Pavement Design Manual

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Revision 4.2
Atlanta, GA 30308

Georgia Department of Transportation

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

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

Please send comments to:

State Pavement Engineer

Georgia Department of Transportation

Office of Materials and Testing

15 Kennedy Drive

Forest Park, Georgia 30297

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Revision History

Revision Number	Revision Date	Revision Summary
1.0	2005	n/a
2.0	2007	n/a
3.0	2019	Replaced Chapter 10 with reference to new Pavement Type Selection Manual
4.0	6/28/2022	Reformatted entire manual. Revised and updated content.
4.1	3/26/24	Updated GDOT branding logo throughout Chapter 1 – Updated Special Provisions hyperlink Chapter 2 - Added reference to GDOT RP 18-05. Added tables to 2.3 Land Distribution Factors section. Updated Guidelines for Geotechnical Studies hyperlink Chapter 4 - Updated Guidelines for Minor Projects Tool and GDOT Roundabout Traffic Tool hyperlinks Chapter 5 - Updated GDOT Roundabout Traffic Tool hyperlinks
4.2	2/5/25	Chapter 2 – Section 2.3 provide clarity on how to use the tables and instructions for multi-lane roundabouts and ramps

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List of Effective Chapters

Document	Revision Number	Revision Date
List of Effective Chapters	4.2	2/5/25
Table of Contents	4.2	2/5/25
Definitions & Terminology	4.1	3/26/24
Chapter 1. Pavement Design Process	4.1	3/26/24
Chapter 2. Design Parameters	4.2	2/5/25
Chapter 3. Pavement Layers	4.1	3/26/24
Chapter 4. Pavement Design Procedure	4.1	3/26/24
Chapter 5. Pavement Design Package	4.1	3/26/24
Appendix A: Typical Values of Layer Coefficients	4.1	3/26/24
Appendix B: Typical SSV, k-values, and RF	4.1	3/26/24

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Table of Contents

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Definitions and Terminology

Acronyms

AADT – Average Annual Daily Traffic

AASHTO – American Association of State Highway and Transportation Officials (http://www.transportation.org)

AC – Asphaltic Concrete

ADT – Average Daily Traffic

ADTT – Average Daily Truck Traffic

CRCP – Continuously Reinforced Concrete Pavement

ESAL – Equivalent Single Axel Load

FHWA – Federal Highway Administration (http://www.fhwa.dot.gov/)

GAB – Graded Aggregate Base

GDOT – Georgia Department of Transportation (http://www.dot.ga.gov)

HMA – Hot Mix Asphalt

JPCP – Jointed Plain Concrete Pavement

LDF – Lane Distribution Factor

MU – Multiple Unit

NHS – National Highway System

OGFC – Open Graded Friction Course

OGI – Open Graded Interlayer

OMAT – Office of Materials and Testing

OTD – Office of Transportation Data

PCC – Portland Cement Concrete

RF – Regional Factor

SMA – Stone Matrix Asphalt

SN – Structural Number

SSS – Soil Survey Summary

SSV – Soil Support Value

SU – Single Unit

TADA – Traffic Analysis And Data Application

TSI – Terminal Serviceability Index

Definition of Terms

Aggregate – Granular material, such as: sand, gravel, crushed stone, crushed hydraulic cement concrete, or iron blast furnace slag.

Asphalt – A brown-to-black bituminous substance that is commonly a residue of petroleum refining and consists mostly of hydrocarbons.

Asphalt Concrete Base – A base type that utilizes hot mix asphalt concrete placed directly on subgrades of high soil support values. This is a common base in South Georgia.

Average Annual Daily Traffic (AADT) – The average 24-hour traffic volume at a given location over a full 365-day year. This means the total number of vehicles passing the site in a year, divided by 365.

Average Daily Traffic (ADT) – The total volume during a given time period (in whole days), greater than one day and less than a year, divided by the number of days in that time period.

Base – A base is one or more layers of specified material of design thickness placed on the subgrade or subbase to support additional pavement layers.

Base Year – The year the paving is completed and anticipated to be open for traffic use.

Concrete – A composite material that consists of a binding medium with embedded particles or fragments of relatively inert filler material. In Portland Cement Concrete, the binder is a mixture of Portland Cement and water; the filer may be a wide variety of natural or artificial aggregates.

Contraction Joint – A joint constructed the transverse direction in JPCP pavements to control cracking of the slab as it cures. Highway contraction joints are created by sawing the concrete. GDOT's typical transverse joint spacing is 15 feet.

Continuously Reinforced Concrete Pavement – PCC pavement constructed with enough longitudinal steel reinforcement to control transverse crack spacings and opening in lieu of transverse contraction joints for accommodating concrete volume change and load transfer.

Design Life – The expected life of a pavement from opening to traffic until a structural rehabilitation is needed.

Design Year – The anticipated future life of the project. The design year is the summation of the base year and the design life. Typically for GDOT projects, the design year is 20 years from the base year.

Equivalent Single Axle Loads (ESAL) – The conversion of traffic loads to equivalent 18,000 pound single axle loads.

Flexible Pavement – Constructed of several thicknesses of asphalt or bituminous concrete layers overlying a base of granular material on a prepared subgrade.

GDOT Policy – A guideline adopted by the Georgia Department of Transportation.

Graded Aggregate Base (GAB) – A type of base that utilizes processed crushed stone or graded aggregate exclusively.

Hot Mix Asphalt (HMA) – A controlled mixture of asphalt binder and aggregate compacted into a uniform dense mass. HMA pavements may also contain additives such as anti-stripping agents and polymers.

Jointed Plain Concrete Pavement (JPCP) – PCC pavement constructed with regularly spaced transverse joints to control naturally occurring cracks. Dowel bars may be used to enhance load transfer at transverse contraction joints.

Lane Distribution Factor (LDF) – A percentage of traffic anticipated to be in the most heavily trafficked lane.

Load Transfer Efficiency – A measure of the ability of a joint or crack to transfer a portion of a load applied on one side of a joint or crack to the other side of the joint or crack.

Multiple Unit Trucks (MU) – Trucks with three or more axles. According to the FHWA Classification scheme, this includes vehicles from Class 6 through Class 13.

Off-System Roads – Roads that are not owned or maintained by GDOT. Local Roads such as county roads fall in this category.

Open Graded Friction Course – A thin HMA surface course consisting of a mix of an asphalt binder and open graded aggregate. An OGFC helps to eliminate standing water on a pavement surface, which reduces tire spray and hydroplaning potential. It has no structural value in pavement design computations.

Overlay – The addition of a new material layer onto an existing pavement surface without removing any existing material.

Regional Factor - Region specific. Deals with drainage characteristics and terrain of area in question.

Rigid Pavement – Pavement that will provide high bending resistance and distributes loads over a comparatively large area.

Single Unit Trucks (SU) – Trucks with two axles. According to the FHWA Classification scheme, this includes vehicles from Class 1 through Class 5.

Soil Cement – A mix of pulverized natural soil with a small amount of Portland Cement and water and compacted to a high density.

