State of Georgia

Department of Transportation

Pavement Type Selection Manual

Pavement Type Selection Manual

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Atlanta, Georgia 30308

GDOT Georgia Department of Transportation

This document was developed as part of the continuing effort to provide guidance within the Georgia Department of Transportation in fulfilling its mission to provide a safe, efficient, and sustainable transportation system through dedicated teamwork and responsible leadership supporting economic development, environmental sensitivity and improved quality of life. This document is not intended to establish policy within the Department, but to provide guidance in adhering to the policies of the Department.

Your comments, suggestions, and ideas for improvements are welcomed.

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The Georgia Department of Transportation maintains this printable document and is solely responsible for ensuring that it is equivalent to the approved Department guidelines.

Revision History

Revision Number	Revision Date	Revision Summary
1.0	1/3/19	Original Manual
1.1	5/15/19	Chapter 1 - Fixed references to chapter 10 which does not exist. Removed an underline that was an error. Revised the wording for the Pavement Evaluation definition to better reflect where guidance is found. It previously referenced chapter 9 and an appendix from when the PTS manual was in the Pavement Design Manual. Chapter 3 - Formula 3.4 was revised to the correct formula

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List of Effective Chapters

Document	Revision Number	Revision Date
List of Effective Chapters	1.1	5/15/19
Table of Contents	1.0	1/3/19
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Chapter 1. Pavement Type Selection Process - Contents

Chapter 1. Pavement Type Selection Process

The selection of pavement type, preservation treatments, and rehabilitation alternatives is a key part in establishing and maintaining a robust Pavement Management Program. The Georgia Department of Transportation has developed a Pavement Type Selection Process to systematically and objectively combine the engineering and economic principles required to reach a sound, well-reasoned decision. This Chapter will discuss the methods and policies incorporated into the Pavement Type Selection Process. This Process is based on the policies, principles, guidance, and methods promulgated and supported by the Federal Highway Administration, National Highway Institute, General Accounting Office, and Office of Management Budget.

1.1 Definitions

1.1.1. Analysis Period

Analysis Period is the length of time for which an LCCA is conducted for economic analysis of the various alternate pavement types under consideration. According to the September 1998 FHWA Bulletin, the LCCA analysis period should be sufficiently long to reflect the long-term cost differences associated with the design strategies. The analysis period shall be long enough to incorporate at least one rehabilitation activity for each alternative. Regardless of the analysis period chosen, the analysis period shall be the same for all alternatives.

For projects requiring LCCA per 2.1, a 40 year analysis period is appropriate.

1.1.2. Decision Factor

A Decision Factor (DF) is a criterion such as Initial Cost that is used in scoring the proposed Pavement Alternatives.

1.1.3. Decision Matrix

The Decision Matrix (DM) is a multi-criteria analysis matrix that uses LCCA results in the Pavement Type Selection process. The DM is used to evaluate possible pavement alternatives using several criteria. Each pavement alternative is scored and ranked, and the recommended alternative is based on the final score which is a maximum of 100.

1.1.4. Design Period

Design Period is the period of time of anticipated traffic volumes and vehicle mix that is used to determine the base and pavement thicknesses. GDOT uses a design period of 20 years for both rigid and flexible pavements.

1.1.5. Discount Rate

Discount rates are used to convert future expenditures into equivalent current costs. Real discount rates reflect the true value of money with no inflation premium and should be used in conjunction with non-inflated cost estimates of future investments.

Because discount rates can significantly influence the analysis results, LCCA should use a reasonable discount rate that reflects historical trends over a long period of time. Higher discount rates typically favor lower initial costs and higher future costs. Lower discount rates do the opposite. According to Publication No. FHWA-SA-98-079 (1998), long-term trends for real discount rates hover around 4 percent, 3 to 5 percent is an acceptable range and is consistent with values historically reported in Appendix A of OMB Circular A-94.

1.1.6. Life Cycle Cost Analysis

Life Cycle Cost Analysis (LCCA) is an economic analysis tool that compares alternate pavement designs, which typically include asphalt and concrete pavement types for a given project. LCCA compares the associated costs, including future maintenance and rehabilitation costs, over an Analysis Period for each alternate pavement type.

