

ASPHALT PAVEMENT DESIGN GUIDE

for Low-Volume Roads and Parking Lots



Asphalt.

SOUTH CAROLINA RIDES ON US

ASPHALT PAVEMENT DESIGN GUIDE

for Low-Volume Roads and Parking Lots

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The South Carolina Asphalt Pavement Association (SCAPA) is a non-profit trade association dedicated to the promotion of asphalt pavement. Its membership is comprised of asphalt producers and companies affiliated with the asphalt pavement industry in South Carolina.



“Together We Know More”

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SECTION 1

NEW PAVEMENT DESIGN & CONSTRUCTION



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INTRODUCTION

This guide has been developed by the South Carolina Asphalt Pavement Association (SCAPA) to assist engineers, architects, cities, towns, and counties in understanding the basic properties of asphalt concrete and the design of quality asphalt pavements for parking lots and low-volume roads. It is not intended that this guide be a substitution for pavement designs by experienced design engineers when actual project specific data are known for the traffic volume and subgrade soil characteristics for a particular project. Instead, this guide is intended to provide basic guidelines when such specific information is not available. In this regard, this guide uses generalizations and simplifications which result in traffic volume and subgrade soil categories and uses average values. For this reason, local conditions or special design considerations cannot be fully addressed in a publication of this type. When design considerations arise that are not covered by this guide, you are encouraged to contact a local SCAPA Contractor Member or the SCAPA office for further assistance.

The content of this guide was based on information provided by similar design guides and other technical resources including:

- The Asphalt Institute's *Asphalt Pavements for Highways and Streets, 9th Edition*
- The National Asphalt Pavement Association's *HMA Pavement Mix Type Selection Guide*
- The South Carolina Department of Transportation's (SCDOT) *Pavement Design Guidelines*
- The American Association of State Highway and Transportation Officials (AASHTO) *Guide for Design of Pavement Structures*

What is Asphalt?

Asphalt may be referred to by several names including hot mix asphalt (HMA), warm mix asphalt (WMA), plant mix asphalt, asphalt concrete, bituminous concrete, blacktop, or Superpave. Asphalt is comprised of aggregate bound together into a solid mass by asphalt binder (also called asphalt cement or liquid asphalt). Approximately 93-96% of the mixture by weight consists of aggregates and the balance (approximately 4-7%) is asphalt binder. Asphalt is manufactured in a central mixing plant where the binder and aggregates are heated, properly proportioned, and mixed.

where the binder and aggregates are properly proportioned, heated, and mixed. The mixture is hauled by trucks to a jobsite where it is deposited into a paver that places it in a smooth layer at a controlled thickness. The fresh asphalt mat is then compacted by rollers while it is still hot. After rolling, the pavement is allowed to cool before opening to traffic.

Asphalt pavements are constructed of one or more courses (or layers) of asphalt placed directly on the subgrade or on an aggregate base.

Benefits of Asphalt

- **Versatility**. Hot mix asphalt pavements can be designed to handle virtually any traffic loading, soils and materials, and can be used to salvage old pavements as well as to build new ones. Phased construction can easily be incorporated.
- **Durability**. Asphalt pavements are long-lasting and because of their flexible nature, they can withstand overloads without serious damage. Quality control is also easy to maintain.
- **Economy**. Asphalt pavements are economical to construct; may be constructed rapidly and are immediately ready for use; require minimal maintenance; and provide outstanding performance.
- **Safety**. Asphalt pavements offer high skid resistance, provide contrast with pavement markings, and have reduced glare.
- **Sustainability**. Asphalt pavements are 100% recyclable and can be composed of recycled materials including reclaimed asphalt pavement (RAP), recycled asphalt shingles (RAS), and ground tire rubber (GTR), among others. Additionally, warm mix asphalt (WMA) can be used to reduce production and construction temperatures and reduce energy consumption.
- **Smoothness**. Asphalt pavements are smooth and uniform and can improve fuel efficiency.

For more facts about asphalt pavements, visit www.scasphalt.org.

DESIGN CONSIDERATIONS

When designing asphalt pavements, there are three main elements that must be considered: **Traffic**, **Subgrade**, and **Drainage**. Each of these design considerations are discussed in more detail in this section. The traffic and subgrade information will be necessary for the pavement thickness design covered in Section 4 of this guide.

Traffic

Pavements are designed to carry many different types of vehicles in the traffic stream including automobiles, light trucks, buses, freight trucks, construction equipment, and sanitation trucks among other vehicle types and loads. Although the main component of most traffic streams is passenger vehicles, the primary consideration in pavement design is heavy trucks. This is because heavy trucks impart far more stress on pavements compared to automobiles and thus are the primary contributors to pavement damage. Based on the axle load factors provided in the *AASHTO Guide for Design of Pavement Structures*, a loaded 5 axle tractor trailer imparts more than 1600 times more damage than a typical passenger car and more than 200 times greater than a large sport utility vehicle (SUV).

For the purposes of this guide, traffic will be categorized into four different classes as detailed in Table 1.1 along with further descriptions on the following pages. For traffic scenarios greater than Class 4, it is recommended to use the *SCDOT Pavement Design Guidelines*. If you have questions about the traffic classification for a particular application, please contact your local SCAPA Contractor Member or the SCAPA of-

a particular application, contact your local SCAPA Member or the SCAPA office.

When designing the layout of a pavement for a particular facility, it is important to keep in mind that there may be multiple traffic classes for different pavement sections within a project. For example, the industrial facility in the photo below consists of a large area of pavement. Because of this large area and multiple uses of the pavement, it is practical to divide the entire facility into different traffic classes based on the type and number of vehicles that will be using a particular pavement section. In this case there is an employee lot that will primarily see passenger car traffic (Traffic Class 1 or 2). There are loading dock areas where trucks will load and unload (Traffic Class 3). There is a network of roads that loaded trucks will travel throughout the facility (Traffic Class 4). By dividing the pavement in this manner, a more practical and economical design will result for the entire pavement network.



Asphalt pavement used at an industrial facility.

Table 1.1. Traffic classes (single-direction traffic).

Class 1 (≤ 50 cars/day)	Class 2 (≤ 5 trucks/day)	Class 3 (≤ 65 trucks/day)	Class 4 (≤ 200 trucks/day)
▪ Driveways ▪ Play areas ▪ Parking lots (≤ 50 stalls) ▪ Seasonal recreation roads	▪ Residential streets ▪ Parking lots (> 50 stalls)	▪ Collector streets ▪ Industrial lots and truck stalls ▪ Bus driveways and loading zones	▪ Major arterial streets ▪ Local business streets ▪ Local industrial streets ▪ Major service drives or entrances

Traffic Class 1

Traffic Class 1 is the lightest duty pavement application covered in this guide and will not have regular truck traffic. These light duty applications include recreation facilities (school play areas, tennis courts, running paths, etc.), residential driveways, small parking lots, and some roadways that may see seasonal passenger car traffic during a portion of the year.



Asphalt pavement used for a school play area.



Asphalt parking lot serving a small plaza.

Traffic Class 2

Traffic Class 2 will see some, but not much regular truck traffic (approximately not more than five trucks per day on average). This would include larger parking lots and residential streets (subdivisions, apartment complexes, etc.) serving mostly passenger cars and light trucks. Truck traffic in these cases would include local delivery trucks sanitation trucks, and school buses.



Asphalt pavement used for an apartment complex.



Asphalt pavement in a residential neighborhood.



Asphalt pavement at a large shopping plaza.

Traffic Class 3

Traffic Class 3 considers a higher volume of trucks in the traffic stream (up to approximately 65 trucks per day) as seen on local collector streets. Included in the “truck” volume would also be transit buses. In addition to local streets, pavements designed for this traffic class would also include industrial parking lots and truck stalls, as well as bus driveways and loading/unloading zones.



Asphalt pavement used for a local collector street.



Asphalt pavement used at a transit bus stop.

Traffic Class 4

Traffic Class 4 is the heaviest duty traffic class considered in this guide and would accommodate up to approximately 200 trucks per day in the traffic stream. Applications meeting this description would include major arterial streets that see relatively high traffic volumes as well as local streets, service drives, and entrances serving commercial and/or industrial facilities that will experience high truck volumes throughout the design life.



Asphalt pavement used at an industrial facility.



Asphalt pavement for a major arterial road.

