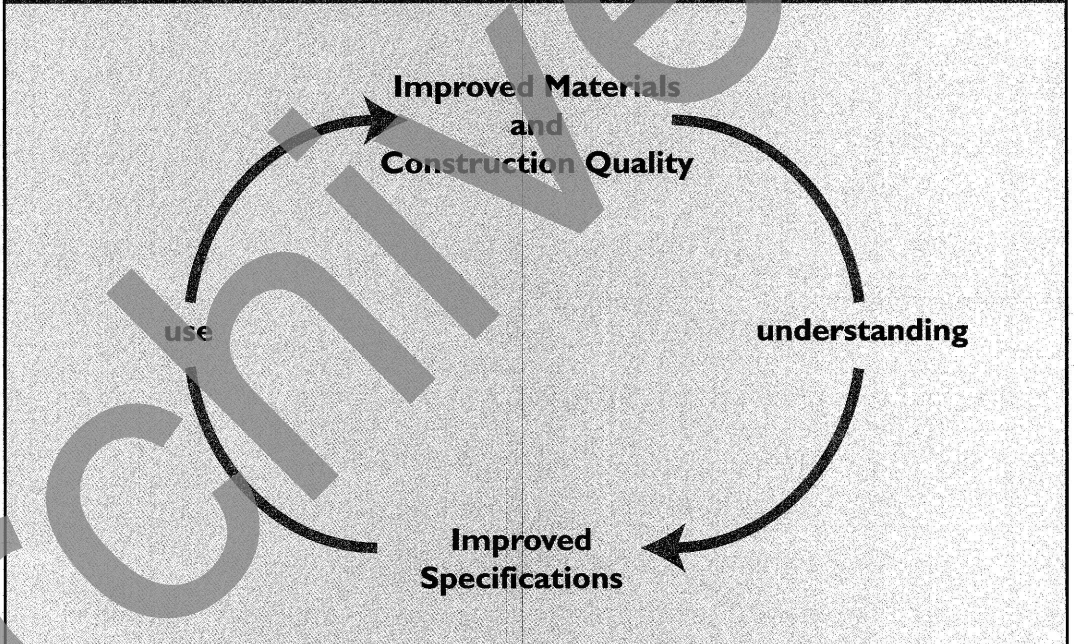
Pavement Management Systems: A Key to PRS Adoption

Research has developed and verified the concepts and framework for PRS. Successful adoption of a PRS by a SHA is highly contingent upon the availability of quality pavement performance and construction and maintenance cost data to validate and refine the relationships to local conditions. The principal source of this information is the State's Pavement Management System. Other information systems such as maintenance and construction management systems may also be information sources. States considering a PRS should evaluate their information system's ability to supply the quality data to build a foundation for successful adoption.

Continuous Quality Improvement

Performance-related specifications are part of a process of continuous quality improvement in highway construction. A better understanding of materials and construction quality characteristics has made the development of PRS possible. The use and refinement of PRS will further increase our understanding of quality characteristics and will establish a continuous quality improvement loop of better specifications and increased understanding. The bottom line is more cost-effective construction and better, longer-lasting roads.

Figure 3: PRS continued quality improvement process



Publications:

1. Irick, P.E., et. al., "Development of Performance-Related Specifications for Portland Cement Concrete Construction," FHWA-RD-89-211, May 1990.
2. Anderson, D.A., D.R. Luhr, and C.E. Antle, "Framework for Development of Performance-Related Specifications for Hot-Mix Asphaltic Concrete," NCHRP Report 332, December 1990.
3. Shook, J.F., et. al., "Performance-Related Specifications for Asphalt Concrete—Phase II," FHWA-RD-91-070, January 1992.
4. Darter, M.I., et. al., "Performance-Related Specifications for Concrete Pavements," FHWA-RD-93-042 to 044 (3 volumes), November 1993.
5. Chamberlin, W.P., "Performance-Related Specifications for Highway Construction and Rehabilitation," NCHRP Synthesis 212, 1995.
6. Darter, M.I., et. al., "Development of Prototype Performance-Related Specification for Concrete Pavements," Transportation Research Record No. 1544, 1996, pp. 81-90.
7. Scott, S., "Contract Management Techniques for Improving Construction Quality," FHWA-RD-97-067, July 1997.

