

CHAPTER 606

Life-Cycle Pavement Cost Analysis

Design Memorandum	Revision Date	Sections Affected
20-01	Jan. 2020	Previously 304-20.00
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The design memorandum applicable revision date is noted in brackets next to each section heading below.

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LIFE-CYCLE PAVEMENT COST ANALYSIS

Life-Cycle Pavement Cost Analysis is an economic evaluation technique that builds on the principles of economic analysis to evaluate the overall long-term solutions for each type of project. LCPCA considers initial and future agency, user, and other relevant costs over the life of alternatives discounted to provide comparative costs. This technique allows a project's cost to be compared over a specified time period. The selection of design alternatives should be made based on an LCPCA sensitivity analysis for pavement life costs. It is the ultimate goal and primary purpose of the pavement designer to determine a pavement treatment that yields the least cost of ownership to the Department unless otherwise directed by INDOT pavement staff. In the instance that the most cost-effective pavement treatment lacks viability from either a project budget or constructability standpoint, the pavement designer should work with INDOT pavement staff to determine if a different pavement treatment should be recommended or if the programmatic intent should be altered through change management.

This section provides the methodology to perform an LCPCA for a pavement project.

606-1.0 GENERAL REQUIREMENTS [REV. JAN. 2022]

An LCPCA will be completed on each alternative for a New Alignment, Reconstruction, or Rehabilitation (Structural) project. In the simplest situation, an LCPCA evaluates costs associated with two or more particular strategies or design scenarios over an analysis period including the initial construction and at least one succeeding rehabilitation activity. These costs for the alternate scenarios or money flows are discounted to the present time. A comparison of the net present value of the scenarios is made to provide information regarding one of the factors involved in the selection of a pavement design.

The economic evaluation of two feasible design strategies or design scenarios has no relation to the method of financing, or the total cost of the project. Inflation is not a factor in the evaluation since two or more scenarios' cash flows are being compared over the same time period with presumably the same inflation effects. Constant real dollars should be used in the LCPCA, and then the budget analysis should decide funding sources, inflation rate, and cash-flow requirements.

An LCPCA will be required for a New Alignment, Reconstruction, or Rehabilitation (Structural) project with mainline pavement of more than 15,000 yd² for determination of pavement type. A

LCPCA should be completed for all projects where costs of different equitable treatments are close ($\leq 10\%$ difference). A least cost of ownership analysis, (cost analysis = \$/lane/mile/year) is also required for each treatment identified in Section 602-1.04 to compare preventive maintenance preservation treatments with differing design lives.

Two scenarios being evaluated with a total net present value within 10% difference (15% for a preservation project with an initial cost as calculated for a cost analysis of less than \$750,000) are considered essentially the same. Other factors should be used to make the final selection such as initial costs, constructability, geotechnical report, work-zone traffic control and user delay costs.

606-2.0 DEFINITIONS

606-2.01 Analysis Period

The analysis period is the number of years over which the pavement life-cycle analysis is conducted. The analysis period should include the initial pavement cost and the cost of at least one subsequent rehabilitation. The analysis period should be at least 50 years in comparing new pavements. In comparing treatments with lesser design lives the number of years may be less.

606-2.02 Discount Rate [Rev. Jan. 2022]

The discount rate is used to equate the cash flows to present worth and determine Equivalent Uniform Annual Cost (EUAC). For general purposes, a 3.5% discount rate can be assumed. However, a range of rates from 0% to 10% can be used to determine if the alternate scenarios are discount-rate sensitive.

606-2.03 Equivalent Uniform Annual Cost (EUAC)

The EUAC is the combining of initial capital costs and all future expenses into equal annual payments over the analysis period.

$$EUAC = (PW) \left[\frac{i(1+i)^n}{(1+i)^n - 1} \right]$$

Where: PW = present worth
 i = discount rate
 n = number of years from year zero.

606-2.04 LCPCA Design Life [Rev. Jan. 2022]

LCPCA design life is the estimated service life of the pavement. The minimum acceptable design life is shown in Section 601-4.0, INDOT Pavement Analyses Philosophy. This should be used for the initial, maintenance, or rehabilitation option. The goal of the pavement designer is to determine a pavement treatment that optimizes pavement design life and is based on least cost of ownership to the department. Overlay designs should be run at a 30-year design life and new, full-depth pavement should be run for a 50-year design life. MEPDG output data should then be analyzed to determine the functional life of the pavement alternative.

The design life of the pavement should be varied to test the LCPCA for sensitivity based on the existing pavement condition, past performance, or the condition of the drainage system. The design life used for the sensitivity analysis should be documented.

