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Guide for Pavement-Type Selection

TRANSPORTATION RESEARCH BOARD
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C O O P E R A T I V E   R E S E A R C H   P R O G R A M S

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ATTACHMENT

Guide for Pavement-Type Selection: Summary of Research Report

Introduction

Pavement-type selection is one of the challenging engineering decisions that highway administrators face today. They must balance issues of both short- and long-term performance with initial and long-term costs. The traveling public generally does not express strong feelings on the type of pavement constructed, as long as reasonable levels of service, safety, and ride quality are provided. However, highway administrators must deal with the competition that exists between the asphalt and concrete pavement industries. National Cooperative Highway Research Program (NCHRP) Project 10-75 was conducted to develop a rational process for pavement-type selection.

One of the earliest discussions about pavement-type selection was contained in *An Informal Guide on Project Procedures,* published by the American Association of State Highway Officials (AASHO) on November 26, 1960. The guide presented the following list of governing factors to serve as the basis of pavement-type selection:

> "To avoid criticism, if that is possible, any decision as to paving type to be used should be firmly based. Judicious and prudent consideration and evaluation of the governing factors will result in a firm base for a decision on paving type.
>
> A list of such factors comprises the following items:
>
> 1. Traffic.
> 2. Soils characteristics.
> 3. Weather.
> 4. Performance of similar pavements in the area.
> 5. Economics or cost comparison.
> 6. Adjacent existing pavements.
> 7. Stage construction.
> 8. Depressed, surface, or elevated design.
> 9. Highway system.
> 10. Conservation of aggregates.
> 11. Stimulation of competition.
> 12. Construction considerations.
> 13. Municipal preference, participating local government preference and recognition of local industry.
> 14. Traffic safety.
> 15. Availability of and adaptations of local materials or of local commercially produced mixes."

This list served as the basis for selection of pavement type on the Interstate system, as well as the basis for the guidance provided in the 1986 and 1993 editions of the AASHTO *Guide for Design of Pavement Structures.* The list is still relevant today and serves as a foundation for the *Guide for Pavement-Type Selection* prepared in this project. The development of the *Mechanistic–Empirical Pavement Design Guide* (MEPDG), pavement management systems, and extensive maintenance and rehabilitation (M&R) cost records makes the development of more rational and less subjective pavement-type selection procedures possible.

Research Objective, Scope, and Summary

The objective of NCHRP Project 10-75 was to develop a *Guide for Pavement-Type Selection.* The Guide includes processes for making decisions regarding pavement-type selection, for both agency-based and contractor-based type selection. This objective was accomplished in two phases. Work scope and findings are summarized in the following sections.

Phase I included (1) collecting and reviewing information relevant to pavement-type selection processes, (2) identifying and evaluating traditional and innovative processes for pavement-type selection, and (3) developing a plan for incorporating the best practices identified into a practical guide. Phase II utilized the findings of Phase I to develop, test, and illustrate the processes suggested for use in agency- and contractor-based pavement-type selection and then incorporated these processes into a Guide for Pavement-Type Selection.

Information on current pavement-type selection processes used by the state departments of transportation (DOTs) and international highway agencies was obtained through a questionnaire. In addition, state agency web sites were visited to review available policy documents. The questionnaire requested information on how certain factors (pavement performance life, discount rate, agency cost) were developed and other information that was not always apparent in the available published operational documents. Also requested was information on planned changes and ongoing research. Thirty-three state DOTs responded to the survey.

Because the questionnaires elicited limited data on design-build contractor pavement-type selection, additional searches were conducted to locate current research and review request for proposal (RFP) documents that had been issued by state DOTs.

A brief questionnaire also was sent to each of the states' flexible and rigid contractor paving associations requesting feedback on the pavement-type selection procedures used in their respective states.

The information gathered was reviewed, evaluated, and summarized. The initial work plan for developing the *Guide for Pavement-Type Selection* was updated based on this information and implemented in Phase II.

Summary of Findings

Table 1 lists state DOTs' responses regarding the use of pavement-type selection procedures.

Twenty-two of the 35 state DOTs responding have a formal type-selection process that requires the consideration of alternative pavement types on major new and reconstruction projects.

Table 1. State DOT pavement-type selection procedures.