Subgrade

The success of any structure, including a pavement structure, is highly dependent on the quality of the foundation upon which it is built. In the case of a pavement structure, the foundation refers to the soil (or subgrade) that the pavement is constructed upon. A higher quality (or stronger) subgrade can withstand greater stresses, which means that the thickness of the pavement structure can be reduced compared to that needed for a weaker subgrade. For this reason, ***it is important that the subgrade soil be thoroughly examined and understood before developing a pavement design.***

To simplify the design process, three main subgrade soil categories have been created for the designs outlined in this guide based on the quality of the soil being used as the pavement subgrade material. As summarized in Table 1.2, the three soil categories are **Poor**, **Medium**, and **Good** and are based on the soil classification,

Good and are based on the soil classification, plasticity, and relative strength. At a minimum, the soil should be evaluated by a geotechnical engineer to determine the following information:

- Particle size distribution (ASTM D422 & D1140 or AASHTO T11 & T27)
- Liquid limit (*LL*) and plasticity index (*PI*) (ASTM D4318 or AASHTO T89 & T90)
- Soil classification (ASTM D2487 or AASHTO M145)
- California bearing ratio (*CBR*) (ASTM D1883 or AASHTO T193)

After determining this information, the appropriate subgrade category can be selected from Table 1.2 to move forward with the design. As noted in Table 1.2, the Group Index (*GI*) can be calculated using the equation below and used to categorize soils based on their suitability as a pavement subgrade material.

$$GI = (F_{200} - 35)[0.2 + 0.005(LL - 40)] + 0.01(F_{200} - 15)(PI - 10)$$

where,

- F*₂₀₀ = Percent of subgrade soil passing the No. 200 sieve
LL = Liquid limit of subgrade soil
PI = Plasticity index of subgrade soil

For soils classified as A-2-6 and A-2-7, the following equation should be used:

$$GI = 0.01(F_{200} - 15)(PI - 10)$$

Table 1.2. Subgrade categories.

	Poor	Medium	Good
Description	✓ Becomes soft and plastic when wet. ✓ Clays and fine silts ▪ ≥50% passing No. 200 ✓ Coarse silts and sandy loams ▪ Deep frost penetration ▪ High water table	✓ Retains a moderate degree of firmness under adverse moisture conditions. ✓ Loams, silty sands, and sandy-gravels containing moderate amounts of fine silts.	✓ Retains a substantial amount of load-supporting capacity when wet. ✓ Clean sands, sand-gravels, and those free of detrimental amounts of plastic fines. ▪ ≤10% passing No. 200 ✓ Relatively unaffected by moisture or frost.
Typical Properties	CBR < 6 LL > 40 PI > 10 GI > 4	CBR: 6–9 LL: 25–40 PI: 6–10 GI: 2–4	CBR ≥ 10 LL < 25 PI < 6 GI < 2

Drainage

Some have said that there are three main keys for a successful pavement: **Drainage, drainage, and drainage.** Needless to say, providing proper drainage is essential for a long-lasting asphalt pavement. Without adequate drainage to divert water away from the pavement structure, the chances of subgrade failure increase due to the fact that many soils become weaker as the moisture content increases. How strong or stable is mud anyway? In addition to reducing the strength of the soil, moisture can also cause expansive soils to increase in volume which could result in heaving of the pavement structure above. There are two categories of drainage for pavements: **Surface drainage** and **subsurface drainage.**

Surface Drainage

Surface drainage refers to the removal of any water present on the surface of the pavement, shoulder, and adjacent ground. For good surface drainage, the pavement and shoulders must be properly crowned or sloped to ensure the rapid flow of water off the roadway to curbs and gutters or to adjacent drainage ditches or swales. It is recommended to use a crown with a cross-slope of at least 2% for roads and longer drive-ways with two or more lanes. For parking lots and other large paved areas, a minimum cross-slope of 1.5% is recommended to help ensure adequate drainage of surface water and avoid standing water.

Cross-slopes less than 1% are not practical because there are many factors that make it difficult to construct pavements with such low slopes without forming flat spots or depressions that could result in areas where water may puddle ("bird baths") and not be removed from the pavement surface. If bird baths are present on a pavement surface, then there is a possibility that the water will be able to seep into the pavement structure through cracks in the surface of the pavement depending on the condition.

When designing roadways and parking lots, ensuring proper crown or cross-slope is typically accounted for in the design. However, there is a tendency among designers to overlook the need for grade information at key points in intersections, cross-overs and transitions between grade lines.



"Bird bath" due to inadequate pavement slope.

tions, cross-overs, and transitions between grade lines.

With adequate flow of water across the pavement surface, it is important to ensure that water does not accumulate at the pavement edge. Depending on the situation, runoff should be collected with a curb and gutter and channeled off the pavement to a properly designed stormwater collection system. Curb and gutter cross sections should be built so that water flows within the designed flow line and not along the interface between the asphalt pavement and the curb face. This will minimize the chance of water seeping into the pavement structure or subgrade.

When a pavement is not surrounded by a curb, drainage ditches should be constructed adjacent to the pavement to collect and divert water away from the pavement. As seen in Figure 1.1, water flows from the pavement and shoulder surfaces down the pavement foreslope into a rounded ditch area. A backslope leads from the bottom of the ditch up to intercept runoff from the adjacent land. The adjacent land is frequently sloped toward the ditch and can contribute to a significant portion of the flow in the drainage ditch.

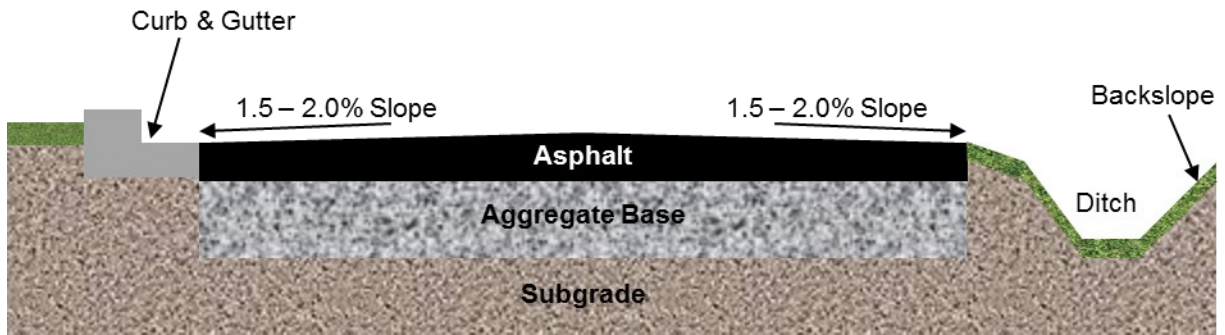


Figure 1.1. Schematic of surface drainage off of a pavement surface into a roadside drainage ditch or curb and gutter (not to scale).

Subsurface Drainage

Subsurface drainage refers to measures used to remove water contained in, or moving through the various layers of material that make up the pavement structure or the adjacent soil. As previously discussed, the accumulation of water in the pavement foundation can be problematic as a high moisture content can substantially reduce the load carrying capacity of the soil and base material and some soils can undergo volumetric changes as the moisture content fluctuates. Additionally, water accumulation within asphalt layers can cause stripping of the asphalt binder from the aggregate, which can deteriorate the pavement.

Water can enter the pavement structure in a number of ways. If the pavement surface becomes cracked, then water can penetrate the pavement surface and infiltrate into the pavement structure and subgrade. Water can also rise from the subgrade beneath the pavement structure due to changes in water table elevations and water draining into the subgrade from adjacent areas.

In situations when water accumulates within the pavement structure, it is necessary to include underdrains, interceptor drains, edge drains, and/or drainage layers with the purpose of diverting water from the pavement structure and preventing water accumulation. Figure 1.2 provides some general schematics of typical subsurface drainage solutions. It should be noted that these are only generic schematics and the technical expertise of an engineer is required to identify areas that need subsurface drainage and to ensure proper functioning of a long-lasting drainage system.



Installation of a pavement underdrain.

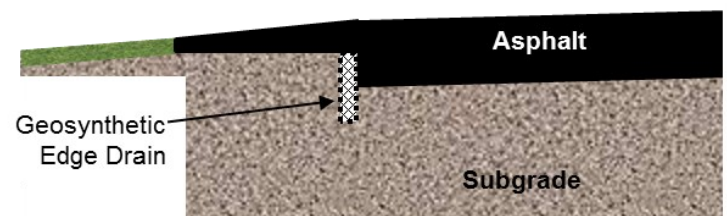
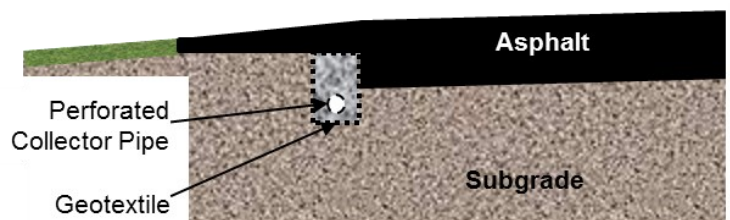
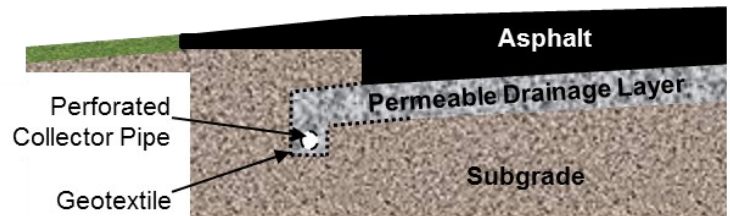


Figure 1.2. Schematics of typical subsurface drainage solutions (not to scale).

