Life Cycle Cost Analysis: Basics & What Matters?

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What is Life-Cycle Cost Analysis?

- Life-cycle cost analysis (LCCA):
  - An analysis technique used to evaluate the overall long-term economic efficiency between competing functionally equivalent pavements (i.e. equal benefits to the user...).
  - Based on well-founded economic principles.
  - Identifies the strategy that will yield the best value by providing the expected performance at the lowest cost over the analysis period.
  - Is not an engineering tool for determining how long a pavement design or rehabilitation alternative will last or how well it will perform.

Why Bother with an LCCA?

- Pavement types perform differently over time, and equivalent designs are not always achievable during initial construction.
- LCCA compares the total discounted cost of each design over a specific analysis period to minimize the financial burden of the roadway on taxpayers.
This is nothing new!

- AASHO in 1960, supported the concept of LCCA.
- FHWA embraced LCCA in its 1981 policy statement on Pavement Type Selection.
- Congress in 1995 required LCCA for projects on the NHS. Rescinded in 1998 (section 1305 of TEA-21), as States pointed to a lack of guidance regarding LCCA.
- In 1998, FHWA issued Interim Technical Bulletin, and has since developed guidance, demos and issued RealCost.
- 2020 House-passed Moving Forward Act, included Sense of Congress that States should use LCCA.

Basic Steps in a Single Project LCCA

**Step 1 – Select the Analysis Period**

**LCCA Analysis Period**

- The analysis period is the timeframe over which the alternative strategies/treatments are compared.
  - Must encompass the initial performance period and at least one major follow-up preservation/rehabilitation activity for each strategy.
- FHWA recommends an analysis period of at least 35 years for all pavement projects.
- ACPA recommends an analysis period of 45-50+ years because common practice in many states is to design the concrete pavement alternate for 30+ years.
Step 2 – Select a Discount Rate

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The real discount rate (also known as the real interest rate) is used in pavement LCCAs.

- Accounts for fluctuations in both investment interest rates and the rate of inflation (can be materials specific... MIT forecasting)
- Today's costs can be used as proxies for future costs.

\[ d = \frac{1 + i_{\text{int}}}{1 + i_{\text{inf}}} - 1 \]

- \( d \) = the real discount rate, %
- \( i_{\text{int}} \) = the interest rate, %
- \( i_{\text{inf}} \) = the inflation rate, %

Determining the Real Discount Rate

- If local interest and inflation rates are not readily available to develop a local real discount rate, FHWA recommends OMB Circular A-94 Appendix C

FHWA GUIDANCE: USE REAL DISCOUNT RATES PUBLISHED ANNUALLY in OMB CIRCULAR A-94

In 1998, FHWA Interim Bulletin suggested 4% based on a 5-yr average of OMB rates...
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Step 3 – Estimate Initial Agency Costs (A)

Initial Agency Costs

- Only those initial agency costs that are different among the various alternatives need to be considered for reasonably similar alternatives.
- Pavement costs include items such as subgrade preparation, bases, and surface material; associated labor and equipment, etc.
- When historical bid prices are used as estimates, consider the impact of material price escalators, payment practices (sy v. tons), bidding practices (shifting), job size, etc.

Initial Agency Costs

- Important to get as correct as possible!
  - Influences results more than anything else in analysis
  - Do not use average bid values blindly
  - Easiest or toughest to get???

Step 4 – Estimate User Costs (B)

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**User Costs**

- Costs that are incurred by **users of the roadway** over the analysis period, mainly:
  - **Work zone costs**: Incurred during lane closures and other periods of construction, preservation/rehabilitation, and maintenance work.
  - **Vehicle operating costs**: Incurred during the normal use of the roadway (*roughness and stiffness*)

**Future Agency Costs**

- **All cost components must be considered** because the present value of costs associated with engineering, administrative, and traffic control are impacted by the time value of money (timing, discount rate).
- Include **multiple rehab scenarios**!
- **Must** include **rehabilitation costs** and timing.

**Preservation and Rehab. Costs**

- **Large future agency costs** associated with improving the condition of the pavement or extending its service life.
- Preservation and rehabilitation **activities and their timing** should be based on the distresses that are predicted to develop in the pavement.
- Best to develop pavement performance predictions based on **local performance history data**; otherwise, AASHTOWare Pavement ME can be used.
Step 6 – Estimate Residual or Salvage Value

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Residual or Salvage Value

- Defined in one of three ways:
  - The net value that the pavement would have in the marketplace if it is recycled at the end of its life.
  - The value of the remaining service life (RSL) at the end of the analysis, OR
  - The value of the existing pavement as a support layer for an overlay at the end of the analysis period.
- Residual or salvage value must be defined the same way for all alternatives.
- Always in final year, so Δ$ is what is important.

Step 7 – Compare Alternatives

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Compare Alternatives

- Alternatives considered must be compared using a common measure of economic worth.
- Investment alternatives such as pavement strategies are most commonly compared on the basis of:
  - Present worth (also called net present value [NPV])
  - Annual worth (also called equivalent uniform annual cost [EUAC])
- NPV and EUAC provide the same ranking
**Analysis Methods**

- **Deterministic** approach – a single defined value is assumed and used for each activity.
- **Probabilistic** approach – variability of each input is accounted for and used to generate a probability distribution for the calculated life-cycle cost.

**Analysis Tools**

- Most modern *spreadsheet software* include standard functions for calculating the present worth and annual worth.
- *Proprietary software* to compute LCCAs include:
  - FHWA’s RealCost (deterministic and probabilistic)
  - ACPA’s StreetPave & WinPAS (both deterministic)
  - CAC’s CANPave (deterministic)
  - Asphalt Pavement Alliance’s (APA’s) LCCA Original and LCCA Express (both deterministic)

**Compare Results**

- Because different components of the LCCA indicate different things about the alternates, the components typically are viewed separately and together to aid in interpretation/evaluation. LCCA is a *decision support* tool!
- When two alternatives have very similar net present values over the analysis period, it is advisable to choose the less *risky alternative* (i.e., the one with the higher proportion of the net present value attributable to initial costs).
- For LCCAs within 10-15%, use ADAB (*)leverage competition*

**So... WHAT REALLY MATTERS?**

- Lessons learned and key takeaways from work at *MIT’s Concrete Sustainability Hub*...