Transportation Synthesis Report

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Pavement Service Life – rev. 2

Prepared for
Bureau of Highway Construction
Division of Transportation Infrastructure Development

Prepared by
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WisDOT RD&T Program
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Transportation Synthesis Reports (TSRs) are brief summaries of currently available information on topics of interest to WisDOT technical staff in highway development, construction and operations. Online and print sources include NCHRP and other TRB programs, AASHTO, the research and practices of other state DOTs, and related academic and industry research. Internet hyperlinks in TSRs are active at the time of publication, but changes on the host server can make them obsolete.

REQUEST FOR REPORT

WisDOT's Bureau of Highway Construction is working on a study of pavement service life. The RD&T Program was asked to look at ways in which service life is defined and understood in other state transportation agencies, particularly neighboring states with climates similar to Wisconsin, and with an eye cast specifically at parameters of time, traffic or truck loads, pavement types, and condition indicator threshold levels.

SUMMARY

We were unable to identify a detailed report by a state or federal agency on the real service lives of pavements in any region. However, there have been various efforts around the country to mine pavement management or historical data for average real pavement service life figures, often broken down into broad categories of flexible or bituminous pavements and rigid or concrete cement pavements.

Rather than focusing on detailed actual service life figures, however, most of this work focuses on adapting averages for use in determining design life or life cycle cost analysis (LCCA) projections. We were unable to find an agency that is working on a sophisticated data collection of actual pavement service lives for any but a few years.

Because of this lack of real service life studies, we surveyed AASHTO Research Advisory Committee members around the country. Survey responses indicated that service life typically is understood as a measure in years from construction to first rehabilitation or overlay, and as no verifiable actual (rather than estimated) service life tracking has been conducted for periods of 20 or more years, this necessarily entails calculations and estimates. Occasionally service life may be measured merely in terms of performance indicators or condition indices, but rarely in traffic loading terms such as ESALs or any other measure.

In this report, we will look first at the survey results, then at specific states, starting with those with climates similar to Wisconsin, and moving then to other states. We also look briefly at Australian research and at work reported by the American Concrete Pavement Association and the Asphalt Pavement Alliance. In each of these sections we highlight definitions of service life and the pavement type categories to which the agency applies the term.

RAC SURVEY – Attachment A

RAC members were asked by Nina McLawhorn, WisDOT's Research Administrator, to indicate how they define or understand the term "pavement service life," in what categories of pavement types it is tracked or defined, and if they could provide reports describing service lives of various pavement types. Answers were accepted through August 6, 2004.

Fourteen states responded – including from New Mexico a separate project level management program response (New Mexico-1) and a design response (New Mexico-II) – as well as the Canadian province of British Columbia.

Only two of these respondents were upper Midwest states – Iowa and Minnesota. Of all these respondents, only Minnesota tracks real service life data. MnDOT measures service life in terms of Present Serviceability Rating – pavement service life is the number of years until it reaches a PSR of 2.5, signifying need for rehabilitation – and it measures the PSR of every mile of pavement in the system each year. Every other respondent transportation agency that speaks or writes of pavement service life does so in terms of design life or life cycle cost analysis for pavement type selection purposes.

Service Life. While a few states define service life in multiple terms, the most common definition (for six states) of service life was number of years from initial construction to the first rehabilitation work, or from last completed work to next. Next most common was to define service life in terms of performance or serviceability indices (four states). A few states define service life as years to failure, though failure can be a serviceability threshold value, the next major rehabilitation, or full reconstruction. Only New Mexico used ESALs as a factor in service life definitions.

Pavement Type Categories. Most states tracked or defined service life in the simplest categories of asphalt concrete or flexible pavement, and cement concrete or rigid pavement. British Columbia uses only asphalt for roads and highways, and Rhode Island uses asphalt or asphalt overlays/composites almost exclusively. Only Iowa, Mississippi, Missouri, and South Dakota categorize service life or pavement condition along more than the simple lines of asphalt versus concrete. South Dakota's is the most sophisticated, using deterioration curves in pavement management and design for several varieties of each pavement family – thin asphalt on thin base, thick asphalt on thin base, short-jointed PCC, long-jointed PCC, etc.

MINNESOTA – Attachment B

We refer to three documents for Minnesota – the RAC Survey, the Pavement Type Selection/LCCA Report, and the MAPA Report. For the latter, MnDOT and the Minnesota Asphalt Pavement Association commissioned ERES Consultants to compare service lives of asphalt pavements on aggregate bases to Portland cement concrete pavements in Minnesota. Analysis of pavement management system data concluded that the two materials offer similar service lives. It also concluded that full-depth HMA outlasted granular base HMA. See RAC Survey, Attachment A; Minnesota PavementType/LCCA, Attachment B; and MAPA summary at http://www.asphaltisbest.com/PDFs/4%20Page%20Color%20Flyer.pdf.

Service Life. In the RAC Survey, service life is the measure in years until pavement reaches a Present Serviceability Index of 2.5. In the Pavement Type Selection Report, service life is an LCCA measure of years until first overlay; however, "historical" service life averages are also reported as, with bituminous pavements, years from construction to first overlay, then from one overlay to another or to end of life, and with concrete pavements, years from construction to first joint repair, then from one joint repair to another or to end of life. In the MAPA report, the term means time to first rehabilitation.

Pavement Type Categories. The RAC Survey notes that MnDOT uses PSR as a measure for each one-mile pavement segment. In the Pavement Type Selection/LCCA Report, the three categories are concrete of all traffic loads, bituminous pavements with BESALs (bituminous ESALs) of less than 7 million, and bituminous pavements with BESALs of 7 million or more; however, the historical service lives (see attachment, p. 9) are categorized only by bituminous or concrete pavements, according to subcategories described above. In the MAPA report, the only pavement types considered were asphalt pavement on aggregate bases, Portland cement concrete pavements, and (tangentially) full-depth HMA.

MARYLAND Attachment C

MDSHA draws service life data from historical records of 1950 and since. The data is used in the pavement management system, but records of the service life of specific sections of roadway are not published. Standard deviation and lane-miles of each category are offered in the attachment, as well. See attached Maryland Service Lives document, also referenced in RAC Survey.

Service Life. The data is expressed in years, a measure of time from construction to first rehabilitation, and also time from one rehabilitation to the next or to end of functional life.

Pavement Type Categories. Rigid and flexible pavements are the only categories of pavement type.

VERMONT
As part of a 1999 statewide study of pavement life – see http://www.aot.state.vt.us/matres/RandD/rd.htm – Vermont has developed a map of state roadways designated by construction year (back to 1983) and indicating, where applicable, that the roadway has reached the end of its service life. See http://www.aot.state.vt.us/matres/RandD/pavemap.htm.

Service Life, the term, and **Pavement Type Categories** were not defined.

MISSOURI
Design lives are based on a review of historical survival and performance data for pavement treatments, and of full-depth HMA and PCC pavement survival data from MoDOT's pavement management database. Historical data on pavement treatments provides little on unbonded PCC overlays, diamond grinding, and full-depth HMA.

See "Pavement Design and Type Selection Process, Phase I Report," specifically pp. 21-23, at http://www.modot.mo.gov/newsandinfo/documents/PavementSelectionProcess_Phase1Report_0204.pdf.

Service Life. On Table 5, p. 23, LCCA design period treatments presented are historical performance averages of the number of years from construction to first rehabilitation, and from construction to second rehabilitation. In Table 6, p. 23, service life is presented in terms of weighted averages from historical data of the number of years from time of construction to first overlay, and from first overlay until second overlay, and second through end of life or reconstruction.

Pavement Type Categories. Service lives in the Tables are expressed in four categories for Table 5 – new full-depth HMA, new jointed plain concrete, conventional HMA overlay, and unbonded jointed plain overlay – and in Table 6 in three categories – jointed plain, and jointed reinforced concrete pavements, and HMA. The latter category entails conventional HMA and the small amount each of Superpave HMA and stone matrix asphalt overlays MoDOT has used over the years since 1958.

FLORIDA
In an effort to develop accurate estimates for flexible pavement life, FDOT surveyed historical data of hundreds of segments of flexible pavement. The only data provided in this 1998 study was weighted averages created with polynomial regression analyses. Data used was based on historical records and data from 1976 and since, and the focus was only on flexible pavement. See summary (full report unavailable) at http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_RD/FDOT_670.pdf.

Service Life. FDOT uses the term "pavement performance life" to mean length of service life in years from date of construction until maintenance or rehabilitation.

Pavement Type Categories. Though real service life data may have been used for calculation, this document provides projected service lives of flexible pavement broken into categories for primary state roadways and interstates, each further broken down into new construction, reconstruction, and resurfacing subcategories, with data for mean, minimum, and maximum service life projections. Researchers present pavement performance life for flexible pavement according to geographical region, highway system type, and project type. Only 279 of the 7,203 segments were flexible pavements used in this study; presumably, data for other pavement types was available.

OHIO
Spurred by concrete industry allegations of favoritism toward asphalt contractors, ODOT's Pavement Selection Advisory Council commissioned a study by ERES Consultants to evaluate pavement selection of all pavement types in the state. See the final report from December 2003, "Neutral Third Party Ohio Pavement Selection Process Analysis," http://www.ohiopavementselection.org/psac/20031212_ntp_final_report.pdf.

- **Service Life.** Though the term is used 19 times in discussions of LCCA and design life in the 189-page document, and is not defined, it variously refers to the time in years from construction to failure, or to first rehabilitation or overlay. In the LCCA data reviewed from other states, design lives are considered in terms of years from original construction to first overlay, and years from original construction to second overlay (Table 3, p. 17).
- **Pavement Type Categories.** The impetus for the report, no doubt, forces broad categorization of pavement into HMA or PCC. However, researchers typically consider periods for first and second overlays over both types, as in Table 3, referenced above.

WASHINGTON STATE

WSDOT commissioned three studies of long-lasting asphalt pavements, and 1999 data from WSDOT's pavement management system was studied to assess pavement durability in years. The interest in pavement life again focuses on LCCA and design life. See a summary of the research in "Study of Long-Lasting Pavements in Washington State" (pp. 88-95), a bookmarked section in *Transportation Research Circular 503: Perpetual Bituminous Pavements*, http://gulliver.trb.org/publications/circulars/circular_503.pdf.

- **Service Life.** Researchers do not use the term, but they measure performance in terms of years from first construction to the time of evaluation, to the time of first resurfacing, and they report on the age in years of the current wearing courses that obtain (pp. 90-94).
- **Pavement Category Types.** The studies break the pavements down into three categories: flexible, cement-treated base with asphalt wearing course, and PCC pavements (p. 89). Summaries of data separate information according to geography/climate, as well as to physical characteristics that include original thickness, ride index, and rut depth (Tables 1-6, pp.90-94).

AUSTRALIA

Austroads draws from historical assessments in estimating pavement life. Currently, data does not support efforts to compare design and functional lives of pavements – see §5.2.1, p. 26 – although Austroads' Long Term Pavement Project research will attempt to correlate design to functional life – see §5.2.2, p. 26. See "Remaining Life of Road Infrastructure Assets: An Overview (AP-R235)," http://203.42.45.20/mall/austroads_v2/pdfs/537_AP-R235.pdf.

Service Life. Defined on pp. 3-4 as the assumed life of pavement, based on historical assessment. Austroads uses the term in calculating "economic-based depreciation" of infrastructure assets.

Pavement Type Categories. See Table I, p. 5. Age-based methods of uncertain variety were used in estimating service lives in terms of depreciation. Figures offered vary between each Austroads region (district), and between pavement types including concrete, asphalt, spray sealed, unsealed, and re-surfaced.

AMERICAN CONCRETE PAVEMENT ASSOCIATION

ACPA features a variety of informational pieces on concrete pavement life from its Web site. See the State Practices Pages, http://www.pavement.com/PavTech/Tech/StPract/Query.asp.

Wisconsin, Minnesota, et al. A 1994 American Concrete Institute paper – "Pavement Costs and Quality" – claims to present actual service life data from FHWA in the years 1985 and 1971, and from Wisconsin, Minnesota, Kentucky, New York, and Colorado. Concrete life values range from as low as 13 years to as high as 35; asphalt ranges from six to 20. Many include the caveat that if drained, the pavement lasts 25 percent longer. Life-cycle costs and rehabilitation costs also are presented. See paper reprint, http://www.pavement.com/Downloads/RP329P.pdf.

- **Service Life** here is defined as time in years until first resurfacing. Data shown is averages of "heavy-duty" highways.
- **Pavement Type Categories** include only asphalt and concrete, with overlays considered and drained pavements also distinguished nominally.

Tennessee. Another ERES Consultants study, this for TnDOT in 2000, compares the service life, life-cycle cost, and benefit-cost ratio of jointed plain concrete pavement (non-doweled) with asphalt concrete pavement, both on an 88-mile stretch of Interstate 40. Data includes costs, historical rehabilitation records, and original pavement information from TNDOT. Constructed between 1961 and 1964, 56 percent was jointed plain concrete pavement and 44 percent was asphalt concrete pavement. Two survival analyses, including one with rehabilitation information, concluded that JPCP had an average pavement life – time from original construction to first overlay, crack-and-seat, or restoration – of over twice that of ACP. This summary is provided by the American Concrete Pavement Association. See http://www.iowaconcretepaving.org/ACPA%20Publications/sr991p.pdf. (Long load time; also available for purchase on the ACPA Order Products Web page at http://www.pavement.com/ecommerce/main.html. Search by Product Code for "sr991".)

