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16. Abstract

This interim report for Project 0-1734 discusses fundamental aspects of pavement type selection, including pavement strategies, pavement design, economic analysis, and important technical and subjective factors.

This report documents the results of the national and Texas questionnaire surveys. The national survey included U.S. departments of transportation (DOTs) and Canadian provincial DOTs. The Texas survey included TxDOT district and area offices, which are primarily responsible for pavement type selection in Texas. The primary objective of these surveys was to obtain information about current pavement type selection practices at the national level and at the Texas level. The response rate achieved for national and TxDOT surveys was 86 percent and 92 percent, respectively.

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AN INFORMATION SYNTHESIS OF PAVEMENT TYPE SELECTION PRATICES OF HIGHWAY AGENCIES

by

Muhammad Arif Beg

Athar Saeed

Paul Anaejionu

W. Ronald Hudson

Research Report Number 1734-1

Research Project 0-1734
Project Title: "Development of a Pavement Type Selection Process"

Conducted for the

TEXAS DEPARTMENT OF TRANSPORTATION

in cooperation with the

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

by the

CENTER FOR TRANSPORTATION RESEARCH

Bureau of Engineering Research

THE UNIVERSITY OF TEXAS AT AUSTIN

October 1997

IMPLEMENTATION STATEMENT

This first interim report for Project 0-1734 includes a literature review and the results of our national- and Texas-level surveys. These results set the stage for year two of this project and will be useful in developing a computer-based decision support tool for pavement type selection for the Texas Department of Transportation (TxDOT).

DISCLAIMERS

W. Ronald Hudson, P.E. (Texas No. 16821)
Research Supervisor

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Research performed in cooperation with the Texas Department of Transporation and the U.S. Department of Transportation, Federal Highway Administration.

TABLE OF CONTENTS

SUMMARY

This interim report for Project 0-1734 discusses fundamental aspects of pavement type selection, including pavement strategies, pavement design, economic analysis, and important technical and subjective factors.

This report documents the results of the national and Texas questionnaire surveys. The national survey included U.S. departments of transportation (DOTs) and Canadian provincial DOTs. The Texas survey included TxDOT district and area offices, which are primarily responsible for pavement type selection in Texas. The primary objective of these surveys was to obtain information about current pavement type selection practices at the national level and at the Texas level. The response rate achieved for national and TxDOT surveys was 86 percent and 92 percent, respectively.

CHAPTER 1. INTRODUCTION

BACKGROUND AND PROBLEM DESCRIPTION

In selecting a pavement type and its structural design, state departments of transportation (DOTs) are challenged to make cost-effective engineering decisions, particularly insofar as large capital investments are involved. The Federal Highway Administration (FHWA) document, "Federal-Aid Policy Guide — Part 626: Pavement Design Policy," (FHWA 91), emphasizes that state highway agencies should set forth a policy to select, design, and manage pavements in a cost-effective manner. To be eligible for federal-aid funding, the design of new and reconstructed pavements should represent an economical solution based on the state's pavement type selection and pavement design procedures.

The Texas Department of Transportation (TxDOT) currently uses no organized procedure for selecting pavement types. In the absence of any formal procedure, TxDOT district and area offices, which are primarily responsible for making pavement type selection decisions, tend to select pavement types on the basis of engineering judgment and historical practice. Yet decision-making practices that do not employ engineering principles cannot be relied upon to make proper pavement type selection decisions that involve large capital investments. Pavement type selection should be based on rational methodologies that compare and evaluate various alternative designs and that consider relevant technical, economic, and local factors. It is therefore important that a well-founded pavement type selection procedure be developed for TxDOT, one that not only will be acceptable to FHWA, but, most importantly, one that can also be used effectively by TxDOT for ensuring the best possible use of tax dollars and for providing to the traveling public pavements of the highest quality.

The conventional primary objective of pavement type selection is to recommend a pavement structure (i.e., number of pavement layers, materials of construction, and layer thickness) that will fulfill the design objectives throughout the design life of the pavement. From this perspective, pavement type selection is a part of the typical pavement design process, whose purpose is to recommend a pavement strategy that will provide a certain specified level of functional and structural performance. It is technically feasible in most cases to consider several combinations of layer thicknesses and pavement materials, including asphalt concrete, portland cement concrete (PCC), chemically stabilized materials (lime- and cement-treated layers), granular materials, etc., to develop several pavement design alternatives. However, selecting the final alternative for the project is a complex task. An economic comparison of design alternatives should be considered an essential exercise in selecting a pavement alternative. The use of life-cycle cost analysis (LCCA) as a part of the evaluation of pavement alternatives has become increasingly popular.

Each of TxDOT's twenty-five district offices has several area offices that use very different approaches to pavement type selection decisions. Most offices have evolved their own unique practices that contribute significantly to their final selection. The Center for

Transportation Research (CTR) rigid pavement database indicates that nine out of twenty-five Texas districts do not have rigid pavements; yet there is no clear indication in terms of technical or environmental factors why these districts have not built any rigid pavements. The most probable cause appears to be local preference and historical-practice-based decision making that occurs in most districts.

Pavement type selection decisions are also affected by several factors that are subjectively considered by decision makers most of the time. These factors include historical practice, highway functional class, initial budget constraints, traffic volume, use of local materials, recycled materials, etc., which are considered important by most practitioners. For example, a relatively common trend in urban districts is to build pavements that will yield longer performance periods (PCC pavements) on high traffic volume roads, such as urban arterial and interstate highways (IH). Such practice is an attempt to minimize traffic disruptions and, hence, user discomfort caused by maintenance and rehabilitation activities on high-volume roads. On the other hand, PCC pavements require relatively large initial investment, and often initial budget constraints do not allow agencies to construct long lasting (typically 30-year performance period) PCC pavements. Highway agencies tend to have limited budgets, which results in building affordable pavements on the basis of initial construction cost. These compromised decisions can increase future maintenance and rehabilitation costs, which can then lead to extra user costs in the form of time delays.

PROJECT OBJECTIVES AND IMPLEMENTATION

The main objective of Project 0-1734 is to develop a rational, broad-based pavement type selection procedure for TxDOT, one that encompasses technical, economic, and subjective factors. This procedure will provide assistance and guidance to TxDOT engineers in selecting the most appropriate pavement type considering influential factors in any individual situation. In addition, the project seeks to develop guidelines for making final type selection decisions based on the consideration of economic as well as other important criteria. And finally, the project will develop a user-friendly, easy-to-manage software package for automating pavement type selection decisions. This program will serve as a guide only; the final decision will always rest with the engineer.

The developed pavement type selection procedure will be included in TxDOT's pavement design training manual. It will provide TxDOT district and area offices with a functional and coherent policy for selecting appropriate pavement types.

RESEARCH APPROACH

A broad-based methodology was needed for developing a rational and systematic pavement type selection procedure for TxDOT. Information synthesis was the main objective of the first year of the project. All tasks — literature review, national survey, and TxDOT survey — were aimed at synthesizing existing pavement type selection practices of various highway agencies.

A detailed literature search was conducted to review available information on topics related to pavement type selection. These topics primarily include project-level pavement design, economic analysis, user costs, and decision-making approaches. The results of the literature review are discussed below.

It was important for the project to review and evaluate current pavement type selection practices of other highway agencies. A national questionnaire survey, primarily aimed at U.S. state DOTs and Canadian provincial DOTs, was carried out to collect up-to-date information at the national level. This exercise provided a broad, national-level synthesis of pavement type selection practices of other DOTs.

It was also necessary to thoroughly investigate TxDOT's pavement type selection practices. A questionnaire survey of TxDOT district and area offices was carried out to obtain information about their pavement type selection practices. The TxDOT survey was more detailed than the national level survey because more specific information was requested. This survey, which provided a summary of pavement type selection practices in Texas, will help in outlining pavement type selection factors prevalent in Texas.

In the near future, the project team plans to assemble an expert working group (EWG) to brainstorm issues related to pavement type selection. This meeting will provide vital input in the development of this procedure from end users and from technical and administrative personnel from TxDOT. The objective is to develop a consensus about the overall framework of the pavement type selection methodology and to gauge the relative importance and the requirement to include particular factors in the type selection methodology.

All the above-mentioned activities will help to outline the fundamentals of a valid pavement type selection methodology for TxDOT. Detailed evaluations will be carried out to quantify important factors and to evaluate relationships among them. Finally, a computer-based system will be developed for making pavement type selection decisions. Figure 1.1 shows the research approach flowchart for Project 0-1734.

SCOPE OF THE PROJECT REPORT AND REPORT ORGANIZATION

This interim project report, 1734-1, summarizes the work accomplished in the first year of this two-year project.

Chapter 1 presented the general background, problem description, and research approach for the project. Several aspects of pavement type selection, including pavement types, pavement strategies, pavement design, LCCA, user costs, and subjective factors, are reported in Chapter 2. Pavement type selection practices of other DOTs are also summarized in Chapter 2. Chapters 3 and 4 document the results and analysis of national and TxDOT questionnaire surveys, respectively. Also included are relevant discussions about responses to several questions requiring descriptive responses. Chapter 5 of this report presents interim findings and recommendations for the project.

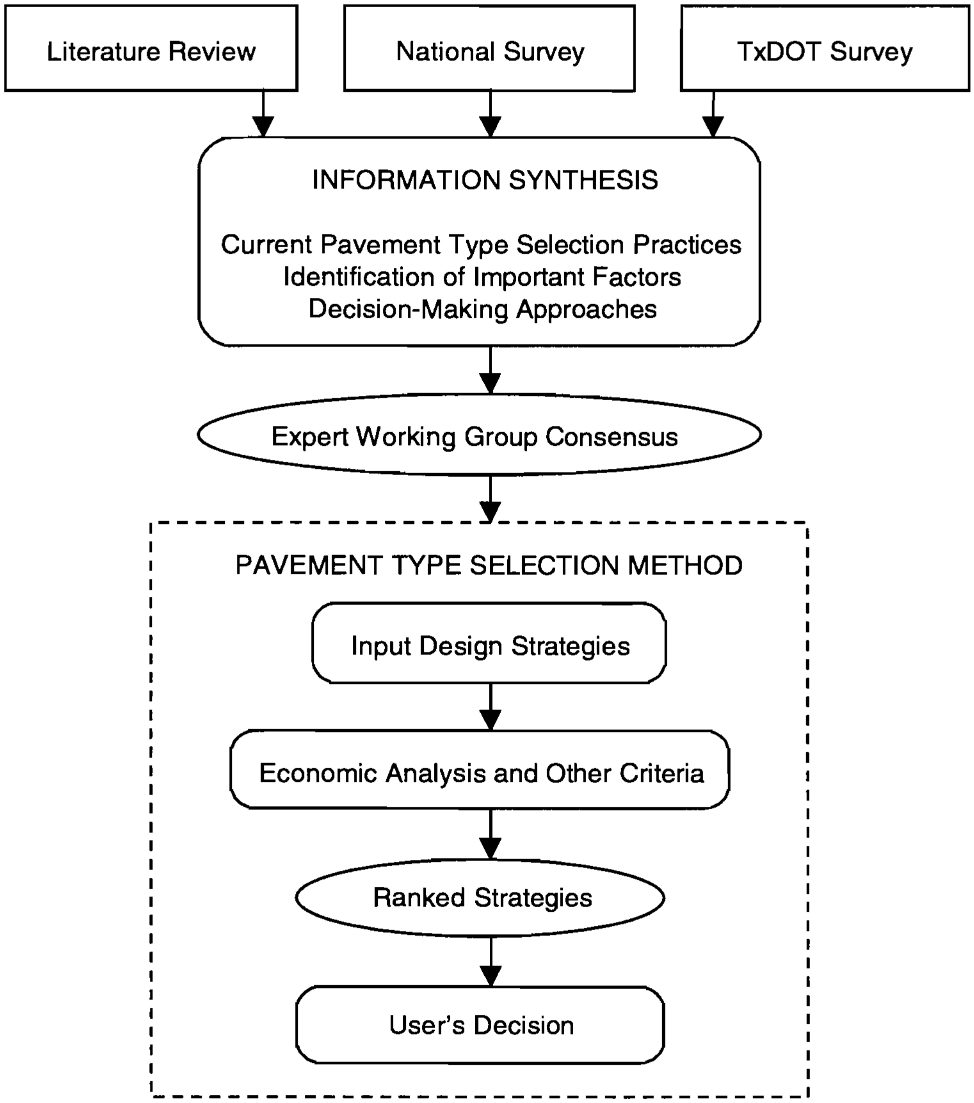

Figure 1.1. Research Approach for Project 1734

CHAPTER 2. FUNDAMENTAL ASPECTS OF PAVEMENT TYPE SELECTION

In addition to describing several fundamental aspects of pavement type selection, this chapter summarizes findings obtained from several literature sources. The topics presented here include pavement types and strategies, pavement design, life-cycle cost analysis (LCCA), user costs, subjective factors, and practices of other highway agencies.

PAVEMENT TYPES AND STRATEGIES

Pavement types include rigid pavement, flexible pavement, composite pavement, full-depth asphalt pavement, and others. Perhaps the most straightforward definition of pavement type by structural function or response relates to the two basic types: (1) flexible and (2) rigid pavements (Haas 94, AASHTO 93, Yoder 75). Rigid pavements generally use portland cement concrete (PCC) as the principal structural layer, while flexible pavements generally use asphalt concrete for the surface layer (and sometimes for the underlying layers). Moreover, different mechanical theories are used to describe rigid and flexible pavement behavior. Slab analysis is commonly used to define the behavior of rigid or PCC pavements, which usually carry load in bending. On the other hand, layered system analysis is commonly used to analyze the behavior of flexible or asphaltic concrete pavements, which predominantly carry load in shear deformation. The term *composite pavements* has often been used to describe pavements that combine both rigid and flexible elements, for example, asphalt concrete surface over an old PCC pavement or over a cement-treated base. Haas and Hudson (Haas 94) recommend assigning composite type pavements to one of the other two types according to the basic load-carrying element and not to the visible surface type.

The TxDOT document, "Design Training Applications: Pavement Design" (TxDOT 93), classifies asphalt-surfaced pavements as either (1) flexible or (2) semirigid. This document explains that a true flexible pavement is typically composed of a relatively thin asphalt concrete surface or asphaltic seal coat over a flexible base or subbase resting on the subgrade. On the other hand, semirigid pavements have layers with relatively higher stiffness owing to either stabilized layers or an increased asphalt concrete surface thickness. Thick-surface asphalt pavements and pavements with stabilized bases are therefore included in the semirigid category. PCC pavements are considered rigid and classified according to their use of joints and reinforcement; PCC pavements include (1) jointed concrete pavement (JCP), (2) jointed reinforced concrete pavement (JRCP), and (3) continuously reinforced concrete pavement (CRCP).

Another relatively recent flexible pavement type is the full-depth asphalt pavement put forward by the Asphalt Institute. As the name indicates, asphalt mixtures are employed for all pavement layers above the subgrade.

Based on the literature reviewed, the general pavement types for new construction and reconstruction projects include:

- Seal coat with granular (flexible) base
- Asphalt concrete pavement with granular (flexible) base
- Full-depth asphalt concrete pavement
- Asphalt concrete pavement with stabilized base

- JCP
- JRCP
- CRCP

According to Haas and Hudson (Haas 94), the concept of design itself has only recently been elevated from the concept of specifying an initial structural section to that of a strategy, where the strategy involves not only the best initial construction and structural section but also the best combination of materials, construction policies, maintenance policies, and overlays. Consideration of LCCA in pavement design has primarily led to a broader and more logical definition of pavement types in terms of pavement strategies. Pavement strategies include several combinations of initial pavement structure and future maintenance and rehabilitation policies. Figure 2.1 shows the wide range of available choices for generating alternative pavement strategies for a project.

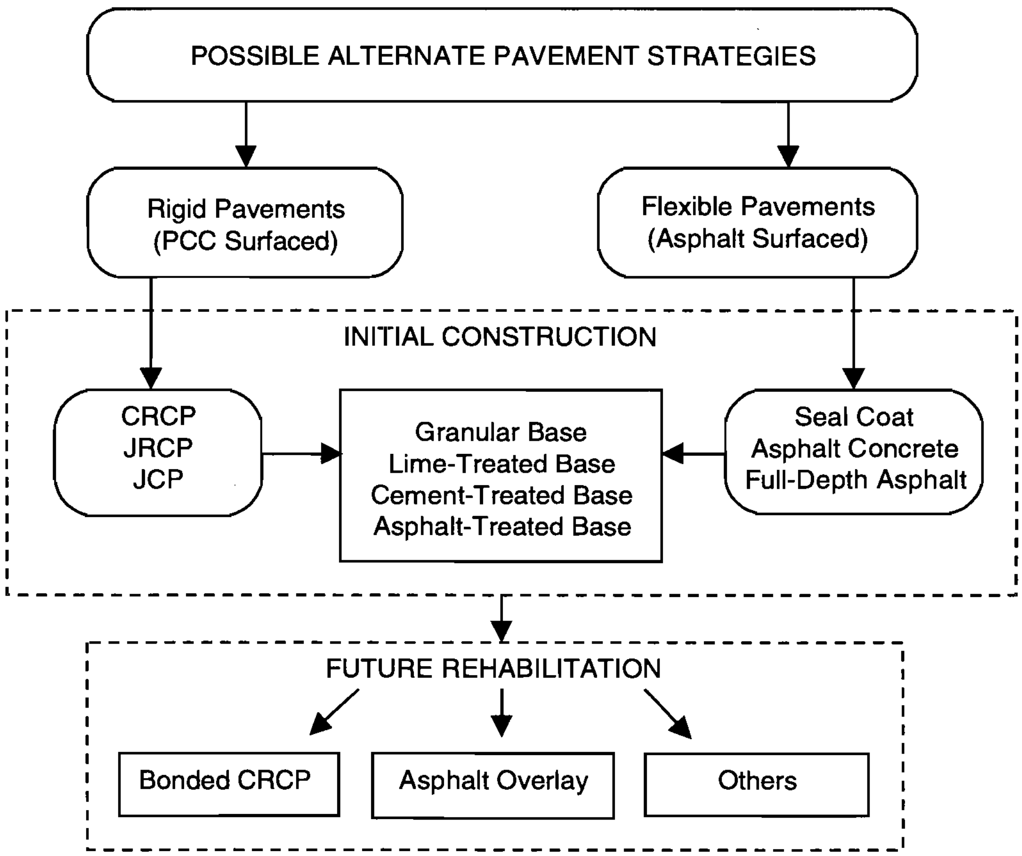

Figure 2.1 Several options to generate candidate pavement strategies

PROJECT LEVEL PAVEMENT DESIGN

The flexible pavement system (FPS) is used statewide by TxDOT for resolving flexible-pavement design problems. The first version of FPS was developed in 1968 (Scrivner 68) under the AASHO Road Test satellite study, which aimed at harmonizing AASHO Road Test results with Texas conditions. In the following years, Darter and Hudson (Darter 73) pioneered the use of a reliability-based approach for pavement design in the FPS. The reliability factor was introduced in the system to take into account the inherent variability that exists in pavement design and construction. The FPS is based on the following general premise: "It is the aim of the engineer to provide, from available materials, a pavement that can be maintained above a specified level of serviceability, over a specified period of time/traffic, with a specified reliability, at a minimum overall cost." A pavement performance equation was developed (Scrivner 68) that predicts the serviceability loss as a function of surface curvature index (SCI), layer materials stiffness coefficients, initial and terminal serviceability, traffic (equivalent single axle loads, or ESALs), temperature, and swelling clay. Material stiffness coefficients were developed through deflection testing with Dynaflect to characterize paving materials. In the current version, FPS-19, stiffness coefficients are replaced by materials' elastic moduli. One significant feature of FPS is an integrated LCCA module, which includes initial construction cost, rehabilitation cost, routine maintenance cost, salvage value, and user cost resulting from traffic delays at work zones. Users of the program can specify layer materials and several design constraints, such as minimum and maximum layer thickness and minimum time to first overlay. The program generates several pavement strategies based on a scheme of incremental increase in layer thicknesses. It performs LCCAs for technically feasible strategies and ranks them according to their net present worth. The FPS-19 has the following pavement type options:

1. Asphalt concrete + flexible base over subgrade
2. Asphalt concrete + asphalt base over subgrade
3. Asphalt concrete + asphalt base + flexible base over subgrade
4. Asphalt concrete + flexible base + stabilized subgrade over subgrade

The program also has an option for asphalt overlay design.

A rigid pavement system (RPS) was also developed for TxDOT (Kher 71). Though a twin of FPS, the RPS has not been updated in recent years and is no longer used by TxDOT. An in-house computer program, TSLAB, was, however, developed by TxDOT using the rigid pavement performance equation in the AASHTO Guide (TxDOT 93). TSLAB generates concrete pavement thickness based on AASHTO design inputs.

The *AASHTO Design Guide for Pavement Structures* (AASHTO 93) documents design methods for both flexible and rigid pavements. The AASHTO Guide design procedures are based on performance equations, which were developed through statistical analysis of the data obtained during the AASHO Road Test, which was conducted from 1958 through 1960 in Ottawa, Illinois. Current AASHTO Guide performance equations predict the number of 18-kip standard axle load repetitions required to reach a specified terminal serviceability level given an initial serviceability level, pavement structure, subgrade resilient modulus, and a selected reliability level. The AASHTO Guide also provides several rehabilitation (overlay) design methods for existing flexible and rigid pavements.

LIFE-CYCLE COST ANALYSIS (LCCA)

An LCCA involves modeling the performance of a particular pavement structure exposed to a given set of conditions over a period of time, forecasting traffic, assigning future maintenance and rehabilitation treatments, and performing economical analyses that include all costs anticipated over the life cycle of the pavement strategy. Cost trade-offs, such as those between the initial construction costs and future maintenance and rehabilitation costs, can then be examined using LCCA. The Canadian pavement management guide (RTAC 77) reports that from a life-cycle cost perspective, pavement costs could be broadly categorized as:

1. agency costs, which generally include initial construction costs, rehabilitation costs, preventive and routine maintenance costs, and salvage value, and
2. user costs, which include indirect costs, such as time delay costs at work zones, vehicle operating costs (VOCs), additional VOCs at work zones, accident costs, and discomfort costs.

Figure 2.2 illustrates a typical pavement design strategy and associated life-cycle cost components for an analysis period of 30 years.

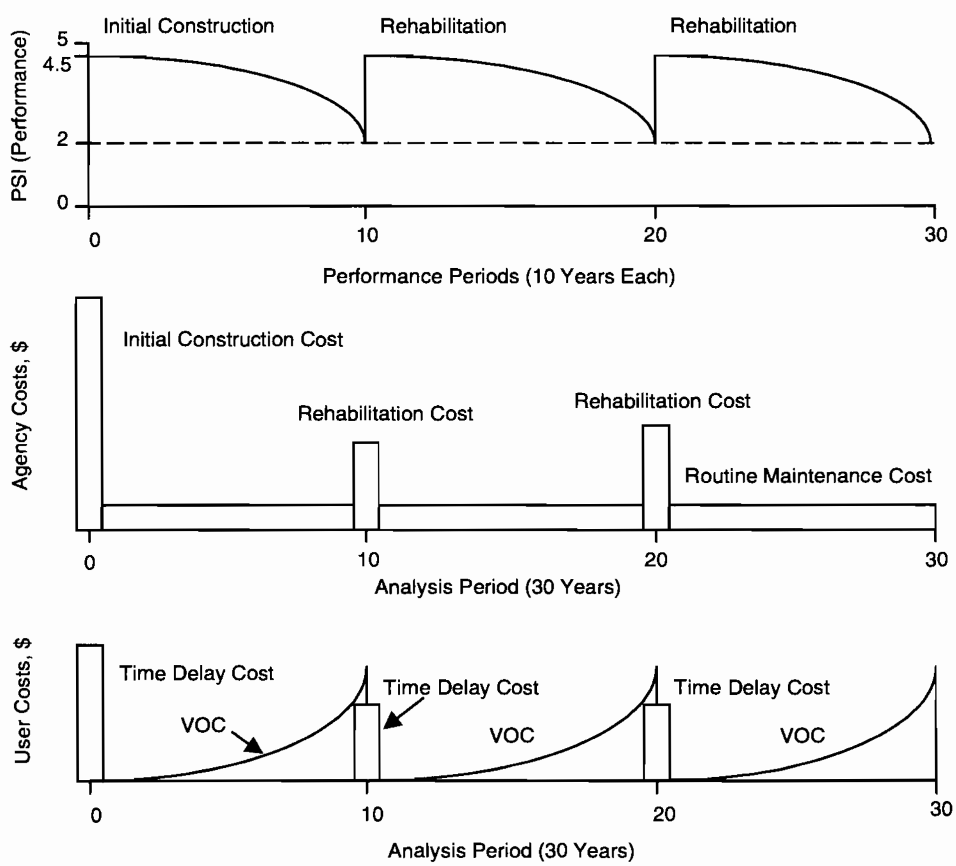

Figure 2.2 A typical pavement strategy and its life-cycle cost components

Researchers and road agencies have carried out several research efforts to develop LCCA-based systems. Hudson et al. (Hudson 88) presented a generic ranking methodology, LCC1, for LCCA of an array of user-defined pavement design strategies. Two pavement surface types (asphalt and PCC), eight types of base course, two types of subbase materials, and several types of future maintenance and rehabilitation alternatives can be specified in the system. The methodology includes the cost models for agency costs and user costs at work zones. The LCC1 methodology evaluates and compares design strategies by computing the present worth and equivalent annuity of life-cycle costs. Uddin et al. reported (Uddin 93) a methodology for LCCA of pavements, including agency and user costs. VOCs are calculated for each year of the analysis period as a function of pavement condition, vehicle type, vehicle speed, traffic volume, highway geometric characteristics, and associated VOC resources. Time delay costs resulting from temporary road closures or traffic diversion during maintenance and rehabilitation activities are also included in the model. The inputs for the traffic delay cost model include detour distance, time and duration of traffic control, number of open lanes, hourly traffic distribution, and percentage of vehicles affected. User cost savings generated from improved pavement condition following the implementation of an appropriate treatment are regarded as benefits.

Analysis Period

The analysis period is the time period used for comparing the relative economic worth of design alternatives. The literature shows several approaches to selecting a reasonable analysis period for evaluating pavement strategies.

Peterson (85) carried out a questionnaire survey of road agencies and reported that analysis periods ranging from 15 to 40 years are used by various highway agencies. He recommended a 25–40-year analysis period, which he considered sufficient for predicting future costs for economic purposes in order to capture the most significant costs. Figure 2.3 shows the variation of present worth factor on a 50-year scale discounted to present worth at 4 percent, 7 percent, and 10 percent discount rates. The area under the curve is the accumulation of the total present worth cost of the system. It should be noted that about 90 percent of the total cost of the system is consumed in the first 25 years in the case of the 10 percent discount rate, and in 35 years in the case of the 7 percent discount rate. On the other hand, about 86 percent of the cost is consumed at the end of the 50-year period with a 4 percent discount rate. It is obvious from this that the use of lower discount rates should correspond to the use of longer analysis periods and vice versa.

The Canadian pavement management guide (RTAC 77) presents a few criteria for selecting the analysis period:

- The analysis period should not extend beyond the period of reliable forecasts; for traffic, 20 years is probably the maximum.
- The analysis period may extend to the point where the discounted costs or benefits become negligible. For example, they are below some arbitrarily set level, say, $1000 per lane kilometer.
- Finally, the length of the analysis period is a policy decision and as such is dependent upon the agency and circumstances; most agencies prefer to use a fixed analysis period approach.

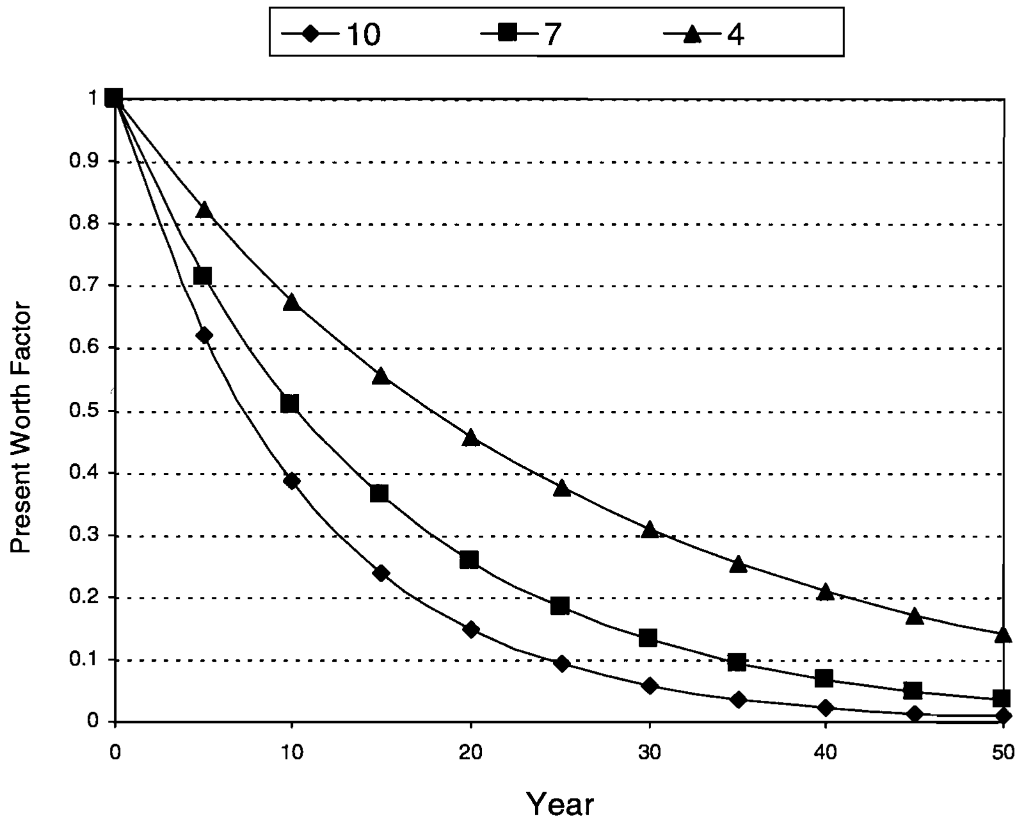

Figure 2.3 Effect of discount factor on LCCA

Scrivner et al. (Scrivener 68) pointed out that ideally the analysis period should end when the road is expected to be abandoned or when it is expected that major reconstruction work will be needed on the road. This is the true life cycle. They agreed, however, that in practice it is better to use an analysis period such that design inputs can reasonably be estimated. Accordingly, they recommended at least a 15-year analysis period, though usually not more than 30 years.