PAVEMENT MATERIALS

In this guide, the pavement structure is defined as all of the components of a pavement above the subgrade. For a given situation, there are multiple combinations of materials and pavement layers that will provide the required load carrying capacity based on the amount of traffic and the subgrade quality. However, there are two basic categories that this guide will cover with respect to material selection: Pavements designed as **full-depth asphalt** (i.e., all pavement layers above the subgrade are asphalt) and those designed with an **aggregate base course** (also referred to as a Macadam base course) directly above the subgrade followed by one or more layers of asphalt. Figure 1.3 provides a generic schematic of typical pavement sections for each category.

The decision of what type of asphalt pavement to design lies with the designer, but is typically based on the quality and cost of available materials as well as the quality of the subgrade. In cases where the subgrade is very poor, the use of an aggregate base course is recommended as it will provide a working platform that will

ed as it will provide a working platform that will help support the heavy equipment used for the subsequent asphalt paving operations. If an aggregate base course is not used in these situations, then there could be constructability issues and the quality and service life of the pavement could suffer.

Selection of the proper materials for each layer of a pavement structure is important because inferior materials will not possess the necessary strength and will lead to premature failure of the pavement. This guide recommends the use of specific materials based on specifications set forth by the South Carolina Department of Transportation (SCDOT) for roadway construction. These specifications are based on decades of research and experience in South Carolina and are used by most asphalt paving contractors. Additionally, the quality of the materials increases the closer they are located to the pavement surface because higher quality materials will be able to withstand the higher stresses in the upper portions of the pavement structure.

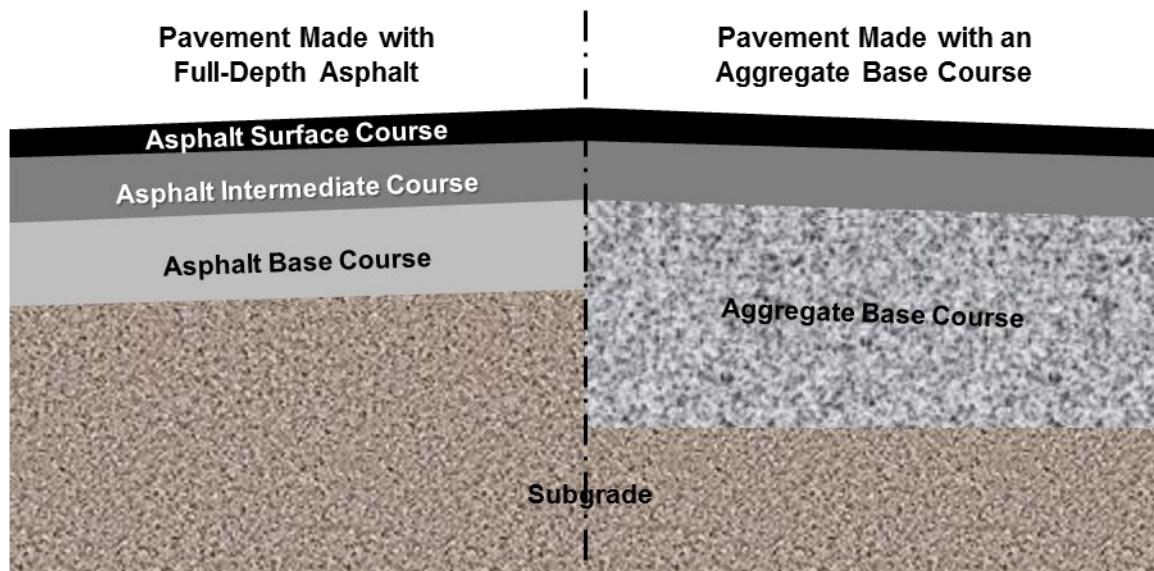


Figure 1.3. Typical cross-sections for full-depth asphalt pavements (on left) and asphalt pavements designed with an aggregate (or Macadam) base course (on right) (not to scale).

When using an aggregate base course in a pavement design, it is recommended to use a crushed aggregate material meeting the gradation requirements in Table 1.3. Most areas of South Carolina have access to crushed aggregate that meets the requirements of the graded aggregate base (GAB) course in Table 1.3. However, in the coastal plain area of the state, the availability of this type of material is limited, so the use of crushed marine limestone as a base course may be necessary as long as it meets the specifications in Table 1.3. In addition to aggregate gradation, it is also very important that the aggregate material be free of vegetative matter, sand, lumps or balls of clay, or other deleterious materials that may reduce the strength of the base course.

The lift thickness provided in Table 1.3 and the tables that follow in this section refers to the maximum recommended thickness that a single lift of material should be placed and compacted. In situations when the total design thickness exceeds the maximum recommended lift thickness for a single lift, the material should be placed in two or more lifts of equal thickness that are less than or equal to the maximum recommended thickness. This will help to ensure proper compaction of the material.

When full-depth asphalt is selected for a pavement design, an asphalt base course will be used instead of an aggregate base course. When this option is selected, the mix design for the asphalt base course should meet the specifications for an SCDOT Base Type B mix included in Table 1.4. An asphalt base course mix is also recommended to be used in asphalt sections greater than 7 in thick, even when an aggregate base course is used.

As indicated in Table 1.4 (and Tables 1.5 and 1.6), reclaimed asphalt pavement (RAP) can be incorporated into an asphalt mixture. RAP is asphalt mix that has been reclaimed from an older pavement, typically using a milling machine, and then crushed and screened at an asphalt plant. It is common practice to include RAP (a recycled material) in new asphalt mixtures. The tables list recommended ranges for RAP content for a particular mix. The RAP content of an asphalt mix will vary from producer to producer based on the specific asphalt plant setup, RAP material, mix design, and experience. You are encouraged to contact your local SCAPA Contractor Member to learn more about their specific practices related

Table 1.3. Aggregate base course specifications.

	Graded Aggregate Base	Marine Limestone Base
Gradation (% passing)		
2 in	100	100
1½ in	95 - 100	95 - 100
1 in	70 - 100	70 - 100
½ in	48 - 75	50 - 85
No. 4	30 - 60	30 - 60
No. 30	11 - 30	17 - 38
No. 200	0 - 12	0 - 20
Liquid Limit	≤ 25	≤ 25
Plasticity Index	≤ 6	≤ 6
Single Lift Thickness (Compacted not loose)	≤ 10 in	≤ 10 in

Table 1.4. Asphalt base course specifications.

SCDOT Base Type B	
Gradation (% passing)	
1½ in	100
1 in	85 - 100
½ in	60 - 80
No. 4	40 - 55
No. 8	30 - 45
Binder	
Grade	PG 64-22
Content	4.0 - 5.5%
RAP Content - Fractionated (% aged binder)	0 - 35%
Single Lift Thickness (Compacted not loose)	Minimum: 3 in Maximum: 4½ in

design, and experience. The RAP content in these tables refers to the percent of aged binder (from RAP) in the mixture. For example, if the RAP content is 25%, this means that 25% of the total binder content comes from the aged binder in the RAP. You are encouraged to contact your local SCAPA Contractor Member to learn more about their specific practices related to the use of RAP and other recycled materials and potential LEED credits related to asphalt pavements.

Depending on the overall thickness of the pavement section, one or two additional asphalt layers will be placed on top of the base course. For thicker sections, an intermediate course will be placed over the base course. When an intermediate asphalt course is used, it is recommended that a SCDOT Intermediate Type C mix design be used meeting the specifications included in Table 1.5.

Table 1.5. Asphalt intermediate course specifications.

SCDOT Intermediate Type C	
Gradation (% passing)	
1 in	100
¾ in	90 - 100
½ in	80 - 95
⅜ in	68 - 87
No. 4	45 - 68
No. 8	30 - 46
No. 30	12 - 29
No. 100	4 - 13
No. 200	2 - 8
	
Binder	
Grade	PG 64-22
Content	4.0 - 6.0%
RAP Content - Fractionated (% aged binder)	0 - 35%
Single Lift Thickness (Compacted not loose)	Minimum: 2 in Maximum: 3 in

The final layer of asphalt included in a pavement design will be an asphalt surface course. There are several functions of the surface course that set these mixtures apart from the intermediate and base mixtures. First off, the surface course will be the driving surface, therefore, it must be smooth. These mixtures are made

with a finer gradation than the intermediate or base mixtures, which reduces the surface texture of the finished pavement, thus creating a smoother ride. The smoother finish of the surface course also looks more appealing than coarser mixes, which is important for certain pavement applications (e.g., businesses, subdivisions, city streets, etc.). As these surface mixtures are directly exposed to the environment, it is important that they are durable and resist aging due to oxidation over time as well as provide a waterproof barrier to keep water from infiltrating the coarser and more permeable materials (intermediate asphalt, base asphalt, and/or aggregate base courses) comprising the pavement structure below. In addition to having a finer gradation, these mixtures also have higher asphalt binder contents compared to intermediate and base course mixtures which improves durability and water resistance. The surface mix types discussed in this guide include SCDOT Surface Course Types B, C, D, and E and the specifications are included in Table 1.6. The surface course most frequently recommended in this guide is the Surface Course Type C as it is the industry standard mix in South Carolina, however, the other mix types may be used for special applications. Surface Type E is mainly used for leveling and preventive maintenance that will be discussed later in this guide.

