INDIANA DEPARTMENT OF TRANSPORTATION

Driving Indiana's Economic Growth

Design Memorandum No. 22-02

January 21, 2022

TO: **All Design, Operations, and District Personnel, and Consultants**

FROM: ***/s/Kumar Dave***
Kumar Dave
Manager, Pavement Design Office
Highway Engineering Division

SUBJECT: **Life-Cycle Pavement Cost Analysis (LCPCA) update**

REVISES: ***Indiana Design Manual*** **(IDM) Sections 601-5.01(04), 606-1.0, 606-2.02, 606-2.04, 606-2.06, 606-3.01, and 606-3.02**

EFFECTIVE: **For lettings on or after May 1, 2022**

IDM Chapter 606, Life-Cycle Pavement Cost Analysis, has been revised to reflect current practice. The revisions align the analysis with the anticipated maintenance and rehabilitation cycles of the INDOT Pavement Asset Management 20-year Plan. Notable revisions include:

- Minimum pavement area required for LCPCA increased from 10,000 yd^2 to 15,000 yd^2.
- Discount rate revised from 4% to 3.5%.
- New LCPCA calculation added where Void Reducing Asphalt Membrane (VRAM) is used.
- Concrete pavement restoration (CPR) and concrete overlay added for PCCP analysis period.

The IDM revisions are included for reference on the following pages.

Questions regarding project specific LCPCA should be directed to the Pavement Design Office, Pankaj Patel at papatel@indot.in.gov.

General questions should be directed to the Pavement Design Office Manager, Kumar Dave at kdave@indot.in.gov.

IDM Revisions

Chapter 601

601-5.01(04) INDOT Final Pavement Design [Rev. Jan. 2022]

The pavement designer will determine if all pertinent data to complete a final pavement design is available. If all pertinent data to complete a pavement design is not available, the pavement designer will work with the Pavement Area Engineer, the District Pavement Engineer, and when necessary the District Project Manager to obtain the necessary information required to complete a final pavement design. Once all pertinent project data has been provided to the pavement designer, a draft of final pavement design should be completed and submitted to INDOT Central Office Pavement Engineering for review.

The final pavement design memorandum should include the intent of the project, existing pavement type, history of the pavement from initial construction through the last treatment, thickness of all layers, site visit findings and recommendations, test data findings and recommendations, key professional engineering assumptions and facts, table of design data, pavement design recommendations, patching summary table, and other pertinent information, i.e., critical utilities issues, recommend future maintenance schedule, and key constructability issues. Constructability issues may include temporary widening, temporary runarounds, temporary ramps, assumed pavement thicknesses or variations, profile grade assumptions, and other challenges. A patching summary table should be approved by the District Pavement Engineer and the design engineer and included in the contract documents before the letting.

A pavement designer contracted by INDOT should submit the final pavement design by memorandum on their letterhead including a report with the information listed below. The submittal should provide evidence that all pavement designs are checked and signed by a qualified peer. The executive summary should be clear and concise and only include the necessary pavement information to implement the design.

1. Executive Summary;
2. Project Description;
3. Pavement History;
4. Methodology for selecting preferred pavement strategy;
5. Assessment of Current Pavement Condition (Functional and Structural) with photographs;
6. Pavement Design and Recommendations, including at least one feasible Alternate Pavement treatment;
7. Life-Cycle Pavement Cost Analysis (LCPCA) for projects equal to or greater than 15,000 yd^2;
8. Functional and Structural life of the pavement alternatives analyzed;
9. Construction and Maintenance Issues and Concerns; and

10. Appendices as follows:

    a. Traffic Data;

    b. Geotechnical Investigation Report;

    c. Pavement Cores with Photographs and Pavement Distress Photographs;

    d. Non-Destructive Testing Results, such as FWD;

    e. HMA Binder Selection using LTPPBind;

    f. Typical Sections;

    g. AASHTOWare Pavement ME Design Input Summary;

    h. AASHTOWare Pavement ME Design output, at least the optimal design and then one failure iteration; and

    i. LCPCA Results.

After the draft of the final pavement design has been reviewed and approved by the INDOT Central Office Pavement Engineering Assigned Reviewer, the final pavement design should be signed, stamped, and sealed with an active Indiana Professional Engineer (PE) stamp by the responsible Engineer for the project. The final pavement design should then be routed by the Central Office pavement designer through the District Pavement Engineer for their review and approval. After district approval, a copy of the design will be sent to the Pavement Area Engineer and Pavement Director. Finally, the pavement design will be reviewed and approved by the Manager of the Pavement Division. The approved final pavement design is then returned to the designer and project manager. This process assures that all pavement designs are checked by a qualified peer.

Chapter 606

606-1.0 GENERAL REQUIREMENTS

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 yd^2 for determination of pavement type. A LCPCA should be completed for all projects where costs of different equitable treatments are close (≤ 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 to be 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.

606-2.02 Discount Rate

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.

606-2.04 LCPCA Design Life

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. The 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

606-2.06 Present Worth (PW)

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.

606-3.01 HMA Pavement

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. <u>Void Reducing Asphalt Membrane (VRAM) use:</u>

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

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.