- **Service Life** is expressed in the number of years between construction and failure. Failure is years until first overlay or restoration.
- **Pavement Type Categories** include only jointed plain concrete pavement and asphalt concrete pavement.

ASPHALT PAVEMENT ALLIANCE

The APA offers papers that incidentally address or refer to pavement service lives. These follow the trends previously noted by couching such references in the larger context of design lives LCCA performance projections. See the APA Resources page and submenus, http://www.asphaltalliance.com/library.asp?MENU=8.

Pavement Type Selection Processes. A position paper on asphalt selection, the document references some of the work we explore above, referring to performance lives – See http://www.asphaltalliance.com/upload/Pavement%20Type%20Selection%20Processes.pdf. (The paper seems to draw data from, in part, "AP101: Perpetual Pavements, a Synthesis" http://www.asphaltalliance.com/upload/APA101.pdf.) Points of interest include:

- While not referring to **Service Life**, the paper suggests the concept of pavement performance life as a definition of years from construction until structural rehabilitation; resurfacing is assumed in performance lives (pp. 4-5).
- The paper recommends pavement performance life projections for HMA in **Pavement Type Categories** of HMA less than eight inches thick, and HMA greater than eight inches thick (pp. 4-5).
- Recommendation that states use a performance life analysis period of at least 40 years. The paper refers to eight states that track pavement life over periods of decades. These periods range from 30 years to a high of 50 years used by Wisconsin (pp. 7-8).
- Draws from studies of asphalt pavement performance average lives for asphalt pavement from construction to first overlay, and first overlay to second (see p. 8, and References, p. 14, especially nos. 6-12).

Kansas. In a paper on LCCA of rural Interstates in Kansas, researchers at the University of Kansas examined historical cost and performance data in order to hone effective LCCA inputs. See "Executive Summary: Evaluation of Expenditures on Rural Interstate Pavements in Kansas" – http://www.asphaltalliance.com/upload/Kansas_Cost_Study_4-02.pdf – especially pp. 28-37.

- **Service Life** is number of years from original construction until major treatment – reconstruction or rehabilitation – becomes necessary; see p. 28.
- **Pavement Type Categories** include HMA and PCC (see Figure 13, p. 30). Performance history curves break down the two types into subcategories that include miles in service without reconstruction or rehabilitation (Figure 13), miles in service without HMA overlay (Figure 14, p. 32), and miles in service without minor maintenance (sealing, patching, etc., Figure 15, p. 34).

KDOT Response. Kansas DOT objected strenuously to the study's methodology, conclusions, and implications for LCCA and pavement type selection, though did not speak directly to matters of actual pavement service life. Objections focused on the comparative value of the study's assessments, which KDOT viewed as biased toward asphalt through skewed sample sizes and disregard for environmental and design forces that bear on pavement type selection. See KDOT Response Letter at http://www.moksacpa.com/seminars.htm under Documents.

- A statement on the first page of the KDOT letter qualifies the value of historical data as the basis of service life projection and underlines the reason for WisDOT's interest in actual performance life data rather than estimates.

  "Past performance and costs are of little value considering the significant changes that have occurred in both the rigid and flexible paving industries. Both paving industries have instituted QC/QA procedures, new specifications have been developed to obtain better quality of materials, and mix design procedures have been made in recent years that will effect performance. Past performance is not indicative of future performance when material properties and construction processes have changed. The findings of the report can not necessarily be used to make judgements about future performance and therefore at best is information about past practice."

Attachment A: Survey of AASHTO RAC Listerv August 12, 2004
Transportation Synthesis Report on Pavement Service Life
Wisconsin Department of Transportation RD&T Program

	State Prov.	Contact	How do you define service life for concrete and asphalt pavements?	Have you determined actual service life as it relates specifically to each pavement type -- e.g. conventional asphalt concrete (CAC Type I), jointed plain concrete with dowels (JPC Type 8), etc.?	Can you provide us with a report documenting this information?
1	BC	Mike Oliver, B.C.Ministry of Transp Mike.Oliver@gems6.gov.bc.ca	Service Life - years until end-of-life rehabilitation. We get approx. 15 to 20 years out of an asphalt pavement, dependent on traffic and environment. (Design life is 20 years.) End of life occurs with an overlay or mill-and-fill, or hot in-place recycling. Pavement condition indices are used, but not as rehabilitation triggers.	No. B.C. uses only asphalt for roads and highways.	No
2	AR	Mark Evans, ASHTD Mark.Evans@arkansashighways.com	Service Life - overall condition or structural adequacy of the pavement structure. In asphalt, indicators include excessive rutting, fatigue cracking, excessive cracking. In concrete, indicators entail excessive faulting and cracking, and pavement texture. Overall capacity and user-safety can also affect service assessments.	No - that's one of our Pavement Management Group's goals.	No.
3	FL	Bruce Dietrich, FLDOT bruce.dietrich@dot.state.fl.us	Service Life - typical time between rehabilitation projects.	Actual performance vaires widely. For LCCA, we use 20 years for jointed plain concrete pavement life, with rehab intervals of 10 years thereafter. For flexible pavement, we use 14-year rehab intervals.	No. Each district reviews latest data on pavement performance via on-line reports from our unpublished Pavement Management database.
4	IA	Michael Heitzman, IADOT Michael.Heitzman@dot.iowa.gov	Not defined, per se. Pavements assessed PCI on 100-point scale; below 40 requires major rehabilitation or reconstruction.	PCI assessed for four categories: PJCP, CRCP, composite, HMA; each PCI category entails specific, sometimes unique, equation variables.	No.
5	KS	Dick McReynolds, KDOT Dick@ksdot.org	Service Life - period in which pavement structure can be effectively and economically rehabilitated and kept in service.	The practical service life for HMA and PCC is 50 years. The actual service life can be shortened by the need for geometric improvements to the roadway. Actual service life can also be affected by funding levels.	No.
6	MD	Timothy Smith, MDSHA tsmith2@sha.state.md.us	Service Life - length of time until first rehabilitation. Rehabs are overlays or major repair that improves structural capacity; after rehab, pavement begins a new service life. Preventive or reactive treatments that add no structure -- such as patching, crack sealing, diamond grinding -- do not end service life. Reconstruction is rare, reserved for re-alignments, traffic volume improvements, utility improvements and such.	Pavement Management System determined HMA pavements have approximate initial service lives of 15 years, and PCC 24 years. (All PCC pavements grouped together because less than 2% of state lane miles are exposed PCC.) PCI equations recalibrated every 7 to 10 years based on comparisons of panel assessments with computed PCI.	No. See the report -- summarized in the TSR -- on pavement type selection that includes data on service life for LCCA, Attachment C.
7	MN	David Janisch, MNDOT Dave.Janisch@dot.state.mn.us	Service life - the time, in years, until pavement reaches a Present Servicability Rating (PSR) of 2.5.	Each section has it's own service life; each state mile is measured for PSR annually, which allows for predicition of remaining life. Rehabilitation practices obscure actual service life data because rehab is often conducted before paving reaches 2.5 PSR, and also for non-structural reasons such as capacity, safety, etc. Design life is 20 years for new asphalt, and 35 years for new concrete.	See Pavement Type Selection/LCCA report, Attachment B.
8	MS	Randy Battey, MDOT randyb@mdot.state.ms.us	Service Life - for design purposes, defined in years (*Editor's note:* from construction until overlay, or from overlay to next overlay or end-of-life.)	Service Life (Design) - rigid pavements (new design is jointed with dowels), 35 years; flexible rural pavement (Superpave with polymer modification), 10 years; flexible urban pavement (Superpave with polymer modification), 20 years	See Design Lives report, Attachment D.
9	MO	John Donahue, MoDOT John.Donahue@modot.mo.gov	Service Life - used interchangeably with Design Life - JPCP and deep-strength HMA only new pavements used; anticipate 45 years with interim maintenance and rehabilitation.	Only began using JPCP in 1993, so no data. Older, thinner JRCP, provided an average of 25 years service life before requiring rehabilitation. Full-depth HMA provided 15-18 years acceptable service. HMA overlays had a 10-year average service life.	See Pavement Team report, http://www.modot.mo.gov/newsandinfo/PavementTypeSelection.htm.

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	State Prov.	Contact	How do you define service life for concrete and asphalt pavements?	Have you determined actual service life as it relates specifically to each pavement type -- e.g. conventional asphalt concrete (CAC Type I), jointed plain concrete with dowels (JPC Type 8), etc.?	Can you provide us with a report documenting this information?
10	NM	Robert Young, NMSHTD Robert.Young@nmshtd.state.nm.us	Service Life - in the Project Level Management Program, service life is defined as the time from when a section of pavement first enters service to the point its condition is such that the useful performance period has ended. We use 5 performance indices for asphalt pavement, and 4 others for rigid.	Pavement's useful performance life ends when it reaches a Remaining Service Life Threshhold value. Once the PI's reach 35, they've reached the RSL Threshold value. The time it takes to reach the RSL Threshold varies with environment, traffic and loading.	No.
11	NM-II	David Catanach, NMSHTD David.Catanach@nmshtd.state.nm.us	Service Life - in Design, we estimate number of cumulative ESAL's for the design years in question via design serviceability index of 2.5 for high-volume, 2.0 for low. Rehabs designed for 10-year ESAL projections; new construction for 20-year.	We've just begun gathering data.	No.
12	NY	Gary Frederick, NYDOT GFREDERICK@dot.state.ny.us	Service Life - length of time a treatment is effective, or life of pavement or overlay until rehabilitation required. When rehab required, a pavement is scored a 5 on a scale of 10.	Each of 11 DOT regions modifies anticipated service life estimates according to their experience with climate, geological characteristics, and traffic.	No.
13	RI	Paul Petsching, RIDOT ppetsch@DOT.STATE.RI.US	Service Life (or Performance Period) - time between successive reconstructions.	No. We use flexible pavements, and composite pavements, with few rigid pavements in the state. Service life varies with traffic loading, pavement structure, variation in structure through rehab and maintenance, etc. Maintenance and rehabilitation extend life significantly.	No .
14	SD	Dave Huft, SDDOT Dave.Huft@state.sd.us	We don't use this concept.	SD employs extensive set of deterioration curves for several families of rigid and flexible pavements (thin asphalt on thin base, thick asphalt on thin base, short-jointed PCC, etc.); this defines the relationship of the expected level of individual distresses (rutting, roughness, faulting, etc.) with time.	See Pavement Management Group System document - http://www.sddot.com/pe/planning/docs/Synopsis2003.pdf. (*Editor's note:* This document mentions only on p.4 "service life" which could be extrapolated from PSR data.)
15	UT	Lloyd Neeley, UTDOT lneeley@utah.gov	Utah uses three terms regarding pavement life. **Remaining Service Life** - estimated no. of years from any given date (usually last survey date) for a pavement section to accumulate distress points equal to threshold value (pavement distress value beyond which pavement considered failed). **Design Life** - Planned no. of years from construction to structural failure from fatigue. For flexible pavement, we design for 20 years; for rigid, 40. **Pavement Life** - Number of years from original construction to complete reconstruction; we use a "pavement life strategy" for each family of pavements, recognizing pavement life may extend well beyond design life and may require multiple rehabilitation treatments over lifetime.	No. Utah has established threshold values and performance curves pertinent to various families of pavements for Pavement Management System. We do not calculate remaining service life on section-by-section basis.	No.
16	VA	Brian Diefenderfer, VaDOT Brian.Diefenderfer@VirginiaDOT.org	Service Life - VaDOT currently uses a combination index of pavement age and visual rating of surface distresses, load-related and not. VaDOT anticipates moving to an automated measure of structural adequacy .	No - that's one of our Pavement Management Group's goals.	VaDOT keeps annual records of visual ratings of surface distresses for asphalt pavements on interstates and primary roadway systems, but only for past 3 years; concrete and secondary system pavements have only 1 year of annual ratings.

Pavement Type Determination Task Force Final Report

Report #: MnDOT/OM-PM--2003-01

FINAL REPORT

Technical Report Documentation Page

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16. Abstract (Limit: 200 words)

This report documents the work of the "Pavement Type Determination Task Force" in reviewing the Mn/DOT "Pavement Selection" process. The terms *Pavement Type Determination* and *Pavement Selection* are identical and refer to the process/procedures used to select the most cost- effective pavement type (asphalt or concrete) on new or reconstruction projects on the trunk highway system.

The objective of the Task Force review was to evaluate the current Mn/DOT pavement selection process and make recommendations based on analysis of available data and best engineering judgment. The thirteen member interdisciplinary task force met seven times and made recommendations for change including: use a 50-year economic analysis period, use a five-year average of the 30-year real discount rate issued by OMB, include preventative maintenance costs, and develop user cost data for analysis.

17. Document Analysis/Descriptors Pavement Type Determination Pavement Selection Economic Analysis Discount Rate		18. Availability Statement	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 50	22. Price

Table of Contents

Recommendations

The Task Force makes the following recommendations to Douglas H. Differt, Deputy Commissioner/Chief Engineer for approval and implementation. The recommendations are categorized as short-term and long-term.

Short-Term Issues

The Task Force recommends the following be implemented as soon as practical. Implementation of the recommendations will be accomplished through a Technical Memorandum.

1. Discount Rate
   The discount rate to be used will be the Real Treasury Interest Rate on a 30-year Treasury Bond, forecast by the U.S. Office of Management and Budget (OMB). A five-year rolling average will be used, updated annually when the OMB forecast is issued, around February/March.

