Pavement Selection Manual

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Michigan Department of Transportation

CONSTRUCTION FIELD SERVICES DIVISION

Engineering Preamble

This manual provides guidance to administrative, engineering, and technical staff. Engineering practice requires that professionals use a combination of technical skills and judgment in decision making. Engineering judgment is necessary to allow decisions to account for unique site-specific conditions and considerations to provide high quality products, within budget, and to protect the public health, safety, and welfare. This manual provides the general operational guidelines; however, it is understood that adaptation, adjustments, and deviations are sometimes necessary. Innovation is a key foundational element to advance the state of engineering practice and develop more effective and efficient engineering solutions and materials. As such, it is essential that our engineering manuals provide a vehicle to promote, pilot, or implement technologies or practices that provide efficiencies and quality products, while maintaining the safety, health, and welfare of the public. It is expected when making significant or impactful deviations from the technical information from these guidance materials, that reasonable consultations with experts, technical committees, and/or policy setting bodies occur prior to actions within the timeframes allowed. It is also expected that these consultations will eliminate any potential conflicts of interest, perceived or otherwise. MDOT Leadership is committed to a culture of innovation to optimize engineering solutions.

The National Society of Professional Engineers Code of Ethics for Engineering is founded on six fundamental canons. Those canons are provided below.

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform Services only in areas of their competence.
3. Issue public statement only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, reasonably, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION

The Michigan Department of Transportation (MDOT) has used various formal and informal pavement selection procedures in the past. The primary procedure that MDOT has used since 1985 is the Life Cycle Cost Analysis (LCCA) method. This method compares costs of the pavement selection alternates to determine the most cost-effective option. Pavement design of the alternates is performed using a combination of the AASHTO 1993 and Mechanistic-Empirical (ME) design methods. Pavement design guidelines can be found in the *Michigan DOT User Guide For Mechanistic-Empirical Pavement Design*:

- https://www.michigan.gov/documents/mdot/MDOT_Mechanistic_Empirical_Pavement_Design_User_Guide_483676_7.pdf

Life Cycle Cost Analysis is an objective, nationally recognized method used to quantify the cost effectiveness of various investment alternatives. Federal agencies have used this method for many years to determine long term capital investment strategies. The federal government, including the Federal Highway Administration (FHWA), recommends that all transportation agencies use an LCCA approach when evaluating various investment alternatives.

State legislation was enacted in 1997 regarding pavement selection and Life Cycle Cost Analysis. The legislation, MCL 247.651h, states that “the department shall develop and implement a life cycle cost analysis for each project for which estimated total pavement costs exceed $1,500,000.00 funded in whole or in part with state funds. The department shall design and award paving projects utilizing material having the lowest life cycle cost.” The legislation also states, “life cycle cost shall compare equivalent designs and shall be based upon Michigan’s actual historic project maintenance, repair, and resurfacing schedules and costs as recorded by the pavement management system and shall include estimates of user costs throughout the entire pavement life.”

The pavement selection process has been developed in cooperation with the asphalt and concrete paving industry associations and uses MDOT’s Pavement Management System as the basis for determining pavement selection on specific projects. The department uses the Equivalent Uniform Annual Cost (EUAC) method to calculate a life cycle cost. Inputs to a life cycle cost analysis include initial construction costs, future maintenance costs, user delay costs for both initial construction and future maintenance activities, and remaining life value. The costs and maintenance schedules are based on actual project history and cost, along with pavement performance data.

Initial Costs (Agency and User)

Initial construction costs may include pavement, shoulders, joints, subbase, base, underdrains, utility relocation, and traffic control. Only work items with costs that vary between alternates will be considered. Work item unit prices are determined using the department’s bid letting system. Initial user costs are based on daily and hourly traffic volumes, the method of maintaining traffic, capacity, and construction work days. When design elements (e.g., Right of Way, drainage, maintenance of traffic, etc.) differ between pavement type, those associated costs can also be factored into the analysis.

Maintaining traffic schemes are developed as part of the Temporary Traffic Control Plan (TTCP) for the project and will be utilized to calculate user costs for the various alternatives being considered in the analysis. Maintaining traffic costs can also be included if they differ between alternatives.

Pavement Preservation Strategies (*Future Maintenance and Future User Costs)*

Maintenance costs are determined from MDOT's actual historic maintenance data. The costs are retrieved from MDOT's project database. Historic maintenance data is also used, when available, to determine the average pavement condition and age at which preventive maintenance actions occur for a particular fix type.

User costs for maintenance activities are determined by assuming typical maintaining traffic schemes, projecting traffic volumes from current values, and averaging the duration of actual historic maintenance activities. Life extension values for any maintenance activity, as well as initial fix life values, are determined using historical pavement condition data from the MDOT Pavement Management System.

All of this information is used to develop preservation strategies for specific rehabilitation or reconstruction fixes. These strategies (maintenance schedules) reflect the overall average maintenance approach that has been used network-wide for a specific fix based on historical records.

Remaining Life Value

The service lives, which MDOT uses as the analysis periods for the LCCA, of competing alternatives are usually different from one another. In these cases, the LCCA analysis period is set to the service life of the shorter alternative, and the longer service life alternative receives a credit for the unused portion of the initial and future maintenance costs. This is calculated on a project-by-project basis, using the LCCA initial costs and the future maintenance costs from the applicable pavement preservation strategy.

CHAPTER 2. PAVEMENT SELECTION PROCESS

Pavement selection is determined using the Life Cycle Cost Analysis method or LCCA, when the total project pavement costs exceed 1.5 million dollars, and when comparable Hot Mix Asphalt (HMA) and concrete designs are available for analysis, per this manual. Table 2-1 below is the current list of comparable HMA and concrete fix types:

Table 2-1. LCCA Fix Type Comparisons

Fix Type	Fix Type Comparison(s)
HMA over Crush and Shaped HMA	*One of the following:* • Thin Concrete Overlay • Concrete Overlay (6"+)
Multiple Course HMA Overlay	*One of the following:* • Thin Concrete Overlay • Concrete Overlay (6"+)
Multiple Course HMA over Asphalt Stabilized Crack Relief Layer Overlay (ASCRL)	• Concrete Overlay (6"+)
Thin Concrete Overlay	*One of the following:* • HMA over Crush and Shaped HMA • Multiple Course HMA Overlay
HMA Reconstruction	• JPCP Reconstruction
JPCP Reconstruction	• HMA Reconstruction
HMA over Rubblized Concrete	• Concrete Overlay (6"+)
Concrete Overlay (6"+)	*One of the following:* • HMA over Crush and Shaped HMA • HMA over Rubblized Concrete • Multiple Course HMA Overlay • ASCRL

Please note the following and contact Pavement Management Section staff with any questions:

1) When making a LCCA request, Region/TSC personnel will identify the HMA and the concrete fix type that will be compared (where multiple alternative comparisons are provided in the table above).
2) Equivalent design lives must be used for the alternatives being compared. See the *Michigan DOT User Guide For Mechanistic-Empirical Pavement Design* for additional details.
3) Certain fixes known under a different name (e.g. 'inlay') may still require an LCCA.
4) It does not matter if the project is a 3R or 4R project.
5) Only pavements on MDOT trunkline are life-cycled.

The following sections describe the process.

A. Calculating the $1.5 Million Threshold

When pavement costs are being totaled to determine if an LCCA is required for a project, only the hard surface cost of the HMA and concrete (including transverse joints) will be included in the threshold estimate. Only the portions of a project with fix-types containing a pavement preservation strategy in Chapter 5 will be included. The cost of any base and subbase materials, rubblization, embankment, HMA separator layers, etc., will not be included. The areas of pavement to include are:

1) Mainline through lanes, including continuous center left turn lanes
2) Ramps
3) Acceleration/deceleration lanes associated with ramps
4) Weave/merge lanes
5) Collector/distributor lanes
6) Service drives

Note: the above encompass both production and miscellaneous paving areas.

When performing the threshold estimate, use the LCCA unit prices established by MDOT Pavement Management Section, which can be found in ProjectWise in the following subfolder: Reference Documents\Life Cycle Cost Analysis\LCCA Prices. Expected market prices can be used for items without a bid history.

If pavement costs exceed $1.5 million for either alternative, an LCCA is required and will be performed per this manual.

If pavement costs are below the $1.5 million LCCA threshold, maintain cost estimate documentation in the project file for possible future reference. If the project scope increases or changes during the design phase, the threshold estimate needs to be recalculated to determine if an LCCA is or is not required.

B. Multiple Roadways to Be Let Together

If a project contains multiple roadway sections that will be packaged together for a letting, the following will apply, depending on the situation:

1) A separate LCCA will be performed for each distinct roadway (I, US, M route, etc.) with pavement costs greater than $1.5 million. In this case, each LCCA, if necessary, will stand on its own, potentially resulting in different pavement alternates being selected for the different roadways.
2) If a particular pavement fix type is currently not life-cycled (does not have a pavement preservation strategy in Chapter 5), then it cannot be included in an LCCA, even when being packaged together with a portion of a project that is life-cycled.

C. Informational and Official LCCA

Exhibit A at the end of this chapter contains a table and a flowchart to summarize the use of informational vs. official LCCA.

For new/reconstruction and major rehabilitation projects with pavement cost greater than $1.5 million, the Region must determine the appropriate time to initiate the LCCA. The LCCA should be completed early enough in the design process to allow designers sufficient time to incorporate the final pavement selection. However, if the LCCA is completed too far in advance of the project's letting, the cost and other data may not be appropriate.

To give designers enough time to incorporate the results, it is recommended that the Regions submit LCCA requests no later than 18 months prior to letting. It is understood that there will likely be exceptions where requests will come in later, but this is recommended as a goal. Official LCCAs will only be performed within 30 months of a project's letting date. Any requests for the official LCCA to be performed more than 30 months in advance of the scheduled letting date requires approval from MDOT's Engineering Operations Committee (EOC).

There are a variety of reasons for a Region to request an LCCA more than 30 months before letting, such as a "shelf job" which is a project with an uncertain let date that is actively under design. In such cases, an informational LCCA will be done, but the final approved LCCA will be performed inside the 30-month period using the latest costs and following the latest processes in place. This informational LCCA may be performed at either of the following two levels of detail.

1) With the first, LCCA staff would informally obtain basic project level information from Region staff. Any other necessary items would be estimated to develop the initial pavement design alternatives and perform the informational LCCA.
2) With the second level of detail, the Region would submit all the normally required documents from which the pavement designs and informational LCCA would be developed. These initial documents could be used for the official LCCA, if they still accurately reflect what will be done on the project. Otherwise, updated documents would need to be submitted.

Regardless of the level of detail, informational LCCAs will not be sent out for industry review, nor will they go to EOC. The Region will determine how best to proceed with the design of the preliminary low-cost pavement alternative until the final alternative is determined with the official LCCA.

* One further note on "shelf jobs": in order to hold the Omissions and Errors Check (OEC) meeting (~95% plan completion stage), there must be an approved LCCA. Therefore, if only an informational LCCA has been done, this may affect how far design can go before putting it on the shelf and will require a re-evaluation when an official LCCA is conducted.

D. Corridor Projects

To prepare a cost estimate for corridor improvement studies, it may be advantageous to know the pavement type. Depending on the length of the corridor under study, multiple, more manageable and affordable projects may eventually be split out and built over a period of time. An informational LCCA could be performed for the entire corridor, thus providing an estimate of the low-cost pavement design. However, a separate Official LCCA will be required for each individual project with over 1.5 million dollars in paving costs at an appropriate time in the future. This could result in the selection of different paving materials along the same corridor.

E. Alternate Pavement Bidding (APB)

If the life cycle cost difference between the two pavement design alternatives is within the specified range, and all the other APB criteria are met, a project can be considered for APB for pavement type selection. Only complete reconstruction, unbonded concrete overlay and HMA over rubblized concrete projects are eligible for APB. Contact the Innovative Contracting Unit for information regarding the entire APB process. If the project continues under development as APB, Pavement Management staff will conduct additional tasks related to LCCA, including development of Equivalent Uniform Annual Cost equations following the LCCA process in place at the time. If the project does not proceed as an APB, the normal LCCA process will continue.

F. LCCA Re-Analysis

Table 2-2 and Figure 2-1 at the end of this chapter summarizes the circumstances requiring re-analysis of an official LCCA.

After the official LCCA has been completed, various project level changes can occur prior to letting which could impact the LCCA. Under certain circumstances, a re-analysis of the LCCA will be required using the most recent data and process to ensure that the lowest cost alternative is chosen. Re-analysis will be performed if:

1) The project gets delayed 24 months or more from the let date specified in the official LCCA.
2) There are major changes in the scope of work, such as the fix type.
3) Changes in project length; 25 percent or 4 lane miles, whichever is less.
4) Major Maintenance of Traffic changes, such as number of lanes maintained, detours vs. part width, or major mainline staging.

Similar changes could also affect an informational LCCA. Re-analysis of an informational LCCA can be requested by the Region if doing so would be helpful to project development.

It is the Region's responsibility to request a re-analysis if any the above project changes occur.

G. LCCA Process Steps

The process is as follows:

STEP 1 - Each Region estimates pavement costs for upcoming projects in that Region using guidance provided in Section A above. The Region requests a pavement selection using the following guidelines:

MDOT Pavement Management staff in the Construction Field Services Division is responsible for preparing a pavement design and selection package for all fix types listed in Table 2-1 with pavement costs greater than $1.5 million.

It is suggested that the Region use some form of objective analysis to determine pavement type selection for the following project types:

a) Any fix types not listed in Table 2-1.

b) Local roads being redesigned due to an MDOT project. Pavement designs for local roads require the concurrence of the local agency.
c) New, reconstruction, and major rehabilitation projects when the pavement cost is less than $1.5 million.

Steps 2-6 pertain to projects where pavement selection is the responsibility of Pavement Management Staff (where LCCA is needed). Otherwise, assistance will be given to the Regions on an as-needed basis.

STEP 2 - The appropriate Region personnel will request, assemble, and provide all necessary information for projects requiring Pavement Management to prepare the pavement design and Life Cycle Cost Analysis. This information includes existing soils information, traffic data, the Temporary Traffic Control Plan (TTCP), as well as other information listed on the Life Cycle Cost Analysis Request checklist, Form 1966, which can be found on MDOT's intranet site. Please allow up to 3 months for completion, reviews, and final EOC approval of the LCCA.

The following provides a brief explanation for some checklist items. Additionally, see Chapter 3 for details on how the following will be used in the LCCA.

Maintenance of Traffic Plans

The project's Temporary Traffic Control Plan (TTCP) will be utilized to assist in estimating initial user delay costs. Maintenance of traffic (MOT) flowcharts applicable to LCCA projects, and further information on the requirements of the TTCP, are located in Appendix I of the Work Zone Safety and Mobility Manual (WZSMM), available on the MDOT website. Examples of a standard TTCP can be obtained through the Construction Field Services Division.

If the TTCP will be different between the HMA and concrete alternatives, then the Region will assemble a Peer Review Team (PRT), as described in the WZSMM, and submit the TTCP using Form 5615, Temporary Traffic Control Plan for Life Cycle Cost Analysis Request checklist, which can be found on MDOT's intranet site. Examples of differences that warrant submission of the LCCA TTCP to a PRT include: one alternative will be maintained by closing one direction of a divided route while the other alternative will be built part-width, different amounts of temporary pavement or temporary shoulder will be needed, etc. After the TTCP has been approved, the Region will send it to the Pavement Selection Engineer of Pavement Management, including the PRT's approval notification.

If the TTCP will be the same for both alternatives, then describe the traffic control plan using Form 5615, including any applicable attachments, and submit it to the Pavement Selection Engineer of the Pavement Management Section, and does not require submittal to a PRT for LCCA purposes.