A LCCA considers at least two viable alternate pavement designs and may incorporate user costs as a result of construction, maintenance, and repair work for each proposed design alternate being evaluated.

1.1.7. Maintenance Projects

Maintenance projects consist of those actions necessary to keep an existing highway facility in good condition.

1.1.8. Net Present Value

Net Present Value (NPV) is the discounted monetary value of expected net benefits (i.e., benefits minus costs). NPV is computed by assigning monetary values to benefits and costs, discounting future benefits ($PV_{benefits}$) and costs (PV_{costs}) using an appropriate discount rate, and subtracting the sum total of discounted costs from the sum total of discounted benefits.

Discounting benefits and costs transforms gains and losses occurring in different time periods to a common unit of measurement. Programs with positive NPV value increase social resources and are generally preferred. Programs with negative NPV should generally be avoided. There is fairly strong agreement in the literature that NPV is the economic efficiency indicator of choice. NPV is discussed in detail in section 3.1.

1.1.9. New Construction Projects

New Construction Projects are construction projects intended to add new capacity to the entire network by adding new facilities.

1.1.10. Pavement Design

Pavement Design is the process of selecting a combination of materials of known strengths and thickness able to withstand and support the anticipated lifetime loadings.

The pavement is designed to perform under the site specific geotechnical, environmental, and traffic conditions.

1.1.11. Pavement Evaluation

A Pavement Evaluation is the systematic investigation of the structural and functional condition of an existing pavement. Pavement Evaluations are needed when the existing pavement or portions thereof are proposed to be utilized in the final construction. GDOT's guidelines for requesting Pavement Evaluations are outlined in Chapter 6 of the Plan Development Process.

1.1.12. Pavement Type Selection

The Pavement Type Selection is a decision support process evaluating a variety of materials (typically, asphalt and concrete), pavement designs, construction and maintenance practices, and Life Cycle Cost Analysis (LCCA) to model the cost of pavement alternatives during the Analysis period.

The differing pavement types considered have different rehabilitation timings and costs during the Analysis Period. Each alternative is scored and ranked using the Decision Matrix. This ranking and scoring completes the analysis part of the Pavement Type Selection.

1.1.13. Rehabilitation Projects

Rehabilitation projects are construction and maintenance resurfacing projects in which the existing pavements are in need of a treatment or upgrade to restore the pavement to an acceptable level of serviceability.

1.1.14. Serviceability Level

Pavement quality will deteriorate over its service life. GDOT uses an initial serviceability level of 4.5 for rigid pavements and 4.2 for flexible pavements with a terminal serviceability level of 2.5 (AASHTO 1972) for all permanent pavement types.

1.1.15. Reconstruction Projects

Reconstruction Projects typically involve substantial structural repairs to an existing highway pavement within the same general right-of-way corridor. Treatments generally require full removal and replacement and/or improvement of the existing pavement structure which includes subbase, based course, and surface course due to pavement condition and structural capabilities.

1.1.16. Widening Projects

Widening Projects are construction projects intended to add capacity to an existing facility. In many parts of the country, roads that were originally constructed in the early 20th century as two-lane farm-to-market roads have been reconstructed over the past few decades into multilane divided arterials to better accommodate the travel demands generated by suburban development. Widening projects may involve making substantial modifications horizontal and vertical alignment in order to eliminate safety and accident problems.

Chapter 2. Life Cycle Cost Analysis (LCCA) - Contents

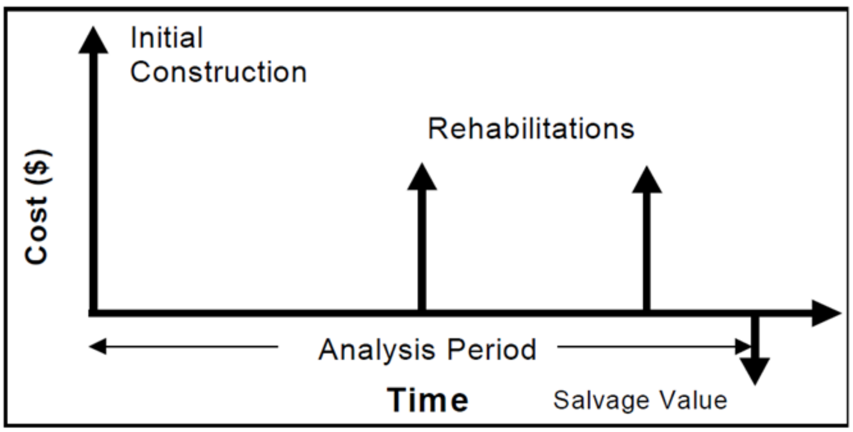
Chapter 2. Life Cycle Cost Analysis (LCCA)