2. Salvage Value
   Continue the current practice of not including the value of any salvage materials at the end of the economic analysis period.

3. Use of Recycled Materials
   Continue the current practice of using available in-place bituminous and concrete pavement materials to determine recycled pavement costs for reconstruction projects.

4. Flexibility
   The pavement type identified as the low-cost option, based on the detailed cost estimate, will be the type utilized, regardless of how close the outcomes are. Districts may request a new cost estimate be done if an error is discovered or additional information becomes available. While it is expected that the vast majority of projects will use the low-cost option, a variance can be requested for those rare occasions where choosing another option may be a better choice. If a variance is requested, the process begins with the District Engineer contacting the Director of the Office of Materials. Ultimately, the variance will need approval from the Deputy Commissioner/Chief Engineer

5. Formal/Informal Process
   Continue the current formal and informal practice and categories. Change the current exempt category to District Process and require those projects to have a life cycle cost analysis performed by the Districts included in the Materials Design Recommendation Memo. Remove unbonded concrete overlays from the pavement selection process (i.e. treat it as a rehabilitation).

6. Activity Timing/Life

Use the following time lines for the economic life cycle cost analysis:

Bituminous Pavement with 20-year BESALs less than 7 million	Bituminous Pavement with 20-year BESALs of 7 million or higher	Concrete Pavement (all traffic levels)
0 – Initial construction	0 – Initial construction	0 – Initial construction
6 – Rout & seal cracks	7 – Fill cracks	17 – Joint reseal & Minor CPR
10 – Surface treatment	15 – Mill & OL	27 – Minor CPR & some full depth
20 – Mill & OL	20 – Fill cracks	40 – Major CPR & grinding
23 – Rout & seal cracks	27 – Mill & OL	50 – End of Analysis (5 years of remaining service life)
27 – Surface treatment	32 – Fill cracks	
35 – Mill & OL	40 – Mill & OL	
38 – Rout & seal cracks	45 – Rout & seal cracks	
43 – Surface treatment	50 – End of Analysis (no residual value)	
50 – End of Analysis (no residual value)		

7. Activity Costs

The activity costs will be calculated using the median cost of projects, built during the last 10 years, involving the types of work outlined in the different scenarios. The projects used to determine costs will be the same ones used to determine the rehabilitation ages. Also, to account for differences in the general inflation rate and the rate experienced by the highway construction sector, the agency costs will be adjusted by the difference in the general rate, measured by the Chained Price Index for the Gross Domestic Product (GDP), and the highway construction industry, measured by the Chained Price Index for State and Local Construction (SLC) Spending. The current difference, calculated by Mn/DOT Office of Investment Management (OIM), is 0.21%. The costs and adjustment factor will be updated each year by the pavement management unit with help from the Office of Technical Support

8. Economic Analysis

Use a 50-year economic analysis period. Also, utilize remaining service life to account for alternates that do not have zero service life at the end of the analysis period.

9. Aggregate Haul Distance

Provide documentation of the current process for selecting aggregate sources and prices, haul distance, and cost estimates.

10. Premium Enhanced Designs

Continue the practice of allowing premium enhanced designs after the pavement type has been determined.

Long-Term Issues

The Task Force recommends the following need further study or evaluation and should not be used to change the pavement selection process at this time. Personnel recommended to lead the study/evaluation efforts are identified below each topic.

1. User Costs
   User costs, defined as costs incurred by the traveling public during the initial construction and subsequent maintenance and rehabilitation activities due to delays, increased vehicle operating costs and crashes (where applicable), should be calculated for each formal pavement selection performed over the next year. After this one-year period, the user costs and agency costs should then be evaluated to determine how best to implement user costs into the pavement selection process.

   Lead Person: Abbie McKenzie, Mn/DOT Office of Investment Management

2. Pavement Design
   Evaluate the standard Mn/DOT Pavement Designs after the new AASHTO Pavement Design Guide has been distributed and calibrated in Minnesota. The Guide is anticipated to be available the spring of 2004 and will require approximately one year to calibrate. After the Mn/DOT Standard Pavement Designs have been revised as a result of the new AASHTO Guide, all projects will have to go through the formal process for a period of time, which will be defined at a later date, to re-evaluate the formal/informal concept and determine what informal criteria, if any, will be used.

   Lead Person: Dave Van Deusen, Mn/DOT Office of Materials

3. Estimating Cost of Materials
   The process for estimating costs, including aggregate source selections, recycled materials, and salvage value should be further investigated. The feasibility of using "regional average costs" for aggregates and other alternative methods should be investigated.

   Lead Person: Nancy Sannes, Mn/DOT Office of Technical Support

4. Task Force Future Activities
   March 2004: 6-month status report on long-term studies.
   September 2004: Completion of most long-term studies and 12-month status report.

Communications

The results of this task force review and any resulting changes to the Mn/DOT Pavement Selection process should be communicated to all interested parties, including federal, state, county and city public agencies and the Minnesota paving and aggregate industries. The Mn/DOT Office of Materials will be responsible for initiating these communications.

Introduction

This report documents the work of the "Pavement Type Determination Task Force" in reviewing the Mn/DOT "Pavement Selection" process. The terms *Pavement Type Determination* and *Pavement Selection* are identical and refer to the process/procedures used to select the most cost-effective pavement type (asphalt or concrete) on new or reconstruction projects on the trunk highway system. Ideally, the pavement type selected is the product of the most favorable combination of economic and engineering factors expressed in terms of the lowest annual cost per mile. Inherent difficulties include the need to make assumptions regarding future materials and performance based on past data and history in a time of changing technology and evolving pavement designs and construction practices. The objective of the Task Force review was to evaluate the current Mn/DOT pavement selection process and make recommendations based on analysis of available data and best engineering judgment.

Background

Mn/DOT has utilized a formal pavement selection procedure since 1959. The procedure has been updated several times and reviewed in depth by task forces in 1977, 1982 and 1995. Changes in funding, traffic, technology, and economic conditions along with discussions with the concrete and asphalt industries led to the current task force review.

The current Pavement Type Determination Task Force was appointed by Douglas J. Weiszhaar, Mn/DOT Deputy Commissioner/Chief Engineer on August 23, 2002. The memo is contained in Appendix A. The task force members are:

- Richard Stehr, Chair, Mn/DOT Director of Engineering Services Division
- Robert Winter, Mn/DOT, Director of District Operations Division
- Patrick Hughes, Mn/DOT, District Engineer, Metro Division
- Keith Shannon, Mn/DOT, Director of Office of Materials (added because of restructuring)
- Nelrae Succio, Mn/DOT, District Engineer, Rochester
- Abby McKenzie, Mn/DOT, Director of Statewide Planning and Analysis Section
- Joseph N. Meade, Mn/DOT, Manager of Pavement Engineering Section
- David Van Deusen, Mn/DOT, Pavement Design Engineer
- Jeff Blue, Waseca County Engineer
- William Lohr, FHWA Division Pavement and Materials Engineer
- David Levinson, University of Minnesota, Department of Civil Engineering
- Mark Snyder, Executive Director, Concrete Paving Association of Minnesota (non-voting member)
- Dave Holt, Executive Director, Minnesota Asphalt Pavement Association, retired in the Fall of 2003 and was replaced by Richard Wolters, Executive Director, Minnesota Asphalt Pavement Association (non-voting members)

Other task force regular participants were David Janisch, Mn/DOT Pavement Management Engineer, who provided technical expert assistance and Lisa Bilotta, Mn/DOT Administrative Secretary Supervisor, who provided office and administrative support.

The charge to the Task Force was to fully evaluate the current Mn/DOT pavement selection process and make recommendations by April 1, 2003. In January of 2003 Mn/DOT went through major organizational restructuring that directly affected several task force members and the April 1 target date was relaxed to accommodate the restructuring.

Review Process

The Task Force met seven times from November 2002 through July 2003. During that time they reviewed the history of the Mn/DOT pavement selection process including previous technical memorandums and reports from previous task forces. They solicited issues from Mn/DOT personnel and the concrete and asphalt paving industries. The Task Force also heard formal presentations from the Minnesota Asphalt Paving Association and the Concrete Paving Association of Minnesota. A facilitated brainstorming and categorization session was used to group issues into common topic areas. The nine topic areas were assigned to subcommittees for evaluation and recommendation. The subcommittees held meetings and reported recommendations to the Task Force. Subcommittee reports/meeting minutes are contained in Appendix B.

The Task Force used data from Mn/DOT's Pavement Management System (PMS) and from experienced Mn/DOT pavement engineers when deciding when certain activities should be performed. The pavement management unit ran several queries on the data to determine the average and median ages when bituminous pavements received their first, second and third overlays and when concrete pavements received their first, second and third joint rehabilitation.

As a check, the Task Force also considered the information contained in pavement performance reports produced by ERES Consultants and sponsored by the Minnesota Asphalt Pavement Association. The ERES reports are based on data obtained from the Mn/DOT Office of Materials, Pavement Management Unit. Although the raw data used for the reports was identical to that used by Mn/DOT Pavement Management, the slightly different definitions and assumptions used by ERES resulted in some different pavement and rehab lives than the Mn/DOT analysis.

The Task Force discussed the subcommittee evaluations and recommendations and then developed recommendations through the consensus process. (The non-voting concrete and asphalt industry representatives were not included in the consensus process.)

The Task Force issues and recommendations are categorized as short-term and long-term: short-term being recommendations that can be implemented now, long-term being recommendations that need further study or should be evaluated with the new AASHTO Pavement Design Guide. This Guide is anticipated to be released this fall and will require approximately one year to calibrate.

Summary of Conclusions

The following Task Force discussion summaries, conclusions and recommendations are organized to align with the subcommittees' issues. Individual subcommittee meeting minutes/reports are contained in Appendix B. The following summaries are also divided into short-term and long-term categories as defined in the Review Process section of this report.

Discount Rate

It is important to use the discount rate to reflect the opportunity cost of capital to the public. A real discount rate, rather than a nominal discount rate is to be used. This eliminates the need to use inflation forecasts to inflate the construction costs and economic values used for road user benefits.

Short-Term
The discount rate to be used will be the Real Treasury Interest Rate on a 30-year Treasury Bond, forecast by the U.S. Office of Management and Budget (OMB). A five-year rolling average will be used, updated annually when the OMB forecast is issued, around February/March. For the year 2003, the five-year average is 3.5%.

Salvage Value

The current process does not consider the salvage value of pavement materials at the end of the pavement life. Although a complete economic cost model would include salvage value, the Task Force consensus is that the salvage value should not be considered because the value/use of the materials 50 years in the future is unknown and the present value of any reasonable salvage value is relatively small. In addition, the economic value of the salvage material will likely be reflected in the bid price for the next reconstruction activity.

Short-Term
Continue the current practice of not including salvage value in the economic analysis.

Use of Recycled Materials

Recycled materials are currently considered in the pavement selection process for both bituminous and concrete pavements. In the District's pavement selection submittal, information on in-place bituminous content based on extraction test results is reported. This is used by Mn/DOT's Estimating Unit to determine the available binder when the mix is recycled at the maximum percentage currently allowed by the specifications. The suitability of in-place concrete for recycling is discussed between District Materials and Office of Materials personnel and a recommendation is made to Estimating Unit.

Recycled materials for base and granular, obtained either by crushing in-place bituminous or concrete surfacing materials, or utilizing in-place aggregate base or granular, are not currently considered. It is realized that this practice is fairly common, especially in the metropolitan area.

The group felt that this was a low priority modification to the process because: 1) recycling is not mandatory (contractor's option) and 2) we do not currently have specific data on usage by District. However, this issue should be investigated over the long-term in conjunction with the aggregate/estimating issues.

Short-Term
Continue the current practice of using available in-place bituminous and concrete materials to determine the cost of designs using recycled pavement.

Long-Term
Investigate the feasibility of incorporating salvaged aggregate into the cost estimate for pavement selection projects.

Flexibility

In the pavement selection process, flexibility refers to the course of action available to the districts if they would prefer a pavement type other than the low-cost option. Currently, the district may request a meeting of the Pavement Selection Committee and present its case for choosing a surface type other than the one with the lowest life-cycle cost. Historically, the trend has been to abide by the low-cost option, regardless of how close the options are. Of the 95 formal pavement selections done from 1990 to 2000, only one project was allowed to use a surface other than the low-cost option.

Short-Term
The pavement selection technical memorandum will be modified to state that the pavement type identified as the low-cost option, based on the life-cycle cost analysis, will be the one used on all projects that go through the formal pavement selection process. Districts may request a new cost estimate be done if an error is discovered or additional information becomes available. While it is expected that the vast majority of projects will use the low-cost option, a variance can be requested for those rare occasions where choosing another option may be a better choice. If a variance is requested, the process begins with the District Engineer contacting the Director of the Office of Materials. Ultimately, the variance will need approval from the Deputy Commissioner/Chief Engineer

Formal/Informal Process

The recommended pavement selection process has three categories that new or reconstruction projects can fall into: District, Informal and Formal.