The TTCP may be draft for use in the LCCA, but major changes to the MOT may require the TTCP to be re-evaluated and approved by a PRT (if applicable) in order for the LCCA to be revised (see Section F above). All elements of a TTCP may not yet be available and may be omitted for this review if they will not affect calculation of user delay or initial MOT cost. This in no way modifies requirements of the final TTCP and/or TMP as specified in the WZSMM.

The TTCP submitted for use in LCCA must include at least the following, using Form 5615 and any separate attachments. For each item, any differences between the HMA and concrete alternatives are to be identified, including cost differences. In addition, any variation of these items for different stages is to be identified.

1) Construction Staging – Provide a description of which portions of the pavement structure will be built in each stage. Provide cross section typicals of the existing roadway and the work zone, specifically detailing lane and shoulder widths, shy distances, and work space.

2) Traffic Control Strategies – Identify how traffic will be accommodated within the work zone (e.g. full roadway closure, lane shifts, temporary crossovers, reversible lanes using moveable barrier, flagging, number of lanes open to traffic, etc.). For long projects utilizing flagging, note whether the work will be performed in shorter segments. Note if other MOT alternatives were considered, what they were, and why they were not selected. Refer to the WZSMM, Appendix I, for guidelines on shy distance and buffer widths, providing reasons when guidelines cannot be met.

3) Temporary Lane Widening Requirements – Identify if temporary widening will be performed for maintaining traffic, noting any limiting factors (i.e., bridge piers, Right of Ways, slopes, etc.)

4) Traffic Volumes – At a minimum, provide the average daily traffic (ADT) for the work zone (including mainline and any ramps). Ideally, provide 24-hour traffic distributions. If traffic information is available for detours or alternate routes, this data should be included. Include Construction Congestion Cost (CO3) runs.

5) Restrictions on Operation – Identify if there will be any restrictions on operating hours. (e.g. night work only, northbound-Friday/southbound-Monday, lane closures, weekday work only, etc.)

6) Posted Speed Limits – Specify both the regular speed limits and any restricted speed limits that will be posted in the work zone during construction.

7) Detour Route – Specify whether a detour will be utilized during the project and the preferred route to direct traffic (if applicable), including speed limits along the detour or alternate routes.

Miscellaneous Paving

A description of which areas would be "miscellaneous" paving will allow specific consideration of these areas in the LCCA with respect to cost and production rates. These areas can be identified by considering where the miscellaneous concrete pay item for the concrete alternate would likely be utilized (e.g. ramps, acceleration/deceleration lanes, etc.). Ultimately, these miscellaneous pavement areas (in square yards) need to be broken down by pavement design (e.g. mainline or ramp) and by stage of construction as specified in the TTCP. This information can be provided by construction stage in a variety of formats:

1) A spreadsheet with all the miscellaneous pavement areas described and calculated.
2) A draft plan set with sufficient detail for Pavement Management staff to identify and calculate the miscellaneous pavement areas.
3) Microstation construction and alignment files with sufficient detail for Pavement Management staff to identify and calculate the miscellaneous pavement areas.

One common situation for freeway projects to keep in mind is the pavement design change at entrance/exit ramps. Generally, mainline miscellaneous pavement extends up to the 22' gore point, then the pavement section changes to the ramp pavement design. Miscellaneous pavement areas need to reflect this break at the 22' gore point.

Examples of miscellaneous pavement calculations can be obtained from Pavement Management staff upon request.

<u>Mixing Rehabilitation and Reconstruction</u>
Major rehabilitation projects generally have a certain amount of reconstruction (and sometimes vice-versa) for bridge touchdown points, under bridges to increase or maintain underclearance, around curves (so significant superelevation corrections aren't performed with HMA or concrete), and sometimes at locations that have failed due to weak subgrade soils. If at least 25 percent or 4 lane miles, whichever is less, of the pavement will receive a different fix type than the majority of the project, and this fix type has a pavement preservation strategy in Chapter 5, then it will be accounted for in the LCCA and the Region is to identify these areas in their LCCA request.

<u>Reuse of Sand Subbase</u>
Reconstruction projects that have existing reusable sand subbase, as determined by a mechanical analysis of subbase samples, should have this reflected in the LCCA calculations. If a Region determines that there is: 1) a sufficient depth of reusable sand subbase for one or both alternatives, or 2) that only a certain overall percentage of the project length has reusable sand, or 3) an estimate of the total volume of reusable sand, they are to specify this in their LCCA request. The length of the project that has, or the total volume of, reusable subbase should be based on a percentage of soil borings meeting existing specifications. To determine if there is sufficient depth to reuse sand in-place, a preliminary pavement design may be necessary.

Be aware that any existing sand subgrade material may also meet the material requirements for sand subbase. If so, it may be left in place and accounted for in the pavement designs as such. However, in the design, sand subgrade either contributes to the subgrade resilient modulus (M_R) or it is included in the pavement section as subbase, but it cannot be both. Therefore, to address this, the following steps will be taken:

1) If the Region elects to leave the existing material in place, prior to requesting a LCCA, the Region shall perform soils investigations to adequately estimate the M_R and elevation of the existing sand subgrade. The material below the designated "top of subgrade" will be assigned a subgrade M_R value.
2) If the "top of subgrade" elevation is somewhere below both the PCC and HMA MDOT standard thickness for sand subbase, then for design assessment, the "top of subgrade" elevation will be located at the elevation necessary to achieve the MDOT standard thickness for sand subbase for whichever pavement section is the deepest.

<u>Utility Relocation</u>
Utility relocation costs can differ between alternates for some projects. For reconstruction projects, utilities sometimes fall within the proposed cross-section. Compaction to obtain density can also be a concern over old utilities due to the possible damage caused by vibrations. If the costs are expected to differ between alternates, they can be factored into the LCCA. If a Region determines that the costs should be included in an LCCA, they are to develop the following estimates for each pavement alternative and provide them as part of their LCCA request.

1) Relocation construction costs:
   a. Public Utilities: only include relocation costs that will be billed to MDOT.
   b. Private Utilities: no relocation costs will be included in the LCCA.
2) The amount of time and maintenance of traffic plan due to utility relocation for any work prior to construction of the project.
3) Any time that would be added to the project schedule because of utility relocation during project construction.

<u>Concrete Widened Slab (i.e., 14′ outside lane)</u>
The Region will determine if project roadway(s) meets the MDOT guidelines for the 14-foot widened outside slab (truck lane only), found in the Michigan Road Design Manual, Chapter 6. If so, only the concrete alternative will incorporate the widened slab design, and it will not be required for the asphalt alternative in the LCCA.

<u>Miscellaneous</u>
When a Region determines that pavement type will affect other design elements differently, those associated costs can be factored into the LCCA. These can include, but are not limited to, Right of Way, drainage, access management, and maintenance of traffic costs (including crossovers, temporary roadways, or widenings). The Region is to develop cost estimates of each impacted design element for both pavement alternatives and provide them as part of their LCCA request.

STEP 3 - The pavement designer prepares the applicable pavement designs to be used in the Life Cycle Cost Analysis (LCCA). The alternates considered should include both a concrete and HMA alternate with comparable design lives. Please see the *Michigan DOT User Guide For Mechanistic-Empirical Pavement Design* for further details.

A Region may consider alternate construction practices, specifications, materials, or modifications to the pavement structure. See Appendix C for the process for how project level pavement modifications may or may not be included in the LCCA.

STEP 4 - The pavement designer submits design alternates to the Pavement Selection Engineer, who prepares the LCCA package. The LCCA package should include:

1) A cover memo indicating the alternate with the lowest life cycle cost and a project summary explaining the project location, existing and proposed pavement sections, existing pavement condition (including RSL and IRI), and traffic volumes. If the project will be proceeding as an APB project, creation of a cover memo is optional.

2) An appendix should also be attached which includes all of the detailed information that was used in the analysis. Items such as unit prices, production rates, soil boring logs, recommendation memos, traffic memos, maintenance of traffic information, construction scheduling analysis, pavement design information, and life cycle cost calculations should all be included in the appendix.

STEP 5 - The Pavement Operations Engineer, along with the Pavement Selection Engineer, Construction Field Services Division Pavement Design Engineer, and any other necessary Lansing/Region personnel, review the pavement selection package. Corrections, if necessary, are made, and an updated package is forwarded to EOC for their information, noting any unique project details (e.g. any known pavement modifications that have been incorporated in accordance with Appendix C, underdrains for one pavement type but not the other, etc.). Next, the LCCA package is sent to the paving industry associations for a two-week review. Draft LCCA packages for APB projects are sent to industry for review prior to submitting the results to the Innovative Contracting Unit. Again, corrections, if any, are made, and the final LCCA package, for non-APB projects only, is submitted to EOC for final review and approval.

The EOC approves the pavement selection based on the alternate that has the lowest life cycle cost, in accordance with MCL 247.651h.

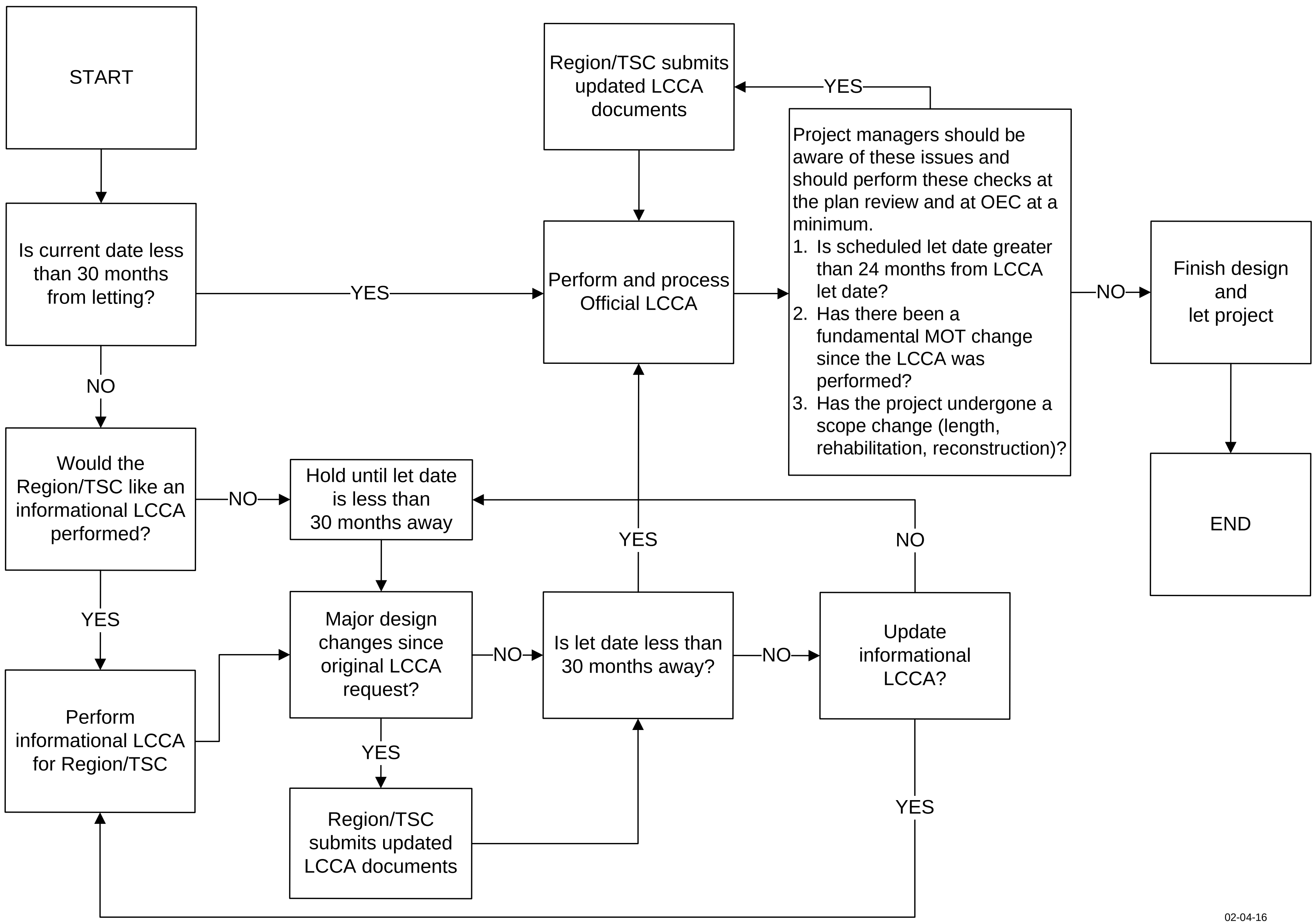
STEP 6 – The Pavement Selection Engineer notifies the appropriate Region personnel of EOC's action.

Table 2-2. Summary of Life Cycle Cost Analysis (LCCA) Use Cases

	Official LCCA	Informational LCCA	Corridor Projects
Use	Projects with defined scope, maintenance of traffic and letting date	Projects with scope of work but limited information on maintenance of traffic or letting date For example: Shelf Projects	For corridor scoping, an Informational LCCA can be performed for estimating pavement costs
Time Frame	Less than 30 months before Letting Date	Greater than 30 months before letting	Greater than 30 months before letting
Limitations	LCCA must be redone if: • Letting Date delayed 24 months or more from Letting Date (as specified in the Official LCCA) • Project Length changes by 25% or 4 lane miles* • Major Scope Change • Major Maintenance of Traffic (MOT) changes with number of lanes maintained, change in detour or number of stages.	LCCA is for information only, when a project is defined, project will be submitted for an Official LCCA.	Individual Projects must go through an Official LCCA when project limits are defined.

* Whichever is less

Figure 2-1. Life Cycle Cost Analysis Process Schedule



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CHAPTER 3. COMPONENTS OF A LIFE CYCLE COST ANALYSIS

A. Economic Analysis Approach

LCCA is used to compare the relative long-term costs of different pavement alternatives. LCCA allows the Engineer to objectively evaluate costs of two or more rehabilitation and/or new/reconstruction alternatives that may have significantly different initial costs and require very different levels of future preventive maintenance expenditures.

The analysis is expressed in terms of Equivalent Uniform Annual Costs (EUAC). The Service Life for each pavement fix has been determined using actual department pavement maintenance records and condition data. A pavement's Service Life is defined as the amount of time (expressed in years) before the pavement is in need of a subsequent rehabilitation or reconstruction. Service Life values can vary significantly based on the type of original rehabilitation or reconstruction method, as well as the number and type of preventive maintenance treatments.

Historical maintenance data is also used to identify what maintenance expenditures actually occur throughout the Service Life. This data, along with Pavement Management System condition data, is used to develop Pavement Preservation Strategies (Chapter 5) that reflect average pavement performance and the associated average maintenance costs. These Pavement Preservation Strategies define the basis for the Life Cycle Cost Analysis.

Future costs are discounted to their present value and annualized over the Service Life, which allows comparison of different alternatives. Federal Highway Administration's September 1998 Interim Technical Bulletin, *Life Cycle Cost Analysis in Pavement Design*, states that "good practice suggests conducting LCCA using constant dollars and real discount rates." It goes on to say that "real discount rates reflect the true time value of money with no inflation premium and should be used in conjunction with non-inflated dollar cost estimates of future investments."

All life-cycle costs will be expressed in current-year dollars. Real discount rates are used in the analysis and no correction is made for inflation. Recommended discount rates are published annually by the Federal Government's Office of Management and Budget. Cost data is based on the department's bidding records.