The Office of Pavement Engineering will maintain a listing of historical bid summaries associated with pavement construction, rehabilitation, and maintenance contract costs identified as part of the proposed LCPCA. The pavement designer should utilize these costs to compare pavement life-cycle costs of different pavement treatments. Current pavement unit costs are available on the INDOT Pay Items List/Unit Price Summaries webpage at <http://www.in.gov/dot/div/contracts/pay>.

606-2.05 Pavement Life-Cycle Cost

A factor in identifying and performing economic analyses of alternatives in the design of new pavement construction or the repair and rehabilitation of existing pavement is the life cycle of the alternative under consideration. The pavement life-cycle cost includes the initial capital cost of construction of pavement items, future maintenance, and future rehabilitation cost estimates. The pavement life-cycle cost may also include user-delay costs during construction and rehabilitation, user vehicle operating and accident expenses, engineering fees, or other expenditures over the life of the pavement. It may also include the residual value, or salvage value of the pavement, at the end of the analysis time period. The pavement designer may consider the minimum acceptable functional lives for the rehabilitation alternatives over the life of the pavement, however the functional lives of pavement alternatives used in comparing pavement life-cycle costs should be based on MEPDG results and observed past performance of similar pavement treatments.

The cost of work-zone traffic control and the cost of user delays during construction between designs may have a significant effect on the analysis. These costs should be quantified for the designs. LCPCA costs can include the following:

1. Agency Costs. These include the following:
 - a. initial construction costs;
 - b. future construction or rehabilitation costs, e.g., overlays, seal coats, or reconstruction;
 - c. maintenance costs which recur throughout the design period;
 - d. salvage return or residual value at the end of the design period, which may be a negative cost;
 - e. engineering and administration costs; and
 - f. traffic-control costs if they are involved.

2. User Costs. These include the following:
 - a. travel time;
 - b. vehicle operation;
 - c. accidents;
 - d. discomfort; and
 - e. time delay and extra vehicle operating costs during resurfacing or major maintenance

606-2.06 Present Worth (PW) [Rev. Jan. 2022]

The PW is the value of money at year zero of future expenditures. The future cash flow is discounted by the discount rate to determine PW. The equation for the present worth of a future overlay is as follows:

$$PW = F \left[\frac{1}{(1+i)^n} \right]$$

Where: F = future construction cost
 i = discount rate
 n = number of years from year zero.

Note: INDOT uses **deterministic** LCPCA and present value for pavement alternative analysis, not EUCA.

606-2.07 Salvage Value (SV)

Salvage value is the residual value of the pavement's remaining service life at the end of the analysis period. As an example, if the pavement surface has 5 yrs. of remaining life at the end of the analysis, the pavement has a remaining value which has not been used. SV is defined as the construction cost of the last cycle times the ratio of the remaining service years to the last cycle design life. The SV of the pavement is calculated from the equation as follows:

$$SV = (C) \left(\frac{RL}{DL} \right)$$

Where: C = last cycle construction cost, \$
 RL = remaining service life, yr.
 DL = last cycle design life, yr.

606-3.0 ANALYSIS STEPS

An example of LCPCA strategy follows. Differing pavement work types with different design lives may be used in alternate LCPCA strategies.

606-3.01 HMA Pavement [Rev. Jan. 2022]

50-year analysis period

A. Joint Adhesive use:

1. Initial Pavement Construction: age 0

2. Preventive Maintenance Treatment:

Joint/Crack Seal, at Year 3 - 25% Longitudinal Joint Seal
Joint/Crack Seal, at Year 6 - 50% Longitudinal Joint Seal
Joint/Crack Seal, at Year 9 - 75% Longitudinal Joint Seal
Joint/Crack Seal, at Year 12 - 100% Longitudinal Joint Seal

3. Preventive Maintenance Treatment:

Mill 1.5 in. and Overlay 1.5 in. Surface, with 1% partial-depth HMA patching based on mainline pavement area, at Year 15.

