PAVEMENT LIFE CYCLE COST ANALYSIS

Moving beyond Engineering Economics.

LIFE CYCLE COST ANALYSIS (LCCA) – WHAT IS IT?

The Transportation Equity Act for the 21st Century (TEA-21) Defines a Life Cycle Cost Analysis as:

> *"A process for evaluating the total economic worth of a usable project segment by analyzing initial costs and discounted future costs, such as maintenance, user costs, reconstruction, rehabilitation, restoring, and resurfacing costs, over the life of the project segment."*

LCCA – WHY DO WE USE IT?

LCCA is an analysis technique that builds on the well-founded principles of economic analysis to evaluate the over-all-long-term economic efficiency between competing alternative investment options. It attempts to identify the best value (the lowest long-term cost that satisfies the performance objective being sought) for investment expenditures.

FHWA Policy on LCCA is that it is a decision support tool, and the results of LCCA are not decisions in and of themselves. The logical analytical evaluation framework that life-cycle cost analyses fosters is as important as the LCCA results themselves.

Office of Engineering, Walls, J., & Smith, M. R., Life-Cycle Cost Analysis in Pavement Design: In Search of Better Investment Decisions (1998). Federal Highway Administration.

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OTHER ACRONYMS

NPV: Net Present Value

FV: Future Value

LCCA DEFINITIONS

Analysis Period: the time period over which alternate design strategies are analyzed.

Performance Period: the estimated pavement performance, and the timing needed for maintenance & rehabilitation efforts.

Discount Rate: the rate of return used to discount future cash flows back to their present value.

Differential Costs: the difference between the cost of two alternatives.

LCCA – WHEN DO WE USE IT?

The LCCA should be conducted as early in the project development cycle as possible. For pavement design, the appropriate time for conducting the LCCA is during the project design stage.

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BEST PRACTICES… SCOPE

You don’t have to include every factor, just the significant factors.

- Inclusion of all potential LCCA factors in every analysis is counterproductive; however, all LCCA factors and assumptions should be addressed, even if only limited to an explanation of the rationale for not including eliminated factors in detail.

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BEST PRACTICES… ANALYSIS PERIOD

Your analysis period should be sufficient to capture the full life cycle of your longest pavement alternative.

- The LCCA analysis period, or the time horizon over which alternatives are evaluated, should be sufficient to reflect long-term cost differences associated with reasonable design strategies.
  - FHWA's LCCA Policy Statement recommends an analysis period of at least 35 years for all pavement projects.
- An analysis period set at terminal serviceability simplifies salvage value computations (the longest life fix has a salvage value of zero).

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BEST PRACTICES… PAVEMENT PERFORMANCE

Use real performance periods for all competing alternatives and associated maintenance activities.

- Performance periods for individual pavement designs and rehabilitation strategies have a significant impact on analysis results. Longer performance periods for individual pavement designs require fewer rehabilitation projects and associated agency and work zones user costs.

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BEST PRACTICES… AGENCY COSTS

Include all agency costs.

- Agency costs include all costs incurred directly by the agency over the life of the project. They typically include initial preliminary engineering, contract administration, construction supervision and construction costs, as well as future routine and preventive maintenance, resurfacing and rehabilitation cost, and the associated administrative cost… Agency costs also include maintenance of traffic cost.

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THE ELEPHANT IN THE ROOM: DISCOUNT RATES

What exactly is the rate of return for Government agencies?

DISCOUNT RATES – A POINT TO CONSIDER

How Do You Choose the Appropriate Discount Rate?

- The discount rate used depends on the type of analysis undertaken. When considering an investment, the investor should use the opportunity cost of putting their money to work elsewhere as an appropriate discount rate. That is the rate of return that the investor could earn in the marketplace on an investment of comparable size and risk.