Discount Rate and Interest Rate

Cash flow streams are converted into their net present worth (NPW) or equivalent uniform annual costs (EUACs) by using discount rates so that the economics of different alternatives can be compared. Epps and Wootan (Epps 81) and Roy and Ray (Roy 84) recommended the use of constant dollars to represent the base year price levels and a real discount rate to represent the difference between the market interest rate and inflation. They argued that the use of current dollars to represent future price levels when the costs are incurred would add more uncertainty to the analysis rather than improve the decision making. The Canadian pavement management guide (RTAC 77) also suggested that the inflation rate should not be taken into account because: (1) it is difficult to forecast, (2) it further adds uncertainty to the analysis, (3) it could help justify higher capital investment today, and (4) benefits will likely increase at the same rate as costs.

The discount rate used in an agency's cash flow calculations is a policy decision; it might vary with the purpose of the analysis, the type of agency, and with the degree of risk and uncertainty. The value of the discount rate is sometimes chosen to coincide with the agency's rate for borrowing money, with a range of 4 percent to 8 percent most commonly used. Moreover, it is important to remember that the purpose of economic evaluation is to provide management with a reliable basis for making decisions. Inserting an inflation factor is no guarantee that the decisions will be better. It is, of course, quite possible to test the sensitivity of a varying discount rate on the ranking of alternatives, and maximum and minimum discount rates might be considered to assist in the selection of alternatives.

Agency Costs

Agency costs mostly include direct costs that road agencies incur in building and operating highway facilities. Agency costs can be further grouped as initial costs and future costs, where the latter will include maintenance and rehabilitation costs and salvage value. Agency costs are typically quantified from historical records. While relatively accurate estimates of initial costs can be established, a much larger degree of uncertainty is associated with future costs, as they depend on how pavements are managed in the future. The following is a partial list of problems related to agency costs reported by Finn (Finn 94):

- Reliable estimates of initial costs must be recognized as having a degree of uncertainty.
- The method to determine salvage value is the subject of some controversy and confusion.
- Any relationship between the cost of routine maintenance and pavement condition has proven to be elusive.

Finn, however, noted that differences resulting from errors in estimating salvage or routine maintenance costs during the life of a project may not be very critical because they contribute only a small portion of the total net present worth.

Peterson (85) outlined the following main agency cost components for a typical highway project.

Initial Construction Cost

Initial construction cost includes all direct costs incurred by an agency to procure a pavement facility. The sources of information for construction costs are primarily previous bids, previous projects, and historical cost data.

Maintenance Costs

Pavement maintenance activities are typically grouped in two categories: (1) annual routine maintenance, which includes minor and spot works (e.g., pothole repair), and (2) preventive maintenance, which includes such periodic work as crack sealing and seal coat activities. Maintenance costs are one of the difficult areas to deal with in an LCCA, as there are certain problems inherent in obtaining accurate and reliable maintenance costs. There is a general problem in predicting very far in advance what type of maintenance will be required and when it will be needed. Maintenance needs are influenced by pavement performance, which is also subiect to uncertainty.

:ehabilitation Costs

Pavement rehabilitation activities include major structural improvements typically at the end of performance periods when the serviceability level approaches some specified terminal value. For some projects, rehabilitation will at times be zero, which constitutes the beginning of an LCCA. Rehabilitation in this case would be treated in a manner similar to how initial construction of pavements is treated. The other type of rehabilitation costs is the future rehabilitation policy for a new or reconstructed pavement (Figure 2.2). As with maintenance, the major problem with future rehabilitation is the inability to accurately predict at what time and to what extent future rehabilitation will be required.

Salvage Value

If a dollar value can be assigned to a given pavement structure at the end of the analysis period, then that value can be included in the LCCA as a salvage or residual value. The issues of analysis period and salvage value are interrelated, insofar as they rely on the use of a fixed analysis period, which requires the consideration of salvage value of a pavement structure. Salvage value, often included in pavement economic analysis, involves the value of reusable materials, positive or negative, at the end of the analysis period. Salvage value can contribute in two ways in engineering and economic analysis of pavements:

- As the salvage structural capacity, effective structural number (SN), or effective slab depth available for the future design. AASHTO pavement overlay design methods are an example of this application.
- As the value of existing pavement structure if it is used as recycled materials for future pavement reconstruction.

Scrivner et al. (Scrivener 68) described the salvage value of pavements as the value of useable materials in the pavement minus the cost of making them usable. The salvage value will be negative if materials must be removed and their new-use value is less than the cost of their removal. Salvage value depends on circumstances that may be unique for each project. In FPS-19, it is left to the user to stipulate the salvage value as a percentage of the cost of initial construction and overlay construction. One approach given in the Canadian pavement management guide (RTAC 77) for establishing salvage value is to design an overlay for each alternative at the end of the analysis period with a service life (say 10 years) and then compare the differences in the present worth of their costs.

User Costs

User costs are indirect or nonagency (soft) costs which accrue to road users. Our literature review showed two broad categories for pavement-related user costs.

VOCs: The function of the VOC is to simulate the effects of the physical characteristics and condition (roughness) of a road on various vehicles' operating speed and consumption of resources (fuel, lubricants, tires, etc.); this information is then used to determine the total operating cost of a vehicle. A pavement strategy that provides an overall lower level of serviceability over a longer time period will result in vehicle operating costs higher than those of a strategy that carries the traffic on a relatively smooth surface for most of the time.

User costs associated to work zone activities: These costs primarily include user delay costs and additional VOCs resulting from speed cycling, stops, stop-and-go travel, and uniform low-speed travel.

Other user costs, such as travel times, denial-of-use costs, discomfort costs, and accident costs, are also mentioned in the literature (Haas 94, Peterson 85, Epps 81), though there was little evidence of their actual use by agencies.

Finn (Finn 1994) supported the use of total costs; he saw user costs as the ideal objective function to determine an optimal solution. However, he emphasized that the questions that should be answered include how user costs are related to levels of roughness or distress and how to estimate costs of delays incurred by users as a result of maintenance and rehabilitation activities.

Ullidtz and Kulkarni (Ullidtz 94) summarized a discussion of a workshop on user costs versus agency cost in the form of two general opinions: (1) User costs should be quantified in monetary value, even if they involve a number of political decisions; and (2) Because uncertainties are too large and can lead to improper decisions, rather than quantifying user costs in monetary value, the impact on users should be considered, using more stable parameters. They reported practitioners' concerns that user costs tend to overwhelm agency costs, resulting in much too expensive and unrealistic levels of maintenance if total costs are to be minimized. In addition, benefits predicted often are so substantial that nobody believes they exist at that level. Most practitioners saw a need to distinguish between the hard agency dollars and the less tangible user benefits. In general, it was agreed that delay costs caused by construction and maintenance activities can be quantified in monetary terms, but that quantifying safety costs and VOCs was considered difficult (though still possible).

Vehicle Operating Cost Models Related to Pavement Condition (Roughness)

The World Bank developed the highway design and standards model (HDM) from data collected in Brazil from 1975 and 1984. The present version of the model, HDM-III, can aid feasibility studies of highway networks or individual projects. The HDM is based on the premise that user costs are related to highway construction and maintenance standards through the effect of road geometry and pavement surface condition, and that the surface roughness is the principal road-related fact affecting user costs in free-flow traffic that can be related to all major pavement performance variables (Watanatada 87). The quantities of resources consumed are determined as a function of the characteristics of each vehicle group (ten groups), surface type (paved or unpaved), vehicle speed, and current condition of the road (roughness). Relations for predicting vehicle speed, fuel consumption, and tire wear are based on principles of vehicle mechanics and driver behavior, while those for predicting maintenance parts and labor requirements are based on econometric analyses of user survey data. HDM VOC models consider only paved and unpaved pavement types and no further classification is sought in the paved category. Bein (Bein 90), after reviewing HDM-III, commented that this model is basically relevant to the study of rural road infrastructure design and planning issues. Although it is formulated for developing countries, the VOC submodel is practical and can be used in developed countries to appraise those roads that do not experience impeded traffic flows.

In a major study on VOCs, the Texas Research and Development Foundation (Zaniewski 82) investigated the effect of highway design and pavement condition on VOCs. The model also drew on the Brazil HDM study results, particularly the effects of pavement roughness on VOC. Zaniewski concluded that fuel consumption is not affected by roughness for the range of conditions encountered in the United States (Zaniewski 82). The most current application of the Zaniewski study is in the MicroBENCOST software developed under National Cooperative Highway Research Program (NCHRP) Project 7-12 by the Texas Transportation Institute (TTI 93). MicroBENCOST features multiple regression fitted equations to VOC tables developed in the Zaniewski study. But the equations are modified for fuel consumption of trucks at zero grade in accordance with data collected in France and updated to reflect the current component unit prices.

Our objective in pavement type selection is to identify relative cost differences among candidate pavement strategies. Zaniewski (Zaniewski 82) and Watanatada (Watanatada 87) studies indicate that the effects of VOC are significant when comparing paved versus unpaved roads. Their results show that when pavements are constructed and maintained reasonably well the VOC differences among pavements are insignificant.

Work Zone Models for User Delay Cost

Memmot and Dudek (Memmot 82) developed a model (QUEWZ) to calculate user costs incurred as a result of lane closures at highway work zones. The data elements needed to run QUEWZ include the lane closure strategy, total number of lanes and the number of open lanes through the work zone, the length of closure, the hours of closure and hourly traffic volumes, average speeds, and the developing of a queue when demand exceeds capacity. The typical hourly speed-volume relationship assumed in the model can be modified by the user as part of the input data. The output from QUEWZ includes vehicle capacity, average speed through the work zone, hourly road user costs, daily user costs, and if queue develops, the average length of queue each hour. The user cost calculations in QUEWZ fall into three general categories:

1. Time delay costs resulting from slowing down and going through the work zone at a reduced speed, and the delay of vehicles in the queue if one develops.
2. Changes in vehicle running/operating costs caused by a lower average running speed through the work zone and queue (if one develops).
3. Speed-change cycling costs resulting from decelerating and accelerating before and after the restricted length, and stop-and-go conditions (if there is a queue).

TxDOT's FPS (Scrivner 68) also considers time delay costs and additional VOCs at work zones. FPS outlines the following two main sources for vehicle time delays: (1) traveling at a reduced, uniform speed in the restricted area, and (2) having to stop because of congestion when the traffic demand exceeds the capacity of the restricted area.

The user must specify one of the five default traffic control and detour strategies as well as the input traffic flow rate during construction. A typical default speed profile of vehicles that are not stopped and those that are stopped is shown in Figures 2.4 and 2.5. User costs incurred by work zone activities include the following components in FPS:

- Excess time and operating costs resulting from speed reductions (decelerating from the approach speed to a stop and then accelerating back to the approach speed).
- Excess time and operating (idling) costs resulting from the need to stop.
- Excess time and operating costs resulting from speed reductions — from the approach speed to through speed and returning to the approach speed (cycling).
- Excess time and operating costs resulting from traveling through work zone at a constant reduced speed.

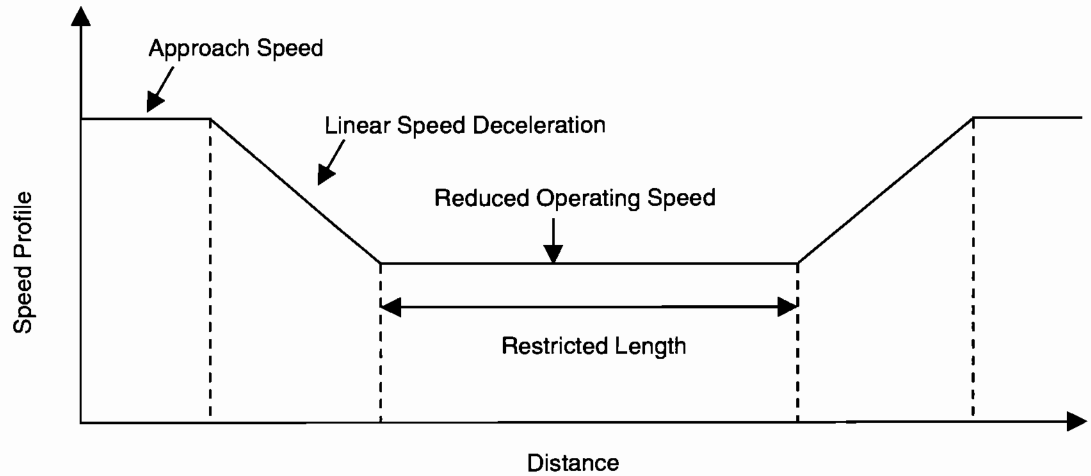

Figure 2.4 Conceptual speed profile for nonstopping vehicles at work zone

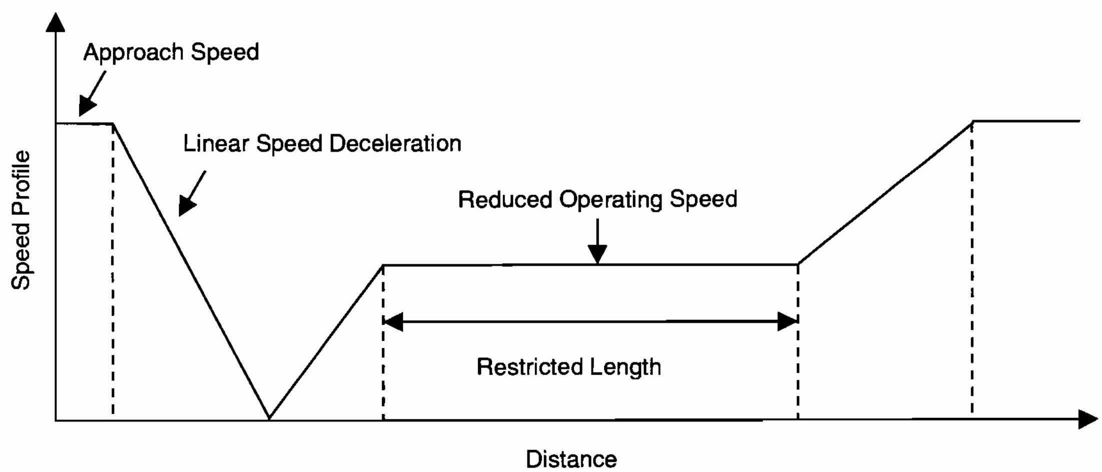

Figure 2.5 Conceptual speed profile for stopping vehicles at work zone

OTHER FACTORS CONSIDERED IN PAVEMENT TYPE SELECTION

While the American Association of State Highway Transportation Officials' Guide (AASHTO 93) outlines several principal and secondary factors that may affect pavement type selection, it does not provide any integrated approach for using them in pavement type selection. The guide recommends that the pavement type selection should be facilitated by a comparison of alternative structural designs for one or more pavement types designed through theoretical or empirically derived methods. However, it cautions that these design methods are not absolutely precise and do not guarantee a certain level of performance from any one alternative and comparable service for all alternatives. It also emphasizes that LCCA procedures are not precise, because reliable data for subsequent stages of construction, maintenance, rehabilitation work, and salvage value are not always available. Also, economic analyses are altruistic in that they do not consider the present or future financial capabilities of the contracting agency.

Even if structural design and economic analysis procedures were perfect, they would not by their nature encompass all factors affecting pavement type determination. Such a determination should properly be one of professional engineering judgment based on the consideration and evaluation of all factors applicable to a given highway section.

The principal factors include those factors that may have a major influence and that may dictate the pavement type in some instances. Some of these major factors are also incorporated in the basic design procedures and influence the structural requirements of the pavement design. In such cases, they are assigned an economic value for comparative purposes. The principal factors identified in Appendix B of the AASHTO Guide include:

- traffic
- subgrade soil characteristics
- weather
- construction considerations, including stage construction, speed of construction, accommodating traffic during construction, ease of replacement, anticipated future widening, seasons of the year when construction must be accomplished
- opportunity to recycle material from an existing pavement structure and potential of future recycling may also be considered
- cost comparisons

The secondary factors identified in Appendix B of the AASHTO Guide include:

- performance history of similar pavements in the area
- adjacent existing pavements providing continuity of pavement type
- availability of local materials or contractor capabilities
- conservation of materials and energy
- stimulation of competition
- municipal preference

The AASHTO Guide supports the explicit use of life-cycle cost comparisons where there are no overriding factors and where several alternative pavement types could serve satisfactorily.

In response to a questionnaire survey conducted by Peterson (85), most highway agencies responded that they use some basis in addition to or in lieu of the economic analysis for pavement type selection. Factors such as traffic volume, continuity of pavements, recycling, use of local materials, and soil type were reportedly generally used as secondary factors (with the economic analysis being primary) and always treated in a subjective manner. In a few cases, these factors were used to eliminate certain alternatives before conducting a more detailed analysis. Some agencies, however, have different opinions in this regard. The Minnesota Department of Transportation (DOT) discarded explicit consideration of subjective factors, arguing that most of these factors were indirectly considered in the economic analysis (Peterson 85).

Road agencies also tend to allow some exceptions to conducting economic analysis for pavement type selection owing to some specific type of the project, physical conditions, or other factors. The California DOT (Peterson 85) procedure requires an economic comparison of properly designed structural sections of different pavement types that would normally be approved for construction if they were selected. However, the requirement for an economic analysis would be secondary under the following circumstances:

- Existing pavement is to be widened or resurfaced with a similar material.
- Extent of the project is less than 6.4 lane km (4 lane miles).
- Unavoidable future flooding or a high water table dictates the use of concrete pavement.
- Short freeway-to-freeway connections are being made between pavements of the same type.

PAVEMENT TYPE SELECTION PRACTICES OF A FEW U.S. DOTS

In response to the national survey, a few state DOTs also provided documents describing their pavement type selection methods. Salient features of these methods are summarized below.

The Nebraska DOT's policy for pavement type selection is based on the lowest life-cycle cost (LCC) if there exist no overriding factors as identified in the AASHTO Guide. If that is not the case, all alternatives 15 percent and higher than the lowest are considered as equal, and other considerations may result in the selection of an alternative with a higher LCC.

The New York DOT published a document describing the policy for project level pavement type selection process for rehabilitation and new or reconstruction projects. The policy is primarily based on LCCA, but it allows a threshold traffic limit of 35,000 AADT for considering alternatives with longer service life over lower service life without performing LCCA calculations. Treatment selection should emphasize lowest LCC, but other factors, such as traffic, drainage, soil type, environment, and design or construction constraints, are allowed to be considered in the decision process. A benchmark analysis period will consist of the life of the longest initial paving type, plus the life of one rehabilitation for that alternative. Other alternatives of lower initial service life should have as many rehabilitation treatments added as necessary to meet or exceed the benchmark analysis period.

The Ohio DOT also uses an LCC-based system for project selection. Typical design alternatives considered are flexible replacement, rigid replacement, unbonded concrete overlay, rubblize and roll, break and seat, and repair and overlay. A 30-year analysis period is used, and appropriate rehabilitation and maintenance actions are specified for each alternative strategy. A sensitivity analysis of LCC with respect to discount rates is also carried out. Although user costs are not considered in the analysis, an estimate of the lane closure time (days) is estimated. LCC and lane closure time are considered in the final selection.

The Pennsylvania DOT reported the use of a present-worth-based economic analysis for pavement type selection. An analysis period of 40 years and a typical initial performance period of 20 years for rigid and 10 years for flexible pavements is used. LCCA includes agency costs and user costs at work zones. A spreadsheet application is used for carrying out the economic analysis.

The Vermont DOT developed a policy based on economic evaluations and endorses the use of flexible pavements for Vermont state highways. The policy, however, allows some warranting situations for consideration of rigid pavements, which include intersections with high volumes of turning and/or stop-and-go traffic, and/or community preference for routes under local control. The justification for the proposed use of rigid pavement, however, should be in the form of an LCCA and should be consistent with the AASHTO Guide design method.

The Virginia DOT also uses an LCCA-based method for pavement type selection. Guidelines state that pavement type selection is not an exact science, and that, therefore, highway engineers can use engineering judgment along with an economic analysis. Thus, a difference of up to 10 percent in LCCA is not considered significant for pavement type selection. Other important factors, such as traffic, soil characteristics, weather, construction consideration, recycling, and local materials, can be considered in such situations.

The Washington DOT uses an LCCA in combination with some other subjective considerations for pavement type selection. LCCA over a period of 20–40 years is recommended, and agency and user delay costs are included. Subjective opinions are also allowed for such factors as traffic, subgrade soils, weather, materials, prior performance, and construction factors in pavement type selection, especially when LCCs are not significantly different.

CHAPTER 3. NATIONAL QUESTIONNAIRE SURVEY

OBJECTIVES

For guidance, it was useful to the project to review and evaluate pavement type selection practices of other highway agencies. While some relevant information was available in published literature, it was not always up to date in most cases. A national questionnaire survey was therefore carried out to gather information about other agencies' pavement type selection practices. U.S. state departments of transportation (DOTs) and Canadian Provincial DOTs were primarily targeted in this survey. Results of this survey would provide an up-to-date synthesis of current pavement type selection practices of state highway agencies. This information will help in developing a basic framework for the pavement type selection process to be developed for the Texas Department of Transportation (TxDOT).

SURVEY QUESTIONNAIRE DESIGN

A broad-based, simple, and easy-to-complete questionnaire was developed for this purpose (see Appendix A). The questionnaire was divided into three main sections: general information, economic analysis, and subjective factors in pavement type selection. Questions were designed to collect information on such items as agency profile, contact person, use of organized procedure for pavement type selection, alternative pavement types, criteria for economic analysis, cost components used in life-cycle cost analysis (LCCA), and subjective factors in pavement type selection decisions.

RESULTS AND ANALYSIS

This section summarizes the results of an analysis of the questionnaire survey sent to sixty-three highway agencies, which included forty-nine state DOTs, the District of Columbia, Puerto Rico, and twelve Canadian provincial DOTs. Texas was not included, since a TxDOT survey was conducted separately. Fifty-four replies were received, yielding an 86 percent response rate; responding were forty-four state DOTs, eight Canadian DOTs, the District of Columbia, and Puerto Rico, as shown in Figure 3.1.

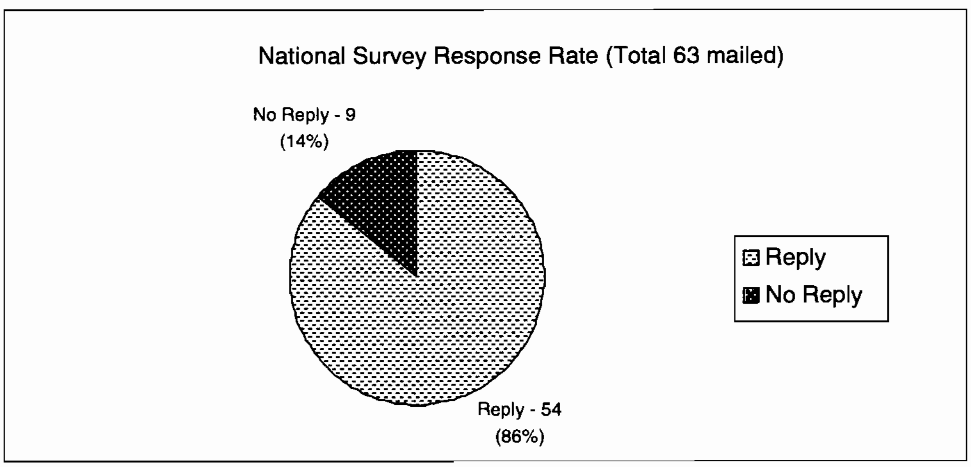

Figure 3.1 National survey response rate

General Information and Pavement Types

Use of Organized Procedure

Forty-five (83 percent) respondents reported that organized procedures are used for pavement type selection for new projects. Similarly, forty-three (80 percent) respondents reported the use of organized procedures for pavement type selection for reconstruction projects. Figure 3.2 shows this result.

How Long Procedure Has Been in Use

Figure 3.3 presents the summary of responses to the question on how long highway agencies have used pertinent procedures for pavement type selection. As the figure indicates, a majority, twenty-three agencies (59 percent), reported that they have been using a type selection procedure for 10 years or less.

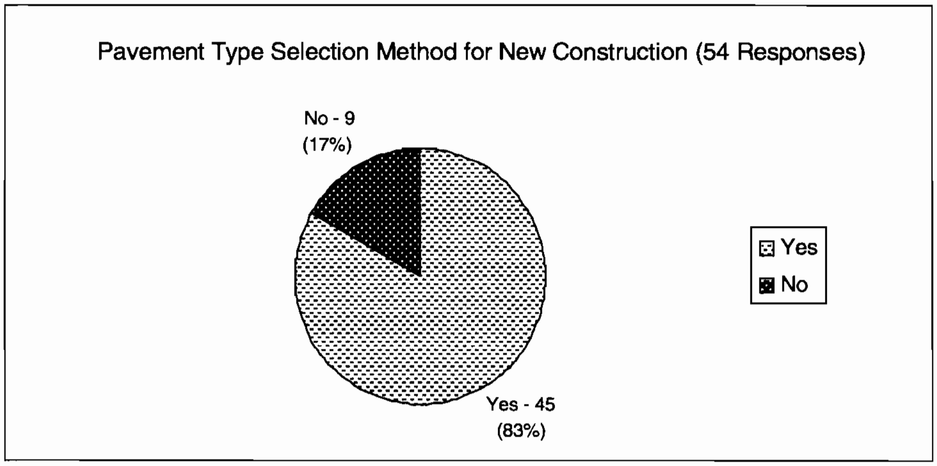

Figure 3.2 Agencies using organized procedure for pavement type

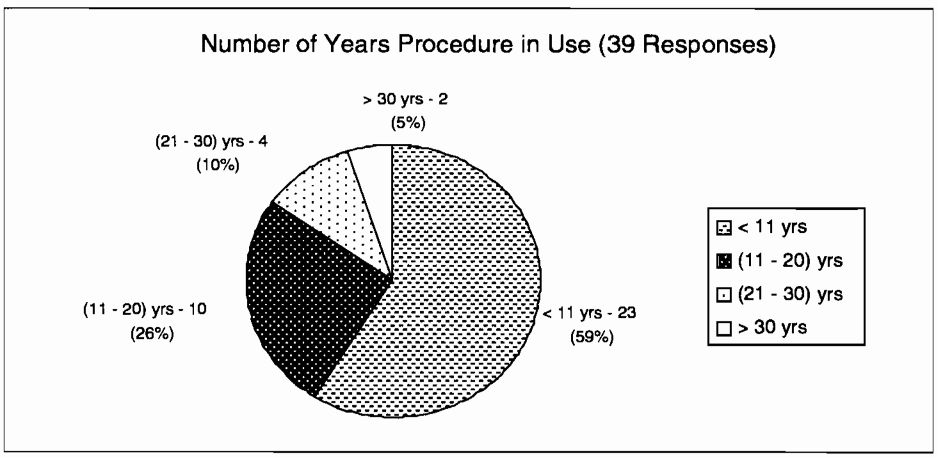

Figure 3.3 "Number of years" agencies are using pavement type selection procedures

Pavement Types

"Asphalt concrete pavement (ACP) with granular base" stands out as the most widely used pavement type among the alternative pavement types that state agencies consider in pavement type selection. Figure 3.4 shows that fifty-one agencies (94 percent) generally consider "ACP with granular base" as one of the alternative pavement types in pavement type selection. The pavement type, "seal coat with granular base," was not specified in the national survey. The other two asphalt pavement types, "ACP with stabilized base" and "full-depth ACP," were also significant and drew a response of 59 percent and 50 percent, respectively.

Among rigid pavements, jointed concrete pavement (JCP) turned out to be the most significant, with forty-three (80 percent) agencies specifying its consideration in pavement type selection. This result apparently is representative of the existing pavement network in states that initially build JCP rigid pavements. According to the survey results, continuously reinforced concrete pavement (CRCP) and jointed reinforced concrete pavement (JRCP) were least considered, as indicated in a response of 28 percent and 22 percent, respectively.

Economic Analysis

Criteria for Economic Analysis

The question about the criteria used for economic analysis drew thirty-five responses (64 percent) in favor of the total life-cycle cost (LCC) methodology. Nine agencies reported the use of only the initial construction cost as the economic criterion. Nine other agencies reported considering both total LCC and initial construction cost criteria for economic-based decisions. Figure 3.5 shows this result. Figure 3.6 illustrates that a total of forty-four (81 percent) respondents mentioned using LCCA. This includes the nine agencies that use both LCC and initial construction cost for economic considerations. This result shows the widespread use and acceptance of LCCA for pavement investment decisions among highway agencies.