4. Preventive Maintenance Treatment:

Joint/Crack Seal, at Year 18 - 25% Longitudinal Joint Seal

Joint/Crack Seal, at Year 21 - 50% Longitudinal Joint Seal

Joint/Crack Seal, at Year 24 - 75% Longitudinal Joint Seal

5. Preventive Maintenance Treatment:

Mill 1.5 in. and Overlay 1.5 in. Surface, with 2% partial-depth HMA patching based on mainline pavement area, at Year 26

6. Preventive Maintenance Treatment:

Joint/Crack Seal, at Year 29 - 25% Longitudinal Joint Seal

Joint/Crack Seal, at Year 32 - 50% Longitudinal Joint Seal

Joint/Crack Seal, at Year 35 - 75% Longitudinal Joint Seal

7. Major Rehabilitation:

Mill 1.5 in. and two-layer Overlay 4 in. = 1.5 in. Surface on 2.5 in. Intermediate, 3% partial-depth and 1% full-depth patching based on mainline pavement area, at Year 36

Note: Variable Depth Aggregate Wedge Shoulder maybe necessary at Year 36.

8. Preventive Maintenance Treatment:

Joint/Crack Seal, at Year 39 - 25% Longitudinal Joint Seal

Joint/Crack Seal, at Year 42 - 50% Longitudinal Joint Seal

Joint/Crack Seal, at Year 44 - 75% Longitudinal Joint Seal

Joint/Crack Seal, at Year 47 - 100% Longitudinal Joint Seal

End of LCPCA, Salvage Value at Year 50 = \$0.00

B. Void Reducing Asphalt Membrane (VRAM) use:

1. Initial Pavement Construction: age 0

2. Preventive Maintenance Treatment:

Thermal/Random Crack Seal, at Year 3 - 100 lft/lane/mile

Thermal/Random Crack Seal, at Year 6 - 200 lft/lane/mile

Random Crack Seal, at Year 9 - 200 lft/lane/mile

Random Crack Seal, at Year 12 - 200 lft/lane/mile

3. Preventive Maintenance Treatment:

Mill 1.5 in. and Overlay 1.5 in. Surface, with 1% partial-depth HMA patching based on mainline pavement area, at Year 15

4. Preventive Maintenance Treatment:

Thermal/Random Crack Seal, at Year 18 - 100 lft/lane/mile

Thermal/Random Crack Seal, at Year 21 - 200 lft/lane/mile

Random Crack Seal, at Year 24 - 200 lft/lane/mile

5. Preventive Maintenance Treatment:

Mill 1.5 in. and Overlay 1.5 in. Surface, with 2% partial-depth HMA patching based on mainline pavement area, at Year 27

6. Preventive Maintenance Treatment:

Thermal/Random Crack Seal, at Year 30 - 100 lft/lane/mile

Thermal/Random Crack Seal, at Year 33 - 200 lft/lane/mile

Random Crack Seal, at Year 36 - 200 lft/lane/mile

7. Major Rehabilitation:

Mill 1.5 in. and two-layer Overlay 4 in. = 1.5 in. Surface on 2.5 in. Intermediate, with 3% partial-depth and 1% full-depth HMA patching based on mainline pavement area, at Year 38

Note: Variable Depth Aggregate Wedge Shoulder maybe necessary at Year 38.

8. Preventive Maintenance Treatment:

Thermal/Random Crack Seal, at Year 41 - 100 lft/lane/mile

Thermal/Random Crack Seal, at Year 44 - 200 lft/lane/mile

Random Crack Seal, at Year 47 - 200 lft/lane/mile

End of LCPCA, Salvage Value at Year 50 = \$X.XX (3 years Remaining Service Life of Major Rehabilitation Treatment)

606-3.02 PCCP [Rev. Jan. 2022]

50-year analysis period

1. Initial Pavement Construction: age 0

2. Concrete Pavement Restoration: Age 10

Seal Longitudinal Joints and Transverse Joints - 10%

3. Concrete Pavement Restoration: Age 18

Seal Longitudinal Joints and Transverse Joints - 20%

Partial Depth Longitudinal and Transvers Joints Repair - 3% Joints

Full Depth PCCP Patch – 1.5% of mainline pavement area

4. Concrete Pavement Restoration: Age 30

Seal Longitudinal Joints and Transverse Joints - 30%

Partial Depth Longitudinal and Transverse Joints Repair - 5% Joints

Full Depth PCCP Patch – 3% of mainline pavement area

Profiling (Diamond Grinding) 100% mainline pavement areas

5. Major Rehabilitation: Age 40

Unbounded Concrete Overlay including 1” HMA overlay to existing concrete pavement for bond braker

Full Depth PCCP Patch – 3% of mainline pavement area

Note: Variable Depth Aggregate Wedge Shoulder maybe necessary at Year 40.

End of LCPCA, Salvage Value at Year 50 = \$XXX (15 years Remaining Service Life of Unbonded Concrete Overlay Treatment)

LCPCA examples are available on the Pavement Design webpage at <https://www.in.gov/indot/3418.htm>.