

Background and Objective

Life cycle cost analysis (LCCA) is often used by state departments of transportation (DOTs) to select the most cost-effective alternatives when planning new roadway construction or reconstruction. Within an LCCA, two types of performance periods are typically considered: initial and rehabilitation. Initial performance period (also known as initial service life) represents the average time in years for a newly constructed or reconstructed pavement to reach an agency's threshold for first rehabilitation. Rehabilitation performance period is the length of time for a rehabilitated pavement to reach an agency's rehabilitation threshold.

The initial performance period can be significantly different for competing alternatives, and it affects the timing of future maintenance and rehabilitation (M&R) activities, in turn, affecting the life cycle cost of each pavement alternative. Since initial service life plays such a critical role in LCCA, the following questions arise: what is the actual initial service life for each pavement type, and is the accurate initial service life being used in LCCA? To address these questions, the following objectives were established for this study:

- Review methods DOTs currently use to determine initial service life for use in LCCA for both asphalt and concrete pavements;
- Determine actual service lives, as the age of the pavement at first rehabilitation, for asphalt and concrete pavements based on historical data; and
- Determine the pavement ride quality at the time of first rehabilitation.

A literature search and a survey of DOTs were conducted to gather information about pavement service life and rehabilitation activities considered in LCCA for both asphalt concrete (AC) and portland cement concrete (PCC) pavements. Analyses of Long-term Pavement Performance (LTPP) program data were conducted to determine the actual timing of first rehabilitation of AC and PCC pavements and the ride quality based on International Roughness Index (IRI) at the first rehabilitation for pavement sections in the U.S. and Canada. The key findings of this investigation are summarized herein.

Methods Currently Used by DOTs to Determine Initial Service Life

The initial performance periods used in LCCA by the majority of agencies ranged between 10 and 15 years

for AC pavements and between 20 and 25 years for PCC pavements. A common method used by agencies to determine pavement performance periods is using historical data from their state pavement management system (PMS). Other methods reported included using expert opinion or engineering judgement and the pavement design life.

Practices for determining the actual timing of the first rehabilitation for both AC and PCC pavements are unique to each DOT and often include various types of condition indices as well as other factors. The individual distresses generally utilized in the indices reported were cracking, IRI, and rutting for flexible pavements, and cracking, IRI, and faulting for rigid pavements. While cracking was commonly reported for both pavement types, cracking is not the same across all pavement types and therefore cannot be compared directly. Given the difference in distress types and cracking definitions for each pavement, condition indices and associated thresholds are not comparable between unlike pavement types. Therefore, actual practices and criteria for determining time of rehabilitation do not appear to be based on achieving equal levels of performance.

IRI is widely used in some aspect of the decision-making process for determining the actual timing of rehabilitation. While some agencies have threshold values associated with IRI, they vary widely by agency. Furthermore, there does not appear to be a nationwide consensus among DOTs on IRI values which indicate the need for first rehabilitation.

Actual Initial Performance Periods for Asphalt and Concrete Pavements

The timing of the first rehabilitation events for AC and PCC pavements were determined for the pavements in selected LTPP General Pavement Study (GPS) experiments and in the Specific Pavement Study (SPS) experiments. The initial pavement service life was calculated based on the dates of the first rehabilitation activity and the original construction reported in the LTPP database.

The common first rehabilitation activity used by DOTs differs among pavement types, with grinding most common for PCC pavements and mill and inlay most common for AC pavements. The average asphalt pavement age at time of first rehabilitation was found to be approximately 18 years (Table 1). However, based on previous surveys of DOTs, initial performance

periods frequently used in LCCA for asphalt pavements are between 10 and 15 years. For concrete pavements, previous surveys showed that most initial performance periods used in LCCA are between 20 and 25 years, whereas the average concrete pavement age at the time of first rehabilitation in the LTPP program is about 24 years (Table 1). This suggests that initial performance period values used for LCCA do not adequately represent the actual age of asphalt pavements at time of first rehabilitation. However, initial performance periods used in LCCA for PCC pavements are generally representative of actual concrete pavement age at time of first rehabilitation.

Pavement Ride Quality at the Time of First Rehabilitation

The last mean roughness index (MRI) values (the average of the left and right wheelpath IRI measurements) measured prior to the first rehabilitation were investigated using pavement sections in selected GPS experiments. The MRI values for the pavement sections were compared with the FHWA categories for ride quality (very good, good, fair, poor, and very poor) associated with IRI measurements (Table 2). In general, AC pavements were smoother than PCC pavements at the time of rehabilitation. AC pavements were most often rehabilitated while in good or fair condition, while PCC pavements were rehabilitated in fair or poor

Table 1. Summary of Middle 90% of Pavement Ages at Time of First Rehabilitation

Pavement Type	No. of Sections	Average	Minimum	Maximum	Standard Deviation
AC	206	17.7	7.1	28.9	5.5
PCC	121	23.8	12.9	35.4	5.8

Table 2. Summary of Middle 90% of Pavement Ages at Time of First Rehabilitation

Pavement Type	Percent of Total Pavement Sections				
	Very Good ** <60 in/mi	Good 60-94 in/mi	Fair 95-119 in/mi	Poor 120-170 in/mi	Very Poor >170 in/mi
AC	9.6%	34.3%	24.1%	17.5%	14.5%
PCC*	1.1%	23.3%	26.7%	34.4%	14.4%

*Sum is not 100% due to rounding **FHWA Categories for Ride Quality (1)

Table 3. Summary of Last MRI Value before First Rehabilitation by Pavement Type

Pavement Type	No. of Sections	Avg MRI (in/mi)	Median MRI (in/mi)	Min MRI (in/mi)	Max MRI (in/mi)	Std. Dev. (in/mi)	95% Confidence Interval (in/mi)
AC	166	112.4	99.4	30.2	359.0	54.0	104.1 – 120.7
PCC	90	129.0	119.2	48.3	260.7	46.1	119.3 – 138.6

condition. For both AC and PCC pavements, more than 85% of the sections were rehabilitated before reaching the threshold of 170 in/mile for the very poor category. Given this high percentage, a MRI value of 170 in/mi is too high to be used as a first rehabilitation trigger.

As shown in Table 3, the 95% confidence interval about the mean for both pavements overlap between 119 in/mi and 121 in/mi, which corresponds well with the early FHWA threshold of 120 in/mi for pavements going from fair to poor ride quality. Thus, an MRI value of 120 in/mi can be considered a functional performance threshold to determine initial performance periods of AC and PCC pavements for use in LCCA.

Recommendations

Based on the key findings of this investigation, the following recommendations can be offered:

- Use of actual measured performance for determining initial service life for LCCA can ensure consistent levels of performance are being compared among unlike pavement types.
- The performance indicators and associated thresholds used to determine initial service life in LCCA should be indicative of when rehabilitation is truly necessitated and should strike a balance between structural and functional performance. A functional performance threshold value of 120 in/mi is recommended to determine initial pavement service life for use in LCCA, as it falls within the 95% confidence interval about the mean for both AC and PCC pavements and corresponds to pavements going from fair to poor ride quality.

While initial performance periods used in LCCA for PCC pavements are generally representative of actual concrete pavement age at time of first rehabilitation, initial performance periods frequently used in LCCA for asphalt pavements (10 and 15 years) are much lower than the average asphalt pavement age at time of first rehabilitation (approximately 18 years) determined in this study. Thus, given the ongoing advancements in material characterization, pavement design, and construction, the pavement initial service life used in LCCA should be re-examined periodically to capture the changes in pavement performance due to changes in design and materials.

References

1. 1999 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance Report. U.S. Department of Transportation, 2000.

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