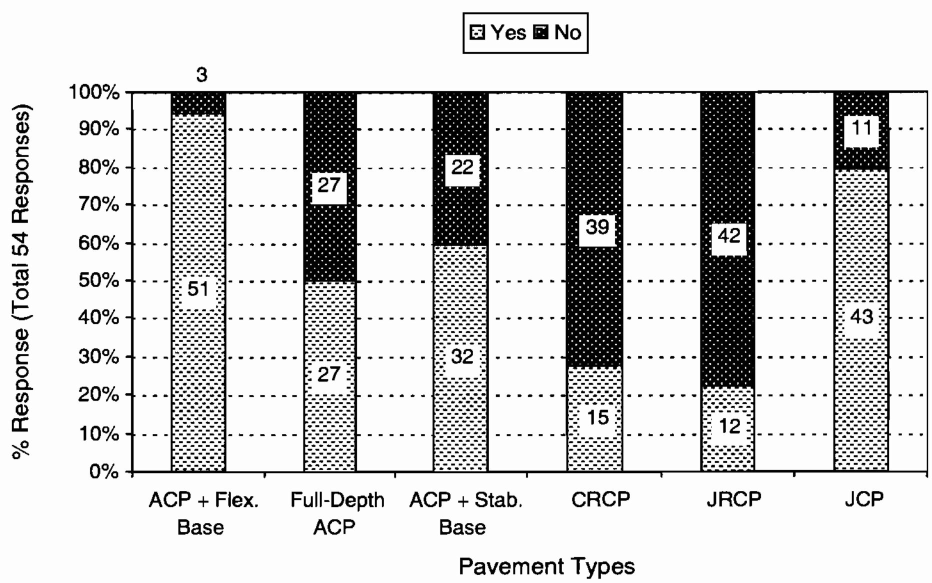

Figure 3.4 General pavement types considered for pavement type selection

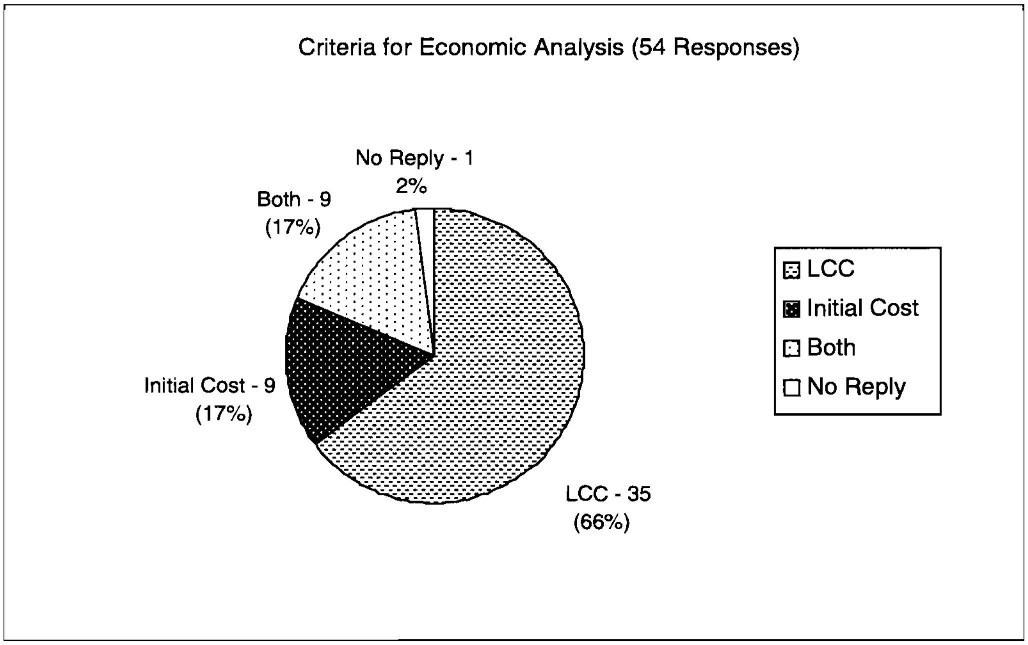

Figure 3.5 Economic analysis criteria used by agencies

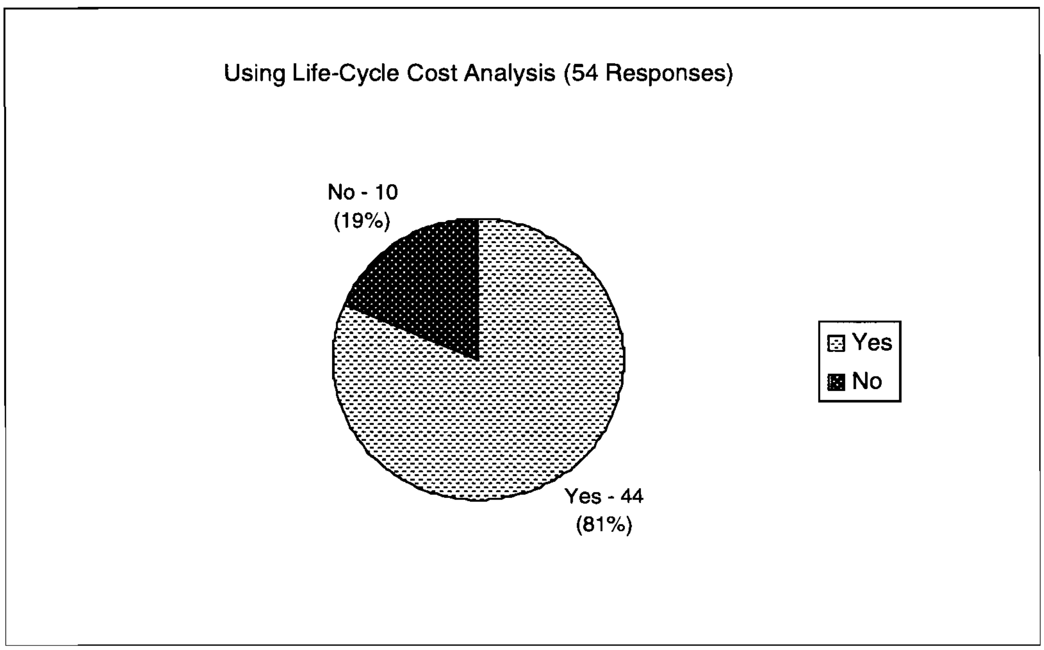

Figure 3.6 Agencies using LCCA

Analysis Period

The analysis period used by agencies ranges from 20 to 50 years, with an estimated average of 38 years. As Figure 3.7 shows, twenty (46 percent) of the forty-four LCCA users employ analysis periods in the range of 31–40 years, and another four users (9 percent) use an analysis period longer than 40 years. Forty-five percent of the agencies, however, reported using an analysis period less than or equal to 30 years. It is reasonable to use a longer analysis period because a low (typically 5 percent to 7 percent) discount rate is used by highway agencies. Moreover, pavement-related costs occur throughout the life cycle of pavement strategies, which generally last 30–40 years before reconstruction. Rigid pavements are typically designed for longer performance periods and consequently require longer analysis periods. On the other hand, flexible pavements typically undergo reconstruction relatively early.

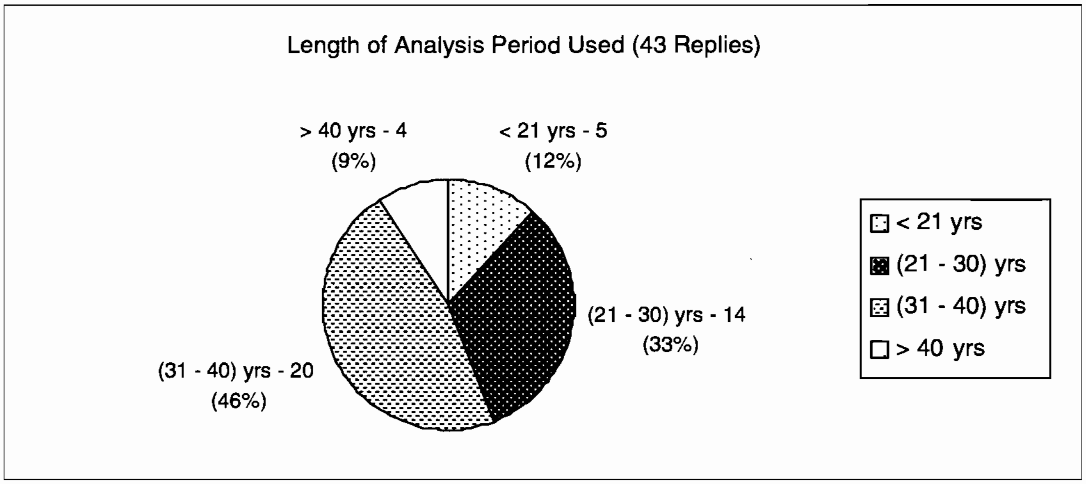

Figure 3.7 Length of analysis period used for LCCA

Performance Period

Replies to the question about the typical initial performance period used by agencies were rather vague. Most agencies provided a range of years, since different pavement types often require different performance periods. There is no obvious or meaningful way to graphically represent the responses to this question. The results show that performance periods range from 5 to 40 years, with a majority of respondents reporting a period of 10–20 years.

Economic Basis for Life-Cycle Cost Analysis

In reply to the question regarding the economic basis used for LCCA, thirty-five (86 percent) LCCA users reported the net present worth (NPW) basis, 7 percent the equivalent uniform annual cost (EUAC) basis, and another 7 percent both NPW and EUAC. Results are shown in Figure 3.8. NPW evaluation is therefore the most widely used economic basis among road agencies. One main reason is that agencies typically use a fixed analysis period, and NPW is the customary economic basis used for equal life comparisons. In economic terms, both criteria yield the same economic ranking of candidate strategies for equal analysis periods. However, if different analysis periods are used, only EUAC will provide a reasonable basis for economic comparison, since NPW comparison has no meaning in this situation.

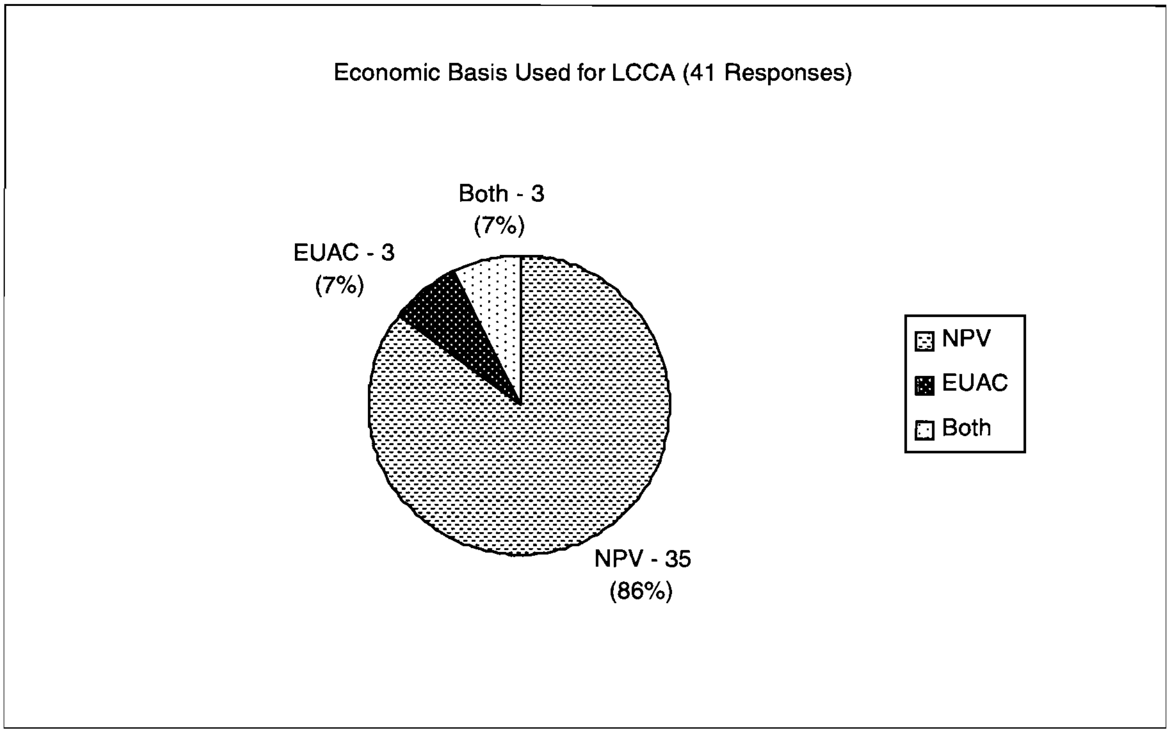

Figure 3.8 Economic basis used for LCCA

Agency Cost Components in Life-Cycle Cost Analysis

The responses regarding agency cost components used in LCCA are summarized in Figure 3.9. An obvious result was the use of initial construction cost and rehabilitation cost by all LCCA users. However, there was a varying response for the other three listed agency cost components: twenty-eight (64 percent), twenty-one (48 percent), and twenty-three (52 percent) agencies consider routine maintenance cost, preventive maintenance cost, and salvage value, respectively, in LCCA. A relatively significant use of routine maintenance cost can be attributed to a relatively easy assignment of annual routine maintenance costs in LCC stream. The use of routine maintenance cost in LCCA would be more valuable if different pavement types required very different routine maintenance costs. For instance, flexible pavements require more frequent routine maintenance than rigid pavements. The reason for the relatively lower use of preventive maintenance cost could be that a large degree of uncertainty exists in forecasting future preventive maintenance needs. A lower response is also observed for the use of salvage value in LCCA. Salvage value is primarily used because not all candidate strategies are at the same salvage level at the end of a fixed analysis period. As discussed in the literature review, the assessment of salvage value of a pavement is not a trivial matter and use of true life cycles for pavement strategies can eliminate the need for salvage value in the analysis.

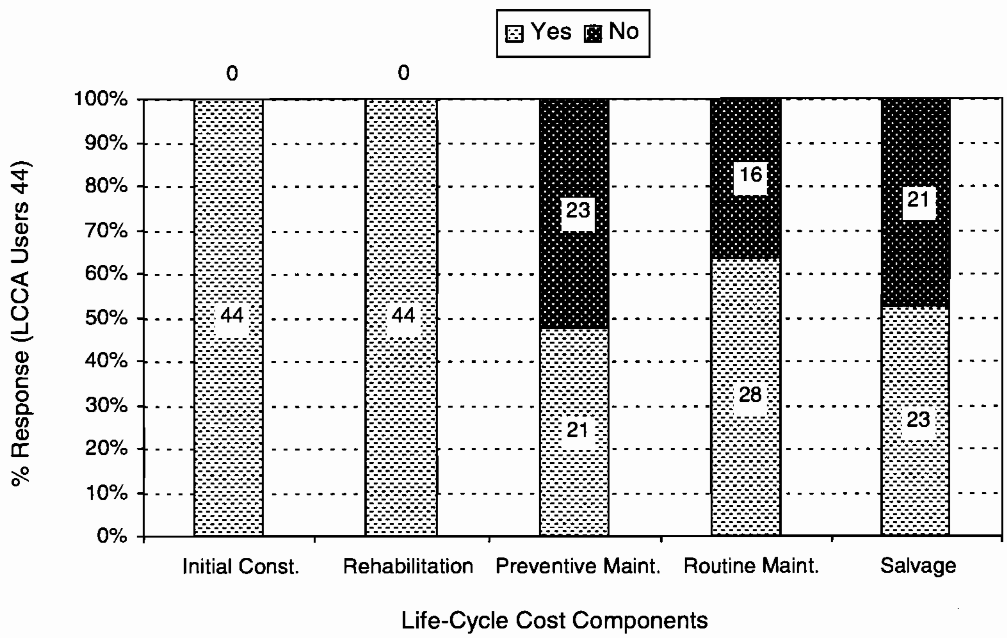

Figure 3.9 Agency cost components used in LCCA

User Costs in Life-Cycle Cost Analysis

For the question regarding whether agencies include user costs in LCCA, thirty-five agencies (80 percent) reported that they do not consider user costs in LCCA. Among the other nine (20 percent) agencies which stated that they include some aspects of user costs, seven respondents (16 percent) considered time delay costs, while only five (11 percent) considered vehicle operating costs (VOCs) at work zones in LCCA. Results are shown in Figures 3.10 and 3.11.

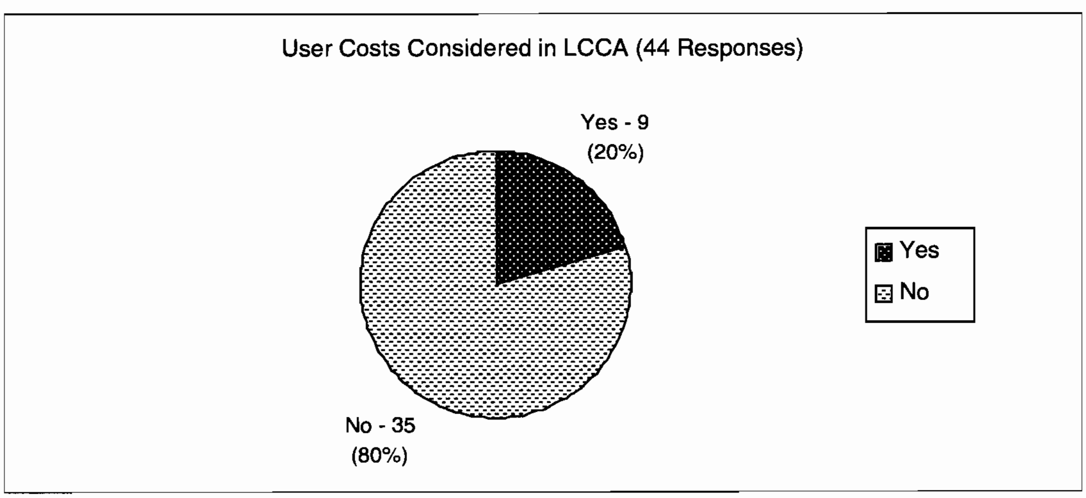

Figure 3.10 User costs considered in LCCA

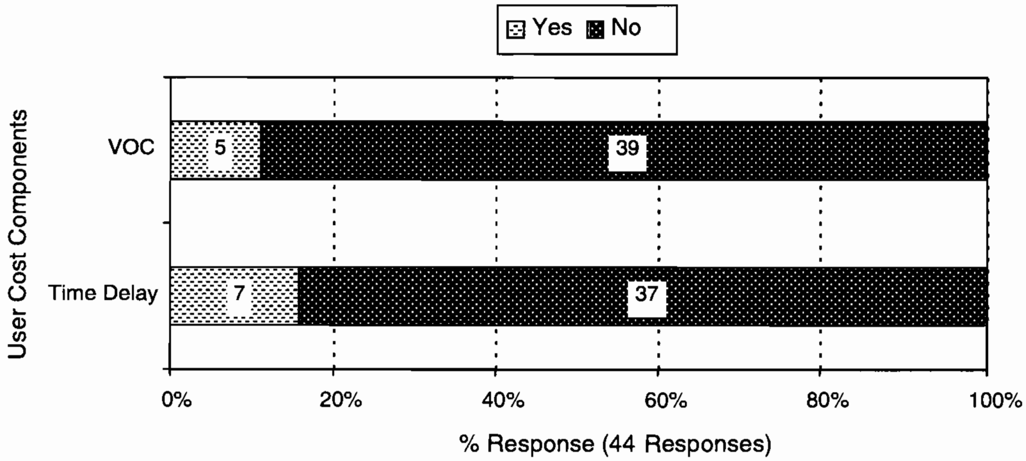

Figure 3.11 User cost components considered in LCCA

A possible reason as to why only a few agencies consider user costs in LCCA is that, in general, user costs are difficult to quantify. No one reported the use of some other user costs, such as accidents, safety, or discomfort in the analysis. This result shows the skepticism of practitioners in highway agencies toward quantifying user costs. The research community, too, has a variety of opinions on issues related to user costs. Apparently, the work zone modeling, calculation of user delay, and assigning dollar values to delay are complex problems involving calculation of time delay resulting from steady low-speed travel, speed change cycles, stops, stop-and-go movements, and queue situations. The other portion of user costs is related to increased VOC at work zones. These costs are related to the increase in VOC resulting from speed change cycles, stops, and stop-and-go movements. The calculation of VOC is an even more complex problem dealing with traffic control, speed profiles, traffic behavior, and additional consumption of vehicle resources (e.g., fuel, oil, tire wear, and increased maintenance caused by work zones). The very complex nature of VOC results in large variations that can overshadow other relatively simpler LCC components (such as agency costs) and add considerable uncertainty if included in the analysis.

Important Technical and Subjective Factors

There are several factors that affect pavement type selection. Some of these factors are technical and can be quantified. On the other hand, some factors are nonquantifiable and are treated subjectively by decision makers. We asked agencies if they "always," "occasionally," or "never" consider these factors in pavement type selection decisions.

The listed factors drew a variety of responses. Based on the "always considered" category, "traffic volume" drew a maximum of 85 percent of the responses. Three other factors, "subgrade soil type," "constructability," and "initial budget considerations," ranked second in the "always considered" category, with percentages of 77, 76, and 75, respectively. The three factors at the bottom of the list in the "always considered" category each drew close to 50 percent (traffic control during M&R at 48 percent, use of recycled materials at 47 percent, and continuity of pavement type at 44 percent).

Based on "never considered" criteria, climatic conditions drew the maximum (19 percent) response. The factor that was not selected by any agency in this category was traffic volume. This result again shows the high significance of the traffic volume factor in pavement type selection. This apparently indicates that practitioners indirectly consider user delay and inconvenience, as more people will be affected by M&R operations in high traffic volume situations. Figure 3.12 presents a summary of the responses for these factors.

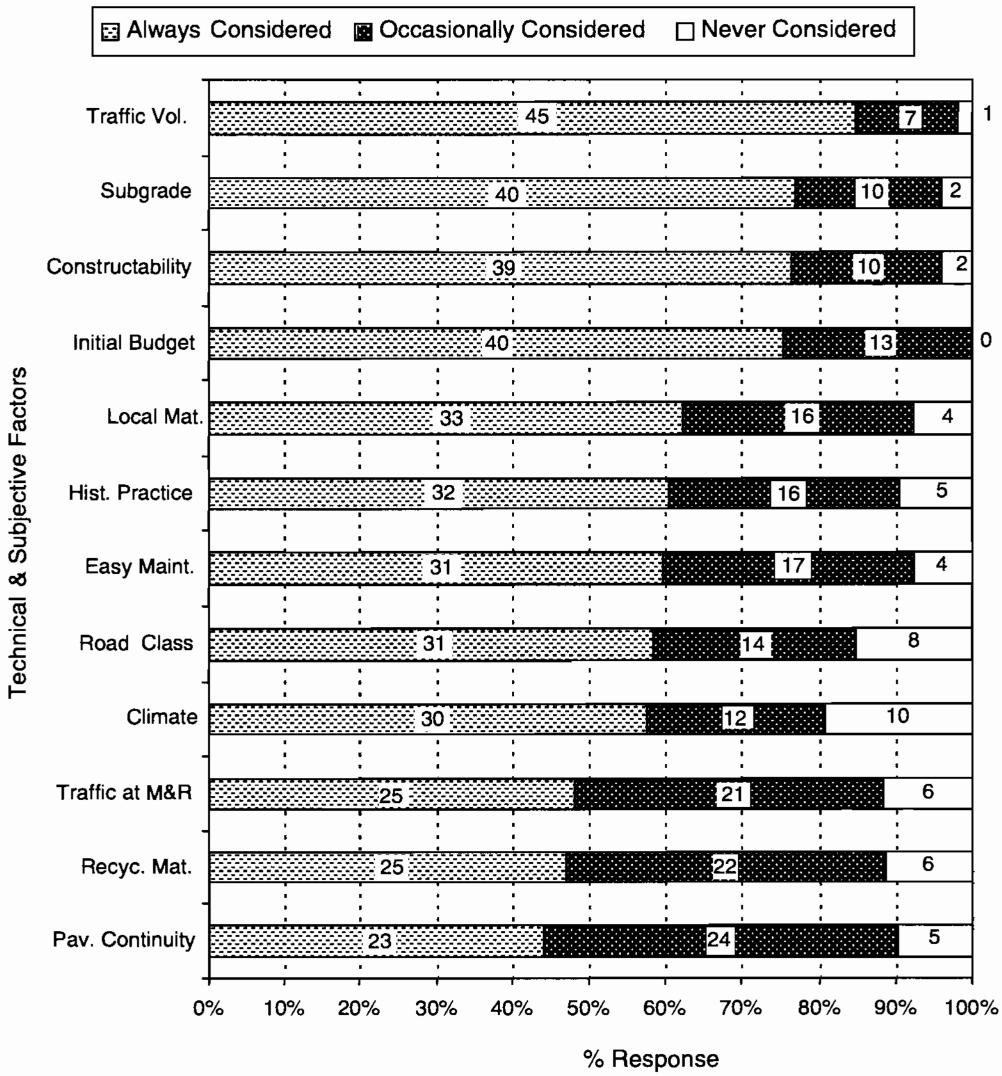

Figure 3.12 Percent responses for "always considered" category of technical and subjective factors

CHAPTER 4. TXDOT QUESTIONNAIRE SURVEY

OBJECTIVES

It was important for the project team to examine current pavement type selection practices of the Texas Department of Transportation's (TxDOT) district and area offices as a basis for developing a coherent policy that can be used throughout TxDOT. A carefully designed questionnaire was aimed at collecting information related to pavement types, pavement design, use of economic analysis, agency costs, user costs, and consideration of technical and subjective factors in pavement type selection. A copy of the questionnaire is included in Appendix B.

RESULTS AND ANALYSIS

TxDOT district offices were requested to complete the questionnaire and to send the questionnaire to at least three area offices in their districts. This approach made the survey sample size flexible, depending on the number of responses obtained from area offices. A total of forty-seven responses were received, representing twenty-three districts; this provided a 92 percent response rate among TxDOT districts. The number of responses from each district is shown in Figure 4.1. Fourteen districts provided one response each by the district office. Nine districts provided multiple responses, including both district and area offices. Two districts — Bryan and Tyler — did not reply.

The questionnaire is divided into three main sections: (1) general information, (2) economic analysis and pavement design, and (3) technical and subjective factors in pavement type selection. Each section includes questions that attempt to gain some useful information regarding local pavement type selection practices.

General Information

How Pavement Type Selection Decisions Are Generally Made

The question regarding "how pavement type selection decisions are generally made and if there is any district policy for this purpose" drew a variety of replies. The replies are summarized in Table 4.1, which shows that districts typically do not use any standard procedure or policy for pavement type selection.

Pavement Types

We asked respondents to reply as to whether they consider several pavement types in pavement type selection. We listed seven pavement types for this purpose. A total of forty-four respondents (94 percent) reported considering "ACP with granular base" for pavement type selection. This result shows that "asphalt concrete pavement (ACP) with granular base" is the most significant pavement type among the alternative pavement types used in Texas. Two other asphalt pavement types—"seal coat with granular base" and "ACP with stabilized base"—also drew forty-two (89 percent) "yes" responses. "Full-depth ACP" obtained a relatively lower 55 percent "yes" response. This may be because many highway networks in Texas districts are not highly trafficked, and thus a "full-depth ACP" may not be required for either structural or economic reasons. Twenty-three (49 percent) respondents reported considering continuously reinforced concrete pavement (CRCP) in pavement type selection. Two other rigid pavement types — jointed concrete pavement (JCP) and jointed reinforced concrete pavement (JRCP) — were the least considered; they obtained ten (21 percent) and nine (19 percent) "yes" responses, respectively. Figure 4.2 shows these results.