Soil Support Value – An index of subgrade strength. It is region specific, ranges from 2.0 to 4.5 and is based upon the California Bearing Ratio.

Soil Survey – A geotechnical study to gather soil data for design purposes.

Stone Matrix Asphalt (SMA) – A mixture of asphalt binder, stabilizer material, mineral filler, and gap-graded aggregate. SMA provides a rut resistant wearing course for pavements.

Structural Layer Coefficient – A measure of the relative ability of a unit thickness of a given material to function as a structural component of the pavement.

Subbase – The layer of aggregate material laid on the subgrade on which the base course is laid. Subbase is often the main load-bearing layer of the pavement and is used to spread the load evenly over the subgrade.

Subgrade – The native materials underneath a constructed pavement. It is the foundation of the pavement structure, on which the subbase is laid.

Terminal Serviceability Index (TSI) – The lowest acceptable serviceability rating before resurfacing or reconstruction becomes necessary.

Chapter 1. Pavement Design Process - Contents

Chapter 1. Pavement Design Process

1.1 Introduction

1.1.1 Pavement Design

Pavement Design is the process of developing the most economical combination of pavement layers, with respect to thickness and type of material, to protect the soil subgrade from the design life cumulative traffic loading. Pavement materials are high dollar items and comprise a large portion of the cost of a project. Sound engineering judgment and careful consideration should be combined to produce a cost-effective and structurally-sound pavement design.

1.1.2 Pavement Policy

The Georgia Department of Transportation, GDOT, currently uses the AASHTO Interim Guide for design for Pavement Structures, 1972, Chapter III Revised, 1981. This guide is based on the results of the AASHTO Road Test, which was completed in the 1960's. Although the data collected and the relationships determined from this test are for a limited scope of test conditions, GDOT has had good success in applying these relationships in designing pavements. This success is evidenced by the overall condition of the pavement structure on Georgia's roads.

1.1.3 Pavement Resources

More information regarding Pavement Design and the Pavement Design Processes can be found in Chapter 10 of the Design Policy Manual.

1.2 Pavement Design Types

Pavements are divided into two broad categories: flexible pavements and rigid pavements.

1.2.1 Flexible Pavements

Flexible pavements are so named because they are relatively deformable under the actions of traffic and rebound when traffic loads are removed. They consist of a base material that has been overlaid by asphaltic concrete layers.

1.2.2 Rigid Pavements

Due to the rigidity and relatively high modulus of elasticity, rigid pavements tend to distribute the applied load over a relatively wide area. The slab itself supplies the major portion of the structural capacity.

1.3 Pavement Structure Basics

1.3.1 Flexible Pavement Lift Thickness

Lift Thicknesses are predominately driven by the nominal maximum aggregate size and the historical ability of contractors to place the material in an acceptable fashion. For surface layers, this includes smoothness requirements from GDOT Specification 400.3.06. The binder and surface layers lift thicknesses are based on safety considerations. The maximum allowable drop-off between adjacent lanes cannot exceed 2 inches under active traffic according to Special Provision 150, which can sometimes dictate lift thickness for overlay designs. Information on the minimum and maximum lift thicknesses for each mix type can be found in the Criteria for Use of Asphaltic Concrete Layer and Mix Types.

1.3.2 Design Period

1.3.2.1 Permanent Pavement

Permanent Pavement design period will reflect the design life of the project. Typical pavement design life is 20 years. There are projects that have a shorter design life. (e.g. Quick projects typically have a design life of 10 years.)

1.3.2.2 Temporary Pavement

The temporary pavement design period is based on the length of time the pavement will be used for staged construction, rounded up to a whole number of years. More information on temporary pavement can be found in Section 4.4.4.

1.3.3 Flexible Pavement Structural Layer Coefficients

Structural Layer Coefficients are a measure of the relative ability of a unit thickness (1 inch) of a given material to function as a structural component of the pavement. Structural Numbers (SN) are a function of layer thickness, structural layer coefficients, and soil support values. Additional information on layer coefficients can be found in the AASHTO Interim Guide for Design of Pavement Structures 1972 (1981 revision) Appendix C.4. Layer coefficients (per inch) for Hot Mix Asphalt (HMA) range from 0.3 to 0.44, while Graded Aggregate Base (GAB) generally is 0.16. However, there are specific layers that do not contribute to the structural strength of the pavement and thus do not have a layer coefficient. These specific layers are:

- Open Graded Friction Course (OGFC)
- Leveling
- Microseal/microsurface treatment
- Chip seal
- Crack Mitigation Layers

Typical Values of Layer Coefficients for GDOT materials can be found in Appendix A.

Chapter 2. Design Parameters - Contents

Chapter 2. Design Parameters

2.1 Prioritization

The route priority will determine the under design percentages for flexible pavements and should follow the guidelines set forth in the Revised Flexible Pavement Underdesign Policy Based on State Route Prioritization dated April 15, 2019. Rigid pavements should use the balanced thickness, rounded up to the next ½ inch, regardless of route priority. In addition to the maps listed in the policy, the prioritization information can be found in the State Functional Classification Map application.

2.2 Traffic

Traffic data is an important component of any pavement evaluation and design analysis. The designs will use the Average Annual Daily Traffic (AADT) and 24-hour truck percentage to calculate the highest Equivalent Single Axle Load (ESAL), unless there are termini that correspond to logical breaks as described in 10.3.3 of the Design Policy Manual. ESAL converts traffic loads to equivalent 18,000 pound single axle loads. Typically, for projects that include pavement construction, traffic diagrams or traffic assignment correspondence will be provided. In addition to the project's base and design years projections, are also provided for the base year plus 2 years and the design year plus 2 years. Designs for the +2 traffic should be included in the Pavement Design Package.

The base year and design year is defined as follows:

- Base Year = Let Date + Construction Time
- Design Year = Base Year + Design Life

2.2.1 Traffic Diagrams

Traffic Diagrams are the graphic representations of existing traffic conditions or future traffic conditions and include traffic turning movements. Generally, the Project Manager will provide traffic diagrams that were approved by the GDOT Office of Planning. However, some projects such as those that are programmed by Traffic Operations may have traffic approved by the State Traffic Engineer. Traffic data typically consists of 24-hour traffic counts and truck percentages with the breakdown of Single Units (SU) and Multiple Units (MU). The program GDOT uses to design flexible and rigid pavements calculates the ESALs. The calculations to determine the ESALs are:

1. Determine the mean AADT.

$$\text{Mean AADT} = \frac{(\text{Base Year AADT} + \text{Design Year AADT})}{2}$$

2. Determine the percentage of other vehicles by subtracting the truck percentage from 100%.
3. Multiply the mean AADT, the design factor, and each percentage of MU, SU, and other vehicles to find each respective mean traffic volume.

$$\text{MU mean traffic volume} = \text{mean AADT} * \text{MU} * \text{MU design factor}$$

$$\text{SU mean traffic volume} = \text{mean AADT} * \text{SU} * \text{SU design factor}$$

Other vehicles mean traffic volume = mean AADT * other vehicles percent * other design factor

Note: The designer should be aware that the design factors are different for flexible and rigid pavements. Design Factors can be found in the table below. The below factors were last validated during GDOT RP 18-05.