All costs are reported on a per mile basis for the entire roadway on undivided roadways (e.g. east & westbound M-57), while costs are computed per directional mile on divided highways (e.g. one bound of I-75). If there are miscellaneous paving areas included in the calculations, all costs will be computed on a per lane-mile basis.

The following equations use the information described above to perform the economic calculations for each LCCA.

$$Present\ Value\ (PV) = \frac{Future\ Cost}{(1+i)^n}$$

Where: $i = Real\ Discount\ Rate\ (2021: 0.7\%)$
$n = Years\ (age\ when\ the\ future\ cost\ is\ incurred)$

$$Equivalent\ Uniform\ Annual\ Cost\ (EUAC) = Sum\ of\ all\ PV\ Costs\ \times \frac{i\ \times (1+i)^n}{(1+i)^n - 1}$$

Where: $i = Real\ Discount\ Rate\ (2021{:}\ 0.7\%)$
$n = Years\ (service\ life)$

B. Initial Construction Costs

Only costs that differ between alternates are considered in the calculation. The following portions of the roadway will be included in the LCCA when present, some of which may not be included in the $1.5 million threshold calculation (See Chapter 2 for calculation of the $1.5 million threshold): mainline pavement, miscellaneous paving areas, ramps, weave/merge/collector/distributor lanes, continuous/contiguous parking lanes, continuous/contiguous non-motorized lanes, and shoulders. Cost items such as the following may be included: HMA and concrete pavement, joints, excavation, subbase, base, rubblization, pavement repairs, separator layers, underdrains, traffic control, utility relocation, etc. Unit prices will be determined from past MDOT projects and will be based on the weighted average of low bid data. The procedure used for unit price determination is further explained in Chapter 6.

Miscellaneous Paving
When the LCCA will include miscellaneous paving areas, costs will be calculated on a per lane mile basis.

1) For the concrete alternate, the average unit price for miscellaneous concrete will be applied to areas identified as miscellaneous paving.
2) For the HMA alternate, the standard HMA average unit prices will be applied to those areas, as there is no separate pay item for miscellaneous HMA.
3) The total of all mainline and all miscellaneous paving area costs will be multiplied by their respective number of lane-miles. This applies to all pay items included in initial construction costs.
4) The above costs will be added together, and then divided by the total number of lane-miles that the project will cover. The result is a weighted average initial cost per lane-mile for all pavement areas.

Major Rehabilitation with Reconstruction
When at least 25 percent or 4 lane miles, whichever is less of the LCCA includes reconstruction areas within a major rehabilitation project (or vice versa), a combined weighted average EUAC will be calculated and used in determining the low-cost pavement alternative.

1) Calculate the EUACs for the rehabilitation and reconstruction portions of the project separately, using their respective service lives, maintenance schedules and the same units (i.e. per mile, per directional mile or per lane-mile).
2) For each pavement type, calculate the combined weighted average EUAC by:
    a. Multiplying the rehabilitation length (using the same units) by the rehabilitation EUAC.
    b. Multiplying the reconstruction length (using the same units) by the reconstruction EUAC.
    c. Adding a and b above together, then dividing by the sum of the rehabilitation and reconstruction length.

<u>Pavement Underdrains</u>
Underdrain use or reuse is generally consistent (using or not using) for both LCCA pavement types. However, when requesting underdrains for one pavement type but not the other, Region staff will need to provide justification. Pavement Management will review the request and may also have another region review the request. Pavement Management will then approve or deny the request. When Pavement Management sends the LCCA to EOC for preliminary approval, there will be a note added describing this unique situation.

<u>Reuse of Sand Subbase</u>
When a reconstruction LCCA will account for the reuse of existing sand subbase, either by leaving it in place or by first stockpiling then reusing it, costs will be assessed as outlined below. Costs will be included for additional sand subbase that needs to be brought on-site to construct the proposed pavement section.

1) For locations that have an insufficient depth of existing sand subbase, but can accommodate a grade raise, the cost of the additional depth of material needed for each design and its placement will be included.
2) One of the following procedures will be used to address other situations, such as: locations that have an adequate depth of existing sand subbase for only part of a project; or the existing sand subbase is deemed reusable for a certain length, or an overall percentage of a project; or a volume of existing sand subbase is estimated to be reusable, but cannot accommodate a grade raise (i.e. reusable material is at the wrong existing elevation).
    a. Reusable sand for a certain length, or an overall percentage, of a project:
        i. Different proposed cross-sections will be priced out for example, one using new sand and another with reused sand to reflect project conditions. When applicable, excavation costs to the bottom of the proposed cross-section will be assessed, assuming that the reusable sand subbase will be stockpiled, and the unsuitable material disposed. 25% of the "Subbase, CIP" pay item cost will be assessed for placement and compaction of reusable sand subbase material. The total amount of sand subbase being placed (new and reusable) will be used to calculate the estimated number of construction days to place sand subbase.
        ii. The length (or lane-miles) of the project where each proposed cross-section applies is determined. These lengths (or lane-miles) could be different between the HMA and concrete alternatives.
        iii. The lengths (or lane-miles) of each proposed cross-section are multiplied by their respective cost, summed, and then divided by the total length (or total lane-miles), to determine a weighted average initial cost for each pavement type.
    b. Estimated volume of existing reusable sand subbase on a project:
        i. Using all the various lane/shoulder combinations in the LCCA, calculate the total pavement area that the project covers.
        ii. Determine a depth of existing reusable sand subbase by spreading the estimated volume out over the total pavement area.
        iii. Compare this depth to the standard subbase thickness needed for each pavement type, and price out the pavement cross-sections appropriately, using a combination of new and reusable sand. Excavation costs to the bottom of the proposed cross-section will be assessed, assuming that the reusable sand subbase will be stockpiled, and the unsuitable material disposed. 25% of the "Subbase, CIP" pay item cost will be assessed for placement and compaction of reusable sand subbase material. The total amount of sand subbase being placed (new and reusable) will be used to calculate the estimated number of construction days to place sand subbase.

Miscellaneous
When utility relocation, Right of Way, drainage, maintenance of traffic, etc., costs are included, they will first be converted into the same units (per directional mile, per mile, or per lane-mile) as the rest of the LCCA, based on whether it is a divided roadway, an undivided roadway or includes miscellaneous pavement areas. This cost will be added to the total Net Present Value (NPV) when calculating each pavement type's EUAC.

If the Region states that lane closures will be necessary prior to the start of the project, or that additional time will be added to the project schedule for utility relocation work, user delay costs will be calculated and added to the LCCA. All steps below are specific to information for public and private utility relocation as provided by the Region:

1) A CO3 analysis will be performed to determine the daily user delay costs based on the maintenance of traffic for the utility work.
2) User delay costs will be multiplied by the number of days the Region estimated to complete the work.
3) The total user delay costs will be converted into the same units (per directional mile, per mile, or per lane-mile) as the other costs in the LCCA.
4) The converted total user delay costs will be added to the total NPV when calculating each pavement type's EUAC.

C. Initial User Costs

User costs are those that are incurred during everyday use of a roadway, but more so within construction work zones which disrupt normal traffic flow. User costs are included in an LCCA because they affect life-cycle costs. They are influenced by the length, duration, and character of capacity restriction and their effect on traffic flow, speed changes, stops, delays, and detours experienced by the roadway users. The project's TTCP will be utilized to assist in estimating these costs. Pavement Management may require further information based on the complexity of the construction work zone for any project and may contact the Region for clarification purposes.

Total user delay costs for each pavement alternative are estimated as follows. A number of estimates and simplifications are incorporated into this process and are applied to every project.

1) The submitted maintaining traffic scheme (TTCP) and traffic volumes are utilized in CO3 to calculate the estimated daily user delay costs.
2) The production rates in Appendix A and the quantities of each associated pay item (production paving and miscellaneous paving areas) are used to calculate the estimated number of construction days to perform each work activity, broken down per stage.
3) For each stage of construction, a simplified linear schedule is developed utilizing the number of construction days for each work activity, simplified pre-determined construction sequencing, work item relationships, and lag times. Sample simplified linear schedules are shown in Appendix B to graphically display the work item relationships and lag times described below. Work item end lag times could be longer than those shown, when the number of days to build a certain item exceeds the minimum end lag time. "Float" may need to be included in the schedule for a particular item when the number of days to build that item needs to be extended to meet the minimums specified below.

a. Work item start times
   i. HMA or concrete paving must begin no sooner than one day after the start of the preceding work item; two days if the preceding work item is a stabilized base layer.
   ii. Other work items must begin no sooner than one half day after the start of the preceding work item.
   iii. If the preceding work item is concrete full depth repair, the work item must begin no sooner than one day after the start of repair.
b. Work item end times
   i. HMA or concrete paving must end no sooner than one day after the end of the preceding work item; two days if the preceding work item is a stabilized base layer.
   ii. Other work items must end no sooner than one half day after the end of the preceding work item.
c. A 16-inch open-graded drainage course will be placed in two lifts, with one half day lag between lifts.
d. For HMA paving, initial production lots (IPL) will be incorporated for each HMA mixture with at least 5,000 tons on the project. A production rate of 1000 tons per day per HMA mixture type for a duration of three days for the first mix type, and one day for all subsequent mix types, will be used for the placement and testing of initial production lots prior to the start of production paving. IPLs will only be utilized in the first stage of construction during which a mix is used; the lower IPL production rate will not be applied in later stages.
e. For concrete paving, a joint sealing and cure time of three days will be added on to the end of paving to allow the pavement to reach sufficient strength to be opened to vehicular traffic and support the construction equipment needed to initiate subsequent controlling work items, such as HMA shoulder placement items.
f. For concrete paving on non-freeways, an additional three days of joint sawing/sealing and cure time per applicable stage will be included in the schedule to address paving gaps and repaving for access management. Quantities necessary to pave the gapped-out areas will be included in the total for concrete paving.
g. Other unique situations may arise, in which case assumptions will be made and reflected in the LCCA package.

4) The total number of construction days for the project is determined from the simplified linear schedule.
5) Total user delay costs are calculated by multiplying the daily costs by the total number of construction days for the project. If weekday and weekend user delay costs differ, the costs are applied accordingly utilizing the simplified approach that work will continue seven days per week until the work is completed. The first day of work is assumed to be a Monday.

D. Future Maintenance Costs

Maintenance costs are based on MDOT maintenance records. Historical maintenance data and pavement condition data from the Pavement Management System have been used to develop maintenance cost schedules otherwise termed “Pavement Preservation Strategies” for the various pavement fixes (see Chapter 5).

Miscellaneous paving areas will follow the maintenance schedules in Chapter 5. These costs will be calculated per lane-mile, consistent with the costs related to initial construction.

E. Future User Costs for Maintenance Activities

Future user delay cost calculations will be performed for each life-cycled project. Project level data used in the user delay cost calculation for initial construction (AADT, number of lanes, speeds, growth rate, etc.) will be used again for each maintenance cycle.

Traffic volumes will be increased based on the growth rate (as provided by the MDOT Statewide and Urban Travel Analysis Section, Statewide Model Unit, of the Bureau of Transportation Planning) and the number of years in the future when the average maintenance cycle occurs. The assumed maintaining traffic schemes will be as follows:

1) A single lane closure on divided roadways
2) A single lane closure on undivided roadways with three or more lanes
3) Flaggers on two-lane, two-way highways

With these inputs, CO3 will be utilized to calculate the average daily user delay costs.

The average number of days (or part of a single day) necessary to perform one lane mile of maintenance is shown in the Pavement Preservation Strategies in Chapter 5.

The daily user cost will then be multiplied by the duration of the maintenance cycle. This value will be the per lane-mile user cost for the maintenance cycle. This may need to be converted into the same units (per directional mile or per mile) as the other costs in the LCCA and then included in the EUAC calculation.

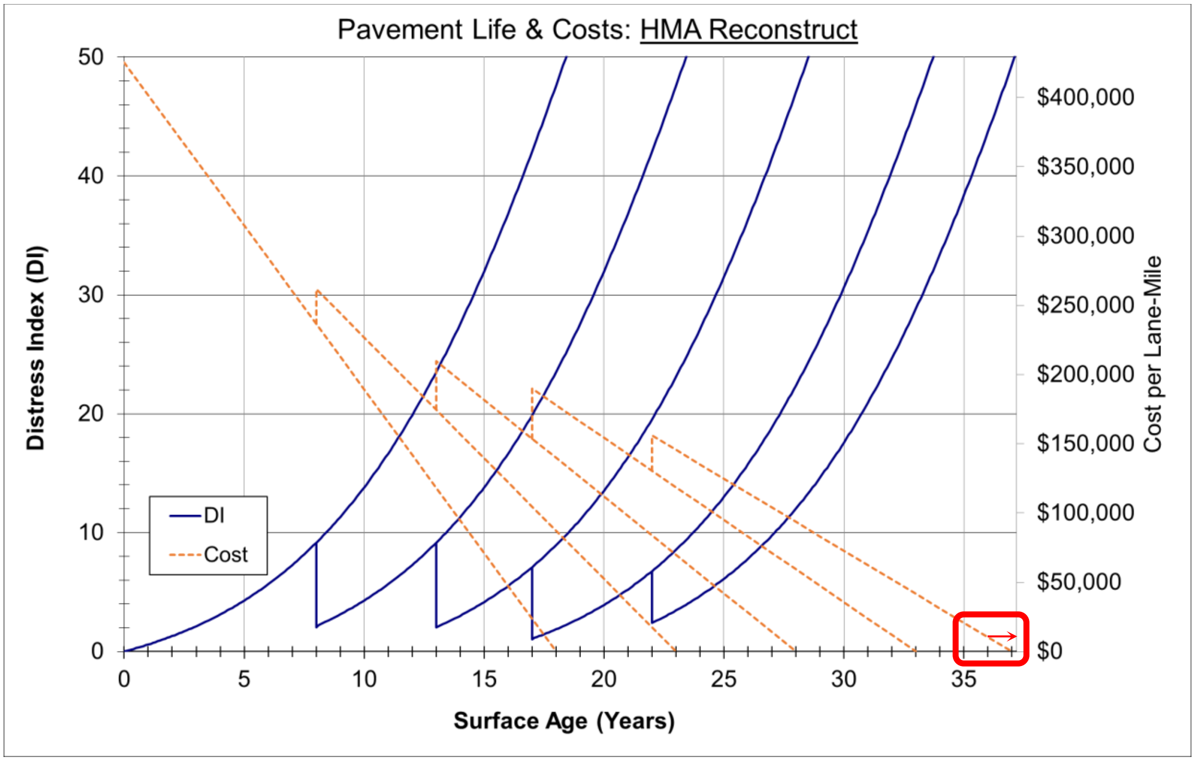
Cost inputs into CO3 are updated annually, and consequently there will be no need to account for inflation separately. Also, it will not be necessary to inflate prices to future dollars since they would be deflated back to present day dollars in a subsequent calculation. More details on these inputs can be found in Chapter 6.

For some roadways, when traffic is aged to the year of the future maintenance activity, CO3 calculations may indicate very large backups and user costs (i.e. over capacity situations). In these situations, it is very likely that maintenance would not be performed during the day, but at some off-peak time in order to meet the standards set forth in MDOT's Mobility Policy. Therefore, when calculating user delay for maintenance activities, if the output states that MDOT's Mobility Policy is being violated (i.e. greater than 10 minutes of user delay), the user delay analysis will be rerun. Night work will be assumed, applying the user costs from 9pm to 5am, with this time frame counting as one day’s worth of maintenance work.