Table 1.6. Asphalt surface course specifications.

	SCDOT Surface Type B	SCDOT Surface Type C	SCDOT Surface Type D	SCDOT Surface Type E
Gradation (% passing)				
¾ in	100	100	100	—
½ in	97 - 100	97 - 100	97 - 100	—
⅜ in	76 - 100	83 - 100	90 - 100	100
No. 4	52 - 75	58 - 80	70 - 95	90 - 100
No. 8	36 - 56	42 - 62	50 - 82	70 - 100
No. 30	16 - 36	20 - 40	20 - 50	36 - 70
No. 100	5 - 18	5 - 20	6 - 20	4 - 28
No. 200	2 - 8	2 - 9	2 - 10	2 - 10
Binder				
Grade	PG 64-22	PG 64-22	PG 64-22	PG 64-22
Content	4.8 - 6.0%	5.0 - 6.8%	5.0 - 6.8%	6.0 - 7.0%
RAP Content - Fractionate (% aged binder)	0 - 25%	0 - 30%	0 - 30%	0 - 30%*
Single Lift Thickness (Compacted not loose)	Minimum: 2 in Maximum: 2½ in	Minimum: 1½ in Maximum: 2½ in	Minimum: 1 in Maximum: 1½ in	Minimum: ½ in Maximum: 1 in
Recommended for Traffic Class	4	1, 2, 3, & 4	1 & 2	1, 2, & Preventive Maintenance

*Fractionate Fine RAP only

The selection of the appropriate surface course mixture should be based on two main criteria: **Traffic volume** and desired **smoothness**. Figure 1.4 can be used to aid in the selection of the appropriate surface mix type for a particular pavement design. As shown in Figure 1.4, Surface Type B is the strongest mix and is only recommended for heavy traffic applications such as pavements designed for Traffic Class 4 in accordance with this guide, or areas that will experience frequent heavy truck traffic such as loading docks. Surface Type B is also the coarsest mix and will have the roughest texture of the mix types as indicated in Figure 1.4 and shown in Figure 1.5.

As previously discussed, a Surface Type C mix is recommended for most other traffic scenarios, but Surface Types D and E mixes can be used for certain light duty pavements where a thinner asphalt lift is required or a smoother texture is desired such as play areas, tennis courts, running tracks, etc.

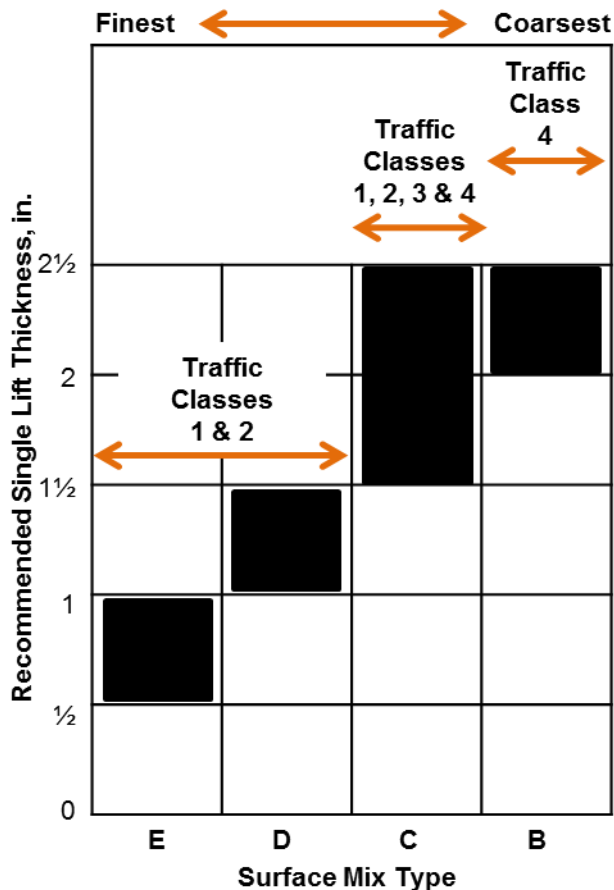


Figure 1.4. Asphalt surface course type selection chart.

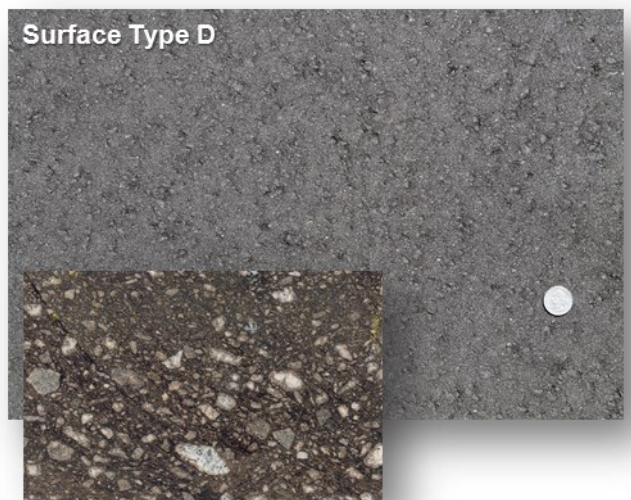
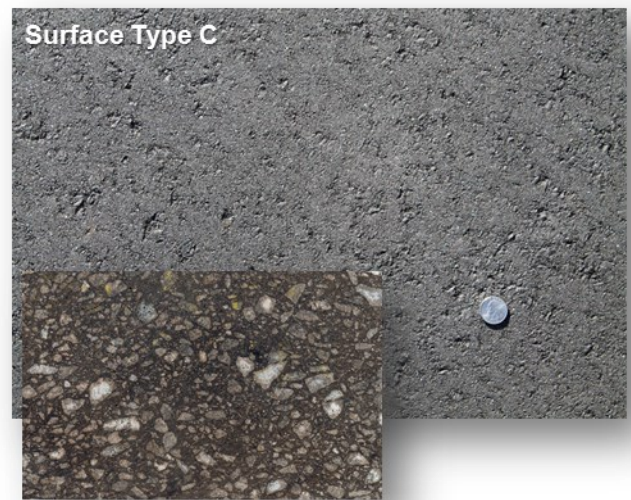
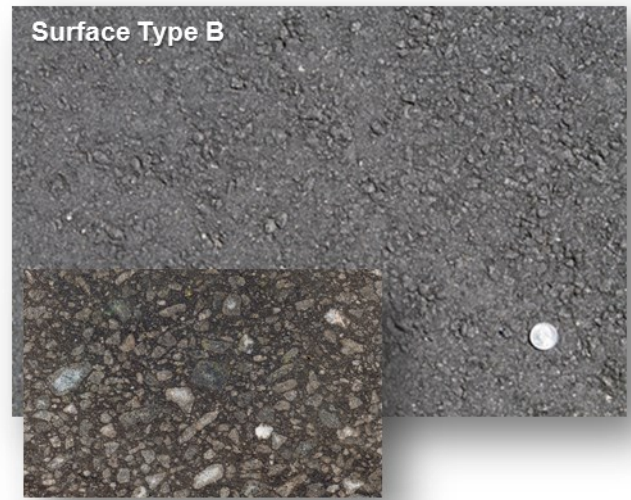


Figure 1.5. Surface texture comparison for surface course types B, C, and D. The inlay photos show a cross-sectional view of each mix type. A US quarter is used as a scale reference.

THICKNESS DESIGN

The thickness of a pavement structure is dependent upon the **Traffic Class** and the **Subgrade Category** discussed earlier in this guide. Having this information, the designer can refer to Figures 1.7 through 1.9 for the asphalt and aggregate base course thicknesses when the pavement is constructed on **Poor**, **Medium**, and **Good** subgrades, respectively. The pavement designs included in this section are recommended minimum pavement designs for given traffic and subgrade conditions. Thickness values less than those recommended should be evaluated by an experienced engineer. It should also be noted that the pavement designs in this section are for new construction and do not cover overlay design.

Thickness Equivalency

Thickness Equivalency

This guide includes asphalt pavement designs for both full-depth asphalt pavements and asphalt pavements that include an aggregate base course. As shown in the thickness design figures (Figures 1.7 through 1.9), the total thickness of a pavement structure made with an aggregate base is thicker than its full-depth asphalt counterpart. This difference can be explained by the concept of thickness equivalency, which considers the relative load carrying capability of different materials. For example, a 4 in thick layer of compacted asphalt is much stronger than a 4 in thick layer of unbound graded aggregate base course and it can, therefore, withstand a greater number of load repetitions before failure occurs (see Figure 1.6). For this reason, 1 in of asphalt cannot be replaced with just 1 in of aggregate base.