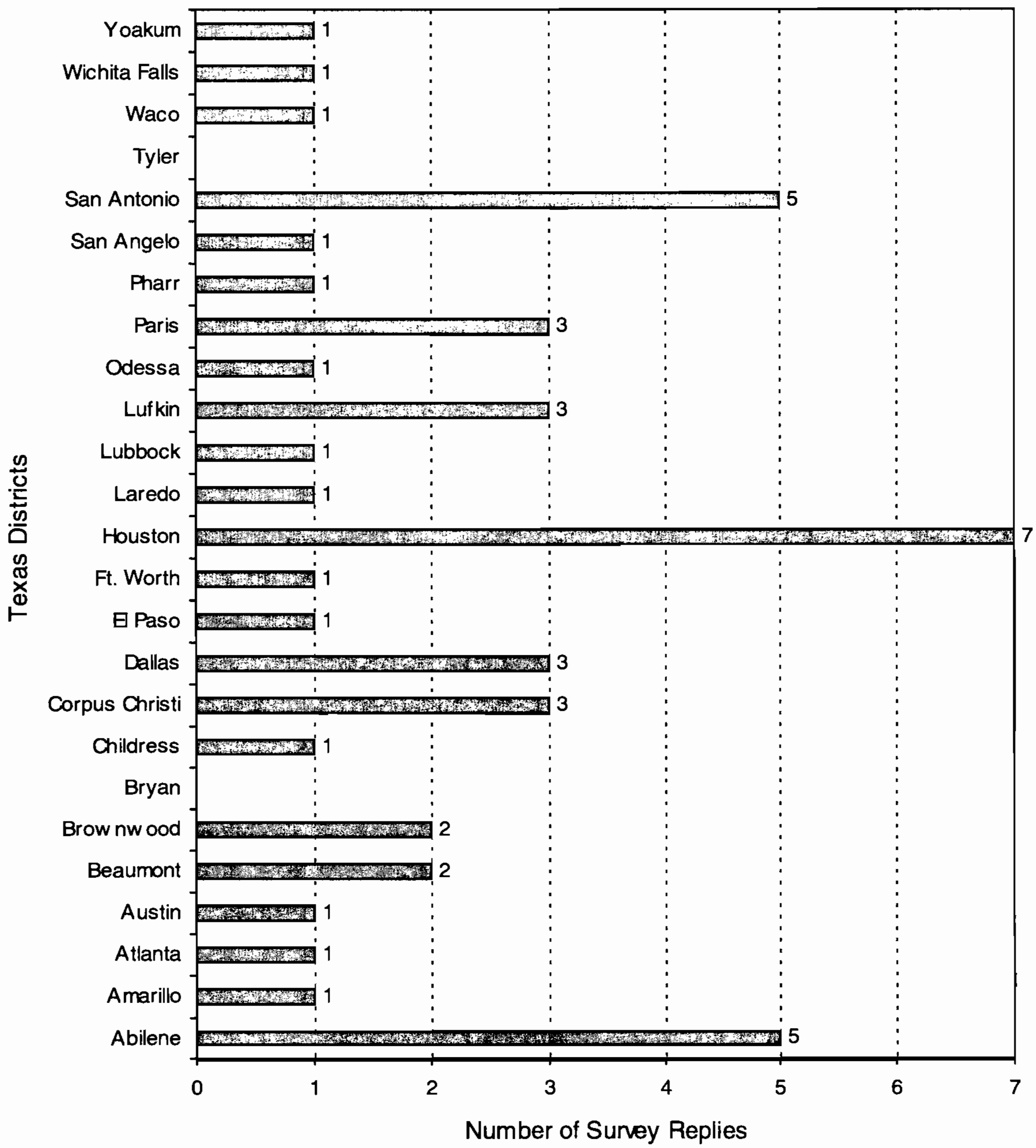

Figure 4.1 Survey responses from Texas districts

Table 4.1 Responses for "how the pavement type selection decisions are generally made"

District	Comments
Abilene 1 (District)	Use FPS-11 or FPS-19 and compare to modified triaxial.
Abilene 2 (Big Spring area)	Hot mix base and surface with flexible base and subbase on interstate and high volume, high % trucks US highways. Flexible base and two-course surface treatment on other roadways. Lime stabilization is used on some subgrade or reconstructed base courses with low triaxial or high PI.
Abilene 3 (Snyder area)	The amount of money usually dictates; with rehabilitation we try to match existing structure as much as possible if it had a good history in the past.
Abilene 4 (Hamlin area)	Economics, past performance, ADT, soil conditions, LCC, material availability, experience (+25 years).
Abilene 5 (Abilene area)	FPS-11 with common sense.
Amarillo (District)	Look at factors of stress, such as rutting and fatigue cracking, and how we can control these problems in reconstruction. The area engineer makes the decisions regarding the pavement type.
Atlanta (District)	It is done by the "District Planning Committee" (about five people).
Austin (District)	The area engineer, who is also responsible for pavement design, does initial selection. Pavement designs for new construction are reviewed by the district pavement engineer. Reconstruction and maintenance strategies are reviewed by district engineer personnel in plan review or by project monitoring selection committee.
Beaumont 1 (Unknown area)	—
Beaumont 2 (Beaumont area)	There is no district policy. Primarily based on historical performance of various pavement types under loading conditions.
Brownwood 1 (District)	No district policy. We use "rule of thumb" based on ADT and location — for example, urban road with high traffic use rigid pavement (portland cement concrete) and for rural road with low traffic use flexible pavements.
Brownwood 2 (Lampasas area)	Consider functional classification, traffic volume, % truck, available materials, service life-cycle cost, constructability, and maintenance.
Childress (District)	There is no district policy in our selection process. We look at history of materials that are located in our area and assess confidence of performance of different materials.
Corpus Christi 1 (District)	I use FPS-11 and FPS-19 along with engineering judgment. Other resources considered include input from maintenance supervisors and area engineers. I develop pavement type selection in the most feasible manner.
Corpus Christi 2 (Karnes area)	There is no written policy in the district. Generally, just run a flexible pavement design for every project.
Corpus Christi 3 (Corpus Christi area)	All flexible pavements, with mostly economical decisions.
Dallas District 1 (District)	There is no specific district policy. We take into consideration the traffic, location, highway type, subgrade, maintenance cost, and adjacent pavements.
Dallas 2 (Dallas Proj. Off.)	Pavement type is recommended by area engineers.
Dallas 3 (Ellis area)	I am not aware of a specific district policy. Type of highway (IH, US, SH, or FM), traffic, urban/rural, adjoining pavement type.
El Paso (District)	No policy. Decision based on many factors, such as funds for project, traffic ADT, type of traffic, traffic control, soil type, and availability of materials.
Fort Worth (District)	Area offices submit recommendations to director of TP&D, who then discusses this with district pavement engineers and district design engineer.
Houston 1 (District Pav. Engr.)	Based on ADT, highway classification, and funding. Prefer to build high-volume roads with concrete.
Houston 2 (District Des. Engr.)	Pavement selected based on cost effectiveness. I am not aware of any district policy governing pavement type.
Houston 3 (Brazoria area)	Comparison to existing pavement along with TxDOT's design procedures.
Houston 4 (Conroe area)	Consideration given to existing pavement type, existing traffic counts and mix, economics (available funding), future traffic, and maintenance.

Table 4.1 (Continued) Responses for "how the pavement type selection decisions are generally made"

District	Comments
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Consider funding, ADT, and district preference.
Houston 7 (Houston area)	—
Laredo (District)	The district utilizes flexible pavements; very rarely (heavy traffic volume, stop-n-go traffic, high percentage of trucks) do we use rigid pavements.
Lubbock (District)	We use good engineering judgment to make pavement design decisions. We collect data (FWD, visual, PMIS, etc.), do analyses (FPS-19, TSLAB, DARWin, Modulus, etc.), and use economic reasoning.
Lufkin 1 (District)	No formal policy; we generally select lowest cost pavement that will meet design life guidelines.
Lufkin 2 (San Augustine area)	Selection is generally made based on past experience and then verified by FPS and triaxial design.
Lufkin 3 (Livingston area)	No hard and fast policy: past experience, cost, engineering judgment, FPS.
Odessa (District)	—
Paris 1 (Sulphur Springs area)	—
Paris 2 (Greenville area)	Basically, I look at the facility, traffic patterns, FPS-19, Mod. Triaxial requirements, the type of project, cost, and available funding
Paris 3 (Sherman area)	Cost, existing condition of roadway, and soil all contribute to how the new pavement type is determined.
Pharr (District)	Consider existing pavement structure and its condition; for improving a rural section to a curb and gutter section usually road is reconstructed rather than widened owing to lowering profile.
San Angelo (District)	We have no formal pavement type selection policy. The quality and availability of materials lend themselves to the selection of flexible pavements on almost every road in our district.
San Antonio 1 (District)	The district policy is to follow state policy.
San Antonio 2 (Floresville area)	Decision based on traffic volume and historical performance of pavements.
San Antonio 3 (Unknown area)	Research existing pavement, review PMIS, take samples of existing materials, verify thickness, test materials, dynaflect or falling weight testing, determine from existing and future trends what will be sufficient for design.
San Antonio 4 (Unknown area)	Within San Antonio most of the roadways are ASB and ACP. Owing to traffic, there is not much discussion on other types.
San Antonio 5 (Unknown area)	History of past projects.
Waco (District)	There is no written policy or prescribed policy governing type selection in the district. Pavement types are chosen based on traffic, especially heavy trucks, LCC comparisons, and available funding to construct.
Wichita Falls (District)	There is no district policy on pavement type selection that I am aware of. Generally, we replace what was placed originally.
Yoakum (District)	No district policy is in place. ADT and % trucks would be the primary considerations when deciding flexible versus rigid. We build mostly flexible pavements.

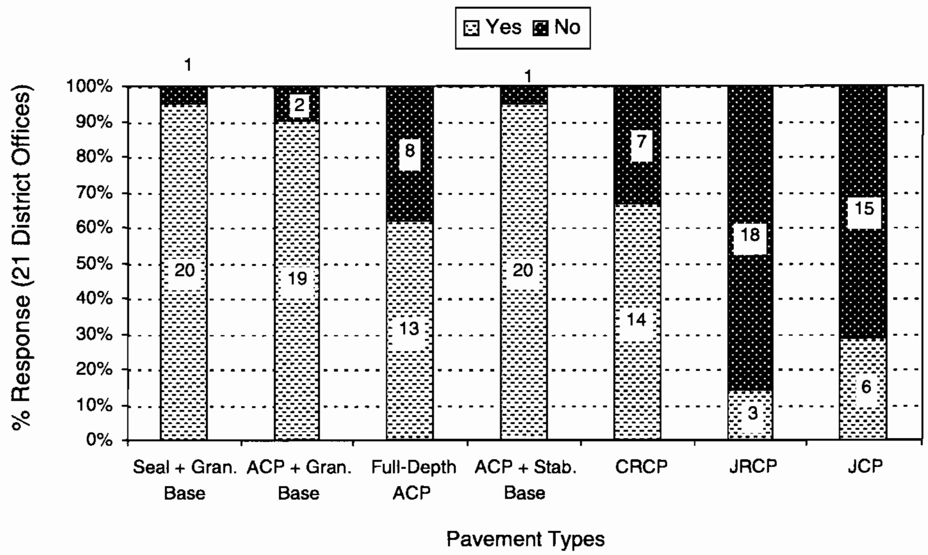

Figure 4.2 General pavement types considered for pavement type selection in Texas

Economic Analysis

Use of Economic Analysis

The questionnaire asked whether economic analysis was conducted as part of pavement type selection. As shown in Figure 4.3, forty-two (89 percent) respondents reported that they use economic analysis in pavement type selection.

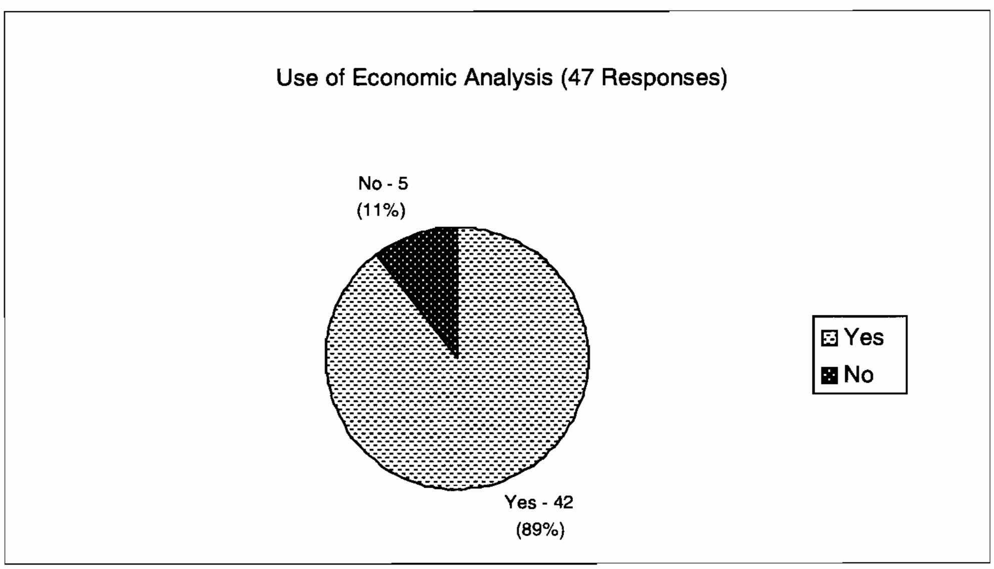

Figure 4.3 Response summary for the use of economic analysis for pavement type selection

Criteria for Economic Analysis

The question regarding the criteria used for economic analysis drew eighteen (42 percent) responses in favor of the total life-cycle cost (LCC) methodology, while twelve respondents (29 percent) preferred the use of initial construction cost as the economic criterion. Another twelve respondents (29 percent) reported the use of both total LCC and initial construction cost as economic criteria. Figure 4.4 shows these results.

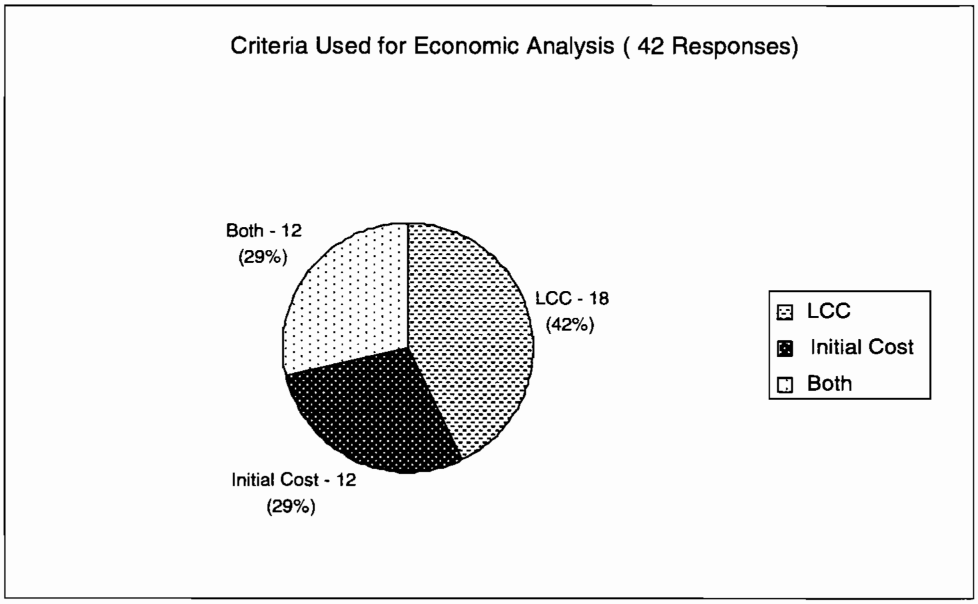

Figure 4.4 Economic analysis criteria used by TxDOT respondents

Agency Cost Components in Life-Cycle Cost Analysis

A summary of responses for the agency cost components used in life-cycle cost analysis (LCCA) is presented in Figure 4.5. All LCCA users report the use of initial construction cost. All other agency cost components also drew a very significant "yes" response: preventive maintenance cost drew twenty-eight (93 percent), rehabilitation costs drew twenty-seven (90 percent), routine maintenance cost drew twenty-six (87 percent), and salvage value drew twenty-four (80 percent), respectively.

User Costs

In reply to the question on user costs, twenty-four respondents (57 percent) support considering user costs in economic analysis. Figure 4.6 shows this result.

In the follow-up question regarding which user cost components should be considered, 63 percent of the respondents favored using user delay costs, while a relatively smaller proportion — 49 percent — responded in favor of using vehicle operating costs (VOCs). These results are shown in Figure 4.7.

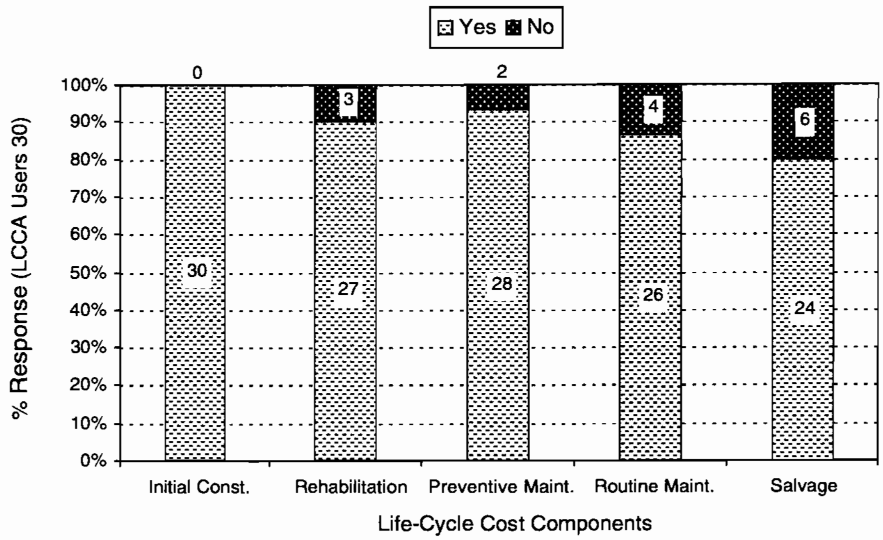

Figure 4.5 Agency cost components used in LCCA

We also asked whether respondents believed that user costs could be computed with reasonable accuracy. As shown in Figure 4.8, about 60 percent believe that user costs cannot be estimated with reasonable accuracy for use in economic analysis.

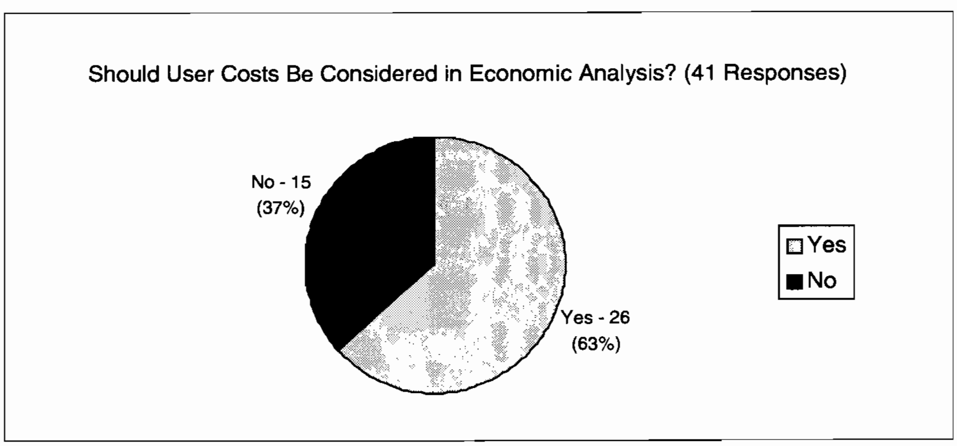

Figure 4.6 Consideration of user costs in economic analysis

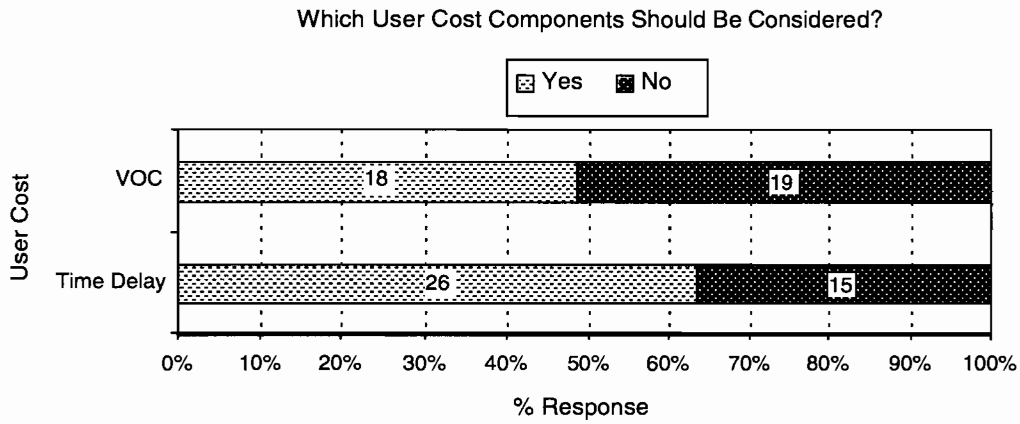

Figure 4.7 Consideration of user cost components in economic analysis

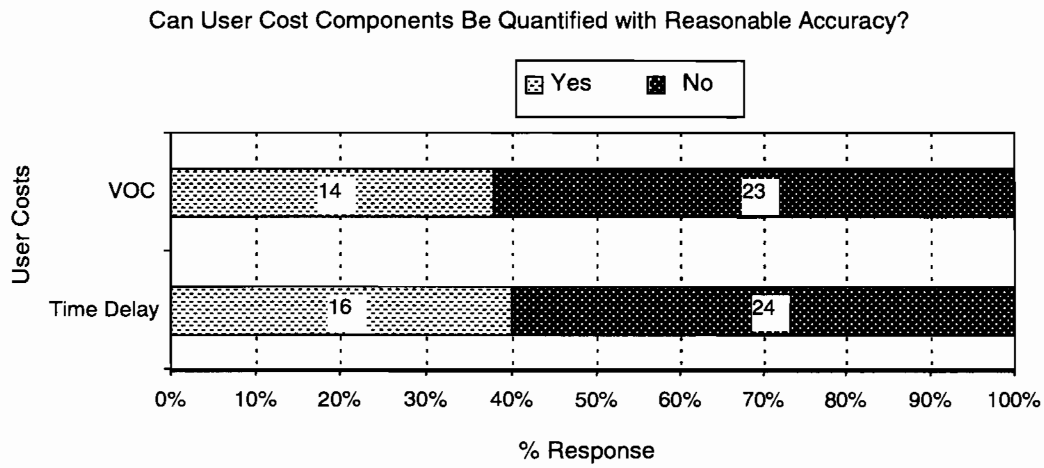

Figure 4.8 Can user cost components be quantified with reasonable accuracy?

Pavement Design Practices

TxDOT uses FPS-19 for flexible pavement design and the AASHTO Guide procedure for rigid pavement design, as described in the Texas pavement design manual (TxDOT 93).

Flexible Pavement Design Related Results: Thirty-seven respondents (95 percent) reported the use of a 20-year analysis period for typical flexible pavement design problems in FPS-19. Table 4.2 shows this result.

Table 4.2 Typical analysis periods used in flexible design

Analysis Period	Number of Responses (Total 39)
20 years	37 (95%)
20–30 years	2 (5%)

The initial performance period typically used in FPS-19 ranges from 6 to 20 years. A large majority of respondents — thirty-three (85 percent) — reported the use of an 8–10-year initial performance period. Few respondents provided a range of years rather than one value for the performance period value. Averages of range limits were taken in these cases, and the averaged values were assigned to one of the performance period classes catalogued in Table 4.3.

Table 4.3 Typical performance periods used in flexible design

Performance Period	**Number of Responses (Total 39)**
6 years	3 (8%)
8 years	23 (59%)
10 years	10 (26%)
15 years	2 (5%)
20 years	1 (3%)

Table 4.4 shows the values of discount factors ranging from 3 to 9 percent. Twenty-nine (81 percent) respondents reported use of a 7 percent discount rate in economic analysis.

Table 4.4 Typical discount factors used in flexible design

Discount Factor	**Number of Responses (Total 36)**
3%	1 (3%)
6%	2 (5%)
7%	29 (81%)
8%	2 (5%)
9%	2 (5%)

FPS-19 allows the use of five reliability levels (50, 80, 95, 99, and 99.9 percent) in design problems. Use of a 95 percent reliability level was dominant among respondents. Table 4.5 summarizes the responses regarding the use of reliability levels in flexible pavement design.

Table 4.5 Typical reliability levels used in flexible design

Reliability Level	**Number of Responses (Total 29)**
90%	2 (7%)
95%	18 (62%)
Varies	9 (31%)

Rigid Pavement Design Related Results: Table 4.6 shows that twenty-three out of twenty-four respondents reported the use of a 30-year analysis period for rigid pavement design in TxDOT using the AASHTO procedure.

Table 4.6 Typical analysis periods used in rigid design

Analysis Period	**Number of Response (Total 24)**
30 years	23 (95%)
30–40 years	1 (5%)

Table 4.7 shows that eight out of nine respondents use a performance period in the range of 20–30 years for rigid pavement design.

Table 4.7 Typical performance periods used in rigid design

Performance Period	Number of Responses (Total 9)
10 years	1 (11%)
20 years	3 (33%)
30 years	5 (56%)

Table 4.8 shows the values of discount factors ranging from 3 to 9 percent for rigid pavement design economic analysis.

Table 4.8 Typical discount factors used in rigid design

Discount Factor	Number of Responses (Total 12)
3%	1 (8%)
5%	1 (8%)
7%	7 (58%)
8%	1 (8%)
9%	2 (16%)

Table 4.9 summarizes the responses regarding the use of reliability levels in rigid pavement design.

Table 4.9 Typical reliability levels used in rigid design

Reliability Level	Number of Responses (Total 18)
95%	7 (39%)
99%	3 (17%)
Varies	8 (44%)

Technical and Subjective Factors

Respondents were asked if they "always," "occasionally," or "never" consider listed technical and subjective factors for pavement type selection. Based on the "always considered" category, "traffic volume" drew the maximum (100 percent) response. Five other factors — "truck traffic" at 91 percent, "constructability" at 89 percent, "initial budget constraint" at 87 percent, "subgrade soil type" at 87 percent, and "historical practice" at 82 percent — also stood as highly significant. Only three factors received less than 50 percent response. These included "traffic control at M&R" (38 percent), "climate" (36 percent), and "use of recycled materials" (17 percent). Figure 4.9 summarizes the responses for these factors.

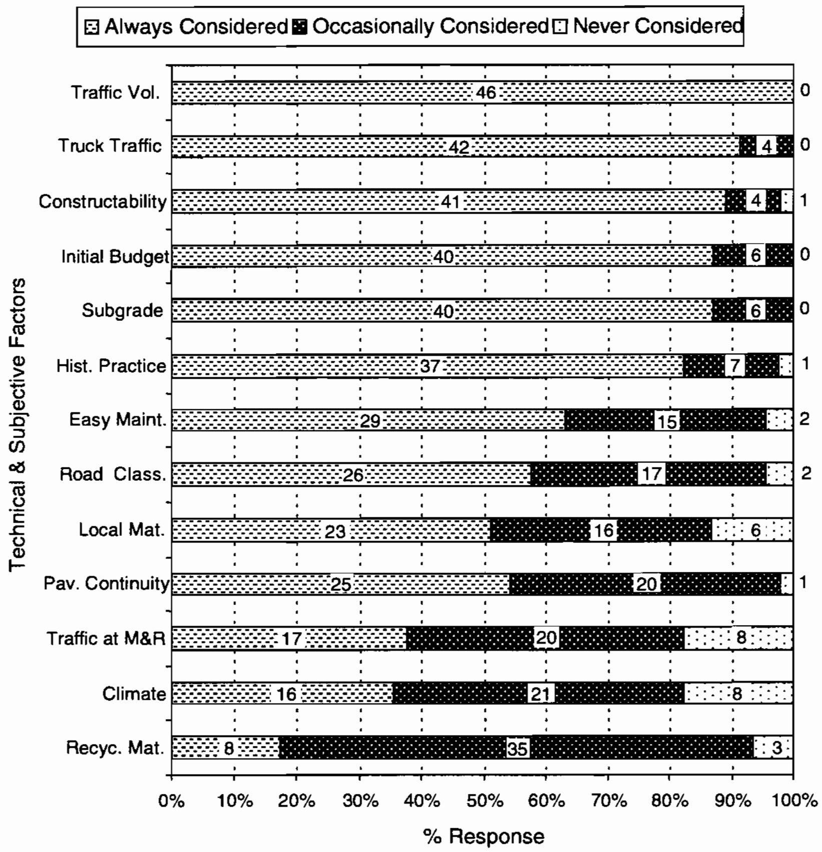

Figure 4.9 Responses for the consideration of technical and subjective factors in pavement type selection

Role of Roadway Functional Class and Traffic Volume in Pavement Type Selection

TxDOT generally classifies highways according to three functional categories, namely, interstate highways (IH), state and US highways (SH), and Farm-to-Market roads (FM). Interstates are generally high traffic volume facilities that also carry significant truck traffic. A more detailed and careful design appraisal from both structural and functional perspectives is required for interstates. They are also generally designed for longer performance periods, keeping in mind the disruption to high volume traffic that occurs during maintenance and rehabilitation activities. Seal coat pavements and thin-surfaced asphalt pavements generally do not fulfill structural requirements under high volume, high truck traffic, and longer performance periods, as required for interstate highways. On the other hand, rigid pavements, thick-surfaced asphalt pavements, and asphalt pavements with stabilized layers offer capabilities to meet design objectives under interstate/high volume operating conditions. In contrast to interstates, FM roads are typically low volume; accordingly, pavement type options that include seal coat pavements and thin-surfaced asphalt pavements are an automatic economic choice in most cases. In general, district and area offices do not consider building rigid pavements in low volume situations. In such cases, specifications are also sometimes relaxed, with the use of local and recycled materials also given more consideration.

A few questions were designed to verify if the roadway functional class and traffic volume are predominant factors considered by practitioners in pavement type selection. Respondents were asked to provide information about which pavement types they generally consider for each of the three roadway functional classes. Figure 4.10 shows the "yes" responses for pavement types based on the roadway functional class criteria. Seal coat pavement type obtained only a 13 percent response for the IH category and soared to 89 percent for the FM category. On the contrary, CRCP obtained a reasonable 64 percent response for the IH category and dropped down to 20 percent for the FM category. "ACP with granular base" drew a high response for all categories: 62 percent response for IH, 89 percent for SH, and 80 percent for FM. "ACP with stabilized base" also drew a similar response of 67 percent for IH, 89 percent for SH, and 73 percent for FM.

