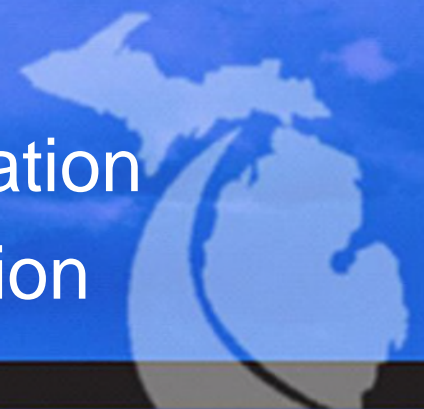


# Design Basic Training

## Life-Cycle Cost Analysis: MDOT's Process of Pavement Selection

Benjamin Krom, PE

Michigan Department of Transportation  
Construction Field Services Division



# Pavement Selection at MDOT

- 1985-1997: Life-Cycle Cost Analysis (LCCA) used as one piece of a decision matrix for pavement selection
- 1997: “LCCA” law goes into effect stating:  
“...for each project for which the estimated total pavement costs exceed \$1,500,000...The department shall design and award paving projects utilizing material having the lowest life-cycle cost.”

# Pavement Selection at MDOT

- LCCA's "shall also compare equivalent designs and shall be based upon Michigan's actual historic project maintenance, repair, and resurfacing schedules and costs..."
- "...and shall include estimates of user costs throughout the entire pavement life."

*(Public Act 79 of 1997, added Section 247.651h to Act 51, while Public Act 501 of 2008 and Public Act 457 of 2016 both modified Section 247.651h of Act 51)*

# References

- MDOT *Pavement Selection Manual* for details on the current MDOT/Industry agreed upon process

[www.Michigan.gov/MDOT](http://www.Michigan.gov/MDOT) » Reports, Publications and Specs » Manuals, Guides, Advisories & Memos » Construction Field Services - Manuals » Pavement Selection Manual

- *Michigan Road Design Manual:*  
Chapter 6.01.06

[www.Michigan.gov/MDOT](http://www.Michigan.gov/MDOT) » Reports, Publications and Specs » Manuals, Guides, Advisories & Memos » Design » Road Design Manual

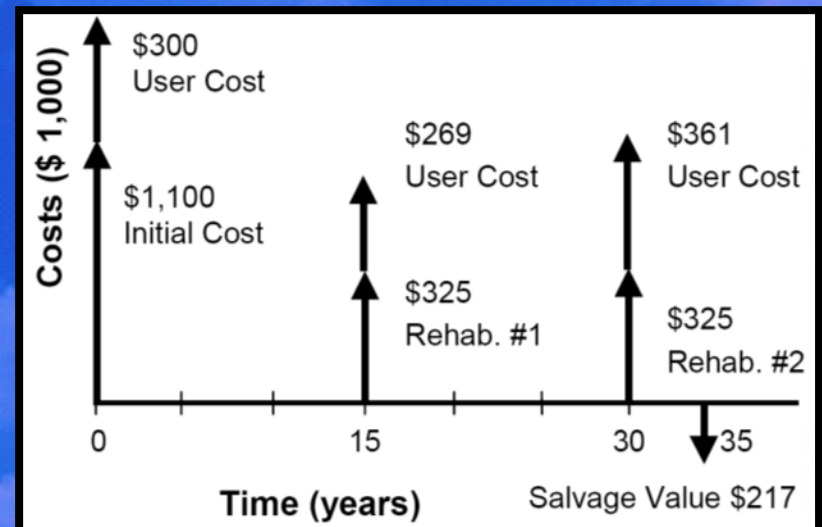


# LCCA: What is it?

Wikipedia's definition: "A life cycle cost analysis calculates the cost of a system or product over its entire life span."

Can include for Pavement:

- Initial Construction Costs
- Rehab/Maintenance Costs
- User Delay Costs
- Salvage/Remaining Life Value



# What Projects get LCCA'd?

HMA  
Reconstruction



Concrete  
Reconstruction



HMA over  
Rubblized Concrete



Unbonded  
Concrete Overlay



# Does my project need an LCCA?

- *Michigan Road Design Manual* says:  
“Pavement costs are determined by separately calculating the cost of paving with both HMA and concrete. When the cost of either the HMA or concrete exceeds \$1.5 million, a life cycle cost analysis is required.”
- *Pavement Selection Manual*, Chapter 2
  - Calculating the \$1.5 million threshold

# How early do I submit a request?

- When in the design process do you need the results?
- Official LCCA's can be requested up to 30 months prior to letting
- If greater than 30 months prior to letting, an *informational* LCCA can be requested



# Review & Approval Process

- Region/Internal Review Meeting
- Preliminary EOC Approval
- Industry Review
- Final EOC Approval
- Notify Regions of Approved Pavement Selection