This section provides information on LCCA for pavement alternatives. Guidelines for when a LCCA is required are included. A discussion of deterministic and probabilistic life cycle cost analysis is included as well as typical analysis procedures, inputs, and evaluation of alternatives.

According to the September 1998 FHWA Interim Technical Bulletin (FHWA-SA-98-079) entitled "Life-Cycle Cost Analysis in Pavement Design - In Search of Better Investment Decisions," the FHWA position on LCCA is that it is a decision support tool, and the results of LCCA are not decisions in and of themselves. The FHWA encourages the use of LCCA in analyzing all major investment decisions where such analyses are likely to increase the efficiency and effectiveness of investment decisions.

LCCA techniques are typically considered when making decisions regarding pavement type selection and determination of appropriate pavement design or pavement rehabilitation strategies. In addition to a LCCA, other factors including, but not limited to, expected life, annualized agency costs and constructability, are also taken into consideration as a decision basis for pavement type selection. An LCCA sample Pavement Life Cycle model showing routine maintenance activities and major Rehabilitations is shown in Figure 2.1 below.

Figure 2.1: Sample Pavement Life-Cycle Model



Source: FHWA LCCA Interim Technical Bulletin

2.1. Projects Requiring LCCA

The LCCA is a tool to aid in the selection of a project's pavement type. A LCCA shall be required for the following project types:

- New location projects.
- Full-depth pavement reconstruction projects as supported by a Pavement Evaluation Study.
- Widening projects where the new lanes are physically separated from existing pavement being retained.

A LCCA may be performed on other projects as determined by the Design engineer or the State Pavement Engineer. LCCA should be performed early in project development to support the Pavement Type Selection process.

Life Cycle Cost Analysis and Pavement Type Selection are not required on the following types of projects:

- Flexible Pavements
    - Traditional single lift overlay or mill and inlay maintenance projects.
- Rigid Pavements
    - Interchange Ramps
    - Roundabouts

2.2. LCCA Methods

Two approaches to LCCA may be employed - deterministic and probabilistic. Traditional LCCA procedures utilize deterministic analysis procedures, with input factors expressed as single "fixed" values without regard to the variability.

These procedures are appropriate when the input factor variables (such as unit costs or timing of rehabilitation) are reasonably well known. However, sensitivity of the results to the input variables should be checked by adjusting the input variables to the high and low end of their expected values, such as best-case and worst-case scenarios, recalculating the life cycle cost and re-evaluating the results.

Deterministic procedures are appropriate when one alternative appears to have a clear economic advantage over other alternatives under both best-case and worst-case scenarios. An example of this is when Alternative A has a lower life cycle cost than Alternative B even when the input variables are chosen to handicap Alternative A and favor Alternative B.

This concept of sensitivity can be taken one step further by performing a probabilistic LCCA. Probabilistic LCCA is an approach involving risk analysis and is considered good practice by FHWA. This process involves Monte Carlo simulation to incorporate variability of the LCCA inputs.

This technique is encouraged when there is a considerable amount of uncertainty in the input variables or when it is desirable to obtain a probability distribution of the results. This technique is also appropriate when the favored alternative in a deterministic analysis switches depending on the values used for the input variables.

The probabilistic approach to LCCA is documented in a FHWA September 1998 Interim Technical Bulletin entitled ”Life Cycle Cost Analysis in Pavement Design - In Search of Better Investment Decisions”. This document will be referred to hereinafter as the September 1998 FHWA Bulletin. Please refer to this manual for a detailed explanation of the procedure.

GDOT uses the FHWA provided spreadsheet tool Real Cost for the economic analysis. Real Cost is supported by FHWA and is readily available to consultants and industry.