Hayes, A. (2023, January 19). Discount rate defined: How it's used by the Fed and in cash-flow analysis. Investopedia. Retrieved January 30, 2023, from https://www.investopedia.com/terms/d/discountrate.asp

- In the public sector, because investment resources come from Jane and John Q. Public in the form of taxes or user fees, the discount rate used needs to be consistent with the opportunity cost of the public at large.

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DISCOUNT RATES – A POINT TO CONSIDER

What about inflation?

- [The FHWA publishes inflation indices.]()
- 3.1% avg. from 2012-21.
- **2.2%** from OMB Circular A-94 App. C

INFLATION INDICES - Updated 6/22/2022
Entered into EEBACS 6/22/2022

	NEW BLS Non-Residential Construction (BNON) [(1)]		NEW 2.0 National Highway CCI (x 1000) [(2b)]		Rebaselined California Highway CCI [(3b)]		NEW Colorado DOT CCI (x 1000) [(4)]		Utah DOT CCI	
Year	Index	*Annual % Inflation*	Index	*Annual % Inflation*	Index	*Annual % Inflation*	Index	*Annual % Inflation*	Index	*Annual % Inflation*
2011 Annual	107.9	*5.68%*	1541.1	7.77%	51.6	*12.17%*	994.4	*7.38%*	295.4	*5.60%*
2012 Annual	109.7	*1.67%*	1607.1	4.28%	49.8	*-3.49%*	1159.0	*16.55%*	289.4	*5.31%*
2013 Annual	110.5	*0.73%*	1593.1	-0.87%	57.1	*14.66%*	1019.7	*-12.02%*	252.0	*-5.81%*
2014 Annual	111.3	*0.72%*	1693.8	6.32%	64.1	*12.22%*	1216.6	*19.31%*	267.6	*35.39%*
2015 Annual	103.4	*-7.10%*	1662.7	-1.84%	72.0	*12.41%*	1045.6	*-14.06%*	272.8	*-10.94%*
2016 Annual	105.4	*1.93%*	1653.4	-0.56%	88.0	*22.19%*	1191.4		285.4	*4.62%*
2017 Annual	110.5	*4.84%*	1661.9	0.51%	88.6	*0.62%*	1327.7	*11.44%*	327.6	*14.80%*
2018 Annual	114.9	*3.98%*	1873.0	12.70%	99.3	*12.07%*	1078.5	*-18.77%*	339.4	*3.59%*
2019 Annual	115.8	*0.78%*	1917.1	2.35%	94.3	*-5.03%*	1233.7	*14.39%*	354.2	*4.36%*
2020 Annual	118.6	2.42%	1862.3	-2.86%	100.0	6.09%	1508.7	22.29%	364.8	*2.99%*
2021 Q1	128.0		1912.0		85.1		1440.8		392.0	
2021 Q2	140.2		2034.3		103.4		1355.0		402.9	10.43%
2021 Q3	140.4		2093.2		83.7		1446.7		discontinued?	
2021 Q4	146.4		2185.2		84.2		1564.1		0.0	
2021 Annual	146.4	23.44%	2185.2	17.34%	82.1	-17.90%	1564.1	3.67%	0.0	
2022 Q1	162.1	10.72%	0.0		0.0		1674.8	7.08%	0.0	
2022 Q2	0.0		0.0		0.0		0.0		0.0	
2022 Q3	0.0		0.0		0.0		0.0		0.0	
2022 Q4	0.0		0.0		0.0		0.0		0.0	
	0.0		0.0		0.0		0.0		0.0	

DISCOUNT RATES – A POINT TO CONSIDER

So, what is the rate of return that surplus tax dollars generally earn in the marketplace?

- 0.0%

Why?

- Governments should avoid taking risks with taxpayer money.
- Government purchases of stock could lead to creeping takeover of private businesses by the government.
- Partial government ownership can lead to conflicts of interest.