F. Remaining Life Value

Use of the EUAC method requires that equivalent analysis periods be used for the alternatives being compared. MDOT relies on the fix type specific service life for the LCCA analysis period, but these are not usually the same for the alternatives being compared. In these cases, the alternative with the shorter service life is used for analysis period and the alternative with the longer service life will receive a remaining life value credit in the LCCA. This is done by performing a straight-line depreciation of the project specific initial construction and future maintenance costs (including future user delay costs) to determine the unused portion of these costs beyond the analysis period. This is visually depicted in Figure 3-1 below, showing HMA new/reconstruction as an example:

Figure 3-1. Remaining Life Value Visualization



The solid lines are the DI-based "performance curves" from Chapter 5, but with each pre-maintenance curve extended to where it would reach a DI of 50, which also equals a remaining service life (RSL) of zero. The dashed lines are the straight-line depreciated initial construction and future maintenance costs, which extend to the corresponding zero RSL year(s) of the performance curve. Following this reconstruction example, HMA has a service life of 37 years, while concrete's service life is 36 years. In the LCCA, the analysis period would be set at 36 years (i.e. the shortest service life of the two alternatives), and the HMA alternative would receive a one-year remaining life value credit (37 years – 36 years = 1 year of remaining life value), identified in the lower righthand corner of the figure above.

In the LCCA, the remaining life value portion of the initial construction costs and the future maintenance costs (including future user delay costs) are calculated separately, then combined at the end. Using the pavement preservation strategies in Chapter 5, these calculations are as follows:

1) Remaining Initial Construction Cost:
   a. Initial Construction Cost × (PM Cycle 1 RSL Before / Initial Const RSL After) × (PM Cycle 2 RSL Before / PM Cycle 1 RSL After) × (PM Cycle *x* RSL Before / PM Cycle *x-1* RSL After) × (Difference in Compared Alternative Service Lives / Last PM Cycle RSL After)
   b. HMA Reconstruction Example: Initial Construction Cost × 10/18 × 10/15 × 11/15 × 11/16 × 1/15
2) Remaining Future Maintenance Costs (including future user delay costs):
   a. ((((((PM Cycle 1 Cost × (PM Cycle 2 RSL Before / PM Cycle 1 RSL After)) + PM Cycle 2 Cost) × (PM Cycle 3 RSL Before / PM Cycle 2 RSL After)) + PM Cycle *x*

Cost) × (PM Cycle *x+1* RSL Before / PM Cycle *x* RSL After)) + Last PM Cycle Cost) × (Difference in Compared Alternative Service Lives / Last PM Cycle RSL After)

b. HMA Reconstruction Example: ((((((PM Cycle 1 Cost × 10/15) + PM Cycle 2 Cost) × 11/15) + PM Cycle 3 Cost) × 11/16) + PM Cycle 4 Cost) × 1/15

3) Sum 1) and 2) above and include as a negative cost alongside the initial construction, initial user delay and the future maintenance costs, prior to calculating the EUAC for the alternative with the longer service life.

Since all the remaining life value costs are already in Present Value, no further cost discounting is performed.

CHAPTER 4. SOFTWARE

Several tools have been developed to assist in completing a pavement design and LCCA. These tools have been developed to minimize the time required to perform an analysis and also maintain uniformity in the analysis method.

Two pavement design methods are used by MDOT. The first is the 1993 version of the AASHTO Guide for Design of Pavement Structures, by way of using the software titled “DARWin Version 3.1.” The second (currently in the process of being implemented) is the AASHTO “Mechanistic-Empirical Pavement Design Guide,” using the software “Pavement ME Design.” See the manual *Michigan DOT User Guide for Mechanistic-Empirical Pavement Design* for further details.

User cost analysis software has been developed by the University of Michigan for MDOT to aid in performing the user cost analysis portion of an LCCA. This software titled “Construction Congestion Cost (CO3)” is based on the user cost analysis method recommended by the Federal Highway Administration (FHWA). This method is explained in FHWA’s publication titled *Life Cycle Cost Analysis in Pavement Design*.

A project costing spreadsheet has been developed by MDOT which calculates initial construction, future maintenance and remaining life value costs that are included in the LCCA. This spreadsheet uses stored unit price data for all applicable work items, maintenance costs, and user input data for each design alternative.

CHAPTER 5. PAVEMENT PRESERVATION STRATEGIES

Pavement preservation strategies (maintenance schedules) are shown in this chapter and reflect the overall maintenance approach that has been used network-wide for a specific fix type. They have been developed by modeling and analyzing historical maintenance activities and costs, and pavement condition data.

The pavement preservation strategies that follow are to be used when applying the maintenance timing and costs for each alternative in a life-cycle cost analysis. The methodology used to create these strategies incorporates a large number of projects for each fix type and provides network/system wide historical averages that may not be indicative of business practices on any actual project.

Table 5-1. New/Reconstructed HMA Pavement Preservation Strategy

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	$28,071*	0.48
Prev. Maintenance	13	9	2	10	5	15	$41,342*	0.63
Prev. Maintenance	17	7	1	11	5	16	$44,005*	0.65
Prev. Maintenance	22	7	2	11	4	15	$32,411*	0.55
Rehabilitation or Reconstruction	37							

* based on actual averaged maintenance costs, all brought into 2019 dollars

Figure 5-1. New/Reconstructed HMA Pavement Service Life Deterioration Curve

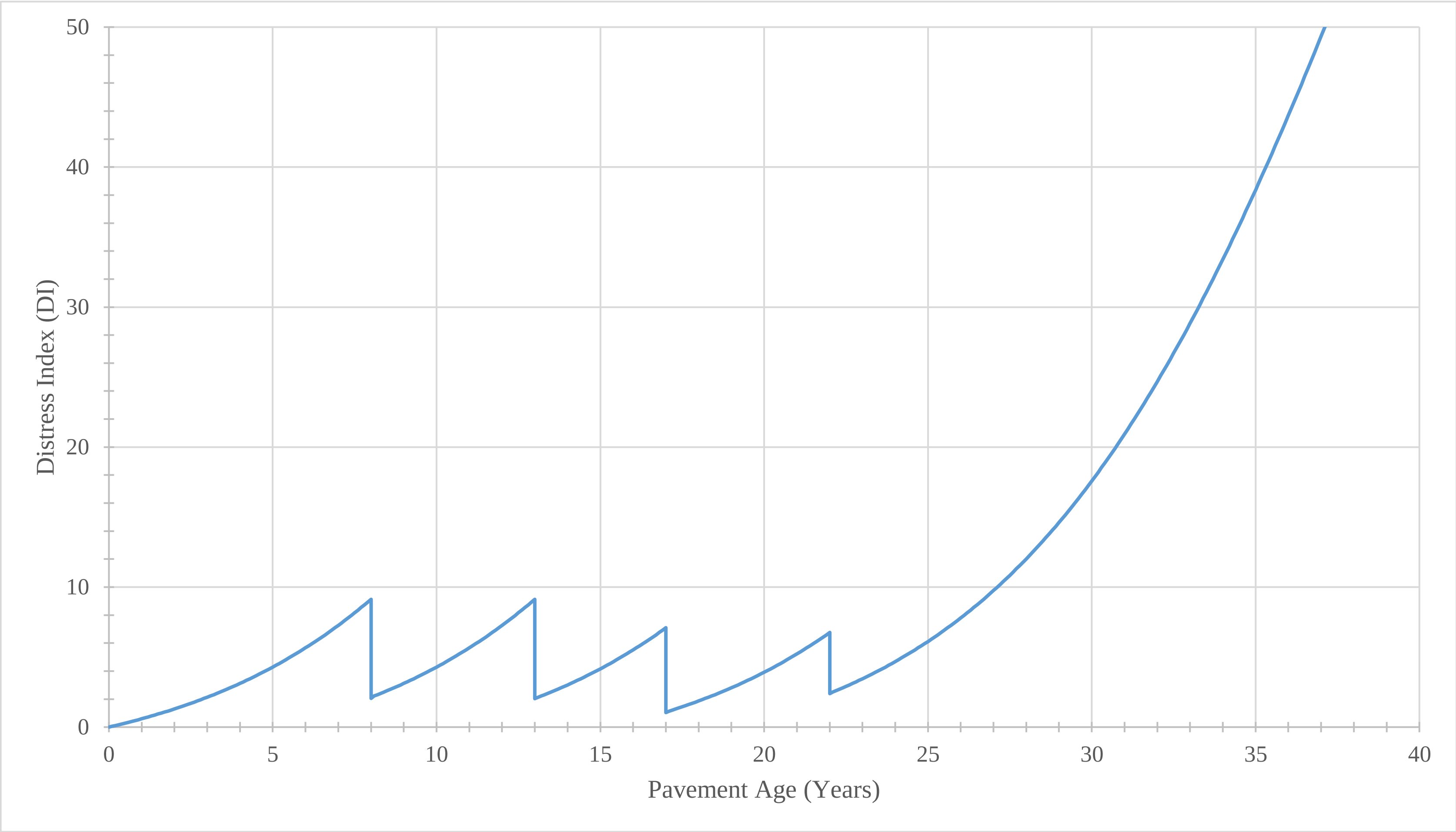


Table 5-2. New/Reconstructed Concrete Pavement Preservation Strategy

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			26	Computed	
Prev. Maintenance	13	7	4	13	3	16	$44,164*	0.92
Prev. Maintenance	17	8	4	12	4	16	$46,592*	1.09
Prev. Maintenance	23	12	8	10	3	13	$64,015*	1.03
Rehabilitation or Reconstruction	36							

* based on actual averaged maintenance costs, all brought into 2019 dollars.

Figure 5-2. New/Reconstructed Concrete Pavement Service Life Deterioration Curve

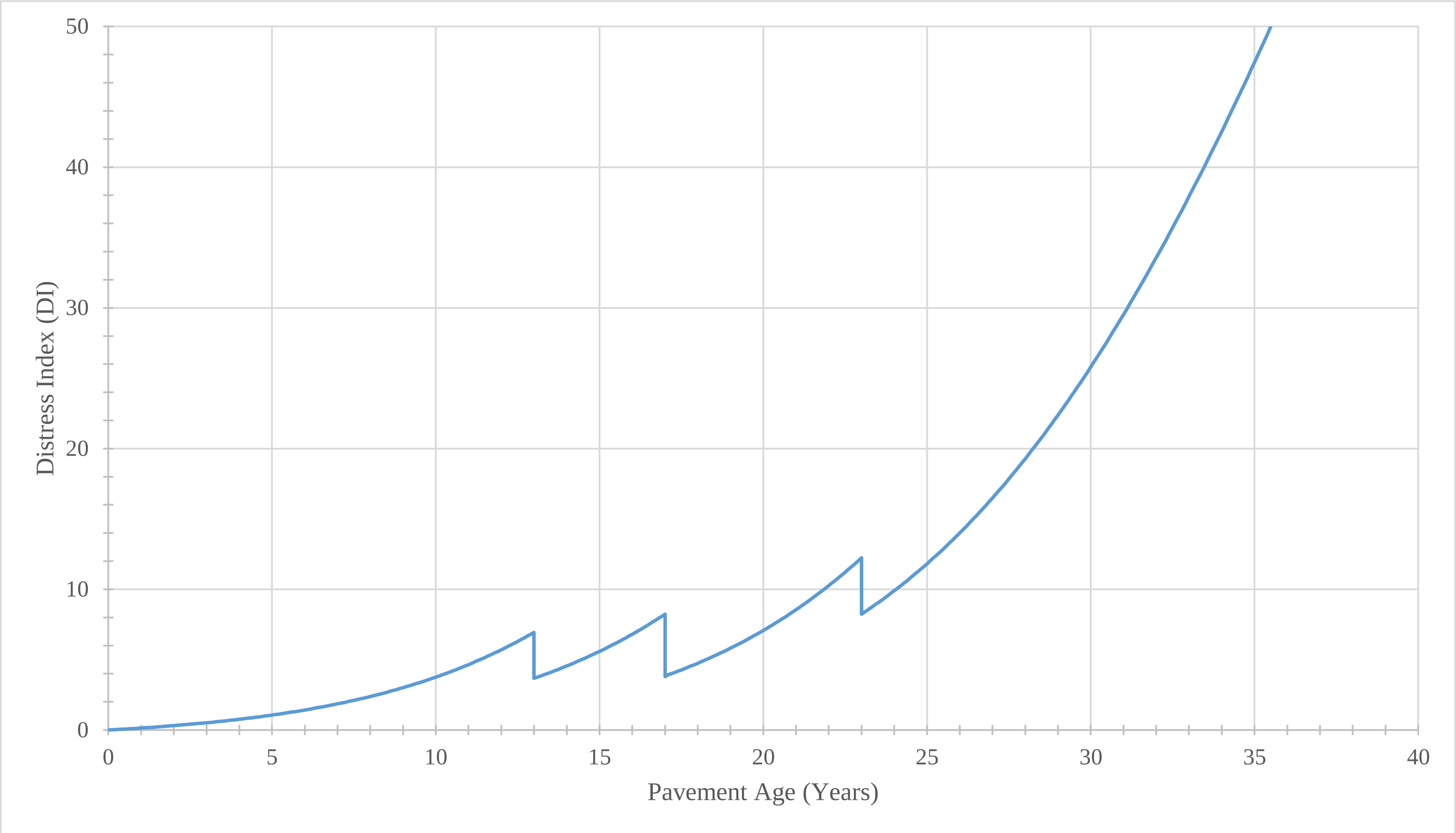


Table 5-3. Concrete Overlay (6"+) Pavement Preservation Strategy

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			19	Computed	
Prev. Maintenance	11	5	3	8	1	9	$19,702*	0.60
Prev. Maintenance	13	8	5	7	1	8	$11,340*	0.63
Prev. Maintenance	15	13	10	6	1	7	$21,219*	0.76
Prev. Maintenance	17	21	15	5	1	6	$20,241*	1.24
Rehabilitation or Reconstruction	23							