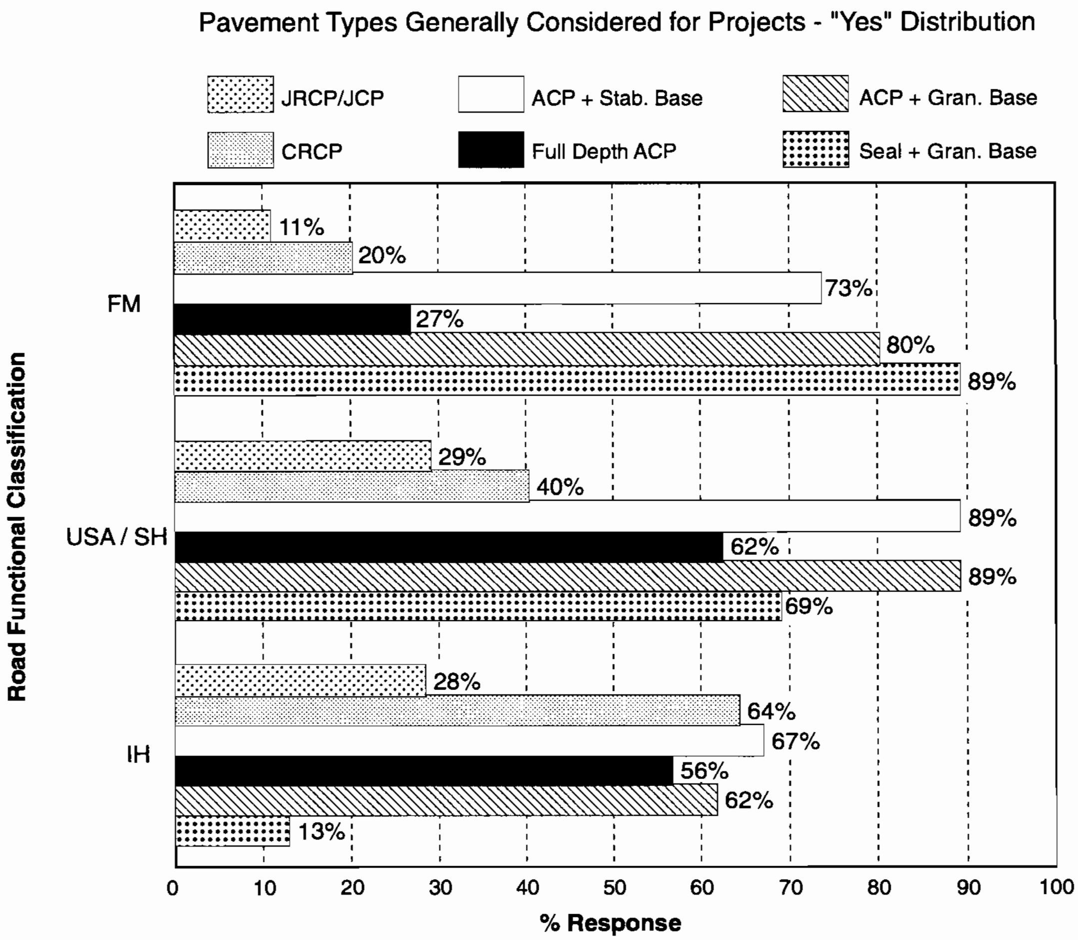

Figure 4.10 Pavement types considered based on roadway functional classification

Meetings held with a few district representatives and the project advisory committee revealed that practicing engineers in districts customarily use a rather vague roadway classification in terms of low, medium, and high traffic volume. There is no consistent definition as to what constitutes low and high traffic volume in districts. West Texas districts are generally rural, and their perceptions of high and low traffic volume are very different as compared with urban districts like Houston and Dallas. The high volume and low volume terminology is also associated with urban roads and rural roads, respectively. Respondents were asked whether they consider listed pavement types for each of the following two roadway categories: "high volume and/or urban roads" and "low/medium volume and/or rural roads." Figure 4.11 shows the "yes" responses for pavement types based on "traffic volume."

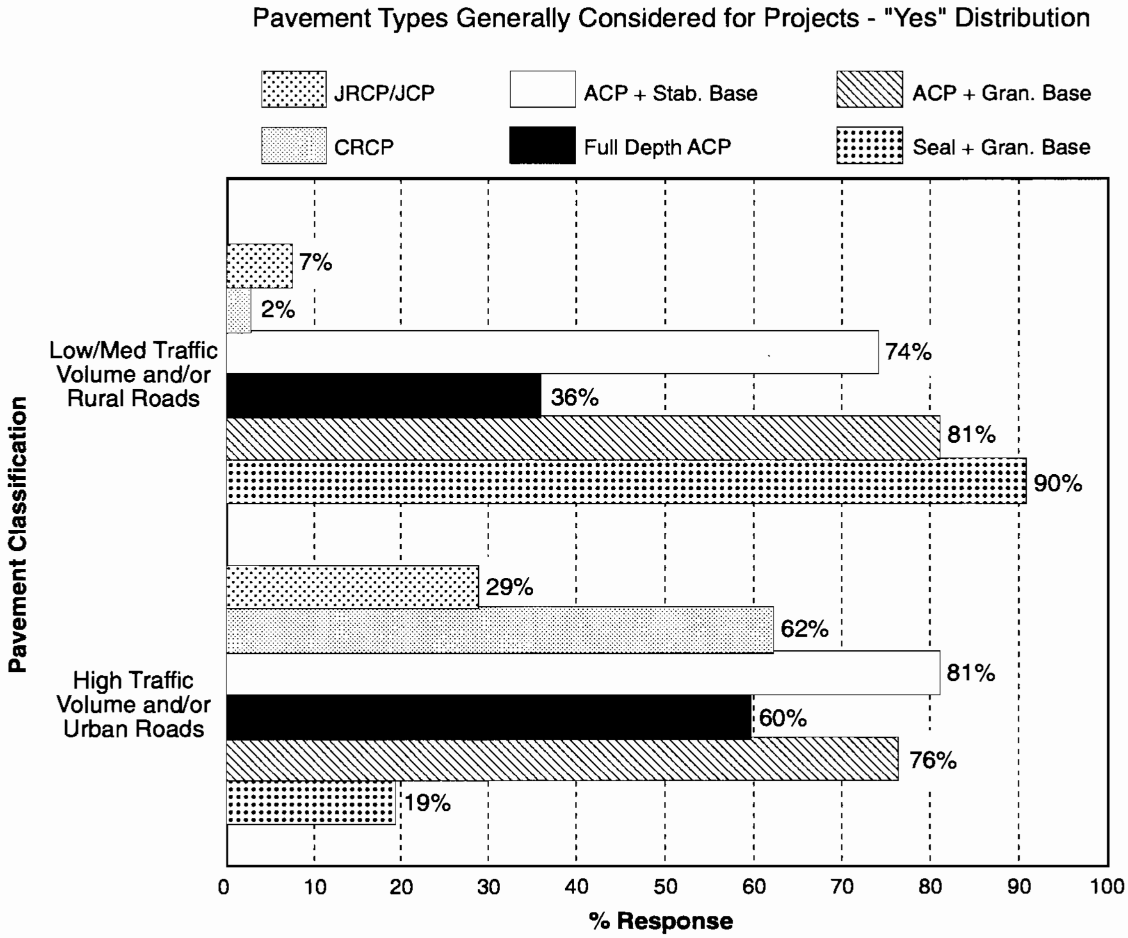

Figure 4.11 Pavement types considered based on traffic volume

Seal coat pavements obtained a 19 percent response for "high traffic" category and reached a maximum of 90 percent for the "low traffic" category. On the other hand, CRCP obtained a 62 percent response for "high traffic" and dropped down to 2 percent for the "low traffic" category. "ACP with granular base" received a 76 percent response for "high traffic" and 81 percent for "low traffic." "ACP with stabilized base" also received a similar response of 81 percent for "high traffic" and 74 percent for "low traffic."

The survey results for two sets of classifications, based on "functional class" and "traffic volume," were compared to determine any similarities between these two categories. Table 4.10 shows a comparison of these responses.

Table 4.10 Comparison of "yes" response percentage for "pavement types considered" based on "Functional Class" and "Traffic Volume"

Pavement Types	IH Projects	High Vol. and/or Urban Projects	FM Projects	Low Vol. and/or Rural Projects	US/SH Projects
Seal Coat + Granular Base	13%	19%	89%	90%	69%
ACP + Granular Base	62%	76%	80%	81%	89%
Full Depth ACP	56%	60%	27%	36%	62%
ACP + Stab. Base	67%	81%	73%	74%	89%
CRCP	64%	62%	20%	2%	40%
JRCP/JCP	28%	29%	11%	7%	29%

Comparison between "IH" and "High Traffic" Categories: Rigid pavement (CRCP, JRCP/JCP) responses for the "IH" and "high traffic" categories are similar. On the other hand, flexible pavement types show a large percentage of responses for the "high traffic" category, as compared with the "IH" category. This discrepancy can be attributed to the noninterstate but highly trafficked proportion of roads in the network. In general, these results show that the "IH" category and the "high traffic" category are synonymous with a majority of practitioners.

Comparison between "FM" and "Low Traffic" Categories: Flexible pavement percent responses for the "FM" and "low traffic" categories are very similar. This also suggests that these two categories are almost synonyms for most practitioners. Only CRCP responses differ: A 20 percent response for the "FM" category drops down to 2 percent for the "low traffic" category.

Comparison between Some Responses in National and TxDOT Surveys

Table 4.11 presents a comparison of ranked responses for the "always considered" category for technical and subjectively considered factors between national and TxDOT surveys. Table 4.11 shows the following results:

- "Traffic volume" obtained the maximum response in both surveys: 85 percent for national and 100 percent for TxDOT survey.
- Both surveys present a very similar ranking of factors.
- Eight out of the twelve factors show a larger response percentage in the TxDOT survey compared with the national survey. This result shows a relatively larger influence of these factors in Texas compared with highway agencies that participated in the national survey. Six factors obtained more than an 80 percent response in the TxDOT survey. On the other hand, a majority of factors appear in the 40–60 percent range in the national survey.

Table 4.11 Percentage responses for "always considered" category for local/subjective factors in TxDOT and national surveys

Local Factors	TxDOT Survey	National Survey
Traffic Volume	100%	85%
Constructability	89%	76%
Initial Budget Constraints	87%	75%
Soil Subgrade	87%	77%
Historical Practice	82%	60%
Easy Maintenance	63%	60%
Road Functional Classification	58%	58%
Local Material	51%	62%
Pavement Continuity	54%	44%
Traffic at M&R	38%	48%
Climate	36%	58%
Recycled Materials	17%	47%
Percent Truck Traffic	91%	-

CHAPTER 5. FINDINGS AND RECOMMENDATIONS

FINDINGS

The following findings result from the project to date.

- A majority (80 percent) of highway agencies participating in the national survey reported using organized procedures for pavement type selection. All of them reported using life-cycle cost analysis (LCCA) as the main criterion for pavement type selection.
- Net present value is the primary economic basis for LCCA among national highway agencies.
- A large proportion of national highway agencies (80 percent) reported that they do not consider user costs in their economic analysis.
- No standard procedures or policies are used for pavement type selection in Texas Department of Transportation (TxDOT) district or area offices.
- A significant proportion of TxDOT respondents (63 percent) supported the notion of considering user delay costs in an economic analysis.
- TxDOT survey results substantiate that IH/high volume/urban projects are typically built with both asphalt and portland cement concrete (PCC) pavements. On the other hand, FM/low volume/rural projects are almost always constructed with asphalt or seal coat pavements. The two sets of roadway classifications, based on "functional class" (IH, SH, FM) and "traffic volume" (high, medium, low), are used synonymously by practitioners.
- "Traffic volume" is the top-ranked factor among the local/subjective factors in both surveys. "Initial budget constraints," "constructability," "subgrade soil type," and "historical practice" are a few other highly ranked factors reported in these surveys.
- Both the national and Texas surveys showed similar "importance rankings" for the technical and subjective factors for the "always considered" category.

RECOMMENDATIONS

Based on the research and analysis documented in this report, the following activities are recommended.

- The pavement type selection procedure for TxDOT should be an economic-based system. The economic analysis should include agency as well as user delay costs.
- Important factors for pavement type selection should be identified. These factors should include quantifiable technical, economical, and subjective factors. A sensitivity analysis may be carried out to determine the importance of these factors.

- An expert group meeting comprising TxDOT representatives should be organized to build a consensus on the factors to be included and on decision criteria for the pavement type selection procedure.
- The feasibility of evaluating trade-offs among important factors (agency costs, user delay costs, and pavement performance) should be investigated.
- Available models for user delay calculations should be evaluated in greater detail. An appropriate model should be identified for use in the pavement type selection procedure.
- Available software should be investigated in the development of a pavement type selection program for TxDOT.

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APPENDIX A:
NATIONAL QUESTIONNAIRE

INFORMATION ABOUT PAVEMENT TYPE SELECTION PRACTICES FROM STATE DOTS
CENTER FOR TRANSPORTATION RESEARCH, THE UNIVERSITY OF TEXAS AT AUSTIN

A. GENERAL INFORMATION

1. Agency: ______________________________
   Address: ______________________________
   City: ______________ State: ______________ Zip: ______________
2. The person filling out this questionnaire:
   Name: ______________________ Title: ______________
   Tel No: ( ) ______________ Fax No: ( ) ______________ E-mail: ______________
3. Do you use an organized procedure for pavement type selection for:
   New Construction Projects Yes ☐ No ☐
   Reconstruction Projects Yes ☐ No ☐
4. How long has the procedure been in use? ________Years
5. Mark the alternative pavement types considered in making the type selection decisions:
   Asphalt Concrete Pavement with Aggregate Base Yes ☐ No ☐
   Full Depth Asphalt Concrete Pavement Yes ☐ No ☐
   Asphalt Concrete Pavement with Stabilized Base Yes ☐ No ☐
   Continuously Reinforced Concrete Pavement (CRCP) Yes ☐ No ☐
   Jointed Reinforced Concrete Pavement (JRCP) Yes ☐ No ☐
   Jointed Concrete Pavement (JCP) Yes ☐ No ☐
   Other: ______________________________
6. Add your comments: ______________________________
   ____

B. ECONOMIC ANALYSIS

7. What criterion is used for economic analysis? First Cost ☐ Life-Cycle Cost ☐
8. If you use life-cycle cost analysis (LCCA), please indicate the following:
   a. Analysis period used ________Years
   b. Performance period of the initial structure used ________Years
   c. Economic basis used Present Worth ☐ Annual Worth ☐
9. Check the agency cost components used in the analysis:
   Initial Construction Cost Yes ☐ No ☐ Rehabilitation Cost Yes ☐ No ☐
   Preventive Maint. Cost Yes ☐ No ☐ Routine Maint. Cost Yes ☐ No ☐

Salvage Value Yes ☐ No ☐

Other: ____________________

10. Are user costs included in the LCCA? Yes ☐ No ☐

11. Check the user cost components considered in the analysis:

Time Delay Cost Yes ☐ No ☐ Vehicle Operating Cost (VOC) Yes ☐ No ☐

Other: ____________________

12. Add your comments on economic aspects: ____________________

____

____

C. SUBJECTIVE FACTORS IN PAVEMENT TYPE SELECTION

13. Check the appropriate box representing the extent of use of the following subjective factors in your agency for making pavement type selection decisions:

FACTORS	Always Considered	Occasionally Considered	Never Considered
Historical Practice	☐	☐	☐
Budget Constraints	☐	☐	☐
Functional Class	☐	☐	☐
Traffic Volume	☐	☐	☐
Traffic Control During M&R	☐	☐	☐
Use of Local Materials	☐	☐	☐
Use of Recycled Materials	☐	☐	☐
Climatic Conditions	☐	☐	☐
Subgrade Soil Type	☐	☐	☐
Continuity of Pavement Type	☐	☐	☐
Constructability	☐	☐	☐
Ease of Maintenance	☐	☐	☐

Other Factors: ____________________

14. Add your comments on these factors: ____________________

____

D. OTHER COMMENTS YOU MIGHT HAVE: ____________________

____

APPENDIX B:
TxDOT QUESTIONNAIRE

INFORMATION ABOUT PAVEMENT TYPE SELECTION PRACTICES IN TEXAS
CENTER FOR TRANSPORTATION RESEARCH, THE UNIVERSITY OF TEXAS AT AUSTIN

A. GENERAL INFORMATION

1. TxDOT District Office: ____________________

Address: ____________________

City: ____________ State: ________ Zip: ________

2. Person completing this information request form:

Name: ____________________ Title: ________

Tel No: ( ) ________ Fax No: ( ) ________ E-mail: ________

3. How do you generally make pavement type selection for reconstruction and new construction projects? Is there any district policy governing pavement type selection? ________

____

____

____

4. Indicate whether or not you generally consider each of the following pavement alternatives when making pavement type selection decisions:

Seal Coat with Aggregate Base	Yes ☐	No ☐
Asphalt Concrete Pavement with Aggregate Base	Yes ☐	No ☐
Full Depth Asphalt Concrete Pavement	Yes ☐	No ☐
Asphalt Concrete Pavement with Stabilized Base	Yes ☐	No ☐
Continuously Reinforced Concrete Pavement (CRCP)	Yes ☐	No ☐
Jointed Reinforced Concrete Pavement (JRCP)	Yes ☐	No ☐
Jointed Concrete Pavement (JCP)	Yes ☐	No ☐

Other, please specify: ____________________

B. ECONOMIC ANALYSIS AND PAVEMENT DESIGN

5. a) Do you conduct any economic analyses as part of pavement type selection?
Yes ☐ No ☐

b) If yes, which criterion do you use? Initial Const. Cost ☐ Life-Cycle Cost (LCC) ☐

c) If you use LCC, do you consider the following agency costs quantitatively:

Initial Construction Cost	Yes ☐	No ☐	Rehabilitation Cost	Yes ☐	No ☐
Preventive Maint. Cost	Yes ☐	No ☐	Routine Maint. Cost	Yes ☐	No ☐
Salvage Value	Yes ☐	No ☐			

Other: ____________________

6. The TxDOT pavement design manual requires the use of FPS-19 for flexible pavement design and AASHTO Guide 93 for rigid pavement design. Please give typical values used for the following design inputs:

Design Inputs	FPS-19 Flexible Pavement Design	AASHTO Guide 93 Rigid Pavement Design
Analysis Period		
Initial Performance Period		
Interest Rate		
Reliability Level		

7a) Both, FPS-19 and the AASHTO guide include an economic analysis based primarily on agency costs. FPS-19, however, includes user costs in the form of delay costs during M&R. Do you believe that user costs should be considered in economic analyses? Yes ☐ No ☐

Please explain why or why not: ____

____

____

____

b) Indicate your opinion about whether the following user cost components should be included in economic analysis?

Vehicle Operating Cost (VOC) Yes ☐ No ☐ Time Delay Cost Yes ☐ No ☐

c) Indicate your opinion about whether the following user cost components can be quantified with reasonable accuracy as compared to agency costs?

VOC Yes ☐ No ☐ Time Delay Cost Yes ☐ No ☐

d) Please specify other user costs that you consider important for economic analysis: ________

____

8. Add other comments you might have on economic aspects: ____________________

____

____

____

C. LOCAL FACTORS IN PAVEMENT TYPE SELECTION

9. Please indicate how often the following factors are considered subjectively in your district for making pavement type selection decisions:

FACTORS	Always Considered	Occasionally Considered	Never Considered
Historical Practice	☐	☐	☐
Initial Budget Constraints	☐	☐	☐
Highway Functional Classification	☐	☐	☐
Traffic Volume (ADT)	☐	☐	☐
Truck Traffic Percentage	☐	☐	☐
Traffic Control During M&R	☐	☐	☐
Use of Local Materials	☐	☐	☐
Use of Recycled Materials	☐	☐	☐
Climatic Conditions	☐	☐	☐
Subgrade Soil Type	☐	☐	☐
Pavement Type Continuity	☐	☐	☐
Constructability	☐	☐	☐
Ease of Maintenance	☐	☐	☐

Other Factors: ____

____

10. Please explain how the following factors affect pavement type selection decisions in your district by giving specific examples:

a) Historical construction practice (for example, some districts in Texas have historically built only flexible pavements): ____

____

____

b) Initial budget constraints (for example, limited initial budget will often result in flexible pavements being recommended): ____

____

____

c) Highway functional classification (for example, often both rigid and flexible pavements are considered for an IH project where as flexible pavements are almost always selected for FM roads): ____

____

____

d) Traffic volume and truck percentage (for example, rigid pavements are often preferred in high-traffic volume and high-truck percentage situations): ____

____

---

e) Whether to use local and/or recycled materials: ____________________

____

____

f) Climatic conditions (for example, stabilized layers and/or rigid pavements are sometimes preferred in wet regions): ____________________

____

____

g) Subgrade soil type (for example, stabilized layers and/or rigid pavements are sometimes preferred on weak subgrade): ____________________

____

____

h) Pavement type continuity (for example, flexible pavement may be preferred to reconstruct a section of existing flexible pavement): ____________________

____

____

i) Constructability (for example, flexible pavements are often considered easier and quicker to build): ____________________

____

____

j) Ease of maintenance (for example, rigid pavements require much fewer maintenance treatments than flexible pavements through the same life-cycle period): ____________________

____

____

11a) Indicate whether you generally consider each of the following pavement alternatives when making pavement type selection decisions for Interstate Highways (IH), State and US Highways (SH/US) and Farm to Market roads (FM):

Pavement Types	**IH**	**US/SH**	**FM**
Seal Coat with Aggregate Base	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Asphalt Concrete Pavement with Aggregate Base	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Full Depth Asphalt Concrete Pavement	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Asphalt Concrete Pavement with Treated Base	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Continuously Reinforced Conc. Pavmts (CRCP)	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Jointed Plain/Reinf. Conc. Pavmts (JCP/JRCP)	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐

b) Please give approximate centerline miles for the following highway classes in your district:

IH: ________________ US/SH: ________________ FM: ________________

c) Give approximate percentage (centerline miles) of existing pavement types in your district with respect to highway functional classes:

Pavement Types	IH %	US/SH %	FM %
Seal Coat with Aggregate Base			
Asphalt Concrete Pavement with Aggregate Base			
Full Depth Asphalt Concrete Pavement			
Asphalt Concrete Pavement with Treated Base			
Continuously Reinforced Conc. Pavmts (CRCP)			
Jointed Plain/Reinf. Conc. Pavmts (JCP/JRCP)			
Total	100%	100%	100%

12a) Give approximate ADT levels which define high-, medium-, and low-traffic volume in your district: High:_________Medium:_________Low:_________

b) Indicate whether you generally consider each of the following pavement alternatives when making pavement type selection decisions for high- and medium-/low-traffic roads:

Pavement Types	High-Traffic and/or Urban Roads	Med.-/Low-Traffic and/or Rural Roads
Seal Coat with Aggregate Base	Yes ☐ No ☐	Yes ☐ No ☐
Asphalt Concrete Pavement with Aggregate Base	Yes ☐ No ☐	Yes ☐ No ☐
Full Depth Asphalt Concrete Pavement	Yes ☐ No ☐	Yes ☐ No ☐
Asphalt Concrete Pavement with Treated Base	Yes ☐ No ☐	Yes ☐ No ☐
Continuously Reinforced Conc. Pavmts (CRCP)	Yes ☐ No ☐	Yes ☐ No ☐
Jointed Plain/Reinf. Conc. Pavmts (JCP/JRCP)	Yes ☐ No ☐	Yes ☐ No ☐

c) Give approximate percentage (centerline miles) of existing pavement types in your district with respect to traffic volume:

Pavement Types	High-Traffic and/or Urban Roads %	Med.-/Low-Traffic and/or Rural Roads %
Seal Coat with Aggregate Base		
Asphalt Concrete Pavement with Aggregate Base		
Full Depth Asphalt Concrete Pavement		
Asphalt Concrete Pavement with Treated Base		
Continuously Reinforced Conc. Pavmts (CRCP)		
Jointed Plain/Reinf. Conc. Pavmts (JCP/JRCP		
Total	100%	100%

13. Please add any other comments you might have on local factors: ______________________

____

____

____

D. OTHER GENERAL COMMENTS YOU MIGHT HAVE: ______________________

____

____

____

____

____

APPENDIX C:
SUMMARY OF DESCRIPTIVE RESPONSES FOR NATIONAL SURVEY

Table C.1. Summary of national survey respondents

State/Province	Respondent	Phone	Fax	E-mail
Alaska	R. Scott Gartin	907-269-6244	907-269-6231	scott_gartin@dot.state.ak.us
Arizona	George Way	602-255-8085	602-255-8138	—
Arkansas	Mark Woods	501-569-2525	501-569-2057	—
British Columbia	Dr. Turgut Erosy	250-356-0390	—	tersoy@viries.gems.gov.bc.ca
California	Robert Marsh	916-654-5640	916-659-6291	trmaint1.rmarsh@trmx3.dot.ca.gov
Connecticut	Colleen Kissane	860-594-3255	860-594-3175	—
Delaware	Al Guckes	302-739-4852	302-739-5270	aquckes@smtp.dot.state.de.us
Dist. of Columbia	Mesfin Lakew	202-645-6142	202-645-0207	—
Florida	Bruce Dietrich	904-414-4371	904-922-9293	bruce.dietrich@dot.state.fl.us
Fredericton	Terry Hughes	506-453-2673	506-444-5826	can009@god.nb.ca
Georgia	Buddy Gratton	404-656-5316	404-657-7286	gratton_b@dot.state.ga.us
Hawaii	Dennis Santo	808-832-3409	808-832-3407	—
Idaho	Robert Smith	208-334-8437	208-334-4411	bsmith@itd.state.id.us
Illinois	Charles Sanders	217-785-0720	217-524-9357	—
Indiana	John Weaver	317-232-7588	317-232-5478	john-weaver@indot.ibmmail.com
Iowa	Chris Brakke	515-239-1882	515-239-1873	—
Kansas	Andrew Gisi	913-296-3008	913-296-2526	agisi@dtmrc.wpo.state.kas.us
Louisiana	Mike Funderburk	504-379-1831	504-379-1859	—
Maine	Michael Burns	207-287-3172	207-287-6737	michael.burns@state.me.us
Maryland	Peter Stephanos	410-321-3541	410-321-2208	pstephanos@sha.state.md.us
Massachusetts	Edmund Naras	617-973-8269	617-973-8035	—
Michigan	Ish Patel	517-373-7596	517-335-2731	pateli@state.mi.us
Minnesota	Loren Hill	612-779-5567	612-779-5580	—
Mississippi	Keith Purvis	601-359-7252	601-359-7063	—
Missouri	Denis Glascock	573-751-6735	573-526-5636	—
Montana	Jim Tompkins	406-444-6295	406-444-6204	u9067@long.mot.mt.gov
Northwest Territ.	George Childs	403-874-5022	403-874-2272	—
Nebraska	Danny Nichols	402-479-4677	401-479-3975	—
Nevada	Sohila Bemanian	702-888-7520	702-888-7501	—
New Hampshire	J. Scott Davis	603-271-2693	—	—
New Jersey	Andris A. Jumikis	609-530-3036	609-530-4666	ajumikis@cpm.dot.state.hj.us
New Mexico	John Tenison	505-827-5641	505-827-5649	jonh.tenison@nmshtd.state.nm.us
New York	Rodney DeLisle	518-485-5706	518-457-8080	semerick@gw.dot.state.ny
Newfoundland	Don Brennan	709-729-2441	709-729-2203	wst05794@wst.gov.nf.ca
North Carolina	Judith Corley-Lay	919-250-4094	919-250-4098	jlay@pmu.dot.state.nc.us
North Dakota	Clayton Schumaker	701-328-6906	701-328-6913	—
Nova Scotia	Frank Gervais	902-421-1065	902-429-3525	sgehfx@fox.nstn.ca
Ohio	Aric Morse	614-644-6953	614-752-4718	amorse@odot.dot.ohio.gov
Oklahoma	Tim Borg	405-521-6773	405-522-4519	—
Ontario	Tom Kazmierowaski	416-235-3512	416-235-3919	kazmiero@mto.gov.on.ca
Oregon	Lucinda Moore	503-986-3115	503-986-3096	lucinda.m.moore@state.or.us
Pennsylvania	J. Michael Long	717-787-1153	717-787-7004	—
Puerto Rico	Edgardo E. Aponte	787-798-3940	787-798-3245	—
Saskatchewan	Allan Widger	306-787-4858	306-787-1007	—
South Carolina	Andrew Johnson	803-737-6202	803-737-6649	johnsonan@mailb.dec.state.sc.gov
South Dakota	Gill Hedman	605-773-3401	605-773-6608	—
Utah	David Blake	801-965-4641	801-965-4551	src0f503.dblake@email.state.ut.us

Vermont	Michael Pologruto	802-828-3876	802-828-5330	mpologruto@aot.state.vt.us
Virginia	Mohamed Elfino	804-328-3173	804-328-3136	—
Washington	Linda Pierce	360-709-5474	310-709-5588	piercel@wsdot.wa.gov
West Virginia	John Lancaster	304-558-3757	304-558-3783	—
Manitoba	Ray Cauwenberghe	204-945-1934	204-945-2229	RVanCauwenberghe@hwys.gov.mb.ca
Wisconsin	Bill Duckert	608-246-5440	608-246-4669	wduckert@state.mail.wi.us
Wyoming	Mike Farrar	307-777-4476	307-777-4481	—

Table C.2. Mention other pavement types considered in pavement type selection (Question 5, other than ACP with granular base, Full Depth ACP, ACP with stabilized base, CRCP, JRCP, JCP)

States	Comments
Alaska	Stone matrix asphalt (SMA) overlay, chip seal, high float treatment.
Arizona	—
Arkansas	—
California	—
Connecticut	—
Delaware	—
District of Columbia	—
Florida	—
Georgia	—
Hawaii	—
Idaho	Asphalt concrete pavement with open graded shot rock base, also check different base types including open graded shot rock base under PCC pavements.
Illinois	—
Indiana	Composite pavements, asphalt concrete over crack and seat or rubblized PCC, concrete overlay over PCC or asphalt concrete.
Iowa	Our full depth asphalt sections have an aggregate subbase as do our PCC pavements.
Kansas	—
Louisiana	—
Maine	—
Maryland	Asphalt and PCC pavements with permeable bases, also consider various treatments to prevent reflective cracking such as joint tape, rubblization, break and seat.
Massachusetts	—
Michigan	—
Minnesota	JPCP with conventional base and with open graded asphalt base (OGAB).
Mississippi	—
Missouri	—
Montana	We have done one JCP with dowels at joints.
Nebraska	—
Nevada	—
New Hampshire	—
New Jersey	—
New Mexico	—
New York	—
North Carolina	In rehabilitation area—also look at rubblization, overlay milling and overlay etc.
North Dakota	Asphalt concrete overlay, blend existing pavement section and overlay with asphalt

	concrete.
Ohio	Rubblize and roll, break and seat, unbonded concrete overlay, repair and overlay.
Oklahoma	—
Oregon	—
Pennsylvania	JCP on rubblized concrete, ACP on rubblized concrete, bituminous overlay.
Puerto Rico	JCP with nonerodable base (asphalt base).
South Carolina	—
South Dakota	—
Utah	—
Vermont	—
Virginia	—
Washington	—
West Virginia	—
Wisconsin	Open graded base course (OGBC) under each pavement type, JCP used with dowels only.
Wyoming	—
Canadian Provinces	
British Columbia	—
Manitoba	Asphalt surface treatment with aggregate base.
New Brunswick	—
Newfoundland	—
Nova Scotia	—
Northwest Terr.	—
Ontario	Deep strength and composite pavements.
Saskatchewan	ACP with soil cement.