State	Pavement Events Warranting Type Selection			Current Pavement-Type Selection Procedure			
	New Const	Re-Const	Rehab	Length Of Time Current Procedure Has Been Used, Years	Procedure Modified In Last 5 Years?	Modifications To Current Procedure Underway?	Projects Using Alternate Bidding To Select Pavement Type
Alabama	Y	Y	N	≥10	Y	N	<1
Arizona[1]	Y[1]	Y[1]	Y[1]	23	N	N	0
Arkansas	Y	Y	Y	10	Y	N	NR
California	Yes	Yes	Yes	2	No	No	0
Colorado	NR	NR	NR	NR	NR	NR	Considering 1
Delaware	NR	NR	NR	NR	NR	NR	0
Georgia	Y	Y	Y	5	Y	Y	NR
Idaho	Y	Y	Y	≥20	Y	Y	1
Illinois	Y	Y	N	≥20	N	Y	0
Indiana	Y	Y	Y	2	Y	Y	NR
Kansas	Y	Y	Y	≥30	Y	Y	1
Louisiana	Y	Y	NR	NR	NR	NR	44
Maine[2]	N[2]	N[2]	N[2]	N/A	N/A	N/A	0
Maryland	Y	Y	N	3	Y	N	0
Michigan	Y	Y	Y	10	N	N	0
Minnesota	Y	Y	N	≥15	Y	N	0
Missouri	Y	Y	Y	4	Y	N	>100
Montana[3]	N[3]	N[3]	N[3]	N/A	N/A	Y	1
Nebraska[4]	N/A[4]	N/A[4]	N/A[4]	N/A	N/A	N/A	Several
Nevada[5]	Y[5]	N	N	12	N	Y	NR
New Hampshire	Y	Y	Y	10	N	Y	0
New Mexico[6]	Y[6]	Y[6]	Y[6]	>5	Y	Y	0
North Carolina	Y	Y	N	18	N	N	4 to 5
North Dakota	Y	Y	Y	30	N	N	0
Ohio	Y	Y	Y	4	Y	N	2
Pennsylvania	NR	NR	NR	NR	NR	NR	2 to 3
South Carolina	Y	Y	N	5	Y	Y	0
South Dakota	Y	Y	Y	14	N	N	0
Tennessee[7]	Y[7]	Y[7]	Y[7]	20	N	Y	1
Texas[8]	Y[8]	Y[8]	NR	NR	Y	Y	0
Utah	Y	Y	N	Few	Y	N	0
Vermont	Y	Y	N	≥10	Y	Y	0
Washington	Y	Y	N	5	N	N	0
West Virginia	Y	Y	Y	5	N	N	0
Wisconsin	Y	Y	Y	≥15	Y	Y	0

[1] Arizona does not have a formal process for pavement-type selection. However, guidelines are provided in their *Preliminary Engineering and Design Manual*.
[2] Maine has no selection process, since they build only hot-mix asphalt (HMA) pavements.
[3] Montana does not have a formal policy for pavement-type selection since they historically have built only HMA pavements. However, because of recent asphalt price escalation, they are performing informal pavement-type selection.
[4] Nebraska does not have a formal procedure. The decision is based on funding, constructability, traffic, and life cycles.
[5] The Nevada Department of Transportation Director and the Principal Materials Engineer are responsible for type selection. While a life-cycle cost analysis (LCCA) may be made, it is not always considered in the final selection.
[6] New Mexico's procedure is informal with the selection made by a team.
[7] Tennessee's procedure is not documented and is not required for all projects.
[8] In Texas, type selection is ultimately at the District's discretion.
NR = no response; N/A = not applicable.

Of these 22 state DOTs, 21 require a life-cycle cost analysis (LCCA). Ten of the states have specific criteria for considering the results of the LCCA. Ten states stipulate that if the difference in life-cycle costs exceeds a specified amount (ranging from 5 to 20 percent), the lower cost alternative usually will be selected. Michigan DOT is required by law to select the alternative with the lowest life-cycle cost.

Twenty-nine of the 35 responding state DOTs perform LCCA for new construction/reconstruction projects, out of which 22 report having formal procedures, 6 indicate use of a probabilistic process, and 14 indicate consideration of user costs in the analysis. Thirteen DOTs perform LCCA for rehabilitation projects. Most DOTs utilize the net present value (NPV) method for computing life-cycle costs, and most use either a custom-developed spreadsheet or the Federal Highway Administration (FHWA) probabilistic LCCA program RealCost. Of the 14 DOTs that consider user costs, most focus on the time delay and vehicle operating cost (VOC) components associated with work zones. In addition, five of these 14 DOTs combine user costs with agency costs to generate a total life-cycle cost, while the other eight DOTs keep the two costs separate. Table 2 summarizes the LCCA approaches used by the responding DOTs.

