2019 Pavement Design Guidelines

Tennessee Department of Transportation
Roadway Design Division

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1.0 Introduction

This manual documents the current policies and practices for developing pavement designs in Tennessee. These policies and practices are consistent with the U.S. Department of Transportation Federal Highway Administration's (FHWA's) pavement policy as codified in 23 CFR 626 (see Appendix 1). The full policy can be viewed online as part of the FHWA's Pavement Notebook at https://www.fhwa.dot.gov/pavement/notebook/chapter00.cfm.

The Pavement Design staff in the Roadway Design Division are responsible for developing pavement designs for all projects for the Tennessee Department of Transportation with the following exceptions:

- Pavement designs for State Industrial Access (SIA) projects are developed based on "standardized designs." Pavement Design staff develop the standard designs but are not involved in the implementation of pavement designs for SIA projects unless specifically requested to provide project-specific designs.
- Pavement Design staff do not develop pavement designs for metro-urban resurfacing projects or for resurfacing projects that are 100% state funded unless there are unique conditions that require a more detailed analysis.
- Design catalogs based on soil type and average daily load (ADL) are used for bridge replacement projects with an ADL < 150.
- Pavement Design Staff are responsible for development of pavement designs for interstate pavement rehabilitation projects. The staff are not usually involved in rehabilitation projects of state routes unless specifically requested.
- Local projects – provide guidance and recommended pavement design.

The roadway designer will develop the pavement sections for the above listed exceptions. The Pavement Design staff will assist with these designs if requested.

This manual supersedes the previous Pavement Design Guidelines, January 1992.

2.0 Design Overview

2.1 Introduction

The pavement design procedures presented herein provide for the type selection and design of new, reconstructed, or rehabilitated pavement structures. The Department will use the *1993 AASHTO Guide for Design of Pavement Structures* for design of new, reconstructed, and rehabilitated pavement structures. The 1993 AASHTO procedure also includes a provision for including design reliability in the pavement design process. The DARWIN software which was developed by AASHTO in support of the *1993 AASHTO Guide for Design of Pavement Structures* is no longer supported by AASHTO. Thus, TDOT is in the process of transitioning from the *1993 AASHTO Guide for Design of Pavement Structures* to the mechanistic, empirically-based AASHTO Pavement ME procedures. As TDOT transitions to the AASHTO Pavement ME, a generic software based on the process presented in the *1993 AASHTO Guide for Design of Pavement Structures* will be used to determine the required structural numbers for design. Two options for a generic software that can be used are WinPAS and PaveXpress. PaveXpress is currently available to the public with no licensing fees. Implementation of AASHTO Pavement ME is discussed below.

Upon completion of a pavement design by the Pavement Design Staff, the pavement design will be approved by the Pavement Design Coordinator for both state-funded and federally-funded projects. After receiving the necessary approval, a copy of the approved design will be sent to the appropriate designer for inclusion in the project plans. UNDER NO CIRCUMSTANCES is the design to be altered without the written approval from the Pavement Design Office, Roadway Design Division. If a designer would like to review a design with the pavement design engineer, a meeting should be arranged at the earliest possible date.

Implementation of AASHTO Pavement ME will be documented in detail upon finalization of the implementation report. Below are the basic components associated with implementation of the AASHTO Pavement ME design methodology.

- More detailed information relating to total truck volumes and truck vehicle classifications.
- Performance related information for all bound pavement materials (asphalt or portland cement concrete).
- More detailed information regarding unbound aggregate materials and soils.
- More robust inclusion of climatic data and information in the design process.
- Allows for the inclusion of reliability parameters for pavement performance during design.

3.0 Design Elements

3.1 Introduction

Pavement design elements determine the material composition and load carrying capacity of the pavement structure. The pavement structure will consist of a subbase, base course, and surface course. It is placed on subgrade, and supports the traffic loadings. The *1993 AASHTO Guide for Design of Pavement Structures* provides a discussion of design considerations in Section 1.2 of that document; those considerations are summarized and included in Appendix 2 of TDOT's 2019 *Pavement Design Guidelines*.

3.2 Pavement Design Elements

The structure life of a pavement is affected by the number of heavy load repetitions applied; hence, a poorly designed pavement will not be evident until several years after construction. To ensure that the pavement is designed properly, several design elements must be considered, including:

- Evaluation of the subgrade for drainage characteristics and bearing capacity;
- Evaluation of existing pavement, if applicable, to determine appropriate rehabilitation strategy;
- Determine the value of the existing materials / pavement structure for the new pavement;
- Evaluate the existing pavement to determine the causes of existing pavement distress;
- Evaluate the use of alternate pavement structures for feasibility of construction and cost effectiveness;
- Determine the projected design traffic;
- Specifications that ensure the pavement materials, construction methods, and finished project are defined to the contractor; and
- Notes on the plans to ensure that the plans, specifications, and special provisions clearly and concisely define the job requirements.

3.2.1 Initial Construction and Reconstruction Projects

In addition to the above-identified design elements, an initial construction or reconstruction project requires the following design information:

- Existing Average Daily Traffic
- Design Year Average Daily Traffic
- Average Daily Load (ADL)
- Number of Traffic Lanes
- Subgrade California Bearing Capacity (CBR) for Asphalt Pavements

- Subgrade K-Value (Modulus of Subgrade Reaction). The subgrade modulus of reaction (K-Value) may be calculated using a number of tools. The resultant K-Value may vary depending on the method of calculation. Options for calculating K-Value include:
  - AASHTO *1993 AASHTO Guide for Design of Pavement Structures* (page II-39)
  - AASHTO 1998 Supplement to the AASHTO Guide for Design of Pavement Structures, Part II – Rigid Pavement Design and Rigid Pavement Joint Design (pages 2-16). "Specifically, the 1998 revision developed a new design model incorporating an improved process for characterizing the design K-Value, and also directly considered the effects of base modulus, base thickness, slab/base friction, joint spacing, edge support, temperature and moisture gradients, and traffic loading on critical slab stresses. In addition, faulting models for undoweled and doweled joints were included to "check" the adequacy of the joint load transfer design" (*Handbook for Pavement Design*, Construction and Management, Chapter 4 Structural Design).
  - The ACPA (American Concrete Pavement Association) Static K-Value Calculator tool is available online at http://apps.acpa.org/applibrary/KValue/.
  - When using WinPAS, PaveXpress, or other generic softwares as a pavement design tool, the designer must first calculate the composite K-Value to be used for design, based on subgrade strength and pavement base layers.
- Project plans showing proposed typical sections
- Roadway Geometric Layout

3.2.2 Rehabilitation Projects

A rehabilitation project requires the following design information:

- Design thickness of the existing pavement structure (from existing plans)
- Existing Average Daily Traffic
- Design Year Average Daily Traffic
- Average Daily Load (ADL)
- Number of Traffic Lanes
- Summary of Distress Data from distress surveys or pavement management data
- Pavement and Subgrade Core Samples
- Split-tensile tests of asphalt cores are not performed on a routine basis. These tests are conducted when review of the cores and results of the distress summary data indicate that there are problems in the underlying layers of the pavement structure.
- Pavement Rut Depth Data
- Pavement Condition Data from Pavement Management Data

- Results from the Falling Weight Deflectometer (FWD) testing when available
- Distress Data – used to pick project per pavement management Region staff
- Distress Data available for use by pavement designers in concert with historical data

3.3 Design Life

The analysis period for design of pavement structure will depend on the type of project. The analysis periods will conform to the following:

Table 3-1: Pavement Structure Analysis Periods

	Design Life
New Construction	20 Years
Major Reconstruction	20 Years
Asphalt Rehabilitation – Interstates & Freeways	8 Years Minimum
Asphalt Rehabilitation – Other Routes	12 Years Minimum
PCC Rehabilitation (CPR)	15 Years or Greater

3.4 Life Cycle Cost Analysis

A life cycle cost analysis (LCCA) will be performed on Interstates and Major Primary Routes for new and reconstructed roadways. The cost for all routine activities of pavement maintenance will be used in the LCCA, and will be based on the most current actual expenditure information available from the Maintenance Division. A detailed discussion of procedures and practices for LCCA is presented in Chapter 7. The following sections provide a brief summary of cost elements to be included with the LCCA.

A LCCA will not be required if:

- The new roadway is adjacent to an existing roadway and the pavement type needs match the existing, or
- The existing pavement is in sound condition and the cost to restore it to an acceptable level of service is minor compared to the cost of a new pavement structure or major rehabilitation.

In either of the above cases, a decision will likely be made based on engineering judgment rather than an engineering and economic analysis of alternative actions.

For the basis of LCCA, it is assumed that the asphalt or the concrete pavements will have a residual value equal to an aggregate base course for reconstruction. It is assumed that at the end of the analysis period, each alternate will be equal and no monetary value will be given for LCCA.

4.0 New Construction and Reconstruction

4.1 Introduction

The administrative and design processes for both flexible and rigid pavements are detailed in the following sections.

4.2 Pavement Design Process

Figure 4.1 presents a flowchart describing the administrative steps for obtaining an approved pavement design for a project. The following sections further describe these specific steps.

4.2.1 Pavement Design Request

To initiate a pavement design, the roadway design engineer will complete the Pavement Design Request Form (Appendix 3). This form will be submitted to the Pavement Design Office of the Roadway Design Division at TDOT.PavementDesign@tn.gov. A copy of the email will be placed in the project folder to document the submittal.

4.2.2 Pavement Design

Once the pavement designer receives the Pavement Design Request Form, the pavement designer will:

- Collect Base Data – Basic project data (traffic, soils, plan set, etc.) should be included on the Pavement Design Request Form. This data includes traffic, soils, plan set, whether traffic is to be maintained during construction, and type of project (new alignment, resurfacing, etc.). If data is not included with the form, then the pavement designer will request the missing information.
- Collect Input from Regional Level – For all projects, the pavement designer will notify the Regional Director that the pavement design process has begun, and will request input from the regional level.
- Review Preliminary Scope of Work – The pavement designer will review the project scope of work.
- Review Project Plans – The pavement designer will review the plan set to determine if alternate pavement designs are feasible. For example, treated base alternates may not be considered where local access must be maintained.
- Make a Field Visit – If base data cannot be determined from available information, the pavement designer may need to make a field visit to the project site.
- Calculate the Required Structural Number – With project level information (traffic, soils, etc.), the pavement designer will calculate the minimum required structural number (SN) using the *1993 AASHTO Guide for Design of Pavement Structures*. The designer should use the design year traffic when calculating the minimum required SN.

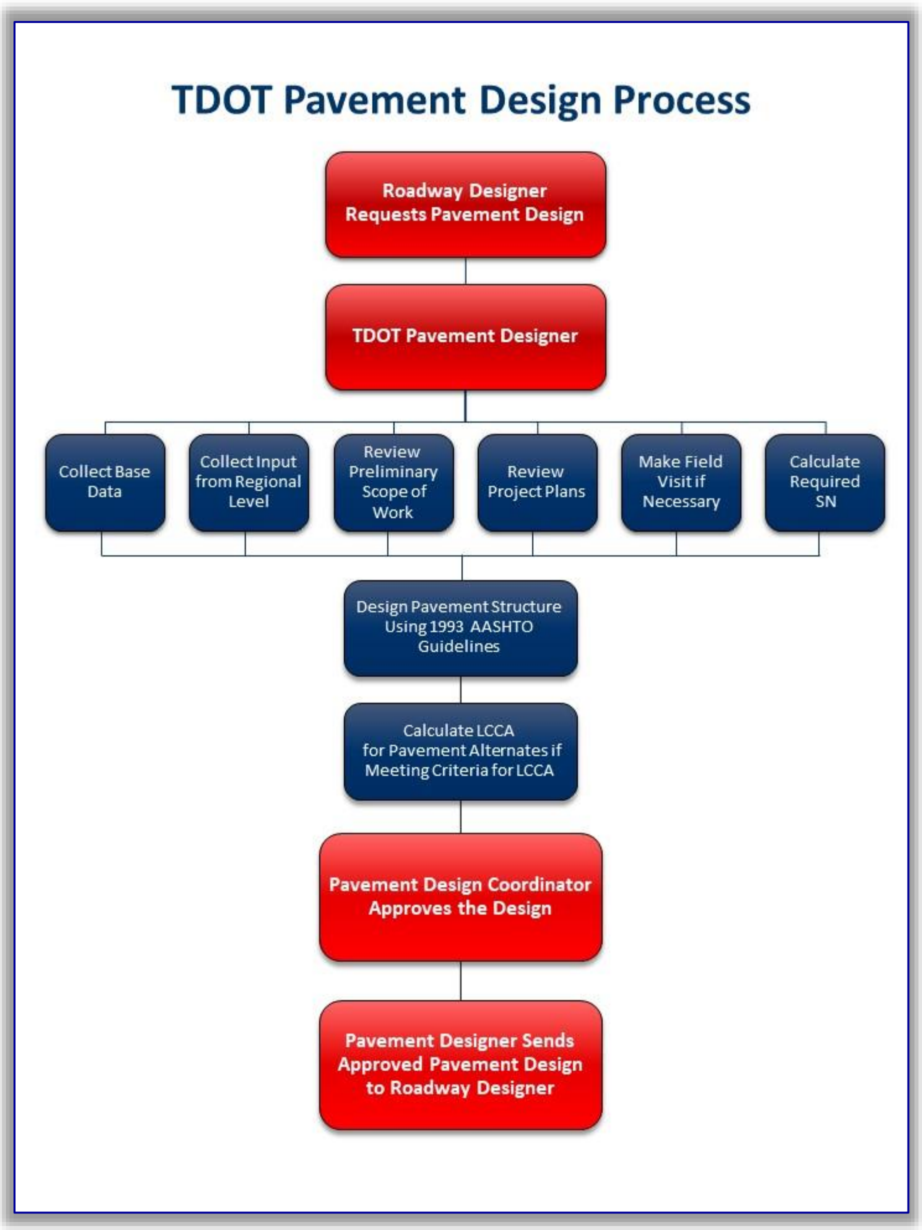


Figure 4-1: TDOT Pavement Design Process – New Construction

- Design the Pavement Structure – Using the data collected, the pavement designer will distribute layer thicknesses to meet the required SN. The layers should be designed to provide the most cost-effective design, while considering the logistics of construction procedures. *Sections 4.3 Flexible Design and 4.4 Rigid Design* provide further detail for the pavement design process. Pavement alternates may be considered for all new construction and reconstruction projects on Interstates, Federal Aid Primary Routes, and other major roadways. Pavement alternates will include asphalt pavements with base alternates as well as concrete pavements.
- Decisions regarding the use of alternative pavement designs are evaluated by the pavement design staff in the context of current TDOT criteria and policy.

- Calculate Life Cycle Cost Analysis (LCCA) for Pavement Alternates – The pavement designer will calculate life cycle cost analyses for the pavement alternates. Chapter 7 of this document describes in greater detail the process used to complete the LCCA.

4.2.3 Pavement Design Approval

The pavement designer will submit the pavement design and life cycle cost analysis to the Assistant Chief Engineer of Design for approval. Once the pavement design has been approved, the pavement designer will forward the approved design to the roadway design engineer who initiated the request. A copy of the pavement design will be kept on file.

4.3 Flexible Pavement Design

4.3.1 Design Input Parameters

The parameters listed in the following paragraph have been for use in calculating the required SN of flexible pavements. These parameters are input into a generic software that uses the *1993 AASHTO Guide for Design of Pavement Structures* to obtain a required SN. Two options for the generic software to be used are WinPAS and PaveXpress.

Pavement reliability is defined as the probability that a pavement section will perform satisfactorily over the design period; typical values used in the design process are 95% for Interstates and Principal Arterials to 90% for local streets and roads.

Overall standard deviation is a measure of the overall confidence the designer may have in the design inputs; TDOT utilizes 0.45 for new flexible pavement design. The range of S_O values provided in Part II (section 2.1.3 of the *1993 AASHTO Guide for Design of Pavement Structures*) are 0.40 – 0.50.

When using various softwares based on the 1993 AASHTO Guide, default values may be provided that are typically associated with the recommended values in the guide. For example, the 1993 AASHTO Guide states that the overall standard deviation for the case where the variance of projected future traffic *is* considered is 0.49 for flexible pavements; the value of 0.44 is used when the variance of projected future traffic is *not* considered.

Subgrade resilient modulus must also be calculated for the roadbed soil materials, this values is typically determined by some sort of index test if not measured directly, a reasonable estimate of resilient modulus (Mr (psi) is to use the relationship of Mr = 1,500 x CBR (California Bearing Ratio). The Pavement Service Ability Index (PSI) is also used in AASHTO 1993 pavement design, this index provides a relative measure of the condition of the roadway structure. The design process utilizes a drop of serviceability over the design life as an measure of performance, a typical change in PSI of 1.7 for most designs, this is determined from an initial serviceability of 4.2 and an final terminal serviceability of 2.5.

The final parameter utilized in the design process is a measure of the traffic over the design life. The concept of Equivalent Single Axle Loads (ESAL) is normally used, and this represents the accumulation of a number of standard axles over the pavement structure. Average annual daily traffic

(AADT), average daily load (ADL), and equivalent single axle loads (ESALs) typically are provided by the Strategic Transportation Investments Division.

4.3.2 Determining Pavement Thicknesses

Each component of the pavement structure is assigned structural credit. This structural credit is calculated using "a" layer coefficients. The "a" coefficient for each layer is multiplied by the layer thickness to establish the structural credit for that layer. The structural credit of each component is then combined to yield an actual SN. Table 4-2 identifies the TDOT established "a" layer coefficients. The "a" layer coefficients have been validated by research efforts from the University of Tennessee[1,2].

Table 4-2: "a" Layer Coefficients

Layer	**"a" Layer Coefficient**
Surface, Grading D	0.40
Surface, Grading E	0.40
Surface, Grading OGFC	0.30
Leveling, Grading C	0.40
Leveling, Grading C-S	0.40
Leveling, Grading C-W	0.40
Binder, Grading B-Mod-2	0.40
Binder, Grading B-Mod	0.40
Binder, Grading B	0.40
Black Base, Grading A	0.40
Black Base, Grading A-S	0.30
Black Base, Grading A-CRL	0.30
Mineral Aggregate Base Grading D	0.10/0.14*
Cement Treated Base	0.23
Lime Fly-Ash Base	0.28
Subgrade Treatment – Lime	0.08
Subgrade Treatment – Cement	0.15

* 0.14 will be used for limestone base in Regions 1 – 4. If limestone is not specified in Region 4, west of the Tennessee River, then 0.10 will be used.

Each pavement material type shown in Table 4-2 has specific gradations and maximum aggregate sizes that influence the ability to compact each layer to the required densities to provide adequate pavement performance. In order to achieve appropriate layer densities during construction, the following table illustrates the minimum and maximum asphalt layer thicknesses associated with each material type.

[1] Huang, Baoshan; Drumm, Eric; Laboratory Evaluation of Layer Structural Coefficients for HMA Pavements, *Volume 1 – Hot Mix Asphalt,* Knoxville: The University of Tennessee, March 2008

[2] Huang, Baoshan; Drumm, Eric; Laboratory Evaluation of Layer Structural Coefficients for HMA Pavements, *Volume 2 – Layer Coefficient and Index Properties of Base Materials,* Knoxville: The University of Tennessee, June 2005 – May 2007

Table 4-3: Asphalt Layer Thickness

ASPHALT LAYER THICKNESS				
TYPE AND GRADING	MAXIMUM NOMINAL AGG. SIZE	MAXIMUM AGGREGATE SIZE	MINIMUM LAYER THICKNESS	MAXIMUM LAYER THICKNESS
Black Base, Grading "A"	2"	2"	3"	4"
Black Base, Grading "A-S"	2"	2"	3"	4"
Black Base, Grading "A-CRL"	2"	2"	3"	4"
Binder, Grading "B"	1-1/2"	2"	3"	4"
Binder, Grading "B-Mod"	1'	1"	1-1/2"	2"
Binder, Grading "B-Mod2"	1-1/8"	1-1/8"	2"	2-3/4"
Surface, Grading "D"	1/2"	5/8"	1-1/8"	1-1/2"
Surface, Grading "E"	1/2"	5/8"	1-1/8"	1-1/2"

* Maximum nominal size is the first screen retaining any material as long as % passing first screen retaining material is 90% to 99%. Otherwise, maximum nominal size is same as maximum size.
** Maximum size is last screen through which 100% of material should pass.

4.3.3 Surface Courses

4.3.3.1 Surface, Grading D

This item is typically used on TDOT projects, unless an open-graded friction course (OGFC) is used. OGFCs have typically only been used in experimental applications. A 1.25-inch layer is the minimum thickness for OGFC, with a maximum layer thickness of 1.5 inches. Typically, a 1.25-inch layer is used for mainline surface course.

4.3.3.2 Surface, Grading E

This item is typically used for shoulder applications. A 1.25-inch layer is the minimum thickness, with a maximum layer thickness of 1.5 inches. Typically, a 1.5-inch layer is used for a shoulder surface course greater than 4 ft wide.

4.3.3.3 Surface, Grading OGFC

Open Graded Friction Courses (OGFC) were at one time used only as an experimental pavement surface application for locations with high wet-weather skidding crash histories or locations with high potential for hydroplaning. More recently, OGFCs have been gaining popularity, especially as mixture design issues contributing to severe raveling and degradation of the surface have been resolved. OGFCs have been shown to reduce tracking spray and backspray and now are being considered more frequently for high-speed applications such as interstates and other high-speed routes.

4.3.4 Leveling Courses

4.3.4.1 Leveling, Grading C

This item is typically used as a pure leveling course. Its main application is generally at the regional level. A 1.25-inch layer is the minimum thickness, with a maximum layer thickness of 1.5 inches.

4.3.4.2 Leveling, Grading C-S

This item is typically used as a surface leveling course prior to the use of an open-graded friction course.

4.3.4.3 Leveling, Grading C-W

This item is typically used as a wearing course. Its main application is generally at the regional level, and it is usually used on low-volume roads. A 1.25-inch layer is the minimum thickness, with a maximum layer thickness of 1.5 inches.

4.3.5 Binder Courses

4.3.5.1 Binder, Grading B-Mod-2

A 2-inch layer is the minimum thickness, with a maximum thickness of 2.75 inches.

4.3.5.2 Binder, Grading B-Mod

This item is generally used at the regional level. A 1.5-inch layer is the minimum thickness, with a maximum layer thickness of 2 inches.

4.3.5.3 Binder, Grading B

This item is generally used at the regional level. A 3-inch layer is the minimum thickness, with a maximum layer thickness of 4 inches.

4.3.6 Black Base Courses

4.3.6.1 Black Base, Grading A

This item is always used on TDOT projects. A 3-inch layer is the minimum thickness, with a maximum layer thickness of 4 inches.

4.3.6.2 Black Base, Grading A-S

This item serves as a drainage layer. It is typically used on 4-lane divided highways. Underdrains are used in conjunction with an A-S mix. If an A-S mix is used, it is followed by Black Base, Grading A > Binder, Grading B-Mod-2 > and Surface, Grading D. A 3-inch layer is the minimum thickness, with a maximum layer thickness of 4 inches.

4.3.6.3 Black Base, Grading A-CRL

This item serves as an asphalt-crack relief layer (A-CRL). It is a modification of the A-S mix and is used in crack and seat projects. Underdrains are used in conjunction with an A-CRL mix. A 3-inch layer is the minimum thickness, with a maximum layer thickness of 4 inches.

4.3.7 Aggregate Base

4.3.7.1 Mineral Aggregate Base Grading D

This item serves as the unbound aggregate layer. On most new construction projects, development of pavement designs begin with a minimum 10 inch aggregate layer for use with asphalt pavement designs. The thicknesses of the asphalt layers are then proportioned accordingly.

The starting thickness for some small projects and other unique situations such as interchange ramps may be less than 10 inches for this unbound aggregate layer, depending on site-specific considerations.

The mineral aggregate base layer has a minimum thickness of 4".

The pavement designer will either daylight the layer or specify to use underdrains. This will be based on project-specific conditions.

4.3.7.2 Treated Permeable Base

Treated base layers also may be used either to provide stability or drainability of the pavement structure. The minimum thicknesses for these layers typically is 4 to 6 inches.

The pavement designer will call for a 4" treated permeable base under concrete pavements. This item will serve as a drainage layer. Underdrains are used in conjunction with a treated permeable base.

Per Standard Specification Section 313, the contractor may elect to use either a cement treated or an asphalt treated permeable base.

4.3.7.3 Lime Fly-Ash Base

This item is used when alternate bases are bid. It consists of stabilizing the mineral aggregate with hydrated lime and fly ash. The pavement designer will consider the type of subgrade as well as any special requests from the region are taken when bidding lime fly-ash base.

4.3.8 Subgrade Treatment

Subgrades with low CBR values are generally treated with cement or other approved processes. A project level geotechnical report will recommend which material is appropriate for the soil encountered within the project limits.

4.3.9 Selecting Pavement Mixes

TDOT uses PG 64-22, PG 70-22, PG 76-22, and PG 82-22 performance grade asphalt binders. Figure 4-2 identifies when each binder grade is used.

Binder	Application
PG 64-22	• Routes where AADT < 10,000
PG 70-22	• Routes where AADT ≥ 10,000 (except as noted) • Specified NHI Routes (SR 5, SR 15, SR 22, SR 43)
PG 76-22	• All Interstates and Freeways
PG 82-22	• High Pavement Stress Locations • Selected Urban Interstate Projects with Extremely High Volumes • Very high volume areas with high % trucks • Intersections with large traffic volumes and/or high truck traffic

Figure 4-2: Selection of Performance Grade Asphalt Binder

4.4 Rigid Pavement Design

4.4.1 Input Parameters

The parameters listed in the following paragraphs are for use in calculating the required thickness of rigid pavements and required SN when asphalt shoulders are used. These parameters are input into a generic software that uses the *1993 AASHTO Guide for Design of Pavement Structures* to obtain a required SN.

Pavement reliability is defined as the probability that a pavement section will perform satisfactorily over the design period; typical values used in the design process are 95% for Interstates and Principal Arterials to 90% for local streets and roads.

Overall standard deviation is a measure of the overall confidence the designer may have in the design inputs; TDOT utilizes 0.35 for new rigid pavement design. The range of S_O values provided in Part II (section 2.1.3 of the *1993 AASHTO Guide for Design of Pavement Structures*) are 0.30 – 0.40.

When using various softwares based on the 1993 AASHTO Guide, default values may be provided that are typically associated with the recommended values in the guide. For example, the 1993 AASHTO Guide states that the overall standard deviation for the case where the variance of projected future traffic *is* considered is 0.39 for rigid pavements; the value of 0.34 is used when the variance of projected future traffic is *not* considered.

Subgrade resilient modulus must also be calculated for the roadbed soil materials, this values is typically determined by some sort of index test if not measured directly, a reasonable estimate of resilient modulus Mr (psi) is to use the relationship of Mr = 1,500 x CBR (California Bearing Ratio). The Pavement Service Ability Index (PSI) is also used in AASHTO 1993 pavement design, this index provides a relative measure of the condition of the roadway structure. The design process utilizes a drop of serviceability over the design life as an measure of performance, a typical change in PSI of 2.0 for most designs, this is determined from an initial serviceability of 4.5 and an final terminal serviceability of 2.5.

Two input parameters are required for PCC strength in the AASHTO design process, the first being elastic modulus. In addition, the PCC modulus of rupture is also utilized. A typical value for modulus of rupture is 663 PSI and a typical value for elastic modulus is 4,475,250 PSI.

Subgrade resilient modulus must also be calculated for the roadbed soil materials; this value is typically determined by some sort of index test if not measured directly.

The load transfer of rigid pavement structures is very important to the overall pavement performance. The 1993 AASHTO design guide outlines various load transfer coefficients ranging from a value of 2.7 for pavements with edge support and tied PCC shoulders to a value of 3.2 for pavements without edge support such as flexible HMA shoulders.

Rigid pavement designs are assigned a drainage coefficient which represents the relative loss of base material strength due to the drainage characteristics and the total time it is exposed to near-saturation conditions. Materials that are free draining, such as treated permeable bases, have a coefficient of 1.2 while slow draining base materials often remain saturated and would have a coefficient of 1.0.

Subgrade strength for rigid pavement design is determined by the Effective Modulus of Subgrade Reaction. This is a composite strength parameter which is determined by the subgrade resilient modulus combined with adjustments for the stiffness of base layers, presence of shallow rock, potential loss of slab support and seasonal variations. It is determined from the *1993 AASHTO Guide for Design of Pavement Structures*, Figure 3.3, pages II-39

Pavement Service Ability Index (PSI) is also used in AASHTO 1993 pavement design, this index provides a relative measure of the condition of the roadway structure. The design process utilizes a drop of serviceability over the design life as a measure of performance.

The final parameter utilized in the design process is a measure of the traffic over the design life, the concept of Equivalent Single Axle Loads (ESAL) is normally used, and this represents the accumulation of a number of standard axles over the pavement structure. Average annual daily traffic (AADT), average daily load (ADL), and equivalent single axle loads (ESALs) typically are provided by the Strategic Transportation Investments Division.

4.4.2 Portland Cement Concrete

This item serves as the PCC layer. The thickness will be derived from a generic pavement design software based on the 1993 *AASHTO Guide for Design of Pavement Structures*. The minimum thickness of portland cement concrete pavements is related to the size of any dowel bar reinforcement and maximum aggregate size. From a practical perspective, the minimum thickness of portland cement concrete pavements that are typically constructed for highway pavements ranges from 6 to 8 inches.

4.4.3 Aggregate Base

4.4.3.1 Mineral Aggregate Base Grading D

This item serves as the unbound aggregate layer. On concrete pavements, the thickness of mineral aggregate base has a minimum of 4 inches. The thickness of the mineral aggregate base will depend on the subgrade.

4.4.3.2 Treated Permeable Base

Treated base layers also may be used either to provide stability or drainability of the pavement structure. The minimum thicknesses for these layers typically is 4 to 6 inches.

The pavement designer will call for a 4" treated permeable base under concrete pavements. This item will serve as a drainage layer. Underdrains are used in conjunction with a treated permeable base.

Per Standard Specification Section 313, the contractor may elect to use either a cement treated or an asphalt treated permeable base.

4.4.4 LCCA – Asphalt Pavements

The maintenance cost for asphalt pavements will include:

- Pothole patching with hot mix asphalt.
- Cleaning and filling of asphalt surface cracks with an asphalt sealant material.
- All overlay of short sections (500 feet or less) will be with asphalt.
- Application of depressions, surface failures, and irregularities will be addressed prior to final surfacing.
- Removal and replacement of failed surfaces, including the removal and replacement of base material, will be addressed.
- Fog sealing with a light application of asphalt emulsion diluted with water to renew the old surface will be used to renew the existing surface if there is no need for structural overlay or resurfacing.
- Application of an asphalt scratch course to level surface depressions or ruts prior to placement of an overlay.

4.4.5 LCCA – Concrete Pavements

The cost for concrete pavements will include:

- Patching the surface by removing faulty surface sections, to include base or subgrade material, and replacing with portland cement concrete and base material
- Cleaning and sealing of both pavement and shoulder joints
- Slab stabilization
- Spall repair
- Asphalt and flyash underseals
- Replacement of load transfer and tie bars for joints

4.5 Other Features

- Staged paving will be used for all projects where low volumes and/or maintenance of traffic allows.
- The percentage of trucks in the design lane is determined from the traffic data.
- The pavement design will consider safety enhancements by addressing problem areas such as rough pavements, poor surface drainage, low skid resistant qualitiesm and other features.

4.6 Example Pavements

Examples of flexible and rigid pavement designs are included in Appendix 4. Pavement designs per this manual may be developed from the *1993 AASHTO Guide for the Design of Pavement Structures,* the *1998 Supplement to the AASHTO Guide for Design of Pavement Structures, Part II – Rigid Pavement Design and Rigid Pavement Joint Design,* or generic softwares predicated on these documents. Two generic softwares that are frequently used include PaveXpress, and WinPAS. The pavement designs presented in these examples have been developed using the 1993 AASHTO Guide directly. These examples include parameters for the following roadway types:

- Rural Interstate
- Urban Interstate
- Principal Arterial
- Collector/Local Road

5.0 Rehabilitation and Resurfacing

5.1 Introduction

Pavement rehabilitation projects include those projects that require a structural overlay design. Resurfacing projects include those projects that have been identified to replace the wearing course based on excessive roughness or surface cracking, inadequate superelevation, insufficient skid resistance, or excessively deformed pavement. This chapter addresses both rehabilitation and resurfacing projects.

5.2 Major and Minor Rehabilitation

On occasion, roadway segments are identified for which Rehabilitation is the next pavement treatment in the Pavement Management Program, following preventive maintenance. Rehabilitation is divided into two (2) categories: (1) Minor rehabilitation and (2) Major rehabilitation. Minor rehabilitation is necessary when repair costs to the pavement exceed the benefits derived from preventive maintenance treatments or when pavement structure needs to be increased. Major rehabilitation is necessary when the pavement deteriorates due to structural deficiencies or structural failure. Minor rehabilitation is limited to a pavement thickness of 2 ¾", with a possible milling depth of up to 1 ¼". Major rehabilitation requires a pavement thickness greater than 2 ¾", with a possible milling depth greater than 1 - ¼".

Since both types of rehabilitation (minor or major) encompass an extensive amount of work to elevate the pavement to an acceptable service level, as well as an excessive cost to perform the work, these treatments are typically delayed until sufficient funds can be set aside without having a significant impact to the resurfacing program. Therefore, these sections of roadway are generally addressed through routine maintenance until the funding for the extensive work can be obligated. Historically, each region will perform only one of these treatments (either minor or major rehabilitation) once every two to three years.

Looking forward, the Pavement Management office intends to develop a program for quantitatively identifying rehabilitation projects, but the necessary data is not available at this time.

5.2.1 Minor Rehabilitation Treatments

5.2.1.1 Flexible and Composite Pavement Treatments

- Leveling Course and Thin Overlay
- Binder Course and Thin Overlay
- Milling (≤1-1/4"), Leveling Course, and Thin Overlay
- Milling (≤1-1/4"), Binder Course, and Thin Overlay
- Performance Grade Leveling Course and Performance Grade Thin Overlay
- Performance Grade Binder Course and Performance Grade Thin Overlay

- Milling (≤1-1/4"), Performance Grade Leveling Course, and Performance Grade Thin Overlay
- Milling (≤1-1/4"), Performance Grade Binder Course, and Performance Grade Thin Overlay

5.2.2 Major Rehabilitation Treatments

5.2.2.1 Flexible and Composite Pavement Treatment

- Binder Course and Thin Overlay
- Milling (≥1-1/4"), Binder Course, and Thin Overlay
- Performance Grade Binder Course and Performance Grade Thin Overlay
- Milling (≥1-1/4"), Performance Grade Binder Course, and Performance Grade Thin Overlay

Some mixes which are used in addition to the wearing surface treatment can include the following: Binders - "B-M" or "B-M2" mix (1 ½" to 2" depth) or Leveling - "C-W" mix (1 ½" depth) or "CS" mix (5/8" depth).

5.3 Rehabilitation Strategies

Overlay design and rehabilitation strategies involve an intensive design process that require many considerations, as shown in Figure 5.1. Development of these designs and strategies requires experience, input from other divisions, and extensive use of engineering judgment.

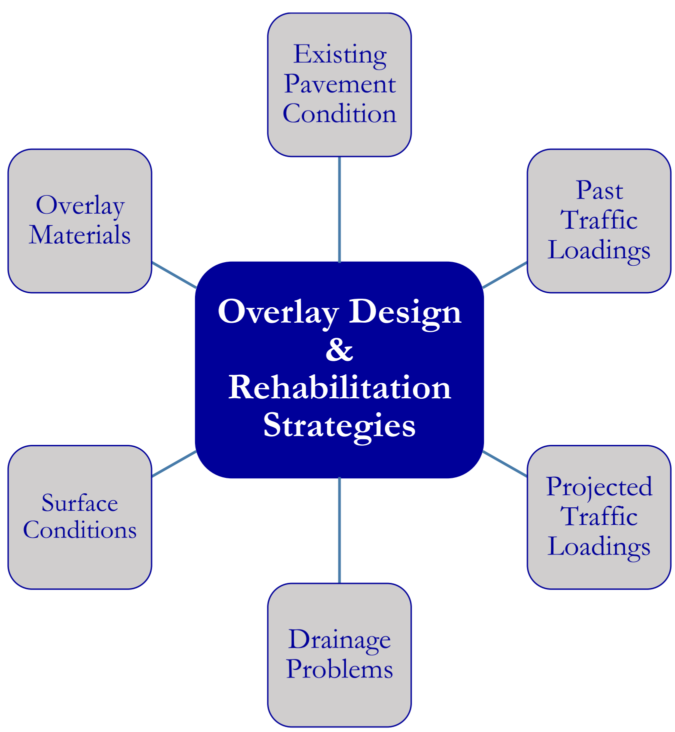


Figure 5-1: Considerations for Overlay Design & Rehabilitation Strategies

Another component of pavement rehabilitation projects could involve rehabilitation of the existing lanes for a section of roadway while widening the roadway adjacent to the existing pavement. Such a scenario may require unique design considerations to address vertical grade constraints for both the surface grade as well as matching elevations for pavement layers for the rehabilitated pavement and the adjacent pavement widening, which can be especially important in maintaining internal pavement drainage.

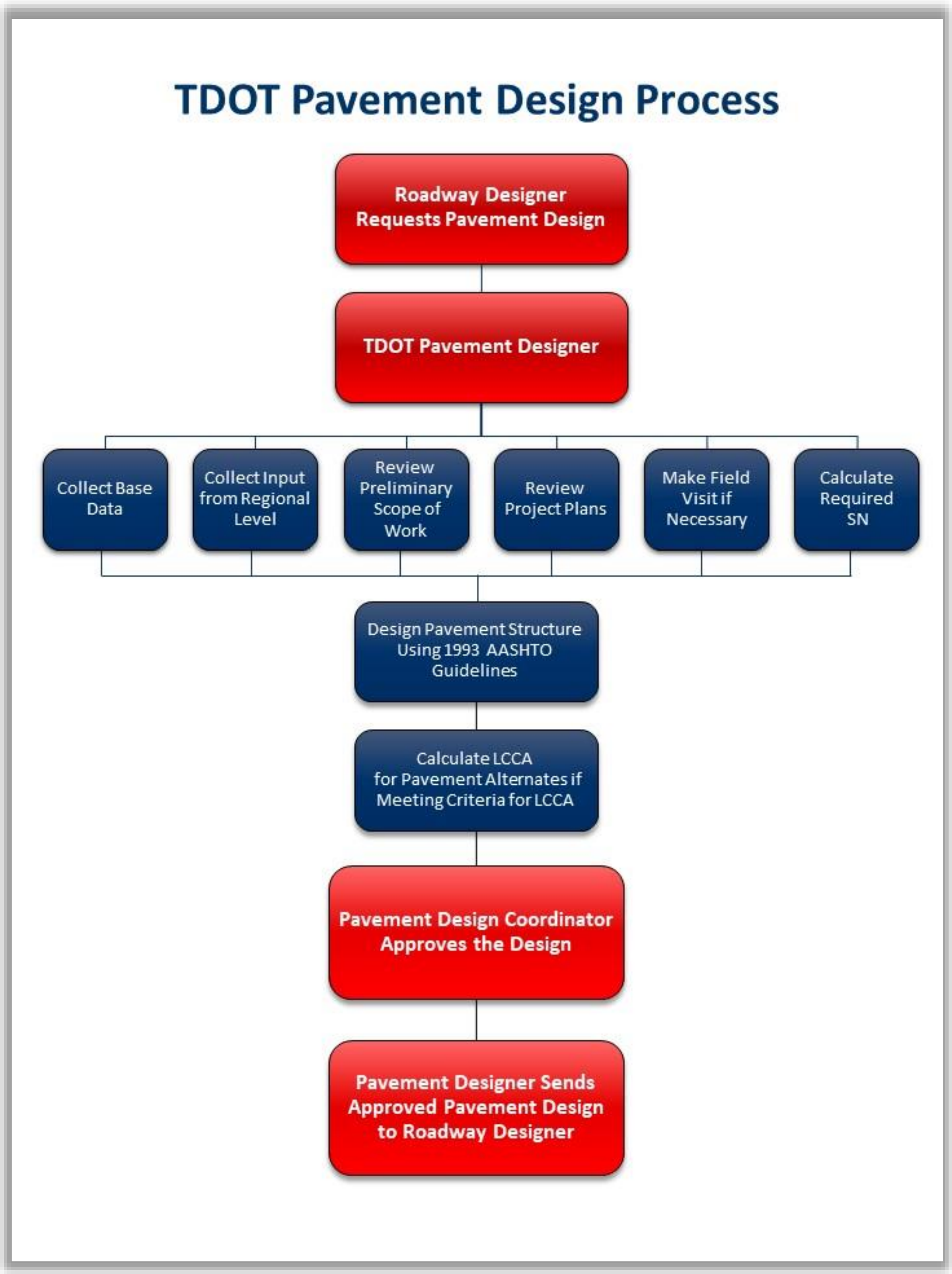


Figure 5-2: TDOT Pavement Design Process – Rehabilitation and Resurfacing

5.3.1 Design Process

Figure 5.2 details the administrative procedure for obtaining an approved pavement design for a rehabilitation project. The following sections further describe these steps.

5.3.1.1 Pavement Design Request

The rehabilitation pavement design will begin when the roadway design engineer completes the Pavement Design Request Form (Appendix 3) or upon receipt of the 4R listing of projects. The Pavement Design Request Form will be submitted to the Pavement Branch of the Roadway Design Division at TDOT.PavementDesign@tn.gov. A copy of the email will be placed in the project folder to document the submittal. The Planning Division will provide the listing of 4R projects.