Table 2.1: 18-kip ESAL Design Factors		
Design Factor	**Rigid Pavement Value**	**Flexible Pavement Value**
MU	2.68	1.5
SU	0.5	0.4

4. Add all the individual mean traffic volumes together to find the total mean traffic volume.

Total Mean Traffic Volume = Other vehicles mean traffic volume + SU mean traffic volume + MU mean traffic volume

5. Multiply the Total Mean Traffic Volume, the number of design years (n), and number of days per year (365).

ESALs = Total Mean Traffic Volume * n* 365

The designer should note that the highest ESAL count may not correspond with the highest AADT.

2.2.2 No Truck Breakdown

If traffic counts were obtained without a breakdown in truck percentages for MU and SU, the Representative 18-kip ESAL factor from the table below should be used for flexible pavements.

Table 2.2: User-Defined Representative Truck Percentages			
Type of Facility	**SU (%)**	**MU (%)**	**Representative 18-kip ESAL Factor**
Rural Interstate Routes	0	100	1.5
	10	90	1.39
	20	80	1.28
U.S. Routes	30	70	1.17
Heavy State Routes and Urban Interstate Routes	40	60	1.06
Medium State Routes	50	50	0.95
	60	40	0.84
Local Collector	70	30	0.73
Light State Routes	80	20	0.62
Secondary System and City Streets	90	10	0.51
	100	0	0.40
Note: "Heavy" State Routes refers to routes having truck percentages of 10% or greater and /or Initial One-Way AADT exceeding 5,000. "Medium" State Routes refers to routes having one-way AADT from 3,000-5,000.			

The program does not have an option to enter an ESAL factor for rigid pavements. Therefore, the percentage of SU and MU from the table above should be used for rigid pavements. The percentages of SU and MU should be used to divide the 24-hour truck percentage into usable SU and MU values.

Example: 24-hour truck % = 10 for a Heavy State Route

SU = 24-hour truck % * 40% = 10 * 40% = 4

MU = 24-hour truck % * 60% = 10 * 60% = 6

For this example, the 24-hour truck % is 10, the SU is 4, and the MU is 6. These values are after the program inputs.

2.2.3 Traffic Assignment

Traffic Assignment sheets are typically one page. and show two-way average daily traffic (ADT), design hourly volume (DHV), k-factor, directional distribution (D), and truck percentages. Unless noted otherwise, the one-way ADT should be half of the ADT. Traffic Assignment sheets are typically used for bridge projects, turn lane projects, and other minor projects that do not require a traffic diagram.

2.2.4 No Traffic Data

If approved traffic data is not available, preliminary traffic data can be obtained from Traffic Analysis and Data Application (TADA). TADA is the GDOT application for reviewing traffic counts collected and reported by the Office of Transportation Data (OTD). Growth rates should be calculated in accordance with Chapter 5 of the Design Traffic Forecasting Manual. To find the growth rate, use historical counts for the past 15 years and document in an excel spreadsheet with any clear outliers omitted. If data is from a portable station, only use years when actual count was performed and not estimated. The minimum growth rate should be 0.5% and the maximum 2%.

2.3 Lane Distribution Factor

The Lane Distribution Factor (LDF) is used to determine the number of 18-kip Equivalent Single Axle Loads (ESALs) in the design lane. Typically, as the number of lanes increase, the LDF will decrease. The recommended LDF values can be found below. Source of LDFs in Table 2.3 A-D come from GDOT RP 22-35 Development of Area-Specific Land Distribution Factors for Pavement Design. Underlined values are extrapolated values. The AADT should be the average of the initial AADT and the design year (20) AADT. Multi-lane ramps and roundabouts should use an LDF of 100%, unless otherwise approved by the State Pavement Engineer.

Table 2.3 A: Lane Distribution Factors (Urban Interstate/Freeway/Expressway)

One-Way ADT	2 Lanes (one direction)	3+ Lanes (one direction)
2,000	91	83
4,000	89	79
6,000	87	76
8,000	85	73
10,000	84	71
15,000	82	68
20,000	80	65
25,000	78	63
30,000	77	61
35,000	76	60
40,000	75	58
50,000	73	56

60,000	72	54
70,000		52
80,000		51
100,000+		49

Table 2.3 B: Lane Distribution Factors (Rural Interstate/Freeway/Expressway)		
One-Way ADT	**2 Lanes (one direction)**	**3+ Lanes (one direction)**
2,000	93	87
4,000	91	83
6,000	90	81
8,000	88	78
10,000	87	77
15,000	85	73
20,000	84	71
25,000	82	69
30,000	81	67
35,000	80	66
40,000	79	64
50,000	78	62
60,000	76	60
70,000		59
80,000		57
100,000+		55

Table 2.3 C: Lane Distribution Factors (Urban Other)		
One-Way ADT	**2 Lanes (one direction)**	**3+ Lanes (one direction)**
2,000	83	70
4,000	79	64
6,000	76	60
8,000	74	57
10,000	72	54
15,000	68	50
20,000	66	47
25,000	64	45
30,000	62	43
35,000	61	42
40,000	59	40

Table 2.3 D: Lane Distribution Factors (Rural Other)		
One-Way ADT	**2 Lanes (one direction)**	**3+ Lanes (one direction)**
2,000	86	75
4,000	83	69
6,000	80	65
8,000	78	62
10,000	76	60
15,000	73	56
20,000	71	53
25,000	69	51
30,000	67	49
35,000	66	47
40,000	64	46

2.4 Soil Survey

2.4.1 Approved Soil Survey

A Soil Survey (SS) provides information about the subgrade and should be completed in accordance with Guidelines for Geotechnical Studies and per Plan Development Process (PDP) 6.3.2. The SS will provide Soil Support Values (SSV) used when developing the pavement designs. The SS will also give recommendations for suitable pavement base types. For rigid pavement designs, the SSV corresponds to a k-value that can be found in Appendix B.

2.4.2 No Soil Survey

If an SS has not been completed, the pavement designs should use the default SSV or k-value for the county. Typical SSV, and k-values can be found in Appendix B. If an SS will not be performed, the typical base types for the county from Geotechnical Manual 4.5.16 Base Uses in Georgia should be used in the pavement design analysis. However, if a Soil Survey is completed at a later date, the designs should be re-evaluated based on the updated values.

2.5 Regional Factor

The Regional Factor (RF) provides an adjustment to the structural number for local environmental and other considerations. The factors considered in determining the regional factor are: topography, rainfall, frost penetration, temperature, ground water table depth, subgrade type, engineering judgment, type of highway facility, and subsurface drainage. The Regional Factors used in the pavement design analysis can be found in Appendix B.