The thickness design options in this guide were based on the thickness equivalencies established by the SCDOT, which are based on decades of research and experience with the asphalt and aggregate base materials in South Carolina. These equivalency coefficients indicate that a 1 in thick layer of asphalt is equivalent to approximately 2½ in of graded aggregate base material.

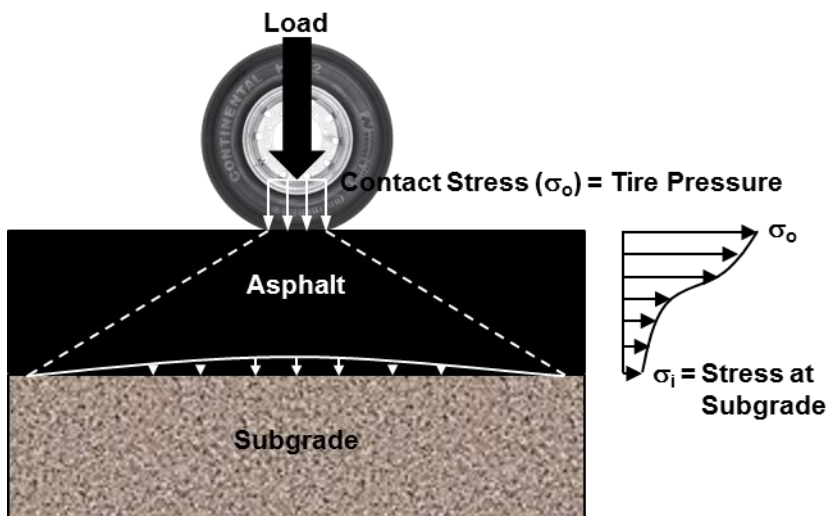
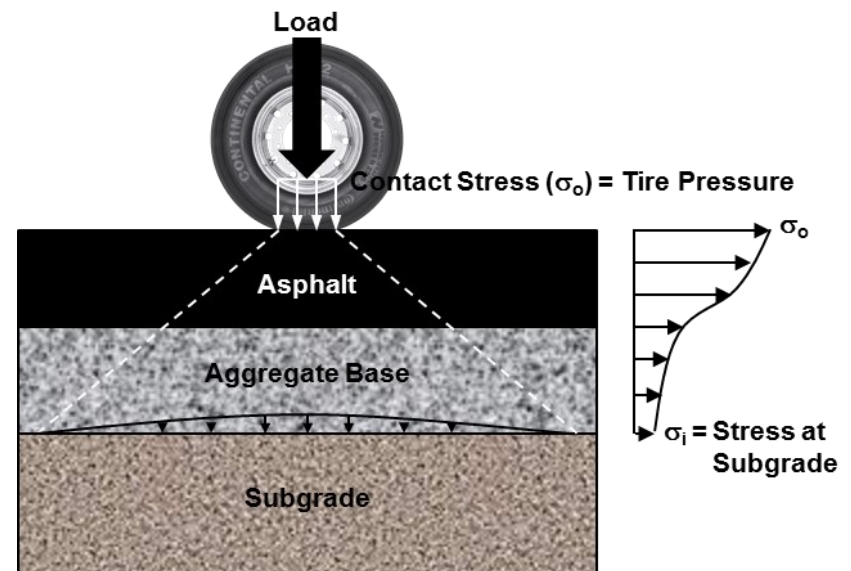


Figure 1.6.4.1. Spread of a wheel load through a full-depth asphalt pavement structure (above) and an asphalt pavement with an aggregate base course (at right).



Poor Subgrade

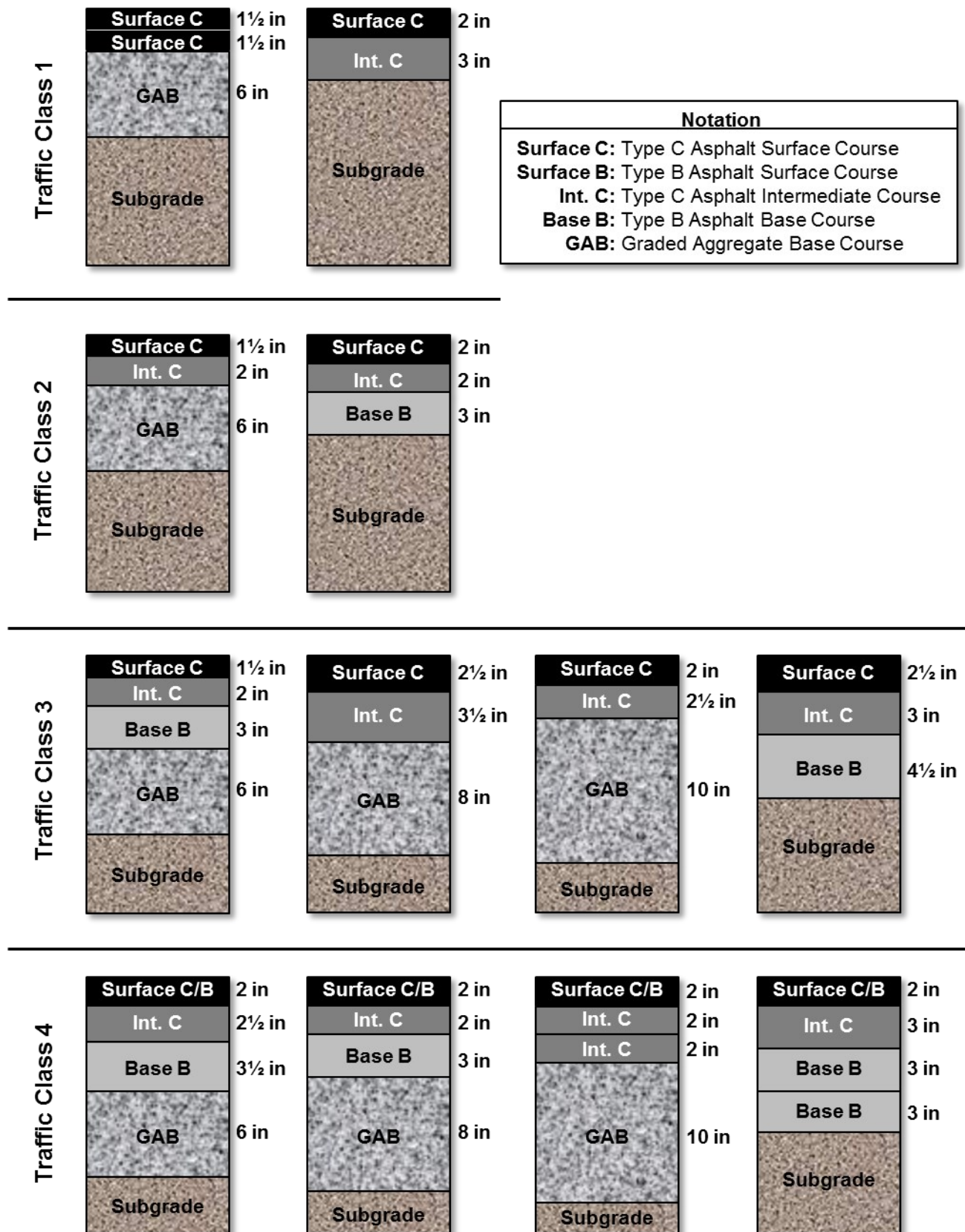


Figure 1.7. Recommended asphalt pavement thickness design options for different traffic classes on a **Poor Subgrade**.