5.3.1.2 Pavement Design

Once the pavement designer receives the Pavement Design Request Form (see Appendix 3) or the listing of 4R projects, the pavement designer will:

- Collect Base Data – Basic project data (traffic, soils, plan set, etc.) should be included on the Pavement Design Request Form. This data includes traffic, soils, plan set, whether traffic is to be maintained during construction, and type of project (new alignment, resurfacing, etc.). If data is not included with the form, then the pavement designer must request the missing information. Base data will be obtained from the various offices and divisions within TDOT responsible for collection and management of the respective data.
- Review Preliminary Scope of Work – The pavement designer will review the project scope of work.
- Research Past Plans – The pavement designer will research past project plans and pavement designs to determine the existing pavement structure.
- Make a Field Visit – If the project is a Federal-Aid project, a field review will be conducted. Participants in the review will include representatives from the Roadway Pavement Design Office, the Regional Director's Office, and the FHWA Office. On non-federally funded projects, the field review will be made based on a project-specific basis to gain a better understanding of existing project conditions.
- Inventory Existing Pavement Condition – For Federal-Aid projects, distress data will be obtained and used to define the existing pavement distresses. When distress data is collected during a field review, photographs of distresses are obtained for documentation of critical distresses that can influence the identification/selection of appropriate rehabilitation strategies. The inventory of existing pavement conditions will be completed consistent with current TDOT practices. Data from these inventories may be derived either from manual distress surveys or from automated distress survey methods.
- Request & Evaluate Various Testing, as necessary
    - Core Samples – The pavement designer will request core samples from the Geotechnical Engineering Section within the Materials and Tests Division. These

cores will be taken at locations representative of the entire project, as well as at distressed areas. A report of the core sample conditions will be supplied by Materials and Tests and will be maintained with the project file. Photographs of the cores may also be taken and stored with the project file. If split-tensile tests are performed on selected asphalt cores, the pavement designer will review the results. When evaluating cores, measurements should include:

- each bound layer
- each unbound layer

Cores should be inspected for hairline cracking and fractures within the core. Asphalt cores also should be inspected for stripping of the asphalt and determination of the asphalt layers. The underlying pavement layers – subbase and subgrade – also should be inspected and characterized.

- Rut Depth – The pavement designer will request and evaluate rutting depths. When rut depths are greater than 0.25 inches, the pavement designer will recommend corrective action, such as milling or applying a scratch course.

- Skidding – The pavement designer will review skid numbers for the project limits.

- FWD – For projects where FWD data is available, the pavement designer will review the results for the structural condition of the existing structure. When available, FWD data should be used to define the insitu structural condition of the existing pavement. FWD data should be evaluated to determine the insitu elastic module for the existing pavement structure. These insitu elastic modules are used to determine the "effective structural number (SN_{EXIST})" in the existing pavement.

- Collect Input – Collection of input data used for development of rehabilitation procedures and overlay designs will be coordinated with the Materials and Tests Division, the Regional Director where the work is being completed, Headquarters Construction Division, and the FHWA.

- Calculate the Required Structural Number (SN) – With project-level information (traffic, soils, existing pavement condition, etc.), the pavement designer will calculate the required structural number (SN) using the *1993 AASHTO Guide for Design of Pavement Structures*. The designer should use the design year traffic when calculating the required SN.

- Design the Pavement Structure – Using the data collected, and combined with the existing pavement SN, the pavement designer will distribute layer thicknesses to meet the required SN. The layers should be designed to provide the most cost-effective design, while considering the logistics of construction procedures. *Sections 4.3 Flexible Design* and *4.4 Rigid Design* provide further detail for the pavement design process. Where feasible, pavement alternates will be considered for all new construction and reconstruction projects on Interstates, Federal-Aid Primary Routes, and other major roadways. Pavement alternates will include asphalt pavements with base alternates as well as concrete pavements. A reconstruct option will also be considered if the pavement has been in place for a time period approaching the original design life.

- Calculate LCCA for Pavement Alternates, as necessary – The pavement designer will calculate life cycle cost analyses (LCCA) for the pavement alternates if necessary. As discussed in *Section 3.4 Life Cycle Cost Analysis,* an LCCA will not be required if the existing pavement is in sound condition and the cost to restore it to an acceptable level of service is minor compared to the cost of a new pavement structure or major rehabilitation. In general, the design for asphalt overlays is the thickness of asphalt associated with the difference between the required Structural Number (SN_{REQ}) and the effective Structural Number for the existing pavement (SN_{EXIST}).

  Overlays for concrete pavements, whether with asphalt or with concrete, are much more complex. In either situation, an assessment of the structural integrity of the existing pavement is essential. Once the structural integrity of the existing concrete pavement has been determined, methodologies presented in the *1993 AASHTO Guide for Design of Pavement Structures* may be used to determine alternative pavement overlay thicknesses using asphalt or concrete.

  Overlays for composite pavement sections are also complex and require a thorough analysis of the existing composite section to define insitu structural conditions. The *1993 AASHTO Guide for Design of Pavement Structures* may be used to determine overlay thickness. However, mechanistic-empirical procedures included in the AASHTOWare Pavement ME software may be more efficient for evaluating composite pavement sections and developing overlay thickness designs.

The design of overlays and rehabilitation strategies requires experience, input from other divisions, and extensive use of engineering judgement.

5.3.1.3 Pavement Design Approval

The pavement designer will submit the pavement design and life cycle cost analysis to the Assistant Chief Engineer of Design for approval. Once the pavement design has been approved, the pavement designer will forward the approved design to the roadway design engineer who initiated the request. A copy of the pavement design will be kept on file.

5.4 Overlay Design

Overlays are a primary rehabilitation strategy for extending the structural life of the pavement. Types of overlays include:

- Asphalt overlay over existing asphalt pavement
- Asphalt overlay over existing portland cement concrete – asphalt overlays over portland cement concrete may include the following:
  - Asphalt over fractured concrete (crack and seat; break and seat; rubblization)
  - Asphalt over non-fractured concrete with relief joints or other measures to minimize reflective cracking
- Portland cement concrete (PCC) overlays over existing PCC pavement

- Bonded PCC overlays are bonded to existing PCC pavement
- Unbonded PCC overlays include a material to prevent the PCC overlay from bonding with the existing PCC pavement. Typical bond-breaker materials include a dense-graded asphalt surface material

- Asphalt overlay over existing composite pavement section. A composite pavement section consists of both asphalt and PCC.

5.4.1 Overlays over Existing Asphalt Pavements

As with new construction and reconstruction design, the required structural number (SN) will be calculated using the *1993 AASHTO Guide for Design of Pavement Structures* to design flexible overlays. The SN attributed to the existing pavement structure will be determined from project-level testing to determine insitu pavement conditions, experience, and engineering judgment. The need to remove layers of existing pavement will be determined by the results of core samples, rut analysis, visual inspection, and falling weight deflectometer (FWD) data where available. The difference in the required SN and the existing SN will define the overlay thickness required.

5.4.1.1 Flexible Pavement Design Input Parameters – Rehabilitation Design

The parameters listed in the following paragraph have been for use in calculating the required SN of flexible pavements. These parameters are input into a generic software that uses the *1993 AASHTO Guide for Design of Pavement Structures* to obtain a required SN. Two options for the generic software to be used are WinPAS and PaveXpress.

Pavement reliability is defined as the probability that a pavement section will perform satisfactorily over the design period, typical values used in the design process are 95% for Principal Arterials to 90% for local streets and roads.

Overall standard deviation is a measure of the overall confidence the designer may have in the design inputs; TDOT utilizes 0.49 for rehabilitation flexible pavement design.

Subgrade resilient modulus must also be calculated for the roadbed soil materials, this values is typically determined by some sort of index test if not measured directly, a reasonable estimate of resilient modulus Mr (psi) is to use the relationship of Mr = 1,500 x CBR (California Bearing Ratio). The Pavement Service Ability Index (PSI) is also used in AASHTO 1993 pavement design, this index provides a relative measure of the condition of the roadway structure. The design process utilizes a drop of serviceability over the design life as an measure of performance, a typical change in PSI of 1.7 for most designs, this is determined from an initial serviceability of 4.2 and an final terminal serviceability of 2.5.

The final parameter utilized in the design process is a measure of the traffic over the design life, the concept of Equivalent Single Axle Loads (ESAL) is normally used, and this represents the accumulation of a number of standard axles over the pavement structure.

5.4.1.2 Rigid Pavement Input Parameters – PCC Overlays over Existing PCC Pavements

The parameters listed in the following paragraph have been for use in calculating the required SN of flexible pavements. These parameters are input into a generic software that uses the *1993 AASHTO Guide for Design of Pavement Structures* to obtain a required SN.

Pavement reliability is defined as the probability that a pavement section will perform satisfactorily over the design period. Typical values used in the design process are 95% for Interstates and Principal Arterials to 90% for local streets and roads.

Overall standard deviation is a measure of the overall confidence the designer may have in the design inputs; TDOT utilizes 0.39 for rehabilitation rigid pavement design.

Two input parameters are required for PCC strength in the AASHTO design process. A typical value for modulus of rupture is 663 PSI and a typical value for elastic modulus is 4,475,250 PSI.

Subgrade resilient modulus must also be calculated for the roadbed soil materials, this values is typically determined by some sort of index test if not measured directly, a reasonable estimate of resilient modulus Mr (psi) is to use the relationship of Mr = 1,500 x CBR (California Bearing Ratio).

The load transfer of rigid pavement structures is very important to the overall pavement performance. The 1993 AASHTO design guide outlines various load transfer coefficients ranging from a value of 2.7 for pavements with edge support and tied PCC shoulders to a value of 3.2 for pavements without edge support such as flexible HMA shoulders.

Rigid pavement designs are assigned a drainage coefficient which represents the relative loss of base material strength due to the drainage characteristics and the total time it is exposed to near-saturation conditions. Materials that are free draining, such as treated permeable bases, have a coefficient of 1.2 while slow draining base materials often remain saturated and would have a coefficient of 1.0.

Subgrade strength for rigid pavement design is determined by the Effective Modulus of Subgrade Reaction. This is a composite strength parameter which is determined by the subgrade resilient modulus combined with adjustments for the stiffness of base layers, presence of shallow rock, potential loss of slab support and seasonal variations. It is determined from the *1993 AASHTO Guide for Design of Pavement Structures*, Figure 3.3, pages II-39

Pavement Service Ability Index (PSI) is also used in AASHTO 1993 pavement design, this index provides a relative measure of the condition of the roadway structure. The design process utilizes a drop of serviceability over the design life as an measure of performance, a typical change in PSI of 2.0 for most designs, this is determined from an initial serviceability of 4.5 and an final terminal serviceability of 2.5.

The final parameter utilized in the design process is a measure of the traffic over the design life, the concept of Equivalent Single Axle Loads (ESAL) is normally used, and this represents the accumulation of a number of standard axles over the pavement structure.

5.4.2 Asphalt Overlays over Existing PCC Pavements

As with new construction and reconstruction design, the *1993 AASHTO Guide for Design of Pavement Structures* may be used to design rigid overlays.

Asphalt overlays over PCC pavements may be either (1) asphalt over fractured PCC or (2) asphalt over non-fractured PCC.

When designing asphalt overlays over fractured PCC, the SN for the fractured PCC may be estimated from literature or previous experience. Thereafter, design for the asphalt overlay follows the same procedures as used for designing an asphalt overlay over an existing asphalt pavement: $SN_{OL} = SN_{REQ} - SN_{EXIST}$. Typical layer coefficients associated with fractured PCC pavements are:

- Cracked and Seated PCC: 0.24 - 0.28
- Broken and Seated PCC: 0.18 - 0.24
- Rubblized PCC: 0.10 - 0.18

Design input parameters present in Table 5-1 should be used for designing asphalt overlays over fractured PCC pavements.

Chapter 5 – Rehabilitation Methods with Overlays, in the *1993 AASHTO Guide for Design of Pavement Structures*, may be used to determine asphalt overlay thicknesses over existing non-fractured PCC pavements.

5.4.3 PCC Overlays over Existing PCC Pavements

Chapter 5 – Rehabilitation Methods with Overlays, in the *1993 AASHTO Guide for Design of Pavement Structures*, also may be used to determine asphalt overlay thicknesses for PCC overlays over existing PCC pavements. Both bonded and unbonded PCC pavement overlays are addressed in Chapter 5.

With the transition from using the empirically based *1993 AASHTO Guide for Design of Pavement Structures* to using the mechanistic-empirically based AASHTOWare Pavement ME software for design of overlays, greater use of both destructive and nondestructive testing data may be more feasible.

5.4.3.1 Flexible Pavement Design Input Parameters – Rehabilitation Design

The parameters listed in the following paragraph are for use in calculating the required SN of flexible pavements. These parameters are input into a generic software that uses the *1993 AASHTO Guide for Design of Pavement Structures* to obtain a required SN.

Pavement reliability is defined as the probability that a pavement section will perform satisfactorily over the design period; typical values used in the design process are 95% for Interstates and Principal Arterials to 90% for local streets and roads.

Overall standard deviation is a measure of the overall confidence the designer may have in the design inputs. A typical value of 0.49 is used for rehabilitation design.

Subgrade resilient modulus must also be calculated for the roadbed soil materials. This value is typically determined by some sort of index test if not measured directly, a reasonable estimate of resilient modulus Mr (psi) is to use the relationship of Mr = 1,500 x CBR (California Bearing Ratio).

The Pavement Service Ability Index (PSI) is also used in AASHTO 1993 pavement design. This index provides a relative measure of the condition of the roadway structure. The design process utilizes a drop of serviceability over the design life as an measure of performance, a typical change in PSI of 1.7 for most designs. This is determined from an initial serviceability of 4.2 and a final terminal serviceability of 2.5.

The final parameter utilized in the design process is a measure of the traffic over the design life, the concept of Equivalent Single Axle Loads (ESAL) is normally used, and this represents the accumulation of a number of standard axles over the pavement structure.

5.5 Falling Weight Deflectometer (FWD) Data for Rehabilitation Design

Deflection testing provides a practical means of evaluating the insitu condition of pavement structures. Uses include:

- Determining individual pavement layer properties such as modulus of elasticity or overall pavement stiffness
- Measuring the load transfer efficiency of rigid pavements across joints and cracks
- Providing more efficient rehabilitation designs based on actual insitu conditions

The current state of practice for nondestructive testing of pavements uses a device termed the Falling Weight Deflectometer (FWD) to impart an impact load on the pavement structure and measures the resulting pavement surface deflections. Analysis of pavement deflections includes methodologies for using the measured deflections to backcalculate the insitu elastic layer module of the existing pavement layers.

5.5.1 FWD Testing

FWD testing should follow the current practice established by TDOT's Materials and Tests Division. General information regarding FWD Testing is further discussed in Sections 5.4.1.1 and 5.4.1.2.

5.5.1.1 FWD Testing Frequency

FWD testing frequency varies depending on the purpose of the testing (network-level testing would generally have test spacing at greater intervals than project-level testing). Network-level testing is typically performed on intervals of 500 – 1,500 ft, while project-level testing may be from 100 – 500 ft. For project-level testing, intervals should be determined based on the observed variability in pavement distress. In general, 30 tests should be used as a minimum if any statistical analysis is going to be performed for use in subsequent rehabilitation design. Testing patterns across the lane should generally adhere to the following guidelines:

Asphalt Pavements	•Test in the outer wheel path of the outer traffic lane
Concrete Pavements	•Test in the outer wheel path of the outer traffic lane for load transfer •In addition to center slab testing, testing of slab corners may be conducted to detect the presence of voids

Figure 5-3: FWD Testing Pattern Guidelines

5.5.1.2 Factors Impacting FWD Testing

There are a number of factors that can affect FWD testing results, which should be considered in order to collect data that matches the actual conditions the roadway experiences during normal use. These factors include climate, pavement structure, and condition and loading used for testing.

- Pavement temperature has a significant effect on the performance for both flexible and rigid pavements.
    - For flexible pavements, the stiffness of the asphalt layers increase with decreasing temperature. Therefore, corrections to a standard pavement temperature for FWD testing data are necessary prior to interpreting the test results.
    - For rigid pavements, the pavement temperature affects both the load transfer testing and the center slab deflection testing. Warmer temperatures tend to "lock up" the joints, which could provide a false measurement of load transfer efficiency. Due to these impacts on PCC pavements, it is generally recommended to conduct FWD testing of rigid pavements in the early morning and during periods of cooler weather throughout the year.
    - Climate may also have impacts on the support conditions beneath the roadway based on the underlying pavement layers being either frozen or saturated at various times throughout the year.
    - FWD data typically are normalized to a standard pavement temperature between 60°F and 90°F.
- Pavement structural thickness and condition may also have significant effects on resulting pavement deflections. Generally, some sort of field evaluation such as coring and/or Ground Penetrating Radar (GPR) testing is used to determine the actual structural layers present. Representative measurement of these layers is critical to providing reasonable backcalculation results that can be used for rehabilitation design. In addition, caution should be used while testing on severely distressed areas to ensure these values are representative of the overall pavement structure.
- Pavement loading should also be considered when conducting deflection testing. Generally, a 9,000 lb. load is used, which simulates the single tire load normally associated

with trucks using the pavement structures. However, care should be taken when testing very thick or very thin pavement structures to ensure reasonable, consistent results can be obtained.

5.5.1.3 Backcalculation Methods

5.5.1.3.1 Background

The utilization of deflection testing provides a practical means to evaluate the in-situ condition of pavement structures. It may be used as a means to determine individual pavement layer properties such as modulus or overall pavement stiffness. It may also be used in measuring the load transfer efficiency of rigid pavements. Results may be used to provide more efficient rehabilitation designs based on the actual in-situ conditions. The current state of practice utilizes the Falling Weight Deflectometer to impart an impact load on the pavement structure and measure the resulting pavement surface deflections.

5.5.1.3.2 Typical Testing Frequency

Testing frequency for FWD testing can vary depending on the purpose of the testing, network level testing would generally have test spacing at greater intervals than project level testing. Network level testing may be on intervals of generally 500 – 1,500 ft., while project level testing may be from 100 – 500 ft. For project level testing intervals should be determined based on the observed variability in pavement distress. In general 30 tests should be used as a minimum if any statistical analysis is going to be performed for use in subsequent rehabilitation design. Testing patterns across the lane generally follow the guidelines below.

Asphalt Pavements: Testing in the outer wheel path of the outer traffic lane

Concrete Pavements: Testing in the outer wheel path of the outer traffic lane for load transfer in addition to center slab testing, testing of slab corners may also be conducted to detect the presence of voids.

5.5.1.3.3 Factors Impacting Deflection Testing

There are a number of factors which impact deflection testing results, such as climate, pavement structure and condition and loading used for testing. Each of these factors should be considered when conducting deflection and analyzing the results of those tests. Attention to these factors is needed such that representative data is collected that matches as closely as possible to actual conditions the roadway endures during normal use.

Pavement temperature has a significant impact on both flexible and rigid pavements. For flexible pavements the stiffness of the asphalt layers increases with decreasing temperature. Therefore, corrections to a standard temperature are necessary prior to interpreting the test results. For rigid pavements the temperature impacts both the load transfer testing and the center slab deflection testing, warmer temperatures tend to “lock up” the joints providing a false measurement of load transfer efficiency. Due to these impacts on PCC pavements it is generally recommend to conduct FWD testing of rigid pavements in the early morning and during periods of cooler weather throughout the year. Climate may also have impacts on the support conditions beneath the roadway based on the underlying pavement layers being either frozen or saturated at various times throughout the year.

Pavement structural thickness and condition may also have significant impact on resulting pavement deflections. Generally, some sort of field evaluation such as coring and/or Ground Penetrating Radar (GPR) testing is used to determine the actual structural layers present. Representative measurement of these layers is critical to providing reasonable backcalculation results which can be used for rehabilitation design. In addition, caution should be used while testing on severely distressed areas to insure these values are representative of the overall pavement structure.

Pavement loading should also be considered when conducting the deflection testing, generally a 9,000 lb. load is used which simulates the single tire load normally seen on pavement structures. Care should be taken however when testing very thick or very thin structures to insure reasonable consistent results can be obtained.

5.5.1.3.4 Backcalculation Methods

In general, most backcalculation procedures involve matching the measured deflections collected in the field with a set of deflections determined based on linear elastic theory. There is no direct solution for a multi-layer pavement structure that would allow for direct calculation of individual layer moduli based on surface deflections. Therefore, most of the available backcalculation procedures utilize some type of optimization process to minimize the error between the measured deflections and the deflections determined based on layered elastic theory for an assumed set of pavement moduli.

There are more than 20 different backcalculation software programs which have been developed over the last 10 – 15 years. In addition, AASHTO has recently announced the development of a backcalculation process which is to be a companion for the PaveME AASHTO software. Each of these software programs have advantages and disadvantages based on how they are intended to be used. Many Highway agencies utilize the MODULUS program developed and supported by Texas A&M. Other agencies utilize similar software that may have been tailored to specific needs within their jurisdiction. In addition, various governmental agencies have software which has been developed for military operations such as PCASE, developed and supported by the Corps of Engineers. Fundamentally many of these software packages could be utilized, however, close attention must be paid on how they can be incorporated into the daily workflow within an agency.

Based on the information that is currently available it would be recommended that a review of the following software packages be conducted as part of the implementation of the AASHTO PaveME process. This will insure the most efficient implementation based on available resources and workflow within the DOT.

Modulus 6.0 – Texas A&M University

PCASE 2.09 -- Corps of Engineers

AASHTO Backcalculation Tool – AASHTO

LMOD by Dynatest Corporation

5.6 Resurfacing

The need to resurface a particular roadway mainly depends on three factors:

- Preventative maintenance
- Condition survey
- Deficiencies related to ride or safety

The primary means of identifying and justifying the need for major resurfacing is in terms of the degrading of the level of service the pavement provides to the motoring public.

Pavements will require resurfacing when:

- Roughness and surface cracking becomes excessive
- Superelevation is inadequate for the operating speed
- Skid resistance is insufficient
- Pavement is excessively deformed and "out of section"

Figure 4 below depicts TDOT's resurfacing delivery process, as illustrated on page 22 of TDOT's *Pavement Resurfacing Program Standard Operating Guidelines,* April 2018. The current version of the complete document is provided in Appendix 5. A sample set of resurfacing plans is included in Appendix 6.

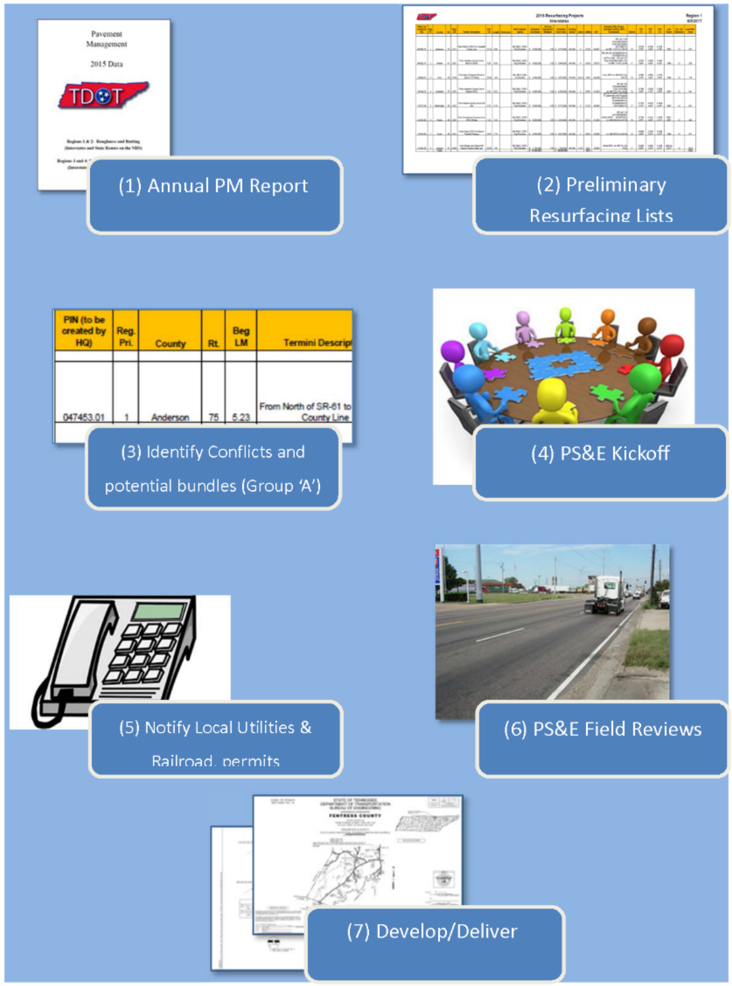


Figure 5-4: Resurfacing Delivery Process

6.0 Pavement Type Selection

6.1 Introduction

The selection of pavement type involves consideration of multiple factors, including traffic, soils, materials, construction, maintenance, and weather/environment. In some cases, the significance of one or more of these factors may override the others. However, pavement selection is not an entirely objective process and not every factor can be quantified.

In most cases, the pavement type selection is based on a comparison of alternate pavement designs consisting of different structural components. A cost estimate will be developed for each of the different pavement types, and for all major construction projects, a life cycle cost analysis will be performed.

6.2 Pavement Type Selection

The process of choosing the appropriate pavement type alternate will involve the factors that are documented in detail in Appendix B of the *1993 AASHTO Guide for Design of Pavement Structures*. These include:

1. Traffic
2. Subgrade soils or rock characteristics
3. Climatic considerations
4. Construction considerations
    a. Speed of construction, maintenance of traffic during construction, and seasonal limitations, etc.
5. Opportunities for recycling or reusing the existing pavement materials
6. Cost comparison
    a. Initial costs
    b. Life cycle costs

Initial costs can be an overriding factor when there are not adequate resources to build a more expensive structure and deferring the project is not desirable.

Life cycle costs should include not only the initial construction costs, but the costs to maintain the desired service level as well. Life cycle cost analysis cannot precisely anticipate future economic conditions or all maintenance requirements.

Other considerations that may influence selection of the pavement type are:

- Performance of other similar pavements in the area.

  - The performance of similar pavement in the area can be valuable when the projects have similar conditions (e.g., traffic, soil, number of lanes, etc.). However, those comparisons should be strongly considered only if the ESAL loading and material characteristics are also similar. In addition, reference pavements should be reevaluated periodically.

- Existing pavements adjacent to the design section.
  - Maintaining continuity of pavement type may simplify maintenance and rehabilitation activities, particularly when there are no major changes in conditions.
- Ease of maintenance.
  - A lower initial cost may result in higher maintenance costs or more complex or frequent maintenance activities, which have undesirable impacts on traffic.
- Are there locally available materials that might provide for a more economical pavement section?
- Are there locally available industries or contractor capabilities that may be a consideration?
- Is there a specific pavement type that can be constructed with lesser impacts to the traveling public during construction or that might influence other safety considerations, such as visibility for pavement markings, reflectivity of lighting, or driving lane and shoulder lane delineation?
- Opportunities for stimulating competition.
  - It is desirable to encourage healthy competition involved in the production of pavement materials, as competition helps to improve products and methods.
- Other preferences such as those that might be associated with participating local governments or municipalities.
  - The input of the community through citizen resource teams and other venues can weigh heavily on the decision making process.
- Evaluations for experimental features or conducting research in regard to specific paving materials, design concepts, and/or construction procedures.

The pavement design engineer will consider the following questions when selecting a pavement type:

- Are there overriding principal factors which dictate a pavement type?
- Have preliminary designs been developed for the appropriate pavement types (e.g., jointed plain concrete pavement with asphalt shoulders; jointed plain concrete pavement with tied concrete shoulders; asphalt/concrete with different bases)?
- Has a life cycle cost analysis been developed for the different pavement types?

- Have all of the secondary factors in pavement type selection been considered?

In cases where a pavement is being widened and the existing pavement is not being improved or changed, the widened pavement will typically be the same type as the existing. However, for special circumstances such as truck climbing lanes, auxiliary lanes between ramp termini, special loading conditions, etc., a different pavement type may be used for the widened lane.

On major interstate and NHS construction and/or rehabilitation projects, TDOT conducts life-cycle cost analyses on various pavement type and base alternates to determine the most cost effective pavement choice.

6.3 Conclusion

Selecting the most appropriate pavement type is not an absolute or exact science. The factors presented above are intended to provide the pavement engineer/designer with a general framework to guide them in their deliberations but is not intended to be either absolute or all-inclusive.

7.0 Life Cycle Cost Analysis

7.1 Introduction

A life cycle cost analysis is the most effective method of measuring the true cost effectiveness of different pavement alternates. Using this method equates the performance of each of the pavement alternates to a common base. By using the present and future costs of each alternate and by applying the future effects of inflation, various alternate designs can be analyzed on a common basis.

MAP-21 (the Moving Ahead for Progress in the 21st Century Act) requires agencies to incorporate life cycle cost analysis (LCCA) and risk-based analyses into their asset management plans for, at a minimum, pavements and bridges on the National Highway System (NHS). It encourages similar proactive management of other transportation assets (NCHRP Synthesis 494).

Life cycle cost analysis will be performed for all major construction projects (i.e., new constructions of interstates and four-lane divided highways).

To calculate the life cycle cost of each alternate, the following data will be used:

1. The type of pavement and its associated costs for construction.
2. The annual maintenance costs associated with the particular pavement type.
3. The maintenance intervals and rehabilitation actions for each alternative.
4. The performance life of the pavement type.
5. The discount (interest) rate for the costs involved.

Although life cycle cost analysis is a useful tool in selecting the pavement type, it must be balanced with engineering judgment and the other considerations for pavement type selection noted in Chapter 6.

7.2 Development of Alternative Pavement Designs

Developing alternative pavement designs typically involves preparing one or multiple asphalt designs and/or a portland cement concrete design for comparative analyses. Consider alternative pavement designs where specific project considerations indicate a need or when life cycle costs analyses indicate that multiple alternatives have similar life cycle costs. If alternative pavement types are bid but one alternative has a higher initial cost than another, it may be necessary to include an adjustment for life cycle cost in the bidding documents (“C Factor”).

When developing alternative pavement designs, take care to ensure that a specific maintenance of traffic is tailored to each pavement type. Paving summaries and typical sections should clearly detail each pavement type being bid.

Candidate projects for alternate pavement types should be evaluated using the following criteria:

- Pavement type selection analysis should always be conducted on the following types of paving construction projects:
    - New interstate or freeway construction or reconstruction projects where work includes a modification to the base or subbase.
    - Four-lane divided highways on new alignment.
    - Two-lane highways converted to four lanes plus a median with less than 15 access points per mile.
    - Other roadways where there is a reasonable expectation that either concrete or asphalt pavement will be competitive.
- Although truly equivalent pavement designs are difficult, if not impossible, to develop, pavement designs for alternate pavement types should be as close to equivalent as practical. Equivalent does not mean that the depth of the pavement structure is equal, but that the pavements are designed to perform equally, and provide the same level of service, over the same performance period.
- In cases where a pavement is being widened and the structure of the existing pavement is not being improved, the widened pavement will be the same type as the existing.

The highway engineer or administrator has the difficult job of balancing the needs of the motoring public and the community with available taxpayer dollars, without an absolute or undisputable method for determining the type of pavement which should be selected for a given set of conditions. Many non-cost factors must be weighed as decisions are made. Though technical calculations may support one pavement type over another, overriding principal factors may dictate the pavement type.

7.3 Rehabilitation Cycles

Asphalt Pavements

Rehab #1 at 10 years =	mill 1.25" and fill 1.25" D
Rehab #2 at 20 years =	mill 1.25" and fill 1.25" D
Rehab #3 at 30 years =	mill 1.25" and fill 1.25" D

Concrete Pavements

Rehab #1 at 15 years =	Full depth repair (1%), partial depth patching (1%) and reseal joints
Rehab #2 at 30 years =	Full depth repair (2%), partial depth patching (2%), and reseal joints

7.4 Cost Information

Agency costs are the anticipated initial costs and future rehabilitation costs expended by the Agency for constructing and maintaining the facility. These costs do not include any costs associated with user delay during initial construction or subsequent maintenance activities.

Initial costs are based on the construction cost, which is estimated by referring to historic data and agency cost estimates.

7.5 Analysis Period

The analysis period for all life cycle cost analyses shall be 40 years. There may be instances where the analysis period may be adjusted due to budgetary constraints or other circumstances. Typically, life cycle cost analyses are based on a 40-year analysis period. Analysis periods of fewer than 30 years would not adequately reflect a long-term comparative analysis of alternatives. Conversely, forecasting performance for alternatives for a period of greater than 50 years is not easily or practically determined and thus, analysis periods of greater than 50 years are not recommended.

7.6 Salvage Value

The salvage value of any pavement type is defined as the useful value of that pavement structure at the end of its life. For all life cycle cost analyses, the salvage value of all pavements should be defined as zero.

7.7 Discount Rate

A discount rate of 3 - 5% will be used to compare alternates for all life cycle cost analyses. The discount rate used for life cycle cost analyses should reasonably reflect the time value of money over the course of the analysis period. Historically, discount rates on the order of 3 -5% have been used for life cycle cost analyses, as it represents the prevailing interest of U.S. Government 10-Year Treasury Notes.

7.8 Examples

The examples below detail a typical life cycle cost analysis for asphalt and concrete pavements.

Table 7-4: Example of Life Cycle Cost Analysis – Asphalt with Aggregate Base

Alternate A (Asphalt w/ Aggregate Base)							New Pavement Design
Activity	**Year**	**Costs ($/LF)**	**LCC Factor**	**Discounted Cost* ($/LF)**	**Mainline Paving (LF)**	**"C" Factor**	**LCC (Net Present Value)**
Initial Construction	0	304.03	1.0000	304.03	31544		$9,590,322
Rehab #1	10	32.23	0.6756	21.77	31544	$686,821	$686,821
Rehab #2	20	32.23	0.4564	14.71	31544	$463,992	$463,992
Rehab #3	30	32.23	0.3083	9.94	31544	$313,456	$313,456
Salvage Value	40	0	0.2083	0.00	31544	$0	$0
Total Net Present Value (NPV)				**$350.45**			**$11,054,591.49**
Total "C" Factor						**$1,464,269**	

* Based on average unit bid cost

Based on the following:		**Initial const. PG64-22**
Life cycle (years) =	40	**Design includes 13' outside lane**
Discount rate (%) =	4.0	
Rehab #1 at 10 years =	mill 1.25" and fill 1.25" D	**PG70-22**
Rehab #2 at 20 years =	mill 1.25" and fill 1.25" D	**PG70-22**
Rehab #3 at 30 years =	mill 1.25" and fill 1.25" D	**PG70-22**

Table 7-5: Example of Life Cycle Cost Analysis – Cement Treated Base with Asphalt Shoulders

Alternate B (Cement Treated Base w/Asphalt Shoulders)				Two Direction			
Activity	Year	Costs ($/LF)	LCC Factor	Discounted Cost ($/LF)	Mainline Paving (LF)	"C" Factor	LCC (Net Present Value)
Initial Construction	0	668.53	1.0000	668.53	9050		$6,050,197
Rehab #1	10	77.55	0.6756	52.39	9050	$474,130	$474,130
Rehab #2	20	77.55	0.4564	35.39	9050	$320,305	$320,305
Rehab #3	30	77.55	0.3083	23.91	9050	$216,387	$216,387
Salvage Value	40	0	0.2083	0.00	9050	$0	$0
Total Net Present Value (NPV)				**$780.22**			**$7,061,017.44**
Total "C" Factor						**$1,010,821**	

Based on the following:

Life cycle (years) = 40

Discount rate (%) = 4.0

Rehab #1 at 10 years = mill 1.25" and fill 1.25" D

Rehab #2 at 20 years = mill 1.25" and fill 1.25" D

Rehab #3 at 30 years = mill 1.25" and fill 1.25" D

***PG 76-22**

**** Design includes 13' outside lane**

Table 7-6: Example of Life Cycle Cost Analysis – Concrete with Aggregate Base

Alternate D (Concrete w/ Aggregate Base)				Two Direction			
Activity	Year	Costs ($/LF)	Discount Factor	Discounted Cost ($/LF)	Mainline Paving (LF)	"C" Factor	LCC (Net Present Value)
Initial Construction	0	851.00	1.0000	851.00	9050		$7,701,550.00
Rehab #1	15	31.19	0.5553	17.32	9050	$156,734.23	$156,734.23
Rehab #2	30	38.30	0.3083	11.81	9050	$106,868	$106,867.88
Rehab #3	0	0.00	1.0000	0.00	9050	$0	$0.00
Salvage Value	40	0.00	0.2083	0.00	9050	$0	$0.00
Total Net Present Value (NPV)				**$880.13**			**$7,965,152.11**
Total "C" Factor						**$263,602**	

Based on the following:

Life cycle (years) = 40

Discount rate (%) = 4.0

Rehab #1 at 15 years = Full depth repair (1%), partial depth patching (1%) and reseal joints

Rehab #2 at 30 years = Full depth repair (2%), partial depth patching (2%), and reseal joints

***** Design includes non-polishing aggregate, 14' joint spacing, and 13' outside lane**

Table 7-7: Example of Life Cycle Cost Analysis – Concrete with Cement Treated Base

Alternate E (Concrete w/ Cement Treated Base)				Two Direction			
Activity	**Year**	**Costs ($/LF)**	**Discount Factor**	**Discounted Cost ($/LF)**	**Mainline Paving (LF)**	**"C" Factor**	**LCC (Net Present Value)**
Initial Construction	0	854.19	1.0000	854.19	9050		$7,730,419.50
Rehab #1	15	31.19	0.5553	17.32	9050	$156,734.23	$156,734.23
Rehab #2	30	38.30	0.3083	11.81	9050	$106,868	$106,867.88
Rehab #3	0	0.00	1.0000	0.00	9050	$0	$0.00
Salvage Value	40	0.00	0.2083	0.00	9050	$0	$0.00
Total Net Present Value (NPV)				**$883.32**			**$7,994,021.61**
Total "C" Factor						**$263,602**	

Based on the following:

Life cycle (years) = 40

Discount rate (%) = 4.0

Rehab #1 at 15 years = Full depth repair (1%), partial depth patching (1%) and reseal joints

Rehab #2 at 30 years = Full depth repair (2%), partial depth patching (2%), and reseal joints

***** Design includes non-polishing aggregate, 14' joint spacing, and 13' outside lane**

8.0 Shoulder Design

8.1 Introduction

The shoulder is that portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles for emergency use. Parked traffic is estimated at 0.05 to 0.1 percent of mainline (traveled-way) traffic. Traffic used to design the shoulders will be at least 2% of the mainline traffic. Shoulders with additional structural capacity may be used at the discretion of the pavement designer where heavy loads may be more apt to use the shoulder. The shoulder is generally referred to as the paved section next to the mainline.

Shoulders provide lateral support of the base and surface courses of the mainline, promote surface drainage, provide a temporary lane for occasional peak traffic use, and delineate the edge of the roadway. Some shoulders are used under peak traffic conditions or as alternate lanes during bridge or highway construction. All shoulders are used by maintenance traffic.

Shoulders should be durable, compatible with the adjacent mainline pavement, strong enough to handle heavy truck encroachment, endure maintenance traffic, and be on the same maintenance schedule as the mainline. They should provide lateral support for the mainline with either a maintainable joint at the mainline, or ideally, no joint next to the mainline.

The shoulder will be designed using the information supplied for the mainline pavement design (See Section 4.2 Pavement Design Process.)

The use of alternate shoulder pavement types will be designed on a case-by-case basis. Flexible shoulders can be designed to accompany either a flexible or rigid mainline pavement design.

8.2 Flexible Shoulder Design

8.2.1 Shoulders 4 ft or Greater in Width

For paved shoulders 4 ft or greater in width, the shoulder will be designed for 2% of the mainline traffic. The process documented in Section 4.3.1 Design Input Parameters and 4.3.2 Determining Pavement Thicknesses should be followed for establishing a minimum required SN and an actual SN for the shoulder. Typically, a 1.5-inch layer is used for a shoulder surface course. A Surface, Grading E course is typically used when the total shoulder quantity allows. If the total quantity does not allow, a Surface, Grading D course is typically used.

The surface grading course on the shoulder should be a lower type, or equal, to that of the mainline surface grading course.

The overall thickness of the flexible shoulder should be equal to the overall thickness of the mainline pavement design (either flexible or rigid).

If shoulders are to be used for MOT during construction or other extended periods of time with mainline traffic, they may be designed to accommodate up to 20% of the mainline traffic.

8.2.2 Shoulders Less than 4 ft

For shoulders less than 4', the surface shall be stone and double bituminous surface treatment or paved with the mainline pavement design. This range in minimum shoulder design is for constructability purposes.

A Surface, Grading E course is typically used when the total shoulder quantity allows. If the total quantity does not allow, a Surface, Grading D course typically is used.

When used, the surface grading course on the shoulder should be a lower type, or equal, to that of the mainline surface grading course.

The overall thickness of the flexible shoulder should be equal to the overall thickness of the mainline pavement design (either flexible or rigid).

8.2.3 Selecting Pavement Mixes

Regardless of shoulder width, the shoulder will use a PG 64-22 performance grade asphalt binder.

8.2.4 Scored Rumble Strips

When scored rumble strips are required (Roadway Design Guidelines Section 4-716.15), flexible shoulders must have a minimum depth of 1.5 inches to construct.

8.3 Rigid Shoulder Design

Rigid pavements may be designed with either tied concrete pavement shoulders or with asphalt and aggregate shoulders. The 1993 AASHTO design guide outlines various load transfer coefficients ranging from a value of 2.7 for pavements with edge support and tied PCC shoulders to a value of 3.2 for pavements without edge support. For tied concrete paved shoulders, the thickness shall be equal to that of the mainline pavement design. For asphalt and aggregate shoulders, the pavement design will be based on 2% of the mainline traffic unless the shoulder will be used for maintenance of traffic, in which case the design will be based on 20% of the mainline traffic.

8.4 Urban Areas

In urban areas, consideration will be given to the use of full depth paving for the paved shoulder width. This will allow for use of the shoulder as a traffic lane if needed for future capacity, for maintenance of traffic during construction, or for future pavement rehabilitation activities.