District Process (formerly called Exempt)

Projects on 2-lane roads less than 2 miles long or multi-lane roads less than 30,000 sq.yds were formerly exempt from the pavement selection process entirely. Technical memorandum 01-22-MRR-07, dated August 6, 2001 states that the District can use whatever pavement surface type it deems most appropriate. The committee felt having an exempt category implied that no cost analysis was required, which is incorrect. As a result, the "Exempt Category" will be renamed

the "District Process." This process will require an informal life-cycle cost analysis by District personnel be included with the materials design recommendation letter when it is submitted to the Pavement Office, as is required in the Mn/DOT Pavement Manual for rehabilitation projects. The District will not have to use the low-cost option if there is a good reason not to do so.

Informal Process

The Informal process determines the pavement type based on design parameters only, no life cycle cost analysis (LCCA) is done. The Informal process was originally established in 1995 as a result of a study of Formal pavement selections done from 1990 to 1994. It was found that nearly all projects with 7-million-or-more 20-year Bituminous Equivalent Standard Axle Loads (BESALs) resulted in the low-cost option being concrete, while those with less than 7-million 20-year BESALs and a subgrade R-value greater than 40 resulted in the low-cost option being bituminous. As a result, the pavement type for any project meeting either of these two criteria is automatically determined, with no LCCA required.

These criteria were used from 1995 to 2001. In 2001, the ESAL boundary used for Informal concrete projects was moved from 7-million to 10-million 20-year BESALs. At this time there is no data to indicate that the current limits should be changed. However, this issue will need to be revisited once all of the other changes have been made to the pavement selection process. In particular, the implementation of the new AASHTO Pavement Design Guide will initially require all projects to go through the Formal process. This will provide a new database for evaluating the appropriateness of having an Informal category and determining the criteria for the different boundaries.

Formal Process

All other projects must go through the Formal process of having the Mn/DOT Estimating Unit do a detailed life-cycle cost analysis to determine the pavement type with the lowest Equivalent Uniform Annual Cost (EUAC) per mile.

<u>Short-Term</u>
Revise the technical memorandum to explain that all new or reconstruction projects must go through the pavement selection process, i.e. no projects are totally exempt. Instead, they must all go through some form of pavement selection process, either District, Informal or Formal.

<u>Long-Term</u>
Once the new AASHTO Pavement Design Guide is in place there will be a period of time, undetermined at this time, when all projects will go through the Formal process. This will be done to reexamine the criteria used to determine when a Formal versus Informal selection is required. The impacts of the changes made to the discount rate, analysis period, activity timing, user costs, etc. will need to be studied. For now, the criteria for Informal pavement selection will remain the same.

Activity Timing/Life

One of the most critical items in the entire pavement selection process is establishing when each pavement type is expected to receive preventive maintenance and rehabilitation. Since neither pavement type is designed to last 50 years, except for 60-year high-performance concrete pavements, intermittent rehabilitation and maintenance is required, such as bituminous overlays, concrete joint repairs, etc.

The current process includes the cost of a bituminous overlay for bituminous pavements in year 20 and a joint reseal for concrete pavements in year 17.5. The committee felt the timing and treatments were not realistic and did not match what actually occurs in the field. As a result, a more realistic sequence of events was determined. The goal was to establish a sequence of events that would achieve a 50-year pavement life as well as recognize and give credit to new designs and materials currently being used. Four pavement experts, three current district material engineers and one former district material engineer, determined what they felt would be a logical sequence of events on a new asphalt and concrete pavement in order to make them last 50 years.

Mn/DOT's pavement management database was also queried to determine the typical ages when certain types of rehabilitation and maintenance were done. The goal was to determine the typical age when bituminous pavements receive their first, second and third overlay as well as the age when concrete pavements receive their first, second and third joint repair. The results are shown in the following tables.

Ages when bituminous pavements historically have been rehabilitated with overlays

Overlay Number	Average Age at time of Overlay	Median Age at time of Overlay
1	19 years	19 years
2	35 years	35 years
3	50 years	50 years

Ages when concrete pavements historically have been rehabilitated with joint repairs

Joint Repair Number	Average Age at time of Joint Repair	Median Age at time of Joint Repair
1	18 years	15 years
2	26 years	24 years
3	36 years	36 years

Two recent reports produced by ERES Consultants and published by the Minnesota Asphalt Pavement Association (MAPA) that looked at the performance of bituminous and concrete pavements using Mn/DOT's pavement management data were also used. The ERES report shows that, on average, bituminous roads built since 1955 last 18 years before they receive their first overlay. On the concrete side, the ERES report shows that by age 24, roughly half of the concrete roads were either overlaid or reconstructed. In addition, half of the concrete pavement received some type of major work (defined as joint repair or diamond grinding) by year 20.

Since concrete joint repairs would be an alternative to the bituminous overlays, nearly all of the concrete pavements built since 1955 were in the need of a joint repair of some kind by age 20. The proposed scenarios are consistent with these findings.

Activity Costs

The next step was to establish the approximate cost of each activity. One approach would be to establish activity costs based on some predetermined thickness for each overlay and some predetermined amount/type of joint repairs. The problem with this method is that sometimes when the first overlay is done the shoulders are also overlaid and sometimes they are left alone. Sometimes the second joint repair project on a concrete pavement involves partial depth repair and diamond grinding and sometimes it involves considerable amounts of full-depth repair. This makes choosing activity costs rather subjective.

The recommended approach is to use the median cost of projects, built during the last 10 years, involving the types of work outlined in the different scenarios. The projects used to determine costs will be the same ones used to determine the median and average rehabilitation ages listed above. For example, the cost of the first overlay will be based on the median cost of overlay projects from the last 10 years where the overlay was the first one since the road was built. The advantage of this procedure is that it is based on actual projects, some involving shoulder work, some not, some involving lots of partial depth repairs, some not. The median cost should represent the most likely expected cost for each of the planned activities. The costs will be updated annually by the Pavement Management Unit, with help from the Office of Technical Support.

The median costs reflect the costs of rehabilitating pavements that were designed and built over 20 years ago. New technology, designs, testing and quality control procedures, and preservation strategies are producing pavements that are expected to last longer and require reduced repairs. In order to recognize this fact, the historical median rehabilitation costs will be reduced by ten percent (10%) for both bituminous and concrete pavements. During the next year, Mn/DOT will explore its data and data from other states to affirm or adjust this figure.

To allow for differences in the highway construction inflation rate and the general inflation rate, the activity costs will also be adjusted by the Price Index forecast for State and Local Construction (SLC) minus the Price Index forecast for the Gross Domestic Product (GDP). The SLC inflation rate currently exceeds the GDP inflation rate by 0.21%. This will be updated annually by OIM and used to adjust the estimated project costs.

Based on these findings and subsequent discussions with the subcommittee and Mn/DOT's concrete engineer and bituminous engineer, the following is recommended:

Case 1. Bituminous Pavement with Low ESALs (20-year BESALs of 7 Million or less)

Pavement Age	Recommended Treatment
0	Initial Construction
6	Route & Seal Cracks
10	Surface Treatment
20	Mill & Overlay
23	Route & Seal Cracks
27	Surface Treatment
35	Mill & Overlay
38	Route & Seal Cracks
43	Surface Treatment
50	End of Analysis Period (no residual value)

Case 2. Bituminous Pavement with High ESALs (20-year BESALs >= 7 Million)

Pavement Age	Recommended Treatment
0	Initial Construction
7	Fill Cracks
15	Mill & Overlay
20	Fill Cracks
27	Mill & Overlay
32	Fill Cracks
40	Mill & Overlay
45	Fill Cracks
50	End of Analysis Period (no residual value)

Case 3. All Concrete Pavements

Pavement Age	Recommended Treatment
0	Initial Construction
17	Joint Reseal and Minor CPR
27	Minor CPR w/some full depth repairs
40	Major CPR & Diamond Grinding
50	End of Analysis Period (5 years of remaining service life)

Economic Analysis Period

The current process uses a 35-year analysis period. A review of the other states' analysis periods indicates that 40 years is the most common and three states use 50 years. The Federal Highway Administration Life Cycle Cost Analysis guideline recommends that the analysis period be long enough to include at least one major rehab for each alternative. Based on the FHWA goal of 50-

year service life for pavements and the results of the Activity Timing/Life Subcommittee, an analysis period of 50 years is recommended.

Short-Term
Use a 50-year economic analysis period. Also, use remaining service life to account for alternates that do not have zero service life at the end of the analysis period. This will be done using straight-line depreciation of the construction cost of the most recent rehabilitation activity.

Aggregate Source and Haul Distance

The main topics discussed are summarized as follows:

Short-Term
The main issue from the standpoint of the industries was the aggregate source location used for the cost estimate. The industries were questioned with regard to whether or not they would divulge their sources. While this would help nail down cost estimates better, contractors are reluctant to release this information. The subcommittee recommended that the current process for selecting aggregate sources, gathering aggregate prices, computing haul distances, and estimating final costs needs to be better documented. Documents detailing the processes are attached to the meeting minutes from the May 28 meeting, contained in Appendix B. These are entitled "Process on Listing Aggregate Sources for Pavement Selection" and "Process for Surface Determination Estimates."

Long-Term
The Mn/DOT Estimating Unit favors the current method for estimating materials costs, stating that it is the best way to capture market forces. MAPA wants to look at the use of average bid prices, stating that the current method is too complicated; if implemented this approach would be easier to use on a wider range of projects. The subcommittee recommends investigating the current process, as well as alternatives, for selecting sources and estimating costs. The use of "average bid prices," as discussed at the full Task Force meeting, is not recommended. If warranted, modifications to the current system should be proposed. The feasibility of "regional average costs" for aggregates should be investigated.

User Costs

The subcommittee recommended calculating user costs for pavement selection. For the pavement selection process, user costs are defined as costs incurred by the traveling public due to delays, increased vehicle operating costs and crashes (where feasible) as a result of the initial construction and subsequent rehabilitation and maintenance activities. The Task Force consensus is that while user costs should be considered, it will take some time to determine just how they will be incorporated into the pavement selection process and cost estimates. The user costs will be calculated by the Office of Investment Management, with help from the Districts and the pavement management unit.

Long-Term
A group will be formed to study user costs, which will be calculated for all Formal pavement determination projects submitted over the next 12 months. The following activities will be included in the user cost analysis:

1. Evaluation of standard best practice staging techniques for pavement construction.
2. Review of standard economic values of user costs.
3. Evaluation of the potential impact of user costs in district planning and design.

Pavement Design

A summary of the discussions are grouped into the following categories:

Short-Term
Unbonded overlays should not be included in the pavement selection process because they are considered to be rehabilitations rather than new or reconstruction.

Long-Term
The group discussed many structural design issues as outlined in the meeting Minutes. There was no clear agreement on the issue of subgrade and subbase design (in particular what constitutes an "enhancement"). It is recommended that further discussions be postponed to coincide with the upcoming release of the new AASHTO Pavement Design Guide. It is possible that current designs and resulting structural sections will be impacted. Further discussions of subgrade, base, and pavement design issues will be much more meaningful after Mn/DOT and the industries have had time to review the design guide. During this time, Mn/DOT should also investigate the possibility of incorporating grading costs in the pavement selection process as discussed in the minutes.

APPENDIX A

Deputy Commissioner Memo Dated August 23, 2002
Scanned Copy

Minnesota Department of Transportation

Memo

Office of the Deputy Commissioner/Chief Engineer
Mail Stop 110
395 John Ireland Blvd
St. Paul, MN 55155

Office Tel: 651/296-8532
Fax: 651/297-4795

Date: August 23, 2002

To: Pavement Type Determination Task Force

From: Douglas J. Weiszhaar
Deputy Commissioner/Chief Engineer

Subject: Evaluation of Current Pavement Type Determination Process

Thank you for agreeing to serve on the Pavement-Type Determination Review Task Force. The two previous in-depth looks at the Surface-Type Determination Process occurred in the early eighties and then again in 1995. AASHTO will be issuing a new pavement design guide later this year or early next year. This, along with discussions with both the concrete and bituminous industries, has led me to ask for another review of the pavement type determination process. There are a number of issues to be investigated around the process which include but are not limited to the following: interest rates, haul distance to aggregate sources, salvage value, maintenance costs, traffic management costs, etc. There are several other issues as well that will be identified through interaction of the task force and input from Program Delivery Group, Program Support Group, and from the concrete and bituminous industry associations.

The goal of this effort will be to keep up the long tradition that Mn/DOT has established in selecting the most cost effective pavement types for the appropriate design period. Representatives of the concrete and bituminous associations, although not voting members of the task force, will be encouraged to participate and provide input. As appropriate, I encourage you to gather information from other agency and industry technical experts. Richard Stehr has agreed to chair this effort.

My expectation is for the task force to fully evaluate the current pavement determination process. The deadline for recommended changes to the process to me is April 1, 2003.

Task Force Members:

Richard Stehr, Chair	Director, Program Support Group
Nelrae Succio	Director of District Operations
Patrick Hughes	Director of Materials and Road Research
~~(To be determined)~~ David Levinson	University of Minnesota
Bill Lohr	FHWA
Joseph Meade	Pavement Engineer
Dave VanDeusen	Pavement Design Engineer
Abby McKenzie	Director, Economic Analysis & Special Studies Section
Bob Winter	Metro Division Engineer
Jeff Blue	Waseca County Engineer

cc: Commissioner Tinklenberg
Jim Swanson
Al Schenkelberg
Al Steger

APPENDIX B

SUBCOMMITTEE REPORTS/MINUTES

Pavement Type Determination Task Force: Discount Rate

Question: Should a Discount Rate be applied to discount agency and road user costs in the future? If so, what is the appropriate rate to use?