Medium Subgrade

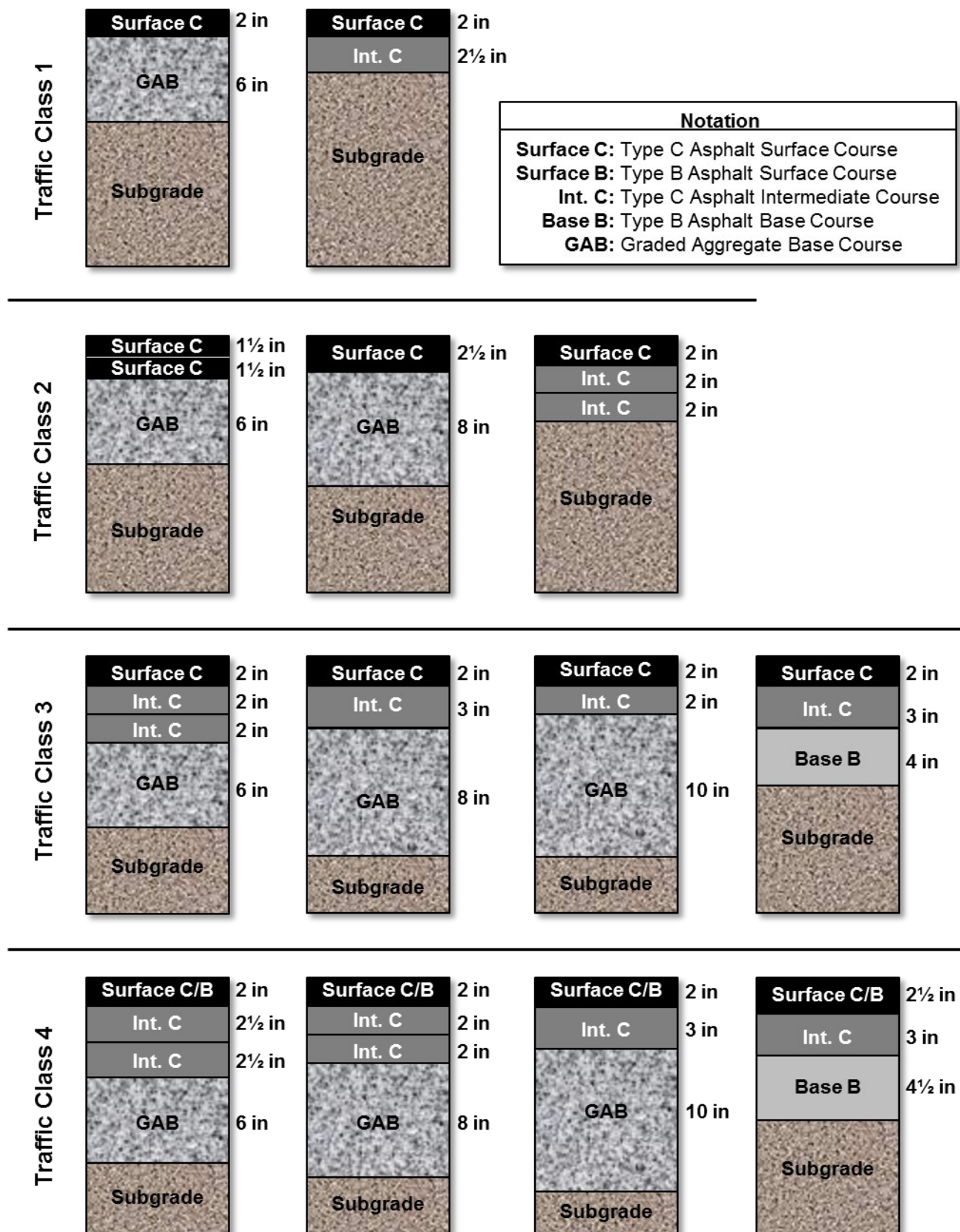


Figure 1.8. Recommended asphalt pavement thickness design options for different traffic classes on a **Medium Subgrade**.

Good Subgrade

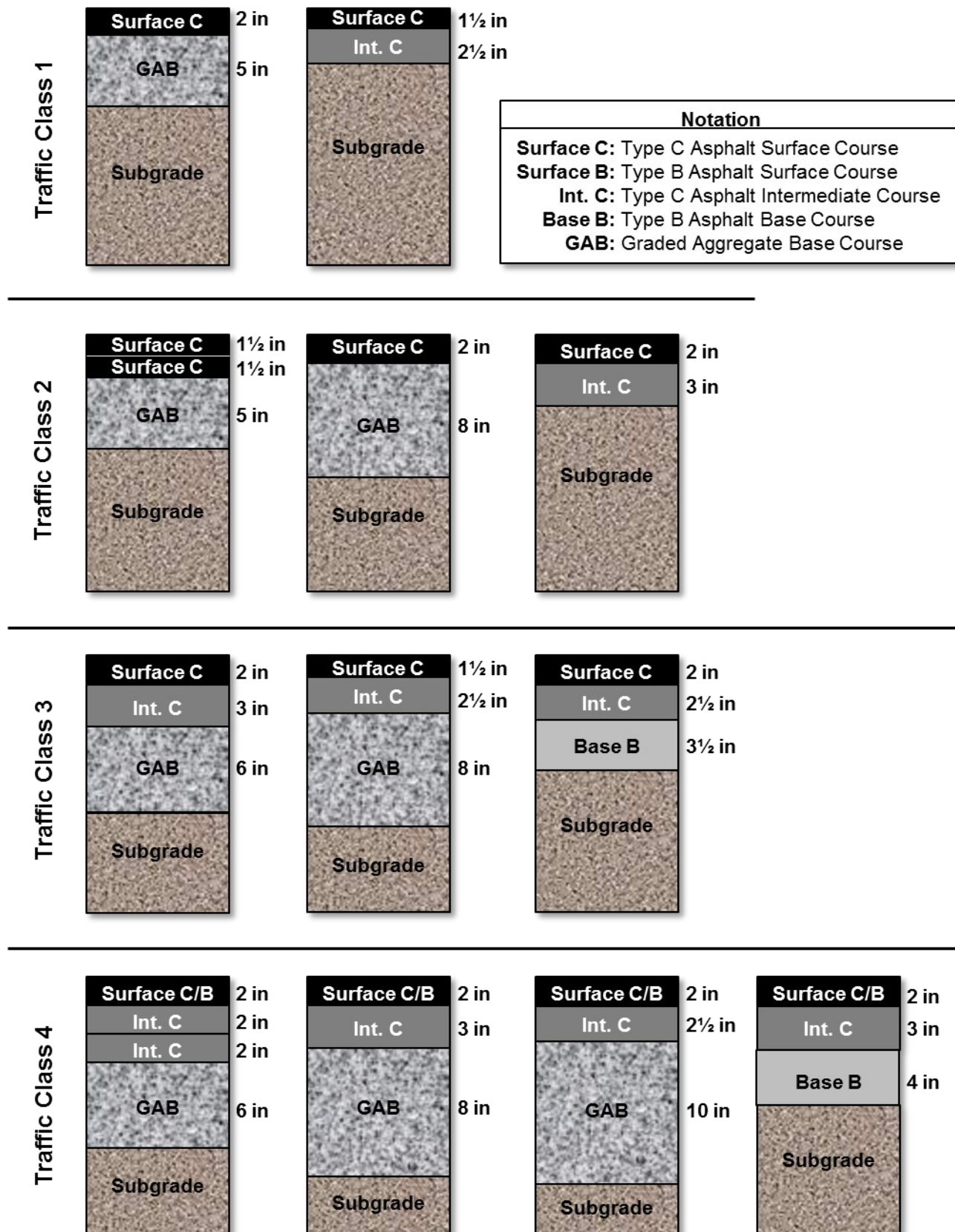


Figure 1.9. Recommended asphalt pavement thickness design options for different traffic classes on a **Good Subgrade**.

ASPHALT PAVEMENT CONSTRUCTION

To achieve a high quality asphalt pavement, the owner should select a contractor with trained personnel and who has demonstrated high quality workmanship on similar projects. For a list of qualified contractors, please contact the SCAPA office or view the membership listing on the SCAPA website (www.scasphalt.org) or at the end of this guide.

Subgrade and Aggregate Base

The subgrade is of the utmost importance because it must serve both as a working platform to support construction equipment and as the foundation for the final pavement structure. During construction, the native soils may be evaluated by proofrolling the area using heavy construction equipment. This is done to identify any unsuitable or soft areas that need to be removed or improved prior to placing subsequent layers. Unsuitable soils can be improved by blending aggregates with soil; by chemical stabilization using cement, kiln dust, or hydrated lime; or by mechanical stabilization using geosynthetics. All debris, topsoil, vegetation, or unsuitable materials should be removed and replaced with quality materials.

Fill materials should be placed in lifts no greater than 8 inches (loose thickness) at the proper moisture content and compacted prior to placement of the next lift. A properly prepared subgrade will not deflect excessively under the weight of a loaded tandem axle truck. Prior to the start of paving operations, the subgrade soils should be checked for stability, moisture content,

the start of paving operations, the subgrade soils should be checked for stability, moisture content, density, and proper grade. For projects designed with an aggregate base between the subgrade and the asphalt pavement, the layer of stone must also be placed and compacted at the proper moisture content to the required density and grade and then proofrolled.

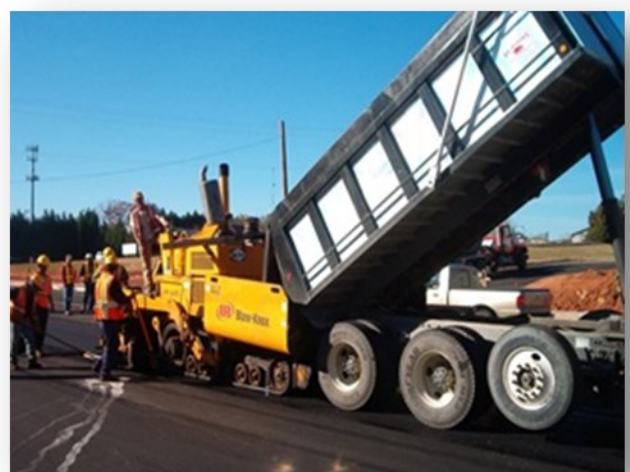
Quality Workmanship

It is important that the owner or prime contractor select a local asphalt paving contractor familiar with the materials that perform best in the region and who is experienced in constructing quality asphalt pavements. The paving contractor is responsible for quality control on the project and will be responsible for the quality of the asphalt mixture and the finished pavement surface. All SCAPA Contractor Members have personnel and facilities that have been certified by the SCDOT.

