Quantifying the Benefits of Polymer Modified Asphalt

BY TIM GLANZMAN

Design engineers have a variety of materials options at their disposal. The performance benefits of polymer modified asphalt (PMA) in overcoming pavement distresses have been acknowledged in both the field and in laboratory tests. For the pavement design engineer, the big question is "How do I quantify the benefits of PMA from an agency perspective?"

The Asphalt Institute answers this question in a new study, Quantification of the Effects of Polymer Modified Asphalt for Reducing Pavement Distress (Asphalt Institute Publication ER-215). This definitive study uses national field performance data to determine enhanced service life of pavements containing polymer modified binders.

The main objective of the study was to quantify the effect of using PMA as compared to conventional mixtures in terms of increasing pavement life and reducing the occurrence of surface distress. It covers the following points in detail:

- Literature review of published findings from field and laboratory evaluations on the performance of PMA mixtures.
- Survey of state agencies on the performance, specification and benefits of PMA mixtures in their state.
- Comparison of PMA and conventional hot mix asphalt (HMA) pavements in field performance across North America with an emphasis on rutting, fatigue and thermal cracking.
- Modeling long-term performance of PMA and conventional HMA pavements and predicting additional service life of PMA pavements.
- Recommendations for incorporating PMA mixes in agency maintenance and rehabilitation timelines.

The Agency Survey

State agencies across the United States were surveyed to get expert opinions on the performance and specification of PMA pavements. Twenty experts representing eighteen different states responded. Approximately 70 percent of the responses indicated that there was definitely a benefit in using PMA mixtures to extend the pavement's service life, 25 percent were unsure and 5 percent had no opinion. In addition, 58 percent said that the use of PMA mixtures significantly reduced maintenance costs. Of those individuals that gave estimates for the extended service life, an average of four to six years of additional performance appeared reasonable.

Primary reasons for specifying PMA mixtures included their durability and improved performance in resisting rutting and thermal cracking. This was not a surprise, as PMA performance in these areas has been widely accepted. However, it was a surprise that not one state cited better fatigue performance as a reason for specifying PMA mixtures. Additionally, even though estimates of the extended service of PMA pavements ranged from four to six years, no states gave additional service life credit for PMA mixes in their design models. Field performance data from the study suggests PMA pavements do indeed offer improved fatigue resistance and enhanced service life, which should be accounted for in the pavement design models.

PMA Field Performance

Integrity of the field performance data was a critical design factor of the study. In addition to being statistically relevant, the sample had to represent the variety of traffic, climate and other environmental factors experienced in North America. There also had to be substantial data available on the binder, mix and construction details to enable further analysis in the study. For these points, government test sections from across the United States, with supplemental data from Canada, were used for the study.

Many of the test sections are from the Long-Term Pavement Performance (LTPP) General Purpose and Special Purpose Studies. Other test sections include non-LTPP field test sections from various states and accelerated testing facilities such as NCAT and FHWA's Accelerated Loading Facility.

Pavement distress measurements were significantly lower in PMA mixes.

For each PMA test section, conventional HMA test sections were chosen to compare rutting, thermal cracking and fatigue cracking performance. Pavement distress measurements in all three of these areas were significantly lower in PMA mixes. The fatigue cracking performance is especially noteworthy given the agency survey results where no state responded that they specified PMA mixes to overcome this distress.

The study found many of the sections with PMA mixtures have no fatigue cracking; while a substantial number of the unmodified sections have exhibited fatigue cracking—in excess of 25 percent. Similarly, many of the PMA test sections had no thermal cracking. In addition, the depth of rutting measured on the flexible pavements and HMA overlays that include PMA mixtures is about 40 percent of that measured on the companion projects.

Predicting Field Performance

While direct field performance comparisons of polymer modified and unmodified asphalt pavement is useful, the question on quantifying the extended service life of PMA is still left unanswered at this point. The study uses mechanistic-empirical (M-E) distress prediction models for rutting and load-related fatigue cracking to quantify the improvement in pavement life. Predicting additional PMA service life based upon thermal cracking performance was not possible due to insufficient mix test data available for the M-E prediction model.

Results from the evaluation of existing pavement performance and subsequent M-E distress prediction models were used to develop guidelines for the expected service life of PMA mixes. The expected increase in service life for various conditions and site features is summarized in Table 1. The estimates assume that the pavement was adequately designed for 20 years using unmodified HMA mixtures and that PMA mixtures are used in the wearing surface and base layers.

Maintenance & Rehabilitation Timelines

Many state highway agencies assume specific maintenance and rehabilitation schedules in choosing pavement materials

Expected Increase in Service Life for Flexible Pavements and HMA Overlays, Assuming a Design Period of 20 Years

Site Feature	Condition Description		Increase in Service Life, Years (1)
Foundation Soils	Non-expansive, coarse-grained soils		5-10
	Expansive soils; moderately to highly plastic soils (Plasticity index >35)		2-5
	Frost susceptible soils in cold climates; moderately to highly frost susceptible (class 3 and 4) (2)		2-5
Water Table Depth	Deep		5-10
	Shallow; adequate drainage		5-8
	Shallow; inadequate drainage		0-2
Traffic	Low	Stop & go/intersections	5-10
		Thoroughfares	3-6
		Heavy loads/special containers	5-10
	Moderate volumes		5-10
	High volumes		5-10
Climate	Hot		5-10
	Mild		2-5
	Cold		3-6
Existing Pavement Condition	HMA	Good condition	5-10
		Poor condition; extensive cracking (3)	1-3
	PCP/JPCP	Good condition (3)	3-6
		Poor condition; faulting & mid-panel cracking (3)	0-2

Notes:

(1) The range of the increase in service life is based on the M-E damage based analyses, comments from the experts and engineering judgment.