Recommendation
After numerous meetings, the recommendation is to:

- Use a discount rate to reflect the opportunity cost of capital to the public since they are the ones foregoing the use of the money by paying taxes, as recommended by the U.S. Office of Management and Budget (OMB).
- Use the same real discount rate to deflate the agency costs and the road user costs.
- Use a real discount rate rather than the nominal discount rate.
- The real discount rate to be used will be the 30 year Real Treasury Bond Rate. This is forecast by OMB for use in the President's budget each year (attached).
- **The discount rate to be used will be the average of the past five years' OMB forecast, and updated annually, around February/March. For the year 2003 the five year average would be 3.5%.**
- To account for differences in the inflation rate experienced by the highway construction sector and the general inflation rate, the agency costs will be inflated by the difference in the highway construction industry, measured by the Chained Price Index for State and Local Construction Spending and the general inflation rate, measured by the Chained Price Index for the Gross Domestic Product (GDP). Based on a recent forecast by Data Resource Inc., the expected difference over the next twenty years is 0.21%. (Table Attached). A long-term forecast of the Mn/DOT Construction Cost Index is not available.

Advantages of the Recommendation

- The discount rate reflects the opportunity cost, the value of the next best alternative, to the public, if the money is not used by Mn/DOT.
- It is a publicly available forecast and recommended by FHWA as a possible candidate.
- The five year average smoothes out the fluctuations in the forecast OMB Treasury bond rates, see attached graph. This also overcomes the concern that if the rate was to change dramatically from year to year it may affect project selection from year to year and not provide consistency over a period of time when decisions are being made.
- An allowance is made to account for periods of time when the inflation rate in the highway construction sector is significantly different from the general economy.
- The forecasts of the Chained Price Index for the GDP and the State and Local Construction Spending are available from a nationally recognized source, Data Resource Inc, a source used by the Minnesota Department of Finance in their forecasts.
- Using the real discount rate, there is no need to inflate the road user costs, for which long-term forecasts are not readily available. This also keeps the analyses simple.

Disadvantages of the Recommendation

- The forecast Chained Price Index of the State and Local Construction Spending seemed low to some based on past Minnesota experience
- When comparing the long-term trends in the Mn/DOT Construction Cost Index and the Chained Price Index for the GDP, the difference was not significant. Therefore, some felt there is no need to account for the differences in the two inflation rates.
- The difference between the GDP price index and the State and Local Construction Spending price index was more significant than the difference between the Mn/DOT Construction Cost Index and the Chained price Index for GDP. Therefore, using the former difference for future differential in the general inflation rate and the inflation rate in the highway construction sector could result in overestimating the agency costs in the future.
- The discount rate will be revised annually. Some may believe this is too frequent a change.

Meeting Minutes
Pavement Type Determination Subcommittee
Economic Analysis Period & Salvage Value
January 27, 2003
1:00PM – 2:15PM
Mn/DOT OMRR Conference Room 1

Members Present: Joe Meade – Chair
Ed Idzorek
Bill Lohr
Dave Holt & Rich Wolters
Mark Snyder

Analysis Period

1) Current analysis period is 35 years.

2) No specific analysis lengths were recommended, but most felt that a period of 35-50 years is reasonable. All agreed that depending on the discount rate, the present worth of future costs may become insignificant at some point.

3) All agreed with the FHWA LCCA guideline: "The Analysis Period must be long enough to include at least one major future rehabilitation for each alternative.

4) **Subcommittee Consensus:** The Analysis Period should be long enough to include the longest alternate initial construction service life plus the first major rehabilitation service life.

Salvage Value

5) Currently salvage value is not considered. However the available bituminous and concrete in the existing pavement are used to calculate recycled pavement costs.

6) Dave H. – Mn/DOT currently does not consider salvage value appropriately in the recycled cost analysis. The analysis should consider salvage value at the initial construction and each rehabilitation. The analysis should also include costs for demolition/preparation of the materials for recycling.

7) Mark S – Salvage Value Present Worth at 35-50 years is very small. Leave the material out of the current analysis for rehabilitations. Only include recycling at the time of new construction.

8) Subcommittee agreement: If average bid prices were used for the estimate, salvage values would not need to be determined because they would be reflected in the average bid price.

Remaining Service Life

9) Ed I – Explained that Remaining Service Life is a necessary part of the economic analysis when all of the alternates service lives do not end at the end of the analysis period.

10) **Subcommittee Consensus:** Remaining Service Life should be used to account for costs of alternates that do not have zero service life at the end of the analysis period. The straight line cost method suggested by the FHWA should be used and a sensitivity analysis performed on curved line cost methods.

11) Joe M. Post Meeting Note:
A check with Mn/DOT Pavement Selection estimator indicates the current practice is: Available bituminous and concrete are only recycled into the same type of pavement. Bituminous recycle is used to reduce the amount of AC in the mixture. Concrete recycle is used to reduce the amount of aggregate in concrete mixture. Bituminous recycle is always considered. Concrete recycle is typically not considered due to current water cement ratio specifications.

12) Mark S. Post Meeting Note:
Also – a follow-up to the Joe's post-meeting follow-up on use of salvage materials in new design assumptions – I believe that both asphalt and concrete materials are being reused without exception. No one is taking these materials to landfill anymore – too expensive and environmental concerns. If salvaged material values are used in new construction cost estimates, they should reflect the value of those materials to the contractor (bituminous as a reclaimed material for use in hot mix or whatever, concrete as a source of aggregate for bases, granular fill, new concrete, or whatever) – whether they are used on the reconstruction of the next job or not. They have a value (and, presumably, a cost of removal), which will be reflected in the contractors bid prices for the job.

Minutes from the Flexibility Subcommittee
of the Pavement Selection Task Force

Thursday, January 30, 2003
1:00pm-2:00pm

Subcommittee Members Present:

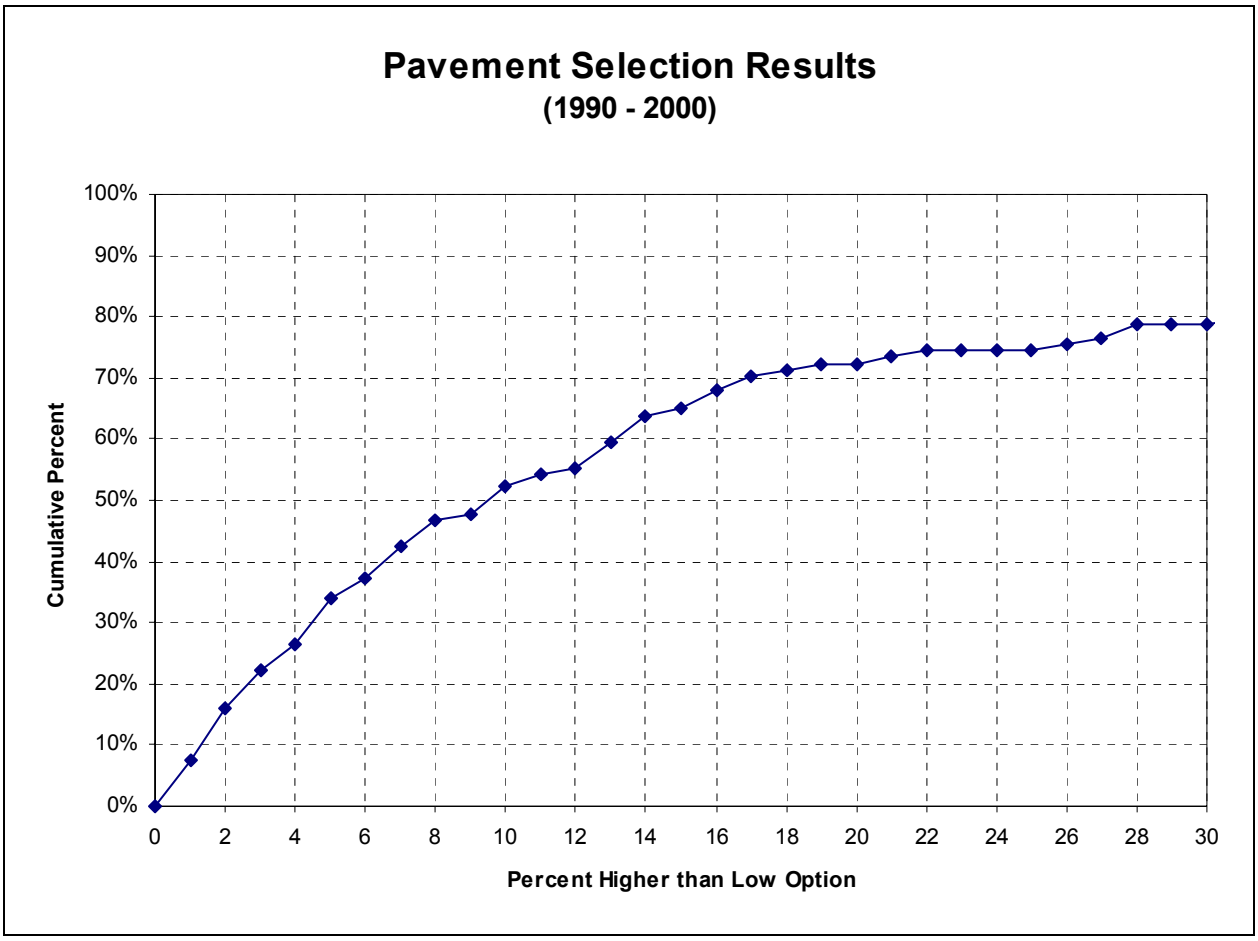
Pat Hughes	Director, Office of Materials and Road Research
Nelrae Succio,	Assistant Director, Program Delivery Group
Dave Janisch,	Pavement Management Engineer

The purpose of this subcommittee is to recommend what options the Districts will have if they do not agree with the Low Cost Option. Currently, the District may request a meeting of the Pavement Selection Committee and present its case for choosing a surface type other than the one with the lowest cost. Historically, the trend has been to abide by the Low Cost Option, regardless of how close the options are. Of the 95 formal pavement selections done from 1990 to 2000, only one project used a surface other than the Low Cost Option.

The 1983 report, "Method of Pavement Selection" states "If the final road cost of any alternative submitted to the Pavement Selection Committee is within 5% of the lowest alternative, those alternatives will be considered equal and other factors may be considered by the Pavement Selection Committee." Although most Districts believe this to be the current policy, this recommendation was never adopted or included in any subsequent technical memorandum on pavement selection. Janisch presented a chart showing that about 35 percent of all formal pavement selections done from 1990 to 2000 had a surface type within 5 percent of the low cost option. As a result, the group felt that adopting the 5 percent rule would not be appropriate.

After much discussion, the group recommended the following:

The pavement type identified in the estimate as the Low Cost Option will be the one used on all projects that go through the formal pavement selection process. If additional information becomes available or errors are discovered, the District may request that a new estimate be done. However, the Low Cost Option identified in the new estimate will determine the surface type.


Pavement Selection Results
(1990 - 2000)
Cumulative Percent
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Percent Higher than Low Option

Minutes from the Informal/Formal Subcommittee
of the Pavement Selection Task Force

Monday, February 3, 2003
10:00pm-12:00pm

Subcommittee Members Present:

Pat Hughes,	Director, Office of Materials and Road Research (OMRR)
Joe Korzilius,	Materials Engineer, Metro West
Perry Collins,	Materials Engineer, D-4
Mike Robinson,	Regional Pavement Reviewer, OMRR
Dave Janisch,	Pavement Management Engineer, OMRR

Absent:

Art Bolland,	Materials Engineer, D-8

The purpose of this subcommittee is to discuss whether Mn/DOT should continue to have both a formal and informal pavement selection process. In addition, the group looked at what criteria are used for a project to be totally exempt from the process. Janisch explained that there are three areas a project can fall into, Exempt, Informal and Formal.

Exempt:
Any new or reconstruction project less than 2-miles long (2-lane roads) or 30,000 sq.yds (multi-lane roads) is currently exempt from the pavement selection process. The current technical memorandum states that the District can use whatever pavement surface type they deem most appropriate.

Informal:
Any project exceeding the exempt limits can use the Informal process if either of the following is true:

- The native subgrade soil R-value is greater than 40 and the 20-year forecasted Bituminous Equivalent Standard Axle Loads (BESALs) are less than 7 million, or

- The 20-year forecasted BESALs are greater than 10 million.

With the informal process, an estimate is not done. Any project meeting the first criteria will have a bituminous surface while those meeting the second criteria will have a concrete surface.

Formal

Any project not meeting either the exempt or informal requirements must go through the formal process. This involves a detailed cost estimate by Mn/DOT's estimating unit, which identifies the surface type with the lowest annual cost.

The group felt that having an exempt process falsely implied that no comparison of alternatives is required for the short projects. It is expected that the Districts are comparing options on their own when determining which pavement type to use. As a result, the group felt that there should not be an exempt process but that the current exempt process should part of the informal process. The District is not

required to use the lowest cost option when doing a comparison of alternatives on these short projects. The choice can be made on the basis if cost, continuity, ease of construction and other factors. The key is that an analysis is required.

Long term, the group also felt that there was not enough data to justify moving the current limits on the informal process that result in an automatic pavement type, bypassing the estimate. In addition, there needs to be coordination between this group and the Design group to discuss how to deal with the frost-free thickness required under each of the different designs. Since this material improves the subgrade R-value, the cost estimate can be affected greatly depending on how this material is dealt with. The group felt the amount of frost-free material should be the same for both the concrete and bituminous options.