9.0 Bridge Approaches

9.1 Introduction

The roadway designer will be responsible for the pavement design on bridge replacement projects for projects with an Average Daily Load (ADL) of less than 150.

9.2 Pavement Design

The pavement design for these bridge replacement projects can be obtained by using the County Soils Groupings shown in Table 9-1. Use the soil grouping number (from Table 9-1), in conjunction with the ADL, to obtain the Pavement Design Number from Table 9-2. The Pavement Design Number can then be used in Table 9-3 to get the pavement design for the bridge replacement project.

ADL's will not be provided when ADT's are ≤ 1,000 and percent trucks is ≤ 7%. In this case, use Pavement Design No. IV for ADT's ≤ 200 and Pavement Design No. I for ADT's > 200 but ≤ 1,000. Design year ADT's should be used.

When the existing road is crushed stone base only or base and double bituminous surface treatment, the roadway surface shall be replaced in kind.

9.3 Shoulder Design

For shoulders greater than 4 ft, the shoulder shall be paved with 1.25 inches of surface grading D-mix.

For shoulders 4 feet or less, the shoulder shall be stone and double bituminous surface treatment or paved with 1.25 inches of surface grading D-mix. This will be determined during a field review.

When used, the surface grading course on the shoulder should be a lower type, or equal, to that of the mainline surface grading course.

9.4 Example Designs for Bridge Approaches

9.4.1 Example 1 – ADL Provided

The designed has a bridge replacement project in Hamblen County with an ADL of 53. Use Table 9-1 to obtain the County Soil Grouping of 2 for Hamblen County. Then, using Table 9-2, look at Soil Group 2 for ADLs 40-59 to obtain a Pavement Design Number I. Finally, use Table 9-3, to obtain the pavement design (1.25" Surface Grading D-mix, 2.00" Binder Grading B-M2, 3.00" Black Base Grading A-mix, 8.00" Mineral Aggregate Base Grading D).

9.4.2 Example 2 – ADL Not Provided

The designed has a bridge replacement project in Hamblen County with an ADT of 874 and 5% trucks. Since the ADT and truck percentage are low, no ADL is given. Using Table 9-3, Pavement Design Number I will be used to obtain the pavement design (1.25" Surface Grading D-mix, 2.00" Binder Grading B-M2, 3.00" Black Base Grading A-mix, 8.00" Mineral Aggregate Base Grading D).

Table 9-8: County Soil Groupings

County	Group	County	Group	County	Group
Anderson	2	Hamilton	3	Morgan	4
Bedford	3	Hancock	6	Obion	5
Benton	2	Hardeman	3	Overton	6
Bledsoe	6	Hardin	2	Perry	3
Blount	4	Hawkins	6	Pickett	5
Bradley	1	Haywood	4	Polk	5
Campbell	4	Henderson	3	Putnam	6
Cannon	4	Henry	3	Rhea	1
Carroll	4	Hickman	4	Roane	4
Carter	6	Houston	6	Robertson	4
Cheatham	3	Humphreys	5	Rutherford	6
Chester	4	Jackson	6	Scott	2
Claiborne	2	Jefferson	4	Sequatchie	3
Clay	6	Johnson	6	Sevier	1
Cocke	5	Knox	4	Shelby	5
Coffee	4	Lake	3	Smith	3
Crockett	4	Lauderdale	4	Stewart	5
Cumberland	5	Lawrence	5	Sullivan	4
Davidson	3	Lewis	4	Sumner	3
Decatur	3	Lincoln	3	Tipton	5
Dekalb	3	Loudon	6	Trousdale	4
Dickson	6	McMinn	3	Unicoi	6
Dyer	5	McNairy	4	Union	5
Fayette	5	Macon	4	Van Buren	5
Fentress	2	Madison	4	Warren	5
Franklin	4	Marion	3	Washington	4
Gibson	5	Marshall	4	Wayne	5
Giles	5	Maury	5	Weakley	4
Grainger	6	Meigs	3	White	4
Greene	5	Monroe	3	Williamson	3
Grundy	2	Montgomery	4	Wilson	2
Hamblen	2	Moore	3		

Table 9-9: Pavement Design Number

FLEX ADLs	County Soil Group Number					
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
1 - 19	I	I	III	III	III	IV
20 - 29	I	I	I	I	III	III
30 - 39	I	I	I	I	I	III
40 - 59	II	I	I	I	I	I
60 - 89	II	II	I	I	I	I
90 - 119	II	II	II	I	I	I
120 - 150	II	II	II	II	I	I

Table 9-10: Pavement Design

Mix Type	Pavement Design Number			
	I*	II	III	IV**
Surface Grading D	1.25”	1.25”	1.25”	1.25”
Binder, Grading B-Mod-2	2.00”	2.00”	2.00”	2.00”
Black Base, Grading A	3.00”	3.00”	-	-
Mineral Aggregate Base Grading D	8.00”	10.00”	12.00”	8.00”

* When ADL’s are not provided, this design will be used for ADT’s > 200 but ≤ 1,000.
** When ADL’s are not provided, this design will be used for ADT’s ≤ 200.

10.0 Subsurface Pavement Drainage

10.1 Introduction

This chapter provides general guidance on the design of edgedrain and underdrain systems to provide positive drainage for pavements.

Pavement drainage is critical to pavement performance. The NCHRP Synthesis 239, Pavement Subsurface Drainage Systems, states that based on a national survey, drained and maintained pavements last up to twice as long as undrained pavements. It also found that maintenance and overlays do not greatly improve the life of pavements that do not have good subsurface drainage.

Because there is no way of stopping water from infiltrating the pavement surface, removal of that water is essential to extending the life of the pavement. The main purpose of subsurface drainage is to remove water as quickly as possible. When granular layers beneath a flexible pavement surface become saturated with water and are not allowed to drain, they become weak. Since the granular layer is a structural component of a flexible pavement system, this weakens the entire structure, causing higher than average damage from each vehicle load (i.e., premature failure). For rigid pavements, water trapped beneath slabs may lead to pumping at the joints and loss of material (voids) beneath the slab. This in turn may lead to loss of support and premature failure of the pavement.

10.2 Basic Pavement Drainage Guidelines

10.2.1 Drainage Design Issues

Underdrains are perforated or porous pipes, installed in narrow trenches and surrounded by crushed stone or underdrain filter material that is both pervious to water and capable of protecting the pipe from infiltration by the surrounding soil. They are used to lower the groundwater level, drain slopes, prevent ground water from entering the pavement, and remove surface water that enters the pavement.

Edgedrains, on the other hand, primarily serve to remove surface water that enters the pavement. Often the terms underdrains and edgedrains are used interchangeably, since they both drain the pavement and are located at the edge of the pavement. The edgedrain systems discussed in this chapter mainly serve to remove surface water, but since they also drain the area below the subgrade surface, they act as underdrains.

Edgedrains or underdrains may be installed without pipes; however, the stone and pipe combination is preferred since it gives protection against the pipe becoming crushed during construction or clogged during use, since the water can freely flow through either the stone or the pipe. The outlet trench should always use a stone and pipe combination, so it will quickly disperse water from the edgedrain.

After a period of time, the underdrain filter material (crushed stone) becomes a natural filter for the underdrain and a geotextile is not necessary. However, there may be instances where a geotextile should be used to wrap the underdrain or edgedrain trench, such as in fine silty subgrade soil or other poor subgrade soil conditions. More detailed design procedures may be found in FHWA Publication

HI-95-038, Revised 1998, NHI Course No. 13213, Geosynthetic Design and Construction Guidelines - Participant Notebook.

Because subbase material is well graded for maximum strength, it is considered to be impermeable compared to the permeable base layer, so water tends to accumulate on the subbase surface. Since a permeable base layer is used in new construction projects, all runoff that enters the pavement section should drain quickly to the edgedrain and then to the outlets. Water that cannot be absorbed into the subbase or exit through the edgedrains will pool in the permeable base layer or the bound layers above and become a bathtub section, causing premature road distress.

Locate outlets and shallow pipes well away from areas of expected future surface maintenance activities such as sign replacement and catch basin clean out or repair.

10.2.2 Drainage Construction Issues

All subsurface drainage designs should be reviewed for constructibility. The following construction problems, along with a suggested solution, should be considered when designing the drainage system:

- Poor grades can leave water pooled in the pipes (check drainage profiles).
- Guiderail and sign posts driven through drains (show guiderail and post locations on typical sections).
- Pipes and other parts of the system crushed and collapsed during construction (include video inspection).
- Inadequate or altered drainage outlet spacings (specify outlet spacing on plans).
- Bad or poor headwall connections.
- Improper use of connectors such as T-connectors used on grades.
- High ditch lines that do not allow proper drainage from outlets (include outlet location table).
- Outlets that have been left out altogether.
- Deep ditch lines that drain well but are not traversable or trap vehicles.

Drainage inspection may be included on projects. Once the pavement is finished, it will be difficult to repair or replace the drainage system and the pavement life may be reduced. Drainage inspection may include either using video inspection or simply pouring water on the drainage layer and checking the outflow.

Maintaining an open drainage aggregate is critical during the remaining construction period. A shovelful of fines can clog the drain. The drainage system should be protected from fouling until the pavement section is complete. If a contamination problem is anticipated, geotextile can be placed over the edgedrain to catch fines; this should be shown in the edgedrain details.

10.2.3 Drainage Maintenance Issues

A well-designed and constructed subsurface drainage system will not perform properly without adequate maintenance. Realistically though, drainage systems will receive little or no maintenance over the life of the pavement, so they should be designed to last as long as possible and to be as maintenance free as practical. By the time pavement distress is identified, the subgrade and subbase usually have already failed and the problem cannot be corrected without removing the pavement. A poor design can be corrected during construction if a deficiency is recognized, but maintenance can seldom correct a poor design.

The combination of vegetative growth, debris, and fines discharging from the edgedrains can eventually plug the outlet pipe. Rodent nests, mowing clippings, and sediment collecting on rodent screens at the headwalls are common maintenance problems. However, outlets often cannot be located or maintained because they are hidden by vegetative growth. The use of outlet markers will alleviate this problem.

Inadequately designed outlet aprons will be rutted easier when mowers travel over them during saturated conditions, blocking the outlet. Some outlets are so plugged that water gushes from the pipes when the obstructions are removed. Therefore, make sure the outlets are adequately designed.

When flexible tubing is used for edgedrains, the pipe will not be perfectly straight. The pipe may become clogged by sediment resulting in slow flow, clogged outlet conditions, or sags in the grade. If the grade is 1% or less, consider using solid walled edgedrain pipe.

Maintaining drainage systems involves cleaning outlets, replacing rodent screens, flushing or replacing outlet pipes, repairing damage, and cleaning ditches.

10.3 New Construction Edgedrain Systems

Subsurface drainage typically is provided by a treated permeable base layer with 4" perforated underdrains with outlets spaced between 100 and 500', depending on grade. This system can handle any surface water that flows through cracks in the pavement.

Edgedrains should be placed continuously along both shoulders for all permeable base installations except in areas where the permeable base is daylighted. If one shoulder is on a high side of the road, such as banked curves or ramps, edgedrains are not needed on the high side of the road. In those locations, the subbase and permeable base layers on the high side of the road should either slope towards the low side of the road, or be daylighted onto the banked curve.

10.4 Retrofit Edgedrain Systems

Retrofit edgedrains are used for rehabilitation, restoration, or maintenance projects that do not have existing functioning subsurface drainage systems. Retrofits typically are effective for pavement that is relatively young (<15 years old), pavements in cut sections, and areas that have adequate ditch depth or means for outlet drainage. For most retrofit applications, the edgedrain is typically placed at the edge of the driving lane under the shoulder. Retrofit edgedrains generally do not use permeable base layers, unless they are retrofitting roads that have existing permeable base layers. The stone trench and pipe edgedrain system is preferred since it has an estimated service life of 10 to 25 years, compared with 5 to 10 years for a prefabricated geocomposite edge drain, and requires fewer outlets.

10.5 Crossdrains

Crossdrains or weeps are narrow drains that run transversely or diagonally across the road. Crossdrains can alleviate problem downhill areas where water is seeping through the pavement or where there is an edgedrain only on one side of the road, or for sag areas to drain from one side to the other. They can be used in new construction or rehabilitation projects. Use of crossdrains, however, should be kept to a minimum since they are a discontinuity in an otherwise uniform pavement section.

Crossdrains typically are 4-inch-wide cut trenches, filled with underdrain filter material and oriented to drain downhill (except in a sag where should be perpendicular to the centerline). In areas where very heavy flows are present, the width of the trench may be expanded at the discretion of the designer. The downhill end of the crossdrain should extend to the edgedrain or may directly outlet, into a ditch, side slope, or into a closed drainage system. Extend the uphill end of the crossdrain to the outer edge of the shoulder or to the edgedrain, if available.

11.0 Innovations in Design

11.1 Overview of Innovative Pavement Techniques

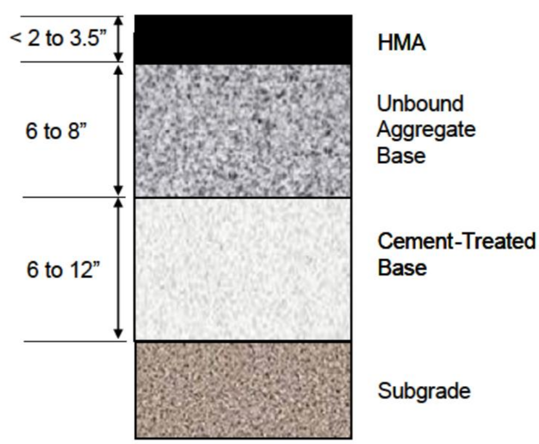
Pavement design is constantly evolving. Below are discussions about pavement designs that are being considered by various agencies across the country.

11.2 Inverted Pavements

Inverted pavement systems are an innovative pavement technology developed in South Africa in the 1970's. The basic concept of the inverted pavement system is to produce very stiff durable base layers which are less susceptible to moisture penetration and damage. This is then capped with a relatively thin asphalt wearing surface that can be replaced periodically. The materials used in an inverted pavement system are the same as what are used in a conventional asphalt flexible pavement system, although the materials are arranged in different order.

The pavement structure consists of the following layers:

- Thin HMA Layer of 2 to 3.5 inches
- Unbound Aggregate Base (UAB) Layer of 6 to 8 inches, compacted to a minimum of 100% modified proctor
- Cement Treated Aggregate Base (CTB) Layer of 6 to 12 inches with cement loading of approximately 5 to 6%



There are several advantages to utilizing the inverted pavement system. One advantage is the initial cost savings from conventional pavements due to the use of thinner HMA layers. In addition, these pavement structures may have a lower life cycle cost and be more sustainable moving forward. By optimizing the structural properties of the aggregate layer in conjunction with a thin HMA layer and a CTB layer, an improved overall life cycle cost can be achieved.

11.3 Full Depth Reclamation

Full-depth reclamation (FDR) of asphalt pavements has proven to be a cost-effective method to rehabilitate existing asphalt roadways. The FDR process involves utilizing the existing in-situ materials to develop a stable pavement foundation that then can be overlaid with a thinner pavement riding surface. This process may be used for complete reconstruction, lane widening, spot repairs, and to increase the overall structural capacity of a roadway.

The FDR process consists of milling and pulverizing in-place the existing roadway asphalt and aggregate base, mixing with portland cement and water, and then compacting into a new roadway base. This new roadway base can then be used as the base for either new asphalt or concrete pavements.

The major benefits of FDR are as follows:

- Cost-effectiveness compared to conventional construction
- Increased structural capacity
- Increased durability (compared to granular base materials)
- Opportunity to improve roadway geometry
- Shortened construction schedule and improved staging, and early opening to traffic
- Reduced impacts on the community during construction

11.4 Thin Concrete Inlay

Bonded concrete overlays of asphalt (BCOA) pavements are typically between 3 to 6 inches thick. The bond between the asphalt and the concrete is critical to ensure that the pavement behaves as one structure, especially for very thin concrete overlays. This monolithic behavior results in reduced stresses and deflections. The purpose of the BCOA is to increase the structural capacity, eliminate surface effects, and/or improve surface friction, noise, and rideability of the existing asphalt pavement.

BCOAs are a good rehabilitation alternative for pavement structures that are typically in fair to good structural condition, but are not structurally sufficient to carry the projected future traffic levels.

11.5 Roller Compacted Concrete (RCC)

RCC pavement essentially mirrors a conventional portland cement concrete (PCC) pavement in terms of materials and pavement thickness. The major differences occur with the material mixing and construction techniques used; pavements are typically placed with a high-density asphalt paver and compacted with a vibratory roller. Generally these pavements are placed without forms, reinforcing steel, or surface finishing.

Traditional concrete pavement joints are not used for RCC pavement; small joints are sawcut to control cracking and to insure good load transfer and tighter cracks.

RCC pavement is best suited for slow speed applications such as parking areas, roadway shoulders, or local streets and roads. To improve the surface texture, RCC can be diamond ground, or a thin asphalt or concrete overlay can be applied.

11.6 Stone Matrix Asphalt (SMA)

Stone Matrix Asphalt is a tough, stable, rut-resistant mixture that utilized stone on stone contact to provide asphalt mixture strength. Generally SMA asphalt mixtures are used in areas of high traffic loadings, due to high overall traffic volume, or a larger than normal level of heaver loaded trucks.

Compared to conventional dense graded mixtures, they generally have a richer binder content to provide better pavement durability. The SMA mixture is generally on the coarse side of the maximum density line of a 0.45 power chart compared to normal mixtures. The higher binder content also may require the use of fibers within the mixture to help with the "mix draindown" phenomenon which may occur as the binder drains away from the aggregate during storage and transport.

Several performance enhancements can be achieved using SMA mixtures, including better rutting performance due to the aggregate contact, enhanced resistance to cracking performance due to higher binder contents and potentially somewhat quitter pavements.

SMA pavement structures can be 20 – 30 percent more expensive than conventional dense-graded asphalt mixtures. Therefore careful project selection should be utilized to insure its full potential can be achieved.

11.7 A+B+C Bidding

Multi-parameter bidding is any process for competitive bidding that takes into account more factors or parameters than just the low bid for materials and labor. The concept of A+B bidding (cost plus time with incentive / disincentive payments is a concept that has been used by some states when there is a primary emphasis to complete construction at the earliest possible date in order to minimize public inconvenience and to enhance public safety. Under this scenario, the agency defines the value of time and the contractor (bidder) bids the cost for materials and labor ("A") and the "time" to complete the project. The product of "time" as bid by the contractor and the value of "time" as defined by the agency defines the "B" component of A+B bidding. The lowest cost for materials and labor ("A") and "B" is used to define the contract. Incentives may be paid if the contractor completes the project earlier than the time bid. Similarly, disincentives may be charged if the contractor fails to complete the project in the time bid. The basis for the incentive or disincentive is the value of time defined by the agency to determine the "B" component of (A+B).

A+B+C bidding for determination of alternate pavement designs has been attributed by some as a means of stimulating competition among paving industries by allowing the industries to select pavement type through competitive bidding.

12.0 Preservation and Preventative Maintenance

12.1 Preventative Maintenance Activities

This chapter provides a summary of the general types of pavement preventative maintenance activities utilized in Tennessee. When available, existing pavement conditions are used as guidance for selection of projects and treatments. Pavement condition must also be coupled with judgement and local experience and circumstances in the selection of the appropriate treatment for a given pavement.

Specific guidance may be found in *TDOT's Pavement Resurfacing Program, Standard Operating Guidelines*, April 2018 (see Appendix 5).

12.1.1 Crack Sealing

Crack sealing is the placement of specialized materials along cracks within the roadway. Crack Sealing is used to minimize the intrusion of water through existing cracks within the roadway, this prevents the erosion of the asphalt mixture and the deterioration of the crack is reduced, in addition less water will infiltrate the subgrade.

12.1.2 Fog Seal

Fog seals are a light application of asphalt emulsions placed on the pavement surface. Fog seals are used to seal the pavement, to help reduce raveling and to seal the old oxidized AC surface.

12.1.3 Longitudinal Joint Stabilization

Longitudinal Joint Stabilization (LJS) is a method to rejuvenate and seal longitudinal construction joint generally applied within two to three years of initial pavement placement.

12.1.4 Slurry Seal

Slurry seals are a mixture of emulsified asphalt, fine aggregate, water and additives, uniformly spread over the pavement surface. Slurry seals are used to improve the pavement surface by slowing raveling, in addition, they may also be effective in sealing minor pavement cracks.

12.1.5 Microsurfacing

Micro-surfacing is a type of slurry seal that uses a polymer-modified emulsion binder, higher quality aggregates, and a set control additive. A single course micro-surface has been used effectively to improve surface friction characteristics and to seal the pavement surface. A multiple course micro-surface has been used to correct certain pavement surface deficiencies including severe rutting, minor surface profile irregularities, polished aggregate or low skid resistance and light to moderate raveling.

12.1.6 Scrub Seal

A scrub seal is an application of emulsion and crushed rock are placed on an asphalt pavement surface and the pushed into the asphalt surface with a scrub broom, helping to insure cracks are sealed. A scrub seal provides an economical treatment that fills crack in deteriorated asphalt pavements pavement and provides a durable wearing course.

12.1.7 Chip Seal

The chip seal process provides an economical treatment that fills cracks and renew a deteriorated asphalt surface. Chip seals contain, a thin film of heated asphalt liquid sprayed on the road surface, followed by the placement of small aggregates ("chips"). The chips are then compacted to orient the chips for maximum adherence to the asphalt, and excess stone is swept from the surface. The primary purpose of the chip seal treatment is to fill cracks and seal the asphalt pavement.

12.1.8 Cape Seal

A cape seal is a chip seal treatment that is topped with one layer of microsurfacing.

The chip seal process provides the treatment that fills cracks, provides a crack relief, while the microsurfacing provides a riding surface. The primary purpose of this dual treatment is to mitigate top down cracking on a deteriorated pavement.

12.1.9 Thin Overlay Treatment

Thin hot mix asphalt (HMA) overlays are one of the most commonly utilized treatments in the pavement preventive maintenance program. A minor amount of structural improvement is provided with this strategy. To qualify as preventive maintenance, an HMA mixture is limited to a 1-3/4 inch overlay. Thin overlays protect the pavement structure, reduce the rate of pavement deterioration, correct surface deficiencies, reduces permeability and improve the ride quality of the pavement.

12.1.10 Chip Seal with Thin Overlay

The chip seal process provides an economical treatment that fills cracks. The thin overlay provides a smooth and more durable riding surface. The primary purpose of this dual treatment is to mitigate top-down cracking on an older pavement being resurfaced. This treatment can be a cheaper alternative to a milling and overlay project.

12.1.11 Open-Graded Friction Course

Open-Graded Friction Course (OGFC) pavement a treatment used to increase safety in areas where concerns exist for wet-weather safety. The porous nature of OGFC allows rain water to move through the pavement surface and drain across the cross slope.

12.1.12 Mill and Replace Treatment

The removal of an existing bituminous surface by the cold milling method and the placement of a HMA mixture limited to a depth of 1-1/4". In preventive maintenance cold milling is used for the restoration of cross slopes, correct specific existing surface deficiencies, and produces a more economical project as compared to an overlay project.

12.1.13 Hot In-Place Recycling

The heating of existing pavement followed and then blending with a polymerized asphalt rejuvenating agent. The heated, rejuvenated mixture is then re-mixed and recompacted with traditional hot-mix paving equipment. This technique provides a good alternative to traditional mill and fill resurfacing by minimizing waste material and need for new materials.

13.0 Glossary of Terms

Aggregate Base – A pavement base course consisting of compacted mineral aggregates, also known as granular base and unbound granular base.

Aggregate Interlock – Load transfer in concrete pavements where shear stresses are carried by the aggregate cement paste interface.

Alligator Cracking (Bottom Up Cracking) – Fatigue cracking or wheel load related cracking, defined as a series of interconnected cracks in an "alligator" pattern. They initiate from the bottom up in the pavement structure; it is calculated as a percentage of the total lane area in the MEPDG software.

Alternatives – Different construction or rehabilitation alternatives that will satisfy design requirements of an agency.

Analysis Period – The period of time used to compare design alternatives in a life cycle cost analysis.

Asphalt Concrete Base – An asphalt aggregate mixture used in the lower levels of the pavement structure.

Asphalt Content – The amount of liquid asphalt included in asphalt concrete represented as a percentage of the total weight of the mixture.

Asphalt Treated Permeable Base – An asphalt aggregate mixture which is free draining, typically used at lower levels of the pavement structure.

Average Annual Daily Traffic (AADT) – The annual average traffic volume for all vehicles along a given segment of roadways.

Average Annual Daily Truck Traffic (AADTT) – The annual average of daily truck traffic throughout the year.

Axle Load Spectra – The distribution of axle loads for a particular axle type (single, tandem, tridem, quad).

Backcalculation – A mathematical methodology for estimating the in-situ material properties from data derived from pavement deflection testing.

Cement Stabilized Subgrade – A prepared subgrade material that has been stabilized using portland cement and water.

Cement Treated Granular Base (CTB) – A mineral aggregate base that has been treated/stabilized with portland cement.

Cement Treated Permeable Base – A free-draining mineral aggregate base that has been treated/stabilized with portland cement and which allows water to pass through.

Composite Pavement – A pavement structure consisting of a rigid concrete pavement with an asphalt pavement overlay.

Construction Month – The month the construction began on the project.

Continuously Reinforced Concrete Pavement – Portland Cement Concrete pavement which has continuous longitudinal steel throughout the pavement. Transverse reinforcing steel may or may not be used.

Crushed Stone Base – A pavement base course consisting of compacted mineral aggregates, which has a gradation that contains less fine material.

Deflection – The vertical movement of a pavement structure under an applied load.

Dense Graded Aggregate Base – A pavement base course consisting of compacted mineral aggregates, which has a gradation which provides a mixture which has very small void spaces.

Design Criteria or Threshold Values – These are pavement distress thresholds that will trigger some type of major rehabilitation. These are generally policy decisions based on the anticipated performance desired by an agency.

Design Life – The length of time for which the pavement structure is being designed, from the time of initial construction until the first major programmed rehabilitation.

Directional Distribution Factor – A factor that describes the proportion of traffic which is traveling in a specific direction on a roadway.

Discount Rate – The time value of money used to compare the future cost of various pavement alternatives to present day value. It is approximately equal to the interest rate, adjusted for inflation.

Dowel – A load transfer device used in jointed concrete pavements, placed at the transverse pavement joints, normally consisting of an epoxy coated round steel bar.

Dynamic Modulus – The ratio of stress to strain under vibratory conditions in shear, compression, or elongation. It is a property of viscoelastic materials. It is also sometimes referred to as the Complex Modulus.

Elastic Layer Theory – A mathematical process wherein the layers of a pavement structure are all assumed to behave elastically.

Endurance Limit – The tensile strain or stress at which not pavement load related fatigue damage occurs.

Faulting – A difference in elevation between two adjacent concrete pavement slabs, generally at transverse joints or cracks.

Finite Element Analysis – A method of engineering analysis wherein a mathematical solution often employing complex differential equations, is approximated algebraically. The geometry of the problem is broken down into discrete elements of finite dimensions that are analyzed through the application of engineering mechanics.

Full Depth Reclamation – The process of pulverizing existing materials of a roadway into a granular base that can then be stabilized with portland cement or other cementitious materials. This material is then used as a base layer for new pavement.

Geogrids – Polymeric grid materials having a high tensile strength with large openings. The openings allow for the interlocking of granular materials with the grids to increase materials shear strength.

Geosynthetics – A material manufactured from polymeric materials used with soil and rock that serve the following functions: filtration, stabilization, separation, reinforcement, and water retention. Typical geosynthetics include, geogrids, fabrics, geomembranes, and drainage materials.

Geotextiles – Permeable fabric used as filters and separation layers to prevent soil migration and soil mixing. In addition, they may be used for shear strength reinforcement.

Granular Base – An unbound base course made up of mineral aggregates.

Hourly Distribution Factor – The percentage of trucks using a facility each hour of the day, primarily used for rigid pavements. Also refers to the proportion of traffic traveling across a roadway segment for a given hour of a day.

Input Levels – The MEPDG inputs are divided into three hierarchical levels, which are generally described as: Level I, direct measurement of properties; Level II, properties estimated from correlations or estimated from other Level I properties; Level III, best estimates based on global or regional values. The process of calculation of predicted performance is the same regardless of input level.

International Roughness Index – A pavement roughness index computed from a longitudinal profile using quarter car simulation at a specific travel speed.

Jointed Plain Concrete Pavement – Unreinforced portland cement concrete pavement, which may or may not contain dowel reinforced transverse joints.

Lane Distribution Factor – The proportion of traffic in one direction that is in each lane of a roadway.

Life Cycle Cost Analysis – An economic analysis process comparing different design alternatives which may have different life spans, including both the initial and all future costs.

Lime Stabilized Subgrade – A prepared subgrade material that has been stabilized using hydrated lime and water.

Load Transfer Device – A mechanical means to transfer traffic loads across concrete pavement joints.

Load Transfer Efficiency – The ability of a joint to transfer load from one side to another. It is typically defined as the deflection of the unloaded side of a concrete joint divided by the loaded slab.

Longitudinal Cracking – A form of fatigue cracking which occurs primarily in the wheel path, parallel to the roadway centerline. These longitudinal cracks generally originate from the pavement surface.

Long-Life Pavements – Pavement structures which have a structural design life of more than 50 years. These pavement structures may also be referred to as perpetual pavements.

Mean Transverse Faulting –The differential elevation across the transverse joint of concrete pavements.

Mechanistic Empirical – A design philosophy or approach where classical mechanics of solids is used in conjunction with empirically defined relationships determined from field observations.

Modulus of Elasticity – The ratio of stress to strain in an elastic material.

Modulus of Subgrade Reaction – The modulus of subgrade reaction (k) is used as a primary input for rigid pavement design. It is defined as load on a particular area of subbase divided by the deflection caused by that load. It estimates the support of the layers below a rigid pavement surface course.

Monthly Distribution Factor – The distribution of truck volumes on a monthly basis in a typical year. Also refers to the proportion of traffic in a given month along a segment of roadway.

Normalized Axle Load Spectra – The normalized axle load spectra is the normalized histogram of axle loads for a specific axle type.

Normalized Truck Classification Distribution – The normalized truck classification is a normalized distribution of different truck types within the traffic stream.

Open Graded Aggregate Base – A mineral aggregate granular base that has a gradation that will allow free draining of water.

Pavement Condition – A quantitative assessment of pavement distress at a specific point in time.

Pavement Performance – A measure of pavement condition over a specified period of time or accumulated traffic.

Pavement Preservation – A treatment used on the roadway to extend service life of a pavement system. This is in contrast to Pavement Rehabilitation, which is designed to extend the structural life of a pavement system. Pavement preservation treatments are generally treatments only applied to the pavement surface.

Pavement Rehabilitation – Work conducted to extend the structural life of a pavement system. This may include adding additional thickness, or removing and replacing a portion of the pavement structure.

PCC Transverse Cracking – Transverse cracking induced by traffic loadings and thermal stresses.

Performance Period – The length of time that an initially constructed or rehabilitated pavement structure will last before reaching a terminal condition.

Pumping – The ejection of subgrade or granular base material from beneath concrete pavements, caused by the vertical movements of concrete slabs.

Punchouts – A broken area of CRCP pavements where vertical displacement has occurred.

Raveling – Pavement distress characterized by the loss of aggregate particles on the surface of an asphalt pavement.

Reflective Cracking – Cracks in pavement surfaces occurring over cracks or joints in the underlying pavements.

Reflective Transverse Cracking – Non-wheel path cracking which is induced by the reflection of underlying joints or cracks from the underlying pavement structure.

Reliability – The probability that a given pavement design will last for its anticipated design life.

Reliability of Design – The probability that the predicted performance measure will not exceed the design threshold within the design analysis period.

Resilient Modulus – A standardized measurement of the modulus of roadbed soil or aggregates.

Rutting – A surface depression in the roadway wheel path resulting from plastic or permanent deformation of the asphalt pavement. Rutting may take place within the asphalt layers, granular base layers, and the subgrade. The surface rutting which is normally measured is the total of rutting in all of these layers.

Salvage Value – The value given to pavement structures that have reached their terminal condition.

Slab Curling – The upward or downward movement of portland cement concrete pavements caused by the temperature differential of the slab from top to bottom.

Spalling – Cracking, breaking, and chipping of pavement edges near concrete joints or cracks.

Standard Error of the Estimate – The standard deviation of the residual errors (predicted - measured) used in the calibration of the design guide.

Structural Response Model – A mechanistic model that predicts deflections, stresses, and strains due to pavement loadings and pavement materials, for the MEPDG so that the mechanistically determined performance prediction can be calculated with empirical observations of pavement performance.

Thermal Transverse Cracking – Non-wheel path cracking which is typically perpendicular to the roadway centerline and is caused by low temperature and thermal cycling. These cracks may intersect other longitudinal cracking, thereby forming "block cracking" which is indicative of thermal damage to the pavement.

Tie Bar – A deformed steel bar used across longitudinal concrete pavement joints.

Traffic Growth Factor – The factor which describes the annual growth in traffic along a given segment of roadway.

Traffic Open Month – The month the roadway is opened to unrestricted traffic.

Transfer Function – A calculation that relates the theoretical calculation of damage to a pavement to actual observed distresses. The transfer function is the empirical part of the pavement distress prediction process carried out by the MEPDG design process. It relates the calculated stresses, strains, and deflections to observed distresses.

Truck Classification Distribution – The distribution of the number of truck applications for each truck classification.

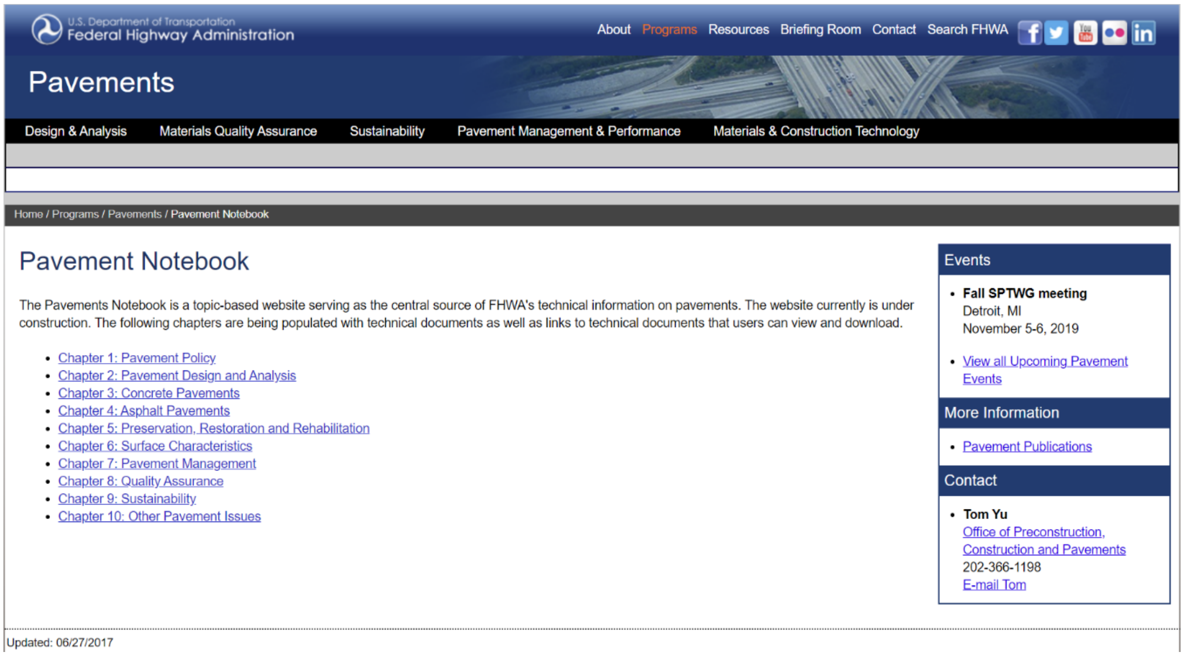
Truck Traffic Classification TTC group – An index number that defines a group of roadways with similar traffic and loading characteristics.

User Costs – The costs realized by the users of a roadway facility. These could be in the form of vehicle operating costs or user delay costs.

Vehicle Classification – The separation of the traffic stream into different classes of vehicles.

Weigh in Motion – The process of estimating the loads applied by each axle of moving vehicles on the roadway.

Appendix 1: FHWA Pavement Notebook Website and 23 CFR 626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Pavements

Design & Analysis Materials Quality Assurance Sustainability Pavement Management & Performance Materials & Construction Technology

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Pavement Notebook

The Pavements Notebook is a topic-based website serving as the central source of FHWA's technical information on pavements. The website currently is under construction. The following chapters are being populated with technical documents as well as links to technical documents that users can view and download.

- Chapter 1: Pavement Policy
- Chapter 2: Pavement Design and Analysis
- Chapter 3: Concrete Pavements
- Chapter 4: Asphalt Pavements
- Chapter 5: Preservation, Restoration and Rehabilitation
- Chapter 6: Surface Characteristics
- Chapter 7: Pavement Management
- Chapter 8: Quality Assurance
- Chapter 9: Sustainability
- Chapter 10: Other Pavement Issues

Events

- **Fall SPTWG meeting**
  Detroit, MI
  November 5-6, 2019
- View all Upcoming Pavement Events

More Information

- Pavement Publications

Contact

- **Tom Yu**
  Office of Preconstruction, Construction and Pavements
  202-366-1198
  E-mail Tom

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Code of Federal Regulations

Title 23 - Highways

Volume: 1
Date: 2013-04-01
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Context: Title 23 - Highways. CHAPTER I - FEDERAL HIGHWAY ADMINISTRATION, DEPARTMENT OF TRANSPORTATION. SUBCHAPTER G - ENGINEERING AND TRAFFIC OPERATIONS.

Pt. 626

PART 626-PAVEMENT POLICY

Sec.
626.1 Purpose.
626.2 Definitions.
626.3 Policy.
Authority'l3 U.S.C. 101(e), 109, and 315; 49 CFR 1.48(b)
Source: 61 FR 67174, Dec. 19, 1996, unless otherwise noted.

§ 626.1 Purpose.

To set forth pavement design policy for Federal-aid highway projects.

§ 626.2 Definitions.

Unless otherwise specified in this part, the definitions in 23 U.S.C. 101(a) are applicable to this part. As used in this part:

Pavement design means a project level activity where detailed engineering and economic considerations are given to alternative combinations of subbase, base, and surface materials which will provide adequate load carrying capacity. Factors which are considered include: Materials, traffic, climate, maintenance, drainage, and life-cycle costs.

§ 626.3 Policy.

Pavement shall be designed to accommodate current and predicted traffic needs in a safe, durable, and cost effective manner.

Appendix 2: Overview of Pavement Design

From the *1993 AASHTO Guide for Design of Pavement Structures*

Design Factors – all design methods

- Traffic Loading (heavy trucks)
- Soil Subgrade Strength
- Pavement Materials Characteristics
  - (strengths of materials comprising the pavement build-up)
- Environmental Conditions
  - (Its effect on soil and pavement material strength)

Design Considerations

The method of design provided in the AASHTO Guide includes consideration of the following items:

- Pavement performance - The pavement's structural and functional performance.
  - STRUCTURAL PERFORMANCE - The expectation of the pavement thickness to provide sufficient structural strength to sustain the traffic loads over the performance period;
  - FUNCTIONAL PERFORMANCE - The expectation of the level of "service" a pavement type will provide to the road user over its life. The dominant component of serviceability is riding comfort or ride quality. Safety is also a consideration.
  - AASHTO Guide: "The serviceability-performance concept is based on five fundamental assumptions, summarized as follows:
    1. Highways are for the comfort and convenience of the travelling public (User)
    2. Comfort or riding quality, is a matter of subjective response or the opinion of the User.
    3. Serviceability can be expressed by the mean of the ratings given by all highway Users and is termed the serviceability rating.
    4. There are physical characteristics of a pavement which can be measured objectively and which can be related to subjective evaluations. This procedure produces an objective serviceability index.
    5. Performance can be represented by the serviceability history of a pavement."
- Traffic
  - Consists of the amount, type and weight of vehicles that are expected to use the roadway. Only truck use of a roadway facility is considered since it is these types of vehicles that are sufficiently heavy to damage the pavement.
- Roadbed soil
  - Roadbed soil is the foundation on which the pavement will be constructed. Soil strength must be known such that the pavement thickness is sufficient to spread the load induced by heavy vehicles on the soil without the soil deforming (rutting).

- Materials of construction
    - The types of materials that will be used in the pavement buildup (asphalt, concrete, crushed stone, rubblized base, etc.) their respective thickness and strengths.
- Environment
    - Addresses the impact of environment on foundation/subgrade strength. Seasonal impacts of wet, dry, freeze, non - freeze environments will affect strength of soil and non stabilized materials (e.g. crushed stone base).
- Drainage
    - Drainage (or lack thereof) impacts foundation/subgrade strength, and as such, impacts the pavement thickness. Saturated soil is weaker than dry soil. Weak soils require greater thickness.
- Reliability
    - Provides consideration of uncertainties in both traffic predictions and performance predictions. Reliability is used as a safety factor. A higher level of reliability is used in the design computations when greater assurance is needed that the pavement will not fail during its life.
- Life cycle costs
    - The cost of a pavement to construct initially and maintain over the “analysis period.”
- Shoulder design
    - Shoulder designs for flexible pavements typically do not directly influence performance per AASHTO, whereas for rigid pavement design, AASHTO considers the impact of tied shoulders on pavement life.

Appendix 3: Pavement Design Request Form

TDOT - ROADWAY DESIGN GUIDELINES

English **Revised: 12-15-14**

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
ROADWAY DESIGN DIVISION
PAVEMENT DESIGN SECTION
SUITE 1300, JAMES K. POLK BUILDING
Nashville, Tennessee 37243-3848

REQUEST FOR PAVEMENT DESIGN

DATE: ____________________ DESIGNER: ____________________
COUNTY: ____________________ ROUTE: ____________________
PROJECT NO. ____________________ PIN: ____________________
DESCRIPTION: ____
____

PROPOSED LETTING DATE:____________________

PLEASE CHECK THE BOX FOR ALL DESIGN ITEMS THAT APPLY TO YOUR PROJECT.