2.3. General Approach to LCCA

When a LCCA analysis is applicable, the analysis should be conducted as early in the project development cycle as possible. The level of detail should be consistent with the level of investment. The general approach to a life cycle cost analysis is described in the following steps:

- Develop the new construction or pavement reconstruction alternatives to be considered.
- Determine the length of the analysis period and the discount rate.
- Determine the performance periods and sequence of rehabilitations for each alternative over the length of the analysis period.
- Determine the agency cost for each alternative and rehabilitation strategy.
- Evaluate user costs for each strategy (if appropriate).
- Compute Net Present Value (NPV) for each alternative.
- Review and analyze the results.
- Adjust input variables and re-run the analysis to determine the sensitivity of the results to the input variables (best-case / worst-case scenarios).
- Use the data to assist in selecting the appropriate alternative.

The September 1998 FHWA Bulletin recommends that costs be estimated in constant or nominal dollars and discounted to the present using a real discount rate. This combination eliminates the need to estimate and include an inflation premium for both cost and discount rates.

According to the September 1998 FHWA Bulletin, Net Present Value (NPV) is the economic efficiency indicator of choice. The Equivalent Uniform Annual Cost (EUAC) indicator is also acceptable, but should be derived from the NPV. Both indicators should be calculated for GDOT projects. This will enable the decision-makers to compare the annual costs and determine maintenance costs could affect the results.

2.4. Analysis Period

GDOT uses an Analysis period of 40 years. This Analysis period length satisfies the requirement that each alternative in the analysis include at least one major rehabilitation.

2.5. Discount Rates

GDOT uses a discount rate of 3%. The discount rate used by GDOT is based on the data published annually in the Office of Management and Budget Circular No. A-94, “Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs.” GDOT evaluates the 30-year Real Discount Rates in establishing a discount rate for use in LCCA. The table below includes data for the past thirty years and the 30-year average used to establish the currently used rate.

Table 2.1: Discount Rates

Year	3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
1988	3.5	4.2	4.7	5.1	- - -	5.6
1989	4.1	4.8	5.3	5.8	- - -	6.1
1990	3.2	3.6	3.9	4.2	- - -	4.6
1991	3.2	3.5	3.7	3.9	- - -	4.2
1992	2.7	3.1	3.3	3.6	- - -	3.8
1993	3.1	3.6	3.9	4.3	- - -	4.5
1994	2.1	2.3	2.5	2.7	- - -	2.8
1995	4.2	4.5	4.6	4.8	- - -	4.9
1996	2.6	2.7	2.8	2.8	- - -	3.0
1997	3.2	3.3	3.4	3.5	- - -	3.6
1998	3.4	3.5	3.5	3.6	- - -	3.8
1999	2.6	2.7	2.7	2.7	- - -	2.9
2000	3.8	3.9	4.0	4.0	- - -	4.2
2001	3.2	3.2	3.2	3.2	- - -	3.2
2002	2.1	2.8	3.0	3.1	- - -	3.9
2003	1.6	1.9	2.2	2.5	- - -	3.2
2004	1.6	2.1	2.4	2.8	3.4	3.5
2005	2.0	2.0	2.3	2.5	3.0	3.1
2006	1.7	2.6	2.7	2.8	3.0	3.0
2007	2.5	2.6	2.7	2.8	3.0	3.0
2008	2.1	2.3	2.4	2.6	2.8	2.8
2009	0.9	1.6	1.9	2.4	2.9	2.7
2010	0.9	1.6	1.9	2.2	2.7	2.7
2011	0.0	0.4	0.8	1.3	2.1	2.3
2012	0.0	0.4	0.7	1.1	1.7	2.0
2013	-1.4	-0.8	-0.4	0.1	0.8	1.1
2014	-0.7	0.0	0.5	1.0	1.6	1.9
2015	0.1	0.4	0.7	0.9	1.2	1.4
2016	0.3	0.6	0.8	1.0	1.2	1.5
2017	-0.5	-0.3	0.0	0.1	0.5	0.7
Average	1.94	2.30	2.54	2.78	2.14	3.20

Source: OMB Circular A-94, Appendix C

2.6. Establishing Strategies, Performance Periods and Activity Timing

Feasible and reasonable strategies must be established for initial construction and subsequent maintenance and rehabilitation. These strategies must be developed using the pavement design guidelines and methods currently adopted by GDOT.