The group recommends the following as items that can be implemented in the short term:

- Remove the Exempt category. All new or reconstruction projects must go through a cost comparison process, whether informally at the District level or formally by the estimating unit in the central office. The Districts are expected to use Life Cycle Cost Analysis (LCCA) to compare alternatives. On the short projects (less than 2-miles of 30,000 sq.yds) the District will not be required to use the low cost option but will be given flexibility.

- Retain the two areas where the pavement type is automatically determined and a cost estimate is not required based on the 20-year BESALs and subgrade soil R-value.

- Remove unbonded concrete overlays from the pavement selection process. They should be considered by the Districts, along with other rehabilitation options, when rehabilitating deteriorated concrete pavements. This will result in only new or reconstruction projects having to go through the pavement selection process.

- Pavement Selections will only require the signature of the Pavement Engineer. Currently, pavement selections resulting in a concrete surface must also be signed by the Chief Engineer.

- Encourage enhanced designs once the surface type has been determined.

Minutes from the Activity Timing Subcommittee
of the Pavement Selection Task Force

Friday, January 31, 2003
10:00am – 2:00pm

Members Present:

Dave Janisch	Maplewood Lab, Pavement Management Engineer
Tony Kempenich	D-3 Materials Engineer
Joe Korzilius	Metro West Materials Engineer
Steve Oakey	D-7 Materials Engineer
Mike Robinson	Maplewood Lab, Regional Pavement Reviewer

The charge of the group was explained as follows: To review the existing timing and sequence of treatments in the pavement selection process and make recommendations for any changes to the process. The group felt the existing timing and sequence of treatments was not accurate and decided to develop a new list.

The group brainstormed possible rehabilitations and preventive maintenance activities that would be feasible for the two pavement types, bituminous and concrete. Then for each pavement, a sequence of treatments was developed based on past history, experience and the new types of materials and designs being used (SuperPave, Premium Concrete, etc). Since the group felt the length of the analysis period might be increased, it was decided to try to come up with a sequence of treatments that would ensure the pavement sections lasted at least 50 years, even though the initial design is based on either 20-years, for bituminous, or 35-years for concrete.

The attached list of activities summarizes the results of the meeting.

Bituminous Pavement Designed for 20-years of ESALs (50-yr analysis period)

0 Initial Construction

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6 Route & Seal Cracks

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10 Surface Treatment

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20 Medium Mill & Overlay (including shoulders)

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23 Route & Seal Cracks

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27 Surface Treatment

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35 Medium Mill & Overlay (including shoulders)

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38 Route & Seal Cracks

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43 Surface Treatment

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50 End of Analysis Period (no residual value)

Concrete Pavement Designed for 35-yeas of ESALs (50 year analysis period)

0

17 Joint Reseal and some partial depth spall repairs (maybe 10% ?)

27 Minor CPR (partial depth repairs) and some full depth repairs.

40 Major CPR (full depth repairs and diamond grinding)

50 End of Analysis Period (some residual value)

Bituminous Pavement with High 20-year ESALs (> 7 Million) with Curb & Gutter

0 Initial Construction

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7 Crack Fill (Blow & Go)

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14 Thin Mill & Overlay (2” Mill & OL)

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26 Medium Mill & Overlay (3” Mill & OL)

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38 Medium Mill & Overlay (3” Mill & OL)

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50 End of Analysis Period (no residual value)

Bituminous Pavement with High 20-year ESALs (> 7 Million) without Curb & Gutter

0 Initial Construction

7 Crack Fill (Blow & Go)

15 Thin Mill & Overlay (2” Mill & OL)

27 Medium Mill & Overlay (Mill 4”, OL 6”, includes shoulders)

32 Crack Fill (Blow & Go)

40 Thick Mill & Overlay (Mill 4”, OL 6”, includes shoulders)

50 End of Analysis Period (some residual value)

Concrete Designed for 60-years of ESALs

0 Initial Construction

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20 Joint Reseal and Minor CPR

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40 Joint Reseal and Major CPR, includes diamond grinding

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60 End of Analysis Period (no residual value)

Pavement Type Determination Task Force
Aggregate/Haul Distance Subgroup
Meeting Minutes
May 28, 2003, 1:00 – 3:00 pm

Attendees:	Nancy Sannes, Estimating	Mark Snyder, CPAM
	Dave Van Deusen, OM	Kay Stutsman, Estimating
	Rich Wolters, MAPA	Terry Beaudry, OM
	Deb Evans, OM	

See attached agenda.

Introduction and Background

After introductions the group reviewed the previous meeting minutes; the minutes of subsequent Task Force meetings was discussed, one recommendation was that the group meet another time to further discuss certain issues.

Discussion

The group discussed the following issues as identified by the Task Force:

a) What constitutes a "tied up" source?
b) Trends in pavement selection and engineers estimates, over/under?
c) Differences in process followed for pavement selection estimate and engineers estimate?
d) Regional factors
e) Salvage materials in aggregate base and granular
f) Roadblocks to changing the current system

The term "tied up" applies to sources where the material is available only to a certain contractor. Both the Aggregates and Estimating consider any available source. Information on potential sources is provided by the Aggregate Engineer, which includes privately owned sources. The practice of providing information on only Mn/DOT-owned or leased pits ceased several years ago. Mn/DOT also considers sources for which the lease has expired. In these cases the owner is contacted.

Haul distance – The group discussed which point(s) on the project are used to figure haul distance. Estimating uses the cheapest combination of price and distance.

The group discussed the need for documenting the source identification and haul distance estimating process in more detail (.

Sources are identified for both coarse and fine aggregate proportions of bituminous and concrete mixtures. The specific mix type (LV or MV, for example) however, is not considered. Haul distances for separate fractions are figured into the cost.

The estimating unit has previously investigated trends between the project engineers estimate and bids. This was discontinued due to complicating factors such as: fluctuations in cement and asphalt prices,

unbalanced bids, regional issues, contractor competitiveness, and increases in the number of contractors. These factors complicate the issues and make it difficult to perform a meaningful analysis.

The estimates prepared for the pavement selection follow the same process as the project engineer's estimate. Differences arise due to the timing and requirements for the engineer's estimate. One difference is that the engineer's estimate is done for all items on the entire job whereas the pavement selection estimate focuses only on the pavement. The project estimate is done at a later stage in the project and means that more information may be available, the project scope may have changed, etc. More specifics on mixture types may be available. The estimating unit reviews past mix design recommendations in that area. They are currently in the process of developing a database to automate this process.

The issue of regional factors was discussed. Regional factors are typically taken into account when evaluating the reasonableness of the engineer's estimate. From the standpoint of this subgroup's charge the term regional factors also applied to the notion of "average bid prices," as discussed at the Task Force meetings. The group decided that this term "average bid prices" should be dropped. Regional factors are built into the current estimating process: job-specific sources and prices are considered based on project location and material availability. It should be noted that MAPA still favors exploring some sort of average bid pricing in lieu of the current process.

Salvage Materials. The processes for considering salvage materials were discussed in the previous subgroup meeting. In the District's pavement selection submittal information on in-place bituminous content based on extraction test results is reported. This is used by Estimating to determine the available binder when the mix is recycled at the percentage currently allowed by the specifications (MAPA is still unsatisfied with the explanation of this process). The suitability of in-place concrete for recycling is discussed between District Materials and Office of Materials personnel and a recommendation is made to Estimating.

Salvaged aggregate base and granular, obtained either by crushing in-place bituminous or concrete surfacing materials, or utilizing in-place aggregate base or granular, are not currently considered. It is realized that this practice is fairly common, especially in the metropolitan area. However, the group felt that this was a low priority modification to the process because: 1) recycling is not mandatory, it is the contractor's option and 2) we do not currently have specific data on usage by District.

Roadblocks to changing the current system – In order to address one of the industry concerns it would be necessary to obtain prices from privately owned sources. MAPA feels that these sources are not being adequately addressed. Recall that each industry is given an opportunity to comment on sources and haul distances during the pavement selection process. However, comments regarding sources owned by private contractor's are seldom received, if at all. Other roadblocks were not discussed primarily due to the fact that it is not clear at this time what changes need to be made. For this reason it was decided that current process for selecting sources and estimating costs for pavement selection be investigated. If warranted, modifications to the current system should be proposed. In particular, some in the subgroup felt that the feasibility of "regional average costs" for aggregates be investigated. This would involve the use of a list of published prices from available sources for computing costs. Keep in mind that the primary issue is obtaining reliable information from privately owned sources.

Other issues:

Timing of pavement selection – Source ownership can change since the pavement selection is done 1 to 2 years in advance. Whether or not this is a major concern is unknown at this time but could be investigated in any study that is done.

Recommendations

Short-Term

The subgroup recommends that the current processes for selecting aggregate sources, gathering aggregate prices, computing haul distances, and estimating final costs needs to be further reviewed and more well documented. A group consisting of Office of Materials and Estimating personnel will prepare the documentation.

Long-Term

The subgroup recommends investigating the current process for selecting sources and estimating costs. The use of "statewide average bid prices," as discussed at the full Task Force meeting, is not recommended. If warranted, modifications to the current system should be proposed. In particular, the Task Force should consider the feasibility of "regional average costs" for aggregates.

Pavement Type Determination Task Force

Aggregate/Haul Distance Subgroup

Agenda

May 28, 2003, 1:00 pm – 3:00 pm

2) Introductions (5 min)

3) Previous meeting summary – review meeting minutes

4) Discussion topics

   a) What constitutes a "tied up" source?
   b) Trends in pavement selection and engineers estimates, over/under?
   c) Differences in process followed for pavement selection estimate and engineers estimate?
   d) Regional factors
   e) Salvage materials in aggregate base and granular
   f) Roadblocks to changing the current system

5) Wrap-up

Process on Listing Aggregate Sources for Pavement Selection

Previously, from at least the early 1980's until about 2000, the Aggregate Engineer would list only State owned or leased pits as possible sources for Pavement selection. The Aggregate Engineer would list the location, last condition survey, average gradation, and the percentage of average shale and spall of each pit. Some of the pits listed would not have had a pit survey for over thirty years previous to listing them as a possible source. The thought was that since aggregate was found previously in an area that it could still be found even though a listed source was depleted, therefore the haul distance would be approximately the same. For the first few years as Aggregate Engineer, I continued this practice, however after consultation with the Pavement Design Engineer, some Materials engineers, and the Estimating Unit, I changed the process for the following reasons: many times the listed pits were depleted and were now located in areas which were developed, therefore sources were not available in the area, and with the advent of LIMS for aggregate test reports and bituminous design recommendations, I was able to obtain current information on where aggregate sources were obtained for construction projects.

The current practice on listing sources is as described as follows. I first look for sources of Mn/DOT or current leased sources, which have a recent, within the last ten years, condition survey. Then I give approximate quantities, gradations, prices, and qualities of the sources as before. For previously leased sources, which have a recent condition survey, I attempt to contact the owners to obtain whether material still exists, assess their willingness to sell the gravel and obtain what their price will be. If I get a positive response from these owners, I also list these as potential sources. I then look through the LIMS aggregate and bituminous design databases to find out which sources were used in previous projects in the area and get contact numbers for these sources. For Concrete paving, I ask the Mn/DOT Concrete staff for copies of previous concrete paving mix designs for paving in the area. I also look for potential concrete sand sources, using previous lab test data for the ASR mortar bar test. Finally, I look through an online phone book for aggregate sources in the area. These sources are then sent to the Estimating Unit for their use and a copy of my recommendations is sent to the District Materials Engineer for review. If the Materials Engineer has an additional source or knows a source is depleted then the list of potential sources is amended. The Estimating Unit then sends the list of sources to the Industry. If the industry proposes an additional source, I assess this then give my recommendation to the Estimating Unit.

Terry Beaudry, Aggregate Engineer June 3, 2003

Process for Surface Determination Estimates

Typical sections are included with the surface determination package that I receive from the materials lab. From the square foot end area from each typical section I compute the total project quantities.

Also included in the surface determination package is a pit information sheet that the Aggregate Engineer compiles together. After plotting the gravel pits on a map I decide where I think the best location to set up a bituminous or concrete plant. To make this decision I consider such things as the distance of the pit or pits to the project, price and the quality of the material, and source of the oil or cement. If there is a commercial plant in the area I will also consider that, especially if there are small quantities. The haul distance is the distance from the pit to the plant or the distance from the plant to the project.

If it is a Mn/DOT leased pit the aggregate engineer includes the price with the pit data. If it is a privately owned pit I call the pit or owner and explain that I am doing a surface determination and ask them what their charge for the aggregate would be. I determine a low price source by the original cost of the aggregate at the pit, possibly disregarding any unusually low/high aggregate prices and then by adding additional costs for production, hauling and placing. An "industry letter" gets sent to both the Concrete Paving Association of Minnesota and Minnesota Asphalt Pavement Association. The letter describes the project, types of material being used and the haul distance to the low cost source. If either industry knows of a closer source they have seven working days to respond to the letter. If the industry responds with an addition source I forward the information on to the aggregate engineer to see if the material is appropriate to use.

Existing roadway material is calculated for possible recycle use. Recycled bituminous can only be recycled into bituminous, concrete into concrete pavement only. Recycled material is not considered for use into aggregate base or shoulder aggregate. If extractions of the existing roadway were taken, I will use that oil content for the oil reduction in the recycled mixture. I consult with the Aggregate Engineer to determine if the existing concrete pavement is suitable for reuse.