NEW ALIGNMENT ☐
WIDENING ☐
INTERSECTING ROADS ☐
RESURFACING ☐
DETOUR ROAD ☐
TRAFFIC TO BE MAINTAINED
DURING CONSTRUCTION ☐

OTHER COMMENTS:____

ATTACHMENTS		**DATE REQUESTED**
TRAFFIC REPORT W/ADL'S	☐	______________
SOILS REPORT	☐	______________
PDF OF PLANS	☐	(TITLE, TYPICAL SECTIONS, PROPOSED LAYOUT)

PLEASE EXPLAIN ANY MISSING ATTACHMENTS (include date requested for soils and traffic):
____
____

cc: Design Manager

Figure 3-3
Request for Pavement Design Form

Appendix 4: Example Pavements

Urban Interstate

- Flexible Pavement Design Input Parameters – Using the 1993 AASHTO Guide for Design of Pavement Structures. The example flexible pavement design structural number was determined using the nomograph in Figure 3.1, "Design Chart for Flexible Pavements Based on Using Mean Values for Each Input", on page II-32 of the 1993 Guide. The following are input parameters used for this pavement design example.
  - Design life – 20 Years
  - Flexible Pavement Design ESALs – Determined by multiplying the design life by the Average Daily Load (ADL) for flexible pavements.
    - Calculation
      - Average Annual Daily Traffic (AADT) = 127,070
      - Use 2,945 ADL for flexible pavement (calculated in the Traffic and Planning Section sheet)
      - Convert the 20 year design life to 7,300 days.
      - Design ESALs = 2,945 ADL * 7,300 days
    - Urban Interstate – 21,498,500 ESALs
    - Use PG 76-22 Binder Grade
  - CBR
    - Urban Interstate – 4
    - Resilient Modulus (Mr) = 1500 * CBR = 1500 * 4 = 6,000 psi
  - Reliability
    - Urban Interstate – 95%
  - Standard Deviation of Error – 0.45 used for flexible pavement
  - Initial Serviceability – 4.2 is used for flexible pavement
  - Terminal Serviceability – 2.5 is used for flexible pavement
  - Change in Serviceability – 1.7 is used for flexible pavement and is reliant on the initial and terminal serviceability.
  - Shoulder Structural Number is determined through the same process.
    - All input values are the same with the exception of traffic loading.
      - In accordance with TDOT Pavement Design Guidelines, use 2% of the mainline traffic loading for the shoulder design, unless the shoulder is to be used for MOT purposes during construction, in which case the designer would use 20% of the mainline traffic loading. In this case 20% is used.
      - Shoulder Design ESALs = 21,498,500 ESALs * 0.20 = 4,299,700 ESALs
      - Shoulder AADT = 25,414
      - Binder Grade PG 64-22 - Regardless of shoulder width, the shoulder will use a PG 64-22 performance grade asphalt binder.
- Rigid Pavement Design Input Parameters – Using the 1993 AASHTO Guide for Design of Pavement Structures. The example rigid pavement design slab thickness was determined using the nomograph in Figure 3.7, "Design Chart for Rigid Pavements Based on Using Mean Values for Each Input", on page II-45 and II-46 of the 1993 Guide. The following are input parameters used for this pavement design example.
  - Design life – 20 Years

- Rigid Pavement Design ESALs – Determined by multiplying the design life by the Average Daily Load (ADL) for rigid pavements.
  - Calculation
    - Average Annual Daily Traffic (AADT) = 127,070
    - Use 4,409 ADL for flexible pavement (calculated in the Traffic and Planning Section sheet)
    - Convert the 20 year design life to 7,300 days.
    - Design ESALs = 4,409 ADL * 7,300 days
  - Urban Interstate – 32,185,700 ESALs
- K-value – was determined using the nomograph in Figure 3.3 on page II-39 in the 1993 Guide.
  - The K-Value can also be calculated using the K-Value equation, k = Mr/19.4
  - For this Urban Interstate Example, we are using a composite K-value solved from the nomograph in Figure 3.3 to account for the cement treated base. The following input parameters were used to develop this k-value.
    - The CBR is 4 resulting in a Mr = 6,000 psi
    - A depth of 4 inches for the subbase thickness and assumed a Subbase Modulus of 750,000 psi was used.
    - K-value = 465 pci
- Reliability
  - Interstate Routes – 95%
- Standard Deviation of Error – 0.35 used for rigid pavement.
- Initial Serviceability – 4.5 is used for rigid pavement.
- Terminal Serviceability – 2.5 is used for rigid pavement.
- Change in Serviceability – 2 is used for rigid pavement and is reliant on the initial and terminal serviceability.
- Modulus of Rupture – 663 psi is used.
- Elastic Modulus – 4,475,250 psi is used.
- Poisson's ratio – 0.3 is used for rigid pavement.
- Joint Spacing – 180 inches (15 feet) is used for rigid pavements.
- Load Transfer Coefficient – 2.7 is used for tied shoulders.
- Base thickness – 6 inches of mineral aggregate grading D is used beneath the cement treated base.
- Drainage Factor – 1.2 is used for rigid pavements.
- Shoulder Slab Thickness and Structural Number is determined through the same process as outlined above.
  - All input values are the same with the exception of traffic loading.
    - In accordance with TDOT Pavement Design Guidelines, use 2% of the mainline traffic loading for the shoulder design, unless the shoulder is to be used for MOT purposes during construction, in which case the designer would use 20% of the mainline traffic loading. In this case 20% is used.
    - For this Urban Interstate Example the shoulders are tied, so slab thickness will be equal to mainline.

TENNESSEE DEPARTMENT OF TRANSPORTATION
MAPPING AND STATISTICS OFFICE
TRAFFIC AND SAFETY PLANNING SECTION

PROJECT NO. URBAN INTERSTATE EXAMPLE ROUTE NO. ____________
COUNTY ________________________ CITY ____________
PROJECT DESCRIPTION ________________________

INTERSTATE

Pavement Structural Design

Calculation of Equivalent Daily 18 Kip Single Axle Loads

Type Vehicle		ADT		Flexible				Rigid		
				18-kip Factor		ADL		18-kip Factor		ADL
Pass. Cars and motorcycles		89,068		0.001		89.068		0.001		89.068
Pick-up, Panel, Van		26,566		0.004		106.264		0.005		132.83
Single Unit	Bus	635		0.300		190.5		0.300		190.5
	2-axle, 6-tire	1,270		0.170		215.9		0.170		215.9
	3-axle or more	1,270		0.700		889		1.000		1270
Comb.	4-axle	1,906		0.700		1334.2		0.780		1486.68
	5 axle or more	6,355		1.100		6990.5		1.780		11311.9
Totals (2030 AADT)		127070				9815.432				14696.88

Suggested Percentages of Trucks in Design Lane

ADT	4 Lane	6 Lane	8 Lane
5,000 or less	90%	75%	70%
5,000 - 10,000	80%	70%	65%
10,000 - 15,000	75%	65%	60%
15,000 - 20,000	75%	65%	55%
20,000 - 30,000	70%	60%	50%
30,000 Plus	65%	60%	50%

No. of Lanes 6
% Trucks in Design Lane 50%
ADL in Design Lane Flex: 0.5 x 0.6 x 9815.432 = 2945
Rigid: 0.5 x 0.6 x 14696.9 = 4409

ADL Calculations By: ____________ Date: ____________

ADL Reviewed By: ____________ Date: ____________

DATE:

COUNTY: PROJECT NO: URBAN INTERSTATE EXAMPLE ROUTE:

DESCRIPTION: FLEXIBLE PAVEMENT DESIGN

CBR:	4	SSV: N/A		DESIGN PERTIOD (YR): 20	
ADL:	2945	SN (REQ'D): 6.25		SN (SHOULDER): 5.0	

ROADWAY DESIGN

PG BINDER	DESCRIPTION	COEFFICIENT	THICKNESS	SN
PG76-22	SURFACE GRADING D	0.4	1.5	0.6
PG76-22	BINDER GRADING BM-2	0.4	2	0.8
PG76-22	BLACK BASE GRADING A	0.4	3	1.2
PG76-22	BLACK BASE GRADING A-S	0.3	3	0.9
	CEMENT TREATED BASE	0.23	9	2.07
	MINERAL AGGREGATE BASE GRADING D	0.1	9	0.9
	PRIME COAT			
	TACK COAT			
		TOTALS	27.5	6.47

SHOULDER DESIGN

PG BINDER	DESCRIPTION	COEFFICIENT	THICKNESS	SN
PG64-22	SURFACE GRADING D	0.4	1.5	0.6
PG64-22	BINDER GRADING BM-2	0.4	2	0.8
PG64-22	BLACK BASE GRADING A	0.4	3	1.2
PG64-22	BLACK BASE GRADING A-S	0.3	3	0.9
	MINERAL AGGREGATE BASE GRADING D	0.1	18	1.8
	PRIME COAT			
	TACK COAT			
		TOTALS	27.5	5.3

DATE:

COUNTY: **PROJECT NO: URBAN INTERSTATE EXAMPLE** **ROUTE:**

DESCRIPTION: RIGID PAVEMENT DESIGN

CBR: 4 **SSV: N/A** **DESIGN PERTIOD (YR): 20**

ADL: 4409 **SLAB THICKNESS (REQ'D): 9.76** **SN (SHOULDER): TIED**

ROADWAY DESIGN

DESCRIPTION	THICKNESS
PCC CONCRETE PAVEMENT	10
CEMENT TREATED PERMEABLE BASE	4
MINERAL AGGREGATE BASE GRADING D	6
TOTALS	20

SHOULDER DESIGN

DESCRIPTION	COEFFICIENT	THICKNESS
PCC CONCRETE PAVEMENT		10
CEMENT TREATED PERMEABLE BASE		4
MINERAL AGGREGATE BASE GRADING D		6
TOTALS		20

Rural Interstate

- Flexible Pavement Design Input Parameters – Using the 1993 AASHTO Guide for Design of Pavement Structures. The example flexible pavement design structural number was determined using the nomograph in Figure 3.1, “Design Chart for Flexible Pavements Based on Using Mean Values for Each Input”, on page II-32 of the 1993 Guide. The following are input parameters used for this pavement design example.
    - Design life – 20 Years
    - Flexible Pavement Design ESALs – Determined by multiplying the design life by the Average Daily Load (ADL) for flexible pavements.
        - Calculation
            - Average Annual Daily Traffic (AADT) = 132,255
            - Use 5680 ADL for flexible pavement (calculated in the Traffic and Planning Section sheet)
            - Convert the 20 year design life to 7,300 days.
            - Design ESALs = 5680 ADL * 7,300 days
        - Rural Interstate – 41,464,000 ESALs
        - Use PG 76-22 Binder Grade
    - CBR
        - Rural Interstate – 2
        - Resilient Modulus (Mr) = 1500 * CBR = 1500 * 2 = 3,000 psi
    - Reliability
        - Rural Interstate – 95%
    - Standard Deviation of Error – 0.45 used for flexible pavement
    - Initial Serviceability – 4.2 is used for flexible pavement
    - Terminal Serviceability – 2.5 is used for flexible pavement
    - Change in Serviceability – 1.7 is used for flexible pavement and is reliant on the initial and terminal serviceability.
    - Shoulder Structural Number is determined using through the same process.
        - All input values are the same with the exception of traffic loading.
            - In accordance with TDOT Pavement Design Guidelines, use 2% of the mainline traffic loading for the shoulder design, unless the shoulder is to be used for MOT purposes during construction, in which case the designer would use 20% of the mainline traffic loading. In this case 20% is used.
            - Shoulder Design ESALs = 41,464,000 ESALs * 0.20 = 8,292,800 ESALs
            - Shoulder AADT = 26,451
            - Binder Grade PG 64-22 - Regardless of shoulder width, the shoulder will use a PG 64-22 performance grade asphalt binder.
- Rigid Pavement Design Input Parameters – Using the 1993 AASHTO Guide for Design of Pavement Structures. The example rigid pavement design slab thickness was determined using the nomograph in Figure 3.7, “Design Chart for Rigid Pavements Based on Using Mean Values for Each Input”, on page II-45 and II-46 of the 1993 Guide. The following are input parameters used for this pavement design example.
    - Design life – 20 Years

- Rigid Pavement Design ESALs – Determined by multiplying the design life by the Average Daily Load (ADL) for rigid pavements.
    - Calculation
        - Average Annual Daily Traffic (AADT) = 132,255
        - Use 8,972 ADL for flexible pavement (calculated in the Traffic and Planning Section sheet)
        - Convert the 20 year design life to 7,300 days.
        - Design ESALs = 8,972 ADL * 7,300 days
    - Rural Interstate – 65,495,600 ESALs
- K-value – was determined using the nomograph in Figure 3.3 on page II-39 in the 1993 Guide.
    - The K-Value can also be calculated using the K-Value equation, k = Mr/19.4
    - For this Urban Interstate Example, we are using a composite K-value solved from the nomograph in Figure 3.3 to account for the cement treated base. The following input parameters were used to develop this k-value.
        - The CBR is 2 resulting in a Mr = 3,000 psi
        - A depth of 4 inches for the subbase thickness and assumed a Subbase Modulus of 750,000 psi was used.
        - K-value = 280 pci
- Reliability
    - Interstate Routes – 95%
- Standard Deviation of Error – 0.35 used for rigid pavement.
- Initial Serviceability – 4.5 is used for rigid pavement.
- Terminal Serviceability – 2.5 is used for rigid pavement.
- Change in Serviceability – 2 is used for rigid pavement and is reliant on the initial and terminal serviceability.
- Modulus of Rupture – 663 psi is used.
- Elastic Modulus – 4,475,250 psi is used.
- Poisson's ratio – 0.3 is used for rigid pavement.
- Joint Spacing – 180 inches (15 feet) is used for rigid pavements.
- Load Transfer Coefficient – 2.7 is used for tied shoulders.
- Base thickness – 6 inches of mineral aggregate grading D is used beneath the cement treated base.
- Drainage Factor – 1.2 is used for rigid pavements.
- Shoulder Slab Thickness and Structural Number is determined through the same process as outlined above.
    - All input values are the same with the exception of traffic loading.
        - In accordance with TDOT Pavement Design Guidelines, use 2% of the mainline traffic loading for the shoulder design, unless the shoulder is to be used for MOT purposes during construction, in which case the designer would use 20% of the mainline traffic loading. In this case 20% is used.
        - For this Urban Interstate Example the shoulders are tied, so slab thickness will be equal to mainline.

TENNESSEE DEPARTMENT OF TRANSPORATION
MAPPING AND STATISTICS OFFICE
TRAFFIC AND SAFETY PLANNING SECTION

PROJECT NO. Rural Interstate Example ROUTE NO.__________
COUNTY ____________________ CITY __________
PROJECT DESCRIPTION ____________________

INTERSTATE

Pavement Structural Design

Calculation of Equivalent Daily 18 Kip Single Axle Loads

Type Vehicle		ADT		Flexible				Rigid		
				18-kip Factor		ADL		18-kip Factor		ADL
Pass. Cars and motorcycles		73,707		0.001		73.707		0.001		73.707
Pick-up, Panel, Van		34,743		0.004		138.972		0.005		173.715
Single Unit	Bus	423		0.300		126.9		0.300		126.9
	2-axle, 6-tire	2,658		0.170		451.86		0.170		451.86
	3-axle or more	1,561		0.700		1092.7		1.000		1561
Comb.	4-axle	608		0.700		425.6		0.780		474.24
	5 axle or more	18,555		1.100		20410.5		1.780		33027.9
Totals (2030 AADT)		132255				22720.24				35889.32

Suggested Percentages of Trucks in Design Lane

ADT	4 Lane	6 Lane	8 Lane
5,000 or less	90%	75%	70%
5,000 - 10,000	80%	70%	65%
10,000 - 15,000	75%	65%	60%
15,000 - 20,000	75%	65%	55%
20,000 - 30,000	70%	60%	50%
30,000 Plus	65%	60%	50%

No. of Lanes 8-10
% Trucks in Design Lane 50%
ADL In Design Lane Flex: 0.5 x 0.5 x 22720 = 5680
Rigid: 0.5 x 0.5 x 35889 = 8972

ADL Calculations By:__________ Date: __________

ADL Reviewed By: __________ Date: __________

DATE:

COUNTY: PROJECT NO: Rural Interstate Example ROUTE:

DESCRIPTION: FLEXIBLE PAVEMENT DESIGN

CBR: 2 SSV: N/A DESIGN PERTIOD (YR): 20

ADL: 5680 SN (REQ'D): 8.26 SN (SHOULDER): 6.78

ROADWAY DESIGN

PG BINDER	DESCRIPTION	COEFFICIENT	THICKNESS	SN
PG76-22	SURFACE GRADING D	0.4	1.5	0.6
PG76-22	BINDER GRADING BM-2	0.4	2.75	1.1
PG76-22	BLACK BASE GRADING A	0.4	6	2.4
PG76-22	BLACK BASE GRADING A-S	0.3	3	0.9
	CEMENT TREATED BASE	0.23	10	2.3
	MINERAL AGGREGATE BASE GRADING D	0.1	10	1
	PRIME COAT			
	TACK COAT			
	TOTALS		33.25	8.3

SHOULDER DESIGN

PG BINDER	DESCRIPTION	COEFFICIENT	THICKNESS	SN
PG64-22	SURFACE GRADING E	0.4	1.5	0.6
PG64-22	BINDER GRADING BM-2	0.4	2.75	1.1
PG64-22	BLACK BASE GRADING A	0.4	6	2.4
PG64-22	BLACK BASE GRADING A-S	0.3	3	0.9
	MINERAL AGGREGATE BASE GRADING D	0.1	20	2
	PRIME COAT			
	TACK COAT			
	TOTALS		33.25	7

DATE:

COUNTY: PROJECT NO: Rural Interstate Example ROUTE:

DESCRIPTION: RIGID PAVEMENT DESIGN

CBR: 2 SSV: N/A DESIGN PERTIOD (YR): 20

ADL: 8972 SLAB THICKNESS (REQ'D): 11.29 SN (SHOULDER): Tied

ROADWAY DESIGN

DESCRIPTION	THICKNESS
PCC CONCRETE PAVEMENT	12
CEMENT TREATED PERMEABLE BASE	4
MINERAL AGGREGATE BASE GRADING D	6
TOTALS	22

SHOULDER DESIGN

DESCRIPTION	THICKNESS
PCC CONCRETE PAVEMENT	12
CEMENT TREATED PERMEABLE BASE	4
MINERAL AGGREGATE BASE GRADING D	6
TOTALS	22

Principal Arterial

- Flexible Pavement Design Input Parameters – Using the 1993 AASHTO Guide for Design of Pavement Structures. The example flexible pavement design structural number was determined using the nomograph in Figure 3.1, "Design Chart for Flexible Pavements Based on Using Mean Values for Each Input", on page II-32 of the 1993 Guide. The following are input parameters used for this pavement design example.
  - Design life – 20 Years
  - Flexible Pavement Design ESALs – Determined by multiplying the design life by the Average Daily Load (ADL) for flexible pavements.
    - Calculation
      - Average Annual Daily Traffic (AADT) = 31,845
      - Use 375 ADL for flexible pavement (calculated in the Traffic and Planning Section sheet)
      - Convert the 20 year design life to 7,300 days.
      - Design ESALs = 375 ADL * 7,300 days
    - Principal Arterial – 2,737,500 ESALs
    - Use Binder Grade PG 70-22
  - CBR
    - Principal Arterial – 3
    - Resilient Modulus (Mr) = 1500 * CBR = 1500 * 3 = 4,500 psi
  - Reliability
    - Principal Arterial – 90%
  - Standard Deviation of Error – 0.45 used for flexible pavement
  - Initial Serviceability – 4.2 is used for flexible pavement
  - Terminal Serviceability – 2.5 is used for flexible pavement
  - Change in Serviceability – 1.7 is used for flexible pavement and is reliant on the initial and terminal serviceability.
  - Shoulder Structural Number is determined through the same process.
    - All input values are the same with the exception of traffic loading.
      - In accordance with TDOT Pavement Design Guidelines, use 2% of the mainline traffic loading for the shoulder design, unless the shoulder is to be used for MOT purposes during construction, in which case the designer would use 20% of the mainline traffic loading. In this case 2% is used.
      - Shoulder Design ESALs = 2,737,500 ESALs * 0.02 = 54,750 ESALs
      - Shoulder AADTT = 637
      - Use Binder Grade PG 64-22
- Rigid Pavement Design Input Parameters – Using the 1993 AASHTO Guide for Design of Pavement Structures. The example rigid pavement design slab thickness was determined using the nomograph in Figure 3.7, "Design Chart for Rigid Pavements Based on Using Mean Values for Each Input", on page II-45 and II-46 of the 1993 Guide. The following are input parameters used for this pavement design example.
  - Design life – 20 Years
  - Rigid Pavement Design ESALs – Determined by multiplying the design life by the Average Daily Load (ADL) for rigid pavements.

        - Calculation
            - Average Annual Daily Traffic (AADT) = 31,845
            - Use 536 ADL for flexible pavement (calculated in the Traffic and Planning Section sheet)
            - Convert the 20 year design life to 7,300 days.
            - Design ESALs = 536 ADL * 7,300 days
        - Principal Arterial – 3,912,800 ESALs
    - K-value – was determined using the nomograph in Figure 3.3 on page II-39 in the 1993 Guide.
        - The K-Value can also be calculated using the K-Value equation, k = Mr/19.4
        - For this Urban Interstate Example, we are using a composite K-value solved from the nomograph in Figure 3.3 to account for the cement treated base. The following input parameters were used to develop this k-value.
            - The CBR is 3 resulting in a Mr = 4,500 psi
            - A depth of 4 inches for the subbase thickness and assumed a Subbase Modulus of 750,000 psi was used.
            - K-value = 375 pci
    - Reliability
        - Principal Arterial – 90%
    - Standard Deviation of Error – 0.35 used for rigid pavement.
    - Initial Serviceability – 4.5 is used for rigid pavement.
    - Terminal Serviceability – 2.5 is used for rigid pavement.
    - Change in Serviceability – 2 is used for rigid pavement and is reliant on the initial and terminal serviceability.
    - Modulus of Rupture – 663 psi is used.
    - Elastic Modulus – 4,475,250 psi is used.
    - Poisson's ratio – 0.3 is used for rigid pavement.
    - Joint Spacing – 180 inches (15 feet) is used for rigid pavements.
    - Load Transfer Coefficient – 3.2 is used for asphalt shoulders.
    - Base thickness – 6 inches of mineral aggregate grading D is used beneath the cement treated base.
    - Drainage Factor – 1.2 is used for rigid pavements.
    - Shoulder Slab Thickness and Structural Number is determined through the same process as outlined above.
        - All input values are the same with the exception of traffic loading.
            - In accordance with TDOT Pavement Design Guidelines, use 2% of the mainline traffic loading for the shoulder design, unless the shoulder is to be used for MOT purposes during construction, in which case the designer would use 20% of the mainline traffic loading. In this case 2% is used.
            - For this Collector/Local Road Example, as mentioned above, the shoulders will be asphalt and a structural number will need to be calculated from the traffic loading.
                - Design ESALs Calculation = 3,912,800 ESALs * 0.02 = 78,256 ESALs
                - Shoulder AADTT = 637
                - Use Binder Grade PG 64-22

TENNESSEE DEPARTMENT OF TRANSPORTATION
MAPPING AND STATISTICS OFFICE
TRAFFIC AND SAFETY PLANNING SECTION

PROJECT NO. Principal Arterial Example ROUTE NO. ____
COUNTY ____ CITY ____
PROJECT DESCRIPTION ____

FAP RURAL

Pavement Structural Design

Calculation of Equivalent Daily 18 Kip Single Axle Loads

Type Vehicle		ADT		Flexible				Rigid		
				18-kip Factor		ADL		18-kip Factor		ADL
Pass. Cars and motorcycles		25,721		0.001		25.721		0.001		25.721
Pick-up, Panel, Van		4,850		0.004		19.4		0.004		19.4
Single Unit	Bus	13		0.300		3.9		0.300		3.9
	2-axle, 6-tire	257		0.260		66.82		0.260		66.82
	3-axle or more	377		1.000		377		1.500		565.5
Comb.	4-axle	310		0.640		198.4		0.800		248
	5 axle or more	317		1.200		380.4		1.900		602.3
Totals (2030 AADT)		31845				1071.641				1531.641

Suggested Percentages of Trucks in Design Lane

ADT	4 Lane	6 Lane	8 Lane
5,000 or less	90%	75%	70%
5,000 - 10,000	80%	70%	65%
10,000 - 15,000	75%	65%	60%
15,000 - 20,000	75%	65%	55%
20,000 - 30,000	70%	60%	50%
30,000 Plus	65%	60%	50%

No. of Lanes 4
% Trucks in Design Lane 70%
ADL In Design Lane Flex: 0.5 x 0.7 x 1071.64 = 375
Rigid: 0.5 x 0.7 x 1531.64 = 536

ADL Calculations By: ____ Date: ____

ADL Reviewed By: ____ Date: ____

DATE:

COUNTY: PROJECT NO: Principal Arterial Example ROUTE:

DESCRIPTION: FLEXIBLE PAVEMENT DESIGN

CBR: 3 SSV: N/A DESIGN PERTIOD (YR): 20

ADL: 375 SN (REQ'D): 4.89 SN (SHOULDER): 2.62

ROADWAY DESIGN

PG BINDER	DESCRIPTION	COEFFICIENT	THICKNESS	SN
PG70-22	SURFACE GRADING D	0.4	1.25	0.5
PG70-22	BLACK BASE GRADING A	0.4	3	1.2
PG70-22	BLACK BASE GRADING A-S	0.3	3	0.9
	CEMENT TREATED BASE	0.23	7	1.61
	MINERAL AGGREGATE BASE GRADING D	0.1	7	0.7
	PRIME COAT			
	TACK COAT			
		TOTALS	21.25	4.91

SHOULDER DESIGN

PG BINDER	DESCRIPTION	COEFFICIENT	THICKNESS	SN
PG64-22	SURFACE GRADING E	0.4	1.25	0.5
PG64-22	BLACK BASE GRADING A	0.4	3	1.2
	MINERAL AGGREGATE BASE GRADING D	0.1	17	1.7
	PRIME COAT			
	TACK COAT			
		TOTALS	21.25	3.4

DATE:

COUNTY: PROJECT NO: Principal Arterial Example ROUTE:

DESCRIPTION: RIGID PAVEMENT DESIGN

CBR: 3 SSV: N/A DESIGN PERTIOD (YR): 20

ADL: 536 SLAB THICKNESS (REQ'D): 7.22 SN (SHOULDER): 2.78

ROADWAY DESIGN

DESCRIPTION	THICKNESS
PCC CONCRETE PAVEMENT	8
CEMENT TREATED PERMEABLE BASE	4
MINERAL AGGREGATE BASE GRADING D	6
TOTALS	18

SHOULDER DESIGN

PG BINDER	DESCRIPTION	COEFFICIENT	THICKNESS	SN
PG64-22	SURFACE GRADING E	0.4	1.25	0.5
PG64-22	BINDER GRADING BM-2	0.4	2	0.8
	MINERAL AGGREGATE BASE GRADING D	0.1	14.75	1.675
	PRIME COAT			
	TACK COAT			
		TOTALS	18	2.78

Collector/Local

- Flexible Pavement Design Input Parameters – Using the 1993 AASHTO Guide for Design of Pavement Structures. The example flexible pavement design structural number was determined using the nomograph in Figure 3.1, “Design Chart for Flexible Pavements Based on Using Mean Values for Each Input”, on page II-32 of the 1993 Guide. The following are input parameters used for this pavement design example.
  - Design life – 20 Years
  - Flexible Pavement Design ESALs – Determined by multiplying the design life by the Average Daily Load (ADL) for flexible pavements.
    - Calculation
      - Average Annual Daily Traffic (AADT) = 2,420
      - Use 51 ADL for flexible pavement (calculated in the Traffic and Planning Section sheet)
      - Convert the 20 year design life to 7,300 days.
      - Design ESALs = 51 ADL * 7,300 days
    - Collector/Local – 372,300 ESALs
    - Use Binder Grade PG 64-22
  - CBR
    - Collector/Local – 2
    - Resilient Modulus (Mr) = 1500 * CBR = 1500 * 2 = 3,000 psi
  - Reliability
    - Collector/Local – 90%
  - Standard Deviation of Error – 0.45 used for flexible pavement
  - Initial Serviceability – 4.2 is used for flexible pavement
  - Terminal Serviceability – 2.5 is used for flexible pavement
  - Change in Serviceability – 1.7 is used for flexible pavement and is reliant on the initial and terminal serviceability.
  - Shoulder Structural Number is determined through the same process.
    - All input values are the same with the exception of traffic loading.
      - In accordance with TDOT Pavement Design Guidelines, use 2% of the mainline traffic loading for the shoulder design, unless the shoulder is to be used for MOT purposes during construction, in which case the designer would use 20% of the mainline traffic loading. In this case 2% is used.
      - Shoulder Design ESALs = 372,000 ESALs * 0.02 = 7,440 ESALs
      - Shoulder AADT = 49
      - Use Binder Grade PG 64-22

TENNESSEE DEPARTMENT OF TRANSPORATION
MAPPING AND STATISTICS OFFICE
TRAFFIC AND SAFETY PLANNING SECTION

PROJECT NO. Collector/Local Example ROUTE NO. ______
COUNTY ______ CITY ______
PROJECT DESCRIPTION ______

______

FAP RURAL

Pavement Structural Design

Calculation of Equivalent Daily 18 Kip Single Axle Loads

Type Vehicle		ADT		Flexible				Rigid		
				18-kip Factor		ADL		18-kip Factor		ADL
Pass. Cars and motorcycles		1,696		0.001		1.696274		0.001		1.696274
Pick-up, Panel, Van		506		0.004		2.023757		0.004		2.023757
Single Unit	Bus	0		0.300		0.080265		0.300		0.080265
	2-axle, 6-tire	33		0.260		8.695412		0.260		8.695412
	3-axle or more	82		1.000		82.40575		1.500		123.6086
Comb.	4-axle	20		0.640		13.01369		0.800		16.26711
	5 axle or more	81		1.200		97.60265		1.900		154.5375
Totals (2030 AADT)		2420				205.5178				306.909

Suggested Percentages of Trucks in Design Lane

ADT	4 Lane	6 Lane	8 Lane
5,000 or less	90%	75%	70%
5,000 - 10,000	80%	70%	65%
10,000 - 15,000	75%	65%	60%
15,000 - 20,000	75%	65%	55%
20,000 - 30,000	70%	60%	50%
30,000 Plus	65%	60%	50%

No. of Lanes 2
% Trucks in Design Lane 50%
ADL in Design Lane Flex: 0.5 x 0.5 x 205.518 = 51
Rigid: 0.5 x 0.5 x 306.909 = 77

ADL Calculations By: ______ Date: ______

ADL Reviewed By: ______ Date: ______

DATE:

COUNTY: PROJECT NO: Collector/Local Example ROUTE:

DESCRIPTION: FLEXIBLE PAVEMENT DESIGN

CBR: 2 SSV: N/A DESIGN PERTIOD (YR): 20

ADL: 51 SN (REQ'D): 4.20 SN (SHOULDER): 2.20

ROADWAY DESIGN

PG BINDER	DESCRIPTION	COEFFICIENT	THICKNESS	SN
PG64-22	SURFACE GRADING D	0.4	1.25	0.5
PG64-22	BLACK BASE GRADING A	0.4	3	1.2
PG64-22	BLACK BASE GRADING A-S	0.3	3	0.9
	CEMENT TREATED BASE	0.23	5	1.15
	MINERAL AGGREGATE BASE GRADING D	0.1	5	0.5
	PRIME COAT			
	TACK COAT			
		TOTALS	17.25	4.25

SHOULDER DESIGN

PG BINDER	DESCRIPTION	COEFFICIENT	THICKNESS	SN
PG64-22	SURFACE GRADING E	0.4	1.25	0.5
PG64-22	BLACK BASE GRADING A	0.4	3	1.2
	MINERAL AGGREGATE BASE GRADING D	0.1	13	1.3
	PRIME COAT			
	TACK COAT			
		TOTALS	17.25	3

Appendix 5: Pavement Resurfacing Program Standard Operating Guidelines

TN TDOT
Department of Transportation

PAVEMENT RESURFACING PROGRAM

STANDARD OPERATING GUIDELINES

April 2018

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INTRODUCTION AND BACKGROUND

TDOT maintains over 5,700 lane miles of interstate and over 32,000 lane miles of state routes. This document intends to serve as guidelines for the selection of routes to be resurfaced and how resurfacing projects can be developed. This document is intended to serve only as guidance and does not supersede Departmental specifications, supplemental specifications, design guidelines, or other departmental guidance. On all resurfacing projects, it is expected that if conflicts are encountered between with this guidance or Departmental specifications and proper engineering judgement, the latter will precede.

These guidelines do not intend to address concerns or provide guidance for new construction, re-construction, widening or other TDOT projects.

CURRENT NETWORK

Table 1 outlines the distribution of mileage throughout the state at the date of publication of these guidelines (April 2018). Annual resurfacing project funding is allocated by the TDOT Program Development office and separated based on available National Highway Performance Program (NHPP), Surface Transportation Program (STP) and state funds. The Department allocates a select amount of NHPP funds specifically for resurfacing interstates, which are part of the NHS. NHPP funds may only be used to fund projects on NHS routes. State funding (451) available for resurfacing projects will be allocated at this same time and can be used for projects on any route on the state highway system. All fund categories are allocated to TDOT regions based on regional percentages of qualifying lane miles.

	REGION 1	REGION 2	REGION 3	REGION 4	TOTAL
Interstates	1,603.6	970.0	2,225.6	1,006.7	5,805.9
% of TOTAL	27.6	16.7	38.3	17.3	100.0
All State Routes	7,513.1	6,737.0	9,009.7	8,592.0	31,851.7
% of TOTAL	23.6	21.2	28.3	27.0	100.0
NHS State Routes	2,830.4	2,479.3	3,670.2	3,676.0	12,655.9
% of TOTAL	22.4	19.6	29.0	29.0	100.0
Non-NHS State Routes	4,682.6	4,257.7	5,339.5	4,916.0	19,195.8
% of TOTAL	24.4	22.2	27.8	25.6	100.0

Table 1. Distribution of state highway lane miles as of April 2018.

Table 2 defines the current condition of the state highway network as reported by the 2016 and 2017 Departmental Annual Pavement Condition Reports. Additional background regarding the collection and interpretation of pavement management can be found in annual Pavement Management Reports and in Pavement Management Guidelines, which are currently being developed with an anticipated publish date of Winter 2017/2018.

	Interstates		**State Routes**	
	2016	**2017**	**2016**	**2017**
Region 1	4.075	4.085	3.642	3.828*
Region 2	4.399	4.227	3.759	3.954*
Region 3	4.223	4.256	3.631*	3.825
Region 4	3.925	3.873	3.139*	3.079

Table 2. Sample pavement condition from 2016 and 2017 Annual Pavement Report. (* *- Only NHS state route segments are considered in off –cycle regions [See Table 3 for details]*)

PAVEMENT MANAGEMENT

The TDOT Pavement Management office procures collection of pavement management system (PMS) data to monitor the health of all pavements on the TDOT network. Pavement data collected per this contract can be categorized into two groups – roughness and distress. Roughness data includes factors that define pavement smoothness, such as the international roughness index (IRI) which is used to calculate the Pavement Smoothness Index (PSI). Distress data includes metrics that define the physical deterioration of pavements such as cracking, rutting, and other pavement distresses. Pavement data is compiled annually by the Pavement Management office and distributed in an Annual PMS Report. The PMS data collection schedule and a description of the metric provided in the annual PMS report are shown in Tables 3 and 4, respectively.

	Regions 1 &2	Regions 3&4
Interstates	Roughness and distress collected annually, far right lane, both directions	
NHS State Routes and other routes	Roughness and distress annually, far right lane, positive (North or East) direction	
Non-NHS State Routes	Roughness and distress collected on **even** years, far right lane, positive (North or East) direction	Roughness and distress collected on **odd** years, far right lane, positive (North or East) direction

Table 3. Pavement Management Data Collection Schedule.

IRI – International Roughness Index	
•	Measurement of the number of vertical deviations over a section of road.
•	Measured in inches/mile
•	Perfect is a “0”
HC IRI – Half-Car IRI	
Half-Car IRI is used by TDOT’s profilers for acceptance testing and warranty jobs. The standard method that is collected by our consultants is Quarter-Car IRI. Half-Car IRI values tend to be slightly better than Quarter-Car IRI values obtained from the same location.	
PSI – Pavement Smoothness Index	
•	Measure of the ROUGHNESS of the road on a scale of 0 – 5.
•	Perfect is a “5”
•	Roughness is defined as: “The deviations of a pavement surface from a true planar surface with characteristic dimensions that affect vehicle dynamics, ride quality, dynamic loads, and drainage; for example, longitudinal profile, transverse profile, and cross slope.”
•	Relates to IRI through: PSI = 5 * e(-0.0055*IRI)
PDI – Pavement Distress Index	
•	A measurement of the roadway DISTRESS on a scale from 0 – 5.
•	Perfect is a “5”
•	Distresses that are evaluated include the following: Fatigue, Rutting, Longitudinal Cracks In the Wheel Path, Patching, Block Cracking, Raveling, Transverse Cracks, Longitudinal Cracks (Non-Wheel Path), & Longitudinal Cracks In the Lane Joints.
•	Each individual Distress mentioned above receives a DEDUCT VALUE based on the severity & number of distresses on a given stretch of road surface.
•	All of the D.V.s are given a weight and subtracted from 5.

Table 4. Pavement Management Data explanation of terms.

PQI – Pavement Quality Index
• Overall Index of the roadway on a scale from 0 – 5.
• Perfect is a "5"
• PQI = PDI 0.7 * PSI 0.3
• PDI encompasses the largest portion of this index because Pavement Distresses indicate current problems and future deterioration of the roadway surface.

Table 4. Pavement Management Data explanation of terms. (continued)

All pavement data is stored in a database and can be queried using the Highway Pavement Management Application (HPMA) software (Figures 1-3). Prior to 2015, less data was collected that what is defined in Table 3, so certain historical data will not be available. For example, NHS state routes were only collected semi-annually prior to 2015.

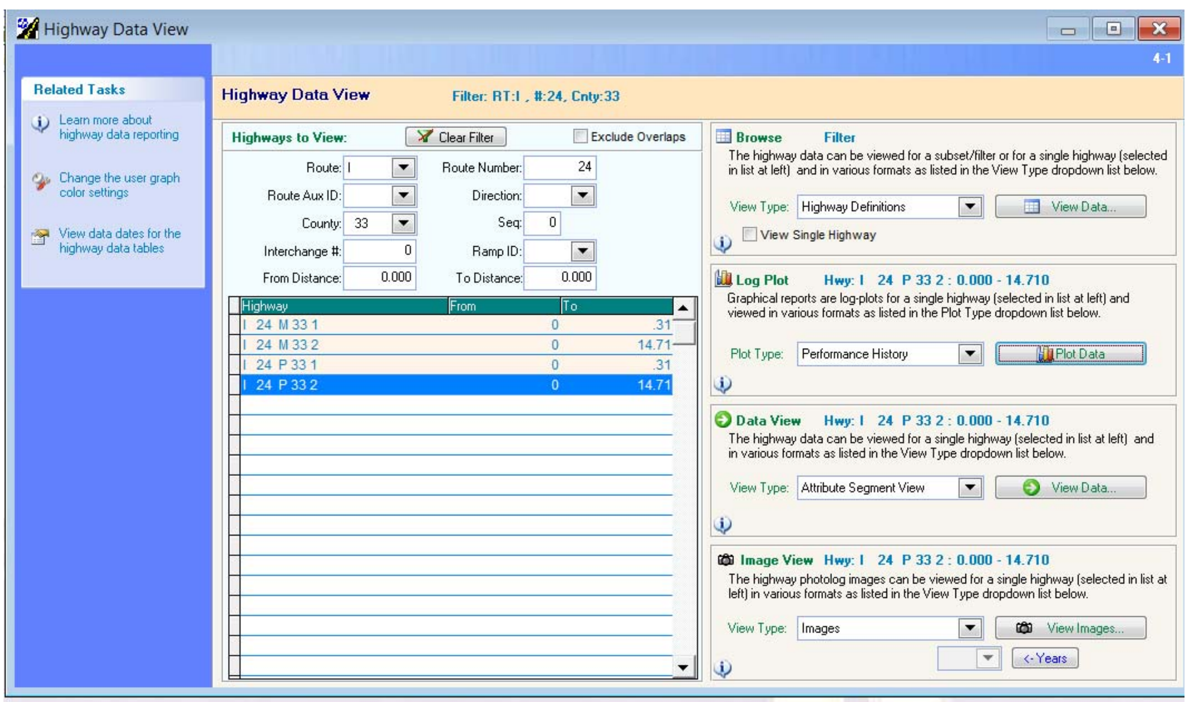


Figure 1. HPMA Highway Data View window and data filter.