2.6 Terminal Serviceability

The Terminal Serviceability Index (TSI) is a rating of the pavement at the end of the design period. During the AASHTO Road Test, the pavements were rated at the initial opening to traffic and then rated at the end of the test, typically a year's worth of traffic. The initial rating was set at 5.0 for new pavement with a smooth ride. At the end of the test period, it was rated again. Although the used pavement had surface distresses and some maintenance, it was still serviceable and riding smooth and was rated 2.5. Therefore, the program defaults to a terminal rating of 2.5. This is the lowest acceptable serviceability rating before resurfacing or reconstruction becomes necessary.

For design of temporary pavements, or stage construction that will not become part of the final pavement structure, use a terminal serviceability index of 2.0.

For additional information on Serviceability see AASHTO Interim Guide for design for Pavement Structures, 1972, Chapter III Revised, 1981 Chapter 1.6

Chapter 3. Pavement Layers - Contents

Chapter 3. Pavement Layers

3.1 Bases

The base layer is the bottom layer of the pavement section in design. Base layer types and acceptable uses are shown on the Base Uses in Georgia Map in the Geotechnical Manual.

3.1.1 GAB

GAB provides added structure and has a low susceptibility to frost. GAB can be placed in one or two layers depending upon its thickness. The maximum single lift thickness is 8 inches with a total maximum GAB thickness of 16 inches, per Section 310 Graded Aggregate Construction of the GDOT Standard Specifications. GAB is typically charged for by the square yards in South Georgia and by the ton in North Georgia. GAB can be used for both rigid and flexible pavements. Construction procedures, testing methods, and specifications regarding the use of GAB is outlined in Section 815 Graded Aggregate of the GDOT Standard Specifications and as modified in Special Provision 815 (February 22, 2019). Typical GAB thicknesses based on SSV and route type can be found in the table below.

Table 3.1: Graded Aggregate Base Thickness Guidelines

Soil Support Value	Minimum GAB for Interstates* (in)	Minimum GAB for State Routes* (in)	Maximum GAB Thickness for Interstates and State Routes * (in)	Minimum GAB for Off System Routes * (in)	Maximum GAB Thickness for Off System Routes * (in)
2.0 - 2.4	12	12	16	10	16
2.5 - 2.9	12	10	16	8	12
3.0 - 3.4	12	10	16	8	12
3.5 - 3.9	12	8	16	6	10
4.0+	12	8	16	6	10

* GAB thickness for Rigid Pavements is 8”.
Factors that could affect base thickness selection are the following:
1. Projected traffic volumes (AADT)
2. Projected truck traffic volumes (AADTT)
3. Type of roadway (major arterial with heavy industry nearby; low-volume rural road with little industry; county road vs. State Route/US route, etc.)

3.1.2 Soil Cement

Soil Cement is a mixture of cement, pulverized soil, and water that is compacted to a high density. The mixture gradually becomes a hard-structural material as the cement hydrates with time. Typical cement content is around 8 percent by weight of soil, depending on the amount of silt and/or clay present. Soil Cement can be used for flexible pavements. Construction procedures, testing methods, and specifications regarding the use of cement for soil stabilizations are outlined in Section 301 Soil Cement Construction and 814.2.02 in the GDOT Standard Specs. Soil Cement cannot be used in areas with gap-graded sands due to potential stability problems during construction.

3.1.3 Asphaltic Concrete Base

Full depth asphalt pavements are constructed by placing multiple layers of HMA directly on the subgrade or improved subbase. The function of an asphalt base is to act as a stress distribution medium for the applied surface load to minimize shear and consolidation deformations in the subgrade. Asphaltic Concrete is generally considered a cost-effective alternate base course in some southern Georgia counties where the SSV is greater than or equal to 3.5. Asphaltic Concrete Base can be used for both rigid and flexible pavements. The minimum lift thickness for Asphaltic base is 3 inches, since it will be constructed with 25mm Superpave. Construction procedures, testing methods, and specifications regarding the use of asphaltic concrete are outlined in Section 828 Hot Mix Asphaltic Concrete mixtures of the GDOT Standard Specifications or Special Provisions. Asphaltic Concrete Base cannot be used in areas with gap-graded sands due to potential stability problems during construction.

3.1.4 Limerock Base

Limerock is a sedimentary rock mined from coastal deposits consisting primarily of carbonates of magnesium and/or calcium. Limerock base can be substituted for GAB during construction so there is no separate pay item for this item. In Georgia, the use of Limerock for roadway construction is generally limited to the southern and southeastern coastal regions where ample sources of Limerock are available (typically hauled in from Florida). Limerock specifications are outlined in 815.2.02 of the GDOT Standard Specifications.

3.1.5 Equivalent Base Thicknesses

If pavement base alternates are included, the asphalt layers above the base should remain the same. The table below shows some of the Approximate Equivalent Thicknesses based on material.

Table 3.2: Approximate Pavement Base Equivalent Thickness

Asphaltic Concrete	=	Soil Cement	=	GAB
3 inches	=	N/A	=	6 inches
4 inches	=	6 inches	=	8 inches
5 inches	=	8 inches	=	10 inches
6 inches	=	10 inches	=	12 inches
7 inches	=	N/A	=	14 inches
8 inches	=	N/A	=	16 inches

3.2 Flexible Pavement

A flexible pavement section normally consists of a base layer (discussed in 3.1 above), asphalt base layer, binder layer and surface layer. Information on layer thicknesses based on Average Daily Traffic (ADT) can be found in the Criteria For Use of Asphaltic Concrete Layer and Mix Types or the Guidelines for Capital Maintenance Projects.

3.2.1 Asphalt Base Course

The asphalt base course is placed directly on top of the base, typically GAB, and under the binder layer. This layer is generally 25 mm Superpave. The recommended a minimum layer thickness is 3 inches for pavement designs even though an allowable minimum lift thickness of 2.5 inches can be used during construction. There is no maximum layer thickness. The thickness of this layer is typically designed in whole inch increments. The maximum single lift thickness for 25 mm Superpave is 5 inches. An example of a method to optimize construction sequences is shown below.

Example: A pavement design with 6” of 25mm Superpave and 6” of GAB would be constructed in 3 lifts – 2 -3” layers of 25mm and 1 layer of GAB. However, the design could be changed to 5” of 25mm and 8" of GAB and reduce the construction sequence to 2 lifts. Both designs have similar structural numbers, but the latter optimizes construction sequencing.

3.2.2 Asphalt Binder Course

The binder course is placed on top of the asphalt base course, and under the surface course. This layer is generally 19 mm Superpave. The typical lift thickness of the binder course is 2 inches with a maximum single lift thickness of 3 inches.

3.2.3 Asphalt Surface Course

The surface layer is placed on top of the binder course and is typically the riding surface unless a drainage course is provided. The type of surface layer used is dependent on the ADT and Average Daily Truck Traffic (ADTT).

3.2.3.1 4.75 mm

The thickness for 4.75 mm Mix is generally 1 inch. This mix is used in maintenance projects.

3.2.3.2 9.5 mm Superpave Type II

When used as the surface course, the thickness for 9.5 mm Superpave Type II is generally 1.25 inches.