In addition, most DOTs had some type of process to consider noneconomic factors in making their pavement-type selection when the LCCA did not indicate a clear preference. This process generally was subjective, with the decision being made by either an individual or a selection committee. Noneconomic factors often considered in pavement-type selection include:

1. Traffic.
2. Soils characteristics.
3. Weather.
4. Performance of similar pavements in the area.
5. Economics or cost comparison.
6. Adjacent existing pavements.
7. Stage construction.
8. Depressed, surface, or elevated design.
9. Highway system.
10. Conservation of aggregates.
11. Stimulation of competition.
12. Construction considerations.
13. Local government preference and recognition of local industry.
14. Sustainability.
15. Traffic safety.
16. Availability of local materials or locally produced mixes.

Several state agencies have experimented with alternate pavement-type bidding. In this approach, the bidders are permitted to select a pavement type among two or more equivalent alternatives provided by the agency. The equivalency of alternatives is established by including a bid adjustment factor to account for the difference in discounted future M&R costs between alternatives. With more alternative choices for selection, the agencies are believed to realize significant cost savings from competition in the pavement industry, given the fact that large fluctuations in material costs can occur between the time of design and the bid letting.

In traditional design-bid-build contracts, the contractor delivers construction services as defined in the standard plans and specifications issued by the highway agency. The contractor assumes no responsibility for the delivered product except a limited-time warranty for materials and workmanship quality. The agency assumes the entire responsibility and risk for design, construction, and post-construction performance of the pavement.

With the inception of alternative contracting methods, the contractor's role has extended into nontraditional services such as design, operations and maintenance, and performance warranty. To address the shifts in responsibilities and risks effectively, agencies use contract provisions to communicate the project scope, performance/design criteria, and other requirements in the RFP. The contractor is obligated to provide the product and services specified in the contract provisions with certain technical, cost, time, and quality requirements.

In design-build contracting, the agencies typically have procured contractor services for only design and construction phases of the projects involving limited-time warranties. In the absence of long-term warranties, the agencies assume responsibilities for managing future performance risks. Considering the short turnover period and limited warranty, the agencies usually stipulate the pavement types to be used in a project and/or specify the criteria to be followed in the selection process. However, in projects where contractors have long-term responsibilities for operations and maintenance, agencies have allowed the contractors to specify the pavement types. In such projects, the contractors were required to follow the project requirements specified in the RFP.

Based on the analysis of the Phase I findings, it was concluded that the pavement-type selection process should have the following key components:

- Criteria specifying the type of projects for which the pavement-type selection process should be applied.
- A formal process for the identification of pavement-type alternatives to be considered. The selection of potential alternatives should be based on a comprehensive and transparent process involving the agency, contractors, and the paving industry. It is expected that alternatives reflect national practices, regional experience, type and size of projects, and type of traffic the pavement is expected to carry. To maximize the economic value, the agency should consider alternatives that stimulate competition and incorporate

Table 2. State DOT LCCA procedures.