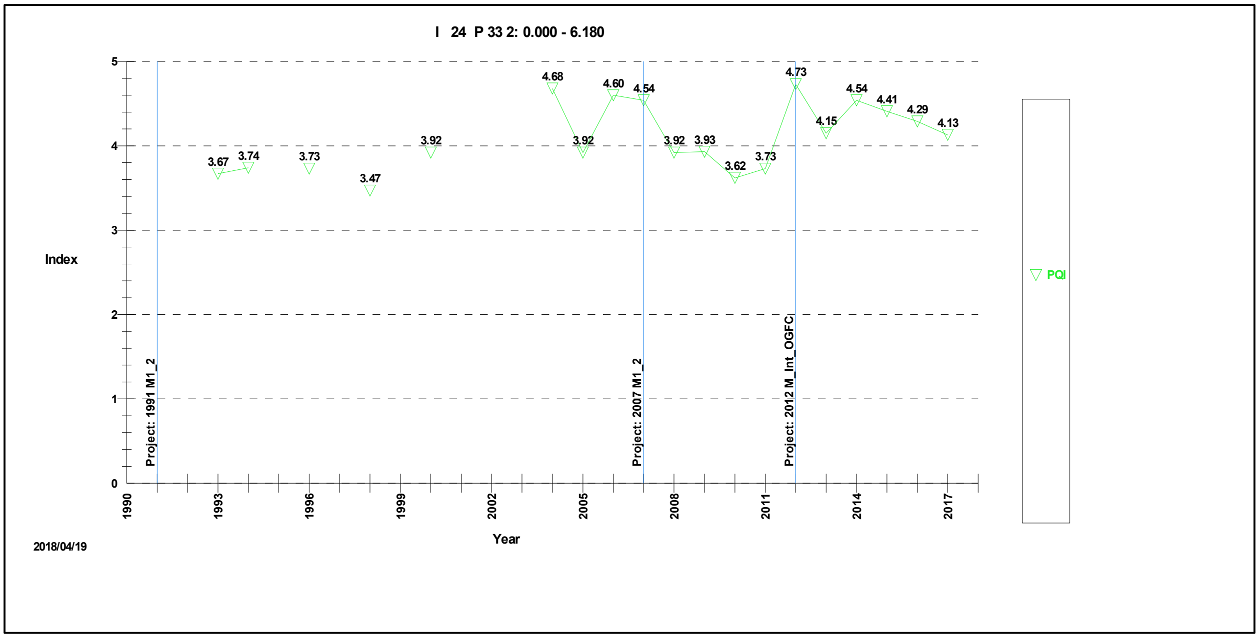
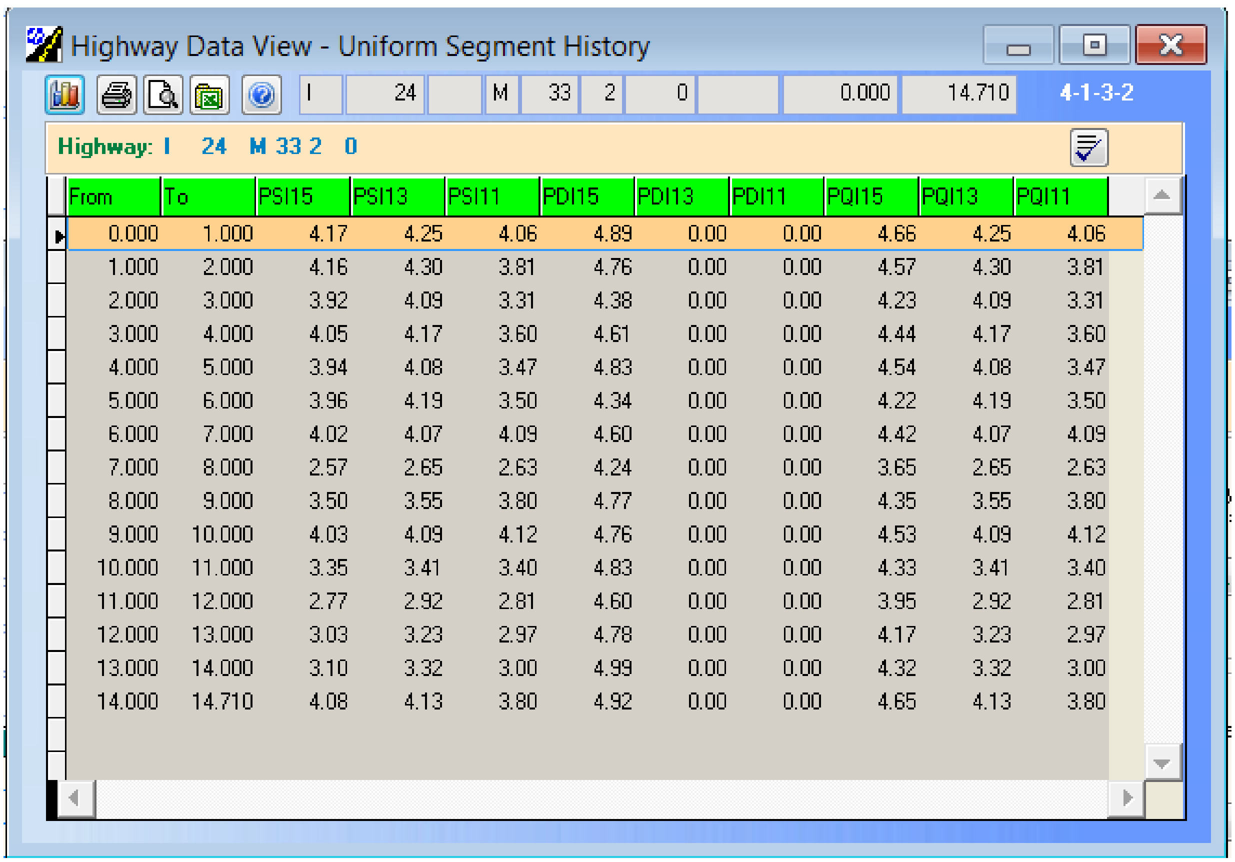


Figure 2. Sample HPMA Performance History log plot.



From	To	PSI15	PSI13	PSI11	PDI15	PDI13	PDI11	PQI15	PQI13	PQI11
0.000	1.000	4.17	4.25	4.06	4.89	0.00	0.00	4.66	4.25	4.06
1.000	2.000	4.16	4.30	3.81	4.76	0.00	0.00	4.57	4.30	3.81
2.000	3.000	3.92	4.09	3.31	4.38	0.00	0.00	4.23	4.09	3.31
3.000	4.000	4.05	4.17	3.60	4.61	0.00	0.00	4.44	4.17	3.60
4.000	5.000	3.94	4.08	3.47	4.83	0.00	0.00	4.54	4.08	3.47
5.000	6.000	3.96	4.19	3.50	4.34	0.00	0.00	4.22	4.19	3.50
6.000	7.000	4.02	4.07	4.09	4.60	0.00	0.00	4.42	4.07	4.09
7.000	8.000	2.57	2.65	2.63	4.24	0.00	0.00	3.65	2.65	2.63
8.000	9.000	3.50	3.55	3.80	4.77	0.00	0.00	4.35	3.55	3.80
9.000	10.000	4.03	4.09	4.12	4.76	0.00	0.00	4.53	4.09	4.12
10.000	11.000	3.35	3.41	3.40	4.83	0.00	0.00	4.33	3.41	3.40
11.000	12.000	2.77	2.92	2.81	4.60	0.00	0.00	3.95	2.92	2.81
12.000	13.000	3.03	3.23	2.97	4.78	0.00	0.00	4.17	3.23	2.97
13.000	14.000	3.10	3.32	3.00	4.99	0.00	0.00	4.32	3.32	3.00
14.000	14.710	4.08	4.13	3.80	4.92	0.00	0.00	4.65	4.13	3.80

Figure 3. Sample HPMA Uniform Length Segment History

PROJECT IDENTIFICATION

Possible resurfacing projects can be identified with data from the annual Pavement Management System (PMS) report and the regional roadway history. The priority of this identification is age and the overall Pavement Quality Indices (PSI, PDI, PQI). Ad hoc pavement management reports can be made available upon request to assist with project identification and selection.

Project History

Since the implementation of the Interstate System in 1956, TDOT maintained a written database of Interstate Construction and resurfacing known as the Interstate Log Book (Figure 4). All data from this log, which ended in 2007, has since been entered into the HPMA project history database.

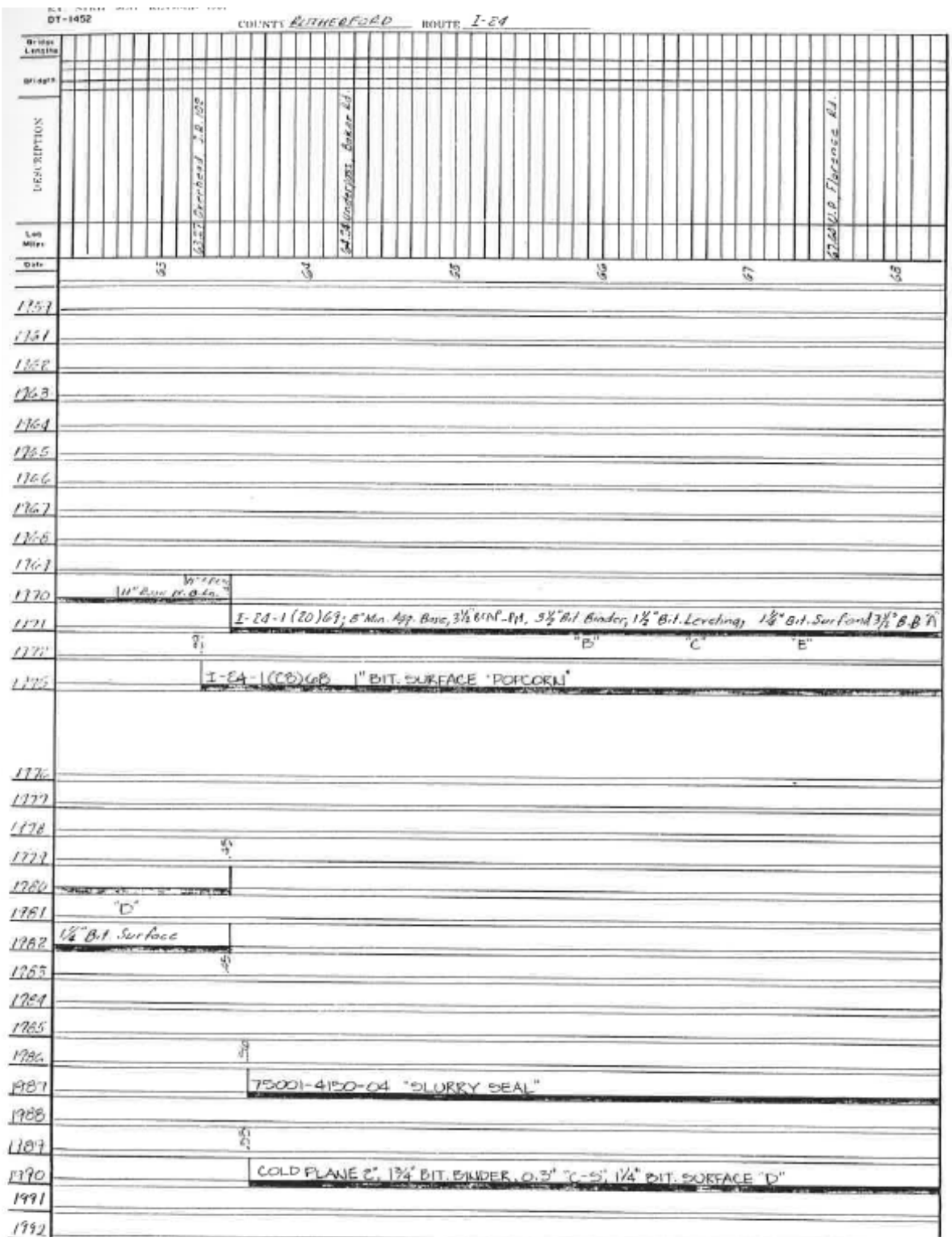


Figure 4. Interstate Log Book.

Construction history for state routes was historically maintained in the "Road Life" database, a written log of all known original construction on state routes. Scanned copies of the Road Life database are stored on TDOT network drives, but have not been entered into any electronic database. Data is limited for county roads absorbed by the Department in 1983, also known as "three digit state routes".

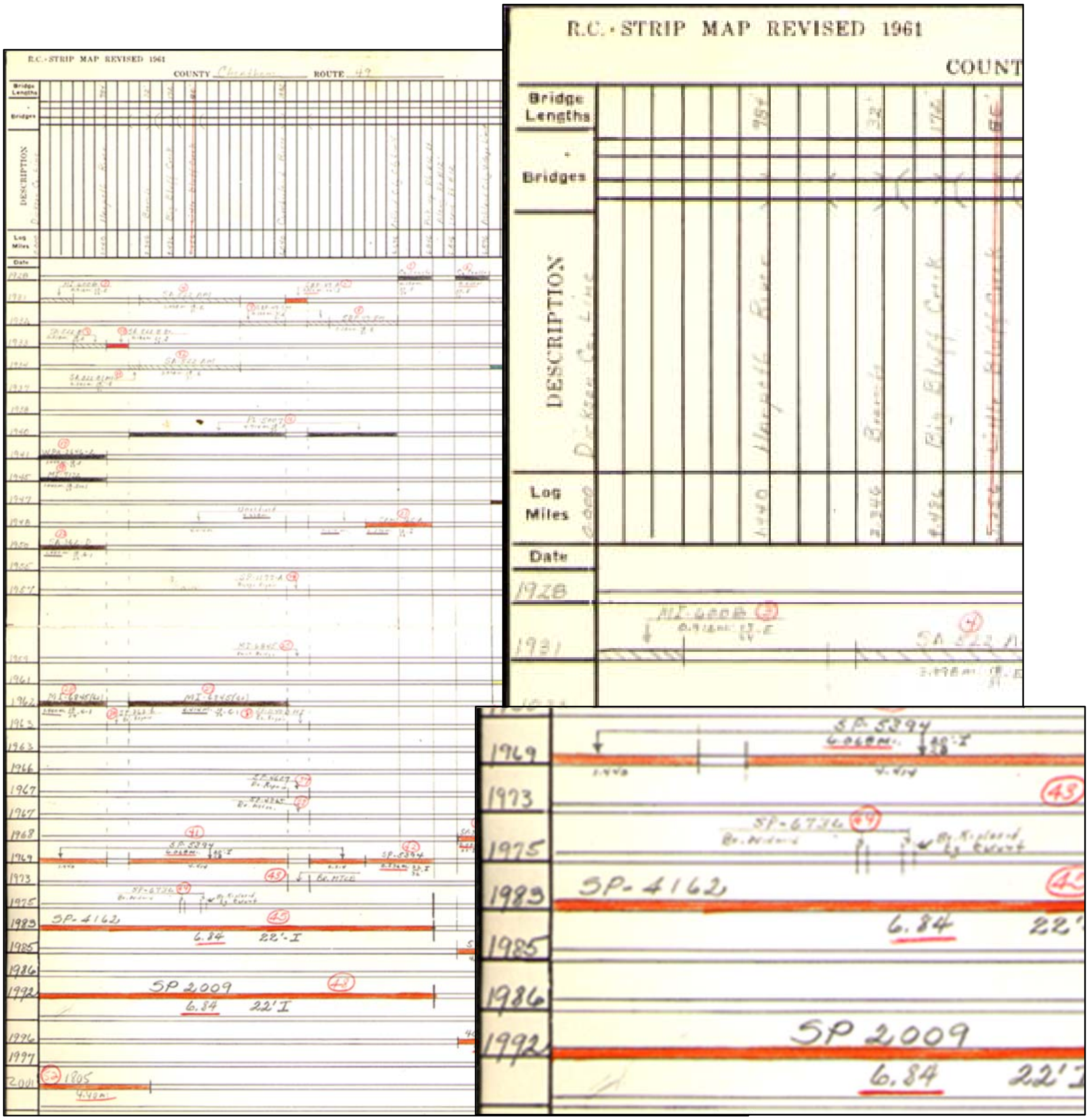
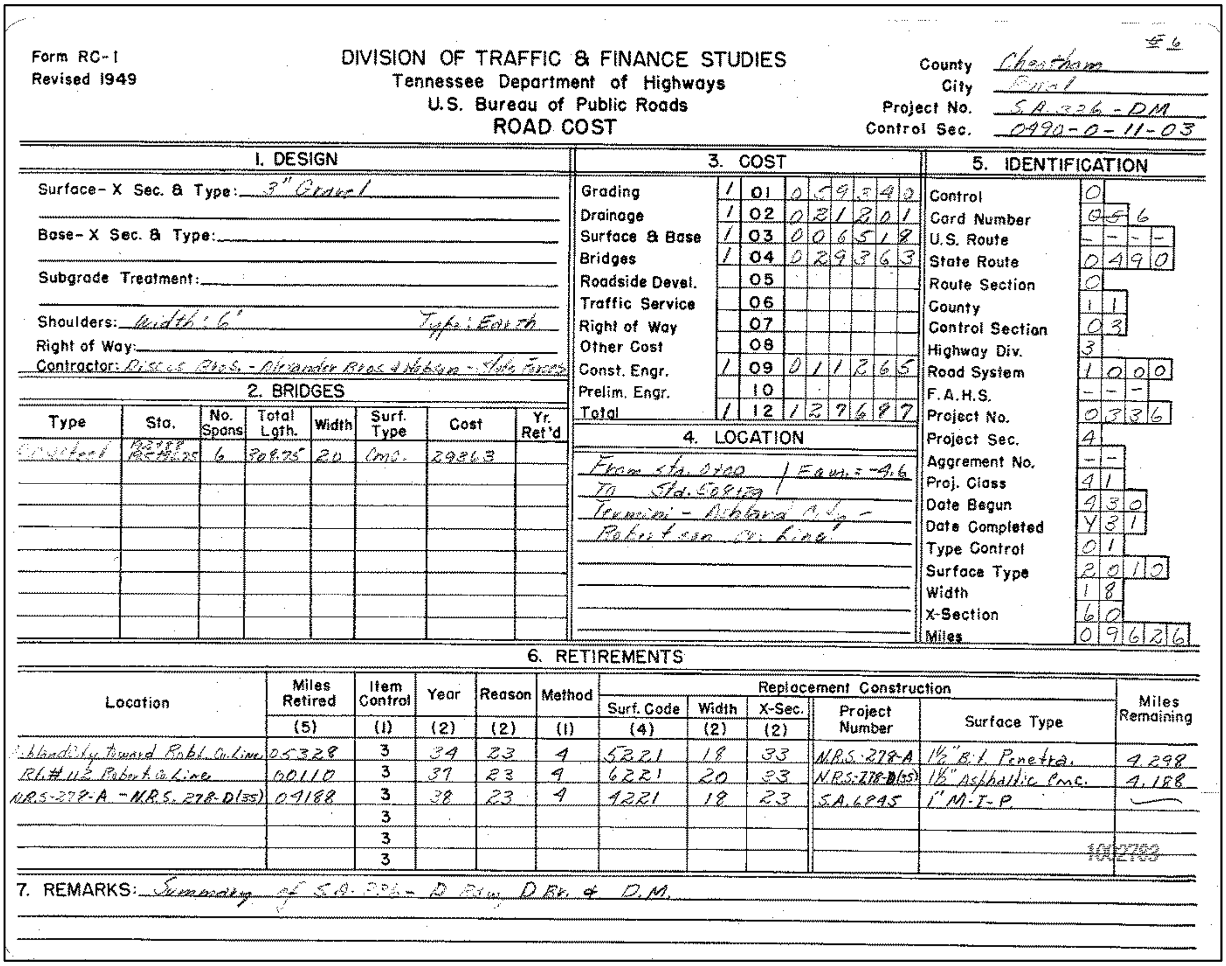


Figure 5. Sample file from Road Life Database, Cheatham SR-49.



Form RC-1
Revised 1949

DIVISION OF TRAFFIC & FINANCE STUDIES
Tennessee Department of Highways
U.S. Bureau of Public Roads
ROAD COST

County: Cheatham
City: Rural
Project No.: S.A. 336 - DM
Control Sec.: 0490-0-11-03

1. DESIGN

Surface- X Sec. & Type: 3" Gravel
Base- X Sec. & Type:
Subgrade Treatment:
Shoulders: Width: 6' Type: Earth
Right of Way:
Contractor: Discus Bros. - Alexander Bros & Hobson - State Forces

2. BRIDGES

Type	Sta.	No. Spans	Total Lgth.	Width	Surf. Type	Cost	Yr. Ret'd
Creosoted	122+88 125+96.75	6	308.75	20	Conc.	29863	

3. COST

Grading	1	01	059540
Drainage	1	02	021201
Surface & Base	1	03	006519
Bridges	1	04	029363
Roadside Devel.		05	
Traffic Service		06	
Right of Way		07	
Other Cost		08	
Const. Engr.	1	09	011265
Prelim. Engr.		10	
Total	1	12	127687

4. LOCATION

From Sta. 0+00 / Equ. = -4.6
To Sta. 508+29 /
Termini - Ashland City - Robertson Co. Line

5. IDENTIFICATION

Control	0
Card Number	6
U.S. Route	- - - -
State Route	0490
Route Section	0
County	11
Control Section	03
Highway Div.	3
Road System	1000
F.A.H.S.	- - -
Project No.	0336
Project Sec.	4
Aggrement No.	- -
Proj. Class	41
Date Begun	430
Date Completed	Y31
Type Control	01
Surface Type	2010
Width	18
X-Section	60
Miles	09626

6. RETIREMENTS

Location	Miles Retired (5)	Item Control (1)	Year (2)	Reason (2)	Method (1)	Replacement Construction: Surf. Code (4)	Width (2)	X-Sec. (2)	Project Number	Surface Type	Miles Remaining
Ashland City toward Robt. Co. Line	05328	3	34	23	4	5221	18	33	N.R.S. 278-A	1½" B.I. Penetra.	4.298
Rt. #112 Robert. Co. Line	00110	3	37	23	4	6221	20	33	N.R.S. 278-D(35)	1½" Asphaltic Conc.	4.188
N.R.S.-278-A - N.R.S. 278-D(35)	04188	3	38	23	4	4221	18	23	S.A. 6845	1" M-I-P	
		3									
		3									
		3									

7. REMARKS: Summary of S.A. 336 - D Bw, D Br. & D.M.

Figure 6. RoadLife Card#6, Cheatham SR-49, April 1930 gravel construction.

In recent years, regional resurfacing coordinators maintained local lists of project history which could be used to determine pavement age as part of the project identification process. As of June 2017, all new resurfacing project segments and other paving projects are being loaded into HPMA construction history database.

OPTIMIZATION

As yearly work plans are developed, the lane-mile-years for entire work plan can be calculated for an individual region, district or the entire state. By the lane-mile-years approach, a target value for developing work plans is equal to the number of lane miles in the network for that plan. For example, there are 5,195.6 lane miles of interstate statewide. To maintain the current levels of network health, an annual work plan for interstates should calculate to a minimum of 5,195.6 lane mile years.

The benefit of any resurfacing project can be estimated by assuming the number of years a particular project contributes to the life of the pavement being resurfaced. These life extension values, based on past experience, provide the ability to estimate the benefit of a selected treatment. The estimated life extension of various resurfacing treatment types and treatment limitations are provided later in this document, under “Treatments”.

Yearly resurfacing work plans can be optimized by calculating the “lane mile years” (LMY) contributed by the selected project. When calculating lane-mile-years for optimizing work plans, the estimated life extension for each treatment must be multiplied by the total lane miles of the project.

Example: Macon County State Route 262 has a Paving Project with a 411 D overlay. The 2-lane project starts at Log Mile 0.00 and ends at Log Mile 7.00.

Required: Calculate Lane-Mile-Years for this project

Solution: This is a 2-lane Route. Assume a 411-D overlay contributes a life extension of 12 years. Since the project is 7.0 miles along, multiply 7.0 x 2 =

14.0 Lane Miles. Then, multiply the 14.0 Lane Miles x 12 year life extension from the table above.

14.0 Lane Miles x 12.0 Years = <u>168.0 Lane-Mile-Years</u>

At current, this is the default procedure for evaluating draft work plans to ensure resurfacing funding is being spent efficiently and in such a manner that the highest benefit is achieved with available funding. As the resurfacing program matures in the coming years, newer metrics and procedures may be identified which more efficiently identify projects and work plans that deliver the highest overall network quality. If new optimization procedures and metrics are developed which are considered superior to the approach described above, these guidelines will be modified accordingly.

RESURFACING LIST DEVELOPMENT PROCESS

1) Annual Pavement Management System (PMS) reports and available resurfacing budgets are distributed to regional staff in early spring. This data, along with available project history information for pavement age, is used to develop draft resurfacing lists. When applicable, the Pavement Management office may suggest projects for consideration based on HPMA analysis outputs.
2) A meeting will be held with district staff to discuss budget restraints and goals.
3) A team from the region will visit potential projects to confirm PMS data, evaluate with visual inspection, and decide potential treatments. Visual inspections help estimate the district/Regional priority of a potential project and verify whether marginal projects can be addressed with routine maintenance. Projects that will not last another year without maintenance are given high priority.
4) Once the regional team has completed its visit and made recommendations for project selection, the resurfacing coordinator will meet with the district staff to discuss project selection, budget, and lane-mile-year goals. After this process has been completed for each district, the resurfacing coordinator will compile a regional list to be submitted to the State Pavement engineer that satisfies budget allocations and goals.
5) Once the Pavement Management Program's proposed work is finalized, the resurfacing coordinator shall submit the region-wide list to the parties listed in "Group A" of the Resurfacing Delivery Schedule (Appendix A). Region resurfacing lists are submitted using the unified resurfacing list format (Appendix B).

Region-wide resurfacing lists should be turned in approximately 33 weeks before the expected letting date of the earliest expected letting on the list, in accordance with the Resurfacing Delivery Schedule (Appendix A). Exact due dates for resurfacing lists will be negotiated between Region Resurfacing Coordinator, Programming, and the State Pavement Engineer to provide enough time to properly enter all information into the

Program/Project/Resource Management System (PPRM). Interstate and State Route lists are submitted separately.

PROJECT DEVELOPMENT AND DELIVERY

Following submittal of the region resurfacing list, the development of projects should abide by the Resurfacing Delivery Schedule (Appendix A), based on the earliest expected letting for projects on the list. Unified Plans, Specifications, and Estimates (PS&E) forms for resurfacing projects are available in Appendix C.

SCHEDULE DATES

In an effort to deliver resurfacing projects in an efficient time frame, the Resurfacing Delivery Schedule offers suggested time frames for each activity based on target letting dates. In general, Interstate projects are initially targeted for the October letting, which requires selection of projects by May of the previous year. If Interstate documents are not on track to be complete for October plans turn-in dates, projects can be postponed for December letting, but it is preferred that all interstate projects be let and awarded by December letting. State Route projects initially target the February letting with the understanding that only a select portion of projects will need to be ready for February. Target letting dates are cooperatively set by the Program Development, Estimating, and Pavement Management offices based on regional priorities and recommendations from the Estimating Office and the Pavement Engineer.

BIKE LANES AND PEDESTRIAN ACCESSIBILITY

The state bicycle and pedestrian coordinator receives resurfacing lists as part of the Resurfacing Delivery Schedule and compares the project lists with state and local bicycle and pedestrian plans, as well as consults with MPO/TPO staff and regional TDOT staff. The bike/ped coordinator then makes recommendations to the resurfacing coordinator for bike/pedestrian upgrades to be included in resurfacing plans. The resurfacing coordinator then works with local governments to determine their desire for upgrade, and coordinates the inclusion of a striping plan (with estimated quantities within the resurfacing plans.

CURB RAMP INSTALLATIONS AND IMPROVEMENTS

In 2007, in an effort to make TDOT facilities more accessible to users with disabilities and to comply with the 1990 Congressional passing of the Americans with Disabilities Act (ADA) and the Public Rights-of-way Accessibility Guidelines (PROWAG), the Department began assisting local governments in the area of compliance with ADA by addressing needed repair and/or installation of curb ramps (elevating the curb ramps to meet ADA guidelines whenever possible) as encountered through the resurfacing program. Elements are identified during the PS&E process such that potential curb ramp installations or improvements will be made to improve accessibility on all TDOT resurfacing projects near existing sidewalk or other related pre-existing pedestrian elements.

PS&E KICK-OFF MEETINGS

Once prioritized resurfacing lists have completed the initial conflict and bundling review process, each region and/or district will hold a PS&E Kickoff meeting to discuss projects prior to mobilizing for PS&E field reviews. Representatives from the following regional office should be in attendance during PS&E kickoff meetings:

- Regional Directors and/or Assistants
- District Managers
- Design
- Regional Traffic
- Those completing PS&E forms
- Materials and test

PS&E FIELD REVIEWS

Field reviews should be completed using the unified PS&E form (Appendix C), which includes fields to be completed to meet Federal and other field review requirements for Low-Cost Safety Improvements, curb ramp/accessibility forms, and bicycle/pedestrian forms. Forms for each previously existed, but were absorbed into the statewide PS&E form in spring 2017.

In general, most observations made during PS&E reviews are recorded for documenting and communicating necessary information to regional design staff for proper development of plans quantities. On most occasions, calculation of quantities should be made using Design Guideline and Standard Drawing formulas. Calculation of quantities should be completed by design staff, using measurements made during PS&E reviews. If quantities are offered in submitted PS&Es – such as striping – design staff should still utilize design standards to check calculations. Some of the elements identified and measured during field reviews include, but are not limited to:

- Measurement of existing/required pavement markings
- Measurement of pavement/shoulder width for cross-section and pavement quantity calculation
- Storm Drain Adjustments
- Utilities – manholes, gas valves, water valves
- Shoulder stone measurements
- Side roads, driveways, intersections and other entrances requiring consideration
- Guardrail repair and upgrades
- Identification of curb ramps requiring repair or installation

Measurements of pavement marking are made under the assumption that layouts of existing pavement markings are correct and quantities required for resurfacing are equivalent. Any assessment for improvement of pavement markings or layouts should be made by regional Traffic or Design staff.

Observations to be made for low-cost safety improvements - such as whether existing horizontal curves, roadside obstacles, or ditches may cause a safety issue - may require assistance from regional Traffic personnel.

Spot Milling and Spot Leveling

On many occasions, a need for small quantity milling or spot leveling or a combination thereof will be identified during development of resurfacing lists. If small areas are identified during PS&Es that require small quantity repair, quantities can be estimated in the field and documented on Page 2 of the PS&E form. Selection of mixtures used for leveling – 307CS, 307BM2, etc – is up to the discretion of regional or district preference. Additional Commentary on Spot Milling is provided herein in the Chapter on *Leveling Courses and Minor Rehabilitation.*

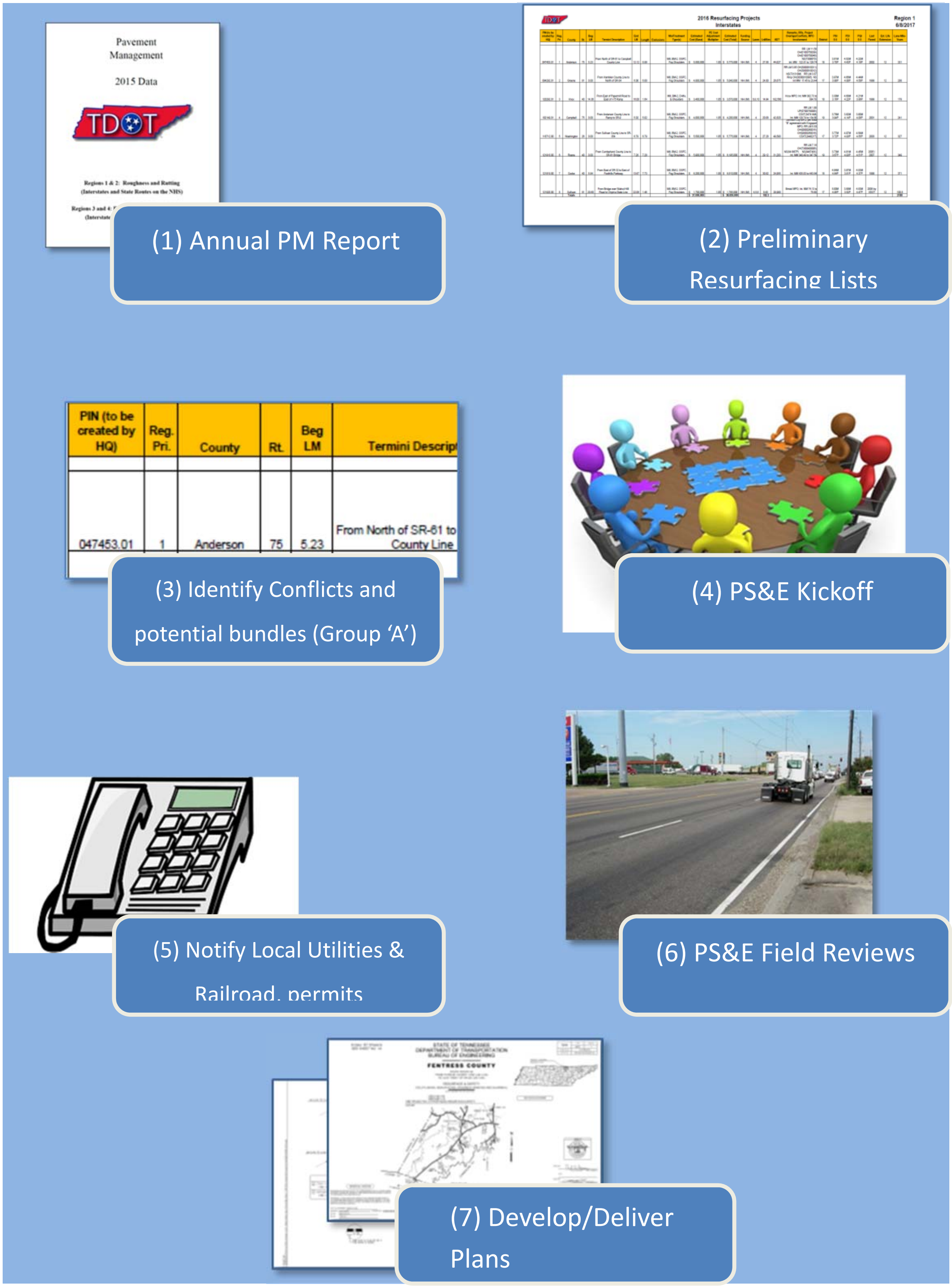


Figure X. Resurfacing Delivery Schedule

PAVEMENT TREATMENT GUIDELINES

The following Chapter outlines typical pavement resurfacing treatments for potential use on TDOT projects. Existing pavement condition and life extension values are based on historical experience, when available. Existing pavement condition values are to be used as guidance for selection of projects, but are guidance only and not expected to be strictly adhered to if local judgement and circumstances indicate otherwise. Life extension values are the official values to be used for calculation of lane-mile-years.

Suggestions for existing pavement condition are provided in terms of index values, HCIRI, and rut depth; but in all situations individual distresses such as block cracking, transverse cracking, patching, etc. should be considered in the final selection of pavement treatments.

CRACK SEALING

Description: Crack sealing is the placement of specialized materials either above or into working cracks using unique configurations to reduce the infiltration of water and to reinforce the adjacent pavement.

Typically, crack sealing will occur by means of utilizing regional on-call crack sealing contracts administered by TN General Services. Regions have the option of utilizing these contracts for contractor-placed crack seal or crack seal supplied by contract and placed by TDOT forces. If so desired, the Region has the option of developing plans for TDOT letting bid contracts, but utilization of on-call contracts should first be considered before pursuing this option.

Purpose: Crack Sealing is used to minimize the intrusion of water through existing cracks. By keeping water out of the pavement, erosion of the mix is kept to a minimum, deterioration of the crack is slowed, and less water is available to saturate the base materials.

Existing pavement condition: There is a wide window of opportunity for cost effective crack sealing of asphalt surfaced pavements. The intent is to select pavements which have sufficient cracking for crack sealing mobilization to be worthwhile, yet preclude excessively cracked pavements. The existing bituminous surface should be on a good base and cross section. On

Centerline joint sealed

both a flexible base and a composite Pavement, the bituminous surface should be four to five years old. However, the surface should be inspected when it is two to three years old to detect premature cracking. The visible surface distress may include: fairly straight open longitudinal and transverse cracks with slight secondary cracking and slight raveling at the crack face, and no patching or very few patches in excellent condition.

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	n/a	n/a	n/a	n/a	4-5
Composite	n/a	n/a	n/a	n/a	4-5

Existing pavement surface preparation: Some air cleaning or routing of cracks may be necessary to

Performance: The effectiveness of the seal will greatly depend upon the width of crack being sealed and the movement of the pavement structure at the crack.

Life Extension – Crack Sealing

Pavement	Years
Flexible	Up to 3 years
Composite	Up to 3 years

The time range is the expected life extending benefit given to the pavement, not the anticipated longevity of the treatment.

Performance Limitations: Generally, all cracks in the traveled lanes and the shoulder areas should be filled. Transverse cracks that have excessive secondary cracking around the main crack should not be individually sealed. The presence of this type of transverse crack is an indication that the pavement surface may warrant a more extensive pavement surface treatment.

Crack sealing materials should be aged at least one year prior to micro-surfacing, any type of Hot Mix Overlay, or other treatment.

This treatment is not a one-shot operation. In order to maintain the sealed pavement surface, this treatment should be followed up by a routine maintenance crack sealing or crack filling operation when additional cracks develop. Care should be taken when doing additional sealing so as not to seal extensive secondary cracks that will result in a safety problem.

Excessive crack sealing of secondary cracks creating safety concerns

Quantity of crack seal is excellent; however, longitudinal crack seal is too heavy.

Items, Guidelines, and Specifications:

Item: 411-04, Crack Sealant

Unit: LB

Specifications: Specifications are currently being added as plans special notes. Contact the Pavement Management office for a copy of the most recent notes for crack sealing.

Design Guidelines: Not available. In general, a rate of 1500 lb/mi has been used.

FOG SEAL

Description: Fog seals are a light application of diluted asphalt emulsion placed directly on the pavement surface.

Purpose: Fog seals are used to seal the pavement, inhibit raveling, and provide some enrichment to a hardened and oxidized AC surface.

Existing pavement condition: Fog seals are most effective when applied on a pavement in relatively good condition with minor cracks and some surface raveling or oxidation.

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 4.00	≥ 3.70	≤ 75	n/a	n/a
Composite	≥ 4.00	≥ 3.70	≤ 75	n/a	n/a

Existing pavement surface preparation: Repair and patch all major pavement defects. All cracks, other than hairline cracks, should be filled with suitable bituminous crack filler. Scrape all oil spots to remove excess oil and dirt. Just before applying the fog sealer clean the asphalt surface of all loose dust, dirt and other debris.

Performance: Fog seals generally last about one to four years before the pavement requires either another application or the placement of a more substantial surface restoration treatment. Fog seals are a low-cost means of rejuvenating the surface of the pavement and inhibiting raveling, and when placed early enough in the life of the pavement, can be effective at prolonging its life.

Life Extension – Fog Seal

Pavement	Years
Flexible	Up to 4 years
Composite	Up to 4 years

Performance Limitations: Fog seals are not effective for sealing a pavement surface with cracks. They do not repair potholes, cracks, or major raveling. Repeated applications of a fog seal at regular intervals increases its effectiveness. Fog seals may also be an immediate remedy to address a surface course constructed with low asphalt content. Aggregate shall be included to boost frictional properties if process is used on roadway.

Items, Guidelines, and Specifications:

Item: 403-05, BITUMINOUS MATERIAL(TC/FOG SEAL)(UNDILUTED)

Unit: TON

Specifications: TDOT Standard Construction Specifications, SS403

Design Guidelines: 4-403.05

Notes: The items listed below may be used on shoulders if desired to reference fog seal materials listed on the Qualified Products List (QPL). A footnote should be included with the estimated quantity indicating "Product must be listed on Qualified Products List (QPL) List 40 for High Performance Fog Seals" or "Product must be listed on Qualified Products List (QPL) List 40 for Standard Fog Seals", respectively.

403-01.10, High Performance Fog Seals, S.Y.

403-01.11, Standard Fog Seals, S.Y.

LONGITUDINAL JOINT STABILIZATION

Description: The weakest section of the pavement is the longitudinal construction joint between traffic lanes. Longitudinal Joint Stabilization (LJS) is a method to rejuvenate and seal longitudinal construction joint. This clear sealing material reduces water intrusion into joints which delays joint failure. This treatment should be applied within two to three years of the pavement's resurfacing.

Existing pavement condition: Longitudinal joint stabilization treatment is most effective when applied on a pavement in relatively good condition. Particular attention should be made for condition of existing joints, which are only candidate for stabilization when in very good condition.

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	n/a	n/a	n/a	n/a	2-3
Composite	n/a	n/a	n/a	n/a	2-3

Existing pavement surface preparation: Ensure surface is in a clean and dry condition.

Performance: Properly selected LJS projects will not immediately affect any pavement index values or distress, but should deter joints from deteriorating into cracks.

Life Extension - LJS

Pavement	Years
Flexible	Up to 3 years
Composite	Up to 3 years

Performance Limitations: Reflectivity of pavement markings is temporarily reduced until material is worn off of pavement markings. Treatment cannot be utilized on lanes adjacent to fog sealed areas.

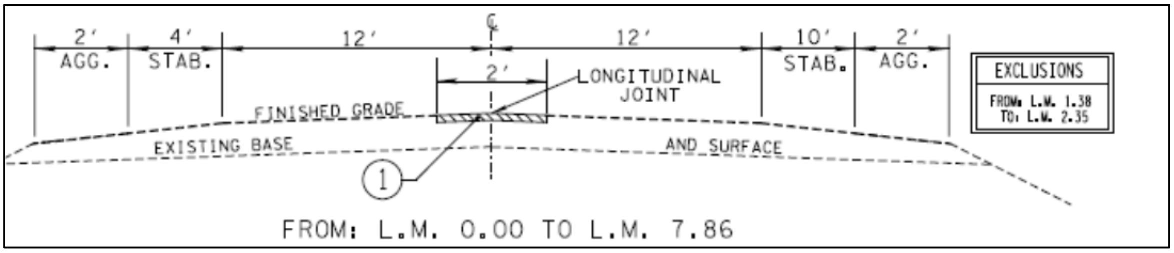
Items, Guidelines, and Specifications

Item: 411-01.12, LONGITUDINAL JOINT STABILIZATION

Unit: S.F.