Information on performance for various pavement strategies may be obtained from Pavement Management System (PMS) data, historical records, or experience. Similar projects in the area can also be reviewed to determine the expected life range for the analysis. If no other data is available, expert opinions should be gathered and documented supporting the expected performance period for the rehabilitation type.

2.7. Ranking of Alternatives

Following the completion of the LCCA analysis, GDOT ranks the alternatives using a multi- criteria analysis matrix. This methodology is adopted from NHI Course 131063 – Hot Mix Asphalt Pavement Evaluation and Rehabilitation. This matrix assigns weights to decision factors including the LCCA results, such as construction costs, maintenance costs, and user delay costs. The following list of other factors that may be considered include:

- Overall pavement management of network (policies).
- Future rehabilitation options and needs.
- Auto and truck traffic volume.
- Initial costs.
- Future maintenance requirements.
- Traffic control during construction (safety and congestion).
- Lane closure time.
- Construction considerations (duration of construction).
- Potential foundation problems.
- Availability of local materials and contractor capabilities.
- Municipal preference, local government preference, and recognition of local industry.

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Chapter 3. Project Costs - Contents

Chapter 3. Project Costs

3.1. Project Costs

The basic formula for computing NPV is:

$$NPV = PV_{benefits} - Pv_{costs} \qquad (3.1)$$

Since the benefits of keeping the roadway above some pre-established terminal serviceability level are the same for all design alternatives, the benefits component drops out and the formula reduces to:

$$NPV = C * \frac{1}{(1+i)^n} \qquad (3.2)$$

Where:

NPV = Net Present Value of future costs, $.

C = Future cost at time t = n, $.

i = Discount rate, expressed as a decimal.

n = Time at which future cost incurred; also analysis period, years.

3.2 Initial Project Construction Costs and Rehabilitation Costs

Agency costs include all costs incurred directly by the agency over the life of the project. These costs are typically dominated by initial construction costs but also include initial preliminary engineering, contract administration, and construction supervision costs. Unit costs will typically be determined by the GDOT bid price data on projects with quantities of comparable scale and geographic location.

For LCCA purposes, only pay items and costs that differ between alternatives are considered in the analysis. Quantities are based on project level input from the designer. Total quantities are used by the Estimating Unit in the Office of Engineering Services to provide project level unit prices.

The basic formula for computing the Initial Project Construction Cost is:

$$\sum U_p Q_p \qquad (3.3)$$

Where: U = unit cost

Q = quantity

p = pay item

3.3 Rehabilitation Intervals

GDOT requires smooth pavements as a deliverable after initial construction for all pavement types. The following cycles are commonly used for GDOT LCCA for a given pavement type. These cycles are based on published research that analyzed pavement performance data from the GDOT Pavement Management Systems.

Table 3.2: Pavement Rehabilitation Cycle

Pavement Type	Maintenance Rehabilitation Cycle
Asphalt	Every 14 years: 5% Deep Patching, Mill & Inlay
JPCP	Every 25 years: 5 % Slab replacement, Grind, Seal Joints
CRCP	Every 30 years: 2.5% Punch-out Repair

3.4 Maintenance Costs

Routine maintenance costs have only a marginal effect on NPV. These are hard to obtain, and are generally very small in comparison to initial and rehabilitation costs. Cost differences between maintenance strategies for two competing alternatives are usually insignificant, especially when discounted over the analysis period. Therefore, only major maintenance and rehabilitation costs will be considered in the analysis.

3.5 Annualized Agency Costs

The Annualized Agency Costs, also referred to as the Equivalent Uniform Annual Costs (EUAC), represents the NPV of all discounted costs and benefits of an alternative as if they were to occur uniformly throughout the analysis period. The preferred method of determining EUAC is to determine the NPV and then use the following formula to convert it to EUAC:

$$\text{EUAC} = \text{NPV} * \left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] \qquad (3.4)$$

Where:

EUAC = Equivalent Uniform Annualized Cost

NPV = Net Present Value of future costs, $.