* based on actual averaged maintenance costs, all brought into 2019 dollars

Figure 5-3. Concrete Overlay (6"+) Pavement Service Life Deterioration Curve

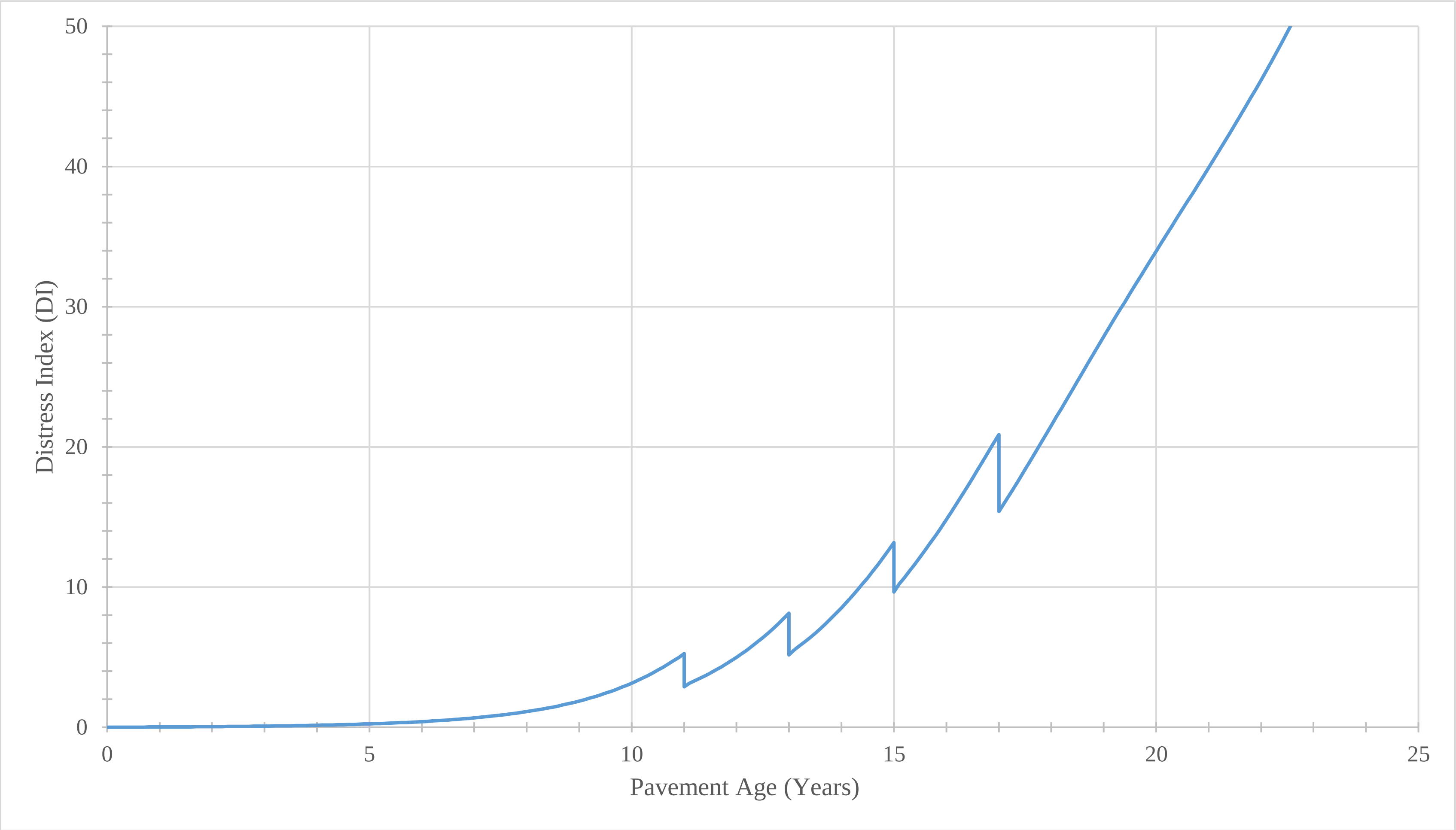


Table 5-4. HMA Overlay on Rubblized Concrete Pavement Preservation Strategy

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			16	Computed	
Prev. Maintenance	7	8	2	9	3	12	$25,844*	0.40
Prev. Maintenance	11	9	3	8	4	12	$45,335*	0.61
Prev. Maintenance	14	8	1	9	5	14	$29,389*	0.59
Prev. Maintenance	19	8	2	9	4	13	$49,158*	0.55
Rehabilitation or Reconstruction	32							

* based on actual averaged maintenance costs, all brought into 2019 dollars

Figure 5-4. HMA Overlay on Rubblized Concrete Pavement Service Life Deterioration Curve

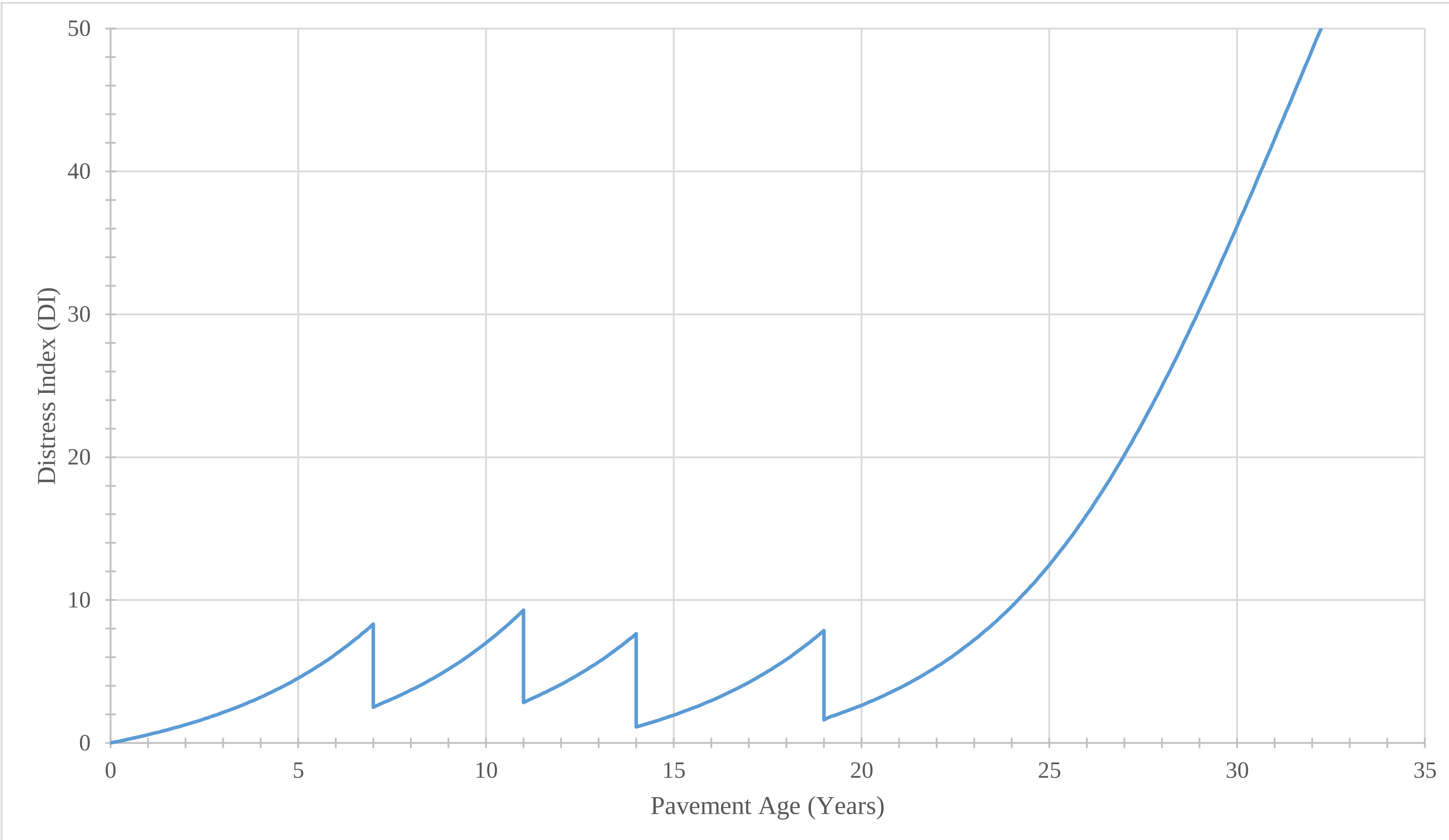


Table 5-5. Thin Concrete Overlay Pavement Preservation Strategy

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			17	Computed	
Prev. Maintenance	5	2	0	12	4	16	$43,769*	0.38
Rehabilitation or Reconstruction	21							

* based on actual averaged maintenance costs, all brought into 2019 dollars

Figure 5-5. Thin Concrete Overlay Pavement Service Life Deterioration Curve

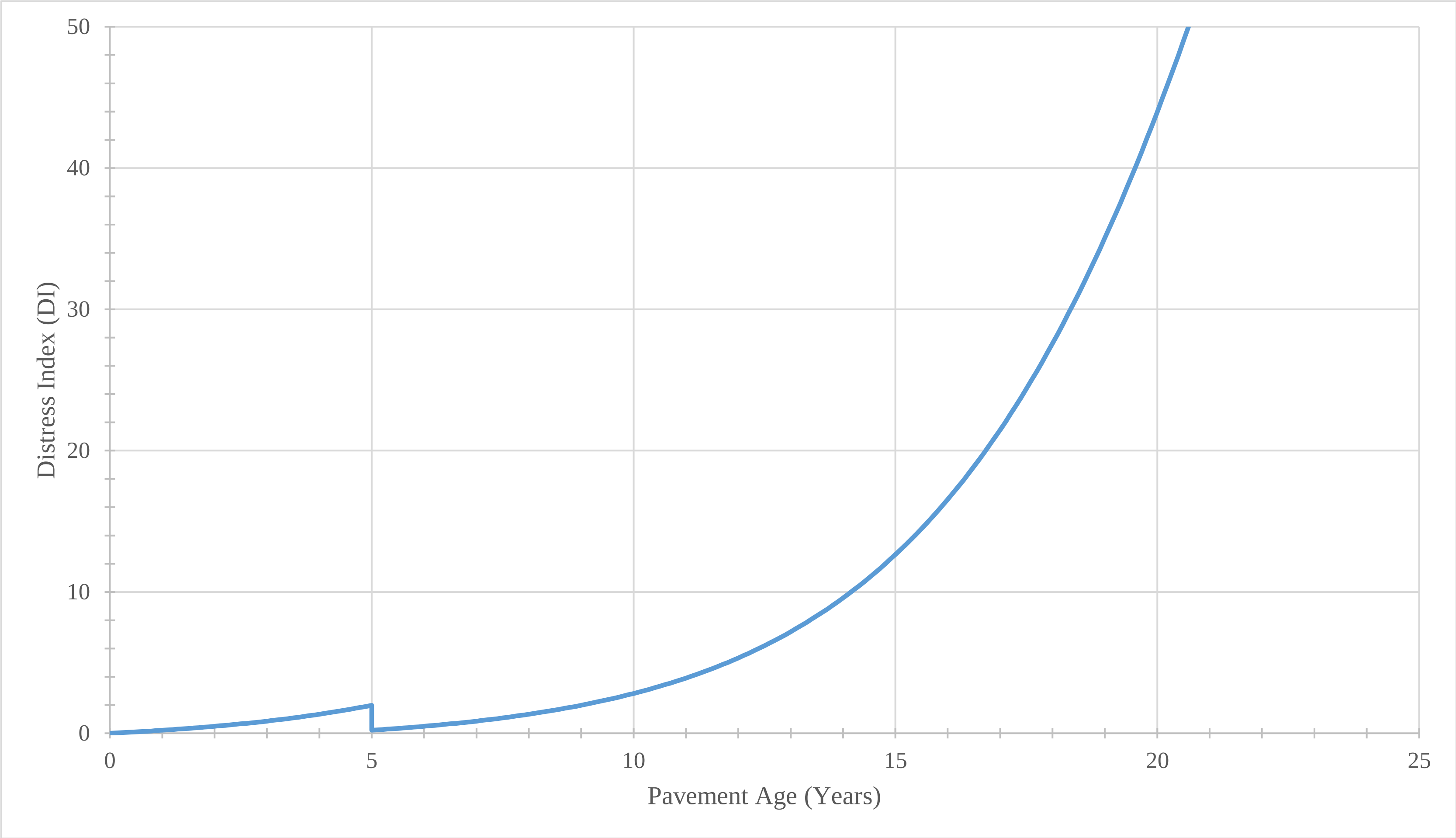


Table 5-6. HMA Overlay on Crush & Shaped HMA Pavement Preservation Strategy

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			19	Computed	
Prev. Maintenance	9	10	3	10	5	15	$27,252*	0.45
Prev. Maintenance	13	9	2	11	5	16	$29,575*	0.48
Prev. Maintenance	18	8	2	11	5	16	$40,246*	0.51
Prev. Maintenance	23	8	2	11	5	16	$38,460*	0.55
Rehabilitation or Reconstruction	39							

* based on actual averaged maintenance costs, all brought into 2019 dollars

Figure 5-6. HMA Overlay on Crush & Shaped HMA Pavement Service Life Deterioration Curve

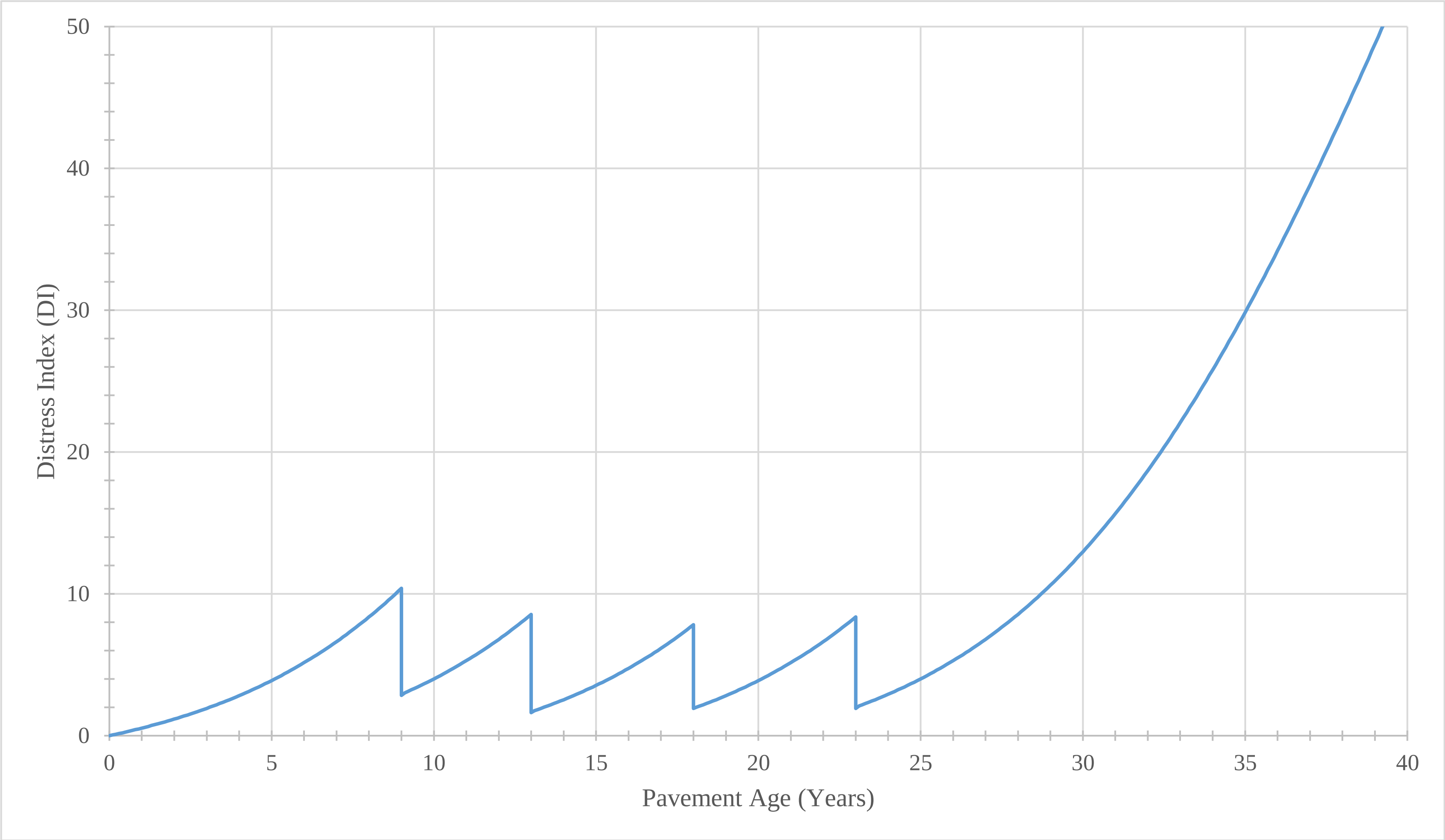


Table 5-7. Multiple Course HMA Overlay Pavement Preservation Strategy

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			21	Computed	
Prev. Maintenance	7	15	5	14	4	18	$29,469*	0.44
Prev. Maintenance	11	14	4	14	4	18	$55,225*	0.67
Prev. Maintenance	16	15	4	13	5	18	$45,751*	0.69
Prev. Maintenance	20	13	4	14	4	18	$45,382*	0.66
Rehabilitation or Reconstruction	38							