Specifications: Qualified Products List, QPL.40.004, Pavement Rejuvenators

Design Guidelines: Design guidelines are not currently available, but plans typically indicate a 2' wide application over all longitudinal joints. Quantities should be based on existing longitudinal construction joints, i.e. the number of lanes -1 when shoulder joints are not being sealed or the number of lanes +1 when shoulders *are* being sealed.

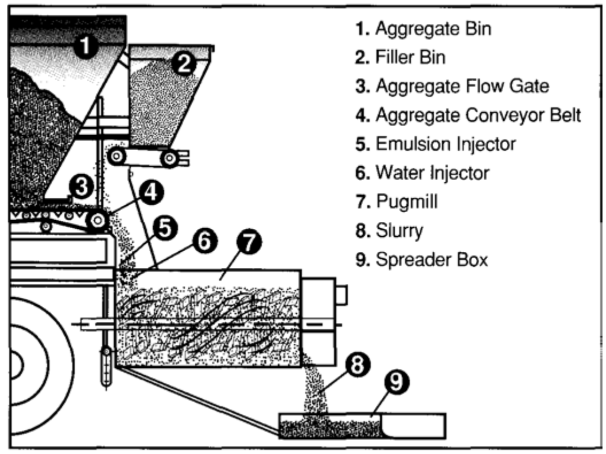


(1) JOINT STABILIZATION

ITEM 411-01.12 LONGITUDINAL JOINT STABILIZATION

SLURRY SEAL

Description: Slurry seals consist of a mixture of emulsified asphalt, fine aggregate, water and additives proportioned, mixed and uniformly spread over a properly prepared surface.



Purpose: Slurry seals are used to stop raveling and loss of matrix and improve surface friction. They can also be effective at sealing minor surface cracks.

Existing pavement condition: They are appropriate when the primary deterioration is related to excessive oxidation and hardening of the existing asphalt.

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 4.00	≥ 3.70	≤ 75	≤ 0.125” (1/8”)	≥7
Composite	≥ 4.00	≥ 3.70	≤ 75	≤ 0.125” (1/8”)	≥7

Existing pavement surface preparation: Immediately prior to applying the slurry seal, the surface shall be cleared of all loose material, oil spots, vegetation, and other objectionable material. It is advisable to pre-treat cracks in the pavement surface with an acceptable crack sealer prior to application of the slurry seal. Tack coat is generally only applied in areas where the existing roadway is extremely dry and raveled.

Performance: The performance life of slurry seal is generally reported as three to five years on roads with moderate to heavy traffic. Slurry seals are effective in reducing the development of pavement cracking and raveling. They perform best when applied to pavements in relatively good condition.

Life Extension – Slurry Seal

Pavement	Years
Flexible	Up to 5 years
Composite	Up to 4 years

Performance Limitations: Slurry seals should not be used on deteriorated pavements. Localized areas of severe distress should be patched prior to the application of the slurry seal. Working cracks should be sealed with a crack sealant, and the presence of a substantial number of wide or working cracks may indicate slurry seals are not an appropriate measure.

Items, Guidelines, and Specifications

Item: 414-02.02: EMULSIFIED ASPHALT SLURRY SEAL

Unit: S.Y.

Specifications: TDOT Standard Construction Specifications, SS414

Design Guidelines: Same calculations and rates as 4-414.05, convert to S.Y. A rate of 16 lbs/s.y. is typically used.

MICROSURFACING

Description: Micro-surfacing is a type of slurry seal that uses a polymer-modified emulsion binder, higher quality aggregates, and a set control additive.

Purpose: A single course micro-surface has been used effectively to improve surface friction characteristics and to seal the pavement surface, thereby addressing oxidation and raveling. A multiple course micro-surface has been used to correct certain pavement surface deficiencies including severe rutting, minor surface profile irregularities, polished aggregate or low skid resistance and light to moderate raveling.

Existing pavement condition: Micro-surfacing does not add significant structure to the existing pavement, so its use should be limited to pavements exhibiting little structural deterioration. The pavement should exhibit a uniform cross-section and a good base. The visible surface distress may include slight cracking, rutting, minor surface irregularities, flushed or polished surface and/or moderate raveling. Tack coat is generally only applied in areas where the existing roadway is extremely dry and raveled. Double applications are capable of improving moderate ruts. If significant rutting (>0.5") exists, additional quantity and notes can be added for a rutfill box.

Single Application @ 22 lbs./s.y.

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 4.00	≥ 3.70	≤ 75	≤ 0.125" (1/8")	≥7
Composite	≥ 4.00	≥ 3.70	≤ 75	≤ 0.125" (1/8")	≥7

Double Application @ 32 lbs./s.y. (18 lb. & 14 lb. Lifts)

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 4.00	≥ 3.70	≤ 75	<0.5" (1/2")	≥7
Composite	≥ 4.00	≥ 3.70	≤ 75	<0.5" (1/2")	≥7

Existing pavement surface preparation: Pavements with fatigue cracking and/or significant linear cracking are not candidates for micro-surfacing unless these deteriorated areas are repaired prior to the placement of the micro- surfacing. Micro-surface is well suited to filling ruts on an otherwise sound pavement. Immediately prior to applying the micro-surface, the surface shall be cleared of all loose material, silt spots, vegetation, and other objectionable material.

Performance: This treatment corrects rutting, flushing and low friction. The service life of micro-surface is generally reported to be about six to eight years. However, in judging its performance, it must be recognized that micro-surface can be placed for different reasons and therefore its performance is tied closely to its application.

Life Extension

Single Application @ 22 lbs./s.y.

Pavement	Years
Flexible	6 to 8
Composite	5 to 7

Double Application @ 32 lbs./s.y. (18 lb. & 14 lb. Lifts)

Pavement	Years
Flexible	7 to 9
Composite	7 to 9

Performance Limitations: A standard micro-surface formulation should not be used on a pavement with moderate to heavy surface cracks. Micro-surface mixes require warm to moderate temperatures for curing; caution is recommended for late season nighttime work.

SR 290 - Putnam County – Minor rutting and cracking. Single course micro-surface.

Items, Guidelines, and Specifications

Items:	414-03.01 EMULSIFIED ASPHALT FOR MICRO-SURFACING, TON
	and
	414-03.02 AGGREGATE FOR MICRO SURFACING, TON
	or
	414-03.03 MICRO SURFACING, S.Y.
Specifications:	TDOT Standard Construction Specifications, SS414
Design Guidelines:	4-414.05, convert to S.Y. for Item No. 414-03.03

SCRUB SEAL

Description: The scrub seal process provides an economical treatment that fills cracks, rejuvenates worn asphalt pavement and provides a durable wearing course. Scrub seals are also used to provide a membrane with resistance to reflective cracking.

Purpose: The primary purpose of the scrub seal treatment is to fill cracks and seal the asphalt pavement.

Ribbon of material in front of broom

Extensive cracking from oxidized pavement

Existing pavement condition: Scrub seals are capable of improving roadways with a large amount of cracking, with individual cracks up to ¼" wide, but they are not intended to improve the structural condition of pavements. Therefore, the seal should only be used on stable asphalt pavements that are dry, oxidized and cracked.

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	n/a	n/a	n/a	≤ 0.125" (1/8")	≥7
Composite	n/a	n/a	n/a	≤ 0.125" (1/8")	≥7

Existing pavement surface preparation: The pavement shall be cleaned of all lose dirt, vegetation and other objectionable material prior to the application to the scrub seal.

Performance: Scrub seal has an estimated life of six years. The scrub seal rejuvenates the existing pavement, seals existing pavement, fills cracks and voids, and provides a skid- resistant wearing surface.

Life Extension – Scrub Seal

Pavement	Years
Flexible	Up to 7 Years
Composite	Up to 7 Years

Performance Limitations: The emulsion bonds to the cracks and seals them from water damage. Pavements with a poor subgrade are not good candidates for a scrub seal.

Scrub seals are often combined with other treatments such as a micro-surface or thin overlay. If not, it is good practice to fog seal as described in SS403 for fog sealing of shoulders.

Application of asphalt sealer

sealer

Aggregate applied to asphalt

Brooming of aggregate cover material

Rolling of aggregate cover material – 2 passes

Scrub Seal approximately one year after placement salt is present from winter treatment

Items, Guidelines, and Specifications

Items: 405-03.01: PM REJUVENATING SCRUB SEAL

Unit: S.Y.

Specifications: SP405SS

***Design Guidelines*:** When utilizing scrub seal as a part of a combination treatment, tack coat is typically excluded, i.e. no tack is required on top of scrub seal when paving over a scrub seal.

CHIP SEAL

Description: The chip seal process provides an economical treatment that fills cracks, rejuvenates worn asphalt pavement and provides a durable wearing course.

Purpose: The primary purpose of the chip seal treatment is to fill cracks and seal the asphalt pavement. When appropriate, chip seal treatments should be considered as a treatment when ADT's are less than 750. Unless the chip seal is to be covered by another treatment, a fog seal is placed immediately following chip seal construction.

Fog Seal Applied after Chip Seal is complete to help curing and lock aggregate in place

Existing pavement condition: Chip seals are capable of improving roadways with significant levels of cracking, with individual cracks up to 3/16” wide, but they are not intended to improve the structural condition of pavements. Therefore the seal should only be used on stable asphalt pavements that are dry, oxidized and cracked.

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	n/a	n/a	n/a	≤ 0.125” (1/8”)	≥7
Composite	n/a	n/a	n/a	≤ 0.125” (1/8”)	≥7

Existing pavement surface preparation: The pavement shall be cleaned of all lose dirt, vegetation and other objectionable material prior to the application to the chip seal.

Performance: Chip seal has an estimated life of six years. The chip seal rejuvenates the existing pavement, seals existing pavement, fills cracks and voids, and provides a skid resistant wearing surface.

Life Extension

Pavement	Years
Flexible	6 Years
Composite	6 Years

Performance Limitations: The emulsion bonds to the cracks and seals them from water damage. Pavements with a poor subgrade are not good candidates for a chip seal.


Aggregate applied to asphalt sealer **Rolling of aggregate cover material – 2 passes**

Completed Chip Seal w/ Fog Seal

Items, Guidelines, and Specifications

Items:	405-01.01, BITUMINOUS MATERIAL (BSC)
	405-01.02, MINERAL AGGREGATE (BSC)
	403-05, BITUMINOUS MATERIAL(TC/FOG SEAL)(UNDILUTED)
Unit:	TON
***Specifications*:**	TDOT Standard Construction Specifications, SS405, Bituminous Seal Coat
Design Guidelines:	4-405.00

CAPE SEAL

Description: A cape seal is a chip seal treatment that is topped with one layer of micro-surfacing. The chip seal process provides an economical treatment that fills cracks, provides a crack relief layer to mitigate reflective cracking in the future and the micro-surfacing provides a riding surface.

Purpose: The primary purpose of this dual treatment is to mitigate top down cracking on an older (but healthy) pavement. This treatment can be a cheaper alternative to a milling and overlay project.

Chip Seal prior to Microsurfacing Lift being placed

Existing pavement condition: As noted for chip seals, Cape Seals are a reliable method for mitigating non-structural top-down cracking. Roadways with moderate distress and acceptable rideability make good candidates for cape seals.

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 3.60	≥ 3.50	≤ 75	≤ 0.25”	≥9
Composite	≥ 3.30	≥ 3.30	≤ 90	≤ 0.25”	≥9

Extensive cracking from oxidation, no structural damage

A cape seal is not intended to improve the structural condition or smoothness of pavements. Therefore, the seal should only be used on stable asphalt pavements with moderate cracking. The existing pavement will need to have a smoother surface (similar to a Microsurfacing candidate) but with top-down cracking.

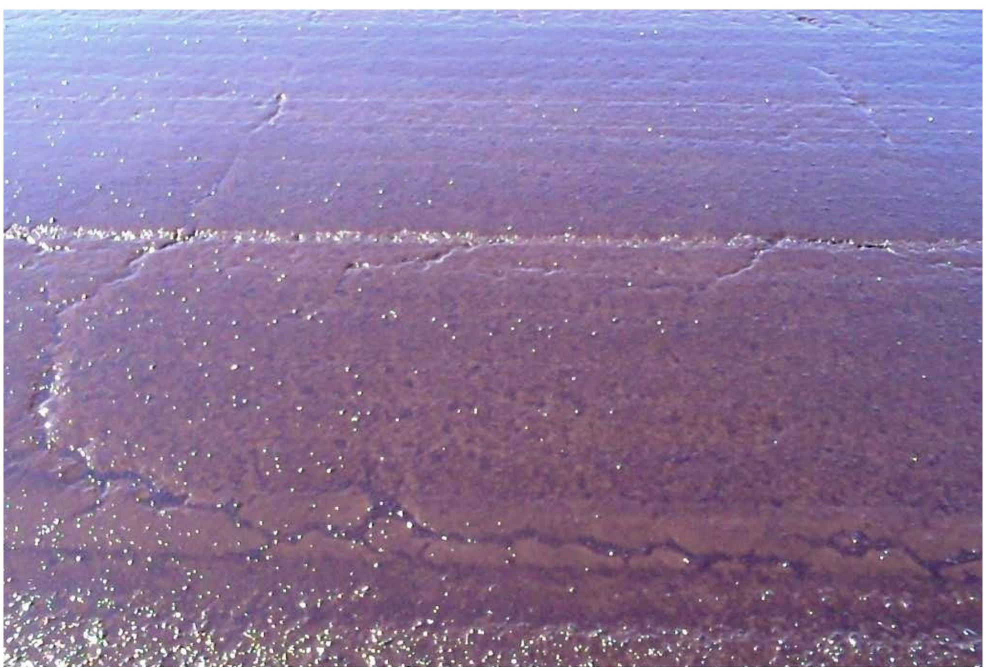
Existing pavement surface preparation: The pavement shall be cleaned of all lose dirt, vegetation and other objectionable material prior to the application to the chip seal.

Performance: Chip seal and Microsurfacing has an estimated life of ten years. The chip seal rejuvenates the existing pavement, seals existing pavement, fills cracks and voids, and the Microsurfacing provides a very durable and smooth riding surface.

Life Extension

Pavement	Years
Flexible	10 Years
Composite	10 Years

Performance Limitations: The emulsion bonds to the cracks and seals them from water damage. Pavements with a poor subgrade are not good candidates for this process.



CRS-2P Emulsion filling the cracks prior to aggregate being dropped

Completed Chip Seal with 24 lbs/SY Microsurfacing

Items, Guidelines, and Specifications

Items: Chip seal items, rates, and calculations are the same as for *Chip Seals*.

Microsurface items, rates, and calculations are the same as for *Microsurfacing*, with the exception that an aggregate rate of 24 lbs/yd^2 should be used.

Unit: See above.

Specifications: See above.

Design Guidelines: See above.

THIN OVERLAY TREATMENT

Description: Thin hot mix asphalt (HMA) overlays are the most commonly utilized treatments in the pavement preventive maintenance program. A minor amount of structural improvement is provided with this strategy. To qualify as preventive maintenance, an HMA mixture is limited to 1-3/4” in thickness as an overlay.

Use of shuttle buggy on thin overlay

Some of the mixes that meet these guidelines are:

- 1-1/4” (132.5 lbs/yd2) of 411-D or 411-TLD mix
- ¾” (85 lbs/yd^2) of Thin Lift “D” or “TL” mix
- 5/8” (65 lbs/yd^2) of Thin Lift “TL” mix

Purpose: Thin overlays protect the pavement structure, reduce the rate of pavement deterioration, correct surface deficiencies, reduce permeability and improve the ride quality of the pavement.

“D” Mix – This treatment is very commonly used typically used on higher ADT routes and on more heavily distressed roadways. Occasionally “D” Mix is used to add structure to routes inherited from the counties in the 1982 Road Program Act.

Thin Lift “D” Mix – This type of mix is similar to the “D” Mix minus the ½” aggregate. This treatment is typically applied to roadways with low-to-moderate ADT volumes and minor-to-moderate cracking.

Thin Lift "TL" Mix – This treatment is typically applied to routes that exhibit little or no distress and acceptable pavement structure. This treatment is only successful as a preservation treatment to combat oxidation of the wearing. No structural improvement and little or no improvement in roadway smoothness can be anticipated.

Existing pavement condition: The existing pavement should exhibit a good base condition and a uniform cross section. The visible surface distress may include moderate raveling, longitudinal and transverse cracks and small amounts of block cracking. Only minor base failures and depressions should be present.

"D" Mix (1 ¼")

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 3.60	≥ 3.50	≥ 75	≤ 0.25"	≥9
Composite	≥ 3.30	≥ 3.30	≥ 90	≤ 0.25"	≥9

Thin Lift "TL" or Thin Lift "D" Mix (3/4")

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 3.90	≥ 3.70	≤ 75	≤ 0.125"	≥7
Composite	n/a	n/a	≤ 75	≤ 0.125"	≥7

Thin Lift Mix (5/8")

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 4.00	≥ 3.70	≤ 65	≤ 0.125"	≥7
Composite	n/a	n/a	≤ 65	≤ 0.125"	≥7

Existing pavement surface preparation: The preparation work should be limited to the repair of the minor base failures and depressions, the filling of voids in the pavement surface, the removal of any patched area with poor adhesion or a very high asphalt content that may bleed up through the new bituminous surface.

Performance: This treatment performs best on flexible pavement structures, but is also applicable to composite pavements depending on the extent of the reflective cracking.

Life Extension ("D" Mix @ 1 ¼")

Pavement	Years
Flexible	12 Years
Composite	10 Years

Life Extension (Thin Lift "D" Mix @ ¾")

Pavement	Years
Flexible	9 Years
Composite	n/a

Life Extension Thin Lift Mix (@ 5/8")

Pavement	Years
Flexible	7 Years
Composite	n/a

Performance Limitations: A thin HMA overlay should not be placed on the following existing pavement conditions: severely distressed composite pavement, severely raveling or rutted bituminous pavement, pavement with a weak base, or a bituminous surface that is de-bonding.

SR 111 - White County - 1-1/4" "D" Mix with 2-foot taper on shoulders

Items, Guidelines, and Specifications

Items:

ITEM NUMBER	DESCRIPTION
411-01.10	GRADING D SURFACE (PG 64-22)
411-02.10	GRADING D SURFACE (PG 70-22)
411-03.10	GRADING D SURFACE (PG 76-22)
411-03.07	GRADING TL SURFACE (PG 64-22)
411-03.08	GRADING TL SURFACE (PG 70-22)
411-03.09	GRADING TL SURFACE (PG 76-22)
411-03.12	GRADING TLD SURFACE ((64-22)
411-03.13	GRADING TLD SURFACE (PG 70-22)
411-03.14	GRADING TLD SURFACE (PG 76-22)

Unit: TON

Specifications: TDOT Standard Construction Specifications, SS411

Design Guidelines: 4-411.00, 4-300.00 (PG Grade Selection)

Notes: In the event that 411-TLD or 411-TL is specified at an application rate of 1-1/4”, a footnote may be required if there is a desire to require density testing or more than 2 rollers (*See Standard Spec 407.15)*

CHIP SEAL WITH THIN OVERLAY

Description: The chip seal process provides an economical treatment that fills cracks, rejuvenates worn asphalt pavement and provides a durable wearing course. The thin overlay provides a smooth and more durable riding surface that looks similar to a thin mix overlay or to 411 D overlay.

Purpose: The primary purpose of this dual treatment is to mitigate top-down cracking on an older (but healthy) pavement. This treatment can be a cheaper alternative to a milling and overlay project and add some additional structure. Chip seals need to be done on the correct route. Not all routes are good candidates due to being in town or in a residential area. These tend to be rural area projects.

Chip Seal prior to Thin Lift of Hot Mix Asphalt being

Existing pavement condition:

There are only two sure ways to mitigate top-down cracking in a pavement:By milling and replacing or by using a polymerized chip seal.

Extensive cracking from oxidized pavement, no structural damage

The chip seal will fill cracks and the aggregate will be used as a crack relief layer. A chip seal is not intended to improve the structural condition of the pavement. Therefore, the seal should only be used on stable asphalt pavements that are dry, oxidized and cracked.

Chip Seal with 5/8" Thin Overlay

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 3.2	≥ 3.5	≥ 3.50	≤ 0.125”	≥7
Composite	n/a	n/a	n/a	n/a	≥7

Chip Seal with 3/4" Thin Lift “TL” or Thin Lift “D” Mix (3/4”) Overlay

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 3.50	≥ 3.40	≤80	≤ 0.125”	≥9
Composite	n/a	n/a	n/a	n/a	≥9

Chip Seal with 1-1/4" 411-D Overlay

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	≥ 3.50	≥ 3.50	≤100	≤ 0.125”	≥9
Composite	n/a	n/a	n/a	n/a	≥9

Existing pavement surface preparation: The pavement shall be cleaned of all lose dirt, vegetation and other objectionable material prior to the application to the chip seals.

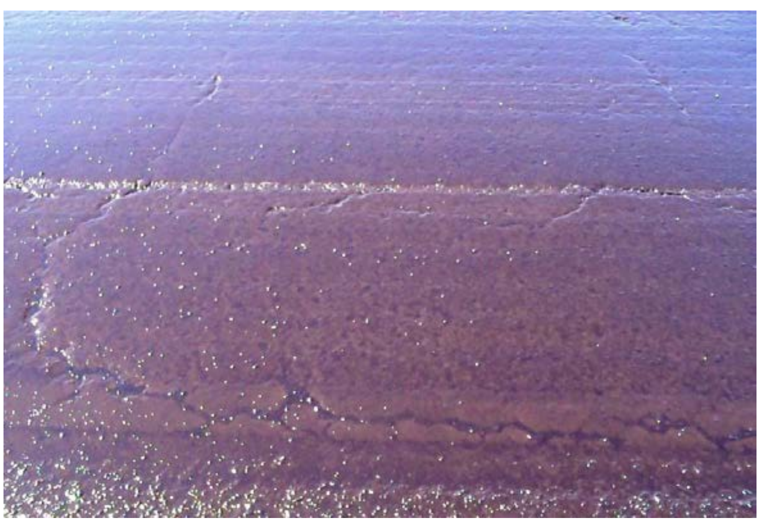
Performance: Chip seal and thin hot mix overlay has an estimated life of 12 years. The chip seal rejuvenates the existing pavement, seals existing pavement, fills cracks and voids, and the thin lift of hot mix asphalt provides a very durable and smooth riding surface.

Life Extension

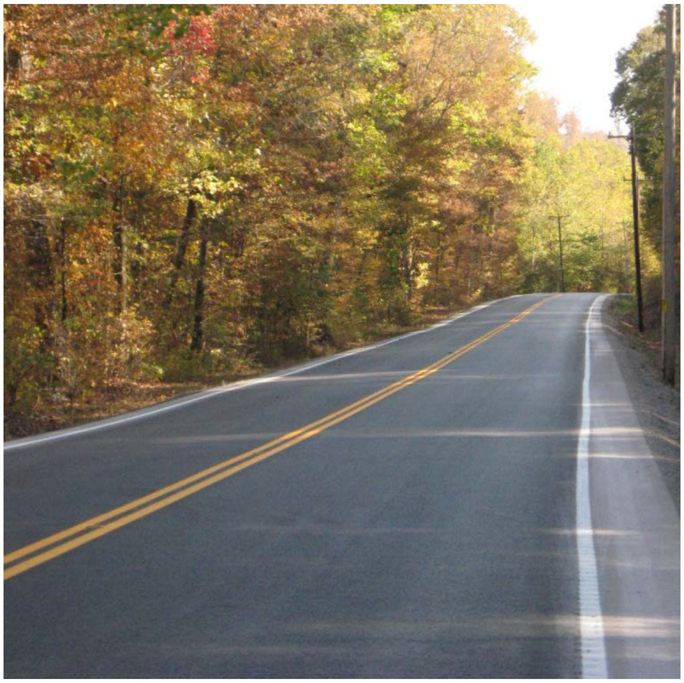
Chip Seal w/ 5/8" Thin Overlay, 3/4" Thin Lift "D" Overlay, or 1-1/4" 411-D Overlay

Pavement	Years
Flexible	12 Years
Composite	n/a

Performance Limitations: The emulsion bonds to the cracks and seals them from water damage. Pavements with a poor subgrade are not good candidates for a chip seal.



CRS2P Emulsion filling cracks prior to aggregate placement



Completed Chip Seal with Thin Overlay

Items, Guidelines, and Specifications

- Chip seal items, rates, and calculations are the same as for **"Chip Seal with a Fog Seal"**
- Thin Overlay items, rates, and calculations are the same as for **"Thin Overlay Treatment"**

OPEN-GRADED FRICTION COURSE

Description: Open-Graded Friction Course (OGFC) pavement is a specialty type treatment used to increase safety in areas where concerns exist for wet-weather safety. The porous nature of OGFC permits rain water to permeate through the surface and drain underneath along the cross slope, minimizing ponding and hydroplaning.

Purpose: OGFC treatments are recommended for areas with high posted speeds and traffic volumes.

Existing Pavement Condition: Existing pavement condition for OGFC treatments are similar to that described for traditional Mill and Replace treatments. OGFCs should be considered in higher-speed areas as an alternative to Mill and Replace. On most occasions, an interlayer mixture should be placed to seal the existing pavement before placement of the OGFC pavement. Milling 1-1/4" prior to placing OGFCs is common.

Mill, CS & OGFC (1/2" 307-CS, 1-1/4" 411-OGFC)

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	<3.50	<3.40	>100	>0.250"	≥9
Composite	<3.50	<3.40	>100	>0.250"	≥9

Mill, C & OGFC (1-1/2" 307-C, 1-1/4" 411-OGFC)

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	<3.50	<3.40	>100	>0.250"	≥9
Composite	<3.50	<3.40	>100	>0.250"	≥9

Existing Pavement Surface Preparation: None.

Performance: OGFC was not a significant part of TDOT's program until 2009, which limits the amount of available data to assess OGFC performance. As of summer 2017, OGFC performance data from Interstate projects is proving to be comparable to Mill and 411D up to 8 years.

Mill, CS & OGFC (1/2" 307-CS, 1-1/4" 411-OGFC)

Pavement	Years
Flexible	9 Years
Composite	n/a

Mill, C & OGFC (1-1/2" 307-C, 1-1/4" 411-OGFC)

Pavement	Years
Flexible	11 Years
Composite	n/a

Performance Limitations: OGFCs typically have higher costs than other pavement treatments, so they should only be used when traffic speeds and volumes indicate a safety benefit may is likely to result from placement.

Items, Guidelines, and Specifications

Asphalt Items: 411-03.23, ACS MIX (PG76-22) OGFC, TON

307-03.10, ASPHALT CONC MIX (PG76-22)(BPMB-HM) GR CS, TON

307-03.09, ASPHALT CONCRETE MIX (PG76-22) (BPMB-HM) GRADING C, TON

Cold Plane Items: 415-01.01, COLD PLANING BITUMINOUS PAVEMENT, TON

or

415-01.02, COLD PLANING BITUMINOUS PAVEMENT , S.Y

or

415-01.03, COLD PLANING BITUMINOUS PAVEMENT, C.Y.

(as directed by Design Guidelines)

Specifications: TDOT Standard Construction Specifications, SS415

Design Guidelines: 4-307.00, 4-411.00

MILL AND REPLACE TREATMENT

Description: The removal of an existing bituminous surface by the cold milling method and the placement of a HMA mixture limited to a depth of 1-1/4". The new inlay (1 ¼" "D" mix or ¾" Thin Lift "D" mix) replaces the surface removed.

Purpose: In preventive maintenance cold milling is used for the restoration of cross slopes, correct specific existing surface deficiencies, and produces a more economical project as compared to an overlay project. The inlay replaces the surface material removed by cold milling.

Existing pavement condition: The existing pavement should exhibit a good base condition. The visible surface distress may include: severe surface raveling, multiple longitudinal and transverse cracking with slight raveling, a small amount of block cracking, patching in fair condition, debonding surface and slight to moderate rutting.

The cold milling operation is used to correct rutting in the existing bituminous surface layer where the rutting is not caused by a weak base and when the condition of the existing pavement has deteriorated to a point where it is not practical to correct the rutting problem by a more economical treatment. The cold milling operation is also used to remove an existing bituminous course that is de-bonding.

Milling Machine and Water Truck

Existing pavement crown and super-elevation sections that have been identified as having a relationship to accidents can be modified by cold milling. In a curb-and-gutter section, cold milling can be used to remove a portion of the existing surface to retain the existing curb face. Cold milling can also be used in those areas where the existing pavement grade cannot be raised.

Mill and Replace Treatment (1-1/4", 411D)

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	<3.50	<3.40	>100	>0.250"	≥9
Composite	<3.50	<3.40	>100	>0.250"	≥9

Mill and Replace Treatment (3/4", 411TLD)

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	<3.70	<3.60	>85	>0.250"	≥9
Composite	<3.70	<3.60	>85	>0.250"	≥9

Existing pavement surface preparation: None.

Performance: This type of treatment will protect the remaining pavement structure, slow the rate of deterioration and improve the ride quality. This treatment performs best on flexible pavement structures, but is also applicable to composite pavements depending on the extent of the reflective cracking. A material transfer device, such as a shuttle buggy, is required on any roadway with sufficient clearance.

Milling machine in operation

Mill and Replace Treatment (1-1/4" 411D or 3/4" 411TLD)

Pavement	Years
Flexible	12 Years
Composite	12 Years

Performance Limitations: This treatment should not be used on an existing pavement that shows evidence of a weak base.

Items, Guidelines, and Specifications

Asphalt Items: Asphalt, rates, and calculations are the same as for **"Thin Overlay Treatment"**

Cold Plane Items: 415-01.01, COLD PLANING BITUMINOUS PAVEMENT, TON

or

415-01.02, COLD PLANING BITUMINOUS PAVEMENT , S.Y

or

415-01.03, COLD PLANING BITUMINOUS PAVEMENT, C.Y.

(as directed by Design Guidelines)

Specifications: TDOT Standard Construction Specifications, SS415

Design Guidelines: 4-411.00, 4-415.00

Notes: It is recommended that - unless evidence is available indicating the existing total pavement thickness is more than sufficient - spread rates selected for milling depth should be less than or equal to rates select for asphalt paving.

In the event that 411-TLD or 411-TL is specified at an application rate of 1-1/4", a footnote may be required if there is a desire to require density testing or more than 2 rollers (*See Standard Spec 407.15)*

HOT IN-PLACE RECYCLING

Description: The heating of existing pavement followed by the addition of a polymerized asphalt rejuvenating agent. The heated, rejuvenated mixture is then re-mixed and re-compacted with traditional hot-mix paving equipment

Purpose: Restore existing pavement conditions to conditions suitable for use as a base for a new surface layer while minimizing waste material and need for new materials.

Existing pavement condition: A hot in-place recycling candidate may have some aggregate raveling, minor to moderate cracking, and the occasional small patched pothole. This treatment should not be selected for roadway segments with a significant amount of high severity cracking or large amounts of patching. The existing surface to be recycled should have retained enough of its original aggregate gradation that it can be recycled into a suitable subsurface layer without a significant need for additional bituminous material.

Hot In-Place Recycling Treatment (1-1/4") with either 22 lb/sy micro or 85 lb/sy 411-TLD

Pavement	PDI	PQI	HCIRI	Rut Depth	Pavement Age (yrs)
Flexible	<3.50	<3.40	>100	>0.250"	≥9
Composite	<3.50	<3.40	>100	>0.250"	≥9

Existing pavement surface preparation: None.

Performance: Not including earlier variations of this method in which the construction specifications were significantly different, TDOT's experience with this treatment began in 2013. Consequently, local performance data is limited.

Hot In-Place Recycling Treatment (1-1/4") with either 22 lb/sy micro or 85 lb/sy 411-TLD

Pavement	Years
Flexible	10 Years
Composite	10 Years

Performance Limitations: This treatment should not be used on an existing pavement that shows evidence of a weak base.

Items, Guidelines, and Specifications

Items: 311-03.01, HOT IN PLACE RECYCLING OF ASPHALT PAVEMENT (1.25IN), S.Y.

311-03.04 HOT IN PLACE RECYCLING OF ASPHALT PAVEMENT (2.00IN), S.Y.

311-03.10 Asphalt Rejuvenating Agent, GAL.

Specifications: SP407HRA

Design Guidelines: The Feb2018 version of SP407HRA lists a rejuvenating rate of 0.10-0.30 gal/sy. The midpoint value may be used for estimating quantities, but other rates within the range may also apply. Check with Regional Resurfacing staff and local Materials and Tests.

LEVELING COURSES AND MINOR REHABILITATION

On occasion, roadway segments are identified that have deteriorated beyond the preventative maintenance criteria listed above but are not yet candidates for Major Rehabilitation. These segments are categorized as candidates for minor rehabilitation, which includes either a full width leveling course or small quantity for spot milling and/or spot leveling mixture.

Specific metrics for existing pavement condition have not yet been identified by the Department to identify when a full leveling course is merited, but historically a pavement segment with a PQI less than 2.3 will require minor rehabilitation. For a list of possible types of Minor Rehabilitation, see the chapter provided herein titled “Major and Minor Rehabilitation”.

Treatments with Full-Width/Full-Length Leveling Course

If a pavement segment is identified which requires a leveling course for the length of the project, this shall be identified on the resurfacing list during initial project selection. In general, 307-CS and 307-BM2 mixtures are most often used as leveling course. A common minimum spread rate used for CS is 40 lbs/yd^2, but higher rates can be specified. The minimum spread rate often used for 307-BM2 is 100 lbs/yd^2, but 170 lbs/yd^2 (1-1/2”) is optimal. The following are common Treatment Types which include leveling courses, not including OGFC treatments:

- Mill, BM-2, & 411D
- Mill, CS, & 411D

Spot Leveling

During field reviews and PS&E reviews, isolated locations of distress may be identified which may benefit from small repairs but are not large or significant enough to merit a full length leveling course. Fields are provided within the PS&E form to permit adding small quantities of milling and/or asphalt mixture to improve these small areas prior to placement of the overall pavement treatment. Mixture can be added to contracts to fill small low spots in the roadway or matching quantities of milling and asphalt can be added for the repair of small areas with significant distress. Quantities are determined based on field measurement. Mixtures commonly used for leveling include 307-CS and 411-E. In areas where deeper repairs are necessary (>2”) additional quantity of 307-BM2 may be required.

Performance

For pavement treatments including full-width leveling courses, performance is dependent on the depth of milling, if any, and the depth of interlayer. Life extension values provided below are based on the average of historical experiences. Longer life extension values may be expected if a higher than average thickness leveling course is placed. Since leveling courses and minor rehab are reserved for roadways with higher normal distress, it is common to expect life extension equivalent to what is expected for mill and replace treatments in lesser-distressed areas.

Life Extension: Mill, BM-2, & 411-D

Pavement	Years
Flexible	12 Years
Composite	12 Years

Life Extension: Mill, CS, and 411-D

Pavement	Years
Flexible	12 Years
Composite	12 Years

Items, Guidelines, and Specifications

- See “Mill and Replace Treatment”

ADDITIONAL COMBINATIONS OF TREATMENTS

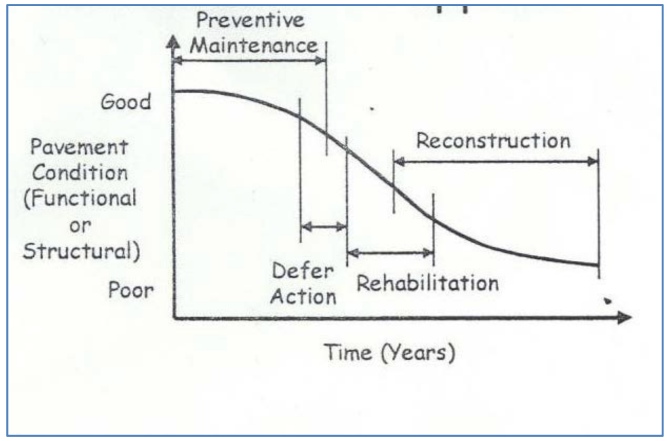
On occasion, during development of resurfacing lists, a need may be identified to use a combination of pavement treatments listed herein. For projects such as these, good judgement should be used to estimate the applicability of the combined treatment and the estimated life extension. For record-keeping purposes, the Pavement Management office will make final decisions on estimated life extension values.

DEVELOPMENT OF NEW RESURFACING TREATMENTS

The Department encourages innovation and the pursuance of technologies that help deliver our mission. As new technologies are made available for consideration as pavement treatment, a few considerations should be made to ensure proper implementation into projects, avoid conflicts with existing specifications, and minimize plans revisions and subsequent construction risks. Below is a list of items to consider when developing new resurfacing treatments:

- A draft special provision is preferred and should be sent to the state spec-writer for approval, especially when used on Federally-funded projects
  - Plans special notes may be used under select circumstances, but is discouraged.
  - SPs should refer to existing standard specifications whenever applicable.
  - Construction acceptance procedures should be included.
- Draft supplemental design guideline considerations should be developed to ensure proper calculations of quantities and necessary footnotes.
  - An assessment should be made to determine of other design guidelines may need to be revised, such as rates of other treatments being used in combination (i.e. micro rates increase to 22 lbs/yd when used over a chip or scrub seal.)
- An assessment should be made as to whether “Just in Time Training” should be provided to Departmental field staff prior to start of work.

MAJOR AND MINOR REHABILITATION



On occasion roadway segment are identified that Rehabilitation is the next pavement treatment in the Pavement Management Program following preventive maintenance. Rehabilitation is divided into two (2) categories: (1) Minor rehabilitation & (2) Major rehabilitation. Minor rehabilitation is necessary when repair costs to the pavement exceed the benefits derived from preventive maintenance treatments or when pavement structure needs to be increased. Major rehabilitation is necessary when the pavement deteriorates due to structural deficiencies or structural failure. Minor rehabilitation is limited to a pavement thickness of 2 ¾", with a possible milling depth of up to 1 ¼". Major rehabilitation requires a pavement thickness greater than 2 ¾", with a possible milling depth greater than 1 - ¼".

Since both types of rehabilitation (minor or major) encompass an extensive amount of work to elevate the pavement to an acceptable service level, as well as an excessive cost to perform the work, these treatments are typically delayed until sufficient funds can be set aside without having a significant impact to the resurfacing program. Therefore, these sections of roadway are generally addressed through routine maintenance until the funding for the extensive work can be obligated. Historically, each region will perform only one of these treatments (either minor or major rehabilitation) once every two to three years.

Looking forward, the Pavement Management office intends to develop a program for quantitatively identifying rehabilitation projects, but the necessary data is not available at this time.

MINOR REHABILIATION TREATMENTS:

Flexible and Composite Pavement Treatments

- Leveling Course and Thin Overlay
- Binder Course and Thin Overlay
- Milling (≤1-1/4”), Leveling Course, and Thin Overlay
- Milling (≤1-1/4”), Binder Course, and Thin Overlay
- Performance Grade Leveling Course and Performance Grade Thin Overlay
- Performance Grade Binder Course and Performance Grade Thin Overlay
- Milling (≤1-1/4”), Performance Grade Leveling Course, and Performance Grade Thin Overlay
- Milling (≤1-1/4”), Performance Grade Binder Course, and Performance Grade Thin Overlay

MAJOR REHABILITATION TREATMENTS:

Flexible and Composite Pavement Treatment

- Binder Course and Thin Overlay
- Milling (≥1-1/4”), Binder Course, and Thin Overlay
- Performance Grade Binder Course and Performance Grade Thin Overlay
- Milling (≥1-1/4”), Performance Grade Binder Course, and Performance Grade Thin Overlay

Some mixes which are used in addition to the wearing surface treatment can include the following: Binders - “B-M” or “B-M2” mix (1 ½” to 2” depth) or Leveling - “C-W” mix (1 ½” depth) or “CS” mix (5/8” depth).

Project selection for both minor and major rehabilitation will use data from the Pavement Management System (PMS) and visual inspection. A high priority for selection will be given to age and the overall pavement quality index (PQI). Both rehabilitation processes requires a PQI of less than 2.3. The PQI is derived from the pavement serviceability index (PSI) and the pavement distress index (PDI).

DeKalb County - SR 26 – Binder (BM-2) Placement

LOW COST SAFETY IMPROVEMENTS / HSIP Funding

Currently, upon creation of state project numbers all resurfacing projects receive a federal Highway Safety Improvement Program (HSIP) project number to cover the cost of qualifying safety improvements. If the total safety improvements do not reach a minimum of $10,000, the cost will be absorbed under the normal resurfacing project number and the HSIP project numbers will be deleted. In the early years of using HSIP funds on resurfacing projects, a "Resurfacing Safety Checklist" was developed, but all qualifying fields have been incorporated into the PS&E form in Appendix C. As safety improvement needs continuously change over time, so does the list of items qualifying for HSIP funds on resurfacing. At current, the items listed below qualify for HSIP funds. This list of items is subject to revision, which will be communicated to regional Resurfacing and Design staff by the State Pavement Engineer.

Items Qualifying for HSIP Funds on Resurfacing Projects

- Quantities added to widen to 2-foot shoulder in situations where the existing shoulder is less than two feet and the widening can occur with minimal grading and no right-of-way acquisition or utility relocations.
- Quantities added to correct superelevation, install high-friction surface treatment (HFST), or install chevrons in areas with concerning crash history and/or substandard geometry.
- Guardrail end terminal improvements per the MASH implementation guidelines (memo attached).
- Curb ramp repairs and new installation per ADA/PROWAG requirements. This includes associated items, such as crosswalk striping or curb items.
- Bike lane signing and pavement markings on projects in which a bike lane is being added.
- Adding centerline rumble strips.
- Replacement of non-frangible sign posts with breakaway posts.
- Adding chevrons or other advance warning signs in areas with poor sight distance.
- Removing vegetation in areas where doing so will improve sight distance.
- Removal or delineation of obstacles within the clear zone.