Trns·port CES (Cost Estimating System) an AASHTO estimating software program is used to determine prices. CES incorporates 5 year old equipment rates, current regional labor rates and current aggregate, oil and cement prices. Total project costs are calculated and then a cost per mile is figured.

Quantities are computed and items are priced for 20 year overlay and for resealing concrete pavement joints at 17 ½ years. Present worth factors are applied to determine which option is most economical. Copies of the report are sent to the Pavement Management Engineer.

Kay Stutsman, Estimating Unit, June 19, 2003

Minutes
User Costs: Pavement Type Determination
January 24, 2003 9:00 a.m.

Attendees: Abby McKenzie, David Levinson, Dave Van Deusen, Deanna Belden

Should we include User Costs?

The group discussed whether Mn/DOT should include user costs in pavement determination analysis. FHWA recommends including user costs in pavement determination, as do the asphalt and concrete industries. How to include them is up for discussion. One comment was that in pavement selection, it is not so clear that user costs need to be included.

A question came up about if the choice of pavement affects the amount of time a facility will be closed for construction. Probably yes.

Mn/DOT staff would need to identify the alternative routes during construction and estimate the distance of the best bypass/detour for analyses such as these.

Mn/DOT is doing approximately 8-10 formal pavement selections per year. Some of those would be new construction. The Investment Analysis section of the Office of Investment Management could do the user cost estimation on that number of formal pavement selections per year.

We should probably use a standard value of time, though any that we use will probably come under a fair amount of scrutiny from the industry. For user cost analysis, some gross assumptions are required, though similar assumptions must be made for estimating agency costs.

Recommendation: The group agreed we should look at user costs during construction activity for pavement selection. We would look at the initial construction period and the rehabilitations during the analysis period.

Summary of the User Cost Estimating Method

The group discussed whether crash costs should be excluded from user cost analyses. The problem is we don't currently have data for crashes in work zones. We would have crash data for the detours, which would have a higher volume, so then would have more crashes.

Since this number would be small, perhaps for simplicity we should not include. However, if the entire facility was shut down for construction and all traffic went to a detour, we could easily calculate the change in crashes. But, if some lanes are left open, it would be inconsistent to calculate the change in crashes for the detour and not for the work zone.

A suggestion was made to have crash cost estimation as a line item and estimate the crash costs if we can.

A question was asked about if we've looked at construction data on how long projects typically take. We haven't, but it would be a good idea. We'd need some standard values for best practices on how we handle reconstruction, resurfacing, etc.

The discussion moved toward the other user costs: delay costs and vehicle operating costs. To do it right, we should include both, though the delay component will be much larger.

We should perhaps look at queue length and compare it to the detour route time. This could be calculated and then applied to everyone. We need to be sure to not have queues that take longer than the alternate route. This is not realistic because people would find a different route.

A question came up about when the construction staging is done, before or after pavement selection. We believe it is done after pavement selection, but there is always a traffic forecast, the termini of the project and other items necessary to do the pavement determination.

Recommendation: The group had a general consensus that we should look at the user costs if we can. Looking at the construction staging will take some time and testing to look at the best practices. Estimates of user delay, vehicle operating costs, and crashes (where feasible) would be provided.

How should we include User Costs in Pavement determination?

The group looked at several potential ways to include user costs in pavement determination.

A. Add agency costs and consider the sum – Economists would add the user costs together. Our experience is that user costs are much larger than agency costs, and we would say then that is how the alternative should be chosen.

B. Add to other costs using weights – Pavement people suggest this method, but we don't know how to decide on the weights.

C. Keep separate and evaluate subjectively – FHWA suggests evaluating the user costs separately from agency costs.

D. Keep separate but have a decision rule – An example of this would be with user costs differ by 50%, and agency costs differ by 10%, then user costs rule. This is essentially assigning weights to the costs.

E. Calculate incremental B/C ratio – This is a method presented by FHWA in their September 1998 Interim Technical Bulletin on LCCA in Pavement Design. It is essentially forming a ratio of the difference in user costs between the two alternatives, over the difference in agency costs between the two alternatives. This method was not very appealing to the group. Why not add the user costs and agency costs together and look at the difference rather than this incremental method.

There are issues about knowing when the rehabilitations will be done. Perhaps Mn/DOT needs to come up with more realistic time tables of when rehabs are done for different types of roadway.

There was concern about the industry reaction if we decide to add the costs together.

Perhaps as a first step, we should come up with a decision rule for looking at user costs since the agency is less confident in user cost estimates than they are with agency cost estimates. To be comfortable adding them together, Mn/DOT would need to be equally confident in both agency and user cost estimates.

A comment was made that there is a perception out there that concrete takes longer because of curing time. But we aren't going to compare alternatives that take a whole extra summer to build.

During the implementation phase, Mn/DOT can work with assumptions to see if they are robust.

We don't want to be stuck in a decision rule for six years. Perhaps a finite test period, like a year, would be appropriate and then revisit how we are looking at including user costs.

Perhaps we should look at some past jobs to see if decisions would be different if user costs had been included. We can bring examples of A+B contracting to the next meeting so people can get a sense of how much user costs are per day for different construction projects. It will take several months to figure out some standard assumptions and look at some real projects.

Recommendation: The group took a vote on how user costs should be included in pavement determination. David Levinson prefers adding the costs together. Dave Van Duesen and Abby McKenzie prefer the decision rule method.

Timing of Implementation

It will take several months to get everyone on board and start looking at construction staging assumptions. Our goal should be to begin estimating user costs by July 1, 2003.

Between the time the Committee makes its decision and implements estimating user costs, the following issues need to be resolved:

1. Standard best practice staging techniques
2. Review of standard economic values
3. Testing against past pavement determination decisions
4. Decision on discount rates
5. Select decision rule

Recommendation: Our recommendation is to look at user costs in pavement determination for a year with a decision rule. After a year, revisit, and decide if the costs should start being added together.

Next Steps

For the next Task Force meeting on February 6, we will provide:

- Summary of A+B contracting user cost values, including traffic volumes
- Meeting minutes from this meeting
- Tables with standard values for time and vehicle operating costs

Pavement Type Determination Task Force
Pavement Design Subgroup
Meeting Minutes
January 31, 2003, 10:00 am – 12:00 pm

Attendees:	Dave Van Deusen, OMRR	Graig Gilbertson, D-2 Materials
	Chris Duininck, Duinick Brothers	Rich Wolters, MAPA
	Matt Zeller, CPAM	Dave Holt, MAPA
	Mike Robinson, OMRR	Jeff Blue, Waseca County Highway Dept.

See attached agenda.

Introduction and Background

Dave Van Deusen chaired the meeting. After introductions the chair gave a brief background on the Task Force. The charge to this specific subgroup was described: to discuss the various topics in detail and clarify them, and prepare recommendations for review by the Task Force at the February 6 meeting. This topic was identified as a long-term issue, meaning that recommendations may be made that will require further work; potential solution(s) probably will not be implemented by the April 2003 deadline.

A brief overview of the pavement selection tech memo and the design procedures was given. The divisions between exempt, informal, and formal were discussed. For each pavement selection job both flexible pavement designs and rigid pavement designs are developed. Two types of pavement sections for each surface type are typically developed. Flexible pavement designs are aggregate base and deep strength. Rigid pavement sections are drainable base and aggregate base. The procedure allows for variations to consider such factors as soil type. Selection of the design options to consider are based on 20 year forecasted flexible pavement ESALs although the respective ESAL forecasts are used for designing each surface type (20 year for flexible, 35 year for rigid). The subgrade support for each surface type is based on the stabilometer R-value, a laboratory soil test performed at OMRR Soils Laboratory. The design R-value is calculated as the mean minus standard deviation of the representative soils on the project.

The discussion centered on the use of select granular material beneath the design alternatives. For flexible aggregate base designs the design chart shows that bituminous and base/granular structural thickness can vary as follows:

Low ESALs, weak soils: HMA ~ 3.5 inches and Base/Granular ~ 12 inches
High ESALs, weak soils: HMA ~ 8.0 inches and Base/Granular ~ 30 inches

For ESALs over 1M (20 year, flexible) there is a 30-inch requirement for both aggregate base and deep strength designs. The requirement is 36 inches when the 20-year ESALs are over 7M. Typically this is automatically met for aggregate base designs based on the design chart. Deep strength designs are a different matter. The deep strength pavement design is based on the full-depth chart; the chart does not address the use of aggregate base or granular directly. Due to the 30 inch requirement a method is needed to give structural credit to the granular required to meet the 30-inch criterion. The method for doing this was presented to the group. It involves calculating an adjusted R-value based on the thickness of select granular required to achieve a 30-inch structure. Each inch of select granular is given 0.5 inch

of GE. The adjusted R-value is interpolated off the graph by moving vertically on the chart a distance equivalent to the GE contribution of the select granular. The 30-inch requirement is relaxed if the subgrade soils are predominantly granular (P200 < 20%). When the 20-year ESALs are less than 1M then there is no 30-inch minimum requirement.

Mn/DOT sometimes uses granular material for embankment fill, over and above the minimum required, for construction expedience and long-term performance. The decision is of course based on in-place soil type, granular materials availability, construction constraints, etc. This is in lieu of constructing the entire embankment out of select, native soils. An example is in an urban section re-construction that has plastic soils in-place. Granular fills are generally much easier to construct than are plastic soils. In these cases a typical recommendation will be to provide a granular embankment, in lieu of or addition to, compacted soil subgrade treatment.

Should these be included in the pavement selection cost estimate? CPAM felt that the answer is no since we do not typically know what the weather will be like when the project gets constructed (construction expedience issue).

For rigid, aggregate base designs over 1M ESALs (20 year, flexible) there is a minimum required 3 inch Class 5 base and 12 inch select granular layer beneath the PCC slab. For 20 year ESALs under 1M there is no minimum requirement for select granular. The in-place soil R-value is adjusted for the added support of the 12-inch granular layer. For the rigid, drainable base design over 1M ESALs the base consists of 4 inches of OGAB and 3 inches of Class 5 filter. The drainable base designs are given a 0.5-inch thickness reduction relative to the aggregate base designs.

Standard rigid pavement widths are based on a protected-edge design for rural situations. Urban jobs will have a non-protected edge design. For a given soil strength and traffic level, protected-edge designs are thinner than non-protected edge designs.

The topic of subgrade treatment was addressed. One Mn/DOT practice is to stabilize the subgrade by constructing compacted layers of soil. This is done to obtain a strong, stable platform for construction and for long-term performance. By specification, Mn/DOT requires that the top 3 feet of the subgrade be compacted to specified moisture and density. In practice, subgrade treatments are generally a function of the following:

- New or re-construction. On re-construction jobs the existing road is evaluated with respect to stability and uniformity. If the in-place road has performed adequately, maintains a good profile, does not experience differential heave, and the proposed road will not require substantial embankment widening, then only minimal subgrade preparation may be required. On new construction, the soils are evaluated and a subgrade treatment is designed with respect to economics and long-term serviceability.
- Soil type, frost susceptibility. Soils that are highly frost susceptible require more corrective action than those that are not. Frost depth is considered when determining the depth of subgrade treatment particularly when the soils are highly frost susceptible, or vary in type or in-place moisture content. The particular treatment will be a function of economics, availability of granular material, and construction constraints. Frost susceptible soils are typically treated by performing soils mixing and compaction and/or soil replacement with granular materials. In

plastic soils subgrade treatment by soil mixing and compaction can be hampered by weather delays. Uniform, granular soils may only require a shallow subcut.

- Soil variability. Alignments constructed on uniform soils require less corrective work (soil mixing and compaction, subcut depth) than do highly variable soils.

It was explained that the above surface and base/subbase thicknesses, for either surface type, are in addition to any subgrade treatments. Good subgrade design practice is an important component in the structural design. The subgrade support value input to each design procedure assumes good subgrade design practice. Furthermore, it was explained that the subgrade treatment should be the same regardless of surface type. Mn/DOT constructs road embankments to last many years beyond the life of the initial surface.

Typically, the District submits a subgrade recommendation along with the Pavement Selection Request submittal. OMRR works with the district to develop the designs.

Industry concerns were discussed. CPAM is concerned about the need for granular in the rigid, aggregate base design. They consider it an enhancement that should be added on later at the District's discretion; it should not be included in the pavement selection estimate. They also consider the drainable base option to be an enhancement; it is not needed for the basic structure. In general CPAM felt that soil improvement is not critical to their product.

D-2 Materials felt that any subcuts should be designed early on in the process, before the pavement selection is submitted. Usually there is ample information to make that recommendation. MAPA agreed with this.

MAPA felt that the use of granular is not a debate between the two surface types but also stated that the benefits of granular material needs to be discussed more. The differences in structural thickness cannot be justified. The moratorium on full-depth bituminous was based on less-than-complete performance data. Many local agencies are using full-depth designs with good performance. Past poor performance was more of a construction problem. The current policy (30 inch requirement) needs to be looked at for cost-effectiveness but should be equal between the two surface types.