* based on actual averaged maintenance costs, all brought into 2019 dollars

Figure 5-7. Multiple Course HMA Overlay Pavement Service Life Deterioration Curve

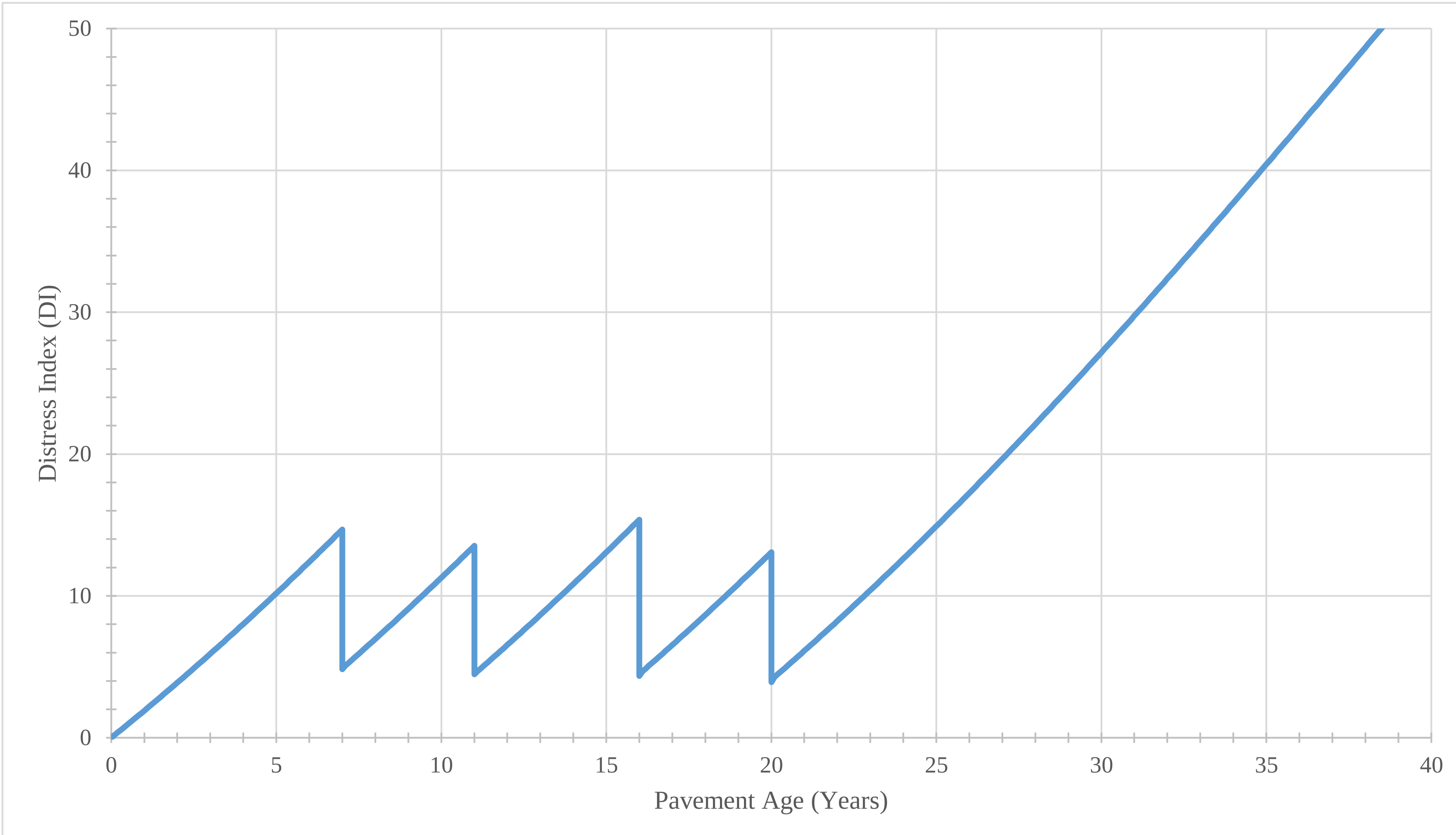
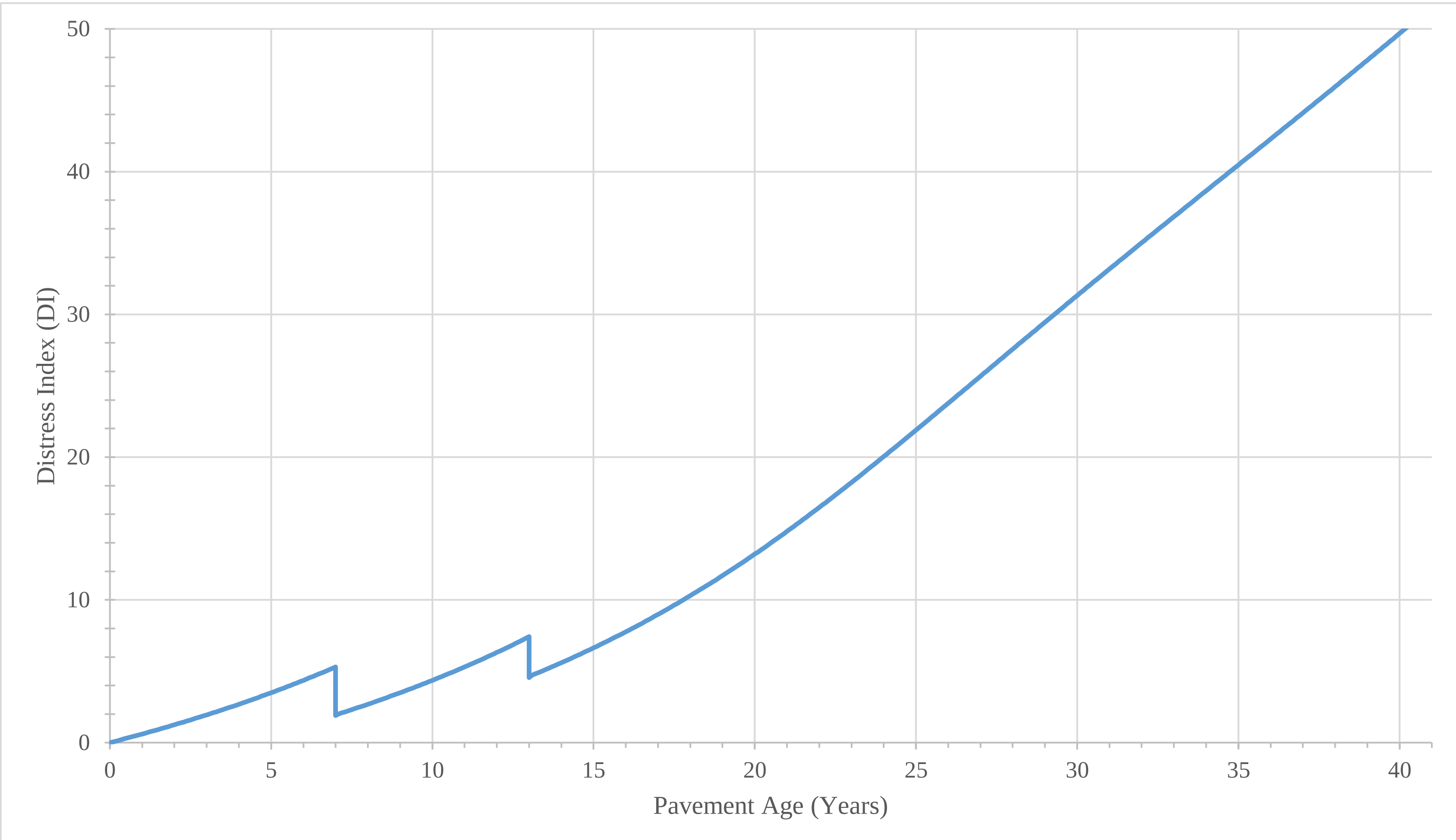


Table 5-8. Multiple Course HMA over Asphalt Stabilized Crack Relief Layer Overlay Pavement Preservation Strategy

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			33	Computed	
Prev. Maintenance	7	5	2	26	4	30	$8,487*	0.29
Prev. Maintenance	13	7	5	24	3	27	$9,452*	0.23
Rehabilitation or Reconstruction	40							

* based on actual averaged maintenance costs, all brought into 2019 dollars

Figure 5-8. Multiple Course HMA over Asphalt Stabilized Crack Relief Layer Overlay Pavement Service Life Deterioration Curve



CHAPTER 6. LCCA PROCESS, PRESERVATION STRATEGY & DATA UPDATES

A. Input for Future LCCA Process Updates

Identification, discussion, and investigation of potential improvements to MDOT's LCCA process will occur according to the schedule described in this section. The schedule provides opportunity for periodic stakeholder input and for appropriate improvements to be incorporated in a timely manner.

To start the LCCA process review cycle, input will be solicited from construction industry and MDOT representatives. Each agency will compile a description of the issue, along with their rationale and recommendations, on why a certain component of the life-cycle process should be changed, included, or deleted. This information will be placed on an issue summary form, completing one form for each individual issue. Once the issue summary forms are shared with all parties, joint meetings will occur to discuss the issues, attempting to find resolution. All parties will need to agree on a proposed change, otherwise it becomes a potential impasse issue. After all the issue summaries are discussed, each agency will select up to five potential impasse issues to bring before an Impasse Panel for a discussion and final decision. The Impasse Panel will be comprised of three MDOT members, appointed by the Chief Operations Officer. Each agency will have the opportunity to explain their issues, as well as their position on the other agencies' issues. The decisions of the Impasse Panel are final and will not be reviewed until the next scheduled process review. However, in the event that a process related issue is identified that should not wait until the next regularly scheduled process update for input, the Chief Operations Officer may initiate meetings to address that issue.

Because MDOT is working within certain constraints, there are some items that may be rejected for consideration. Industry may submit issues, even if they may be in one of these areas, and a determination will be made regarding whether each issue will be considered in the process review. The Impasse Panel may be called upon to make this determination.

MDOT will develop the implementation plan to allow proper allocation of limited resources. Implementation is expected to require revisions to this manual and will include inflation of published maintenance costs as described in Section F of this chapter. No new maintenance project data will be added. Some changes to the process may conflict with the existing pavement preservation strategies and thus, will not be incorporated into the manual until the pavement preservation strategies are updated per Section B of this chapter.

Since a regular schedule for process input is in place, industry review of individual LCCA packages will be limited to whether the process in place is being followed appropriately. Any comments related to the process itself should not be included and will not be considered at that time. This will eliminate expenditure of MDOT resources to respond to and investigate such comments and will avoid related delays to LCCA decisions.

The next LCCA Process Review is expected to begin in 2022 and follow the approximate schedule shown in Table 6-1 below. A finalized schedule will be developed prior to the start of the Process Review. Subsequent cycles will occur every four years.

Table 6-1. 2022 LCCA Process Review Preliminary Schedule

Step	Activity	Assigned To	Approximate Target Completion Date
1	Develop a list of issues for discussion during the process review. Document each issue in writing, in a pre-determined Issue Summary format.	MDOT technical experts, Paving industry groups	February 2022
2	All documented issues are shared between the parties.	MDOT technical experts	April 2022
3	MDOT conducts meetings with both industries (joint meetings) in an attempt to resolve the issues. MDOT documents each meeting and sends a summary to both industries with decisions for each issue (agreement or potential impasse issue).	MDOT technical experts, Paving industry groups	August 2022
4	Each party identifies the issues that they wish to go before the Impasse Panel. This will be limited to 5 issues from each party.	MDOT technical experts, Paving industry groups	September 2022
5	The MDOT Impasse Panel Coordinator works with MDOT technical experts, APAM, and MCA to develop the Impasse Issue Summary documents in a pre-determined format. Each party will submit their recommendation, response, and reasoning on each Impasse Issue.	MDOT Impasse Panel Coordinator	October 2022
6	The completed Impasse Issue Summary documents are given to the Impasse Panel and shared with MDOT technical experts, APAM, and MCA.	MDOT Impasse Panel Coordinator	November 2022
7	The Impasse Panel holds meetings for the identified issues and makes decisions for each. Representatives for MDOT, APAM, and MCA attend the meetings to present their recommendations.	Impasse Panel, MDOT technical experts, Paving industry groups	March 2023
8	The decisions of the Impasse Panel are documented and distributed to all parties.	MDOT Impasse Panel Coordinator	April 2023
9	Set implementation schedule.	MDOT technical experts	May 2023
10	Implement.	MDOT technical experts	Late 2023

Note: The amount of time for individual steps is expected to vary, and deviations from this schedule may be necessary for those and subsequent steps. More specific dates will be developed in early 2022.

B. Process for Pavement Preservation Strategy Updates

The pavement preservation strategies will be updated every four years, approximately two years after the overall process update.

Updates will be performed in accordance with the process in place when the updates begin. In addition, data (e.g. Distress Index, IRI, maintenance projects, etc.) available at the time of each data "pull" will be utilized, even if additional data becomes available during the process. This will eliminate back tracking to redo steps.

Information will be shared with industry when draft updates are available. This may occur at one or more milestones during the process if MDOT deems it beneficial, but at least will occur when draft pavement preservation strategies have been developed. Their input will be focused on whether the process was followed accurately, as well as possible alternatives for decisions that were based on engineering judgment. Any suggestions for process improvements will be considered during the regularly scheduled updates for the LCCA process as a whole, not during the pavement preservation strategy update process. While industry input will be considered, MDOT retains final decision-making authority and consensus is not mandatory.

C. Unit Prices – HMA & Concrete

Unit prices used in the pavement selection process to determine initial construction costs are updated based on the following procedure. However, note that there may be unique situations where these procedures do not result in an average unit price. Other methods may be utilized to estimate an average unit price, or an average unit price may not be reported for certain items.

Prices are updated on a semiannual basis. Publication of updated prices is targeted for March and September every year. The March publication will be based on price data ending with the prior December letting. The September publication will be based on price data ending with the prior June letting. Updated prices will be sent to construction industry representatives, providing one month for review and comment. However, the final decision for selected prices resides with MDOT. The updated unit prices will be used in any LCCA that has not yet started internal review by the time the new prices are officially published. MDOT will provide a list of LCCA's that have already reached, or are expected to reach, the internal review stage during the one-month unit price review and comment period. These LCCA's will continue to use the currently approved prices. If the status of any of these LCCA's change during the unit price review period, which could alter which unit price dataset is used in the analysis, MDOT will immediately inform the construction industry representatives.

Unit prices will be determined from past MDOT projects only, no local agency projects, and will be based on the weighted average (by quantity) of low bid data, when possible, following steps 1-4 listed below. Unit prices will be determined for a regional area except when steps 1-4 result in a statewide average price. There are three regional areas that are considered. The three areas are: Superior/North Regions, Grand/Bay/Southwest Regions, and University/Metro Regions.

The steps listed below are the order in which price data will be queried. Steps 1 & 3 are on a regional area basis. Steps 2 & 4 are on a statewide basis. If a given unit price cannot be obtained from the first step, the query will proceed to the second and continue through the steps until a unit price can be obtained. When unit price data is not available for a specific work item, unit prices of similar work items will be considered in unit price determination as outlined in steps 3 & 4.

In rare instances, project unit prices may be encountered that are significantly higher or lower than would reasonably be expected on future projects, and for which a similar trend for that particular item would not reasonably be expected. It is possible that such unit prices should not be included in the LCCA unit prices. When an abnormal unit price is identified by MDOT or either paving industry, they will work together to come to consensus on whether it should be included. If they cannot reach consensus on the inclusion or exclusion of specific unit prices, the decision will be made by MDOT's Engineering Operations Committee.