MICHIGAN DEPARTMENT OF TRANSPORTATION ENGINEERING OPERATIONS COMMITTEE AGENDA ITEM	
Submitted By: Benjamin Krom	Date: February 5, 2007
1. Subject/Issue – Pavement Selection	
A. I-75 Reconstruction: CS 09034 JN 84072	
B. M-60 Rehabilitation: CS 14062 & 78041 JN 53367, 83263 & 78857	
C. M-29 Reconstruction: CS 50072 JN 45727	
Issue Statement – Department Policy requires that a Life Cycle Cost Analysis (LCCA) be used to determine the most cost effective pavement design.	
2. Major Issue(s) – no comments from industry on any of these LCCA's.	
3. Background – Pavement selection was determined using the procedures outlined in the MDOT Pavement Design and Selection Manual. Department Policy requires that the pavement alternate with the lowest EUAC be selected. Final pavement selection requires approval by the Engineering Operations Committee.	
4. Recommendation(s) – Approve the pavement alternate with the lowest EUAC.	

Enclosure

BK:clc

cc w/o enclosure: Larry E. Tibbits  
John C. Friend  
Brenda J. O'Brien  
File

# An LCCA is Conceived

- Region Submits a Request Including:
    - Existing Soils Info
    - MOT Scheme
    - General Traffic Info (ADT, ESAL's, etc.)
    - Proposed Pav't Widths
    - Grade Changes
    - Other Unique Project Features
- (Fillable Form 1966)

Michigan Department of Transportation  
1966 (03/16)

## LIFE CYCLE COST ANALYSIS REQUEST

Page 1 of 2

**INSTRUCTIONS:** Please complete this form for all Life Cycle Cost Analysis requests and submit with the following required attachments to the following Pavement Operations staff via mail, I.D. mail, e-mail, or link to ProjectWise.

<p><u>I.D. Mail / E-mail</u> Ben Krom, Pavement Performance &amp; Selection Engineer Pavement Operations Construction Field Services Division C &amp; T Building-E020 KromB@michigan.gov</p>	<p><u>Mailing Address</u> Construction Field Services Division 8885 Ricks Road or P.O. Box 30049 Lansing, MI 48917 Lansing, MI 48909</p>
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Carefully read all requirements for necessary attachments, checkboxes, and descriptions needed to complete a Life Cycle Cost Analysis. Please note that (\*) indicates the minimum information needed to perform a pavement design. Further information on Life Cycle Cost Analysis requirements can be located in the *Pavement Selection Manual*.

**LCCA CONTACT INFORMATION**

CONTACT NAME:	TELEPHONE NUMBER:	SUBMITTAL DATE:	DATE NEEDED**:
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REGION STAFF TO INCLUDE IN THE LCCA REVIEW:

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\*\*Pavement Operations staff endeavor to provide requested information within 90 days of LCCA receipt, depending on data availability. Assigned staff will contact the requestor if data collection or analysis will require additional time.

**LCCA PROJECT DESCRIPTION**

PLAN COMPLETION DATE:	LET DATE:	JOB NUMBER(S):
CONTROL SECTION:		
BEGINNING MILE POINT:		
ENDING MILE POINT:		
REGION:	ROUTE(S):	PROJECT LENGTH:

PROJECT LIMITS:

NEW/RECONSTRUCTED HMA/PCC     HMA OVER RUBBLIZED PCC/UNBONDED PCC OVERLAY

**LCCA REQUIREMENTS**

**SOILS**    \*  Soils memo signed by the Region Soils Engineer including:

- Resilient Modulus ( $M_R$ ) recommendation for both AASHTO 1993 and M-E designs, and method used to obtain
- Existing mainline pavement and shoulder section. (Describe in memo or attach typical)

Do you intend to reuse the sand subbase? What limits or percentage of the project can be reused? (Reconstruction only)

No     Yes (If yes, must meet Class III/IIA requirements)

Subgrade Classification (AASHTO for M-E purposes)

Soil borings (if available)

**TRAFFIC:**

- Approved Temporary Traffic Control Plan (TTCP) by the Safety and Mobility Peer Team
- \*  Traffic Information memo from Statewide and Urban Travel Analysis Section, Statewide Model Unit (Complete Traffic Analysis Request, #1730, including ADT, % commercial traffic, growth rate, ESAL's, M-E inputs)
- 24 Hour traffic distribution (Weekday and weekend if available)

# Pavement Design

- MDOT currently uses two design methods:
  - Guide for Design of Pavement Structures (AASHTO 1993)
  - Mechanistic-Empirical Pavement Design Guide (AASHTO 2008)
- Equivalent designs are developed per:
  - Projected flexible/rigid ESAL's, CADT, & traffic distributions
  - Subgrade material characteristics
  - Climatic data