3.2.3.3 12.5 mm Superpave

When used as the surface course, the thickness for 12.5 mm Superpave is generally 1.5 inches.

3.2.3.4 12.5 mm Superpave Polymer Modified

When used as the surface course, the thickness for 12.5 mm Superpave is generally 1.5 inches.

3.2.3.5 12.5 mm SMA

SMA provides additional structure and friction for high volume roads. The shape of stone is a defining characteristic. When used as the surface course, SMA generally should be 1.5 inches. However, SMA as surface course on an interstate should be 2.0 inches.

3.2.4 Asphalt Drainage Course

For higher volume routes, such as interstates, a drainage course may be added as a surface course.

3.2.4.1 OGFC

OGFC improves safety by draining water from the surface to provide more traction and reducing tire splash during rain.

3.2.4.2 PEM

PEM is a porous pavement structure in which the pores provide a path of least resistance for the water that is displaced under the wheels of vehicles. PEM is no longer being recommended for pavement designs.

3.3 Rigid Pavement

A rigid pavement section normally consists of a GAB base layer, Portland Cement Concrete (PCC), and may include an asphalt interlayer. The slab is generally Jointed Plain Concrete Pavement (JPCP).

3.3.1 Interlayer

The purpose of an asphalt interlayer is to separate the PCC pavement from the underlying layers in an unbound design and to create uniform friction for the JPCP layer. An asphalt interlayer also serves as a separator for subgrade fines from the PCC Pavement. The asphalt interlayer is typically used on interstate routes; however, it may be used on state routes with high truck traffic. An interlayer is required for Continuously Reinforced Concrete Pavements (CRCP).

3.3.2 Surface Course

3.3.2.1 JPCP

JPCP pavements contain enough joints to inhibit natural cracks occurring at locations other than the joints. Jointed Plain Concrete Pavement has transverse joints spaced at regular intervals. The transverse joints are used to control temperature induced contraction and expansion in the concrete. Smooth dowel bars are used at the transverse joints for load transfer. The transverse joints are spaced as shown in GA STD 5046H. Longitudinal joints are used to control random longitudinal cracking. Longitudinal joints are tied together with steel tie-bars to prevent the joints from opening. JPCP pavement thicknesses range from 6-12 inches. When JPCP is next to an asphalt concrete shoulder the JPCP lane width should be widened to 13 feet and striped at 12 feet to reduce edge distress.

3.3.2.2 CRCP

A CRCP is a PCC pavement that has continuous longitudinal steel reinforcements and no intermediate transverse expansion or contraction joints. CRCP pavement designs should be included in Pavement Design Packages as an alternate when a Pavement Type Selection is required for the project. A CRCP pavement has the following features:

- The pavement is allowed to crack in a random transverse cracking pattern and the cracks are held tightly together by the continuous steel reinforcement.
- Due to the high degree of continuity in its construction, a CRCP pavement exhibits only minor cracking with good load transfer.
- The continuity also provides a more homogeneous load distribution onto the subgrade and thus provides added capacity in overcoming moderate settlement.
- The edge conditions in JPCP do not exist in CRCP pavements.

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Chapter 4. Pavement Design Procedure - Contents

Chapter 4. Pavement Design Procedure

4.1 Introduction

The pavement design approach can be outlined in the following steps:

1. Quantify the loading conditions of the pavement by estimating the number of anticipated number of ESALs for the design period.
2. Define the environmental conditions for the pavement location.
3. Select economical, locally available construction materials with appropriate engineering properties for use in the construction of this pavement
4. Determine the pavement structure, based on empirical rules for flexible pavement or a stress-strain analysis for rigid pavement.
5. Repeat this process until a satisfactory pavement design is achieved.

4.2 Pavement Design Calculations

4.2.1 Flexible Pavements Calculation

The design procedure to satisfy the required structural number (SN) includes the determination of total thickness of the pavement structure, as well as the thickness of the individual layers. Layer coefficients are included in Appendix A.

The structural number represents the structural strength required for a pavement with given combinations of SSV, ESALs, Terminal Serviceability Index, and Regional Factor.

The required SN must be converted to actual layer thickness by means of an appropriate layer coefficient representing the relative strength of the material to be used for each layer. The general equation for structural number is:

$$SN = a_1D_1 + a_2D_2 + a_3D_3 + \cdots \ldots \ldots \ldots a_nD_n$$

Where

$a_1, a_2, a_3 \ldots a_n$ are layer coefficients representative each layer

$D_1, D_2, D_3 \ldots D_n$ are actual thickness in inches of each layer

The layer coefficient expresses the empirical relationship between SN and thickness and is a measure of the relative ability of the material to function as a structural component of the pavement. Average values of layer coefficients were determined from the AASHTO Road Test.

4.2.2 Rigid Pavements Calculation

The design procedure includes the determination of the PCC pavement thickness, spacing for JPCP, and steel reinforcement sizing.

It is essential that the user or the designer understand the limitations of rigid design, which are:

1. The design chart scales for working stress (psi) in concrete and modulus of subgrade reaction (k) are derived from the Spangler modifications of the Westergaard theory of stress distribution in rigid slabs.
2. There is no adjustment for environmental or regional factor.

3. Although the traffic repetitions used in the development of the design relationship were experienced over only a 2-year period, the traffic analysis period that must be selected for design is usually considerably longer than 2 years (typically 20 years). The traffic analysis period should not be confused with pavement life, which is affected by other factors in the addition to traffic.

GDOT designs all rigid pavements based on the 1981 revision to Chapter 3 of the 1972 AASHTO Interim Guide for Design of Pavement Structures. The table below lists rigid pavement design factors and the typical values used by GDOT.

Table 4.1: Typical GDOT Values used in Rigid Pavement design

Design Factor	Symbol	Value
18-kip ESAL	MU SU Other	2.68 0.50 0.004
Initial Serviceability	P0	4.5
Terminal Serviceability Index	Pt	2.5
Modulus of Rupture	S'_c = 0.75 * f_r	450 psi
Modulus of Elasticity of Concrete	E_c = 57,000$\sqrt{f_c}$	3,200,000psi
Poisson's Ratio of Concrete	v	0.15
Modulus of subgrade reaction	k	Provided in Appendix B

The following equation governs the design of rigid pavements according to the 1981 revision of the 1972 AASHTO Interim Guide for Design of Pavement Structures.

$$\log(ESALs) = 7.53 \times \log(D+1) - 0.06 + \frac{\log\left(\frac{4.5 - P_t}{4.5 - 1.5}\right)}{1 + \frac{1.62 \times 10^7}{(D+1)^{8.46}}} + (4.22 - 0.32 \times P_t) \times \log[(\frac{f_r}{690}) \times \frac{D^{0.75} - 1.132}{D^{0.75} - \frac{18.42}{\left(\frac{E_c}{k_{eff}}\right)^{0.25}}}]$$

Where

ESAL is the total lifetime rigid ESALs anticipated to be applied on the pavement

D is the concrete slab thickness

P_t is the pavement Terminal Serviceability Index

f_r is the working stress of concrete = 0.75 * S'_c = 0.75 * 600 = 450 psi. A higher value can be used if properly documented in accordance with the Standard Specification for Construction of Transportation Systems, Section 430 or 439 and approved by the Concrete Branch at OMAT

E_c is the Modulus of Elasticity of concrete which is derived from the ACI Code = 3,200,000psi for 3000 psi concrete. A higher value can be used if properly documented in accordance with the Standard Specification for Construction of Transportation Systems, Section 430 or 439 and approved by the Concrete Branch at OMAT

k_{eff} is the effective modulus of reaction of subgrade and all underlying structural layers

4.3 GDOT Pavement Design Program 2.0 Step by Step

GDOT Pavement Design Program 2.0 is the current design procedure.