The paving contractor should utilize a self propelled asphalt paving machine capable of producing a smooth and consistent layer of material. Best practices at the asphalt plant and during trucking operations, will minimize the potential for material segregation (physical separation of the larger aggregates and smaller aggregates) of the mixture. The contractor must also ensure adequate compaction equipment is available to meet the project specifications while achieving a smooth finish.



Preparation of subgrade and aggregate base course.



Haul truck depositing asphalt into a paver.

Asphalt Base Construction

The asphalt base course should be placed directly on the soil subgrade (full-depth design) or on the prepared aggregate base (aggregate base design). Asphalt mixtures used in base applications have larger aggregates and are typically placed in thicker lifts (3-4½ in). The base layer should be placed and compacted to the thickness indicated on the plans, which represent the finished and compacted pavement thickness—not the loose thickness prior to compaction. Compaction of the base layer(s) is critical to the performance of the pavement because it provides the structural foundation to support the weight of the traffic. To achieve compaction of a base mixture, research and experience indicates that the thickness of the layer must be at least three times the size of the largest aggregate in the mixture.

Following the placement of an asphalt base or intermediate course, it is a best practice to not allow it to remain exposed to the environment for long periods of time because water can more easily penetrate the surface of these mixtures. The combination of a coarse aggregate gradation and relatively low binder content makes these mixtures more permeable than surface type mixtures. For this reason, it is recommended to place a surface course over the asphalt base and intermediate courses as soon as possible to protect the integrity of the pavement structure.

Tack Coat

The purpose of a tack coat is to promote bonding between pavement layers. A tack coat may not be required if the asphalt layers are placed in subsequent days and the surface remains clean and free of dust. Older pavement surfaces and milled surfaces that will receive an overlay will often utilize a tack coat.

The tack coat material is typically placed just prior to paving and must be applied to an asphalt surface that is clean and free of dust, debris, or loose materials. When tack coat is used, it is important to uniformly coat the paving surface.

Most tack coat products are asphalt emulsions which require time to “break” or cure. When the emulsion is initially sprayed on the paving surface, it has a brown color. After the tack coat breaks, the product will turn black in color and become sticky indicating it is ready for



Application of a tack coat prior to paving.

tack coat breaks, the product will turn black in color and become sticky indicating that it is ready for the next layer of asphalt. The time necessary for the tack coat to break is dependent on the type of emulsion and the weather conditions at the time of placement.

Intermediate Course Construction

If an asphalt base course is not included in a pavement design, then the intermediate course should be placed directly on the soil subgrade (full-depth design) or on the prepared aggregate base (aggregate base design). Asphalt intermediate course mixtures are comprised of smaller aggregates than asphalt base mixtures, but larger than surface course mixtures, therefore, the layer thickness will be adjusted accordingly so the lift thickness is at least three times the size of the maximum aggregate size. As with all asphalt layers, proper compaction of the asphalt intermediate course is critical to the performance of the pavement.

When an intermediate course is included in the pavement design, it is important not to leave it exposed to the elements for an extended duration. As with an asphalt base mix, an intermediate mixture is more permeable than a surface course, so it is susceptible to water intrusion over time. Therefore, it is recommended to place a surface course over the intermediate course as soon as possible to protect the pavement structure.

Surface Course Construction

The asphalt surface layer is typically placed in one layer and compacted to the finished grade shown on the plans. The finished surface should not vary from the established grade by more than $\frac{1}{4}$ inch in 10 feet when measured in any direction. Rolling and compaction should start as soon as the asphalt material can be compacted without displacement and continue until it is thoroughly compacted and all the roller marks are removed. Proper compaction of the surface course will ensure a strong, smooth, and water-tight pavement wearing course.



Placement of an asphalt surface course.



Initial breakdown compaction of an asphalt surface course.

Asphalt Pavement Quality Checklist

The following checklist identifies several items that are critical to constructing a long-lasting asphalt pavement.

- ✓ The asphalt plant is approved by the SCDOT to produce plant mixed asphalt material.
- ✓ The job mix formula (JMF) for the specified asphalt mix is approved by the SCDOT.
- ✓ The laboratory and field QC personnel are certified by the SCDOT.
- ✓ The asphalt content of the mix is within the specified tolerance compared to the JMF.
- ✓ The gradation of the aggregate comprising the asphalt mixture is within the specified tolerances compared to the JMF.
- ✓ A tack coat has been applied to the paving surface as necessary.
- ✓ The paving contractor established a roller pattern to ensure proper, consistent compaction of the asphalt courses and is following the roller pattern throughout construction.
- ✓ Pavement layer density is monitored with the use of a calibrated density gauge or pavement cores depending on the specifications.
- ✓ The pavement thickness is within the specified tolerance. This may require an engineering firm to cut cores to verify compacted thickness.



Measuring pavement density with a nuclear density gauge.

Asphalt Pavement Maintenance and Resurfacing

Pavement maintenance is the routine work performed to keep a pavement, which is exposed to normal conditions of traffic and nature, as near to its original condition as possible. Pavements are constantly exposed to traffic and environmental forces that lead to deterioration. For this reason, pavements require maintenance over time.

Addressing pavement deterioration at the proper time and in the proper manner can significantly increase the life of a pavement. Early detection and repair of minor defects are among the most important activities of road maintenance crews. In their first stages, cracks and other surface breaks are almost unnoticeable, but they may develop into serious defects if not repaired in a timely manner. Open joints and cracks allow water to enter the subgrade and can lead to structural failure.

Pavement maintenance involves the identification of pavement distress types and the determination of appropriate maintenance activities. Common maintenance activities for asphalt pavements include patching, overlays, and preventive maintenance treatments.

Patching

At some point in time, most pavements will require patching whether it is due to pavement deterioration or utility cuts. As patching is a common pavement maintenance activity, it is important to use quality materials and best practices. When patching, it is important to remove the failing pavement and subgrade in order for the patch to be structurally sound. There are two main types of patching: **Full-depth patching** and **surface patching**.

Full-Depth Patching

Full-depth patching is used to make permanent pavement repairs for isolated areas of pavement distress such as fatigue cracking and potholes due to subgrade failure. When using full-depth patching, the entire thickness of asphalt over the affected area is removed. This exposes the aggregate base or subgrade, which can also be repaired if required. After proper repair and compaction of the pavement foundation, the boundary of the patch area should be sprayed with tack coat, then the asphalt patch



Finished full-depth patch.

should be placed using a surface course mixture and proper compaction techniques.

Surface Patching

Surface patches are intended to be for temporary repairs on pavements that are in relatively good condition and are structurally sound. These patches can be placed without excavating the existing surface, but milling a portion of the pavement in the affected area can also be done to improve the quality of the patch.

Before placing the patch mix, it is important to be sure that the area is clean and dry before applying a tack coat to the entire area. The asphalt should then be placed in such a manner that the patch thickness is feathered to a zero thickness at the edges. After proper compaction, it is recommended to apply a seal coat to the feathered edges to reduce the potential for raveling and moisture intrusion.

Overlays

Asphalt overlays are used to extend the life of a pavement as either preventive maintenance on a pavement in good condition, or to improve the structural capacity of a pavement reaching the end of its design life. Overlays also improve riding quality, the cross section, and they increase a pavement's resistance to water intrusion and deicing chemicals. The result is a better riding surface and stronger pavement than the original.

An asphalt overlay offers the following advantages:

- **Convenience.** The pavement may remain in use while it is being upgraded.
- **Economy.** An old pavement may be improved and returned to service more quickly and for less cost than a new road can be constructed.
- **Durability.** Well-designed, well-constructed improvements provide a pavement that is stronger than new, which reduces maintenance requirements.

Before constructing an asphalt overlay, the existing pavement must be properly prepared by repairing distressed areas, sealing cracks, correcting drainage deficiencies, and/or leveling the existing pavement to make slope corrections or fill ruts. In some cases, it may be necessary to remove a certain thickness of the existing pavement using a milling machine.



Removal of a controlled thickness of asphalt pavement using a milling machine.

Each resurfacing project must be designed on an individual basis. The thickness of the overlay is based on the intended purpose of the overlay (preventive maintenance or structural upgrade), structure and condition of the existing pavement, and anticipated traffic. The overlay will consist of an asphalt surface course (typically Surface Type C, D, or E). Selection of the mix type will be based on the overlay thickness, the expected traffic, and the desired texture.



Compaction of an asphalt overlay.

Preventive Maintenance Treatments

Preventive maintenance is a broad term including several types and combinations of asphalt and asphalt aggregate applications, which are usually less than 1 in thick and can be applied to any kind of asphalt pavement surface. The primary objectives of a preventive maintenance treatment are to prolong a pavement's lifespan by protecting it from exposure, mechanical wear, and water. However, most of these treatments do not enhance the structural capacity of the pavement, so it is important that preventive maintenance treatments are applied to pavements that are structurally sound.

