Life Cycle Cost Analysis:
Basics & What Matters?

CP Tech Center/ACPA Webinar

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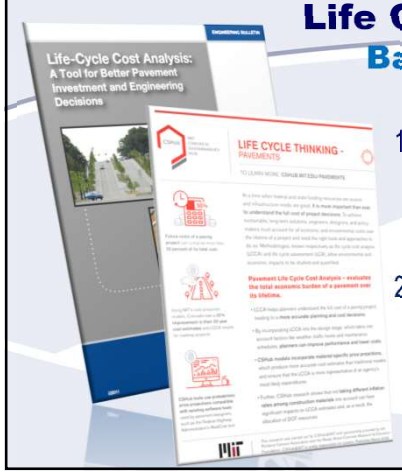
Life Cycle Cost Analysis:
Basics & What Matters?



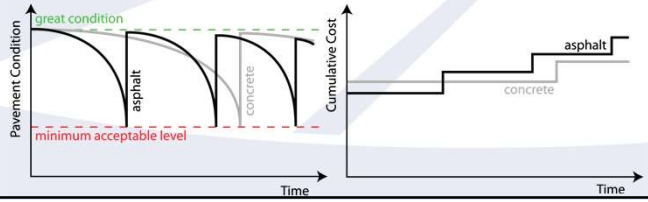
1) Introductory content based on information in ACPA's LCCA Engineering Bulletin (EB011) and *wikipave.org*
2) What have we learned & key takeaways from work at CSHub MIT CONCRETE SUSTAINABILITY HUB

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.

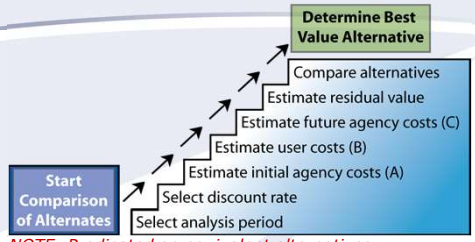
Why Bother with an LCCA?

- 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 Rescinded in 1998 (section 1305 of TEA-21), as States pointed to a lack of guidance regarding LCCA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….



NOTE: Predicated on equivalent alternatives

Life-Cycle Cost Analysis

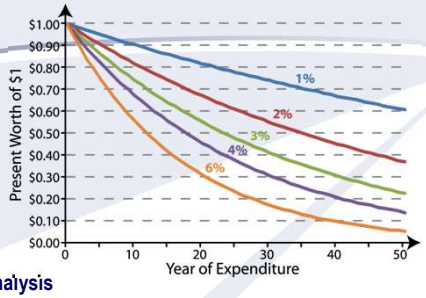
Basic Steps in a Single Project LCCA

Life-Cycle Cost Analysis

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.***



Life-Cycle Cost Analysis

Step 2 – Select a Discount Rate

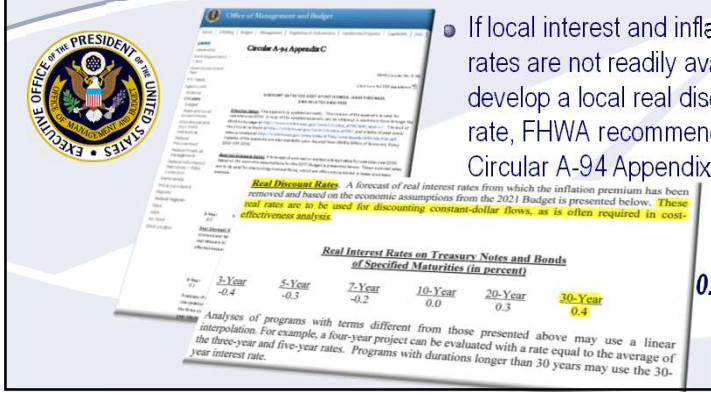
LCCA Discount Rate

- 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.

$$d = \frac{1 + i_{int}}{1 + i_{inf}} - 1$$

d = the real discount rate, %
i_{int} = the interest rate, %
i_{inf} = the inflation rate, %

Determining the Real Discount Rate



Circular A-94 Appendix C

Real Discount Rates. A forecast of real interest rates from which the inflation premium has been removed and based on the economic assumptions from the 2021 Budget is presented below. These real rates are to be used for discounting constant-dollar flows, as is often required in cost-effectiveness analysis.