Steps are as follows:

1) 1 or more projects in the last 24 months with individual project threshold of 34,000 square yards of concrete pavement or 11,500 tons of hot mix asphalt, within a regional area.
    a. Subsequently, after a project meets the first step criteria, for a given hot mix asphalt mixture (i.e. 3EML, 3EH, etc.), there must be a minimum of 6000 tons of the mixture on the project in order for it to be included in the data set.
    b. If less than 7 of the 12 production concrete pavement item thicknesses have a qualified price from projects in the last 24 months, then the following additional steps will be taken, but only for those qualified thicknesses that do not have a qualified price in the last 24 months:
        i. Projects going back an <u>additional</u> 24 months (i.e. in the last 25-48 months), with individual project threshold of 34,000 square yards of concrete pavement are identified.
        ii. Prices will be adjusted using the "Concrete Products" (WPU133) Producer Price Index (PPI) using the procedure explained via the example below:
            1. Assume that a qualified 9 ½ inch concrete pavement project was let in July 2017 and the $35.00/syd price will to be adjusted two years forward, to July 2019 dollars.
            2. The monthly PPI for July 2017 was 254.8, and 273.1 for July 2019.
            3. The adjusted price is calculated by: (273.1 / 254.8) * $35.00/syd = $37.51/syd.
        iii. These projects will not be included on the "LCCA qualified project list" described below.
2) Statewide weighted average of projects that meet the individual project thresholds per Step 1.
3) Prorate the unit price for the next closest concrete thickness (using both sides of the thickness when available) within a regional area. Calculate a unit price for the hot mix asphalt type by applying the price of a similar hot mix asphalt type within a regional area.
4) Prorate the unit price for the next closest concrete thickness (using both sides of the thickness when available) on a statewide basis. Calculate a unit price for the hot mix asphalt type by applying the price of a similar hot mix asphalt type on a statewide basis.

    <u>Note</u>: When querying hot mix asphalt mixes in Step 1 above, the query will be for individual mix types (i.e. mix traffic level) on a project; for example, the summation of EMH mixes will be separate from the summation of EL mixes, even if both are present on the same project.

Those projects which meet the criteria set forth in Step 1 are compiled into a "LCCA qualified project list" for later use. Those projects identified in Step 1.b will not be included.

D. Unit Prices – Common Items

Common items are those items that are neither an HMA mixture nor a mainline concrete pavement but are part of the cross-section work including repairs to the existing pavement. Examples of common items would be all granular base/subbase materials, underdrains, pavement joints, and miscellaneous concrete.

To calculate a unit price for common items, first a "LCCA qualified project list" must be built based upon completing the previous steps for concrete pavements and HMA mixtures. The only common item prices that may be used in a weighted average price are those that are included in a project on the "LCCA qualified project list" and meet the quantity thresholds listed in Table 6-2 below:

Table 6-2. Common Item Quantity Thresholds

Work Items	Units	Quantity Threshold
Embankment, CIP	Cyd	5000
Excavation, Earth	Cyd	16700
Subbase, CIP	Cyd	9300
Aggregate Base Open-Graded Drainage Cse Stabilized Bases Aggregate Base Conditioning Geotextile Separator Rubblized Pavt Operation HMA Base Crushing and Shaping Cold Milling HMA Surface	Syd	34000
Underdrains	Ft	15800
Joint and Crack, Cleanout	Ft	1000
Pavt Joint and Crack Repr, Det 7 Pavt Joint and Crack Repr, Det 8	Ft	4000
Hand Patching	Ton	750
Joint, Contraction, CP	Ft	15840
Joint, Contraction, C3P	Ft	10560
Conc Pavt, Misc, Nonreinf, High Performance	Syd	6000
Conc Pavt, Ovly, Misc, Furnishing and Placing, High Performance	Cyd	587
Conc Pavt, Ovly, Misc, Finishing and Curing, High Performance	Syd	3520
Cold Milling Conc Pavt	Syd	3520
Pavt Repr Operation	Syd	500

Subsequent steps are as follows:

1) A regional weighted average unit price for projects in the last 24 months is determined first.

2) If a regional price cannot be determined, a weighted statewide average price is calculated.
3) Finally, items with no bids in the last 24 months are prorated, and when applicable, averaged using both sides of the thickness (for example), first on a regional basis, then on a statewide basis.

When a unit price without a bid history (e.g. stabilized bases) is required in order to complete an LCCA, MDOT reserves the right to use current market prices or other information to estimate a unit price. Once actual bid history is established, the preceding steps will be followed to estimate a unit price for use in future LCCAs.

E. Real Discount Rate

A five-year average of the 30-year real discount rates is calculated and used in LCCA calculations, using the yearly rates obtained from the Federal Office of Management and Budget Circular A-94. It is updated yearly, usually in January. For information on the current rates, see https://www.whitehouse.gov/omb/information-for-agencies/circulars/.

F. Maintenance Costs

Published maintenance costs will be inflated using the annual Producer Price Index (PPI), using the procedure explained via the example below:

1) Assume that the latest published maintenance costs were all in 2007 dollars and are to be inflated to 2009 dollars.
2) The annual PPI for 2007 was 195.5, and 205.2 for 2009.
3) The percent increase is calculated by: (205.2/195.5) – 1 * 100% = 4.96%.
4) All the 2007 published maintenance costs would be inflated by 4.96% to bring them into 2009 dollars.

If the index decreased, costs would be deflated accordingly.

The PPI for “material and supply inputs to highway and street construction” (BHWY) was utilized until mid-2010 when it was discontinued. The Bureau of Labor Statistics (BLS) replaced it with the “other nonresidential construction” index (BONS). In late 2014, BLS created a new index: “inputs to highways and streets, excluding capital investment, labor, and imports” (listed at BLS as: WPUIP231231). All three indices must be utilized in combination for future updates. The new index will be correlated with the old indices in order to properly inflate maintenance costs to present day dollars.

Published maintenance costs will be inflated in conjunction with LCCA process updates described in section A of this chapter. In years when the pavement preservation strategies are updated, inflation of costs will be included as part of the process to incorporate new data.

G. CO3 Inputs

The user costs per hour for cars and trucks are updated following the method presented in Federal Highway Administration publication number FHWA-SA-98-079, titled *Life-Cycle Cost Analysis in Pavement Design*. Yearly updates of these costs are performed by MDOT, by using the latest yearly Consumer Price Index (CPI), which is usually published in mid-January by the United States Department of Labor, Bureau of Labor Statistics.

The user cost per mile for cars (also vans, pickups, and panel trucks) is the Internal Revenue Service (IRS) standard mileage rate for business travel. Normally this value is updated once per year, but depending on the stability of fuel prices, the IRS may update this value anytime throughout the year, in which case CO3 would be updated as well.

For tractor-trailer trucks, an operating cost per mile was calculated from the 2003 Motor Carrier Annual Report (the latest available data) and is annually indexed into present day dollars using the CPI.

The latest cost values, as well as other CO3 information, can be found on MDOT's CO3 webpage:

- http://www.michigan.gov/mdot/0,4616,7-151-9625_54944-227053--,00.html

CHAPTER 7. DEFINITIONS

APAM – Asphalt Pavement Association of Michigan.

ASCRL – Asphalt Stabilized Crack Relief Layer.

Capital Preventive Maintenance – "Preventive maintenance is a planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves, retards future deterioration and maintains or improves the functional condition of the system without (significantly) increasing structural capacity." Preventive maintenance is applied to pavements having a remaining service life of three years or greater. Examples of capital preventive maintenance include HMA crack sealing, chip sealing, micro-surfacing, concrete joint resealing, concrete crack sealing, thin HMA overlays, diamond grinding, full depth concrete repairs, and dowel bar retrofit.

Composite Pavement – A pavement with an HMA surface that is placed on a concrete pavement, or a concrete surface placed on an HMA pavement.

Concrete Pavement – A pavement with a Portland cement concrete surface that is placed on either a granular, aggregate or stabilized base.

Design Life – The anticipated life of the pavement section at the time of initial construction. Design life, as fix life, does not include any additional life estimates provided by anticipated future preventive maintenance. This term is also used to define the number of years for which design Equivalent Single Axle Loads are calculated as an input parameter for formal pavement design calculations.

Distress Index (DI) – An index that quantifies the level of surface distress that exists on a pavement section based on 1/10-mile increments. The scale starts at zero and increases numerically as distress level increases (pavement condition worsens).

Equivalent Single Axle Load (ESAL) – Standard form of measurement used in pavement design to describe the damage caused by one pass of an 18,000-pound load.

Equivalent Uniform Annual Cost (EUAC) – a value that represents the sum of all present value costs as if they were to occur uniformly throughout the analysis period.

Fix Life – The anticipated pavement life provided by the fix, excluding any future preventive maintenance treatments.

HMA Pavement – A pavement with a Hot Mix Asphalt surface that is placed on either a granular, aggregate or stabilized base.

International Roughness Index (IRI) – A statistic used to estimate the amount of roughness in a measured longitudinal profile (for the pavement surface). IRI is computed from a single longitudinal profile using standardized simulation of a passenger vehicle's suspension motion (The Golden Car). IRI is commonly reported with units of in/mi or m/km, with a value of 0 equaling perfection.

Life Cycle Cost Analysis (LCCA) – An economic analysis method that evaluates the long-term costs of an investment alternative. The method can be used to compare the relative costs of various investment alternatives.

MCA – Michigan Concrete Association.

Poor Pavement – A pavement with an RSL of 0 to 2 years and/or an IRI of 170 or greater.

Reconstruction – Typically removes and replaces the entire pavement structure. Sometimes the aggregate materials may be left in place and incorporated in the new pavement structure. Reconstruction projects have a design life of twenty years or more. This fix is typically applied to pavements with a remaining service life of two years or less.

Rehabilitation – A fix that improves, salvages, and/or reconditions an existing pavement. Rehabilitation fixes are typically applied to pavements with a remaining service life of two years or less. These fixes include: two or three course HMA overlays, concrete patching & diamond grinding, crush & shape with HMA overlay, rubblize & multiple course HMA overlay, and concrete overlays.

Remaining Life – The remaining service life of a pavement alternative at the end of the life-cycle analysis period. Remaining life is applied as a monetary credit based on a straight line depreciation of the initial construction and future maintenance costs.

Remaining Service Life (RSL) – The estimated number of years, from a specified date in time, until a pavement section is projected to reach a DI of 50. RSL is a function of project history and projected growth of pavement surface distress.

Service Life (Analysis Period) – The anticipated life of a rehabilitation or new/reconstruction, including additional pavement life provided by anticipated future preventive maintenance. This term is used to describe the number of years from the initial new construction, reconstruction or rehabilitation of a pavement to a subsequent rehabilitation or reconstruction. Analysis period is the term typically used to describe the time used in a life cycle cost analysis, over which all costs are evaluated.

REFERENCES

Life Cycle Cost Analysis in Pavement Design, Federal Highway Administration Publication No. FHWA-SA-98-079, 1998.

AASHTO Guide for Design of Pavement Structures, American Association of State Highway and Transportation Officials, 1993.

DARWin Version 3.01, American Association of State Highway and Transportation Officials, 1997.

AASHTO Mechanistic-Empirical Pavement Design Guide, American Association of State Highway and Transportation Officials, 2020.

AASHTOWare Pavement ME Design Version 2.3, American Association of State Highway and Transportation Officials, 2016.

Michigan DOT User Guide for Mechanistic-Empirical Pavement Design, Interim Edition, Michigan Department of Transportation, August 2020.

Construction Congestion Cost (CO3), Robert I. Carr, University of Michigan, 1997.

OMB Circular Number A-94, Federal Office of Management and Budget, 1999.

LCCA CONTACTS IN PAVEMENT OPERATIONS

Title	Phone Number
Pavement Management Engineer	517-636-4928
Lead Pavement Design Engineer	517-636-6006
Pavement Design Engineer	517-636-4920
Pavement Performance & Selection Engineer	517-636-4966
Pavement Analyst	517-636-4952
Pavement Engineer	517-636-5730

APPENDIX A: LCCA PRODUCTION RATES

In Table A-1 below, the HMA and concrete paving production rates were reviewed and modified in 2018/2019, while all other rates are the result of the 2009/2010 LCCA Technical Agenda.

Table A-1: LCCA Production Rates

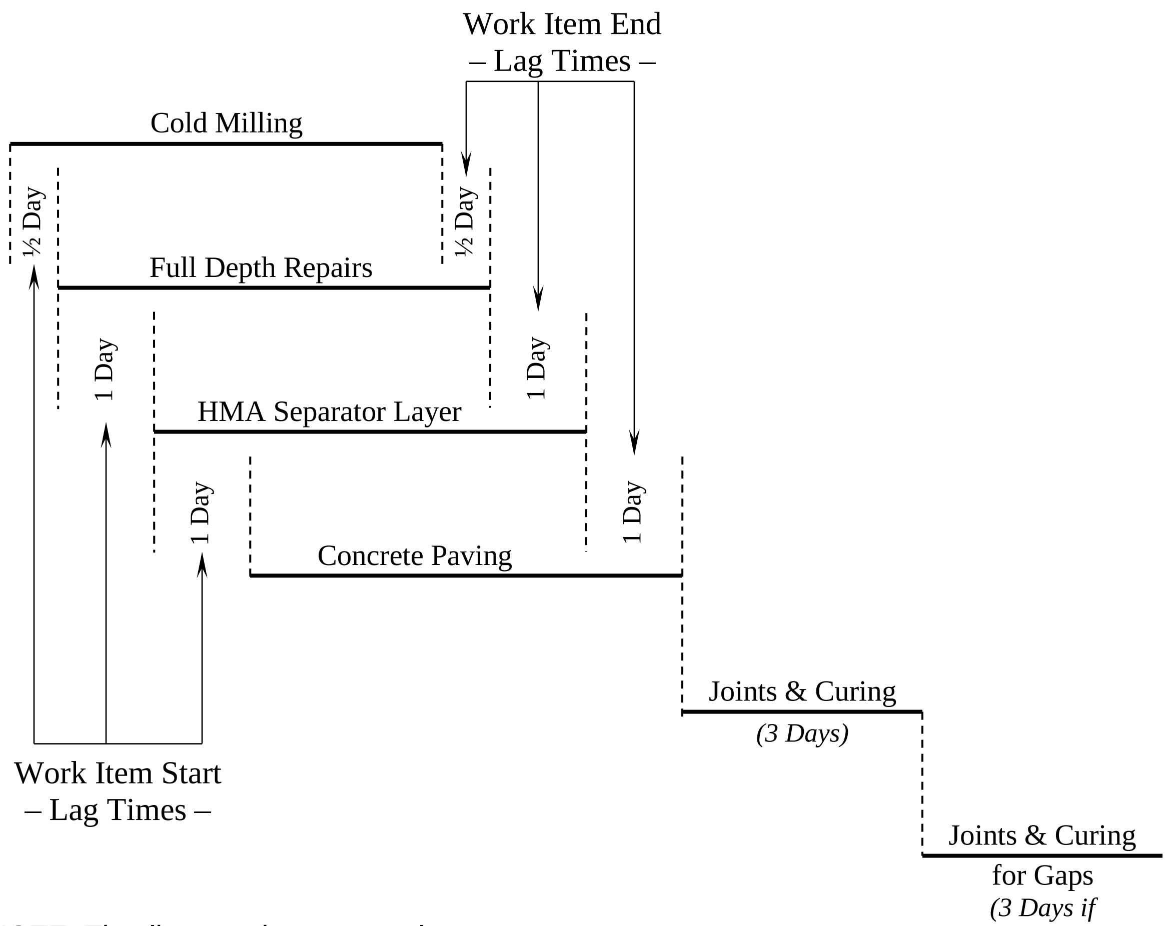
Work Items	Units	Freeway LCCA Rates	Non-Freeway LCCA Rates
Embankment, CIP Excavation, Earth Subbase Reuse, CIP Subbase, CIP	Cyd/day	3000	2700
Aggregate Base Open-Graded Drainage Cse Stabilized Bases	Syd/day	5200	4700
Aggregate Base Conditioning	Syd/day	7900	7100
Geotextile Separator	Syd/day	6100	5500
Rubblized Pavt Operation	Syd/day	7100	6400
HMA Base Crushing and Shaping	Syd/day	12000	10800
Underdrain Installation	Ft/day	4900	4400
Cold Milling HMA Surface	Syd/day	8500	7600
Pavt Joint and Crack Repr, Det 7 Pavt Joint and Crack Repr, Det 8	Ft/day	700	600
Hand Patching	Tons/day	700	600
HMA Separator Layer	Syd/day	41800	36400
HMA Paving	Tons/day	2300	2000
Concrete Paving	Cyd/day	2000	1100
Conc Pavt, Ovly, Furnishing and Placing	Cyd/day	2200	1900
Pavt Repr Operation	Syd/day	800 (6′ repair) 500 (4′ repair)	700 (6′ repair) 450 (4′ repair)

Note: HMA and concrete paving production rates will be reduced by 70% for freeway projects, and 80% for non-freeway projects, in areas of miscellaneous paving.