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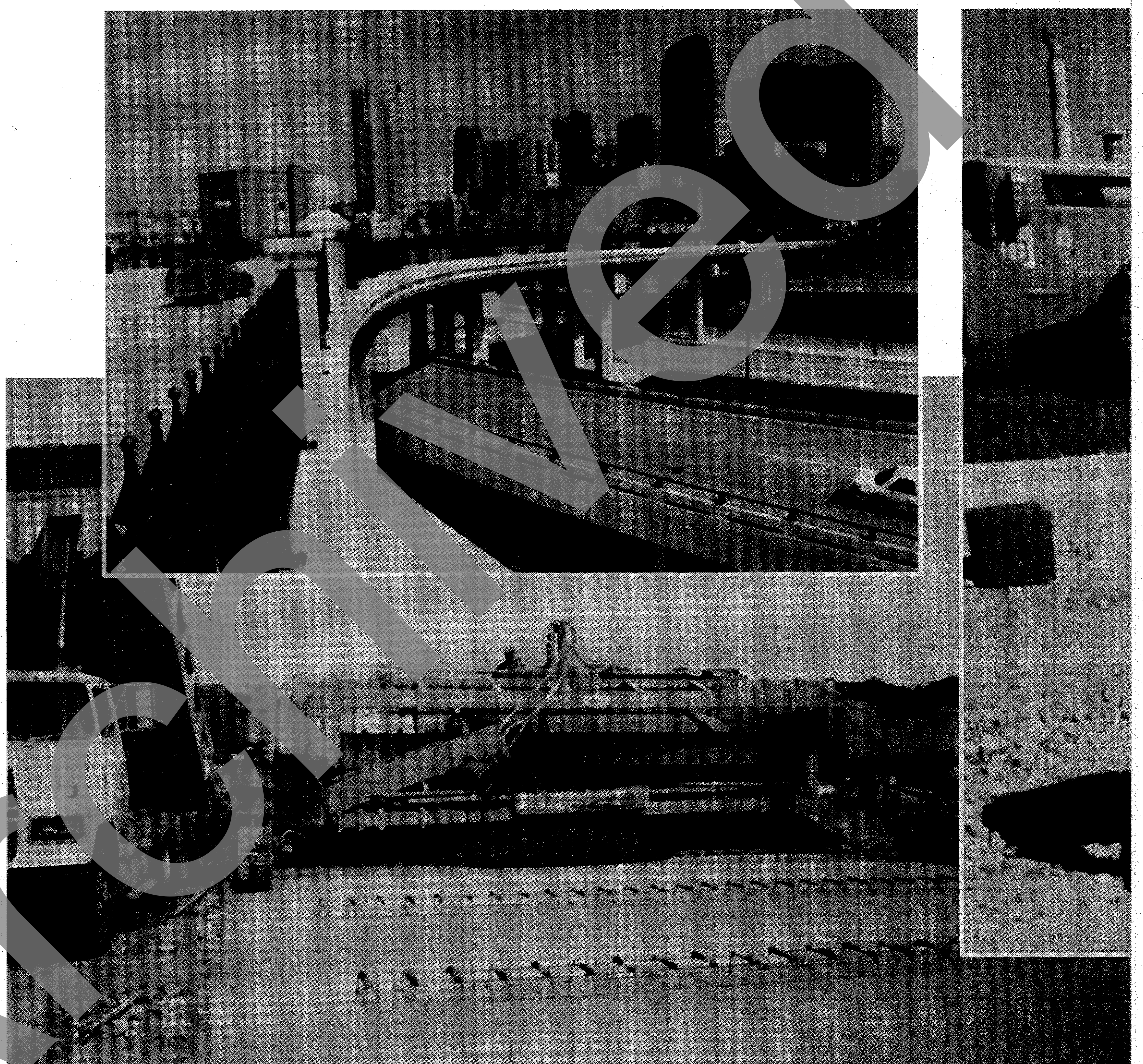

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