- Reshaping of ditches as a safety improvement.
- Adding proper safety headwalls to pipe culverts within the clear zone.
- Warning systems and other related items per Railroad Coordination requirements
- Use of Safety Edge, where applicable (There are no charges or items associated with this inclusion)
- Striping, snowplowable markers, rumble strips, and rumble stripes which are:
    - Being installed for the 1st time in accordance with Design Guidelines Table 4-3, attached.
    - Being installed above and beyond what is required per Design Guidelines Table 4-3 as supported by crash history. This includes instances in which these items are pre-existing but are above and beyond what is required per Design Guidelines Table 4-3 and supported by crash history.
    - Any of these items which are pre-existing and are being installed per Table 4-3 do not qualify for HSIP funds.
    - Pavement marking items are listed on a separate portion of the PS&E form. Recommendations for these upgrades should be documented somewhere, such as on the 'Notes-Remarks' page.

If a Roadway Safety Audit (RSA) project is identified within the limits of a resurfacing project and bundled into the resurfacing project, those items obviously still qualify for HSIP funds.

SPECIAL PROVISIONS FOR SMOOTHNESS ACCEPTANCE

The assignment of the ride quality Special Provisions SP411B or SP411C, as well as the determination of any ride exclusions to the specification, shall be made at the Regional level by those performing PS&E field reviews. Both the applicable Special Provision and the defined exclusions shall be noted during PS&E reviews. The default procedure for selecting smoothness provisions will be for SP411B to be placed on Interstate and controlled access projects and SP411C only be placed on projects with ≥1-1/4" of asphalt. If a need is identified meriting use of SP411C on thinner projects, that recommendation can be made by district staff and approved at the Regional level.

A prioritized resurfacing list shall be furnished by the Director of each region to the Regional Materials and Test (M&T) office. Pre-construction smoothness (Pre-ride) reports shall be completed by the Regional M&T offices for:

- All SP411C single lift overlay projects
- All SP411B and SP411C mill & fill projects on the resurfacing list showing a Pavement Management System (PMS) Half-Car International Roughness Index (HCIRI) greater than 80 inches per mile.

The projects shall be tested within a reasonable time frame, at least two weeks prior to the letting advertise date. In an effort to provide the most current test data, pre-ride data will no longer need to be submitted prior to turn-in date for inclusion in resurfacing plans, but will instead be due two weeks prior to advertising and will be made available to bidders by the Construction Division.

Appendix A – Resurfacing Delivery Schedule

Appendix B – Blank Resurfacing List

Appendix C – PS&E Form

Appendix D – Sample Set of Resurfacing Plans

Appendix E – Additional Information

Appendix 6: Sample Set of Resurfacing Plans

TENN.	YEAR	SHEET NO.
	2018	1
FED. AID PROJ. NO.	HSIP-280(11)	
STATE PROJ. NO.	16024-4215-04, 16024-3215-94	

Index Of Sheets

See Sheet 1A

COMBINED WITH 124937.00

Only place this note when a project is combined with another

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING

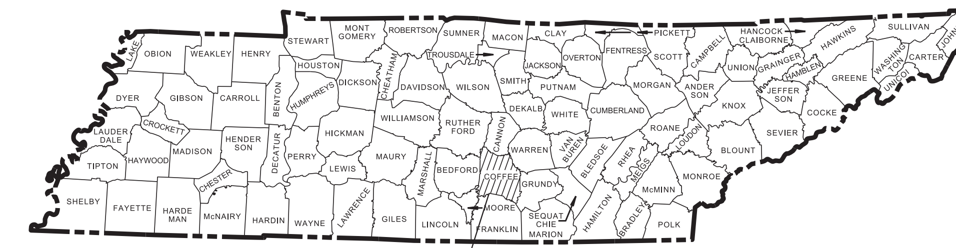
COFFEE COUNTY

STATE ROUTE 280
FROM SR-2 (LM 0.00)
TO SR-53 (LM 10.60)

RESURFACE & SAFETY

THIN LIFT D, PAVEMENT MARKINGS, COLD PLANING & GUARDRAIL

STATE HIGHWAY NO. 280 F.A.H.S. NO. N/A



PROJECT LOCATION

BRIDGE ID. # 16021220005 16S44000009 16S44000007 16S42900007 16S42900009

RAIL ROAD UNDERPASS

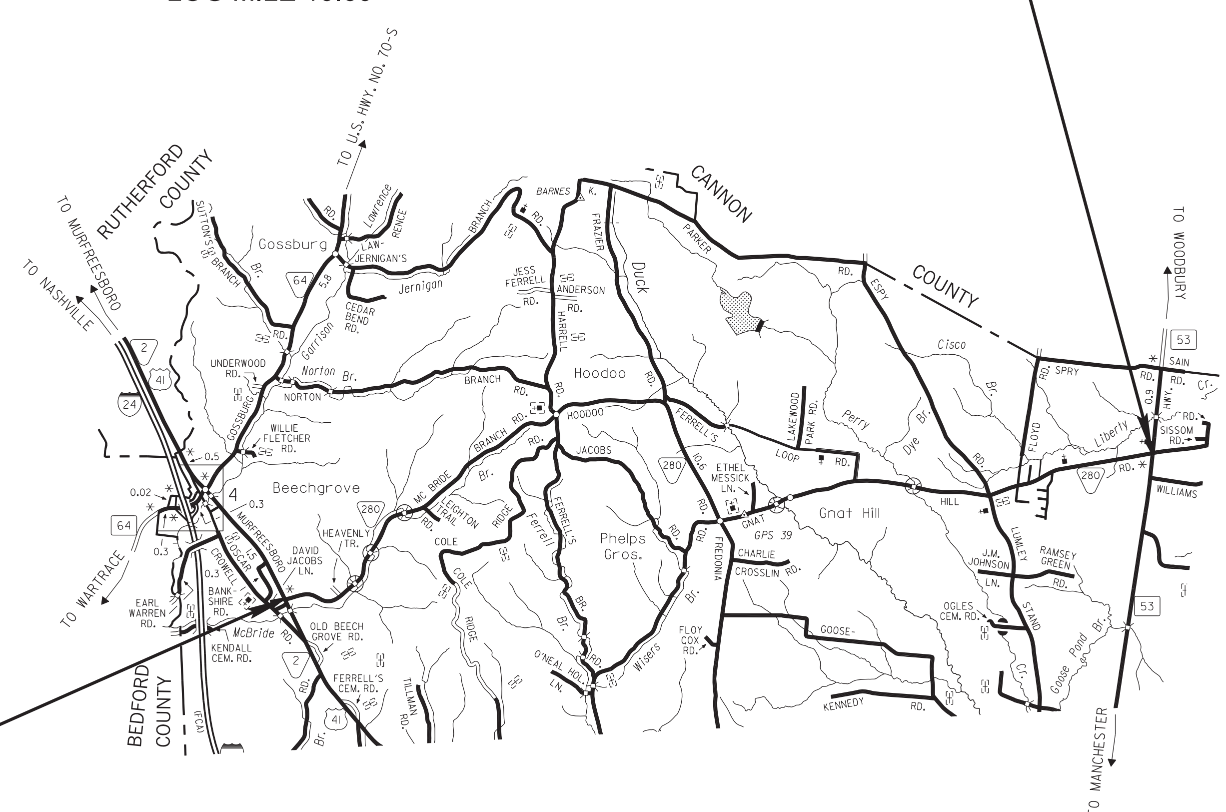
NORFOLK SOUTHERN CORP. (INC)
ID# [47S24060001] AT L.M. 1.87

SEE SHEET NO. 6 FOR NOTES.

R/R OVERPASSES
CSXT
(#347601V) @LM 0.56

NO EXCLUSIONS

16024-4215-04
16024-3215-94
END PROJECT NO. HSIP-280(11) RESURFACE & SAFETY
LOG MILE 10.60



16024-4215-04
16024-3215-94
BEGIN PROJECT NO. HSIP-280(11) RESURFACE & SAFETY
LOG MILE 0.00

0 1 2 3 MILES

SCALE: 1"= 5280

SEALED BY

APPROVED: Paul D. Degges
PAUL D. DEGGES, CHIEF ENGINEER

DATE:

APPROVED:
JOHN SCHROER, COMMISSIONER

SPECIAL NOTES

PROPOSALS MAY BE REJECTED BY THE COMMISSIONER IF ANY OF THE UNIT PRICES CONTAINED THEREIN ARE OBVIOUSLY UNBALANCED, EITHER EXCESSIVE OR BELOW THE REASONABLE COST ANALYSIS VALUE.

THIS PROJECT TO BE CONSTRUCTED UNDER THE STANDARD SPECIFICATIONS OF THE TENNESSEE DEPARTMENT OF TRANSPORTATION DATED JANUARY 1, 2015 AND ADDITIONAL SPECIFICATIONS AND SPECIAL PROVISIONS CONTAINED IN THE PLANS AND IN THE PROPOSAL CONTRACT.

TDOT ROAD SP. SV. 2 : JANE DOE

DESIGNER : JOHN SMITH   CHECKED BY : BILL MARTIN

P.E. NO. 98023-4217-04

PIN NO. 124938.00

PROJECT LENGTH 10.60 MILES

TOTAL LANE MILES RESURFACED 21.20 MILES

TRAFFIC DATA	
ADT (2018)	1900
LM	POSTED SPEED
LM 0.00-6.10	55 MPH
LM 6.10-10.60	40 MPH

OR

TRAFFIC DATA	
ADT (2018)	1900
POSTED SPEED	45 MPH

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED:

DIVISION ADMINISTRATOR   DATE

TYPE	YEAR	PROJECT NO.	SHEET NO.
RESURF	2018	HSIP-280(11)	1A

ROADWAY INDEX

SHEET NAME	SHEET NO.
TITLE SHEET	1
ROADWAY INDEX AND STANDARD ROADWAY DRAWINGS	1A
ESTIMATED ROADWAY QUANTITIES	2A
TYPICAL SECTIONS AND PAVEMENT SCHEDULE	2B
GENERAL NOTES	2C0 – 2C1
SPECIAL NOTES	2D
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UTILITY NOTES and UTILITY OWNERS	3
PAVEMENT EDGE DROP OFF NOTES	4

NOTE: THE ALPHABETICAL LETTERS "I", "O" & "Q" ARE NOT USED IN NUMBERING OF SHEETS.

NO PROJECT COMMITMENTS

STANDARD ROADWAY DRAWINGS

DWG.	REV.	DESCRIPTION
ROADWAY DESIGN STANDARDS		
RD-A-1	12-18-99	STANDARD ABBREVIATIONS
RD-L-1	10-26-94	STANDARD LEGEND
RD-L-2	09-05-01	STANDARD LEGEND FOR UTILITY INSTALLATIONS
ROADWAY AND PAVEMENT APPURTENANCES		
RP-H-3	10-10-16	CURB RAMP AND TRUNCATED DOME SURFACE DETAIL
RP-H-7	10-10-16	PERPENDICULAR CURB RAMP IN CURVE
RP-H-9	10-10-16	PARALLEL CURB RAMP IN CURVE
SAFETY DESIGN AND FENCES		
S-CZ-1		CLEAR ZONE CRITERIA
S-PL-1		SAFETY PLAN AT ROADSIDE HAZARDS
S-PL-2	10-10-16	SAFETY PLAN AT SIDEROADS OR PRIVATE DRIVES
S-PL-6	10-10-16	SAFETY PLAN SAFETY HARDWARE PLACEMENT ON OUTSIDE EDGE
S-GR31-1	03-28-17	W-BEAM GUARDRAIL
S-GR31-1A		W-BEAM BARRIER FASTENING HARDWARE
S-GRS-3	03-28-17	SPECIAL CASE: GUARDRAIL FOOTING
S-GRS-4	03-16-17	SPECIAL CASE GUARDRAIL HEIGHT TRANSITION DETAIL
S-GRC-1	10-10-16	GUARDRAIL CONNECTION TO BRIDGE ENDS OR BARRIER WALL
S-GRT-2	03-28-17	TYPE 38 GUARDRAIL TERMINAL
S-GRT-2P	07-05-17	EARTH PAD FOR TYPE 38 AND TYPE 21 TERMINAL
S-GRT-2R	07-05-17	EARTH PAD FOR TYPE 38 AND TYPE 21 TERMINAL (RETROFIT)
S-GRA-4	07-05-17	IN-LINE GUARDRAIL ANCHOR
DESIGN - TRAFFIC CONTROL		
T-M-1	07-05-17	DETAILS OF PAVEMENT MARKINGS FOR CONVENTIONAL ROADS AND MARKING ABBREVIATIONS
T-M-2	07-05-17	DETAILS OF PAVEMENT MARKINGS FOR CONVENTIONAL ROADS
T-M-3	07-24-14	MARKING STANDARDS FOR TRAFFIC ISLANDS, MEDIANS & PAVED SHOULDERS ON CONVENTIONAL ROADS
T-M-4	10-10-16	STANDARD INTERSECTION PAVEMENT MARKINGS
T-M-16	01-30-15	ASPHALT SHOULDER RUMBLE STRIPE INSTALLATION DETAILS FOR NON-ACCESS CONTROLLED ROUTES
T-WZ-10	04-02-12	ADVANCE ROAD WORK SIGNING ON HIGHWAYS AND FREEWAYS

STANDARD TRAFFIC OPERATIONS DRAWINGS

DWG.	REV.	DESCRIPTION
SIGNALS		
T-SG-2	06-27-16	LOOP LEAD-INS, CONDUIT AND PULL BOXES
T-SG-3	07-11-17	STANDARD NOTES AND DETAILS OF INDUCTIVE LOOPS

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ROADWAY INDEX AND STANDARD ROADWAY DRAWINGS

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TYPE	YEAR	PROJECT NO.	SHEET NO.
RESURF	2018	HSIP-280(11)	2A

ESTIMATED ROADWAY QUANTITIES

	ITEM NO.	DESCRIPTION	UNIT	(RESURFACING) 16024-4215-04 QUANTITY	(SAFETY) 16024-3215-94 QUANTITY	TOTAL QUANTITY
	208-01.05	BROOMING & DEGRASSING SHOULDERS	L.M.	21.2		
(1)(2)	303-01	MINERAL AGGREGATE, TYPE A BASE, GRADING BASE	TON	2208	250	2458
(3)	403-01	BITUMINOUS MATERIAL FOR TACK COAT (TC)	TON	76		76
	405-01.01	BITUMINOUS MATERIAL (BSC)	TON	235		235
	405-01.02	MINERAL AGGREGATE (bsc)	TON	2057		2057
(4)	307-01.07	ASPHALT CONCRETE MIX (PG64-22) (BPMB-HM) GRADING B-M	TON	970		970
(5)	411-02.10	ACS MIX(PG70-22) GRADING D	TON	11670		11670
	411-12.03	SCORING FOR RUMBLE STRIPE (NON-CONTINUOUS) (8IN WIDTH)	L.M.	16		16
(6)	415-01.01	COLD PLANING BITUMINOUS PAVEMENT	TON	11552		11552
	611-01-20	UTILITY ADJUSTMENT MANHOLE	EACH	3		3
	611-09.01	UTILITY ADJUSTMENT CATCHBASIN	EACH	1		1
	701-02.01	CONCRETE CURB RAMP (RETROFIT)	S.F.		220	220
	701-02-03	CONCRETE CURB RAMP	S.F.		165	165
	705-01.01	GUARDRAIL AT BRIDGE ENDS	L.F.		108	108
	705-06.01	W BEAM GR (TYPE 2) MASH TL3	L.F.		50	50
	705-04.09	EARTH PAD FOR TYPE 38 GR END TREATMENT	EACH		12	12
(2)	705-06.20	TANGENT ENERGY ABSORBING TERM MASH TL-3	EACH		12	12
(2)(7)	706-01	GUARDRAIL REMOVED	L.F.		50	50
	712.01	TRAFFIC CONTROL	LS	1		1
	712-04.01	FLEXIBLE DRUMS (CHANNELIZATING)	EACH	38		38
	712-05.01	WARNING LIGHTS (TYPE A)	EACH	38		38
(8)	712-06	SIGNS (CONSTRUCTION)	S.F.	657		657
	713-02.14	FLEXIBLE DELINEATOR (WHITE)	EACH	20		20
	716-01.21	Snwplwble Pvmt Mrkrs (Bi-Dir) (1 Color)	EACH	400	300	700
	716-01.30	REMOVAL OF SNOWPLOWABLE REFLECTIVE MARKER	EACH	400		400
(9)	716-02.05	PLASTIC PAVEMENT MARKING (STOP LINE)	L.F.	365		365
(9)	716-03.03	PLASTIC WORD PAVEMENT MARKING (STOP AHEAD)	EACH	4		4
(10)	716-05.01	PAINTED PAVEMENT MARKING (4" LINE)	L.M.	42		42
(11)	716-12.02	ENHANCED FLATLINE THERMO PVMT MRKING (6IN LINE)	L.M.	12.2		12.2
(11)	716-13.01	SPRAY THERMO PVMT MRKNG (60mil) (4IN LINE)	L.M.	18		18
(11)	716-13.02	SPRAY THERMO PVMT MRKNG (60mil) (6IN LINE)	L.M.	12.2		12.2
(12)	716-13.05	SPRAY THERMO PVMT MRKNG (60mil) (6IN DOTTED LINE)	L.F.	150		150
	717-01	MOBILIZATION	LS	1		1
	730-14.02	SAW SLOT	L.F.	800		800
	730-14.03	LOOP WIRE	L.F.	1600		1600

FOOTNOTES

(1) AS DIRECTED BY THE TDOT PROJECT ENGINEER
(2) 250 TONS FOR GUARDRAIL PAD WORK IN ADDITION TO ROCK FROM EARTH PAD. SEE GUARDRAIL TABULATION BLOCK ON SHEET 2E FOR DETAILS
(3) INCLUDES 2 TONS FOR DRIVEWAYS, BUSINESS, & FIELD ENTRANCES
(4) INCLUDES 970 TONS FOR SPOT LEVELING AS DIRECTED BY THE TDOT PROJECT ENGINEER
(5) INCLUDES 350 TONS FOR DRIVEWAYS, BUSINESS, & FIELD ENTRANCES
(6) INCLUDES 340 TONS FOR DRIVEWAYS, BUSINESS, & FIELD ENTRANCES
(7) REMOVED GUARDRAIL TO BECOME PROPERTY OF THE CONTRACTOR
(8) SEE SIGN TABULATION BLOCK SHEET 2E
(9) CONTRACTOR MAY ELECT TO SUBSTITUTE PREFORMED PLASTIC FOR THERMOPLASTIC. PREFORMED PLASTIC SHALL BE PAID FOR AT THE SAME UNTIL PRICE AS BID FOR THERMOPLASTIC.
(10) TO BE USED FOR TEMPORARY MARKINGS ONLY
(11) TO BE USED FOR PERMANENT PAVEMENT MARKING ONLY.
(12) INCLUDES 60 LF DOTTED WHITE LINE AND 90 LF OF DOUBLE DOTTED YELLOW CENTERLINE TO BE PLACED THROUGH THE INTERSECTIONS OF PAUL HARRELL ROAD AND FERRELL BRANCH ROAD AS DIRECTED BY THE TRAFFIC ENGINEER

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ESTIMATED ROADWAY QUANTITIES

TYPE	YEAR	PROJECT NO.	SHEET NO.
RESURF	2018	HSIP-280(11)	2B
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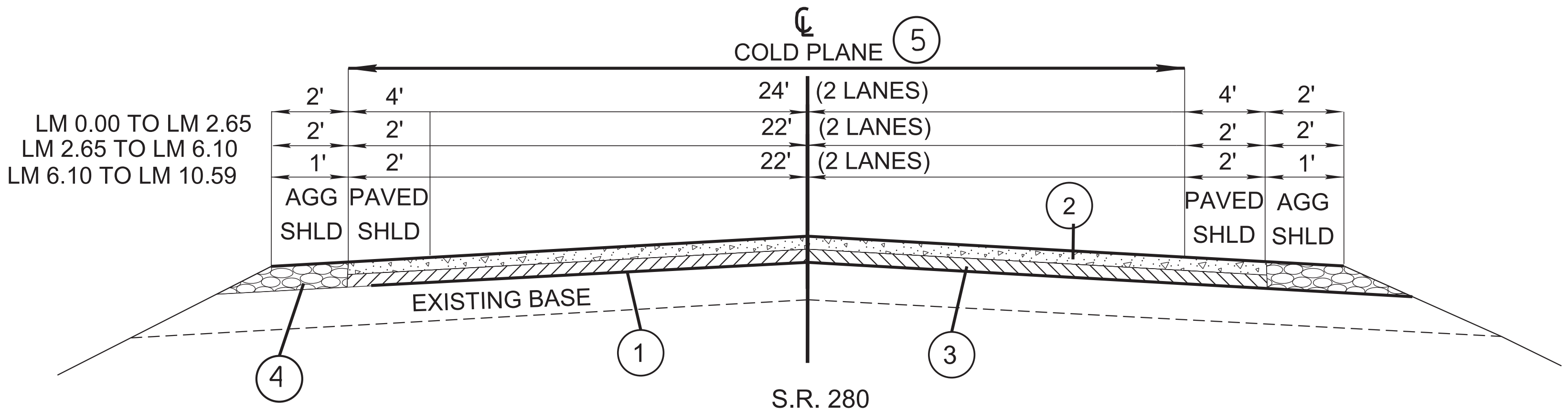
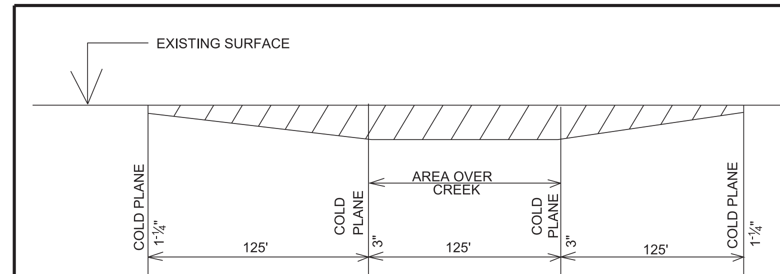


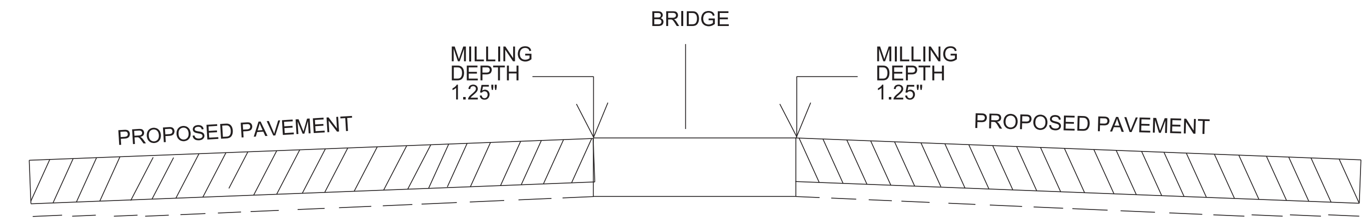
S.R. 280
TYPICAL SECTION

PROPOSED PAVEMENT SCHEDULE

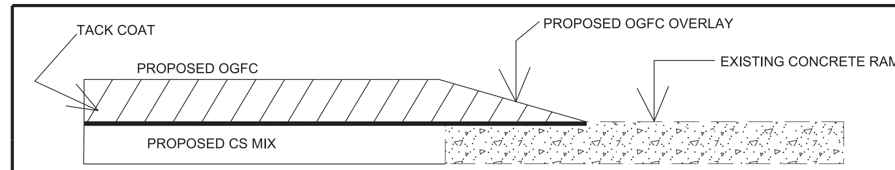
1	TACK COAT (TC) @ (0.08 - 0.12 GAL/SY) ITEM 403-01 BITUMINOUS MATERIAL FOR TACK COAT (TC)
2	ASPHALTIC CONCRETE SURFACE (ACS) @ 1.25" THICK (APPROX. 132.5 LBS/SY) ITEM 411-02.10 D MIX (PG70-22) D ASPHALT
3	BITUMINOUS SEAL COAT (BSC) APPLICATION (CHIP SEAL) 405-01.01 BITUMINOUS MATERIAL FOR (BSC) @ 0.26-0.36 GAL/SY 405-01.02 MINERAL AGGREGATE FOR (BSC) @ 16-26 LBS/SY
4	MINERAL AGGREGATE BASE @ 2" THICK FOR SHOULDERS 303-01 MINERAL AGGREGATE, TYPE A BASE, GRADING B
5	COLD PLANING 1.25" THICK (APPROX. 131.25 LBS/SY)



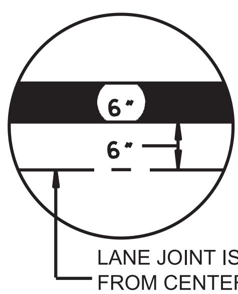
DETAILS OF COLD PLANING
BRIDGES OVER MCBRIDE BRANCH (L.M. 2.56) AND PERRY CREEK (L.M. 8.78)



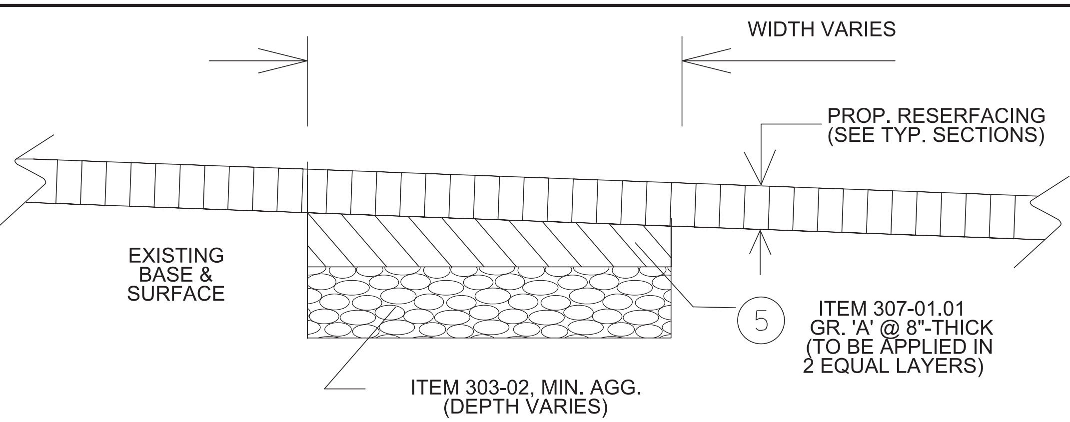
BRIDGE DETAILS



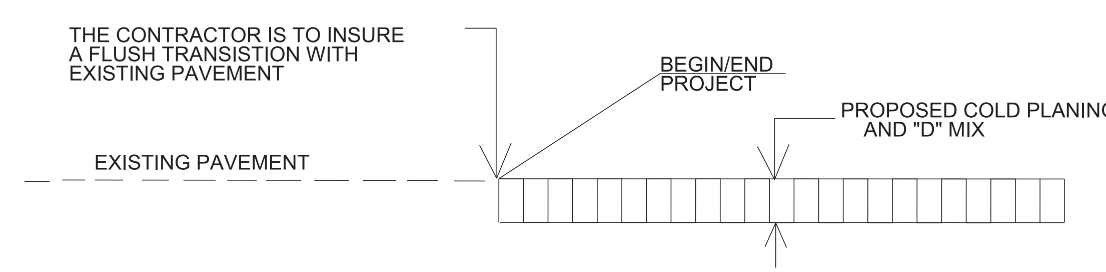
OGFC OVERLAY DETAIL FOR CONCRETE RAMP
(COST TO BE INCLUDED IN THE PRICE BID FOR THE PROPOSED SURFACE MIX)



LANE JOINT IS TO BE OFF SET 6"
FROM CENTER OF ROADWAY.



DETAIL OF BREAKOUT

PAVEMENT DETAILS


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TYPICAL SECTIONS AND PAVEMENT SCHEDULE

TYPE	YEAR	PROJECT NO.	SHEET NO.
RESURF	2018	HSIP-280(11)	2C

GENERAL NOTES

GUARDRAIL

(1) THE CONTRACTOR SHALL NOT REMOVE ANY SECTIONS OF EXISTING GUARDRAIL TO REWORK SHOULDERS OR FLATTEN SLOPES UNTIL THE ENGINEER CONCURS IN THE NECESSITY OF REMOVAL DUE TO CONSTRUCTION REQUIREMENTS AND THE APPROPRIATE WARNING DEVICES ARE INSTALLED. THE PROPOSED GUARDRAIL, INCLUDING ANY ANCHOR SYSTEM, SHALL BE INSTALLED QUICKLY TO MINIMIZE TRAFFIC EXPOSURE TO ANY HAZARD. NO PAYMENT WILL BE MADE FOR A SECTION OF PROPOSED GUARDRAIL, INCLUDING ANCHORS, UNTIL IT IS COMPLETE IN PLACE.

(2) IF ANY APPROACH END OF A SECTION OF GUARDRAIL OR BRIDGE RAIL MUST TEMPORARILY BE LEFT INCOMPLETE AND EXPOSED TO TRAFFIC, THE CONTRACTOR SHALL USE TWO (2) TEMPORARY BARRICADES OR DRUMS WITH TYPE "A" LIGHTS AND ROUNDED END ELEMENTS AS MINIMUM MEASURES TO PROTECT TRAFFIC FROM THE HAZARD OF AN EXPOSED END. ALL COST OF FURNISHING AND INSTALLING TEMPORARY BARRICADES OR DRUMS WITH TYPE "A" LIGHTS TO DELINEATE GUARDRAIL END AND A TEMPORARY ROUNDED END ELEMENT SHALL BE INCLUDED IN THE COST OF THE PROPOSED GUARDRAIL END TERMINAL.

PAVEMENT MARKINGS

TEMPORARY PAVEMENT MARKINGS ON INTERMEDIATE LAYERS

(1) TEMPORARY PAVEMENT LINE MARKINGS ON INTERMEDIATE LAYERS OF PAVEMENT SHALL BE REFLECTIVE TAPE OR REFLECTORIZED PAINT INSTALLED TO PERMANENT STANDARDS AT THE END OF EACH DAYS WORK. SHORT, UNMARKED SECTIONS SHALL NOT BE ALLOWED. THESE MARKINGS WILL BE MEASURED AND PAID FOR UNDER ITEM NO. 716-05.01, PAINTED PAVEMENT MARKING (4" LINE), L.M.

FINAL PAVEMENT MARKING

(2) THE CONTRACTOR WILL BE REQUIRED TO PERFORM THE FOLLOWING WORK:

a. SHOULDERS SHALL BE BROOMED AND DE-GRASSED AND MATERIAL SHALL BE PICKED UP AND REMOVED. THIS WILL BE PAID FOR UNDER ITEM NUMBER 208-01.05.

b. REMOVE ALL GARBAGE AND CONSTRUCTION DEBRIS FROM PROJECT. THE COST FOR THIS WILL BE INCLUDED IN THE PRICE BID FOR OTHER ITEMS OF CONSTRUCTION.

(3) PERMANENT PAVEMENT LINE MARKINGS SHALL BE 6" ENHANCED FLATLINE THERMOPLASTIC INSTALLED TO PERMANENT STANDARDS AT THE END OF EACH DAY'S WORK. SHORT UNMARKED SECTIONS SHALL NOT BE ALLOWED. PAVEMENT MARKINGS WILL BE MEASURED AND PAID FOR UNDER ITEM NO. 716-12.02, ENHANCED FLATLINE THERMO PVMT MRKNG (6IN LINE), L.M. THE CONTRACTOR SHALL HAVE THE OPTION OF USING REFLECTORIZED PAINT INSTALLED TO PERMANENT STANDARDS AT THE END OF EACH DAY'S WORK AND THEN INSTALLING THE PERMANENT MARKINGS AFTER THE PAVING OPERATION IS COMPLETED. THE TEMPORARY MARKINGS FOR THE FINAL SURFACE WILL NOT BE MEASURED AND PAID FOR DIRECTLY, BUT THE COSTS ARE TO BE INCLUDED IN THE PRICE BID FOR THE PERMANENT MARKINGS.

(4) PERMANENT PAVEMENT LINE MARKINGS SHALL BE 4" SPRAY THERMOPLASTIC (60 mil) INSTALLED TO PERMANENT STANDARDS AT THE END OF EACH DAY'S WORK. SHORT UNMARKED SECTIONS SHALL NOT BE ALLOWED. PAVEMENT MARKINGS WILL BE MEASURED AND PAID FOR UNDER ITEM NO. 716-13.01, SPRAY THERMO PVMT MRKNG (60 mil) (4IN LINE), L.M. THE CONTRACTOR SHALL HAVE THE OPTION OF USING REFLECTORIZED PAINT INSTALLED TO PERMANENT STANDARDS AT THE END OF EACH DAY'S WORK AND THEN INSTALLING THE PERMANENT MARKINGS AFTER THE PAVING OPERATION IS COMPLETED. THE TEMPORARY MARKINGS FOR THE FINAL SURFACE WILL NOT BE MEASURED AND PAID FOR DIRECTLY, BUT THE COSTS ARE TO BE INCLUDED IN THE PRICE BID FOR THE PERMANENT MARKINGS.

(5) PERMANENT PAVEMENT LINE MARKINGS SHALL BE 6" SPRAY THERMOPLASTIC (60 mil) INSTALLED TO PERMANENT STANDARDS AT THE END OF EACH DAY'S WORK. SHORT UNMARKED SECTIONS SHALL NOT BE ALLOWED. PAVEMENT MARKINGS WILL BE MEASURED AND PAID FOR UNDER ITEM NO. 716-13.02, SPRAY THERMO PVMT MRKNG (60 mil) (6IN LINE), L.M. THE CONTRACTOR SHALL HAVE THE OPTION OF USING REFLECTORIZED PAINT INSTALLED TO PERMANENT STANDARDS AT THE END OF EACH DAY'S WORK AND THEN INSTALLING THE PERMANENT MARKINGS AFTER THE PAVING OPERATION IS COMPLETED. THE TEMPORARY MARKINGS FOR THE FINAL SURFACE WILL NOT BE MEASURED AND PAID FOR DIRECTLY, BUT THE COSTS ARE TO BE INCLUDED IN THE PRICE BID FOR THE PERMANENT MARKINGS.

(6) PERMANENT PAVEMENT LINE MARKINGS SHALL BE REFLECTORIZED PAINT INSTALLED TO PERMANENT STANDARDS AT THE END OF EACH DAY'S WORK. SHORT, UNMARKED SECTIONS SHALL NOT BE ALLOWED. THESE MARKINGS WILL BE MEASURED AND PAID FOR UNDER ITEM NO. 716-05.01, PAINTED PAVEMENT MARKING (4IN LINE), L.M.

PAVEMENT

PAVING

(1) THE CONTRACTOR SHALL BE REQUIRED TO PAVE IN THE DIRECTION OF TRAFFIC.

(2) THE CONTRACTOR SHALL BE REQUIRED TO COLD PLANE AND PAVE IN THE DIRECTION OF TRAFFIC.

RESURFACING

(3) WHERE DIRECTED BY THE TDOT ENGINEER, THE CONTRACTOR SHALL BE REQUIRED TO SHAPE PUBLIC SIDE ROADS, BUSINESS ENTRANCES, AND PRIVATE DRIVES, AS WELL AS CLEANING OF EXISTING DRAINS BEFORE PLACING MATERIALS. ALL COSTS ARE TO BE INCLUDED IN THE PRICE BID FOR OTHER ITEMS OF CONSTRUCTION.

(4) ALL PUBLIC SIDE ROADS SHALL BE PAVED ONE PAVER WIDTH THROUGH THE INTERSECTION AS A MINIMUM. A SATISFACTORY TRANSITION FROM THE NEW PAVEMENT TO THE EXISTING GRADE OF THE INTERSECTING PUBLIC ROAD OR BUSINESS ENTRANCE SHALL BE PROVIDED. SHOULD THE PAVEMENT OF THE INTERSECTING PUBLIC ROAD BE DISTRESSED, THE RESURFACING WIDTH MAY BE INCREASED TO THE NORMAL RIGHT OF WAY LINE.

(5) PRIVATE DRIVEWAYS, FIELD ENTRANCES, AND BUSINESS ENTRANCES WILL BE RESURFACED A PAVER WIDTH (LANE WIDTH) AS A MINIMUM. A PAVEMENT TAPER TO TRANSITION THE NEW PAVEMENT SHALL BE REQUIRED, IT SHALL BE BASED ON AN ADDITIONAL ONE FOOT OF WIDTH PER ONE INCH DEPTH OF PAVEMENT. IF THE SHOULDER IS NARROW ENOUGH THAT THE SUM OF THE SHOULDER AND THE TRANSITION ARE LESS THAN A PAVER WIDTH, THE TRANSITION SHALL OCCUR WITHIN THE PAVER WIDTH. IF THE SUM OF THE SHOULDER AND THE TRANSITION IS GREATER THAN A PAVER WIDTH (LANE WIDTH), THE TRANSITION SHALL OCCUR OUTSIDE OF THE PAVER WIDTH.

(6) IN ALL CASES, THE LENGTH OF THE PAVEMENT TRANSITION, THE THICKNESS AND WIDTH OF THE RESURFACING AND ANY ADDITIONAL PAVEMENT MATERIALS SHALL BE AS DIRECTED BY THE TDOT ENGINEER.

CONSTRUCTION WORK ZONE & TRAFFIC CONTROL

(1) ADVANCED WARNING SIGNS SHALL NOT BE DISPLAYED MORE THAN FORTY-EIGHT (48) HOURS BEFORE PHYSICAL CONSTRUCTION BEGINS. SIGNS MAY BE ERECTED UP TO ONE WEEK BEFORE NEEDED, IF THE SIGN FACE IS FULLY COVERED.

(2) IF THE CONTRACTOR MOVES OFF THE PROJECT, HE SHALL COVER OR REMOVE ALL UNNEEDED SIGNS AS DIRECTED BY THE ENGINEER. COSTS OF REMOVAL, COVERING, AND REINSTALLING SIGNS SHALL NOT BE MEASURED AND PAID FOR SEPARATELY, BUT ALL COSTS SHALL BE INCLUDED IN THE ORIGINAL UNIT PRICE BID FOR ITEM NO 712-06, SIGNS (CONSTRUCTION) PER SQUARE FOOT.

(3) A LONG TERM BUT SPORADIC USE WARNING SIGN, SUCH AS A FLAGGER SIGN, MAY REMAIN IN PLACE WHEN NOT REQUIRED PROVIDED THE SIGN FACE IS FULLY COVERED.

(4) TRAFFIC CONTROL DEVICES SHALL NOT BE DISPLAYED OR ERECTED UNLESS RELATED CONDITIONS ARE PRESENT NECESSITATING WARNING.

(5) USE OF BARRICADES, PORTABLE BARRIER RAILS, AND DRUMS SHALL BE LIMITED TO THE IMMEDIATE AREAS OF CONSTRUCTION WHERE A HAZARD IS PRESENT. THESE DEVICES SHALL NOT BE STORED ALONG THE ROADWAY WITHIN THIRTY (30) FEET OF THE EDGE OF THE TRAVELED WAY BEFORE OR AFTER USE UNLESS PROTECTED BY GUARDRAIL, BRIDGE RAIL, AND/OR BARRIERS INSTALLED FOR OTHER PURPOSES FOR ROADWAYS WITH CURRENT ADT'S LESS THAN 1500 AND DESIGN SPEED OF LESS THAN 60 MPH. THIS DISTANCE SHALL INCREASE TO FORTY-FIVE (45) FEET FOR ROADWAYS WITH CURRENT ADT'S OF 1500 OR GREATER AND DESIGN SPEED OF 60 MPH OR GREATER OR ON THE OUTSIDE OF A HORIZONTAL CURVE. THESE DEVICES SHALL BE REMOVED FROM THE CONSTRUCTION WORK ZONE WHEN THE ENGINEER DETERMINES THEY ARE NO LONGER NEEDED. WHERE THERE IS INSUFFICIENT RIGHT-OF-WAY TO PROVIDE FOR THIS REQUIRED SETBACK, THE CONTRACTOR SHALL DETERMINE THE ALTERNATE LOCATIONS AND REQUEST THE ENGINEER'S APPROVAL TO USE THEM.

(6) THE CONTRACTOR SHALL NOT BE PERMITTED TO PARK ANY VEHICLES OR CONSTRUCTION EQUIPMENT DURING PERIODS OF INACTIVITY, WITHIN THIRTY (30) FEET OF THE EDGE OF PAVEMENT WHEN THE LANE IS OPEN TO TRAFFIC UNLESS PROTECTED BY GUARDRAIL, BRIDGE RAIL, AND/OR BARRIERS INSTALLED FOR OTHER PURPOSES FOR ROADWAYS WITH CURRENT ADT'S LESS THAN 1500 AND DESIGN SPEED OF LESS THAN 60 MPH. THIS DISTANCE SHALL BE INCREASED TO FORTY-FIVE (45) FEET FOR ROADWAYS WITH CURRENT ADT'S OF 1500 OR GREATER AND DESIGN SPEED OF 60 MPH OR GREATER OR ON THE OUTSIDE OF A HORIZONTAL CURVE. PRIVATELY OWNED VEHICLES SHALL NOT BE ALLOWED TO PARK WITHIN THIRTY (30) FEET OF AN OPEN TRAFFIC LANE AT ANY TIME UNLESS PROTECTED AS DESCRIBED ABOVE FOR ROADWAYS WITH CURRENT ADT'S LESS THAN 1500 AND DESIGN SPEED OF LESS THAN 60 MPH. THIS DISTANCE SHALL BE INCREASED TO FORTY-FIVE (45) FEET FOR ROADWAYS WITH CURRENT ADT'S OF 1500 OR GREATER AND DESIGN SPEED OF 60 MPH OR GREATER OR ON THE OUTSIDE OF A HORIZONTAL CURVE. WHERE THERE IS INSUFFICIENT RIGHT-OF-WAY TO PROVIDE FOR THIS REQUIRED SETBACK, THE CONTRACTOR SHALL DETERMINE THE ALTERNATE LOCATIONS AND REQUEST THE ENGINEER'S APPROVAL TO USE THEM.