State	Perform LCCA	LCCA Approach					LCCA Package Used				
		NPV	EUAC	Determi nistic	Proba bilistic	Consider User Costs	Use State-Developed Spreadsheet/Software	FHWA Probabilistic Spreadsheet RealCost	State-Customized Version of RealCost	Proprietary/ Industry Software	AASHTO Darwin
Alabama	Y	Y	N	Y	N	N	N	N	N	N	Y
Arizona	Optional	Y	N	Y	N	Y	N	Y	N	N	N
Arkansas	Y	Y	N	Y	N	N	Y	N	N	N	N
California	Y	Y	N	Y	N	Y	N	N	Deterministic only	No	No
Colorado	Y	Y	N	N	Y	Y	N	Y	N	N	Y
Delaware	Optional	N	Y	Y	Y	Y	N	Y	N	N	N
Georgia	Y	Y	Y	Y	N	Y	Y	N	N	N	N
Idaho	Y	Y	Y	Y	N	N	Y	N	N	N	N
Illinois	Y	N	Y	Y	N	N	Y	N	N	N	N
Indiana	Y	Y	Y	N	Y	N	N	Y	N	N	N
Kansas	Y	Y	N	Y	N	Y	Y	N	N	N	N
Louisiana	Y	Y	N	Y	N	Y	N	N	Y	N	N
Maine	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Maryland	Y	Y	N	N	Y	Y	N	Y	Y	N	N
Michigan	Y	N	Y	Y	N	Y	Y	N	N	N	N
Minnesota	Y	Y	N	Y	N	N	Y	N	N	N	N
Missouri	Y	Y	N	Y	N	N	Y	N	N	N	N
Montana	Optional	Y	N	Y	N	N	Y	N	N	N	N
Nebraska	Optional	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Nevada	Optional	Y	N	Y	N	N	Y	N	N	N	N
New Hampshire	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
New Mexico	Optional	Y	N	Y	N	Y	Y	N	N	N	N
North Carolina	Y	N	Y	Y	N	N	Y	N	N	N	N
North Dakota	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ohio	Y	Y	N	Y	N	N	Y	N	N	N	N
Pennsylvania	Cost > $15M	Y	Y	Y	N	Y	Y	N	N	N	N
South Carolina	Y	Y	N	Y	Y	Y	Y	Y	N	N	N
South Dakota	N	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Tennessee	N	Y	Y	Y	N	N	Y	Y	N	Y	Y
Texas	Optional	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Utah	Y	Y	N	Y	N	N	Y	Y	N	N	N
Vermont	Y	Y	N	Y	N	Y	N	Y	N	N	Y
Washington	Y	Y	N	Y	Y	Y	N	Y	N	Y	N
West Virginia	Y	Y	N	Y	N	N	N	N	N	N	Y
Wisconsin	Y	N	Y	Y	N	N	Y	N	N	N	N

Note: EUAC = equivalent uniform annual costs; NA= not applicable; NR = no response.

innovative approaches. This activity should be overseen by a pavement-type selection committee composed of agency design, construction, and maintenance personnel.

- Procedures for the estimation of pavement service life. Techniques range from expert modeling using the opinions of experienced engineers to detailed performance-prediction modeling using historical performance data to develop survival curves.
- A framework for the LCCA. The analysis period should be sufficiently long to distinguish any differences between pavement alternatives and long enough such that each alternative pavement strategy includes at least one future major rehabilitation event. The discount rate should be based on economic factors established by the agency or the Office of Management and Budget (OMB) Circular A-94 Appendix C. The process must include procedures for estimating current and future costs. Both agency and user costs should be evaluated, and supplemental costs such as those incurred for contract administration, engineering, and traffic control may be considered if significantly different for pavement-type alternatives. However, user and agency costs should be evaluated separately, because the dollar value of user costs often is significantly greater than that of agency costs. The LCCA methodology may be computed deterministically or probabilistically, and general guidance such as that developed by Walls and Smith (1998) should be followed in the development of the procedures.
- An alternative screening matrix should be utilized to weigh both the economic (initial, rehabilitation, maintenance, and user costs) and noneconomic (geometrics, pavement and lane continuity, traffic during construction, availability of local materials, local preference, noise, safety, sustainability) factors in comparing alternatives. The factors and ratings should be established based on local conditions.
- Alternate bidding is a variation of the design-bid-build process, where the agency provides complete designs for two or more equivalent pavement alternatives and selection is based on the alternative receiving the lowest bid. Alternate bidding should be used for projects having alternatives with equivalent designs where the analysis of economic and noneconomic factors does not indicate a clear preference between alternatives.
- In design-build projects (where the contractor assumes no operational responsibilities and provides no extended warranty), the agency is responsible for risks associated with future performance. In such cases, the agency stipulates the preferred pavement alternative(s) or specifies the criteria for contractor-based selection. In either case, the contractor can follow the agency's selection process (including life-cycle assumptions) or any other similar process accepted by the agency.
- On alternative contracting projects (design-build, design-build with operations and maintenance, and long-term performance warranty methods), the agency should perform a risk analysis to determine the contractor's scope and how stringent the contract provisions for pavement-type selection should be.
- In design-build projects involving operations and maintenance responsibilities and long-term performance warranty, the contractor assumes the risks associated with post-construction for an extended period of time. In such cases, the contractor selection process is stipulated largely by the performance criteria specified in the RFP.
- If a considerable length of time elapses between the original pavement-type selection and a call for bids, the selection should be reviewed to ensure that conditions have not changed.

An overview of the process is shown in Figure 1.