4.3.1 To Begin

The basic information needed to begin a pavement design is the PI number, the county, and a short project description.

4.3.2 Full Depth Flexible Design

Begin a Full Depth Flexible Pavement Design.

4.3.2.1 Traffic and Miscellaneous Data

The first step is to create a descriptive design name. The program asks for the initial year, initial year one-way AADT, the design year, and design year one-way AADT. It solves for the average traffic and determines the difference in years, as a whole number. The next input is the 24-hour truck percentages and a breakdown of the SU/MU percentages. If SU/MU is not available, use the representative 18-kip ESAL factor shown in Table 2.2. The program will ask if barrier walls, or curb and gutter are present and the number of lanes in one direction. The last section is the design remarks where any discrepancies in the design can be discussed (i.e. no SU/MU breakdown, station ranges, additional roads that will use the same design, etc.)

4.3.2.2 Design Data

If the correct county was input into the beginning screen, the SSV and RF should automatically populate. The SSV can be changed if the value given in the SS differs from the default value. The terminal serviceability index should remain 2.5 unless the pavement will not be retained as part of the final pavement structure. The User Defined 18-kip ESAL box should stay empty unless the breakdown of SU and MU were not provided. The Lane Distribution Factor should be input and can be found in Table 2.3.

4.3.2.3 Pavement Design Calculation Methods

This screen does not require inputs. It gives the Total Lifetime Flexible ESALs.

4.3.2.4 Proposed Full Depth Flexible Pavement Structure

This screen will have pull down menus for the various courses. The material for each layer was discussed in Chapter 3 Pavement Layer and thicknesses for each layer can be found in the Criteria for Use of Asphaltic Concrete Layer and Mix Types.

If you are designing mainline pavement for an interstate, or when a drainage course is required, an OGFC layer will be the top course. However, the OGFC will be laid at 100 lbs/sy and not the 90 lbs/sy the program supplies. This should be noted on the design.

The first line should be the surface course. The second line should be the binder course. The third line will be the asphalt base (if needed). The last line will be the base course. After all appropriate courses and thickness have been added, the “calculate” button should be pressed. This will prompt the program to determine the proposed SN and compare it to the required SN to give an underdesigned value. If the underdesigned value does not meet the Revised Flexible Pavement Underdesign Policy Based on State Route Prioritization, then the “Edit Input Values” button can be pressed to alter the courses and thickness as needed. Once the underdesign value has been met, the design can be saved.

Note: To design a full depth pavement section w/ AC base, the programs can be utilized in two alternatives. One is to have the AC base be its own course or the second option would be to combine the AC base w/ the 25mm asphalt base layer in one course. Examples are shown in Figures 4.1 and 4.2 below.

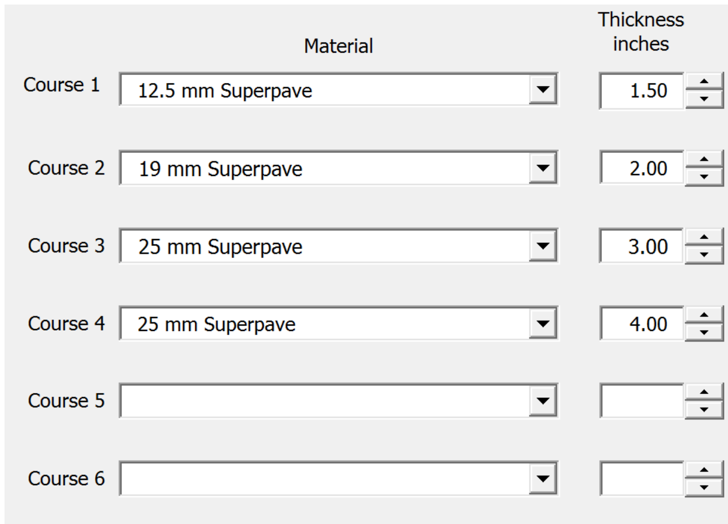

Figure 4-1: First alternative to design asphalt base

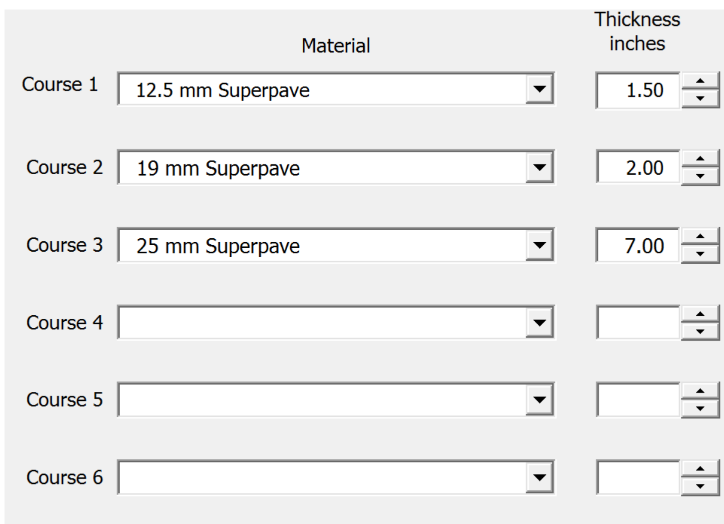

Figure 4-2: Second alternative to design asphalt base

4.3.3 Full Depth Rigid Design

Begin a Full Depth Rigid Design.

4.3.3.1 Section Information

The first step is to create a descriptive design name. The location section can be a brief description or the stations to which the design will correspond. The beginning station, ending station, and station length should be entered in feet. The number of lanes in one direction, if the project is an interstate, and if curb and gutter/ or barrier wall will be present should be answered. The last section is the design remarks where any discrepancies in the design can be discussed (i.e. no SU/MU breakdown, etc.).

4.3.3.2 Design Data Page 1

The program asks for the initial year and initial year one-way AADT, and the design year and design year one-way AADT. The next input is the 24-hour truck percentages, SU, and MU percentages. The Concrete Factors and ESAL Factors sections are defaults and should not be changed.

4.3.3.3 Design Data Page 2

If the correct county was input into the beginning screen, the soil support value and subgrade modulus should automatically populate. The SSV can be changed if the value given in the SS differs from the default value. The terminal serviceability index should remain 2.5. The Lane Distribution Factor should be input and can be found in Table 2.3. Using user values in the User k-Values box is not recommended.