I = Discount rate, expressed as a decimal.

n = Time at which future cost incurred; also analysis period, years.

3.6 Salvage Value

Salvage value is the prorated value of the most recent rehabilitation based on the remaining service life of the rehabilitation. The discounted salvage value is subtracted from the sum of the other cost values.

3.7 User Costs

This topic is referred to in detail in the September 1998 FHWA Technical Bulletin. User costs are the delay, vehicle operating, and crash costs incurred by users of the facility.

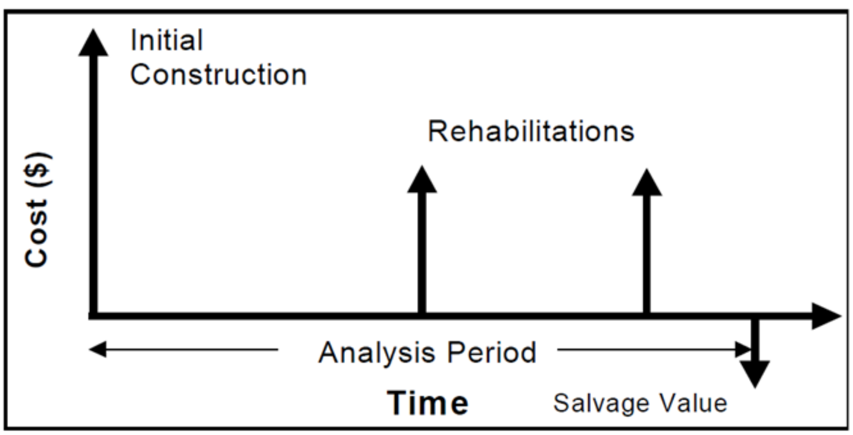
According to the September 1998 FHWA Bulletin, vehicle delay and crash costs are unlikely to vary among alternative pavement designs between periods of construction or maintenance. Although vehicle operating costs may vary between pavement design strategies, there is little research on quantifying such cost differentials under the pavement condition levels prevailing in the USA.

When work zone capacity exceeds vehicle demand of the facility, differences in user costs between pavement design strategies are considered insignificant. This is the typical case for GDOT projects.

User costs may become a significant factor when a large queue occurs on one alternative but not the others. For those projects in locations where one of the alternatives being considered will create a significant queue for an extended period of time either during initial construction or rehabilitation, a user cost analysis should be considered in addition to an agency cost LCCA. Agency costs and user costs shall be evaluated separately. The results shall not be added together at the end to provide one cost for a given alternative.

The above expenditures discounted to NPV, occur over the analysis period. They can be graphically represented on a diagram to help visualize the extent and timing of those expenditures. This diagram is called the Expenditure Stream Diagram. They are generally developed for each pavement design strategy. Figure 3.1 below depicts an expenditure stream for a pavement design alternative being considered for a typical project.

Figure 3.1 Typical Expenditure Stream



Source: FHWA LCCA Interim Technical Bulletin

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Chapter 4. Interpreting and Presenting Results - Contents

Chapter 4. Interpreting and Presenting Results

Once completed, the LCCA may be subjected to a sensitivity analysis to evaluate best-case and worst-case scenarios. The sensitivity analysis can be used to develop an understanding for the impact of variability of the individual inputs on the overall LCCA results.

A common situation is to evaluate the LCCA for various discount rates. Variations in unit costs or activity timing can also have a significant effect on the NPV. Summary tables or plots of NPV versus individual input variables are useful in interpreting these results. This information may also be included in the Pavement Type Selection Report.

In addition to LCCA, other issues shall be factored into the selection of a given alternative, including but not limited to:

- Initial construction agency costs and construction duration;
- Annualized agency costs;
- Annualized user costs;
- Schedule;
- Utilities and Maintenance;
- Traffic Staging and Maintenance; and
- Engineering judgement (incorporate the experience and input of others as necessary).

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Chapter 5. Pavement Type Selection Summary - Contents

Chapter 5. Pavement Type Selection Summary

The Pavement Type Selection Process consists of the following steps.