(2) Without sufficient thickness of non-frost susceptible materials to prevent frost from penetrating frost susceptible soils.

(3) Without the use of any reflection cracking mitigation techniques.

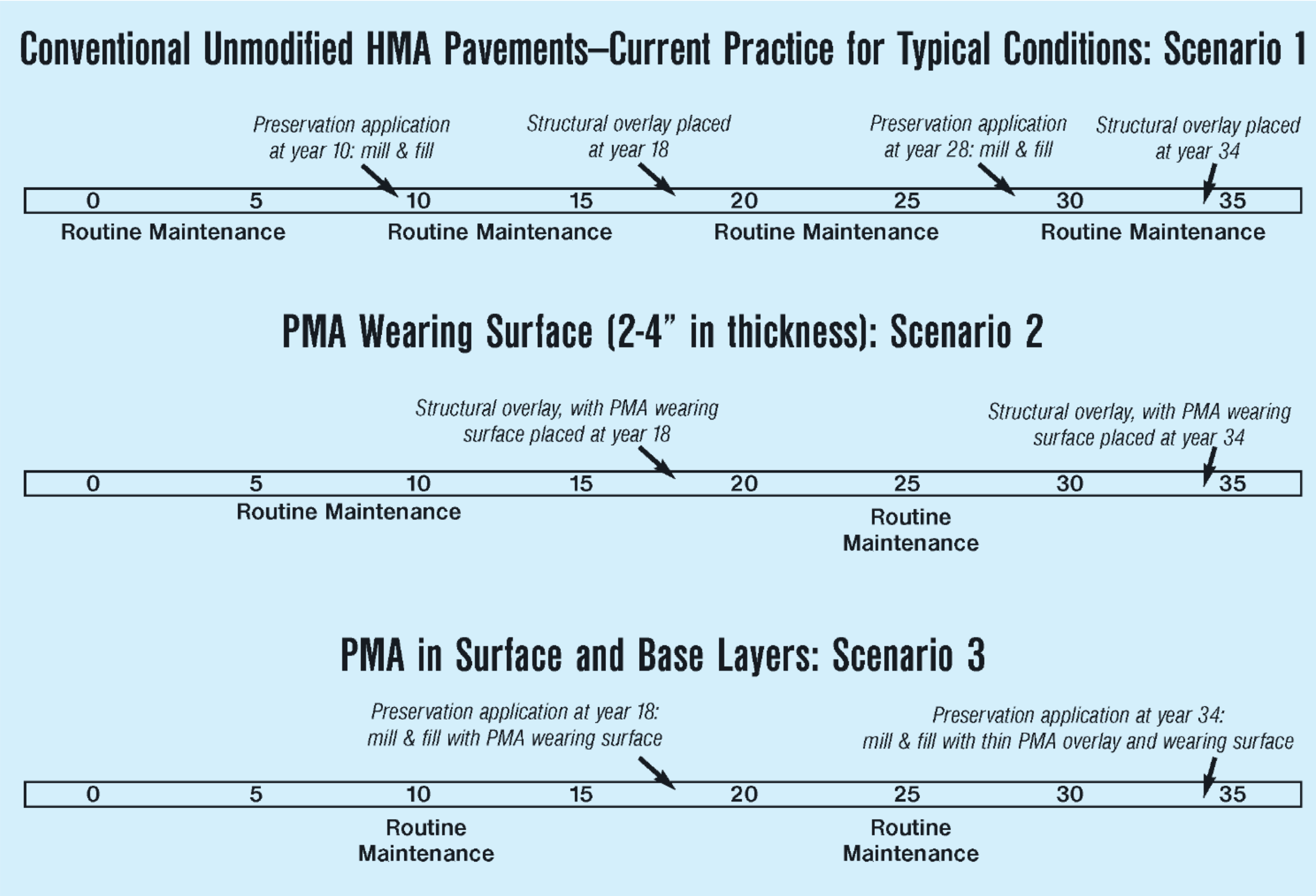

Figure 1. Generic maintenance and rehabilitation schedules for HMA pavements and overlays designed for 20 years using current pavement thickness design procedures.

and in conducting life-cycle cost analysis. The data from this study demonstrates the need to modify those assumptions when using PMA mixes. A generic maintenance and rehabilitation schedule for unmodified HMA is assumed in Scenario 1 of Figure 1.

Using this generic timeline would significantly underestimate the performance of a PMA mix and result in a higher than justified life-cycle cost. Using the results from the M-E damage-based analyses and the actual distress comparisons, a revised maintenance and rehabilitation schedule was prepared for HMA pavements designed for 20 years with PMA wearing courses in Scenario 2, and those pavements with PMA mixtures used for the wearing and base layers in Scenario 3. The changes to the structural rehabilitation and routine maintenance schedule from the use of PMA are significant and should result in substantial savings in the life-cycle cost of a PMA pavement.

Summary

Pavement design engineers have a variety of materials options at their disposal. It is common today to seek an asphalt solution based on its performance, cost effectiveness, noise reduction, and being able to get in and out of the job site quickly. The survey of state agencies and analysis of government data indicates that PMA performance is being significantly underestimated in the pavement design and selection process. PMA mixes significantly improve resistance to rutting, fatigue cracking and thermal cracking, and extend the service life of an asphalt pavement. This new study quantifies the benefits of PMA and provides a foundation for changes in modeling the long-term performance of PMA pavements.

Using this new data in the analysis of life-cycle costs and selection of paving materials is extremely beneficial—particularly in an era of constrained budgets. ▲

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