The *Guide for Pavement-Type Selection* developed under this project contains a comprehensive set of procedures, including an alternative preference screening matrix that highway agencies can use to develop pavement-type selection policies and processes. Each step is described, and the factors that should be considered are identified. Because of differences in agency decision-making processes, it is expected that each agency will adapt these procedures to meet its specific needs.

Details on research performed in this project are documented in the project research report, available on the *NCHRP Report 703* web page at http://www.trb.org/Main/Blurbs/165531.aspx.

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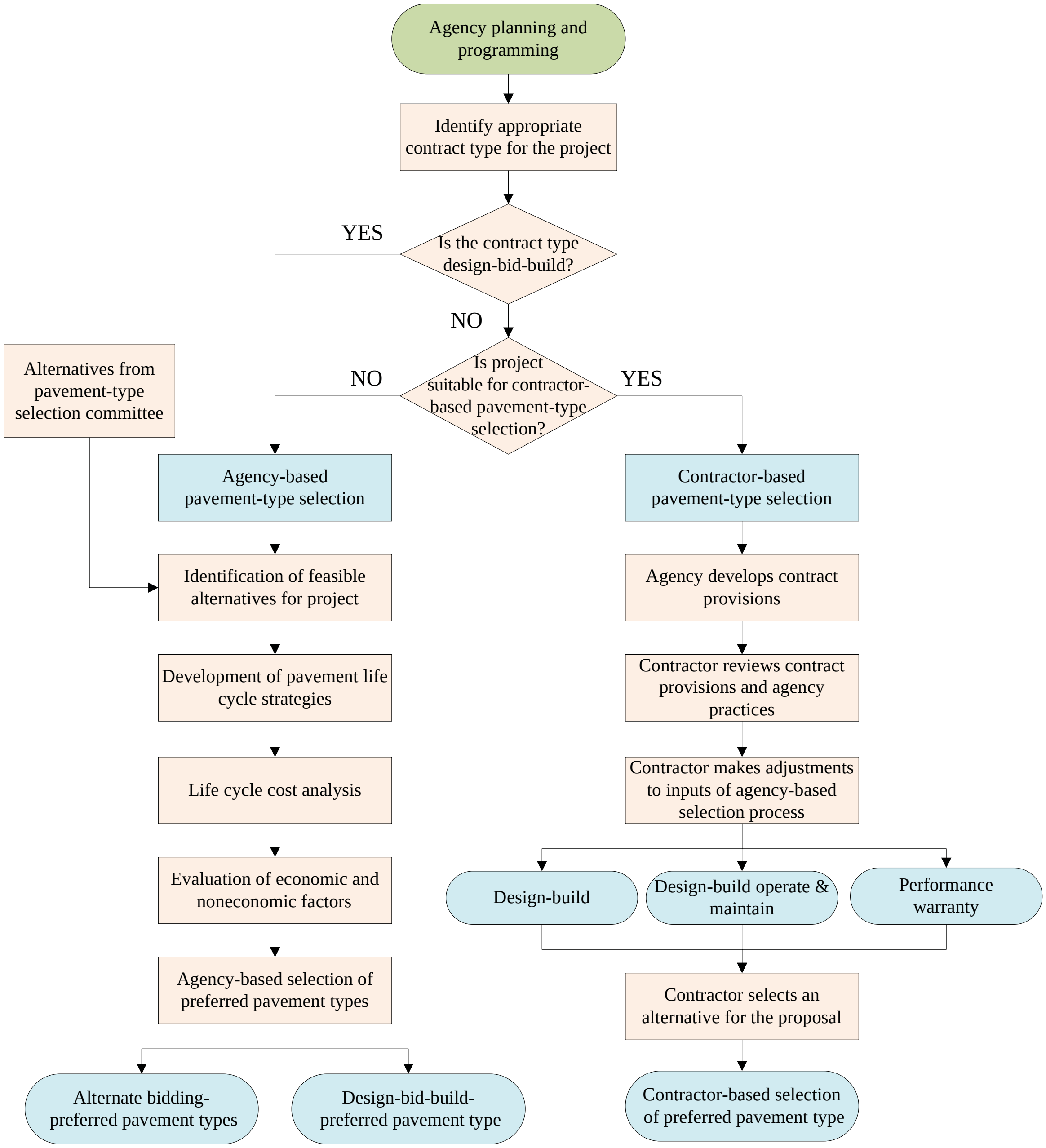

Figure 1. Overview of the pavement-type selection process.