Table C.3. General comments on pavement types and type selection procedures used by agencies (Question 6)

States	**Comments**
Alaska	—
Arizona	—
Arkansas	—
California	—
Connecticut	—
Delaware	We are constantly modifying our selection procedure.
District of Columbia	Presently, we are in the process of developing a design catalog that would consider various types of pavements and perform life-cycle cost analysis.
Florida	—
Georgia	—
Hawaii	—
Idaho	—
Illinois	—
Indiana	—
Iowa	—
Kansas	Does not construct CRCP and JRCP at this time.
Louisiana	—
Maine	—
Maryland	—

Massachusetts	Type selection is used on rehabilitation projects. New construction is almost exclusively asphalt concrete. PCC over asphalt concrete is used on an experimental basis.
Michigan	—
Minnesota	—
Mississippi	—
Missouri	—
Montana	—
Nebraska	—
Nevada	—
New Hampshire	Asphalt pavements (3"–5") on gravel bases (24"–36") comprise 99% of the pavement types used in New Hampshire.
New Jersey	—
New Mexico	—
New York	Full depth ACP and JCP include 100-mm thick permeable base layer directly beneath the pavement. These are the only two pavement types we use for new and reconstructed pavements in New York state.
North Carolina	—
North Dakota	—
Ohio	Procedure only used for major rehabilitation projects.
Oklahoma	—
Oregon	—
Pennsylvania	—
Puerto Rico	—
South Carolina	Procedure only used for major projects.
South Dakota	—
Utah	—
Vermont	We consider different pavement types in our type selection procedure. A life-cycle cost analysis is developed on a case-by-case basis but generally flexible pavements are more cost effective in Vermont.
Virginia	—
Washington	—
West Virginia	—
Wisconsin	—
Wyoming	—
Canadian Provinces	
British Columbia	No PCC pavements used, some full depth asphalt concrete pavements on rehabilitation projects.
Manitoba	—
New Brunswick	—
Newfoundland	—
Nova Scotia	—
Northwest Terr.	—
Ontario	—
Saskatchewan	The majority of pavement structures are granular with asphalt surface or double sealed surface for low-volume roads.

Table C.4. Any other agency cost components used in the economic analysis (Question 9, other than initial construction cost, rehabilitation cost, preventive maintenance cost, routine maintenance cost, salvage value)

States	Comments
Alaska	—
Arizona	Traffic control, mobilization.
Arkansas	—
California	—
Connecticut	—
Delaware	—
District of Columbia	—
Florida	—
Georgia	—
Hawaii	—
Idaho	—
Illinois	—
Indiana	—
Iowa	Salvage value considered the same for both pavement types.
Kansas	—
Louisiana	—
Maine	—
Maryland	—
Massachusetts	Remaining life.
Michigan	—
Minnesota	—
Mississippi	—
Missouri	—
Montana	—
Nebraska	—
Nevada	—
New Hampshire	—
New Jersey	—
New Mexico	—
New York	—
North Carolina	—
North Dakota	—
Ohio	—
Oklahoma	—
Oregon	Cost of maintenance informally considered by looking at difference in equivalent uniform annual cost (EUAC) and estimating if maintenance costs could realistically make up the difference.
Pennsylvania	—
Puerto Rico	—
South Carolina	—
South Dakota	—
Utah	—
Vermont	—
Virginia	—
Washington	In the process of assigning actual costs for maintenance activities.

West Virginia	—
Wisconsin	Traffic control (full life).
Wyoming	—
Canadian Provinces	
British Columbia	Consideration of LCC and salvage value is being used more in decision-making than before.
Manitoba	—
New Brunswick	—
Newfoundland	—
Nova Scotia	—
Northwest Terr.	—
Ontario	—
Saskatchewan	—

Table C.5. Other user cost components you consider in the analysis (Question 11, other than VOC and time delay)

States	**Comments**
Alaska	—
Arizona	—
Arkansas	—
California	—
Connecticut	User cost cannot be quantified accurately.
Delaware	—
District of Columbia	—
Florida	—
Georgia	—
Hawaii	—
Idaho	—
Illinois	—
Indiana	Time delay considered separately.
Iowa	—
Kansas	—
Louisiana	—
Maine	—
Maryland	—
Massachusetts	—
Michigan	We are going to include user cost in life-cycle cost analysis in next 2–6 months.
Minnesota	—
Mississippi	—
Missouri	—
Montana	—
Nebraska	—
Nevada	—
New Hampshire	—
New Jersey	—
New Mexico	—
New York	—
North Carolina	—

North Dakota	—
Ohio	A time delay is currently considered separate from LCCA, no dollar figures.
Oklahoma	—
Oregon	—
Pennsylvania	—
Puerto Rico	—
South Carolina	—
South Dakota	—
Utah	—
Vermont	—
Virginia	—
Washington	Construction duration.
West Virginia	—
Wisconsin	—
Wyoming	—
Canadian Provinces	
British Columbia	—
Manitoba	—
New Brunswick	—
Newfoundland	—
Nova Scotia	—
Northwest Terr.	—
Ontario	—
Saskatchewan	—

Table C.6. General comments on economic analysis for pavement type selection (Question 12)

States	**Comments**
Alaska	Pavement management uses life-cycle costing, design does not yet.
Arizona	—
Arkansas	—
California	—
Connecticut	—
Delaware	—
District of Columbia	—
Florida	Differences in maintenance and salvage costs are not significant enough to consider in typical analysis.
Georgia	—
Hawaii	—
Idaho	Use standardized unit costs and 4% discount rate.
Illinois	—
Indiana	Life-cycle cost calculated on major projects or when no clear engineering solution is evident in alternatives.
Iowa	Performance period for the initial pavement is 40 years for PCC. For the ACP alternative we consider a 20-year initial period with an overlay at year 20 to get a 40-year analysis period.
Kansas	—
Louisiana	—

Maine	—
Maryland	Our LCCP is a computer program developed by the University of MD following AASHTO method. It is used for comparing multiple AC and PCC fixes. We are currently developing new procedures to compare both AC plus PCC fixes together.
Massachusetts	Time delay costs have been considered on specific projects to select between alternatives having similar life-cycle cost. User costs are considered secondary versus primary agency costs.
Michigan	—
Minnesota	All reconstruction projects use the effects of recycling in the analysis.
Mississippi	—
Missouri	We believe user cost should be included but do not have a consensus as to what constitutes user cost.
Montana	—
Nebraska	—
Nevada	—
New Hampshire	We are hopeful that life-cycle cost analysis can be incorporated into PMS decision-making process for treatment type selection in the future.
New Jersey	—
New Mexico	—
New York	If user costs were included in the LCCA, PCC would become more competitive. I have enclosed a copy of our pavement rehabilitation manual that details our LCCA procedure.
North Carolina	—
North Dakota	Life-cycle costs are used when projects are over $25 million and currently we have not reached this level.
Ohio	An example LCCA is included.
Oklahoma	Life-cycle cost analysis will be implemented as directed by FHWA when PMS is brought up to date.
Oregon	We do not use user cost in our analysis because they tend to make all other—actual project costs—look insignificant to the analysis
Pennsylvania	—
Puerto Rico	—
South Carolina	We may do a life-cycle analysis, but initial cost due to agency funding constraints frequently prevails.
South Dakota	We are currently using present day cost for all future rehabilitation and maintenance cost. A research task force is looking at any changes to the system currently in use.
Utah	Discount rates and construction inflation rates are most critical to the analysis.
Vermont	—
Virginia	—
Washington	—
West Virginia	—
Wisconsin	—
Wyoming	—
Canadian Provinces	
British Columbia	—
Manitoba	We have begun a life-cycle analysis process to study investment decisions; user costs predominate the analysis; and future implementation of the process is unknown.
New Brunswick	—
Newfoundland	We do not perform LCC analysis explicitly, but feel we would benefit from doing so.

Nova Scotia	—
Northwest Terr.	Environmental cost considerations are included where applicable.
Ontario	Currently, having an independent review (consultant assignment) of MTOs LCC methodology in conjunction with the asphalt concrete, and PCC paving industries.
Saskatchewan	Generally, analysis is on lowest agency initial cost but for cost benefit analysis user costs are included.

Table C.7. Any other local or subjective factors considered important in pavement type selection (Question 13)

States	**Comments**
Alaska	Studded tire use levels, permafrost maintenance cost.
Arizona	Risk of early failure.
Arkansas	—
California	—
Connecticut	Performance of similar pavement types.
Delaware	—
District of Columbia	Some of the above factors had been used to set the existing system.
Florida	—
Georgia	—
Hawaii	—
Idaho	—
Illinois	Adjacent pavement type.
Indiana	—
Iowa	—
Kansas	—
Louisiana	—
Maine	—
Maryland	—
Massachusetts	—
Michigan	—
Minnesota	—
Mississippi	—
Missouri	—
Montana	—
Nebraska	—
Nevada	—
New Hampshire	—
New Jersey	—
New Mexico	—
New York	—
North Carolina	Division preferences regarding pavement and materials.
North Dakota	—
Ohio	All of the listed factors should ideally be considered in the performance considerations of the LCCA.
Oklahoma	—
Oregon	Staging of new construction.
Pennsylvania	—
Puerto Rico	Performance of similar pavements in the area and traffic loads.

South Carolina	—
South Dakota	—
Utah	—
Vermont	—
Virginia	Maintaining competition between asphalt and concrete industries
Washington	—
West Virginia	—
Wisconsin	—
Wyoming	—
Canadian Provinces	
British Columbia	—
Manitoba	—
New Brunswick	—
Newfoundland	—
Nova Scotia	—
Northwest Terr.	—
Ontario	Performance of existing pavements under similar conditions.
Saskatchewan	Past performance and existing condition.

Table C.8. Comments on local or subjective factors (Question 14)

States	**Comments**
Alaska	—
Arizona	—
Arkansas	—
California	—
Connecticut	Constructability and delays to motorists are the most critical factors.
Delaware	—
District of Columbia	New system being developed that would use the above factors including soil, traffic, climate, material type, etc.
Florida	Climate and recycling do not vary significantly in the state.
Georgia	—
Hawaii	—
Idaho	Initial budget constraint is a major factor to rehabilitation projects particularly.
Illinois	We also consider high stress intersections where we have a stop condition and high-truck volumes or a large number of truck turning maneuvers.
Indiana	Cost is the major focus; subjective factors are considered when costs of alternatives are very close.
Iowa	Most of these factors come into play when determining the appropriate pavement thickness.
Kansas	Traffic, climate, and soil type are considered in the pavement design.
Louisiana	—
Maine	—
Maryland	—
Massachusetts	—
Michigan	We are using two reports for life-cycle costing, (1) method of pavement selection of new and reconstruction pavements June 22, 1992, (2) rehabilitated Pavements June 4, 1995.
Minnesota	If 20 years designs ESALs >7,000,000 project is concrete, and if <7,000,000 and R-

	value>40 (granular) project is bituminous.
Mississippi	—
Missouri	While the factors are considered and may have a significant effect, they may not be allowed to influence the decision.
Montana	—
Nebraska	—
Nevada	—
New Hampshire	—
New Jersey	—
New Mexico	—
New York	PCC is more expensive than HMA in terms of LCCA (neglecting user cost). Other subjective factors must be used to justify PCC. We tend to use PCC on interstate highways, when traffic volumes and % trucks is high, and when trying to bridge soft/hard spots beneath the pavement.
North Carolina	—
North Dakota	—
Ohio	—
Oklahoma	—
Oregon	—
Pennsylvania	Functional class, traffic volume, climatic conditions and subgrade soil type are accounted for in the structural design of each alternative. Traffic control during M&R, use of local materials, constructability, and ease of maintenance are reflected in the unit cost used in the life-cycle cost analysis.
Puerto Rico	—
South Carolina	Climatic conditions are not typically considered because they are typically uniform across South Carolina.
South Dakota	—
Utah	—
Vermont	—
Virginia	—
Washington	—
West Virginia	—
Wisconsin	—
Wyoming	—
Canadian Provinces	
British Columbia	Use of recycled materials consideration is growing (about 90% to 95% now).
Manitoba	All projects are structurally designed to accommodate future ESALs.
New Brunswick	—
Newfoundland	Historical practice and budget constraints related to initial cost are the highest priority factors.
Nova Scotia	—
Northwest Terr.	—
Ontario	—
Saskatchewan	New construction is almost always subbase, base, and asphalt concrete or double seal coat.

Table C.9. General comments on pavement type selection (Question D)

States	Comments
Alaska	—
Arizona	—
Arkansas	—
California	—
Connecticut	—
Delaware	A committee evaluates the economic and subjective factors that are involved and a consensus decision is made. Both the rigid and flexible pavement industries have reviewed our economic analysis input assumptions, costs, life expectancies, and maintenance/rehabilitation options.
District of Columbia	—
Florida	Procedure is currently being updated. We will send a copy when finalized.
Georgia	—
Hawaii	—
Idaho	Life-cycle costing is used to develop relative equivalent uniform annual cost but several of above factors many control recommendations.
Illinois	—
Indiana	—
Iowa	—
Kansas	—
Louisiana	—
Maine	A life-cycle cost approach done 5 years ago on a bypass study suggested that bituminous and concrete pavements were at equal cost after 30 years and bituminous was chosen or budgetary reasons.
Maryland	—
Massachusetts	—
Michigan	—
Minnesota	Rigid initial cost + cost of resealing joints at year 17 ½. Flexible initial cost + cost of overlay at year 20, if ADT > 10,000,000 also included overlay at year 12.
Mississippi	—
Missouri	—
Montana	—
Nebraska	—
Nevada	—
New Hampshire	—
New Jersey	—
New Mexico	—
New York	—
North Carolina	—
North Dakota	—
Ohio	The LCCA is not a final answer to a problem. It is only a decision-making tool.
Oklahoma	—
Oregon	—
Pennsylvania	Gaylord Chamberledge, chief of the roadway management division has previously sent a copy of the Pavement Policy Manual, Penn. DOT Publication 242 to Ron Hudson. Our LCCA policy is located in this manual. Also Mohammed Beg has received our LCCA spreadsheets.
Puerto Rico	—
South Carolina	—

South Dakota	—
Utah	—
Vermont	Copy of VADOT type selection policy included.
Virginia	See attached policy for pavement type selection.
Washington	—
West Virginia	—
Wisconsin	—
Wyoming	—
Canadian Provinces	
British Columbia	—
Manitoba	The plan is to have pavement designers conduct a life-cycle cost analysis on each project including only construction, maintenance and rehabilitation costs, to assist or justify treatment selection.
New Brunswick	—
Newfoundland	A couple of unsuccessful trials with portland cement concrete pavements about 15 years ago along with high initial cost has basically eliminated PCC pavements from further consideration.
Nova Scotia	—
Northwest Terr.	—
Ontario	—
Saskatchewan	All rehabilitation projects consider recycling. Full-depth structures that performed poorly may be buried in granular or have a granular sandwich added.

APPENDIX D:
SUMMARY OF DESCRIPTIVE RESPONSES FOR TxDOT SURVEY

Table D.1. Summary of TxDOT survey respondents

District	Person	Title	District/area
Abilene 1 (District)	David L. Songo	Pavement Engineer	District
Abilene 2 (Big Spring area)	Dan Richardson	area Engineer	area
Abilene 3 (Snyder area)	Michael W. Taylor	Engineering Assistant II	area
Abilene 4 (Hamlin area)	Joe Higgins	area Engineer	area
Abilene 5 (Abilene area)	Blair Haynie, P.E.	area Engineer	area
Amarillo (District)	Ronald L Johnston	Pavement Engineer	District
Atlanta (District)	Tommy Ellison	Pavement Engineer	District
Austin (District)	Christopher Freeman,	Design Engineer	District
Beaumont 1 (Unknown area)	Rod Thrailcill	Assistant area Engineer	area
Beaumont 2 (Beaumont area)	Duane Browning	area Engineer	area
Brownwood 1 (District)	Elias H. Rmeili	Design Engineer	District
Brownwood 2 (Lampasas area)	Thomas M. Dahl	Assistant area Engineer	area
Childress (District)	Marty Smith	Pavement/Design Engineer	District
Corpus Christi 1 (District)	John A. Hernandez	Pavement Engineer	District
Corpus Christi 2 (Karnes area)	Phillip Pawelek	Engineering Assistant VI	area
Corpus Christi 3 (Corp. Ch. area)	Art Clendendy	area Engineer	area
Dallas District 1 (District)	Joe B. Tompson	Pavement Engineer	District
Dallas 2 (Dallas Proj. Off.)	Becky Brunsen	Engineering Assistant	area
Dallas 3 (Ellis area)	Scott T. Morrow	Design Engineer	area
El Paso (District)	Leo Betancourt	Pavement Engineer	District
Fort Worth (District)	Andrew Wimsatt	Pavement Engineer	District
Houston 1 (District Pav. Engr.)	Pat Henry	Pavement Engineer	District
Houston 2 (District Des. Engr.)	William R. Brudnick	Sup. Design Engineer	District
Houston 3 (Brazoria area)	Charles Machart	Engineer Spec.	area
Houston 4 (Conroe area)	Michael Beitler	Design Engineer	area
Houston 5 (E. Harris area)	Greg Ranft	Assistant area Engineer	area
Houston 6 (Fort Bend area)	Nancy L. Adamson	Assistant area Engineer	area
Houston 7 (Cent. Houston area)	—	—	area
Laredo (District)	Rogelio F. Garcia	Design Engineer	District
Lubbock (District)	Jack O. Tucker	Pavement Engineer	District
Lufkin 1 (District)	Robert Neel	Pavement/Design Engineer	District
Lufkin 2 (San Augustine area)	Clark Slacum	area Engineer	area
Lufkin 3 (Livingston area)	Harry W. Thompson	area Engineer	area
Odessa (District)	Jamshid Jahangir, P.E.	Pavement/Design Engineer	District
Paris 1 (Sulphur Springs area)	Bradley L. Martin	Assistant area Engineer	area
Paris 2 (Greenville area)	Jon W. Clements	area Engineer	area
Paris 3 (Sherman area)	Ronnie W. Perry	Assistant area Engineer	area
Pharr (District)	John DelaGarza	Pavement Engineer	District
San Angelo (District)	Matt C. Carr	Adv. Proj. Devp. Engineer	District
San Antonio 1 (District)	Gilbert G. Gavia	Design Engineer	District
San Antonio 2 (Floresville area)	Ken Davenport	Assistant area Engineer	area

San Antonio 3 (Unknown area)	Garland C Galm	area Engineer	area
San Antonio 4 (Unknown area)	—	—	area
San Antonio 5 (Unknown area)	—	—	area
Waco (District)	Billy S. Pigg	Engineer IV	District
Wichita Falls (District)	Richard K. Stegar	Pavement Engineer	District
Yoakum (District)	Gerald Freytag	Pavement Engineer	District

Table D.2. Cont'd summary of TxDOT survey respondents

District	**Telephone**	**Fax**	**E-mail**
Abilene 1 (District)	915-676-6813	915-676-6902	dsongo@gw.mail.dot.state.tx.us
Abilene 2 (Big Spring area)	915-263-4768	915-263-1370	—
Abilene 3 (Snyder area)	915-573-0143	915-573-0049	—
Abilene 4 (Hamlin area)	915-576-2769	915-576-2389	jhiggin@gw.mail.dot.state.tx.us
Abilene 5 (Abilene area)	915-676-6930	915-676-6933	bhaynie@canalott.com
Amarillo (District)	806-356-3253	806-356-3263	—
Atlanta (District)	903-799-1212	903-799-1214	telliso@gw.mail.dot.state.tx.us
Austin (District)	512-832-7133	512-832-7148	—
Beaumont 1 (Unknown area)	409-3336-2244	409-336-3786	—
Beaumont 2 (Beaumont area)	409-898-5771	409-898-5804	—
Brownwood 1 (District)	915-643-0441	915-643-0306	—
Brownwood 2 (Lampasas area)	512-556-5435	512-556-8077	—
Childress (District)	817-937-7250	817-937-7154	—
Corpus Christi 1 (District)	512-808-2300	512-808-2407	—
Corpus Christi 2 (Karnes area)	210-780-3993	210-780-3715	—
Corpus Christi 3 (Corp. Ch. area)	512-346-1180	512-364-5648	—
Dallas District 1 (District)	214-320-6165	214-320-6625	—
Dallas 2 (Dallas Proj. Off.)	214-320-4411	214-320-6655	rbrunse@gw.mail.dot.state.tx.us
Dallas 3 (Ellis area)	972-938-1570	972-938-2045	—
El Paso (District)	915-774-4263	915-774-4330	—
Fort Worth (District)	817-370-6702	817-370-6848	awimsat@gw.mail.dot.state.tx.us
Houston 1 (District Pav. Engr.)	713-802-5417	713-802-5030	—
Houston 2 (District Des. Engr.)	713-802-5599	713-802-5350	—
Houston 3 (Brazoria area)	409-849-5784	409-848-1131	—
Houston 4 (Conroe area)	409-756-3458	409-756-3453	—
Houston 5 (E. Harris area)	713-636-7405	713-636-7449	—
Houston 6 (Fort Bend area)	281-342-5449	281-341-0753	nadamso@gw.mail.dot.state.tx.us
Houston 7 (Cent. Houston area)	—	—	—
Laredo (District)	210-712-7442	210-712-7402	rgarcia@gw.mail.dot.state.tx.us
Lubbock (District)	806-748-4499	806-748-4348	jtucker@gw.mail.dot.state.tx.us
Lufkin 1 (District)	409-633-4317	409-633-4378	rneel@gw.mail.dot.state.tx.us
Lufkin 2 (San Augustine area)	409-275-9671	409-275-9034	cslacum@gw.mail.dot.state.tx.us
Lufkin 3 (Livingston area)	409-327-8981	409-327-3311	hthomps@gw.mail.dot.state.tx.us
Odessa (District)	915-333-9261	915-333-9260	jjahang@gw.mail.dot.state.tx.us

Paris 1 (Sulphur Springs area)	903-885-9514	903-439-3622	—
Paris 2 (Greenville area)	903-455-2363	903-954-8354	—
Paris 3 (Sherman area)	903-892-6529	903-813-0134	rperry@gw.mail.dot.state.tx.us
Pharr (District)	210-702-6163	210-702-6172	—
San Angelo (District)	915-947-9233	915-947-9244	mcarr@gw.mail.dot.state.tx.us
San Antonio 1 (District)	210-615-5881	210-615-6296	—
San Antonio 2 (Floresville area)	210-393-3144	210-393-3012	sat.kdavenp@gw.mail.dot.state.tx.us
San Antonio 3 (Unknown area)	210-426-2270	210-426-5212	—
San Antonio 4 (Unknown area)	—	—	—
San Antonio 5 (Unknown area)	—	—	—
Waco (District)	254-867-2740	254-867-2738	—
Wichita Falls (District)	817-720-7765	817-720-7875	rstegar@gw.mail.dot.state.tx.us
Yoakum (District)	512-293-4374	512-293-4372	gfreyta@gw.mail.dot.state.tx.us

Table D.3. How do you generally make pavement type selection decisions? Is there any district policy governing pavement type selection? (Question 3)

District	Comments
Abilene 1 (District)	Use FPS-11 or FPS-19 and compare to modified triaxial.
Abilene 2 (Big Spring area)	Hot mix base and surface with flexible base and subbase on interstate and high volume, high % trucks US highways. Flexible base and two-course surface treatment on other roadways. Lime stabilization is used on some subgrade or reconstructed base courses with low triaxial or high PI.
Abilene 3 (Snyder area)	The amount of money usually dictates and with rehabilitation we try to match existing structure as much as possible if it had a positive history of working in the past.
Abilene 4 (Hamlin area)	Economics, past performance, ADT, soil conditions, LCC, material availability, experience (+25 years).
Abilene 5 (Abilene area)	FPS-11 with common sense.
Amarillo (District)	Look at factors of stress such as rutting and fatigue cracking and how we can control these problems in reconstruction. The area engineer makes the decisions regarding the pavement type.
Atlanta (District)	It is done by the "District Planning Committee," about five people.
Austin (District)	The area engineer, who is also responsible for pavement design, does initial selection. Pavement designs for new construction are reviewed by the district pavement engineer. Reconstruction and maintenance strategies are reviewed by district engineer personnel in plan review or PM selection committee.
Beaumont 1 (Unknown area)	—
Beaumont 2 (Beaumont area)	There is no district policy. Primarily based on historical performance of various pavement types under loading conditions.
Brownwood 1 (District)	No district policy. We use "rule of thumb" based on ADT and location, for example, urban road with high traffic use rigid pavement (PCC) and for rural road with low traffic use flexible pavements.
Brownwood 2 (Lampasas area)	Consider functional classification, traffic volume, % truck, available materials, service life-cycle cost, constructability and maintenance.

Childress (District)	There is no district policy in our selection process. We look at history of material that are located in our area and confidence of performance of different materials.
Corpus Christi 1 (District)	I use FPS-11 and FPS-19 along with engineering judgement. Other resources considered are inputs from maintenance supervisors and area engineers. I develop pavement type selection in most feasible manner.
Corpus Christi 2 (Karnes area)	There is no written policy in the district. Generally just run a flexible pavement design for every project.
Corpus Christi 3 (Cor. Ch. area)	All flexible pavements, mostly economical decisions.
Dallas District 1 (District)	There is no specific district policy. We take into consideration the traffic, location, highway type, subgrade, maintenance cost, and adjoining pavements.
Dallas 2 (Dallas Proj. Off.)	Pavement type is recommended by area engineers.
Dallas 3 (Ellis area)	I am not aware of a specific district policy. Type of highway (IH, US, SH, or FM), traffic, urban/rural, adjoining pavement type.
El Paso (District)	No policy. Decision based on many factors such as: funds for project, traffic ADT, type of traffic, traffic control, soil type and availability of materials.
Fort Worth (District)	area offices submit recommendations to director of TP&D who then discusses this with district pavement engineers and district design engineer.
Houston 1 (District Pav. Engr.)	Based on ADT, highway classification and funding. Prefer to build high volume roads with concrete.
Houston 2 (District Des. Engr.)	Pavement selected based on cost effectiveness. I am not aware of any district policy governing pavement type.
Houston 3 (Brazoria area)	Comparison to existing pavement along with TxDOT's pavement design procedures.
Houston 4 (Conroe area)	Consideration given to existing pavement type, existing traffic counts and mix, economics (available funding), future traffic and maintenance.
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Consider funding, ADT and district preference.
Houston 7 (Cent. Houston area)	—
Laredo (District)	The district utilizes flexible pavements, very rarely (heavy traffic volume, stop-n-go traffic, high percentage of trucks) do we use rigid pavements.
Lubbock (District)	We use good engineering judgement to make pavement design decisions. We collect data (FWD, visual, PMIS, etc.), do analyses (FPS-19, TSLAB, DARWin, Modulus, etc.) and use economic reasoning.
Lufkin 1 (District)	No formal policy, we generally select lowest cost pavement that will meet design life guidelines.
Lufkin 2 (San Augustine area)	Selection is generally made based on past experience and then verified by FPS and triaxial design.
Lufkin 3 (Livingston area)	No hard fast policy, past experience, cost, engineering judgement, FPS.
Odessa (District)	—
Paris 1 (Sulphur Springs area)	—
Paris 2 (Greenville area)	Basically, I look at the facility, traffic patterns, FPS-19, Mod. Triaxial requirements, the type of project, cost and available funding.
Paris 3 (Sherman area)	Cost, existing condition of roadway and soil all contribute in how the new pavement type is determined.
Pharr (District)	Consider existing pavement structure and its condition, for improving a rural section to a curb and gutter section usually road is reconstructed rather than widened due to lowering profile.

San Angelo (District)	We have no formal pavement type selection policy. The quality and availability of materials lends itself to the selection of flexible pavements on almost every road in our district.
San Antonio 1 (District)	The district policy is to follow state policy.
San Antonio 2 (Floresville area)	Decision based on traffic volume and historical performance of pavements.
San Antonio 3 (Unknown area)	Research existing pavement, review PMIS, take samples of existing materials, verify thickness, test materials, dynaflect or falling weight testing, determine from existing and future trends what will be sufficient for pavement design.
San Antonio 4 (Unknown area)	Within San Antonio most of the roadways are ASB and ACP. Due to traffic there is not much discussion on other types.
San Antonio 5 (Unknown area)	History of past projects.
Waco (District)	There is no written policy or prescribed policy governing type selection in the district. Pavement types are chosen based upon traffic, especially heavy trucks, life cycle cost comparisons and available funding to construct.
Wichita Falls (District)	There is no district policy on pavement type selection that I am aware of. Generally we replace what was placed originally.
Yoakum (District)	No district policy is in place. ADT and % trucks would be the primary considerations when deciding flexible versus rigid. We build mostly flexible pavements.