Discussion Topics

The following list was on the agenda for topics to discuss:

a) Discussion of subgrade design approaches
b) Design procedures - present and future, including structural thickness, drainage layers, 30 inch design
c) Policy on select granular material
d) Consideration of other construction types such as rubblization, whitetopping, etc.
e) Others?
    ESAL criteria, 10M vs. 7M
    Full-depth moratorium
    Unbonded PCC overlay
    Traffic estimates

M-E design
Design R-value

The discussion turned to the topic of subgrade design approaches and of ways to equalize the total structural depth between the two surface types. Alternatives that were discussed included:

- On jobs where it is warranted, utilize all granular beneath surface and base layers to the total depth of the design subgrade treatment. CPAM did not favor this and suggested that much granular is not needed; it was proposed that, if that were the case, we could eliminate dowels from the initial construction and incorporate surface rehab such as diamond grinding at a specified date in the LCCA. CPAM feels that enhancements, if included in the initial construction costs, should reflect increases in performance lives that are reflected in the LCCA.
- Continue with current practice except for the addition of an estimate for construction costs for subgrade soil compaction. The total depth, from top of surface to bottom of compacted subgrade, would be the same for either surface type.
- Design for "minimum" structural requirements. There was not a clear consensus on the definition of "minimum" structural requirements.

The ESAL cutoffs for formal/informal were discussed. CPAM wants to revert to the previous 7M cutoff. If that does not happen then the entire range should be opened up to both surface types. MAPA explained that they would like to have a chance at higher traffic volume jobs (in excess of current 10M cutoff). Metro overlay jobs that are failing are due to underlying PCC deterioration. MAPA feels that they can compete in this area.

Based on the discussions at the meeting there seems to be an impression that replacing native subgrade soils with granular material has an effect on flexible pavement surface thickness. This is true for deep-strength designs but is not true for aggregate base designs.

The group discussed consideration of other designs such as rubblizing, whitetopping, etc. MAPA does not have an issue with unbonded PCC overlays but wants to see rubblizing shown in the list of design types to compete with unbonded overlays. CPAM felt that unbonded overlays should be compared to rubblization. Another alternative would be to take the unbonded overlay option out of the list of design types. No signature would be required. Unbonded overlays were originally required to have the signature of the Chief Engineer. This was because this type of fix was considered experimental back when it was first shown in the tech memo. Since then it has become much more common; standard designs exist for which performance appears to be good.

Subgrade excavation costs should somehow be considered, especially with reconstruction jobs where the surface profile is remaining essentially the same. Differences in actual costs arise between the two surface types. Flexible designs typically require a greater depth than rigid. The current method does not consider the costs of excavating and hauling excess material. MAPA would like to see the cost of fill placement and compaction considered. This might be difficult since an assumption would have to be made regarding what a contractor would do with this excess. For example, a contractor may either haul it off the project for disposal or he may place it in the slopes outside the 1.5h:1v line.

It was suggested that, when determining the design R-value (mean minus standard deviation), that poorer soils should be excluded from the calculation if it is know that the District will be removed. This is typically the case but depends on the nature of the in place soils uniformity. Districts are required to submit a soils profile along with the pavement selection request so that a cost-effective subgrade treatment can be developed.

Mn/DOTs work on M-E design was discussed. Will Mn/DOT implement MnPAVE or the 2002 Design Guide? It was explained that MnPAVE is for flexible pavements only. Mn/DOT needs a M-E design procedure for rigid pavements as well as flexible. There are several advantages to adopting the 2002 Design Guide including 1) consistency in inputs where applicable, such as traffic, materials, and climate and 2) consistency in support from other states and AASHTO. It was decided that M-E design is a long-term process. Mn/DOT will evaluate the 2002 Guide upon its release and make a decision after that. However, the evaluation will take some time due to the complexity of the program and the scope of the undertaking. When the software becomes available Mn/DOT and the industries will be involved in the evaluation process.

Summary

A summary of the discussions are grouped into the following categories:

Subgrade Design / Pavement Design

- Definition of "enhancements." Do current minimum standards for granular material constitute "enhancements?"
- Definition of "structure" vs. "subgrade design" vs. "frost protection."
    - Proposed definition of "structure": The total GE (coupled with minimum surfacing requirements and existing layer coefficients) or actual layer thickness as determined by an accepted design procedure.
- Should "enhancements" only be included if an increase in the performance life is included in the LCCA?
- Future meetings will be needed to discuss design issues. In particular, there was no clear agreement on an overall design strategy. Several options were discussed:

  >Put all structures on an equal footing. For new construction this would involve computing estimates for the designed pavement structures plus any compacted fill, to a certain depth. The depth would be based on current subgrade design criteria and would be the same for either surface type. For reconstruction on the same alignment consider the difference in cost between excavation requirements for the various alternatives. In other words, develop estimates that consider the fact that bituminous options require a minimum 30 inch structure whereas concrete options do not. This assumes that the existing embankment has performed satisfactorily and will not require reconstruction.
  >Design "minimum" pavements. The term "minimum" is going to need some more clarification.
  >Design it as it will be built. In some cases this is what is being done now. Total depths to bottom of granular are kept the same for all options. However, R-value adjustments are not made for any material over and above the minimum required.
  >Combination of the above.
  >Continue as is.

- MAPA suggests revisiting the bituminous full-depth designs.

- Traffic estimates. One of the industries suggested finding a way of dealing with low traffic estimates. Since the methods for producing traffic forecasts will change with the 2002 Design Guide it is suggested that this issue be further discussed when the Guide is evaluated.

Unbonded Overlays / Rubblization

Unbonded overlays. Take this option off the list or leave it in and add rubblization.

Recommendations

1. There was no clear agreement on the issue of subgrade and subbase design (in particular what constitutes an "enhancement"). It is recommended that further discussions be postponed to coincide with the upcoming release of the 2002 Design Guide. It is possible that current designs and resulting structural sections will be impacted. Further discussions of subgrade, base, and pavement design issues will be much more meaningful after Mn/DOT and the industries have had time to review the 2002 Design Guide.

2. Mn/DOT should investigate the possibility of incorporating grading costs in the pavement selection process as discussed in the summary above. It would be wise to postpone this to coincide with evaluation of the 2002 Design Guide.

Pavement Type Determination Task Force
Pavement Design Subgroup Agenda
January 31, 2003, 10:00 am – 12:00 pm

1) Introductions (5 min)

2) Subgroup charge, discuss previous Task Force activities (5 min)
   a) Charge: discuss topics in detail and clarify, prepare recommendations for review by the Task Force at the February 6 meeting.
   b) This topic was identified as a long-term issue, meaning that recommendations may be made that will require further work; potential solution(s) probably will not be implemented by the April 2003 deadline.

3) Current practice (30 min)

4) Topics (40 min)
   a) Discussion of subgrade design approaches
   b) Design procedures - present and future, including structural thickness, drainage layers, 30 inch design
   c) Policy on select granular material
   d) Consideration of other construction types such as rubblization, whitetopping, etc.
   e) Others (see previously identified issues below)?

5) Prioritize each topic with specific recommendations (40 min)

6) Wrapup

Industry	Issue
MAPA	Full-depth moratorium
	Use of select granular
	ESAL criteria > 10M
	Unbonded PCC overlay
CPAM	Unbonded PCC overlay
	Use of select granular
	Subgrade excavation costs
	M-E Design, need for both HMA and PCC
	Traffic estimates
	Aggregate sources

B2b. Service Lives

Construction history data from the MDSHA pavement management system was utilized to determine the average and standard deviation of service life for typical pavement type initial lives and subsequent future rehabilitation lives. Construction history information was used in the development of this data because it documents MDSHA's history of typical length of service lives and the timing of future rehabilitations. It is logical to estimate that similar trends would exist in the future for the length of initial service lives and the timing of future rehabilitation operations for various pavement types. Throughout the team meetings of the PTST, there was some concern expressed by material industry representatives that past pavement types may have been rehabilitated for other reasons other than performance. The following are just a couple examples: a roadway may be resurfaced when it is widened for capacity or safety reasons prior to a need for performance reasons, a roadway may be resurfaced for hydraulic and cross slope reasons prior to a need for performance reasons, or a roadway may be rehabilitated with an approach and timing not preferred by a particular material industry. However, all the reasons roadways were resurfaced in the past are good reasons for including that information in the dataset to be used to predict future lives and performance. The same conditions that caused a roadway to be rehabilitated in the past for non-performance reasons does not preclude those conditions for arising again with the same results in the future.

Therefore, the majority of the data from the pavement management system was used in the developed of service information used in the LCCA. However, some filters were placed on the data to ensure that the dataset was appropriate for the PTST objective, yet had a large enough population to ensure some significance. Data from our construction history information dates back to the early 1900's. However, there are some gaps in the timing of past rehabilitations prior to 1950. Therefore, the dataset was limited to roadways built since 1950. MDSHA occasionally will stage construction of a single project or the sequencing of resurfacing of several adjacent projects. In these cases, our construction history data collection efforts would capture a roadway resurfaced with a base layer followed by the final resurfacing potentially 2 to 3 years later. For this scenario, future rehabilitations on any given pavement type were filtered out of the dataset so that the it included only construction records that occurred at least 4 years after the previous construction or rehabilitation. Several other filters were considered, but not utilized to lower the standard deviation of the dataset, yet include a large enough population in the dataset to ensure some significance. One example of a filter option not used to develop the final dataset was not including roadways that had been widened in an attempt to capture only those roadways resurfaced for performance reasons. However, the average and standard deviation of this smaller dataset was not significantly different than the final dataset used for LCCA inputs. For this reason and the reasons discussed above, this filter was not utilized. The tables below show the service life statistics and population of data used to develop those statistics.

Average Service Life Statistics for LCCA

Cycle	Flexible Pavement	Rigid Pavement	Composite Pavement
Initial	14.8	24.0	
1st Rehabilitation	11.9		9.8
2nd Rehabilitation	11.1		8.1
3rd Rehabilitation	12.0		8.6

Service Life Standard Deviation Statistics for LCCA

Cycle	Flexible Pavement	Rigid Pavement	Composite Pavement
Initial	5.8	6.8	
1st Rehabilitation	4.7		3.0
2nd Rehabilitation	4.4		1.9
3rd Rehabilitation	4.5		1.9

Lane-mile Population Used in Service Life Statistics for LCCA

Cycle	Flexible Pavement	Rigid Pavement	Composite Pavement
Initial	4,527	2,144	
1st Rehabilitation	3,000		1,307
2nd Rehabilitation	1,227		553
3rd Rehabilitation	355		113

In the same manner that the material cost information will be updated routinely to ensure the most accurate data is available; the service life information will be updated routinely. Once a year, the same effort to gather and filter erroneous data will be used to develop service life information. With the size of the population used to develop these values, it is not expected that these values will change significantly over time. There are a few future rehabilitation strategies that do not have a large population in MDSHA's past. Concrete pavement restoration (CPR) is the most notable example. Material industry representatives on the PTST were requested to provide input and supporting backup information on these strategies to be considered by the team. The rigid pavement industry members provided the PTST with several documents that contained information about the typical timing and the service life of CPR. The various documents provided a range of CPR lives, but the industry did not recommend a specific

timing and service life for CPR. After reviewing the information provided and consulting with other state DOTs, MDSHA will schedule CPR 20 years after initial PCC construction in the LCCA. A 10 year average life will be expected from the CPR treatment. Standard Deviations for these service lives were calculated using the same coefficient of variation that was developed from MDSHA historical data for initial PCC construction. Appendix Section B4 contains the final service life inputs that will be used in the LCCA.

A1a. Construction Duration

Construction duration information has an impact on length of the initial construction and future rehabilitation strategies and therefore a major influence on user costs. MDSHA has a portion of its experienced and knowledgeable staff dedicated to developing estimates for total contract duration based on the time required to complete individual construction operations. These estimates are completed with historical information about the speed of construction of different operations and engineering judgment. The PTST will rely on the information provided by the experienced MDSHA construction personnel for construction duration information. The construction duration information used in LCCA is provided in Section B4.

A2. Future Pavement Rehabilitation Design

The MDSHA Pavement Design Guide will be used to assist in determining the appropriate pavement rehabilitation strategies to be completed in the future years in a LCCA. However, the existing condition of the roadway is a huge input used in determining the appropriate pavement rehabilitation approach. The future pre-rehabilitation pavement condition is not available in the present, therefore, the component analysis portion of the MDSHA Pavement Design Guide and the expected traffic volumes will be used to assist in determining the future structural improvements for a roadway. However, various functional improvements and pre-overlay repairs will need to be estimated based on typical and historical performance of MDSHA roadways. The following table displays these rehabilitation estimates that will be used in the LCCA.

Attachment D: Pavement Service Life, Mississippi DOT

Overlay lives for Interstate & 4 lane routes

For new flexible pavements:

Overlay #1 is performed after 11.53 years
41.7% of the time it is 1 lift with no milling
17.6% of the time it is 1 lift with milling
12.2% of the time it is 3 lifts with milling
10.6% of the time it is 3 lifts with no milling

Overlay #2 is performed after 9.24 more years
52.3% of the time it is 2 lifts with milling
32.7% of the time it is 1 lift with no milling
11.3% of the time it is 1 lift with milling
3.7% of the time it is 2 lifts with no milling

Overlay #3 is performed after 7.71 more years
68.0% of the time it is 1 lift with milling
24.3% of the time it is 2 lifts with milling
7.7% of the time it is 1 lift with no milling

Overlay #4 is performed after 5.9 more years
100% of the time it is 1 lift with milling (only 18 miles of data)

For new jointed concrete pavements:

Overlay #1 happens after 33.7 years and it is 3 lifts (4.5") 69.6% of the time
2 lifts 22.2% of the time
1 lift 8.3% of the time