4.3.3.4 Initial Calculation Results

This screen does not require inputs. It gives the Total Lifetime Rigid ESALs, the Calculated Concrete Thickness, and the Modulus of Subgrade/Subbase Reaction.

4.3.3.5 Proposed Rigid Pavement Structure

The program will give a design based on the inputs; however, it will leave the PCC Course blank. After choosing the PCC course (JPCP or CRCP), the "Calculate" button should be pressed. The program will output the structure results. The PCC course thickness should be based on the balanced thickness. The balanced thickness should be rounded up to the nearest half inch (Example: balanced thickness = 9.35 use 9.5; balanced thickness = 10.65 use 11). The GAB thickness should be 8 inches. The Interlayer course can be 0 or 3 inches. Once the balanced thickness has been met, the design can be saved.

4.3.4 Overlay Flexible Pavement Design

Begin an Overlay Flexible Pavement Design.

4.3.4.1 Traffic and Miscellaneous Data

The first step is to create a descriptive design name. The program asks for the initial year, initial year one-way AADT, the design year, and design year one-way AADT. It solves for the average traffic and determines the difference in years, as a whole number. The next input is the 24-hour truck percentages and a breakdown of the SU/MU percentages. If this is not available, use the representative 18-kip ESAL factor shown in Table 2.2. The program will ask if barrier walls, or curb and gutter are present on the project, and the number of lanes in 1 direction. There is also an input for the milling depth. The last section is the design remarks where any discrepancies in the design can be discussed (i.e. no SU/MU breakdown, station ranges, additional roads that will use the same design, etc.).

4.3.4.2 Design Data

If the correct county was input on the beginning screen, the soil support value and regional factor should automatically populate. The SSV can be changed if the value given in the SS differs from the default value. The terminal serviceability index should remain 2.5 unless the pavement is a temporary pavement. The User Defined 18-kip ESAL box should stay empty, unless the breakdown of SU and MU were not provided. The Lane Distribution Factor should be input and can be found in Table 2.3.

4.3.4.3 Pavement Design Calculation Methods

This screen does not require inputs. It gives the Total Lifetime Flexible ESALs.

4.3.4.4 Proposed Overlay Flexible Pavement Structure

This screen will have pull down menus for the various courses. New pavement that is being added to the roadway will be entered into the Overlay sections. All pavement sections already on the roadway will be entered in the "Existing" section.

When inputting the existing asphaltic concrete, the milling depth should be taken into consideration as the program does not reduce the existing based on milling depth input. Further information on designing an overlay/inlay pavement design can be found in the Pavement Evaluation Summary Manual.

4.4 Special Pavements and Considerations

4.4.1 Minor Projects

Projects with AADT less than 10,000 and AADTT less than 1,000 can use the Guidelines for Minor Pavement Projects. The Guidelines for Minor Projects Tool is a program in which the project information can be input and give the corresponding minor project design. Minor Projects are not required to have an approved Pavement Design Package, if following the Minor Project Guidelines.

4.4.2 Roundabouts

Roundabouts have a preferred pavement structure of JPCP. This is due to the slow turning movements as vehicles enter and proceed through the roundabout. If the roundabout will be a flexible pavement, the surface course should be 12.5 mm Superpave Polymer Modified. When constructing a roundabout, the roundabout pavement structure should extend to the beginning of the splitter island on each approach. Roundabout designs should use the specified highest circulating traffic. This should be determined using the GDOT Roundabout Traffic Tool.

4.4.3 Interstate Ramps

Interstate ramp designs are generally PCC with 3 inches of interlayer on 8 inches of GAB.

4.4.4 Temporary Pavements

When temporary pavement is retained as part of a permanent pavement, the underdesign target shall match that of permanent pavement design. The underdesign target for temporary pavement that will later be removed is 15% based on the Revised Flexible Underdesign Policy Based on State Route Prioritization.

Terminal Serviceability Index is lowered to 2.0 for temporary pavement that will later be removed.

The temporary pavement design period is the number of years the pavement will be used for construction staging or detour. The initial year should be the same year that the project is let. The final year is the initial year plus the proposed construction duration, which should correlate to the initial design year. Traffic for the final year will be the same as the initial design year. Traffic for the initial let year can be calculated using the final year traffic or existing traffic and a calculated growth rate.

The minimum temporary pavement structure is given below based on the time the temporary pavement will be driven on and truck percentage. Final temporary pavement design will need approval from the SPE.

AADTT is the Annual Average Daily Truck Traffic, which is calculated by multiplying the AADT by the 24-hr truck percentage.

- ≤1 year with an AADTT < 1000
    - 0 inch – Surface Course
    - 4 inches – 19 mm Superpave
    - 0 inch – 25 mm Superpave
    - 6 inches – GAB
- ≤1 year with an AADTT ≥ 1000
    - 1.50 inch – 12.5 mm Superpave
    - 2 inches – 19 mm Superpave
    - 0 inch – 25 mm Superpave
    - 6 inches – GAB
- >1 year and an AADTT < 1000
    - 1.25 inch – 9.5 mm Superpave
    - 2 inches – 19 mm Superpave
    - 0 inch – 25 mm Superpave
    - 6 inches – GAB
- >1 year and an AADTT ≥ 1000
    - 1.5 inches – 12.5 mm Superpave
    - 2 inches – 19 mm Superpave
    - 0 inch – 25 mm Superpave
    - 6 inches - GAB

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Chapter 5. Pavement Design Package - Contents

Chapter 5. Pavement Design Package

5.1 Introduction

Pavement designs are required for all non-maintenance projects unless otherwise specified in PDP 10.2.6. All full-depth designs and temporary pavements must be submitted in a Pavement Design Package, except where noted below. Information on projects that require a Pavement Design Package can be found in the Pavement Design Process Section 6.4.2.

5.2 Procedure

5.2.1 Submission Process

The Pavement Design Submission and Approval Process outlines the submission process. The process is completely digital with the use of Bluebeam PDFs and ProjectWise. The file should be flattened to remove any previous markups and/or comments. All changes to the report must be done before the signatures and signature boxes are applied to avoid errors with the signatures.

5.2.2 Submittal Checklist

The Pavement Design Submittal Checklist lists all the information needed in a Pavement Design Package. The order of the package should be the same as the order on the checklist.

5.3 Special Pavement Packages and Considerations

5.3.1 Minor Projects

Minor projects do not require a pavement design package if the Guidelines for Minor Pavement Projects are followed. A Pavement Design Package may be submitted if a thinner design is preferred. Do not submit design packages that use the same designs provided in the guidelines.

5.3.2 Bridge Replacements

The traffic assignment or forecast sheet for Bridge Replacements usually list 2-way traffic.

5.3.3 Roundabouts

Roundabout designs should use the highest circulating traffic. This should be determined using the GDOT Roundabout Traffic Tool.