Table D.4. Mention other pavement types considered in pavement type selection (Question 4; other than seal coat with granular base, ACP with granular base, full depth ACP, ACP with stabilized base, CRCP, JRCP, JCP)

District	**Comments**
Abilene 1 (District)	—
Abilene 2 (Big Spring area)	—
Abilene 3 (Snyder area)	Concrete pavements are not used because neither traffic demand nor available dollars are sufficient to support such usage.
Abilene 4 (Hamlin area)	—
Abilene 5 (Abilene area)	—
Amarillo (District)	—
Atlanta (District)	—
Austin (District)	—
Beaumont 1 (Unknown area)	—
Beaumont 2 (Beaumont area)	—
Brownwood 1 (District)	—
Brownwood 2 (Lampasas area)	—
Childress (District)	—
Corpus Christi 1 (District)	—
Corpus Christi 2 (Karnes area)	—
Corpus Christi 3 (Cor. Ch. area)	—
Dallas District 1 (District)	—
Dallas 2 (Dallas Proj. Off.)	—
Dallas 3 (Ellis area)	—
El Paso (District)	—
Fort Worth (District)	—

Houston 1 (District Pav. Engr.)	—
Houston 2 (District Des. Engr.)	—
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	—
Houston 7 (Cent. Houston area)	—
Laredo (District)	Concrete pavement contraction design (CPCD), fast track concrete.
Lubbock (District)	Combinations during construction phases.
Lufkin 1 (District)	Cement stabilized sand.
Lufkin 2 (San Augustine area)	—
Lufkin 3 (Livingston area)	—
Odessa (District)	—
Paris 1 (Sulphur Springs area)	—
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	—
Pharr (District)	JCP only considered at intersections.
San Angelo (District)	—
San Antonio 1 (District)	—
San Antonio 2 (Floresville area)	—
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	—
San Antonio 5 (Unknown area)	—
Waco (District)	Depending on the road, any one of these might be considered. Generally all are not considered for each road.
Wichita Falls (District)	—
Yoakum (District)	—

Table D.5. Report other agency costs used in the economic analysis (Question 5c, other than initial construction cost, rehabilitation cost, preventive maintenance cost, routine maintenance cost, salvage value)

District	**Comments**
Abilene 1 (District)	—
Abilene 2 (Big Spring area)	—
Abilene 3 (Snyder area)	As analysis in FPS-19.
Abilene 4 (Hamlin area)	—
Abilene 5 (Abilene area)	—
Amarillo (District)	—
Atlanta (District)	FPS-19 considers initial cost, salvage and routine maintenance.
Austin (District)	—
Beaumont 1 (Unknown area)	—
Beaumont 2 (Beaumont area)	—
Brownwood 1 (District)	—
Brownwood 2 (Lampasas area)	—
Childress (District)	—
Corpus Christi 1 (District)	—

Corpus Christi 2 (Karnes area)	—
Corpus Christi 3 (Cor. Ch. area)	—
Dallas District 1 (District)	—
Dallas 2 (Dallas Proj. Off.)	—
Dallas 3 (Ellis area)	—
El Paso (District)	—
Fort Worth (District)	We do a life-cycle cost analysis for flexible pavement strategies using FPS-19.
Houston 1 (District Pav. Engr.)	—
Houston 2 (District Des. Engr.)	—
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	—
Houston 7 (Cent. Houston area)	—
Laredo (District)	—
Lubbock (District)	—
Lufkin 1 (District)	—
Lufkin 2 (San Augustine area)	—
Lufkin 3 (Livingston area)	—
Odessa (District)	—
Paris 1 (Sulphur Springs area)	—
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	—
Pharr (District)	We use TxDOT program FPS which takes into consideration the above mentioned costs.
San Angelo (District)	—
San Antonio 1 (District)	—
San Antonio 2 (Floresville area)	—
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	—
San Antonio 5 (Unknown area)	—
Waco (District)	—
Wichita Falls (District)	This is when using FPS-11 or FPS-19.
Yoakum (District)	User costs for rehabilitation.

Table D.6. Explain whether or not user costs should be considered in economic analyses (Question 7a)

District	**Comments**
Abilene 1 (District)	—
Abilene 2 (Big Spring area)	Don't really know whether current methods are realistic. In my area delay cost aren't really significant.
Abilene 3 (Snyder area)	Because I do not know how this is calculated or what approximations go into it, I am not confident that it is accurate. Also, perhaps citizens would rather be inconvenienced than taxed more heavily.
Abilene 4 (Hamlin area)	Most highways in region have a relative low ADT.

Abilene 5 (Abilene area)	Difficult to determine, this amount is very small in comparison to the cost of the project.
Amarillo (District)	Different construction methods take longer than others do.
Atlanta (District)	Probably only for very high-volume facilities.
Austin (District)	Delays due to maintenance on asphalt roads are insignificant.
Beaumont 1 (Unknown area)	User costs probably should be considered in the form of delay costs for M&R on high-volume facilities. Delay costs on medium-low volume facilities are usually insignificant.
Beaumont 2 (Beaumont area)	—
Brownwood 1 (District)	Taxpayers expect smooth and long lasting roads.
Brownwood 2 (Lampasas area)	As a public service agency spending user dollars collected from user fees (gasoline taxes), the cost to the users should include user fees spent by the agency and other user costs in the form of delay.
Childress (District)	I feel that only strength of material, traffic volume, initial performance period, etc., should determine pavement structure. Get most pavement structure for construction dollar.
Corpus Christi 1 (District)	User costs should be considered as part of a design, but not in developing pavement strategies and/or pavement structure.
Corpus Christi 2 (Karnes area)	User costs tend to be low and about the same for each flexible pavement analyzed. User cost would seem unpredictable based on field conditions.
Corpus Christi 3 (Cor. Ch. area)	Depending on the size of the job or its location, the duration of user delay/inconvenience may warrant a different design to reduce the impact to the user.
Dallas District 1 (District)	Because user costs are real costs that are affected by pavements and maintenance.
Dallas 2 (Dallas Proj. Off.)	Our users are our customers and should be treated as such. Their time is valuable to them, and it should be to us.
Dallas 3 (Ellis area)	This can vary so widely depending on the location of the roadway, which is not reliable.
El Paso (District)	Hard to quantify.
Fort Worth (District)	—
Houston 1 (District Pav. Engr.)	—
Houston 2 (District Des. Engr.)	Because both costs are paid by the taxpayers.
Houston 3 (Brazoria area)	Usually the short time spans of these delays do not have a large impact on these costs.
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	On interstate, freeways and other very high ADT roadways and highly urbanized areas.
Houston 7 (Cent. Houston area)	User costs in certain environment are of a critical nature to get an accurate economic analysis.
Laredo (District)	User costs (delay costs during M&R) are short term (during construction), and the economic analyses we are interested in are long term (i.e., 20 years).
Lubbock (District)	No, because they are unreliable and can skew the design, because construction and maintenance are only 5% of the life of a roadway at the most, and we have other considerations which cause delays already such as accidents, weather, etc.
Lufkin 1 (District)	User costs should be based on life of project and not strictly delays during construction.

Lufkin 2 (San Augustine area)	M&R costs are too hard to accurately predict and vary depending on conditions specific to each roadway.
Lufkin 3 (Livingston area)	—
Odessa (District)	—
Paris 1 (Sulphur Springs area)	I think user cost should be considered with high-traffic volumes. In our county, we generally have traffic counts where user costs are not generally considered significant.
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	No reasonable method to quantify user cost.
Pharr (District)	If you reduce user cost, the fuel consumed will be reduced, which will reduce impact on natural resources and environment.
San Angelo (District)	The ADT in our district's counties are typically very low, and user costs are negligible.
San Antonio 1 (District)	It's a case of pay-me-now or pay-me-later.
San Antonio 2 (Floresville area)	Traffic disruptions for the public really do need to be considered.
San Antonio 3 (Unknown area)	In high traffic urban areas, it can have an impact on decisions.
San Antonio 4 (Unknown area)	Due to the amount of traffic in San Antonio, delays sometimes become a big problem.
San Antonio 5 (Unknown area)	—
Waco (District)	Although user costs are very important when choosing M&R treatments, these costs vary greatly between different treatments, and true values are difficult to assign.
Wichita Falls (District)	This way all costs are included.
Yoakum (District)	Because we need to be taking into account the delay and aggravation we cause and how frequently these distresses are forced upon the user.

Table D.7. Other user costs (excluding VOC and Time Delay) which you consider important for economic analysis (Question 7d)

District	Comments
Abilene 1 (District)	—
Abilene 2 (Big Spring area)	—
Abilene 3 (Snyder area)	—
Abilene 4 (Hamlin area)	—
Abilene 5 (Abilene area)	—
Amarillo (District)	—
Atlanta (District)	—
Austin (District)	—
Beaumont 1 (Unknown area)	—
Beaumont 2 (Beaumont area)	—
Brownwood 1 (District)	—
Brownwood 2 (Lampasas area)	—
Childress (District)	—
Corpus Christi 1 (District)	—
Corpus Christi 2 (Karnes area)	—
Corpus Christi 3 (Cor. Ch. area)	—
Dallas District 1 (District)	—
Dallas 2 (Dallas Proj. Off.)	—

Dallas 3 (Ellis area)	—
El Paso (District)	—
Fort Worth (District)	—
Houston 1 (District Pav. Engr.)	—
Houston 2 (District Des. Engr.)	—
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Impact to business accessibility.
Houston 7 (Cent. Houston area)	—
Laredo (District)	—
Lubbock (District)	—
Lufkin 1 (District)	Vehicle damages, cost of delay for persons.
Lufkin 2 (San Augustine area)	—
Lufkin 3 (Livingston area)	—
Odessa (District)	—
Paris 1 (Sulphur Springs area)	—
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	—
Pharr (District)	—
San Angelo (District)	—
San Antonio 1 (District)	—
San Antonio 2 (Floresville area)	—
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	—
San Antonio 5 (Unknown area)	—
Waco (District)	—
Wichita Falls (District)	—
Yoakum (District)	—

Table D.8. General comments on economic analysis (Question 8)

District	Comments
Abilene 1 (District)	—
Abilene 2 (Big Spring area)	—
Abilene 3 (Snyder area)	Although we say that we look at life-cycle costs, that's not really true. It is really the initial cost of construction that is crucial. If the money is not there initially, it won't get built. Also, there is no guarantee that future money will be available to do the work that is estimated in life-cycle cost analysis.
Abilene 4 (Hamlin area)	—
Abilene 5 (Abilene area)	—
Amarillo (District)	—
Atlanta (District)	The pavement type selection is more important than the thickness of pavement to the exact inch. The pavement type selection is probably the most important input in the design process and has the greatest impact on long-term cost.
Austin (District)	—

Beaumont 1 (Unknown area)	—
Beaumont 2 (Beaumont area)	—
Brownwood 1 (District)	Should be practical and simple.
Brownwood 2 (Lampasas area)	—
Childress (District)	—
Corpus Christi 1 (District)	VOC and delay costs should be considered in design but not in the development of the pavement structure.
Corpus Christi 2 (Karnes area)	Type of material located locally. In our area we have an abundance of caliche material, and almost all-existing roadways have this for the base usually treated with the lime. We have given base alternates in plans but contractors find the caliche more economical.
Corpus Christi 3 (Cor. Ch. area)	Too many variables would have to go into VOC; time delay can be analyzed as a whole.
Dallas District 1 (District)	—
Dallas 2 (Dallas Proj. Off.)	—
Dallas 3 (Ellis area)	—
El Paso (District)	—
Fort Worth (District)	—
Houston 1 (District Pav. Engr.)	—
Houston 2 (District Des. Engr.)	—
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	—
Houston 7 (Cent. Houston area)	—
Laredo (District)	—
Lubbock (District)	The different phases of construction will affect traffic differently each day. Lost time to users should not be considered very seriously because we don't consider traffic jams, accidents, or bad weather.
Lufkin 1 (District)	—
Lufkin 2 (San Augustine area)	—
Lufkin 3 (Livingston area)	—
Odessa (District)	—
Paris 1 (Sulphur Springs area)	—
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	—
Pharr (District)	—
San Angelo (District)	—
San Antonio 1 (District)	—
San Antonio 2 (Floresville area)	—
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	—
San Antonio 5 (Unknown area)	—
Waco (District)	Economic analysis needs to consider user cost associated with initial construction. Concrete pavement construction can sometimes take from 6 to 18 additional months to construct than would a flexible section (in this district anyway!).
Wichita Falls (District)	—
Yoakum (District)	—

Table D.9. Other local subjective factors you consider important for pavement type selection (Question 9)

District	Comments
Abilene 1 (District)	—
Abilene 2 (Big Spring area)	—
Abilene 3 (Snyder area)	—
Abilene 4 (Hamlin area)	—
Abilene 5 (Abilene area)	—
Amarillo (District)	—
Atlanta (District)	—
Austin (District)	—
Beaumont 1 (Unknown area)	—
Beaumont 2 (Beaumont area)	—
Brownwood 1 (District)	—
Brownwood 2 (Lampasas area)	—
Childress (District)	—
Corpus Christi 1 (District)	—
Corpus Christi 2 (Karnes area)	—
Corpus Christi 3 (Cor. Ch. area)	—
Dallas District 1 (District)	—
Dallas 2 (Dallas Proj. Off.)	—
Dallas 3 (Ellis area)	—
El Paso (District)	—
Fort Worth (District)	—
Houston 1 (District Pav. Engr.)	—
Houston 2 (District Des. Engr.)	—
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	—
Houston 7 (Cent. Houston area)	—
Laredo (District)	—
Lubbock (District)	Ease of maintenance seems to be more of roadway design factor.
Lufkin 1 (District)	—
Lufkin 2 (San Augustine area)	—
Lufkin 3 (Livingston area)	—
Odessa (District)	—
Paris 1 (Sulphur Springs area)	—
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	—
Pharr (District)	—
San Angelo (District)	—
San Antonio 1 (District)	—
San Antonio 2 (Floresville area)	—
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	—

San Antonio 5 (Unknown area)	—
Waco (District)	—
Wichita Falls (District)	—
Yoakum (District)	—

Table D.10. Explain how "Historical Construction Practice" affects pavement type selection in your area (example, some districts in Texas have historically built only flexible pavements) (Question 10a)

District	**Comments**
Abilene 1 (District)	Low ADTs do not warrant concrete pavement. We use flexible pavement due to economic concerns.
Abilene 2 (Big Spring area)	Materials and construction contractors for flexible pavements are available in the area.
Abilene 3 (Snyder area)	Historically, we have used flexible bases; we know that our soils are good and that our local bases are generally of better quality.
Abilene 4 (Hamlin area)	With low ADT, concrete pavement is not normally a consideration. This is more economical rather than historical.
Abilene 5 (Abilene area)	Contractors are set up for HMAC and seal coats in this area, very little concrete pavements except in intersections.
Amarillo (District)	We build flexible pavements mainly with a very thin ACP surface.
Atlanta (District)	We do not presently use cement treated base or lime-fly ash because of excessive cracking; we have used both in the past and flexible bases have performed well.
Austin (District)	Successful strategies from the past are given importance.
Beaumont 1 (Unknown area)	We do not consider using CRCP or cement stabilized base with asphalt surfaces because of the poor performance experienced.
Beaumont 2 (Beaumont area)	District does not typically use CRCP based on past experience.
Brownwood 1 (District)	In a rural district with low traffic, we feel, based on experience, that a seal coat surface over a flexible base lasts longer than an AC surface over a flexible base.
Brownwood 2 (Lampasas area)	Historical construction practice provides confidence in construction of similar pavements under somewhat similar conditions.
Childress (District)	Engineers like to use materials that they have had positive experience with. If flexible pavements have performed well, we will continue to use them.
Corpus Christi 1 (District)	Have received benefit from past experience on good and/or bad pavement design.
Corpus Christi 2 (Karnes area)	Karnes area office handles Bee, Goliad, and Karnes counties and has only used flexible pavements.
Corpus Christi 3 (Cor. Ch. area)	Review what's in place currently how has it performed?
Dallas District 1 (District)	Existing pavements that have performed well give information about future pavements.
Dallas 2 (Dallas Proj. Off.)	Major factor in pavement type selection.
Dallas 3 (Ellis area)	—
El Paso (District)	Historic information for rural areas where pavements usually last 40 years with base and surface treatments and no significant increase in traffic.
Fort Worth (District)	CRCP has historically performed better than JCP and ACP on interstate highways.
Houston 1 (District Pav. Engr.)	High-volume roads are built of concrete.

Houston 2 (District Des. Engr.)	In general, the Houston district uses concrete pavement, especially on freeways.
Houston 3 (Brazoria area)	Larger volume ADT dictate durable and thick pavements such as portland cement concrete pavement.
Houston 4 (Conroe area)	Build ACP structures on lower volume roadways.
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Houston historically used concrete pavement on freeways and high-volume roadways.
Houston 7 (Cent. Houston area)	—
Laredo (District)	We have not had the subgrade problems or traffic volumes to justify the usage of rigid pavements. Recently, though, we have seen an increase in truck traffic.
Lubbock (District)	We respect proven construction methods, but we have to question them and their applicability to improved construction methods and standards.
Lufkin 1 (District)	Generally open except for financial considerations.
Lufkin 2 (San Augustine area)	We have produced roads with long life spans using local materials, based on that fact that we continue to use the same general base design.
Lufkin 3 (Livingston area)	We have only built flexible pavements. No local materials used since iron ore is essentially gone.
Odessa (District)	Our district historically builds flexible pavements, builds IH and high-volume roads with ACP surface and low-volume roads with surface treatment.
Paris 1 (Sulphur Springs area)	Low-volume FM roadways almost always rehabilitated by scarifying the existing base and adding additional base for increased pavement.
Paris 2 (Greenville area)	By experience we have a large database to rely on. We use what works and forget the rest.
Paris 3 (Sherman area)	Flexible base is our first option.
Pharr (District)	We build flexible pavements and are now starting to use concrete at intersections. Our contractors do not build concrete roads and now have to teach their workers.
San Angelo (District)	Our district has historically built only flexible pavements.
San Antonio 1 (District)	For depths of materials and not for type of pavement.
San Antonio 2 (Floresville area)	Historically, practice plays a large role; many design decisions are based on personal experience.
San Antonio 3 (Unknown area)	They (flexible pavements) fit the area they are being used in.
San Antonio 4 (Unknown area)	Historical data is used more on pavement depth.
San Antonio 5 (Unknown area)	Generally use flexible pavements.
Waco (District)	Flexible pavements are designed not guessed at. We do not use this practice.
Wichita Falls (District)	Typically, someone up the design chain of command decided the pavement structure to be built, and this went straight into the typical section.
Yoakum (District)	Flexible pavement traditionally built here except for IH 10, US 59, SH 71.

Table D.11. Explain how "Initial Budget Constraints" affect pavement type selection in your area (example, limited initial budget will often result in flexible pavements being recommended) (Question 10b)

District	Comments
Abilene 1 (District)	Budget is a consideration.
Abilene 2 (Big Spring area)	Project controls are usually long and all existing pavements are flexible; reconstruction or rehabilitation would be very costly and limited amount of construction work would be possible if rigid construction was performed.
Abilene 3 (Snyder area)	Realistically, initial budget constraint is the key factor to determine what the design will be. You have a fixed amount of dollars and generally cannot go over that amount. Advanced planning and programming is not done to get more money that may be required for more costly pavement structures.
Abilene 4 (Hamlin area)	Base stabilization often considered if local base is not available.
Abilene 5 (Abilene area)	Budget for project is established long before the FPS is performed.
Amarillo (District)	More highways can be rehabilitated if we mainly use flexible pavements.
Atlanta (District)	Budget constraints are always a factor. However, to not build proper strength pavement can be costly in long term. We try to build the required pavement structure.
Austin (District)	Pavement design is usually completed before funding or preliminary estimate is finalized.
Beaumont 1 (Unknown area)	For principal facilities (high ADT and high % trucks) initial budget constraints affect length not pavement types.
Beaumont 2 (Beaumont area)	Funding drives most pavement type decisions.
Brownwood 1 (District)	Rural districts cannot afford to build PCC pavements; also pavements are designed to last 10 years instead of 20.
Brownwood 2 (Lampasas area)	In reality, to build a project, only a limited amount of funds can be made available, and it forces a decision to build within budgetary constraints.
Childress (District)	Money is always an object of concern; however, we are getting to a point where we are trying to design for longer initial performance periods.
Corpus Christi 1 (District)	Constraints are more critical on minor and major rehabilitation projects. This is due to the three-year letting schedule.
Corpus Christi 2 (Karnes area)	Built a new roadway to a state prison and had to keep funding under the $6,000,000 funding cap for this type of construction. Flexible pavement consisted of seal coat on treated base.
Corpus Christi 3 (Cor. Ch. area)	Need to try to keep project within original estimate budget. Original pavement section is a guesstimate of what may be constructed. (a couple of inches of additional material can be costly).
Dallas District 1 (District)	Sometimes this is a problem.
Dallas 2 (Dallas Proj. Off.)	Generally not a problem.
Dallas 3 (Ellis area)	It is generally accepted that rigid is more expensive than flexible. On non-freeway pavement, it is not considered feasible to use rigid pavement.
El Paso (District)	Initial budgets limit type of pavement selected (usually flexible), also limit time of initial life, reducing time to first overlay.
Fort Worth (District)	Because of budget, the westbound lanes of US highway will be flexible; the westbound lanes have lowered truck traffic also.
Houston 1 (District Pav. Engr.)	If short of funds will go with lowest initial cost.
Houston 2 (District Des. Engr.)	Typically a fixed amount of funds are allocated to project; therefore, cost must be considered. In my opinion, this does not mean flexible versus concrete.

Houston 3 (Brazoria area)	The example above as noted is typical of a majority of the projects.
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Limited budget results in flexible pavements on borderline projects.
Houston 7 (Cent. Houston area)	—
Laredo (District)	We look first at the traffic volumes to see if they warrant the use of rigid pavements. We then work with the budget to meet our needs.
Lubbock (District)	We work within a budget and consider life of roadway with respect to ADT and functional class, etc.
Lufkin 1 (District)	Very little concrete pavements considered because of high cost. Limestone base generally restricted due to cost.
Lufkin 2 (San Augustine area)	Our local material (iron ore gravel) is the cheapest base we have; because it produces a good cheap pavement base, we continue to use it.
Lufkin 3 (Livingston area)	—
Odessa (District)	Initial budget constraints will cause the district to use flexible base and surface treatments or scarify and reshape existing base.
Paris 1 (Sulphur Springs area)	Almost all of our roads are constructed with flexible pavements with the occasional exception of some IH projects.
Paris 2 (Greenville area)	Not so, you are wasting money if you cannot build it to meet design parameters.
Paris 3 (Sherman area)	Initial budget typically limits you to a flexible base roadway.
Pharr (District)	For low-volume rural roadways a widening is sometimes done with an ACP overlay on the existing road, rather than reconstruction, which will cost more.
San Angelo (District)	We always want the best possible pavement structure. We will select a surface treatment over ACP if funding is a constraint.
San Antonio 1 (District)	Flexible cost so much less than rigid so we always check out the cost of flexible to use to compare to the possible use of rigid.
San Antonio 2 (Floresville area)	Many of our projects are 100% state funds, not much money in those programs, use a lot of seal coat.
San Antonio 3 (Unknown area)	You have to stretch the initial dollar as far as it will go. Try to provide a pavement that is manageable for maintenance.
San Antonio 4 (Unknown area)	Budget constraints would result in flexible base rather than ASB; could reduce pavement depth causing future work.
San Antonio 5 (Unknown area)	—
Waco (District)	It is a big concern to all. If warranted, could be a deciding factor in pavement type selection.
Wichita Falls (District)	On new roads often this limits the number of lane miles to be rehabilitated or a decrease in the overlay thickness.
Yoakum (District)	Agree with your example.

Table D.12. Explain how "Highway Functional Classification" affects pavement type selection in your area (example, often both rigid and flexible pavements are considered for an IH project, whereas flexible pavements are almost always selected for FM roads) (Question 10c)

District	Comments
Abilene 1 (District)	Concrete too expensive for our ADTs.
Abilene 2 (Big Spring area)	Maintenance costs
Abilene 3 (Snyder area)	Ditto 10b, hot mix is considered only for IH or special situations, not FM roads.
Abilene 4 (Hamlin area)	Not so much effect on pavement structure as to roadway geometry and paved shoulders.
Abilene 5 (Abilene area)	Most FM roads receive seal coats, and HMAC is used on other classifications. This is generally true; it does not change from this.
Amarillo (District)	FM roads consist of only flexible pavements.
Atlanta (District)	We try to design first for traffic loads; FM or state highway with excessive truck traffic would get a "heavy" pavement.
Austin (District)	Most of US 183 freeway will be rigid pavement.
Beaumont 1 (Unknown area)	Rigid pavements are considered for IH 10, SH 146, SH 321, US 90, US 59, and SH 73.
Beaumont 2 (Beaumont area)	Typically, rigid pavements are considered for IH.
Brownwood 1 (District)	I do not think this is a big factor. I believe traffic will govern pavement type.
Brownwood 2 (Lampasas area)	It influences required service life.
Childress (District)	Interstate and a few urban areas on US 287 are only places we look at for concrete; all other roads are flexible pavements.
Corpus Christi 1 (District)	Urban FM roads—tendency to use hot mix for the riding surface. Rural FM roads—tendency to use seal coat.
Corpus Christi 2 (Karnes area)	No interstate highways located in our area.
Corpus Christi 3 (Cor. Ch. area)	Functional classification will determine the performance and reliability levels as well as the surface type.
Dallas District 1 (District)	Not generally a problem.
Dallas 2 (Dallas Proj. Off.)	Not a significant influence.
Dallas 3 (Ellis area)	Rigid pavement is always specified for IH projects. Other highways receive flexible pavement with the exception of three, five-lane urban roadways we have constructed with C&E and storm sewer.
El Paso (District)	This is not as important as traffic.
Fort Worth (District)	Interstate reconstruction will be CRCP.
Houston 1 (District Pav. Engr.)	More likely to use rigid for IH and flexible for FM.
Houston 2 (District Des. Engr.)	Functional classification does influence pavement type selection. FM roads classified as urban freeways will probably be rigid pavements, while those classified as rural arterials will be flexible.
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Houston uses rigid pavements for interstates and freeways.
Houston 7 (Cent. Houston area)	—
Laredo (District)	We don't look at this in considering pavement type.
Lubbock (District)	That is correct—why should you make a rigid FM with low ADT and low % truck? It's not cost effective.

Lufkin 1 (District)	ACP on major arterials, surface treatments on FM roads.
Lufkin 2 (San Augustine area)	In this area, the classification and traffic volume are closely related. Therefore, we design the higher-class roadways to a higher standard than the low-volume roads, but it is due to the higher traffic volumes with higher % truck.
Lufkin 3 (Livingston area)	—
Odessa (District)	We use flexible base for all functional classes.
Paris 1 (Sulphur Springs area)	Typically only IH projects are considered for rigid pavement sections.
Paris 2 (Greenville area)	Build what is needed and can be maintained by local forces.
Paris 3 (Sherman area)	Typically, all US, SH, and FM projects are flexible.
Pharr (District)	With NAFTA on board, we are building heftier roads (major routes linking to Mexico). If rut problem develops, may change to concrete.
San Angelo (District)	We are more conservative in selecting pavement materials on more heavily traveled highways.
San Antonio 1 (District)	The ADT is looked at more than the functional class.
San Antonio 2 (Floresville area)	"Higher" functional classes generally have higher traffic volumes that lead to more use of ACP.
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	—
San Antonio 5 (Unknown area)	Most projects are state highways or FM roads.
Waco (District)	This is true in most cases.
Wichita Falls (District)	We typically replace with similar materials unless the frequency of maintenance is prohibitive, which leads to use rigid.
Yoakum (District)	Agree with your example.

Table D.13. Explain how "Traffic Volume and Truck Percentage" affect pavement type selection in your area (example, rigid pavements are often preferred in high traffic volume and high truck percentage situations) (Question 10d)

District	**Comments**
Abilene 1 (District)	Don't have this.
Abilene 2 (Big Spring area)	We use all flexible pavements.
Abilene 3 (Snyder area)	These factors are considered within FPS-19 and the modified triaxial design test to allow adequate layer thickness.
Abilene 4 (Hamlin area)	Part of FPS-19.
Abilene 5 (Abilene area)	Low volume receive seal coats, high volume receive HMAC.
Amarillo (District)	Higher traffic volumes and truck percentage play an important part in deciding what strategy.
Atlanta (District)	Our district, other than IH, does not use a lot of concrete roads. High percentage of trucks and ADT would indicate stronger pavement structures. The greater the loading, the heavier the structure.
Austin (District)	See "10c."
Beaumont 1 (Unknown area)	Rigid pavements are preferred on high traffic and high truck percentage facilities, especially at intersections.
Beaumont 2 (Beaumont area)	Only rigid pavements are considered for high-volume routes with high truck percentage.
Brownwood 1 (District)	Design pavement for at least 20 years, with low maintenance because of safety and user cost.
Brownwood 2 (Lampasas area)	Consideration given to complexity of doing future maintenance and rehabilitation work.

