Understanding the True Economics of Using Polymer Modified Asphalt through Life Cycle Cost Analysis

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This is a follow-up to the related article published in the Spring 2005 edition of Asphalt magazine that discussed the new Asphalt Institute (AI) study titled Quantifying the Effects of PMA for Reducing Pavement Distress. The results were published in AI Engineering Report (ER) 215 and summarized in AI Informational Series (IS) 215.

This study analyzed an extensive collection of field performance data, making direct comparisons between polymer modified asphalt (PMA) mixes and unmodified conventional mixes. The data included 84 pairs of PMA and unmodified companion test sections from the FHWA Long Term Pavement Performance (LTPP) program and other governmental agency test sections located across the United States and Canada.

While comparisons are insightful regarding relative pavement performance differences between PMA and conventional mixes under similar conditions, they do not directly answer the question of how much longer a pavement should be expected to last with PMA. To quantify the expected improvement in pavement life based on the field data, the study used mechanistic-empirical prediction models for rutting and load-related fatigue cracking. Projected service-life increases were then reported based on specific site conditions of the foundation, existing pavement and drainage as well as traffic and climate. A final part of the study showed how a typical maintenance and rehabilitation schedule for unmodified HMA pavements could be extended with the use of PMA just in the wearing surface, as well as in both the wearing surface and base layers.

The purpose of life cycle cost analysis (LCCA) is to evaluate the overall long-term economic efficiency between competing alternative investment options. Typically in LCCA, costs of all activities over the analysis period are computed back to a net present worth (NPW), accounting for the discount rate over time. **This article uses LCCA to compare the activity timelines of alternative PMA strategies provided in the referenced report.**

Assumptions made in this analysis are based on constructing a 14.5-inch thick HMA pavement, maintenance activities based on Pennsylvania DOT policy, an analysis period of 40 years and a discount rate of 4 percent. Prices and quantities assumed are shown below.

MIX PRICES *(from Maryland DOT's Pavement Selection Process)*	
Wearing (PG 64-22)	$36/ton or $1.97/sy-in
Wearing (PG76-22)	$41/ton or $2.24/sy-in
Binder and Base (PG 64-22)	$35/ton or $1.91/sy-in
Binder and Base (PG 76-22)	$40/ton or $2.19/sy-in
Milling	$1.40/sy
HMA Patching	$36/sy
Quantities (per mile)	
Mainline: 2-lanes @12 ft. ea.	14,080sy
Shoulders: 1 @ 10 ft. and 1 @ 4 ft.	8,212sy

ASSUMED PRICES AND QUANTITIES

The three example scenarios shown in the referenced report are:

1) Using conventional unmodified mixes for all layers
2) Using PMA for the top 2-inch wearing surface only
3) Using PMA for both the wearing surface and bottom 4-inch base layer (consistent with a Perpetual Pavement).

The schedule of maintenance and rehabilitation activities associated with each of these alternatives was shown in Figure 1 of the related article in the last edition of *Asphalt*.

The initial cost and NPW (back to Year 0) of each activity during the 40-year analysis period for Scenarios 1, 2 and 3 are shown in the three tables to the right. Costs are based on the per-mile quantities provided in the earlier table. With Scenario 1, resurfacing is scheduled for years 10 and 28 and structural overlays for years 18 and 34. By using PMA in the wearing course (Scenario 2), the resurfacings at years 10 and 28 are eliminated. By building a Perpetual Pavement and using PMA in the wearing and base courses (Scenario 3), the structural overlays at years 18 and 34 are replaced with resurfacings. The total NPW, or life cycle cost, is tabulated for each scenario.

The table on the next page summarizes and compares the initial and life cycle costs for each of the three scenarios. Scenarios 4 and 5 were added to take a more conservative approach, where the 2.5-inch binder course was also modified just below the modified 2-inch wearing course to achieve the same extended performance in Scenarios 2 and 3 respectively. While PMA increased initial construction cost by 1 percent per inch of PMA used, the overall life cycle cost savings over 40 years was substantial. Even with

YEAR	ACTIVITY	COST, $	NPW, $
0	HMA Construction 10" Base 2.5" Binder 2" Wearing	668K	668K
10	Resurfacing 2" Mill/Fill 1% Patching (not on shoulders)	87K	58K
18	Structural Overlay 2" Mill 3% Patching and Scratch 2.5" Binder 2" Wearing (including shoulders)	285K	141K
28	Same as Year 10	87K	29K
34	Same as Year 18	285K	75K
	Annual Maintenance ($1.8K/yr)	73K	33K
	(costs are per mile)	**Total NPW:**	**$1,005K**

SCENARIO 1: USING UNMODIFIED HMA FOR ALL LAYERS

YEAR	ACTIVITY	COST, $	NPW, $
0	HMA Construction 10" Base 2.5" Binder 2" Wearing	682K	682K
18	Structural Overlay 2" Mill 3% Patching and Scratch 2.5" Binder 2" Wearing (including shoulders)	298K	147K
34	Same as Year 18	298K	79K
	Annual Maintenance ($1.8K/yr)	73K	33K
	(costs are per mile)	**Total NPW:**	**$941K**

SCENARIO 2: USING PMA FOR WEARING COURSE (TOP 2")

YEAR	ACTIVITY	COST, $	NPW, $
0	HMA Construction 10" Base 2.5" Binder 2" Wearing	709K	709K
18	Resurfacing 2" Mill/Fill (including shoulders)	141K	70K
34	Same as Year 18	141K	37K
	Annual Maintenance ($1.8K/yr)	73K	33K
	(costs are per mile)	**Total NPW:**	**$849K**

SCENARIO 3: PERPETUAL PAVEMENT: PMA FOR WEARING (TOP 2") AND BASE (BOTTOM 4") COURSE

Scenario	Initial Cost, $	Initial Cost Increase, %	LCC	LCC Savings, %
1) All layers unmodified	669K	—	1,005K	—
2) PMA for Wearing (2") Course	682K	2.0%	941K	6.5%
3) Perpetual Pavement: PMA for Wearing (2") and Base (4") Courses	709K	6.0%	849K	15.5%
4) More Conservative Approach: PMA for Wearing (2") and Binder (2.5") Courses with same activity schedule as Scenario 2	698K	4.5%	964K	4.5%
5) More Conservative Approach: PMA for Wearing (2"), Binder (2.5") and Base (4") Courses with same activity schedule as Scenario 3	725K	8.5%	864K	14.0%

SUMMARY OF COSTS FOR SCENARIOS 1, 2 AND 3, PLUS TWO ADDITIONAL (4&5) SCENARIOS

the more conservative Scenarios 4 and 5 where more PMA was used, the life cycle cost savings were 4.5 percent and 14 percent respectively.

It should be noted that this analysis does not consider user delay costs, which would be reduced with the longer service lives of PMA mixes. Considering user delay costs makes the use of PMA even more attractive.

It is important to emphasize that these are examples illustrating the framework for an analysis to quantify the long-term economic benefits of using PMA, or any other premium mix for that matter. Each agency should use their unique set of estimated LCCA inputs such as performance periods, prices, designs, strategies, discount rates and user cost considerations.

When performing LCCA, agencies should consider the extended performance lives that are typically achieved from using PMA or any premium mix. When comparing asphalt and concrete pavement alternatives, this applies as well. Too often, the performance periods assumed for initial asphalt construction and overlays do not consider the improvements realized for using premium materials and mixes.

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