5.1 Field Engineering and Design

- Complete a Pavement Evaluation if existing pavement is being retained based on the proposed design, i.e., if the proposed roadway profile and cross sections show the existing pavement can be retained and incorporated into the final roadway.
- Develop pavement design alternates for comparison.
- Plan appropriate maintenance treatments at regular intervals for the various design alternates.

5.2 Economic Analysis

- Perform a LCCA comparing the proposed pavement design and maintenance strategies.
- Incorporate user delay costs as appropriate for all construction periods.

5.3 GDOT Decision Matrix

The GDOT Decision Matrix is the final step in the Pavement Type Selection Process. The Decision Matrix consists of key GDOT Decision factors:

- Construction and Future Rehabilitation Costs
- Duration of Construction and Rehabilitation Activities
- Annualized Costs
    - User Costs
    - Agency Costs
- Other factors from list in Section 2.7.

Each Decision Factor is assigned a weight.

- Weights are based on relative importance in the selection process.
- The sum of Decision Factor weights equals 100.

Each pavement alternative is scored and ranked and the alternative recommended is based on the final score.

Below are the typical Decision Factor weights used in the GDOT Decision Matrix:

- 55 --- Initial Construction Costs (Agency)
- 25 --- Rehabilitation Costs (Agency)
- 5 -----Annualized Costs (Agency)
- 5 -----Annualized Costs (User)
- 5 -----Initial Construction Duration

- 5 -----Duration of Rehabilitation Activities

Each Pavement Alternative is scored comparatively for each Decision Factor and a Scoring Factor is assigned; e.g. the lowest cost is assigned the highest score. The product of the Weighting Factors and the Scoring Factors for each Pavement Alternative are summed and the Pavement Alternatives are ranked.

Table 5.1 Example worksheet of a selection process incorporating multiple selected decision factors and assigned weightings.

	DECISION FACTORS							
Decision Factor Names	**Initial Cost**	**Life Cycle Costs**	**Expected Life**	**Ease of Repairing/ Maintaining**	**Construction Traffic Control**	**Proven Design in Agency**	**Total Score**	**Rank**
Weightings	25	15	20	15	10	15		
Alternative 1	60 / 15	60 / 9	100 / 20	80 / 12	90 / 9	100 / 15	80	1
Alternative 2	60 / 15	60 / 9	100 / 20	80 / 12	90 / 9	100 / 15	80	1
Alternative 3	60 / 15	60 / 9	70 / 14	50 / 7.5	60 / 6	40 / 6	57.5	4
Alternative 4	60 / 15	60 / 9	70 / 14	50 / 7.5	60 / 6	40 / 6	57.5	4
Alternative 5	60 / 15	40 / 6	100 / 20	80 / 12	100 / 10	90 / 13.5	76.5	3

The assignment of Scoring Factors is subjective and the following is guidance on assigning Scoring Factors. The Scoring Factor is a ratio that ranges from 0.00 to 1.00 and measures distributional differences in Decision Factors. The Scoring Factor is based on the optimum value for each Decision Factor. The optimum value can be either the minimum or maximum value depending on the Decision Factor. As an example, for a Decision Factor illustrating cost, the optimum value of the Decision Factor will be the minimum cost value. Furthermore, for a Decision Factor illustrating pavement life, the optimum value of the Decision Factor will be the maximum life value. The Scoring Factor for each Decision Factor is calculated as a ratio. This ratio is based upon the optimum value per Decision Factor. Thus, the pavement alternative with the optimum value will have the Scoring Factor of 1.00. All other pavement alternatives will have a Scoring Factor which will be proportioned based on its particular value to the optimum value and will be lower than 1.00.

Table 5.2: Sample Decision Matrix

Alternatives	Decision Factors						Total Score	Rank
	Initial Agency Construction Costs	Rehabilitation Costs	Annualized Agency Costs	Annualized User Costs	Initial Construction Duration	Duration of Rehabilitation Activities		
	55	25	5	5	5	5		
A	1.00 55.0	0.44 11.0	1.00 5.0	1.00 5.0	1.00 5.0	0.67 3.4	84.4	1
B	0.69 38.0	1.00 25.0	0.83 4.2	0.69 3.4	0.54 2.7	1.00 5.0	78.3	2

Using the Decision Matrix in Table 5.1 as an example, the Initial Construction costs for Alternative A is 1.35 million and the Initial Construction costs for Alternative B is 1.95 million. In this example, Alternative A has the optimal value when looking at Initial Construction Costs thus it receives as Scoring Factor of 1.0. All other Scoring Factors for the pavement alternatives being analyzed are based on the optimal value. The Scoring Factor for each Pavement Alternative is the ratio of that Alternatives value to the optimal value. The Pavement Alternative with the highest Total Score is generally selected as the preferred Pavement Alternative in the Pavement Type Selection process with exceptions noted below in 5.5.