Childress (District)	High-traffic roads are usually concrete pavements. We do have high truck % on some US highways where we use flexible pavements.
Corpus Christi 1 (District)	Currently, we use flexible pavements; we may consider rigid pavements at high truck traffic intersections/turning movements.
Corpus Christi 2 (Karnes area)	This area has low daily traffic counts, so flexible pavements can be used regularly.
Corpus Christi 3 (Cor. Ch. area)	Volume determines type of surfaces as well as thickness of material.
Dallas District 1 (District)	Traffic volume is key factor in determining pavement types.
Dallas 2 (Dallas Proj. Off.)	Major influence on pavement selection.
Dallas 3 (Ellis area)	This is a consideration, but it has not altered any of my decisions; that is, I haven't encountered a situation off of the IH system where the traffic dictated the pavement type.
El Paso (District)	%Trucks influence for rigid pavements with high traffic volume.
Fort Worth (District)	High ADT roadways in Tarrant County will be concrete if reconstruction is planned.
Houston 1 (District Pav. Engr.)	Agree with example.
Houston 2 (District Des. Engr.)	High traffic volume and truck percentage results in a thicker pavement and cost effectiveness to determine pavement type selection.
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Does affect preference toward rigid pavement.
Houston 7 (Cent. Houston area)	—
Laredo (District)	This is the single-most important factor that we look at when determining pavement type.
Lubbock (District)	Example is correct; we also design in a similar fashion.
Lufkin 1 (District)	Very little effect.
Lufkin 2 (San Augustine area)	A higher standard than the low-volume roads, but it is due to the higher traffic volume with higher truck numbers.
Lufkin 3 (Livingston area)	—
Odessa (District)	Our district uses flexible base with surface treatment for low truck percentage and flex base and ACP for high situation.
Paris 1 (Sulphur Springs area)	Again, only IH projects are considered for pavement section. This is due to high traffic and high truck traffic on the IH system.
Paris 2 (Greenville area)	Traffic volume and % truck is the driving force.
Paris 3 (Sherman area)	Rigid pavement is used on US 75 due to high traffic volumes.
Pharr (District)	We are beginning to use concrete (rigid) pavements at intersections that have high truck traffic and volumes.
San Angelo (District)	Oil field traffic is one of our main considerations.
San Antonio 1 (District)	Part of the design, but not really a factor on whether we use flexible or rigid.
San Antonio 2 (Floresville area)	Very important when determining layer thickness and when deciding what type of surface is used (ACP versus seal coat)
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	Traffic volume and trucks would increase pavement depth.
San Antonio 5 (Unknown area)	Our rural area has lower traffic volumes.
Waco (District)	Your example is true.
Wichita Falls (District)	Agree with example.
Yoakum (District)	Agree with example.

Table D.14. Explain how the use of "Local and/or Recycled Materials" affects pavement type selection in your area (Question 10e)

District	Comments
Abilene 1 (District)	Research. We use our asphalt (RAP) in base.
Abilene 2 (Big Spring area)	We utilize recycled material on FM and SH rehabilitation works.
Abilene 3 (Snyder area)	Cost usually dictates this.
Abilene 4 (Hamlin area)	Often considered due to economic consideration on rehabilitation works.
Abilene 5 (Abilene area)	Both are used, it depends on current typical section and existing materials; local sources always are used.
Amarillo (District)	Large volumes of RAP generated within the project will always be used.
Atlanta (District)	—
Austin (District)	Local materials are always used for construction, but not always for maintenance.
Beaumont 1 (Unknown area)	Local aggregates are rare and generally not considered. Crushed concrete for base and RAP are sometimes used for cement stabilized base (FM 1409) and ACP (SH 124), respectively.
Beaumont 2 (Beaumont area)	No local aggregates exist.
Brownwood 1 (District)	We have a good source of flexible base; therefore, most of our roadways consist of flexible base and seal coat surface.
Brownwood 2 (Lampasas area)	This influences cost. When durable local materials are available, this is a consideration.
Childress (District)	We always try to use the existing base and RAP in our pavement design.
Corpus Christi 1 (District)	When feasible, will incorporate recycled asphalt pavement into the base layer; local material depends on availability; most contracts will use local materials.
Corpus Christi 2 (Karnes area)	Contractors tend to use local caliche pits for base or large projects. Recycled materials not readily available.
Corpus Christi 3 (Cor. Ch. area)	Depends on the availability of material, quality of existing pavement material, and sequence of construction.
Dallas District 1 (District)	Not generally a factor in determining pavement types.
Dallas 2 (Dallas Proj. Off.)	Does not affect pavement selection.
Dallas 3 (Ellis area)	We do not consider this.
El Paso (District)	It is going to cost us to dispose, cost to reuse material.
Fort Worth (District)	Rural areas where material sources are not near by may consider recycling materials.
Houston 1 (District Pav. Engr.)	Not a factor in pavement type selection.
Houston 2 (District Des. Engr.)	In my opinion, the salvage value can be applied to both rigid and flexible.
Houston 3 (Brazoria area)	Recycled materials are offered as an option.
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Does not usually affect decision as to rigid or flexible.
Houston 7 (Cent. Houston area)	—
Laredo (District)	We look at the material that is available and the quality of that material. (It helps to use local materials with respect to funding budget).
Lubbock (District)	We use good materials—local if possible—recycled if applicable—and when in doubt, we stabilize.
Lufkin 1 (District)	Historically used local iron ore bases.

Lufkin 2 (San Augustine area)	We only have one source of local material and no source for recycled materials.
Lufkin 3 (Livingston area)	—
Odessa (District)	Sometimes, but not very often.
Paris 1 (Sulphur Springs area)	—
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	Flexible base is a preferred local material; recycled is not preferred.
Pharr (District)	Recycled material (salvage) is always considered for reducing the cost of material.
San Angelo (District)	Availability of materials is always a concern; however, we seldom use recycled surfacing materials.
San Antonio 1 (District)	We use only material that is recycled from our roadways.
San Antonio 2 (Floresville area)	Material for flexible pavement more readily available locally. Recycled material used to improved subgrade.
San Antonio 3 (Unknown area)	Cost effectiveness and quality of the material is a consideration.
San Antonio 4 (Unknown area)	—
San Antonio 5 (Unknown area)	—
Waco (District)	This factor may not be as large a factor as some of the others.
Wichita Falls (District)	We have tried recycled pavement in base, and it did not work, primarily due to construction methods. The use of local materials should be investigated.
Yoakum (District)	Local material (gravel) is a must (at least as an alternate bid item) because of attention the local suppliers pay.

Table D.15. Explain how "Climatic Conditions" affect pavement type selection in your area (example, stabilized layers and/or rigid pavements are sometimes preferred in wet regions) (Question 10f)

District	**Comments**
Abilene 1 (District)	Very dry here.
Abilene 2 (Big Spring area)	We are in arid region, only stabilize high PI and weak existing bases.
Abilene 3 (Snyder area)	For our dry region, we choose type C hot-mix over denser type D. Also, drainable bases are usually not needed.
Abilene 4 (Hamlin area)	Not used.
Abilene 5 (Abilene area)	It is fairly dry in Abilene, therefore seal coats and HMAC.
Amarillo (District)	Not a major player because of the arid region we are located in.
Atlanta (District)	We have a lot of rainfall and usually use lime treated subbase in lieu of low PI sand subbase.
Austin (District)	Our climate affects mix-design and type of overlay used for M&R. Stabilizing subgrade is used in high PI clay soils regardless of climate.
Beaumont 1 (Unknown area)	Rigid pavements on stabilized base with lime treated subgrades are preferred because of the amount of rainfall received.
Beaumont 2 (Beaumont area)	Stabilized base and concrete pavements are preferred because of wet region.
Brownwood 1 (District)	Also stabilized layers are used where freeze-thaw cycles occur.
Brownwood 2 (Lampasas area)	Affects frequency of freeze-thaw cycles and importance of preventing water from entering pavement structure.
Childress (District)	Do not really have much effect on pavement selection in our district.
Corpus Christi 1 (District)	Climatic conditions are not considered.
Corpus Christi 2 (Karnes area)	Located in dry area.

Corpus Christi 3 (Cor. Ch. area)	All layers receive stabilization lime/cement except when using limestone base.
Dallas District 1 (District)	At this time, it is a big factor.
Dallas 2 (Dallas Proj. Off.)	Considered during pavement selection.
Dallas 3 (Ellis area)	We do not consider this.
El Paso (District)	Determines use of drainable bases without flows for rigid pavement.
Fort Worth (District)	—
Houston 1 (District Pav. Engr.)	Agree with the example.
Houston 2 (District Des. Engr.)	The overall climate for this district does not vary much, thus, does not affect decision to select rigid versus flexible pavement. However, the district predominantly used stabilized base.
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Houston cohesive soil influences preference towards rigid pavement selection.
Houston 7 (Cent. Houston area)	—
Laredo (District)	We stabilize the subgrade and base layers with lime (percentage determined by testing). Climatic conditions vary significantly in the district; we do not look too closely at this factor.
Lubbock (District)	This is a dry region, but we stabilize in areas of wet subgrade and lake bottoms and where we need more strength.
Lufkin 1 (District)	Very little effect.
Lufkin 2 (San Augustine area)	Each roadway has its own particular design needs. This area of Texas receives approx. 50 inches of rain per year, so groundwater is a big factor.
Lufkin 3 (Livingston area)	—
Odessa (District)	We use stabilized base in wet regions.
Paris 1 (Sulphur Springs area)	On our low-volume roads we usually stabilize the subgrade, on medium- to high-volume roads we usually stabilize the subgrade and base layers.
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	Climate condition is typically not a factor.
Pharr (District)	Since we predominately build flexible pavements in our district, they are located near the coast, and a high table is known to exist. We usually lime treat subgrades twelve inches in our lower district.
San Angelo (District)	Moisture is our major climatic concern.
San Antonio 1 (District)	Ours is not too wet of a region or district.
San Antonio 2 (Floresville area)	Not a big consideration.
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	—
San Antonio 5 (Unknown area)	Our region is not excessively wet.
Waco (District)	Generally not a big factor in pavement selection here.
Wichita Falls (District)	Generally look at subgrade.
Yoakum (District)	Not used.

Table D.16. Explain how "Subgrade Soil Type" affects pavement type selection in your area (example, stabilized layers and/or rigid pavements are sometimes preferred on weak subgrade) (Question 10g)

District	**Comments**
Abilene 1 (District)	Have good subgrade here.
Abilene 2 (Big Spring area)	We stabilize with high PI subgrade and weak existing bases.
Abilene 3 (Snyder area)	Subgrade soil type is considered in both FPS-19 and modified trixial design tests to determine appropriate thickness. Also, a soil with high sulfates would not get cement treated. The PI of the soil is determined to see if stability is adequate.
Abilene 4 (Hamlin area)	Lime in clay subgrade is often used, but strength gained not reflected in FPS-19.
Abilene 5 (Abilene area)	In weak soil areas of high PI, we will stabilize the layers.
Amarillo (District)	We use stabilized layers a tremendous amount.
Atlanta (District)	We usually stabilize subgrade deeper on weaker subgrade.
Austin (District)	See "10f."
Beaumont 1 (Unknown area)	Lime-treated subgrades are preferred under flexible and rigid pavements. This is a good working layer to place base and prevents water from pumping into base. Subgrades in this area are generally weak with a high plasticity index and conducive to swelling when wet.
Beaumont 2 (Beaumont area)	See your example.
Brownwood 1 (District)	If subgrade soil is highly expansive, I will use flexible pavement or CRCP, not JPCP.
Brownwood 2 (Lampasas area)	Influences required thickness and cost of various types of pavement structures.
Childress (District)	Our district, as a practice, likes to improve subgrade by lime treatment.
Corpus Christi 1 (District)	Generally, we stabilize the subgrade and base layers.
Corpus Christi 2 (Karnes area)	Typically stabilized subgrade in all projects, sandy soil treatment with cement, and loam and clay soil with lime.
Corpus Christi 3 (Cor. Ch. area)	All subgrades receive lime/cement, percentage of lime/cement based on triaxial loading tests.
Dallas District 1 (District)	The PVR of subgrade sometimes affects the pavement type selection.
Dallas 2 (Dallas Proj. Off.)	Considered during pavement selection.
Dallas 3 (Ellis area)	As stated in part (d) above, this is a valid consideration, but I have not encountered a situation where it has altered my decision. (It is my understanding that flexible is generally better on bad subgrade because there will be distress and flex is cheaper to maintain.)
El Paso (District)	Stabilized layers if necessary, geotextile use at rigid pavements for weak subgrades.
Fort Worth (District)	The eastern part of the district where soils are weak uses stabilized layers.
Houston 1 (District Pav. Engr.)	Clay soil influences decision to use concrete.
Houston 2 (District Des. Engr.)	Soil type influences type of base material used.
Houston 3 (Brazoria area)	Lime treatment is preferred and used on all projects as workable platform.
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Houston cohesive soil influences preference toward rigid pavement selection.
Houston 7 (Cent. Houston area)	—
Laredo (District)	We elect to stabilize all subgrades without regard to type.

Lubbock (District)	If a subgrade is in question for stability purposes, we will stabilize.
Lufkin 1 (District)	—
Lufkin 2 (San Augustine area)	As per "10f" above, wet and or weak subgrades are generally lime treated if soil PI is 19 or above.
Lufkin 3 (Livingston area)	—
Odessa (District)	If the subgrade is weak, we usually stabilize the subgrade and the base.
Paris 1 (Sulphur Springs area)	We usually stabilize the subgrade.
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	Lime and cement stabilization is typically used on weak subgrades.
Pharr (District)	Same as above (10f).
San Angelo (District)	We always consider the type of soil during pavement design.
San Antonio 1 (District)	Part of the foundation design, but not a factor in deciding between flexible or rigid.
San Antonio 2 (Floresville area)	Plays a part in decision to stabilize or not. Not an influence on flexible/rigid determination in this area.
San Antonio 3 (Unknown area)	Stabilize the subgrade with flexible layers over it.
San Antonio 4 (Unknown area)	Would require ASB rather than flexible base.
San Antonio 5 (Unknown area)	Weak subgrades are considered in pavement design.
Waco (District)	True, to a certain point.
Wichita Falls (District)	Look at subgrade and historical problems and experience with materials.
Yoakum (District)	We use the modified triaxial design procedure to check FPS thickness.

Table D.17. Explain how "Pavement Type Continuity" affects pavement type selection in your area (for example, flexible pavement may be preferred to reconstruct a section of existing flexible pavement) (Question 10h)

District	**Comments**
Abilene 1 (District)	We have flexible pavements only.
Abilene 2 (Big Spring area)	All existing roadways are flexible; reconstruction with rigid would be expensive.
Abilene 3 (Snyder area)	This is fairly common. We usually go back in with a similar type of pavement unless we see a problem area that shows the need for a different design solution. For example, we found one problem with ASB that was cracking, so we replaced only that section with flexible base.
Abilene 4 (Hamlin area)	Not normally a factor.
Abilene 5 (Abilene area)	Having continuity helps with maintenance, and therefore we try to use continuity in our designs.
Amarillo (District)	We use the same type of pavements if it has performed well through its service life.
Atlanta (District)	Not a major factor. To match what is at the termini of project would be more significant.
Austin (District)	We do not hesitate to change to a new pavement section when a failure has occurred. However, we try to have continuity of surface.
Beaumont 1 (Unknown area)	Generally, pavement continuity is maintained. However, at heavily traveled intersections rigid pavements are considered even if the existing facilities are flexible pavements.
Beaumont 2 (Beaumont area)	Your example is valid especially considering recycling existing pavement.
Brownwood 1 (District)	If we widen or add shoulders, we try to build the same structure as the existing.

Brownwood 2 (Lampasas area)	Try to construct maintainable pavement structures. Consistency along a route makes for more efficient maintenance operations.
Childress (District)	We like to have pavement continuity. However, it does not sway our selection of pavement types.
Corpus Christi 1 (District)	This may be considered on a case-by-case basis depending on past performance.
Corpus Christi 2 (Karnes area)	Rehabilitation projects incorporate the existing bases in the roadway, usually stabilized with lime or cement.
Corpus Christi 3 (Cor. Ch. area)	If project is a continuation of an adjacent project or if similar use and traffic—we will examine the existing pavement design and how well it is holding up in the field.
Dallas District 1 (District)	Your example is true.
Dallas 2 (Dallas Proj. Off.)	A large job will be split into smaller sections and pavement type continuity is very important.
Dallas 3 (Ellis area)	I have constructed a section of US highway using concrete primarily because the section that we tied onto was rigid, and it was considered desirable, given the location and traffic also, to continue with rigid pavements.
El Paso (District)	If phasing to major projects, let to smaller projects.
Fort Worth (District)	If a project abutting a new construction project is concrete, the new project will be concrete.
Houston 1 (District Pav. Engr.)	Will try to maintain same pavement type.
Houston 2 (District Des. Engr.)	In general, continuity does not affect type selection.
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Reconstruction and widening projects usually.
Houston 7 (Cent. Houston area)	—
Laredo (District)	We look more at needs than continuity.
Lubbock (District)	Normally that is true; the only exception would be in cities—at intersections where rutting or other structural failures occur.
Lufkin 1 (District)	Very little effect.
Lufkin 2 (San Augustine area)	This is not much of a factor; flexible base is a good solution to our traffic loads, and so rigid pavement with its higher cost is not used.
Lufkin 3 (Livingston area)	—
Odessa (District)	If the existing pavement structure is flexible base, we try to use flexible base for the extension or proposed project.
Paris 1 (Sulphur Springs area)	Almost all our roads are flexible pavement sections. On roadways that are rigid, it is considered acceptable to place flexible pavement over the existing concrete.
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	We stay consistent with the existing pavement.
Pharr (District)	Not here. We have removed old concrete roads built in the 1940s and built flexible pavements.
San Angelo (District)	It is more expensive to maintain several types of pavements.
San Antonio 1 (District)	Continuity should always be a factor.
San Antonio 2 (Floresville area)	Less concerned with continuity than with quality of construction.
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	Reduce joint problem and future overlay problems.
San Antonio 5 (Unknown area)	Pavement type considers continuity.
Waco (District)	A consideration, not a deciding factor.

Wichita Falls (District)	This is generally what we can afford.
Yoakum (District)	Absolutely agree with example.

Table D.18. Explain how "Constructability" concerns affect pavement type selection in your area (example, flexible pavements are often considered easier and quicker to build) (Question 10i)

District	**Comments**
Abilene 1 (District)	Flexible pavements are fast and easy.
Abilene 2 (Big Spring area)	Easier to maintain and spot repair with maintenance forces (flexible pavements).
Abilene 3 (Snyder area)	We consider minimum thickness of hot mix to be 2" and flexible base lifts of 4" or more are minimum for constructability.
Abilene 4 (Hamlin area)	Easier to construct = less delays and lower bid prices (flexible pavements).
Abilene 5 (Abilene area)	Flexible pavements are easier to build.
Amarillo (District)	Your example is true.
Atlanta (District)	This almost always considered. On US 59 this, and also the excellent load carrying capabilities, are why we went with full depth ACP.
Austin (District)	You bet! Rigid pavement construction is only feasible for new roads with no traffic on them (freeways).
Beaumont 1 (Unknown area)	Constructability generally affects the decision to lime-stabilize the subgrade for reconstruction projects. Sometimes it is not feasible to lime-treat subgrades or base under traffic.
Beaumont 2 (Beaumont area)	—
Brownwood 1 (District)	PCC pavements maybe used in high traffic areas instead of flexible. Some flexible pavements take longer to build than PCC over the natural subgrade
Brownwood 2 (Lampasas area)	Desire that which can be constructed in a usual manner.
Childress (District)	Does not really have a great impact on pavement selection.
Corpus Christi 1 (District)	This is not an issue as our district uses flexible pavements.
Corpus Christi 2 (Karnes area)	Contractors have the necessary equipment for building flexible pavement.
Corpus Christi 3 (Cor. Ch. area)	This is always taken into account.
Dallas District 1 (District)	This is some times true.
Dallas 2 (Dallas Proj. Off.)	Not a major influence.
Dallas 3 (Ellis area)	Not considered.
El Paso (District)	Important factor when traffic controls warrants or amount of traffic affected.
Fort Worth (District)	Because of the need to open the pavement to traffic quickly and because of adjacent businesses, flexible pavement.
Houston 1 (District Pav. Engr.)	May use flexible to reduce closure time.
Houston 2 (District Des. Engr.)	This generally does not affect most projects.
Houston 3 (Brazoria area)	This is not a factor.
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Not usually a major factor.
Houston 7 (Cent. Houston area)	—
Laredo (District)	We seek to make construction as easy (and quick) as possible for the contractor. Our emphasis, though, is at meeting our needs.
Lubbock (District)	Example is true—it is considered.

Lufkin 1 (District)	Used cement stabilization on in-place base for rehabilitation.
Lufkin 2 (San Augustine area)	Constructability is a very important issue, an easier to build base can usually be better built as well.
Lufkin 3 (Livingston area)	—
Odessa (District)	It is definitely easier to use flexible base in our district.
Paris 1 (Sulphur Springs area)	Our constructability concerns are usually centered on what type of flexible pavement to provide instead of flexible versus rigid.
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	Construction widths and materials are always considered.
Pharr (District)	We sometimes design roads to be built with two layers of ACP. Phase I: build half the road first to first lift of ACP, Phase II: build other half to first lift of ACP then place final course ACP.
San Angelo (District)	Concrete pavement (fast track) is being used to construct intersections of high-volume roadways.
San Antonio 1 (District)	Constructability should always be a factor.
San Antonio 2 (Floresville area)	Expertise in this area is with flexible pavements. Makes it easier for us to monitor construction.
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	Used to determine ASB versus flexible base.
San Antonio 5 (Unknown area)	Construction that is usually on existing roadways sometimes is a factor.
Waco (District)	Yes, if constructability and the ability to expedite are important to the project success.
Wichita Falls (District)	Considered when necessary.
Yoakum (District)	Agree with example. Also, full depth asphalt pavements allow quicker construction and quicker changeover of traffic in phase construction projects.

Table D.19. Explain how "Ease of Maintenance" concerns affect pavement type selection in your area (example, rigid pavements require much fewer maintenance treatments than flexible pavement through the same life cycle) (Question 10j)

District	Comments
Abilene 1 (District)	Really hard to repair concrete pavement if failed.
Abilene 2 (Big Spring area)	Example is true.
Abilene 3 (Snyder area)	Unfortunately, maintenance costs are not weighed as they probably should be. We assume we will build maintenance-free section that will last up to 20 years, but we don't always achieve that.
Abilene 4 (Hamlin area)	Rigid pavement can also be maintenance's worst nightmare if failure occurs.
Abilene 5 (Abilene area)	Rigid pavements have higher rehabilitation costs.
Amarillo (District)	We will use rigid pavements where having maintenance would be an inconvenience.
Atlanta (District)	It seems that this is not an extreme consideration.
Austin (District)	This has been considered in design for new freeways in the district.
Beaumont 1 (Unknown area)	See 10h.
Beaumont 2 (Beaumont area)	Prefer rigid pavements to avoid maintenance in early years.
Brownwood 1 (District)	In urban areas, PCC is used because of low maintenance.
Brownwood 2 (Lampasas area)	Consideration is given to equipment already owned by TxDOT to maintain and repair pavement type (only set up for flexible type).

Childress (District)	Does not really have a great impact on pavement selection.
Corpus Christi 1 (District)	Generally, this issue is not a consideration because rigid pavements that are not constructed in our district.
Corpus Christi 2 (Karnes area)	Rigid pavements do require fewer treatments. If the pavement does fail, fixing these sections would almost always require getting a contract. Maintenance offices do not have the equipment.
Corpus Christi 3 (Cor. Ch. area)	Try not to build/create maintenance headaches.
Dallas District 1 (District)	Maintenance is one of the largest factors.
Dallas 2 (Dallas Proj. Off.)	Considered during pavement selection.
Dallas 3 (Ellis area)	Not considered.
El Paso (District)	Important factor for urban areas or high-volume traffic.
Fort Worth (District)	For high ADT highways where maintenance work would be dangerous CRCP would be constructed.
Houston 1 (District Pav. Engr.)	Used concrete on high-volume roads to reduce maintenance.
Houston 2 (District Des. Engr.)	This is factored in the economic analyses and affects overall pavement selection.
Houston 3 (Brazoria area)	Maintenance is always a high priority.
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	Usually a factor.
Houston 7 (Cent. Houston area)	—
Laredo (District)	We believe that if we construct the pavement type that is needed and stabilize all underlying layers, ease of maintenance will be inherent.
Lubbock (District)	The example is true—it is considered.
Lufkin 1 (District)	Used cement stabilized bases for 12–15 years, considering other option now because of maintenance problems.
Lufkin 2 (San Augustine area)	Maintenance sections here utilize the same methods as the contractors for flexible pavements. Therefore, they are well suited to repair flexible pavements.
Lufkin 3 (Livingston area)	—
Odessa (District)	—
Paris 1 (Sulphur Springs area)	This is one factor we consider on IH projects. For example, IH 30 through Sulphur Springs will be rebuilt using rigid pavement in the near future primarily because of maintenance issues.
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	If possible, maintenance concerns are addressed, but they usually conflict with initial budget.
Pharr (District)	—
San Angelo (District)	See 10h.
San Antonio 1 (District)	Should be a factor, but most of the time we cannot spend more now to save maintenance dollars later.
San Antonio 2 (Floresville area)	Local maintenance forces have little/no experience with rigid pavement.
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	—
San Antonio 5 (Unknown area)	Flexible pavement is easier to maintain.
Waco (District)	Maintenance and maintenance treatments used on a section is a big consideration.
Wichita Falls (District)	Considered when necessary.
Yoakum (District)	Agree with example. Also full depth asphalt (a disadvantage) could strip, and ACP is more difficult to rework than flexible base.

Table D.20. Other comments regarding local/subjective factors (Question 13)

District	Comments
Abilene 1 (District)	—
Abilene 2 (Big Spring area)	—
Abilene 3 (Snyder area)	—
Abilene 4 (Hamlin area)	Concrete pavements on high-volume urban intersections are a good practice in this district.
Abilene 5 (Abilene area)	—
Amarillo (District)	—
Atlanta (District)	—
Austin (District)	—
Beaumont 1 (Unknown area)	—
Beaumont 2 (Beaumont area)	—
Brownwood 1 (District)	—
Brownwood 2 (Lampasas area)	—
Childress (District)	—
Corpus Christi 1 (District)	Rural roads, medium traffic includes some SH and US roads. (Aggregate base Type A Grade 1 limestone base.)
Corpus Christi 2 (Karnes area)	Concrete in our area is higher because there is only one supplier located in our area. This makes flexible pavement our only reasonable option, economically.
Corpus Christi 3 (Cor. Ch. area)	—
Dallas District 1 (District)	—
Dallas 2 (Dallas Proj. Off.)	—
Dallas 3 (Ellis area)	—
El Paso (District)	—
Fort Worth (District)	—
Houston 1 (District Pav. Engr.)	—
Houston 2 (District Des. Engr.)	—
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—
Houston 6 (Fort Bend area)	—
Houston 7 (Cent. Houston area)	—
Laredo (District)	—
Lubbock (District)	Local materials are cheaper than transporting other better materials—therefore, we recycle and stabilize to get strength and economy.
Lufkin 1 (District)	—
Lufkin 2 (San Augustine area)	This office also uses seal coat on treated bases as a pavement structure. Aggregate base is also commonly treated with cement (5–8%).
Lufkin 3 (Livingston area)	—
Odessa (District)	—
Paris 1 (Sulphur Springs area)	—
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	—
Pharr (District)	—

San Angelo (District)	—
San Antonio 1 (District)	—
San Antonio 2 (Floresville area)	—
San Antonio 3 (Unknown area)	We generally try to determine pavement structure based on subgrade, traffic, type of traffic, maintenance, history, possible material sources, adjacent land use, and future traffic types.
San Antonio 4 (Unknown area)	—
San Antonio 5 (Unknown area)	—
Waco (District)	—
Wichita Falls (District)	Rural districts usually have very limited funding, and therefore limited choices for rehabilitation.
Yoakum (District)	—

Table D.21. Other general comments (Question D)

District	**Comments**
Abilene 1 (District)	In our district ADTs are low, and most highways are rural. We have good subgrade and good flexible base.
Abilene 2 (Big Spring area)	—
Abilene 3 (Snyder area)	—
Abilene 4 (Hamlin area)	—
Abilene 5 (Abilene area)	—
Amarillo (District)	—
Atlanta (District)	—
Austin (District)	Pavement selection in the Austin district is done on a case-by-case basis using sound engineering judgment and good business practices.
Beaumont 1 (Unknown area)	—
Beaumont 2 (Beaumont area)	—
Brownwood 1 (District)	Good simple and comprehensive questionnaire.
Brownwood 2 (Lampasas area)	—
Childress (District)	—
Corpus Christi 1 (District)	For bridge overpass we may use Type A Grade 1 base (limestone base untreated) in lieu of stabilized base. This is due to relatively small base quantities.
Corpus Christi 2 (Karnes area)	—
Corpus Christi 3 (Cor. Ch. area)	—
Dallas District 1 (District)	—
Dallas 2 (Dallas Proj. Off.)	—
Dallas 3 (Ellis area)	—
El Paso (District)	It would be real hard to come up with a policy to dictate pavement type selection. Too many variables to consider.
Fort Worth (District)	We are moving more towards rehabilitation than new pavement construction.
Houston 1 (District Pav. Engr.)	—
Houston 2 (District Des. Engr.)	—
Houston 3 (Brazoria area)	—
Houston 4 (Conroe area)	—
Houston 5 (E. Harris area)	—

Houston 6 (Fort Bend area)	—
Houston 7 (Cent. Houston area)	—
Laredo (District)	—
Lubbock (District)	TxDOT requires that each district have a pavement design engineer who must review each pavement design and submit a report to the Austin office for consideration. There is a published pavement design report guideline that you should read.
Lufkin 1 (District)	—
Lufkin 2 (San Augustine area)	Base design is primarily driven by strength of subgrade and traffic volumes.
Lufkin 3 (Livingston area)	—
Odessa (District)	—
Paris 1 (Sulphur Springs area)	—
Paris 2 (Greenville area)	—
Paris 3 (Sherman area)	—
Pharr (District)	We have some old concrete roads that have been overlaid with ACP. These were counted as ACP with treated base because it was not considered as a pavement type.
San Angelo (District)	—
San Antonio 1 (District)	—
San Antonio 2 (Floresville area)	—
San Antonio 3 (Unknown area)	—
San Antonio 4 (Unknown area)	—
San Antonio 5 (Unknown area)	—
Waco (District)	—
Wichita Falls (District)	—
Yoakum (District)	This survey was not distributed to anyone else in this district. Historical aspects, in my opinion, seem to have the strongest effect on pavement type selection.