# Pavement & Related Item Costs

- Pavement Selection Manual, *Chapter 6*
- LCCA Unit Prices updated every 6 months
- PW: Ref Docs/LCCA/LCCA Prices

MDOT LCCA Unit Prices			R e g i o n s					
			10/21/19		NEW		10/21/19	
Price Updates: 04-17-2020			1 & 2	1 & 2	3, 4 & 5	3, 4 & 5	6 & 7	6 & 7
2050010	Cyd	Embankment, CIP	\$4.26	\$4.26	\$4.05	\$3.67	\$1.43	\$1.03
2050016	Cyd	Excavation, Earth	\$2.83	\$3.72	\$4.75	\$5.14	\$9.58	\$9.90
3010002	Cyd	Subbase, CIP	\$4.73	\$5.94	\$6.35	\$6.79	\$14.74	\$14.67
3017021	Cyd	Subbase Reuse, CIP	\$1.18	\$1.49	\$1.59	\$1.70	\$3.69	\$3.67
3020016	Syd	Aggregate Base, 6 inch	\$7.80	\$7.80	\$6.86	\$6.62	\$8.48	\$8.48
3020050	Syd	Aggregate Base, Conditioning	\$2.60	\$2.83	\$2.60	\$2.83	\$2.60	\$2.83
3030006	Syd	Open-Graded Dr Cse, 6 inch	\$8.43	\$8.34	\$8.71	\$8.65	\$7.75	\$7.75
3037011	Syd	Open-Graded Dr Cse, 16 inch	\$23.74	\$23.74	\$23.74	\$23.74	\$23.74	\$23.74
3037011	Syd	Cement Stabilized Base	\$17.23	\$17.40	\$13.11	\$11.00	\$17.86	\$17.86
3040001	Syd	Rubblized Pavt Operation	\$2.30	\$2.30	\$2.30	\$2.30	\$2.30	\$2.30
3050002	Syd	HMA Base Crushing and Shaping	\$1.32	\$1.57	\$1.40	\$1.40	\$1.34	\$1.53
3080005	Syd	Geotextile Separator	\$1.12	\$1.08	\$1.25	\$1.44	\$1.09	\$1.03

# Initial User Delay Costs

- 1997 law states that LCCA's "...shall include estimates of user costs throughout the entire pavement life."
- MDOT utilizes COnstruction COngestion COsts (CO<sup>3</sup>) Software
- Developed through UMTRI in 1997 with financial support from MDOT

# Initial User Delay Costs

- Staging based on Temporary Traffic Control Plan
  - Same MOT: send to Pavt Selection Eng.
  - Different MOT: send to Field Ops Eng.
- Fillable Form 5615
- Determine the number of days to construct each alternative
- Based on established production rates

# Maintenance Costs

- 1997 law states that LCCA's "shall be based upon Michigan's actual historic project maintenance, repair, and resurfacing schedules and costs as recorded by the pavement management system..."
- Major update in July 2019
  - *Pavement Selection Manual* not updated yet

# Pavement Preservation Strategy

## Fix Type: New/Reconstruction HMA Pavement

Activity	Approx. Age	Distress Index (Before)	Distress Index (After)	RSL (yrs) (Before fix)	Life (yrs) Extension	RSL (yrs) (After fix)	Cost per Lane-Mile	Time to Fix 1 Lane-Mile (In Days)
Initial Construction	0		0			18	Computed	
Prev. Maintenance	8	9	2	10	5	15	\$25,944*	0.48
Prev. Maintenance	13	9	2	10	5	15	\$38,209*	0.63
Prev. Maintenance	17	7	1	11	5	16	\$40,670*	0.65
Prev. Maintenance	22	7	2	11	4	15	\$29,955*	0.55
Rehabilitation or Reconstruction	37							