5.4 Pavement Type Selection Guidelines

In general, pavement type selections should be based on the following guidelines and consultations between the Design Engineer and the Pavement Management Branch at OMAT.

<u>New Location/Full Depth Reconstruction/Separated Widening Projects</u>

- For projects requiring LCCA per 2.1 and the Decision Matrix shows “no clear preference,” where the highest and lowest final scores are separated by less than 10, then the project should proceed as an alternate bid pavement project without a material price bid adjustment.

<u>Rehabilitation projects (fair or better pavement condition)</u>

- If the existing pavement is flexible, then a mill and inlay is typically recommended based on traffic requirements and the findings contained in the Pavement Evaluation report.
- If the pavement is rigid, then selective slab or partial slab replacement, dowel bar retrofit, or other suitable rehabilitation technique is typically recommended.

<u>Widening projects (adjoining new/old pavements)</u>

- If the pavement on the existing lanes is in good or better condition, then the same pavement type should be used for the additional lane(s).
- If the existing pavement is in fair or worse condition, and if :

- The Existing Pavement is Flexible: then partial or full depth reconstruction would be considered, and the following two options are considered:
  - Partial depth reconstruction may be accomplished with an AC pavement.
  - If the mill depth is such that a rigid pavement may serve just as well, then a rigid pavement (overlay) may also be recommended.
  - Project constraints may favor one type over another.
- The Existing Pavement is Rigid:
  - A flexible or rigid overlay may be considered.
- The Existing Pavement is Composite:

  Based on the thickness and condition of the existing asphaltic concrete over the PCC pavement.
  - If the condition of the asphaltic concrete is fair or better, then mill and inlay is typically recommended with a depth determined by traffic volumes and the findings in the Pavement Evaluation report.
  - If the condition of the asphaltic concrete is poor or worse, then removal of the asphaltic concrete and replacement with 3 inches of 19 mm AC and a concrete overlay may be recommended to meet traffic needs.

References

Referenced Publications

This section includes reference information, descriptions of publications, and where available, links to referenced publications. Publications are listed alphabetically by source.

Federal Highway Administration (FHWA)

- **Life-Cycle Cost Analysis in Pavement Design – Interim Technical Bulletin (1998)**
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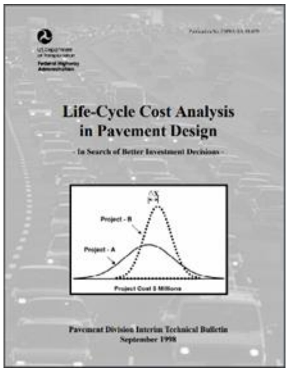

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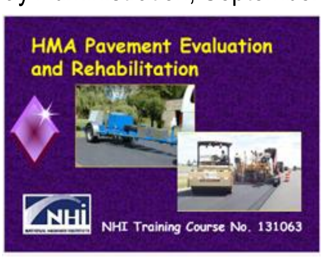

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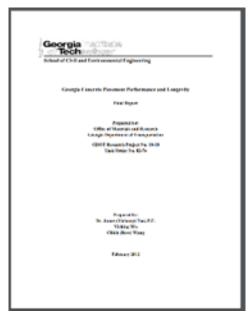

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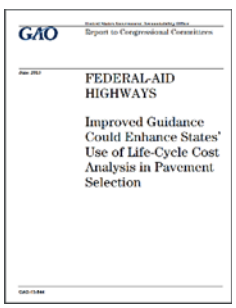
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Report to Congressional Committees

FEDERAL-AID HIGHWAYS

Improved Guidance Could Enhance States' Use of Life-Cycle Cost Analysis in Pavement Selection

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