5.3.4 Base year Traffic infractions/Letting date moving

In the event the project is shelved or the let date falls behind schedule and the base year traffic becomes out-of-date, the designs with the +2 years traffic can be used in lieu of the base year traffic designs. If both the base year traffic and the +2 traffic becomes out-of-date, the traffic must be updated and new designs should be submitted for approval.

5.3.5 Operational Improvements

Transportation Enhancement (TE) and Livable Centers Initiative (LCI) enhancement projects do not require approval for pavement designs per the Pavement Exemptions for Transportation Enhancement (TE) and Livable Centers Initiative (LCI) Programs policy.

5.3.5.1 Shoulders

Paved shoulder width (inside or outside) of 4 feet or less should be the same pavement design as the travel lanes and maintain the same cross slope as that of the adjacent lane. Paved shoulder designs do not have to be approved by the State Pavement Engineer (SPE), unless the shoulder is being used for construction staging traffic or is being built into a future travel lane.

5.3.5.2 Turn lanes

Turn lanes should be designed to be consistent with the travel lanes in both thickness and materials. Turn lane designs should use minor project guidelines or the designs should be submitted for approval.

5.3.5.3 Passing Lanes

Passing lanes should be designed to be consistent with the travel lanes in both thickness and materials. Passing lane designs should use minor project guidelines or the designs should be submitted for approval.

5.3.5.4 Intersection Improvements

Intersection improvements do not require the approval of the SPE if the designs follow the Minor Project Guidelines.

5.3.6 Temporary Pavements

Temporary pavement will be removed after construction and will not become any part of the permanent pavement structure. Minor projects have a Temporary Pavement For Minor Projects Guideline. All other temporary pavements should be submitted with the pavement design package for approval.

5.3.7 Exemptions

LCI Enhancement and TE projects are exempt from submitting a Pavement Design Package.

Appendix A. Typical Value of Layer Coefficients

Table A-1: Typical Values of Layer Coefficients	
Material	**Structural Coefficients**
Asphaltic Concrete (top 4 ½”)	0.44
Asphaltic concrete (>4 ½" from surface)	0.40
Graded Aggregate and Crushed Limestone (Compacted to Modified Density)	0.16
Soil Cement	0.20

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Appendix B. Typical Values for SSV, RF, and k-values

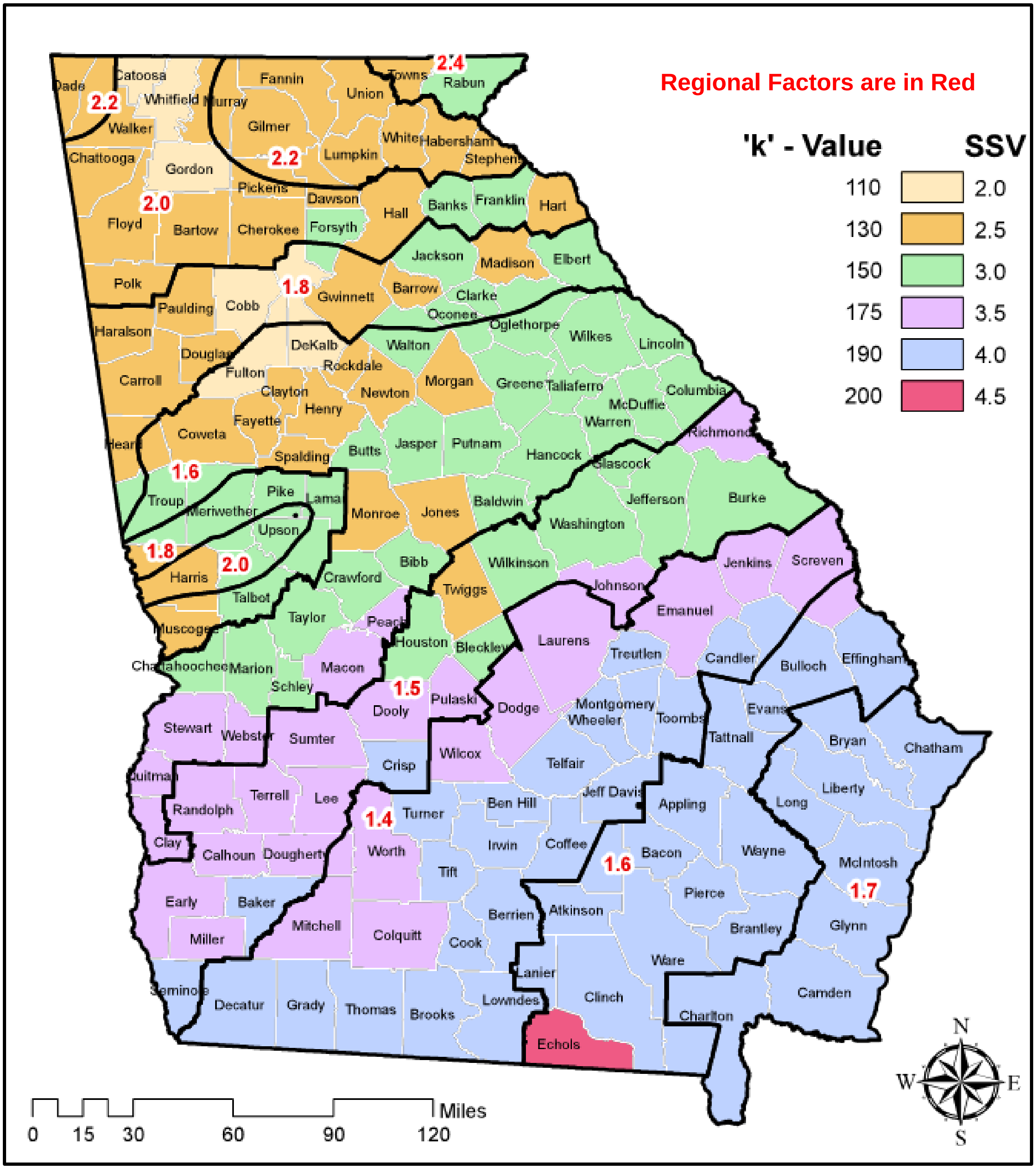

Figure B-1: Georgia Map Showing Typical Values for Soil Support Values (SSV), Regional Factor (RF), and k-values

Table B-1: k_{eff} values for PCC Pavement				
Values for k_{eff} over GAB				
k_{sub}(pci)	GAB Thickness (inches)			
	8	10	12	14
110	150	170	190	215
130	190	205	225	245
150	200	215	245	270
175	215	240	265	295
190	235	260	290	315
200	250	275	300	320
k_{sub} is the k-value on top of subgrade				

Table B-2: k_{eff} values for PCC Pavement				
Values for k_{eff} over GAB with 3-inch interlayer				
k_{sub}(pci)	GAB Thickness (inches)			
	8	10	12	14
110	220	240	260	295
130	260	285	300	315
150	280	295	325	355
175	295	325	355	390
190	315	355	385	415
200	330	375	400	420
k_{sub} is the k-value on top of subgrade				