DISCOUNT RATES – AN EXAMPLE

Real Discount Rates

What the Feds Say:

- Real Discount Rate = 2.0%*

What your budget likely says:

- Real Discount Rate = -2.2%**

***Fed Real Discount Rate**

4.2% (30-treasury security rate)

<u>-2.2% (30-year inflation premium)</u>

2.0%

****Local Cash Discount Rate**

0.0% (rate of return on cash)

<u>-2.2% (30-year inflation premium)</u>

-2.2%

DISCOUNT RATES – AN EXAMPLE

Say you have a Mill & Overlay project that you want to delay 5-years, that would cost $1,000,000 today; how much do you need to set-aside to pay for the project in the future?

What the Federal Government says:

- Nominal Interest Rate* (30 yr): 4.2%
- Inflation Rate: 2.2%
- Real Discount Rate: **2.0%**
- =-PV(2.0%,5,0,1000000)

Set-aside: $905,730.81

*The Federal Government uses Treasury Rates to determine the nominal interest rate.

What your budget says:

- Nominal Interest Rate** (30 yr): 0.0%
- Inflation Rate: 2.2%
- Real Discount Rate: **-2.2%**
- =-PV(-2.2%,5,0,1000000)

Set-aside: $1,117,649.75

**Local/State governments do not have the ability to issue Treasury Notes. The nominal interest rate is most appropriate the cost of debt at the Local/State level (the cost of debt for projects not financed is generally 0.0%)

DISCOUNT RATES – AN EXAMPLE

Say you have a Mill & Overlay project that you want to delay 20-years, that would cost $1,000,000 today; how much do you need to set-aside to pay for the project in the future?

What the Federal Government says:

- Nominal Interest Rate* (30 yr): 4.2%
- Inflation Rate: 2.2%
- Real Discount Rate: **2.0%**
- =-PV(2.0%,20,0,1000000)

Set-aside: $672,971.33

*The Federal Government uses Treasury Rates to determine the nominal interest rate.

What your budget says:

- Nominal Interest Rate** (30 yr): 0.0%
- Inflation Rate: 2.2%
- Real Discount Rate: **-2.2%**
- =-PV(-2.2%,20,0,1000000)

Set-aside: $1,560,353.16

**Local/State governments do not have the ability to issue Treasury Notes. The nominal interest rate is most appropriate the cost of debt at the Local/State level (the cost of debt for projects not financed is generally 0.0%)

THE ELEPHANT IN THE ROOM: DIFFERENTIAL COSTS

We can just ignore all things common to each competing alternative, right?

LET'S TALK PHILOSOPHY – DIFFERENTIAL COSTS

Should we just ignore everything that is common to all alternatives?

What the FHWA says:

- LCCA need only consider differential costs between alternatives. Costs common to all alternatives cancel out, these cost factors are generally noted and excluded from LCCA calculations.

– but –

- LCCA results are just one of many factors that influence the ultimate selection of a pavement design strategy.

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DIFFERENTIAL COSTS – A COMMON EXAMPLE

What about scenarios where the pavement cost is a small percentage of the overall project cost? A quick example of a generic urban reconstruction project:

	Bituminous Alternative	Concrete Alternative
Non-Pavement Costs	$15 million	$15 million
NPV Pavement	$500,000	$575,000
Percent of Low NPV (excludes Non-Pavement Costs)	100.0%	115.0%
Percent of Low NPV (includes Non-Pavement Costs)	100.0%	100.5%

BEST PRACTICES… DIFFERENTIAL COSTS

Ignore costs that are common to all alternatives as a general rule, but it is important to consider the entire project cost as well.

THE ELEPHANT IN THE ROOM: USER COSTS

Whose money do I really care about?

LET'S TALK PHILOSOPHY – USER COSTS

Whose money is most important, the Agency's or the Taxpayer's?

What most agencies' practices show:

- The agency only worries about their direct budget. Any savings to the taxpayers does not result in more funds available in the agency budget.

What the Taxpayer wants:

- The Government should consider the entire impact of agency decisions on the taxpayer.