Real Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)

3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
-0.4	-0.3	-0.2	0.0	0.3	0.4

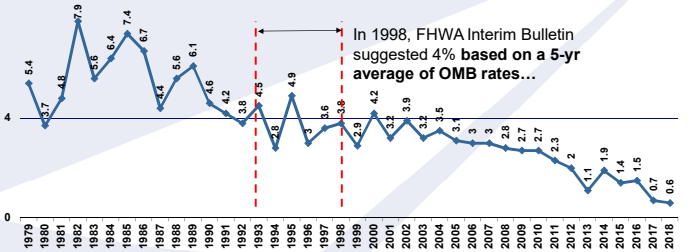
Analyses of programs with terms different from those presented above may use a linear interpolation. For example, a four-year project can be evaluated with a rate equal to the average of the three-year and five-year rates. Programs with durations longer than 30 years may use the 30-year interest rate.

- 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

0.4%

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

OMB 30-Yr Real Interest Rates Per Circular A94 Appendix C



In 1998, FHWA Interim Bulletin suggested 4% **based on a 5-yr average of OMB rates…**

Life-Cycle Cost Analysis

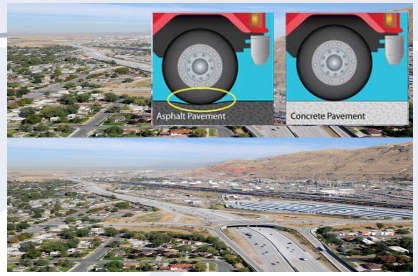
Step 3 – Estimate Initial Agency Costs (A)

Initial Agency Costs

- Only those **initial agency costs that are different** among the various alternatives need to be considered for reasonably similar alternates.
- **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???



Life-Cycle Cost Analysis

Step 4 – Estimate User Costs (B)

User Costs

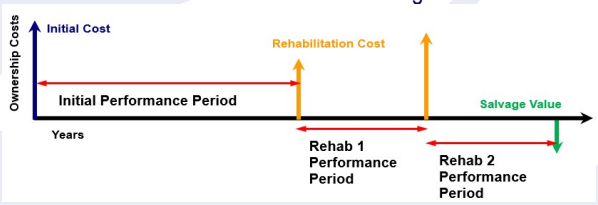
- Costs that are incurred by **users of the roadway** over the analysis period, mainly....
  - **Work zone costs:** Incurred during lane closures and other periods of construction, preservation/rehabilitation, and maintenance work.
  - **Vehicle operating costs:** Incurred during the normal use of the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

Life-Cycle Cost Analysis

Step 5 – Estimate Future Agency Costs (C)

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

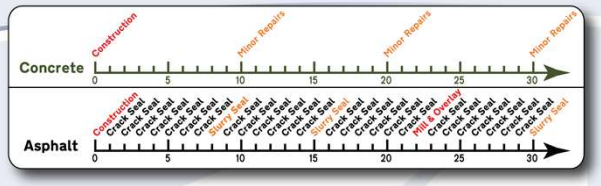
- **Large future agency costs** associated with improving the condition of the pavement or extending its service life.
- Preservation and rehabilitation **activities and their timing** should be based on the distresses that are predicted to develop in the pavement.
- Best to develop pavement performance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

Life-Cycle Cost Analysis

Step 6 – Estimate Residual *or* Salvage Value

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.



Pavement Management Plan from City of Leawood, Kansas

Life-Cycle Cost Analysis

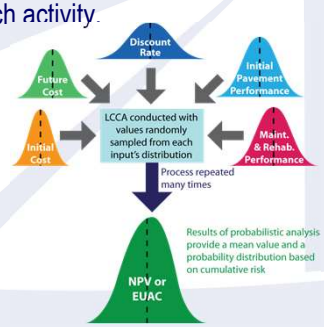
Step 7 – Compare Alternatives

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**…