(7) ALL DETOUR AND CONSTRUCTION SIGNING SHALL BE IN STRICT ACCORDANCE WITH THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES.

(8) ALL DETOURS SHALL BE PAVED, STRIPED, SIGNED AND FLEXIBLE DRUMS ARE TO BE IN PLACE BEFORE IT IS OPENED TO TRAFFIC.

EROSION PREVENTION AND SEDIMENT CONTROL

DISTURBED AREA

(1) IF DISTURBED ACREAGE IS EQUAL TO ONE ACRE OR MORE, PLEASE CONTACT TDOT ENVIRONMENTAL DIVISION, PERMITS SECTION AS SOON AS POSSIBLE BECAUSE AN NPDES PERMIT WILL BE REQUIRED.

SEDIMENT CONTROL

(2) EPSC MEASURES SHALL BE INSTALLED AND FUNCTIONAL PRIOR TO ANY EARTH MOVING OPERATIONS, AND SHALL BE MAINTAINED THROUGHOUT THE CONSTRUCTION PERIOD EXCEPT AS SUCH WORK MAY BE NECESSARY TO INSTALL EPSC MEASURES.

(3) THE CONTRACTOR SHALL ESTABLISH AND MAINTAIN A PROACTIVE METHOD TO PREVENT THE OFFSITE MIGRATION OR DEPOSIT OF SEDIMENT OFF THE PROJECT LIMITS (E.G. R.O.W., EASEMENTS, ETC.), INTO WATERS OF THE STATE/U.S., OR ONTO ROADWAYS USED BY THE GENERAL PUBLIC. IF SEDIMENT ESCAPES THE CONSTRUCTION SITE, OFFSITE ACCUMULATIONS OF SEDIMENT THAT HAVE NOT REACHED A STREAM MUST BE REMOVED AT A FREQUENCY SUFFICIENT TO MINIMIZE OFFSITE IMPACTS (E.G., FUGITIVE SEDIMENT THAT HAS ESCAPED THE CONSTRUCTION SITE AND HAS COLLECTED IN A STREET MUST BE REMOVED SO THAT IT IS NOT SUBSEQUENTLY WASHED INTO STORM SEWERS AND STREAMS BY THE NEXT RAIN AND/OR SO THAT IT DOES NOT POSE A SAFETY HAZARD TO USERS OF PUBLIC STREETS). ARRANGEMENTS CONCERNING REMOVAL OF SEDIMENT ON ADJOINING PROPERTY MUST BE NEGOTIATED WITH THE ADJOINING PROPERTY OWNER BEFORE REMOVAL OF SEDIMENT.

NATURAL RESOURCES

(4) THE OPERATION OF EQUIPMENT IN WATERS OF THE STATE/U.S., INCLUDING WETLANDS AND EPHEMERAL, INTERMITTENT, AND PERENNIAL STREAMS, IS NOT ALLOWED.

(5) THE CONTRACTOR SHALL TAKE APPROPRIATE STEPS PRIOR TO ANY CONSTRUCTION AND MAINTENANCE ACTIVITIES TO ENSURE THAT ENVIRONMENTAL FEATURES (E.G., STREAMS, WETLANDS, SPRINGS, ETC.) ARE NOT IMPACTED BEYOND PERMITTED LOCATIONS. IF THE CONTRACTOR OR TDOT INSPECTOR IS UNSURE OF THE IDENTITY OF AN ENVIRONMENTAL FEATURE, THE INSPECTOR SHALL CONTACT THE TDOT REGION ENVIRONMENTAL TECH GROUP IMMEDIATELY.

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GENERAL NOTES

TYPE	YEAR	PROJECT NO.	SHEET NO.
RESURF	2018	HSIP-280(11)	2C1

GENERAL NOTES CONTINUED

SPECIES

(1) SHOULD CLIFF SWALLOW OR BARN SWALLOW NESTS, EGGS, OR BIRDS (YOUNG AND ADULTS) BE PRESENT, THE CONTRACTOR SHALL CONTACT THE REGIONAL ECOLOGY OFFICE TO DETERMINE IF SEASONAL RESTRICTIONS WILL BE NECESSARY. GENERALLY, BIRDS, NESTS, AND EGGS MAY NOT BE DISTURBED BETWEEN APRIL 15 AND JULY 31. FROM AUGUST 1 TO APRIL 14, NESTS CAN BE REMOVED OR DESTROYED SO LONG AS BIRDS OR EGGS ARE NOT PRESENT, AND MEASURES IMPLEMENTED TO PREVENT FUTURE NEST BUILDING AT THE SITE (I.E., CLOSING OFF AREA USING NETTING).

(2) IF THE REMOVAL OF ANY TREES WITH A DIAMETER AT BREAST HEIGHT (DBH) GREATER THAN 3 INCHES IS DEEMED NECESSARY THE TDOT SUPERVISOR SHALL CONTACT THE TDOT ENVIRONMENTAL DIVISION, ECOLOGY SECTION IMMEDIATELY.

GOOD HOUSEKEEPING MEASURES & WASTE DISPOSAL

(3) THE CONTRACTOR SHALL ESTABLISH AND MAINTAIN A PROACTIVE METHOD TO PREVENT LITTER AND CONSTRUCTION WASTES FROM ENTERING WATERS OF THE STATE/U.S. THESE MATERIALS SHALL BE REMOVED FROM STORMWATER EXPOSURE PRIOR TO ANTICIPATED STORM EVENTS OR BEFORE BEING CARRIED OFFSITE BY WIND, OR OTHERWISE PREVENTED FROM BECOMING A POLLUTANT SOURCE FOR STORMWATER DISCHARGES. AFTER USE, MATERIALS USED FOR EPSC SHALL BE REMOVED FROM THE SITE.

(4) THE CONTRACTOR SHALL TAKE APPROPRIATE STEPS TO ENSURE THAT PETROLEUM PRODUCTS OR OTHER CHEMICAL POLLUTANTS ARE PREVENTED FROM ENTERING WATERS OF THE STATE/U.S. ALL EQUIPMENT REFUELING, SERVICING, AND STAGING AREAS SHALL COMPLY WITH ALL LOCAL, STATE, AND FEDERAL LAWS, RULES, REGULATIONS, AND ORDINANCES, INCLUDING THOSE OF THE NATIONAL FIRE PROTECTION ASSOCIATION. APPROPRIATE CONTAINMENT MEASURES FOR THESE AREAS SHALL BE USED.

(5) CONTRACTORS SHALL PROVIDE DESIGNATED TRUCK WASHOUT AREAS ON THE SITE. THESE AREAS MUST BE SELF CONTAINED, NOT CONNECTED TO ANY STORMWATER OUTLET OF THE SITE, AND PROPERLY SIGNED. WASH DOWN OR WASTE DISCHARGE OF CONCRETE TRUCKS SHALL NOT BE PERMITTED ONSITE UNLESS PROPER SETTLEMENT AREAS HAVE BEEN PROVIDED IN ACCORDANCE WITH BOTH STATE AND FEDERAL REGULATIONS.

(6) WHEEL WASH WATER SHALL BE COLLECTED AND ALLOWED TO SETTLE OUT SUSPENDED SOLIDS PRIOR TO DISCHARGE. WHEEL WASH WATER SHALL NOT BE DISCHARGED DIRECTLY INTO ANY STORMWATER SYSTEM OR STORMWATER TREATMENT SYSTEM.

(7) IF PORTABLE SANITARY FACILITIES ARE PROVIDED ON CONSTRUCTION SITES, SANITARY WASTE SHALL BE COLLECTED FROM THE PORTABLE UNITS IN A TIMELY MANNER BY A LICENSED WASTE MANAGEMENT CONTRACTOR OR AS REQUIRED BY ANY REGULATIONS. THE CONTRACTOR SHALL OBTAIN ANY AND ALL NECESSARY PERMITS TO DISPOSE OF SANITARY WASTE.

(8) ONLY CONSTRUCTION PRODUCTS NEEDED SHALL BE STORED ONSITE BY THE CONTRACTOR. THE CONTRACTOR SHALL STORE ALL MATERIALS UNDER COVER AND IN APPROPRIATE CONTAINERS. PRODUCTS MUST BE STORED IN ORIGINAL CONTAINERS AND LABELED. MATERIAL MIXING SHALL BE CONDUCTED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS. THE CONTRACTOR'S RESPONSIBLE PARTY SHALL INSPECT MATERIALS STORAGE AREAS REGULARLY TO ENSURE PROPER USE AND DISPOSAL.

(9) WHEN POSSIBLE, ALL PRODUCTS SHALL BE USED COMPLETELY BEFORE PROPERLY DISPOSING OF THE CONTAINER OFFSITE. THE MANUFACTURER'S DIRECTIONS FOR DISPOSAL OF MATERIALS AND CONTAINERS SHALL BE FOLLOWED.

(10) ALL PAINT CONTAINERS SHALL BE TIGHTLY SEALED AND STORED WHEN NOT REQUIRED FOR USE. EXCESS PAINT SHALL BE DISPOSED OF ACCORDING TO THE MANUFACTURER'S INSTRUCTIONS AND APPLICABLE STATE AND LOCAL REGULATIONS.

(11) ALL HAZARDOUS WASTE MATERIALS SHALL BE DISPOSED OF IN A MANNER WHICH IS COMPLIANT WITH LOCAL OR STATE REGULATIONS. SITE PERSONNEL SHALL BE INSTRUCTED IN THESE PRACTICES, AND THE INDIVIDUAL DESIGNATED AS THE CONTRACTOR'S RESPONSIBLE PARTY SHALL BE RESPONSIBLE FOR SEEING THAT THESE PRACTICES ARE FOLLOWED. THE CONTRACTOR SHALL OBTAIN ANY AND ALL NECESSARY PERMITS TO DISPOSE OF HAZARDOUS MATERIAL.

(12) OPEN BURNING IS PROHIBITED UNLESS IT IS SPECIFICALLY ALLOWED BY LAW. IF ALLOWED, NATURAL VEGETATION, TREES, AND UNTREATED LUMBER SHALL BE THE ONLY MATERIALS THAT CAN BE OPEN BURNED. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL APPLICABLE STATE AND LOCAL PERMITS PRIOR TO ANY BURNING.

(13) DISPOSAL OF ONSITE VEGETATION AND TREES BY CHIPPING THEM INTO MULCH IS PREFERABLE TO OPEN BURNING. THIS MULCH MAY BE USED AS AN ONSITE SOIL STABILIZATION MEASURE WHERE APPROPRIATE.

(14) WASTE MATERIAL (EARTH, ROCK, ASPHALT, CONCRETE, ETC.) NOT REQUIRED FOR THE CONSTRUCTION OF THE PROJECT WILL BE DISPOSED OF BY THE CONTRACTOR. IMPACTS TO WATERS OF THE STATE/U.S. SHALL BE AVOIDED IF POSSIBLE. IF UNAVOIDABLE, THE CONTRACTOR WILL OBTAIN ANY AND ALL NECESSARY PERMITS INCLUDING, BUT NOT LIMITED TO NPDES, AQUATIC RESOURCES ALTERATION PERMIT(S), CORPS OF ENGINEERS SECTION 404 PERMITS, AND TVA SECTION 26A PERMITS TO DISPOSE OF WASTE MATERIALS.

SPILL PREVENTION, MANAGEMENT & NOTIFICATION

(15) ALL ONSITE VEHICLES SHALL BE MONITORED FOR LEAKS AND RECEIVE REGULAR PREVENTIVE MAINTENANCE TO REDUCE THE CHANCE OF LEAKAGE AND SPILLS.

(16) FOR ALL HAZARDOUS MATERIALS STORED ONSITE, THE MANUFACTURER'S RECOMMENDED METHODS FOR SPILL CLEAN UP SHALL BE CLEARLY POSTED. SITE PERSONNEL SHALL BE MADE AWARE OF THE PROCEDURES AND THE LOCATIONS OF THE INFORMATION AND CLEANUP SUPPLIES.

(17) APPROPRIATE CLEANUP MATERIALS AND EQUIPMENT SHALL BE MAINTAINED BY THE CONTRACTOR IN THE MATERIALS STORAGE AREA ONSITE AND UNDER COVER. SPILL RESPONSE EQUIPMENT SHALL BE INSPECTED AND MAINTAINED BY THE CONTRACTOR AS NECESSARY TO REPLACE ANY MATERIALS USED IN SPILL RESPONSE ACTIVITIES.

(18) ALL SPILLS SHALL BE CLEANED IMMEDIATELY AFTER DISCOVERY AND THE MATERIALS DISPOSED OF PROPERLY. THE SPILL AREA SHALL BE KEPT WELL VENTILATED AND PERSONNEL WILL WEAR APPROPRIATE PROTECTIVE CLOTHING TO PREVENT INJURY FROM CONTACT WITH A HAZARDOUS SUBSTANCE.

(19) THE CONTRACTOR'S RESPONSIBLE PARTY SHALL BE THE SPILL PREVENTION AND CLEANUP COORDINATOR. THE CONTRACTOR IS RESPONSIBLE FOR ENSURING THAT THE SITE SUPERINTENDENT HAS HAD APPROPRIATE TRAINING FOR HAZARDOUS MATERIALS HANDLING, SPILL MANAGEMENT, AND CLEANUP.

(20) IF AN OIL SHEEN IS OBSERVED ON SURFACE WATER (E.G. SETTLING PONDS, DETENTION PONDS, SWALES), ACTION SHALL BE TAKEN IMMEDIATELY TO REMOVE THE MATERIAL CAUSING THE SHEEN. THE CONTRACTOR SHALL USE APPROPRIATE MATERIALS TO CONTAIN AND ABSORB THE SPILL. THE SOURCE OF THE OIL SHEEN WILL ALSO BE IDENTIFIED AND REMOVED OR REPAIRED AS NECESSARY TO PREVENT FURTHER RELEASES.

(21) FERTILIZERS SHALL BE APPLIED ONLY IN THE AMOUNTS SPECIFIED. ONCE APPLIED, FERTILIZERS SHALL BE WORKED INTO THE SOIL TO LIMIT THE EXPOSURE TO STORMWATER.

(22) IF A SPILL OCCURS THE CONTRACTOR'S RESPONSIBLE PARTY SHALL BE RESPONSIBLE FOR COMPLETING THE SPILL REPORTING FORM AND FOR REPORTING THE SPILL TO THE TDOT PROJECT RESPONSIBLE PARTY. ALL SPILLS MUST BE REPORTED TO THE APPROPRIATE AGENCY, AND MEASURES SHALL BE TAKEN IMMEDIATELY TO PREVENT THE POLLUTION OF WATERS OF THE STATE/U.S., INCLUDING GROUNDWATER, SHOULD A SPILL OCCUR.

(23) WHERE A RELEASE CONTAINING A HAZARDOUS SUBSTANCE IN AN AMOUNT EQUAL TO OR IN EXCESS OF A REPORTABLE QUANTITY ESTABLISHED UNDER EITHER 40 CFR 117 OR 40 CFR 302 OCCURS DURING A 24 HOUR PERIOD, SEE THE LATEST TENNESSEE GENERAL PERMIT NO. TNR100000 STORMWATER DISCHARGES FROM CONSTRUCTION ACTIVITIES SECTION 5.1 FOR REPORTING REQUIREMENTS.

(24) CONTRACTOR'S BULK FUEL AND PETROLEUM PRODUCTS STORED ONSITE OR ADJACENT TO THE R.O.W. IN ABOVE GROUND STORAGE CONTAINERS WITH A COMBINED CAPACITY OF 1320 GALLONS OR MORE SHALL HAVE SECONDARY CONTAINMENT. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PREPARING A SPILL PREVENTION CONTROL AND COUNTERMEASURE (SPCC) PLAN FOR THE BULK STORAGE AND BE SOLELY RESPONSIBLE FOR OBTAINING ANY NECESSARY LOCAL, STATE, AND FEDERAL PERMITS. THE SPCC PLAN AND/OR PERMITS SHALL BE KEPT ONSITE AND A COPY PROVIDED TO THE TDOT PROJECT RESPONSIBLE PARTY PRIOR TO STORING 1320 GALLONS ON SITE.

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GENERAL NOTES

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SPECIAL NOTES

PAVEMENT

RESURFACING

(1) TRAFFIC WILL BE ALLOWED TO TEMPORARILY DRIVE ON THE MILLED SURFACE OF THE ROADWAY UNDER THE FOLLOWING CONDITIONS ONLY:

a. THE MILLED SURFACE IS FINE TEXTURED. THE FINE TEXTURE SHALL BE OBTAINED BY A MILLING MACHINE UTILIZING A MILLING HEAD WITH TEETH SPACING 3/8" OR LESS OPERATING AT LESS THAN 80 FEET PER MINUTE.

b. THE SURFACE SHALL BE SWEPT AND CLEANED OF ALL LOOSE MATERIALS.

c. THE DIFFERENCE IN ELEVATION BETWEEN THE MILLED SURFACE AND THE ADJACENT LANE SHALL NOT EXCEED 1 1/2 INCHES.

d. THE MILLED SURFACE SHALL BE PAVED WITHIN 72 HOURS IF THE CURRENT ADT IS ≥ 70,000 OR WITHIN 96 HOURS IF THE CURRENT ADT IS < 70,000.

e. RAIN OR INCLEMENT WEATHER IS NOT EXPECTED OR FORECASTED WITHIN 48 HOURS AFTER MILLING.

f. ALL APPLICABLE SIGNING IS INSTALLED IN ACCORDANCE WITH THE MUTCD SIGNING SHALL INCLUDE MOTORCYCLE WARNING SIGNS (TN-64) PLACED IN ADVANCE OF ANY MILLED AREAS.

g. IF MILLED SURFACE BEGINS TO DETERIORATE, PAVING TO COVER UP DETERIORATING MILLED SURFACES SHOULD OCCUR AS DIRECTED BY THE ENGINEER DURING THE NEXT WORKING DAY. IF SEVERE DISTRESS OCCURS, IMMEDIATE RESPONSE WILL BE REQUIRED.

h. ONLY ONE LANE IN EACH DIRECTION SHALL HAVE A MILLED SURFACE AT ONE TIME.

TRAFFIC CONTROL

(2) THE CONTRACTOR SHALL COMPLY WITH SECTION 712 OF THE STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION REGARDING TEMPORARY TRAFFIC CONTROL AND THE CURRENT EDITION OF THE "MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES".

(3) THE CONTRACTOR SHALL MAKE PROVISIONS TO SAFELY CONTROL TRAFFIC INGRESS AT ALL ROADWAY WITHIN THE FLAGGED WORK ZONE TO THE SATISFICATION OF THE TDOT PROJECT SUPERVISOR, ALL COST ASSOCIATED WITH THE CONTROLS WILL BE INCLUDED IN THE PRICE BID FOR TRAFFIC CONTROL.

(4) EXSITING CONSTRUCTION, REGULATORY, AND WARNING SIGNS WHICH CONFLICT WITH THE CONTRACTION SIGNING SHALL BE REMOVED DURING CONTRUCTION AND REINSTALLED AS DIRECTED BY THE TDOT PROJECT SUPERVISOR. ALL COST TO BE INCLUDED IN THE PRICE BID FOR ITEM 712-01, TRAFFIC CONTROL, PER LUMP SUM.

(5) THE CONTRACTOR SHALL GIVE THE TDOT PROJECT SUPERVISOR A MINIMUM OF SEVEN (7) DAYS NOTICE PRIOR TO STARTING WORK SO THAT SUFFICIENT NOTICE CAN BE PREPARED AND DISTURBED TO THE MEDIA.

(6) IMMEDIATELY UPON COMPLETION OF EACH CONSTUCTION PHASE, ALL TRAFFIC CONTROL ITEMS THAT ARE NOT NECESSARY FOR THE SUCEEDING PHASE SHALL BE REMOVED, COVERED OR TURNED TO FACE AWAY FROM TRAFFIC.

(7) THE CONSTRCTOR SHALL PROVIDE FLAGGER AT EACH SIDE OF THE ROAD WITHIN THE PAVEING OPERATION.

LANE CLOSURES

(8) THE RESTRICTION OF TRAFFIC TO ONE LANE SHALL NOT EXCEED ONE DAY'S PAVING OPERATION.

(9) LANE CLOSURES WITH LEFT LANE MERGE AND LANE SHIFT TRAFFIC CONTROL IS TO USED ON ALL LANE CLOSURES.

(10) THE CONTRACTOR SHALL KEEP ALLL TRFFIC LANES OPEN TO TRAFFIC DURING NON-WORKING HOURS AND/OR NON-WORK DAYS.

(11) OVERNIGHT LANE CLOSURES WILL BE NOT ALLOWED UNLESS DIRECTED BY THE TODT PROJECT SUPERVISOR.

(12) THE CONTRACOR SHALL NOT BE ALLOWED TO INTERRUPT TRAFFIC FLOW AND SHALL MAINTAIN ALL LANES OF TRAFFIC IN EACH DIRECTION ON THE FOLLOWING DAYS:

a. OFFICAL STATE HOLIDAYS.

b. FRIDAY AT 6:00 PM UNTIL TUESDAY AT 7:00 AM. IF A STATE HOLIDAY OCCURS OR IS OBSERVED ON MONDAY.

c. THURSDAY AT 6:00 PM UNTIL MONDAY AT 7:00 AM. IF A STATE HOLIDAY OCCURS OR IS OBSERVED ON FRIDAY.

d. FRIDAY AT 6:00 PM UNTIL SUNDAY AT 7:00 PM OR AS DIRECTED BY THE TDOT PROJECT SUPERVISOR, ON WEEKENDS OF TH EUNIVERSITY OF TENNESSEE, KNOXVILLE HOME GAMES.

e. DURING LOCAL FESTIVALS, GAMES OR EVENTS THAT COULD BE IMPEDED BY THE PAVING OPERATIONS WHERE AND AS DIRECTED BY THE TDOT PROJECT SUPERVISOR.

PAVING

(1) ANY QUANTITIES REMAINING ON THE ITEMS COMPLETED PRIOR TO THE PAVING OPERATION WILL NOT BE CONVERTED TO ADDITIONAL ASPHALT FOR THE ROADWAY.

PAVEMENT MARKING

(1) THE CONTRACTOR IS RESPONSIBLE FOR THE LAYOUT OF ALL PAVEMENT MARKINGS. ANY CHANGE FROM THE EXISTING PAVEMENT MARKINGS MUST BE APPROVED BY THE REGIONAL TRAFFIC MANAGER.

(2) EXISTING PAVEMENT MARKINGS IN THE SIDE RADII SHALL BE RETRACTED AS DIRECTED BY THE TDOT PROJECT SUPERVISOR DURING FINAL STRIPING.

(3) THE CONTRACTOR SHALL REMOVE EXISTING PAVEMENT MARKINGS AS DIRECTED BY THE TDOT PROJECT SUPERVIOSR. COST OF REMOVAL IS TO BE INCLUDED IN OTHER ITEMS OF CONSTRUCTION.

MISCELLANEOUS

(1) TIME ON THE PROJECT WILL START THE DAY THAT CONSTRUCTION SIGNS ARE PUT UP OR IN ACCORDNACE WITH SP108B IF MAXIMUM AMOUNT OF CALENDAR DAYS IS SPECIIFIED.

(2) THE CONTRACTOR ME BE REQUIRED TO REMOVE AND RESET EXSITING SIGNS WHERE AND AS DIRECTED BY THE TDOT PROJECT SUPERVISOR. EXISTING SIGNS THAT ARE LOST, DAMAGED, OR MISPLACED SHALL BE REPLACED AT THE CONSTRACTOR'S EXPENSE.

NPDES

(1) FOR TYPE 38 TERMINALS NEEDED ON THE PROJECT, USE THE EARTH PAD FOR TYPE 38 TERMINAL (RETROFIT) SHOWN ON STANDARD DRAWING S-GRT-2R. IF THE PROPOSED NUMBER OF EARTH PADS FOR TYPE 38 TERMINALS AS SHOWN ON STANDARD DRAWING S-GRT-2P EXCEEDS A QUANTITY OF 10, CONTACT THE TDOT REGIONAL ENVIRONMENTAL TECH OFFICE IMMEDIATELY TO DETERMINE IF A STORMWATER PERMIT WILL BE REQUIRED

MULTIMODAL

(13) THE CONTRACTOR SHALL IDENTIFY LOCATIONS WITHIN THE PROJECT LIMITS WHERE THE TDOT ROADWAY STANDARDS CANNOT BE USED DUE TO SITE LIMITATIONS. A SITE LAYOUT DETAIL SHOWING THE PROPOSED ALTERATIONS AND DEVIATIONS SHALL BE SUBMITTED TO THE PROJECT SUPERVISOR THREE WEEKS PRIOR TO THE BEGINNING OF ANY CONSTRUCTION. THE DEPARTMENT WILL REVIEW AND EVALUATE THE DETAILS FOR PROPER INSTALLATIONS THAT WILL MEET REGULATIONS.

RAILROAD NOTES

(1) THE CONTRACTOR SHALL COLD PLANE AND RESURFACE THE ROADWAY NEAR AND UNDER THE RAILROAD'S UNDERPASS/BRIDGE STRUCTURE., SO AS TO NOT DIMINISH THE EXISTING VERTICAL CLEARANCE BETWEEN THE HIGHEST POINT OF THE ROADWAY PAVEMENT AND LOWEST POINT OF THE RAILROAD BRIDGE SUPERSTRUCTURE.

(2) THE CONTRACTOR SHALL CONDUCT HIS WORK SO AS TO PROTECT THE ____________________TRACK FACILITIES AND PROPERTIES FROM ANY DAMAGE. TH EWORK SHALL BE DONE IN ACCORDANCE WITH REGULATIONS STIPULATED BY ____________________ SO TO MAINTAIN CLEARANCE AND NOT INTERRUPT TRAIN TRAFFIC IN ANY MANNER.

(3) THE CONTRCTOR SHALL NOT, FOR ANY REASON, STORE ANY OF HIS CONSTRUCTION EQUIPMENT OR DUMP WASTE MATERIALS ON THE RAILROAD'S RIGHT-OF-WAY.

(4) THE CONTRACTOR IS PROHIBITED FROM INSTALLING ANY CONSTRUCTION SIGNS, MESSSAGE BOARDS, ARROW BOARDS AND/OR OTHER TEMPORARY TRAFFIC CONTROL SIGNS OR DEVICES WITHIN THE RAILROAD'S RIGHT-OF-WAY. IN ALL CASES, THESE SIGNS AND DEVICES MUST NEVER BE PLACED IN A POSITION SO AS TO OBSTRUCT THE VIEW OF ANY ADVANCE WARNING DEVICES SUCH AS CROSSBUCK SIGNS, CROSSING SIGNALS, ETC.

(5) THE CONSTRACTOR SHALL NOTIFY AND COORDINATE HIS WORK AT THE RAILROAD CORSSING WITH THE FOLLOWING REPRESENTATIVE OF THE RAILROAD:

MR./MS. ________________________

INSERT TITLE HERE

ADDRESS

CITY, STATE, ZIP

PHONE: _______________

EMAIL: ____________________

AND/OR

MR./MS. ________________________

INSERT TITLE HERE

ADDRESS

CITY, STATE, ZIP

PHONE: _______________

EMAIL: ____________________

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SPECIAL NOTES

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Tabulated Guardrail

Log Mile	SIDE	Guardrail Removal 706-01 (L.F.)	Min. Agg. 303-01 (TON)	Type 38 Terminal MASH TL3 705-06.20 (EACH)	Comments
8.129	Rt	50	25	1	
8.109	Lt		25	1	
8.091	Lt		25	1	
8.091	Rt		25	1	
8.669	Rt		25	1	
8.669	Lt		25	1	
8.629	Rt		25	2	
8.629	Lt		25	2	
8.522	Lt		25	2	
8.340	Rt		25		
Total		50	250	12	

OR

THERE IS NO GUARDRAIL ON THIS PROJECT

BRIDGE DECK RECOMMENDATIONS

BRIDGE NUMBER	LOCATION (L.M.)	CROSSES OVER/UNDER	BRIDGE LENGTH	BRIDGE DECK RECOMMENDATIONS
16021220005	1.85	BRANCH	50	Do not cold plane but pave with plan quantities
16S44000009	2.56	MCBRIDE BRANCH	45	Cold plane and pave with plan quantities
16S44000007	3.47	MCBRIDE BRANCH	65	Leave as is
16S42900007	6.50	DUCK RIVER	80	Leave as is
16S42900009	8.78	PERRY CREEK	50	Cold plane and pave with plan quantities

OR

THERE ARE NO BRIDGES IN PROJECT LIMITS

SIGNS (CONSTRUCTION) 712-06

QTY	MUTCD	DESCRIPTION	SIZE (IN X IN)	ITEM NO. 712-06 (S.F.)
20	G20-2a	END ROAD WORK	36 X 18	90
30	W8-11	UNEVEN LANES	36 X 36	270
18	W20-1	ROAD WORK AHEAD	36 X36	162
2	W20-1	ROAD WORK 1 MILE	36 X 36	18
2	W20-1	ROAD WORK 1/2 MILE	36 X 36	18
2	W20-1	ROAD WORK 1000'	36 X 36	18
2	W20-7a	ADVANCE FLAGGER	36 X 36	18
4	W3-4	BE PREPARED TO STOP	36 X 36	36
2	W21-2	FRESH OIL	36 X 36	18
2	G20-1	ROAD WORK NEXT 11 MILES	36 X 18	9
		TOTAL		657

UTILITY ADJUSTMENTS

TYPE	OWNER	NUMBER
SEWER MANHOLE	METRO WATER	3
WATER VALVE	METRO WATER	6
STATE STORM DRAIN ADJUSTMENTS		
CATCH BASINS		1
MANHOLES		3
VALVE		6

OR

THERE ARE NO UTILITY ADJUSTMENTS ON THIS PROJECT

CURB RAMP TABULATION

ROADWAY		LOCATION				QUADRANT				STANDARD DRAWING NO.	CONCRETE (RETROFIT) ITEM NO. 701-02.01 S.F.	CONCRETE (NEW) ITEM NO. 701-02.03 S.F.	TRUNCATED DOME ITEM NO. 716-10.30 S.F.	REMARKS
MAINLINE	INTERSECTING	STATION or LOG MILE (L.M.)	Left	Median	Right	N.	S.	E.	W.					
SR 280	Harrell Rd.	5.76	X						X	RP-H-7		55		For sidewalk going in one direction
SR 280	Harrell Rd.	5.76	X					X		RP-H-7		55		For sidewalk going in one direction
SR 280	Loop Rd.	8.8	X						X	RP-H-7		55		For sidewalk going in one direction
SR 280	Espy	9.52			X			X		RP-H-9	110			Use blended transition
SR 280	Espy	9.52			X				X	RP-H-9	110			Use parallel curb ramp
										TOTALS	220	165	0	

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TABULATED QUANTITIES

TYPE	YEAR	PROJECT NO.	SHEET NO.
RESURF	2017	HSIP-280(11)	3
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		.	

UTILITIES

(1) THE LOCATIONS OF UTILITIES SHOWN WITHIN THESE PLANS ARE APPROXIMATE ONLY. EXACT LOCATIONS SHALL BE DETERMINED IN THE FIELD BY CONTACTING THE UTILITY COMPANIES INVOLVED. NOTIFICATION BY CALLING THE TENNESSEE ONE CALL SYSTEM, INC., AT 1-800-351-1111 AS REQUIRED BY TCA 65-31-106 WILL BE REQUIRED.

(2) UNLESS OTHERWISE NOTED, ALL UTILITY ADJUSTMENTS WILL BE PERFORMED BY THE UTILITY OR IT'S REPRESENTATIVE. THE CONTRACTOR AND UTILITY OWNERS WILL BE REQUIRED TO COOPERATE WITH EACH OTHER IN ORDER TO EXPEDITE THE WORK REQUIRED BY THIS CONTRACT. ON CONTRACTS WHERE CONSTRUCTION STAKES, LINES, AND GRADES ARE CONTRACT ITEMS, THE CONTRACTOR WILL BE REQUIRED TO PROVIDE RIGHT-OF-WAY OR SLOPE STAKES, DITCH OR STREAM BED GRADES, OR OTHER ESSENTIAL SURVEY STAKING TO PREVENT CONFLICTS WITH THE HIGHWAY CONSTRUCTION. FREQUENTLY, THIS WILL BE REQUIRED AS THE FIRST ITEM OF WORK AND AT ANY LOCATION ON THE PROJECT DIRECTED BY THE ENGINEER.

(3) THE CONTRACTOR WILL PROVIDE ALL NECESSARY PROTECTIVE MEASURES TO SAFEGUARD EXISTING UTILITIES FROM DAMAGE DURING CONSTRUCTION OF THIS PROJECT. IN THE EVENT THAT SPECIAL EQUIPMENT IS REQUIRED TO WORK OVER AND AROUND THE UTILITIES, THE CONTRACTOR WILL BE REQUIRED TO FURNISH SUCH EQUIPMENT. THE COST OF PROTECTING UTILITIES FROM DAMAGE AND FURNISHING SPECIAL EQUIPMENT WILL BE INCLUDED IN THE PRICE BID FOR OTHER ITEMS OF CONSTRUCTION.

(4) PRIOR TO SUBMITTING HIS BID, THE CONTRACTOR WILL BE SOLELY RESPONSIBLE FOR CONTACTING OWNERS OF ALL AFFECTED UTILITIES IN ORDER TO DETERMINE THE EXTENT TO WHICH UTILITY RELOCATIONS AND/OR ADJUSTMENTS WILL HAVE UPON THE SCHEDULE OF WORK FOR THE PROJECT. WHILE SOME WORK MAY BE REQUIRED 'AROUND' UTILITY FACILITIES THAT WILL REMAIN IN PLACE, OTHER UTILITY FACILITIES MAY NEED TO BE ADJUSTED CONCURRENTLY WITH THE CONTRACTOR'S OPERATIONS. ADVANCE CLEAR CUTTING MAY BE REQUIRED BY THE ENGINEER AT ANY LOCATION WHERE CLEARING IS CALLED FOR IN THE SPECIFICATIONS AND CLEAR CUTTING IS NECESSARY FOR A UTILITY RELOCATION. ANY ADDITIONAL COST WILL BE INCLUDED IN THE UNIT PRICE BID FOR THE CLEARING ITEM SPECIFIED IN THE PLANS.

(5) THE CONTRACTOR SHALL NOTIFY EACH INDIVIDUAL UTILITY OWNER OF HIS PLAN OF OPERATION IN THE AREA OF THE UTILITIES. PRIOR TO COMMENCING WORK, THE CONTRACTOR SHALL CONTACT THE UTILITY OWNERS AND REQUEST THEM TO PROPERLY LOCATE THEIR RESPECTIVE UTILITY ON THE GROUND. THIS NOTIFICATION SHALL BE GIVEN AT LEAST THREE (3) BUSINESS DAYS PRIOR TO COMMENCEMENT OF OPERATIONS AROUND THE UTILITY IN ACCORDANCE WITH TCA 65-31-106.

UTILITY OWNER

CABLE:
UTILITY NAME
Address
City, State Zip
CONTACT: Name
OFFICE PHONE: ___ ___ ____
CELL PHONE: ___ ___ ____
Email: Address

ELECTRIC:
UTILITY NAME
Address
City, State Zip
CONTACT: Name
OFFICE PHONE: ___ ___ ____
CELL PHONE: ___ ___ ____
Email: Address

GAS:
UTILITY NAME
Address
City, State Zip
CONTACT: Name
OFFICE PHONE: ___ ___ ____
CELL PHONE: ___ ___ ____
Email: Address

TELEPHONE:
UTILITY NAME
Address
City, State Zip
CONTACT: Name
OFFICE PHONE: ___ ___ ____
CELL PHONE: ___ ___ ____
Email: Address

WATER:
UTILITY NAME
Address
City, State Zip
CONTACT: Name
OFFICE PHONE: ___ ___ ____
CELL PHONE: ___ ___ ____
Email: Address

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UTILITY NOTES
AND
UTILITY OWNERS

TYPE	YEAR	PROJECT NO.	SHEET NO.
RESURF	2017	HSIP-280(11)	4
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PAVEMENT EDGE DROP-OFF NOTES

A. DIFFERENCES IN ELEVATION BETWEEN ADJACENT TRAFFIC LANES OR TRAFFIC LANE AND SHOULDER WHERE THE TRAFFIC LANE IS BEING USED BY TRAFFIC, CAUSED BY BASE, PAVING OR RESURFACING:

1. DIFFERENCES IN ELEVATION BETWEEN ADJACENT ROADWAY ELEMENTS GREATER THAN 0.75 INCH AND NOT EXCEEDING 2 INCHES:

   a. WARNING SIGNS, UNEVEN LANES (W8-11) AND/OR SHOULDER DROP-OFF WITH PLAQUE (W8-17 AND W8-17P), SHALL BE PLACED IN ADVANCE OF AND THROUGHOUT THE EXPOSED AREA. MAXIMUM SPACING BETWEEN SIGNS SHALL BE 2,000 FEET WITH A MINIMUM OF 2 SIGNS PER EXPOSED AREA. WHERE UNEVEN PAVEMENT IS ENCOUNTERED, SIGNS SHALL BE PLACED ON EACH SIDE OF THE ROADWAY.

   b. DIFFERENCES IN ELEVATION BETWEEN ADJACENT TRAFFIC LANES BEING UTILIZED BY TRAFFIC CAUSED BY ADDED PAVEMENT SHALL BE ELIMINATED WITHIN THREE WORKDAYS.

   c. DIFFERENCES IN ELEVATION BETWEEN ADJACENT TRAFFIC LANES BEING UTILIZED BY TRAFFIC CAUSED BY COLD PLANING SHALL BE ELIMINATED WITHIN THREE WORKDAYS.

   d. WHEN THE DIFFERENCE IN ELEVATION IS BETWEEN THE TRAFFIC LANE BEING UTILIZED BY TRAFFIC AND SHOULDER THE DIFFERENCE IN ELEVATION SHALL BE ELIMINATED WITHIN SEVEN WORKDAYS AFTER THE CONDITION IS CREATED.

2. DIFFERENCES IN ELEVATION BETWEEN ADJACENT ROADWAY ELEMENTS GREATER THAN 2 INCHES AND NOT EXCEEDING 6 INCHES. TRAFFIC IS NOT TO BE ALLOWED TO TRAVERSE THIS DIFFERENCE IN ELEVATION.

   a. SEPARATION SHALL BE ACCOMPLISHED BY DRUMS, BARRICADES OR OTHER APPROVED DEVICES IN ACCORDANCE WITH THE FOLLOWING:

      (1) WHERE POSTED SPEEDS ARE 50 MPH OR GREATER, SPACING OF THE PROTECTIVE DEVICES SHALL NOT EXCEED 100 FEET.

      (2) WHERE POSTED SPEEDS ARE LESS THAN 50 MPH, THE MAXIMUM SPACING OF THE PROTECTIVE DEVICES IN FEET SHALL NOT EXCEED TWICE THE POSTED SPEED IN MILES PER HOUR OR 50 FEET, WHICHEVER SPACING IS GREATER.

   b. IF THE DIFFERENCE IN ELEVATION IS ELIMINATED OR DECREASED TO 2 INCHES OR LESS BY THE END OF EACH WORKDAY, CONES MAY BE USED DURING DAYLIGHT HOURS IN LIEU OF DRUMS, BARRICADES OR OTHER APPROVED PROTECTIVE DEVICES MENTIONED IN PARAGRAPH a, PROVIDED WARNING SIGNS ARE ERECTED. WARNING SIGNS (UNEVEN LANES AND/OR SHOULDER DROP-OFF) SHALL BE PLACED IN ADVANCE OF AND THROUGHOUT THE EXPOSED AREA. MAXIMUM SPACING BETWEEN SIGNS SHALL BE 2,000 FEET WITH A MINIMUM OF 2 SIGNS PER EXPOSED AREA. WHERE UNEVEN PAVEMENT IS ENCOUNTERED, SIGNS SHALL BE PLACED ON EACH SIDE OF THE ROADWAY.

   c. WHEN THE DIFFERENCE IN ELEVATION IS BETWEEN THE THROUGH TRAFFIC LANE AND THE SHOULDER AND THE ELEVATION DIFFERENCE IS LESS THAN 3.5 INCHES, THE CONTRACTOR MAY USE WARNING SIGNS AND/OR PROTECTIVE DEVICES AS APPLICABLE AND APPROVED BY THE ENGINEER. SEE PARAGRAPH a REGARDING USE OF DRUMS, BARRICADES OR OTHER APPROVED PROTECTIVE DEVICES. WARNING SIGNS (UNEVEN LANES AND/OR SHOULDER DROP-OFF) WILL BE PLACED IN ADVANCE OF AND THROUGHOUT THE EXPOSED AREA. MAXIMUM SPACING BETWEEN SIGNS SHALL BE 2,000 FEET WITH A MINIMUM OF 2 SIGNS PER EXPOSED AREA. WHERE UNEVEN PAVEMENT IS ENCOUNTERED, SIGNS SHALL BE PLACED ON EACH SIDE OF THE ROADWAY.

   IN THESE SITUATIONS, THE CONTRACTOR SHALL LIMIT HIS OPERATIONS TO ONE WORK ZONE NOT EXCEEDING 2 MILES IN LENGTH UNLESS OTHERWISE NOTED ON THE PLANS OR APPROVED BY THE ENGINEER. ONCE THE CONTRACTOR BEGINS WORK IN A WORK ZONE, A CONTINUOUS OPERATION SHALL BE MAINTAINED UNTIL THE DIFFERENCE IN ELEVATION IS ELIMINATED. SIMULTANEOUS WORK ON SEPARATE ROADWAYS OF DIVIDED HIGHWAYS WILL BE CONSIDERED INDEPENDENTLY IN REGARD TO RESTRICTION OF WORK ZONE ACTIVITY.

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**STATE OF TENNESSEE
DEPARTMENT OF
TRANSPORTATION**

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