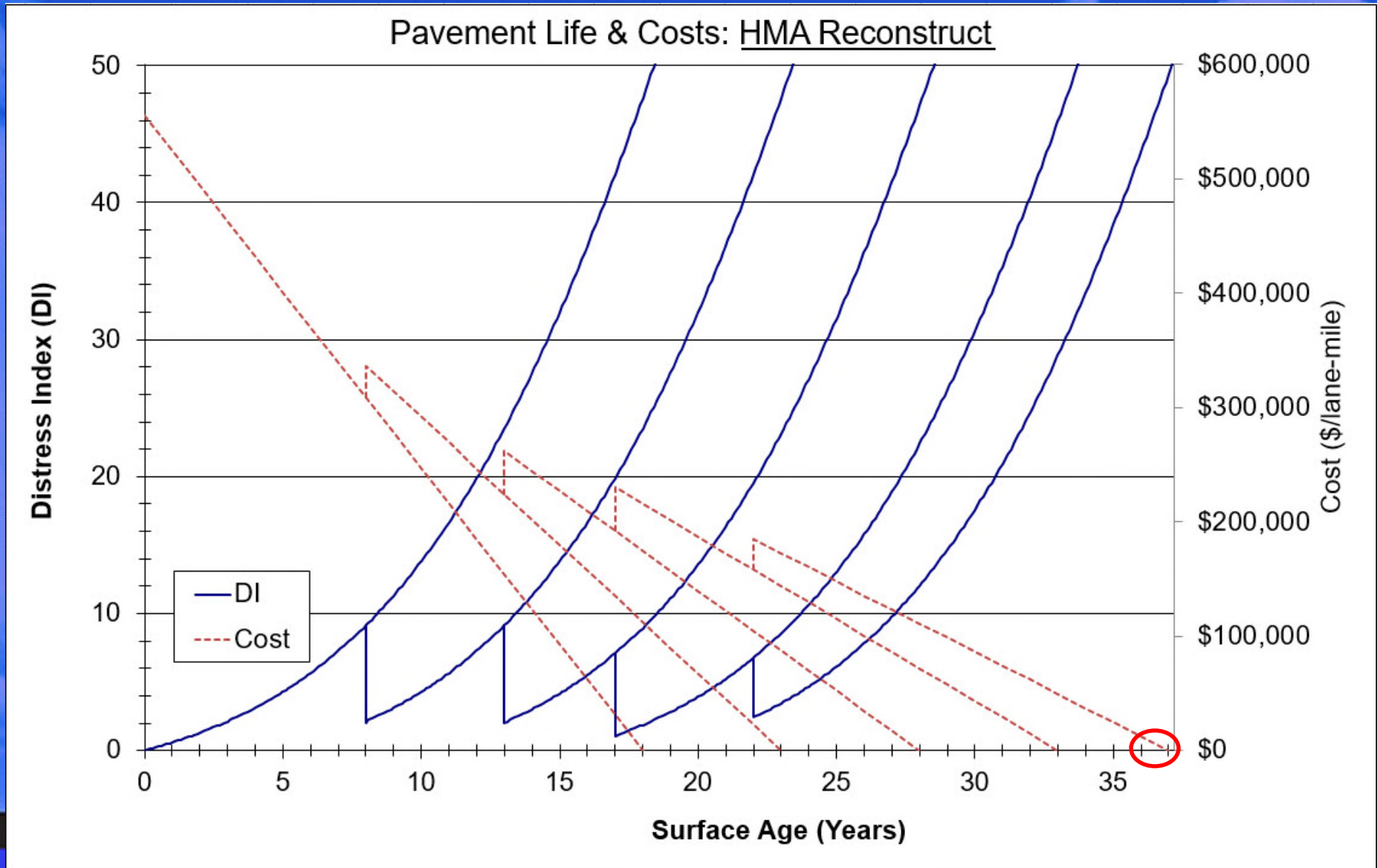


# Remaining Life Value

- Use the smaller Service Life for both
- Longer Service Life Alternative will receive a credit for its Remaining Life
- Straight-line depreciation of Initial and Future Maintenance Costs



# Remaining Life Value



# Pavement Selection Results

## EUAC Summary

### I-94/US-31 Reconstruction

<u>Alternative</u>	<u>PV Initial Construction Cost</u>	<u>PV Initial User Cost</u>	<u>PV Maintenance Cost</u>	<u>PV Remaining Life Value</u>	<u>n</u>	<u>EUAC</u>	<u>EUAC % Difference</u>
#1: HMA	\$522,222	\$79,783	\$124,102	-\$11,651	36	<b>\$25,829</b>	14.77%
#2: JPCP	\$646,762	\$61,243	\$130,247	\$0	36	<b>\$30,305</b>	
$EUAC = NPV * (i * (1+i)^n / ((1+i)^n - 1))$							
Note: All costs are per lane-mile NPV = Net Present Value i = Real Discount Rate (2019: 1.5%) n = Number of years PV = Present Value EUAC = Equivalent Uniform Annual Cost							

# Alternate Pavement Bidding

- LCCA at bid time:
  - Agency Supplies:
    - Historical Maintenance Costs
    - Daily User Delay Cost(s)
  - Bidder Supplies:
    - Construction Costs
    - # of days to Construct
  - Calculate EUAC to select the low bidder

# Future LCCA Changes

- 2018/2019 LCCA Process Review
  - Mostly implemented; still need to document
  - Long-term items: thin recon's, IRI modeling
- More fix types requiring an LCCA
  - Crush & Shape, ASCRL, thin concrete overlay, multi-course HMA (mill &) overlays
  - For projects let:
    - January 2023 & beyond



# Questions?