Are you comfortable describing your agencies current practices to the taxpayer?

BEST PRACTICES… USER COSTS

Include all significant user costs that differ between competing alternatives.

- User costs are the delay, vehicle operating, and crash costs incurred by the users of a facility and should be included in the LCCA.
- Different vehicle classes have different operating characteristics and associated operating costs, and as a result, user costs should be analyzed for at least three broad vehicle classes: Passenger Vehicles, Single-Unit Trucks, and Combination Trucks.

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BEST PRACTICES… USER COSTS

- In the simplest sense, user costs are costs incurred by the highway user over the life of the project. In LCCA, highway user costs of concern are the differential costs incurred by the motoring public between competing alternative highway improvements and associated maintenance and rehabilitation strategies over the analysis period.
- In the LCCA of pavement design alternatives, there are user costs associated with both normal operations and work zone operations. The normal operations category reflects highway user costs associated with using a facility during periods free of construction, maintenance, and/or rehabilitation (i.e., work zone) activities that restrict the capacity of the facility. User costs in this category are a function of the differential pavement performance (roughness) of the alternative.

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BEST PRACTICES… USER COSTS

- If pavement performance curves and levels differ substantially [between alternative designs], significant vehicle operating cost differentials can develop.
- Intuitively, differences in pavement performance can produce differences in vehicle operating costs [(VOC)]. Slight differences in VOC rates caused by differences in pavement performance characteristics (primarily roughness), when multiplied by several years Vehicle Mile(s) Traveled (VMT), could result in huge VOC differentials over the life of the design strategy.

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THE ELEPHANT IN THE ROOM: ITERATION

I only need to calculate the LCCA once, right?

BEST PRACTICES… DESIGN ITERATION

The analyst should use the LCCA results to help develop more cost-effective strategies, and then re-run the LCCA.

- Once the net present values have been computed for each alternative, … the analyst needs to step back and reevaluate the competing design strategies.
- The Overall benefit of conducting a life-cycle cost analysis is not necessarily the LCCA results themselves, but rather how the designer can use the information resulting from the analysis to modify the proposed alternatives and develop more cost-effective strategies.

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BEST PRACTICES… SUNK COSTS

Ignore Sunk Costs

- Not all cases of sunk cost are this clear and, again, analysts need to take care to guard against including them in LCCA. An example more specific to pavement design might involve the reluctance of a designer to select an alternative with a much lower life-cycle cost because it would mean wasting the money previously spent on developing final plans for a clearly inferior alternative.

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BEST PRACTICES… END OF LIFE

Deduct any residual value at the end of the analysis period.

- Salvage value should be based on the remaining life of an alternative at the end of the analysis period as a prorated share of the last rehabilitation cost.

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LCCA – OTHER FACTORS

LCCA results are just one of many factors that influence the ultimate selection of a pavement design strategy. The final decision may include a number of additional factors outside the LCCA process, such as local politics, availability of funding, industry capability to perform the required construction, and agency experience with a particular pavement type, as well as the accuracy of the pavement design and rehabilitation models.

Many assumptions, estimates, and projections feed the LCCA process. The variability associated with these inputs can have a major influence on the confidence the analyst can place in LCCA results. It all depends on the accuracy of the inputs used.

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LCCA – ISN'T THIS ALL TOO COMPLICATED?

LCCA is a sound economic strategy to incorporate into our pavement selections, however, it is only one of many tools.

Sound engineering judgement is still required.

LCCA doesn't have to be difficult, there are many tools available.

- CPAM has developed a LCCA tool which greatly simplifies this process.

CPAM LCCA TOOL

THANK YOU

Dan Labo, P.E.

Director of Engineering Services

Phone: 651-762-0402
Mobile: 763-213-7731
Email: djlabo@cpamn.com

Concrete Paving Association of Minnesota (CPAM)
3596 Linden Avenue, Suite B5
White Bear Lake, MN 55110

www.concreteisbetter.com