APPENDIX B: SAMPLE SIMPLIFIED LINEAR SCHEDULES

The following are examples to demonstrate the work item relationships and lag times as described in the manual, and are meant to cover only the main ideas, not every situation. Work item end lag times could be longer than those shown, when the number of days to build a certain item exceeds the minimum lag time shown. In practice, the number of days to build a certain item may need to be extended to meet the minimums, which means there will be a certain amount of "float" for that particular item in the schedule. Finally, for concrete paving on non-freeways, an additional three days of joint sawing/sealing and cure time per applicable stage to address paving gaps and repaving for access management will be included in the simplified linear schedule.

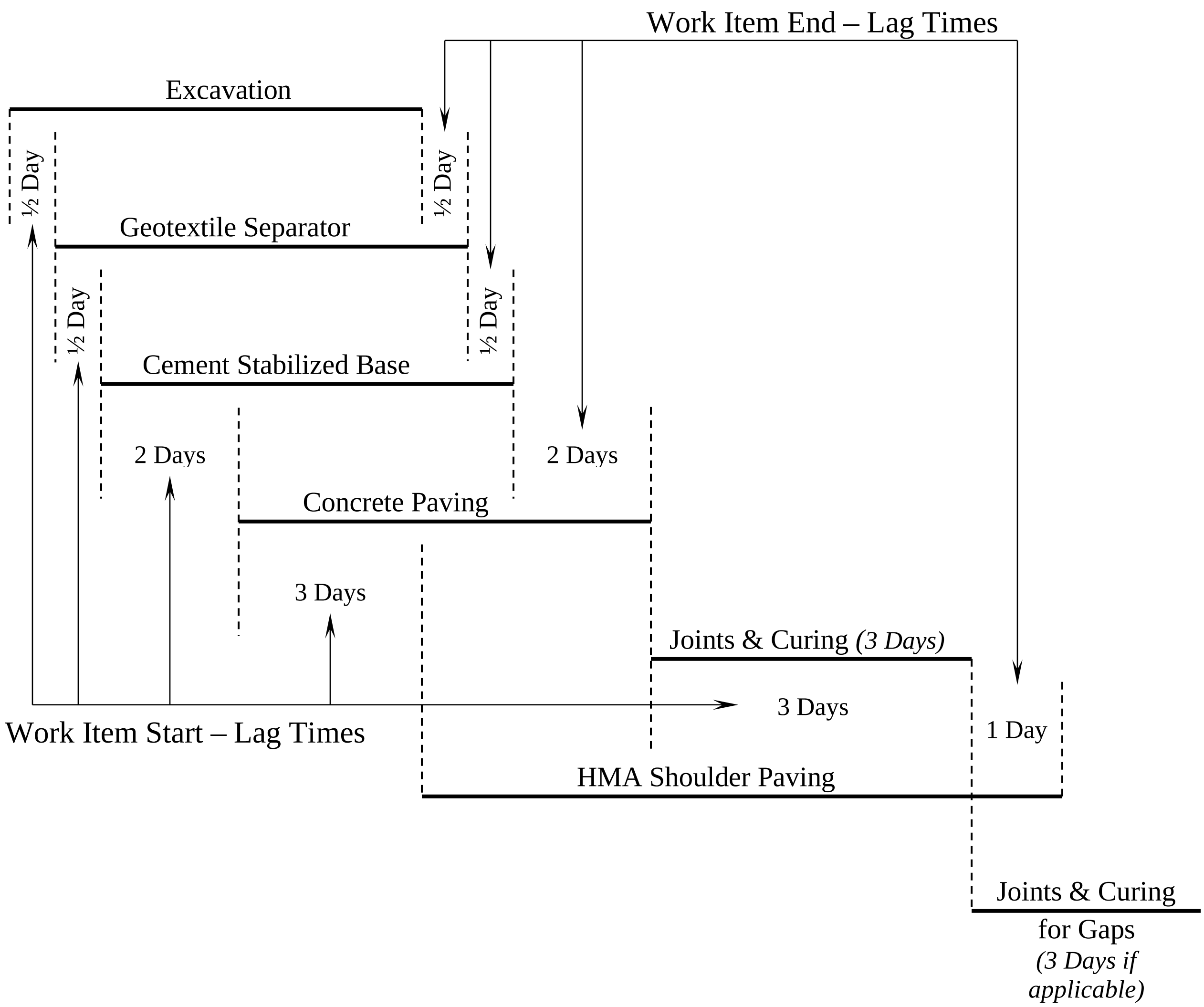
Figure B-1. Unbonded concrete overlay example: starting with cold-milling of the existing composite pavement, followed by full depth repairs, etc.



NOTE: Timeline not drawn to scale

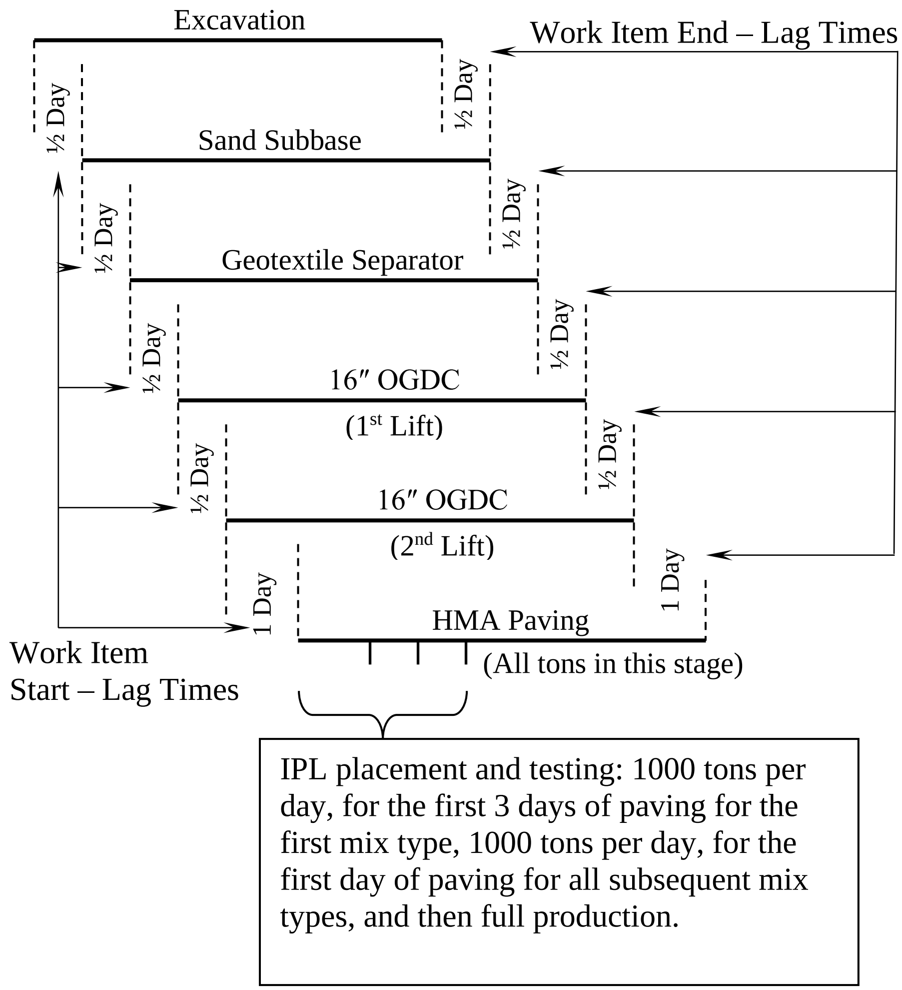
<u>Float Example</u>: if Full Depth Repairs take 3 days, but Cold Milling takes 5 days, then there are 2 days of "float" for Full Depth Repairs so that it can meet minimum work item start and end times. So, the Work Item Start Lag Time for Full Depth Repairs could be up to 2 ½ days instead of ½ day.

Figure B-2. Concrete reconstruction on a stabilized base example: re-using the existing sand subbase and placing HMA shoulders



NOTE: Timeline not drawn to scale

Figure B-3. HMA reconstruction in Metro example: placement of 16″ of OGDC, plus paving of the HMA Initial Production Lots



NOTE: Timeline not drawn to scale

APPENDIX C: PAVEMENT MODIFICATIONS IN LCCA VERSUS DEMONSTRATION PROJECTS

To further clarify and define how project level enhancements are incorporated into a Life Cycle Cost Analysis (LCCA) (MCL 247.651h) or the Pavement Demonstration Program (MCL 247.651i), the Michigan Department of Transportation (MDOT), in partnership with the paving industry groups of Michigan, have developed this summary. When project level pavement related modifications that differ from a typical MDOT design are considered, they may or may not be accounted for in LCCA, or the project may be added to the Demonstration Program. To determine this distinction, recommended definitions and divisions are further outlined as follows:

A. <u>Pavement Modifications</u>: These projects incorporate a different construction practice, changes in specifications, or unique modifications to the pavement structure, with the aim of improved cost-effectiveness and/or performance of the pavement, and which may eventually be rolled into standard practice.
   1. Examples:
      i. Current pavement & construction examples include those projects using:
         a. Stabilized Base Course
         b. Stone Matrix Asphalt (SMA)
         c. Alternate Dowel Bar Materials
         d. Alternate Cements
         e. PCC Joints: Seal or No Seal
         f. Drainage Changes
         g. Alternate Aggregate Specifications
         h. Fiber Addition to the Paving Mix
         i. Transverse Joint Spacing Changes
         j. Surface Texture Specifications
         k. Alternate spacing/location of dowel bars
         l. Two-Lift Concrete Pavement Construction
      ii. The following examples of past modifications are now part of standard practice or are permissive use items and will not be considered as a modification or Demonstration Project.
         a. Regression of Air Voids
         b. Material Transfer Device (MTD)
         c. Warm-mix Asphalt
         d. Rubber Modified Asphalt
         e. Recycled Shingles
         f. Echelon Paving
         g. Modified PG Binders
         h. Widened outside lane (i.e. 14′ lane)

2. If the LCCA EUAC difference between the standard pavement alternatives is greater than 10% then MDOT can make whatever modifications it deems necessary to the low-cost alternative for that project.
3. Modifications that increase the Initial Construction Cost of the standard LCCA greater than 5%, but less than or equal to 10%, will be included in the LCCA. Modifications that increase the Initial Construction Cost of the standard LCCA greater than 10% cannot be included in the project. A completed LCCA would be reevaluated if a modification of this type were added later in the project. Prices not yet available from previous projects will be estimated by MDOT pavement specialists and industry groups.
4. For modifications that increase the Initial Construction Cost of the standard LCCA less than or equal to 5%, these can be included in the project with no separate/additional costs being included in the LCCA, but the standard LCCA unit prices would be used.
5. If the project qualifies as an Alternate Pavement Bidding (APB) project, the inclusion of a modification would need to be evaluated by CFS staff. If approved by CFS, this would be presented to the Engineering Operations Committee (EOC) for their consideration. If a modification cannot be included equivalently for both alternatives, then the Region will need to decide which is preferred: a project level modification or APB; one or the other, not both. If the Region chooses a modification (over APB), then a request to use that modification and waive APB must be brought to the EOC for their consideration and approval. If the Region determines that a modification is desired after APB has been approved by the EOC, then this process would start over again, beginning with the CFS evaluation of the proposed modification.
6. MDOT pavement specialists and managers will continuously evaluate pavement modifications for their inclusion into standard practice and reevaluate all modifications at least every 4 years during the LCCA process review. This group may make recommendations to move a pavement modification into standard practice. At the discretion of MDOT staff, approval may or may not be required by the EOC. After implementation, costs for pay items involving the modification will be added to the standard LCCA unit prices to be included in future LCCAs.
7. Before a design modification is rolled into standard practice, or allowed permissively, the cost of these modifications will be evaluated on a project-by-project basis to determine whether or not to include them in the standard LCCA unit prices. All standard, (non-modified) pay items will be evaluated for inclusion in the standard LCCA unit prices. Any performance benefits will be rolled into the regular performance curves over time.
8. Modifications will be recorded. MDOT pavement specialists will evaluate on a project-by-project basis whether a project that includes a modification be included on the standard performance tracking list or be maintained on a separate list.

B. <u>Demonstration Projects</u>: These projects are those with larger modifications that are made to a pavement and/or its structure with the aim of improved cost-effectiveness, performance of the pavement and/or new construction methods. Additionally, these projects may come with a greater potential risk. These may eventually be rolled into standard practice, with the goal of producing a unique LCCA performance curve based on the actual performance of the demonstrated aspect. However, a population for each demonstrated aspect needs to first be built and then its performance evaluated.

1. Current and past examples include those projects using:
   i. Perpetual Pavement
   ii. Hot In Place Recycling
   iii. Pre-cast Concrete Pavement (not pre-cast patches)
   iv. Cold In Place Recycling
2. As long as the project has over $1.5M in paving costs, per MCL 247.651h, these types of projects would not require an LCCA, but would fall under the Demonstration Program legislation, and all its requirements.
3. Unit prices for demo projects will be evaluated on a project-by-project basis to determine their inclusion in the standard LCCA unit prices.
4. As long as these projects are under the Demonstration Program umbrella, they would not be eligible for APB.

C. Both: Some projects may fall into either category. These projects would require further evaluation and determination by the Department, early in the design process.

1. Current examples include those projects using:
   i. Thickness Changes (pavement and/or base/subbase)
   ii. Fabrics / Geotextiles
   iii. Subgrade stabilization
2. These types of modifications may or may not be included in the LCCA, depending on the scope of the modification, and will be evaluated on a project-by-project basis.
   i. If a modification is proposed to solve a unique, project specific need, then it would be accounted for in the LCCA, and in the pavement design methodology, if possible. These unique, project-level modifications will be evaluated on a project-by-project basis to determine whether or not to include them in the standard LCCA unit prices. (E.g. a project location has poor subgrade soils, so the Region proposes subgrade stabilization or some form of geo-grid geotextile, in lieu of subgrade undercutting. The pavement design method would take this into account and additional costs would be included in the LCCA.)
   ii. Other non-project specific scenarios would need to be evaluated to determine if the modification would cause the project to fall under the Demonstration Program legislation, and all its requirements.