There are different types of preventive maintenance treatments, but the most common are ultra-thin asphalt overlays, chip seals, and other options. Ultra-thin asphalt overlays consists of a $\frac{1}{2}$ to 1 in layer of a Surface Type E mix. These overlays can be used on parking lots and low-volume roads and because they are made with a plant-mixed asphalt, they provide some level of structural value to the pavement.

Chip seals are typically used for low-volume roads and consist of a polymer modified asphalt emulsion sprayed on the road then covered with a layer of single-sized aggregate. In addition to sealing the pavement surface, chip seals can also improve the skid resistance.

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SECTION 2

ASPHALT OVERLAYS



Asphalt.

SOUTH CAROLINA RIDES ON US

INTRODUCTION

Almost every pavement will require some level of preventive maintenance or rehabilitation throughout its service life as the result of exposure to the environment, traffic loading, or local development needs. The most common solution to meet these needs are asphalt overlays. An overlay is a layer of asphalt that is placed over top of an existing pavement structure. It is best to properly prepare the existing pavement prior to placing the overlay to increase the effectiveness of the overlay in increasing the service life of the pavement.

Before designing an asphalt overlay, it is important to determine the intended purpose of the overlay. Overlays can be used as a preventive maintenance treatment to maintain, or preserve, the condition of pavements in good condition (preservation overlays). They can also be used to improve the structural capacity of distressed pavements or account for increased traffic demand (structural overlays). Therefore, the designer must first determine the purpose of the overlay: preservation or structural.

To make this determination, designers should estimate the future traffic demand for the pavement and evaluate the condition of the existing pavement. If the traffic demand has not changed for the pavement in question and the pavement is in good condition, then a preservation overlay should be considered. However, if the traffic demand has increased significantly or the pavement exhibits distresses due to structural deficiencies, then a structural overlay is needed.

This guide provides the designer with:

- A procedure to evaluate the condition of an existing asphalt pavement
- Guidance to determine the purpose of an asphalt overlay
- A method to design the thickness of an asphalt overlay
- Recommendations related to the materials used for asphalt overlays
- Best practices for construction of asphalt overlays

The content of this guide was based on information provided by similar design guides and other technical resources including:

- The American Association of State Highway and Transportation Officials (AASHTO) *Guide for Design of Pavement Structures*
- The Asphalt Institute's *Asphalt Overlays for Highway and Street Rehabilitation*
- The National Asphalt Pavement Association's *Thin Asphalt Overlays for Pavement Preservation*



Placement of an asphalt overlay.

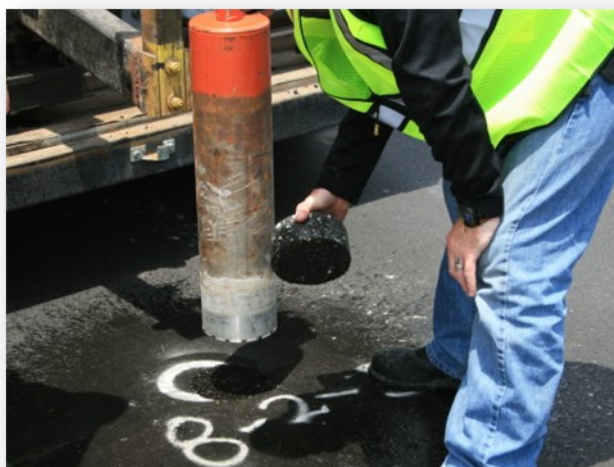


Newly placed asphalt overlay.

PAVEMENT EVALUATION

The first step in determining the function and design of an asphalt overlay is to assess the current condition of the pavement in question. The pavement evaluation procedure outlined in this section should be used for this purpose. This evaluation procedure is a simplified visual survey method to determine the condition of the pavement based on surface distress observations. This evaluation will identify three categories of pavement distress: cracking, rutting, and surface defects. Descriptions of each type of distress and severity levels are provided in Appendix B.

1. Drive the length of the pavement of interest to identify the types of distress exhibited throughout the section. While conducting the pavement evaluation, it is important to note whether distresses are isolated to certain areas along the pavement section, or if they persist throughout. If distresses are isolated, the evaluator should identify potential causes for the distresses so that repair solutions (e.g., full-depth patching) can be considered prior to overlay design. If effectively repaired, these isolated areas of distress can be ignored in the Pavement Condition Grade determination.
2. Conduct a closer investigation to measure the extent of each distress. This may be very detailed where the evaluator measures the area or length and the severity of each distress as appropriate. Or it could be a more approximate estimation of the area/length and severity based on observation. The level of detail is at the discretion of the designer.
3. During the pavement evaluation, it is recommended to obtain cores of the pavement structure in multiple locations, if possible. These cores are necessary to determine the thickness of each layer of the existing pavement structure.
 - a. After removing the core, the thickness of the asphalt and other bound material should be measured.
 - b. If an aggregate base course is present, the evaluator should measure the thickness of this layer. When measuring the aggregate layer thickness, do not include portions where the aggregate has mixed with subgrade soil.
 - c. During this process, the soil and aggregate base material can be sampled for further laboratory testing to determine its properties and quality as a pavement subgrade (see Section 1).
4. If possible, it is recommended to obtain cores at locations where cracking is present. This will help the evaluator determine the depth of cracking and identify potential causes of cracking. It can also inform decisions about whether a portion of the asphalt should be removed by milling or simply sealed prior to overlay.
5. Document the findings of the evaluation. It is often helpful to create distress maps of the pavement section to provide a visual representation of the locations, severity, and extent of distresses. This is important in tracking the rate of deterioration of a pavement over time or to compare and monitor the pavement condition after an overlay is applied.



Coring an asphalt pavement.

The results of the pavement evaluation can be used to assign a grade to each category of pavement condition as summarized in Tables 2.1 (Rutting Grade) and 2.2 (Cracking Grade).

Table 2.1. Pavement condition grade (Rutting)

Rutting Grade	Condition Description
A	Little or no rutting
B	< ¼ inch rutting
C	¼ to ½ inch rutting
D	½ to 1 inch rutting
F	> 1 inch rutting



Measuring the rut depth of an asphalt pavement.

Table 2.2. Pavement condition grade (Cracking)

Cracking Grade	Condition Description
A	Little or no fatigue cracking and/or only low severity transverse cracking
B	< 10% low-severity fatigue cracking and/or < 5% moderate and high-severity transverse, longitudinal, or block cracking
C	> 10% low-severity fatigue cracking and/or < 10% moderate and high-severity fatigue cracking and/or 5-10% moderate and high-severity transverse, longitudinal, or block cracking
D	> 10% moderate-severity fatigue cracking and/or < 10% high-severity fatigue cracking and/or > 10% moderate and high-severity transverse, longitudinal, or block cracking
F	> 10% high-severity fatigue cracking and/or > 10% high-severity transverse, longitudinal, or block cracking

TYPE OF OVERLAY

The function of the overlay can be determined based on the future traffic loading and the existing pavement condition. Using the rutting and cracking grades (Tables 2.1 and 2.2), the function of the overlay can be identified using Table 2.3. Overlays used for preservation are designed to preserve the condition of a pavement in good condition. This type of overlay is typically thin ($\frac{1}{2}$ – 1 inch) and is, therefore, referred to a **thinlay**. Structural overlays are used to restore the structural integrity of a deteriorating pavement, or increase the structural capacity of a pavement that will be exposed to increased traffic loading. In situations where severe cracking and/or rutting exist, the pavement section should be reconstructed following after being re-designed for the appropriate traffic and subgrade conditions.

Preservation Overlay

If a pavement is generally in good condition with minor cracking or rutting and the traffic has not changed significantly from the original design (see Table 2.3), the goal is to maintain the good condition while sealing the pavement surface to minimize the intrusion of water and limit further oxidation. Thin asphalt overlays are effective approaches to pavement preservation because of their ability to

- Provide a smooth surface with improved ride quality.
- Reduce pavement distresses due to the ability to withstand heavy traffic and high shear stresses resulting from an engineered approach to materials selection and design.

stresses resulting from an engineered approach to materials selection and design.

- Maintain surface geometrics by maintaining grade and slope with minimal drainage impact, particularly with small nominal maximum aggregate size mixtures
- Reduce noise levels resulting from low tire-pavement noise generation.
- Reduce life cycle costs through increased pavement service life when placed on structurally sound pavements.
- Provide long-lasting service that is easily maintained with no binder runoff or loose stones.



Thin lift asphalt overlay (thinlay).

Table 2.3. Overlay function based on Pavement Condition Grade

Overlay Function	Pavement Condition Grade		Traffic Compared to Initial Design
	Cracking	Rutting	
Preservation	A, B	A, B	Decrease or No Change
Structural	A, B	A, B	Increase
	B, C, D	A, B, C	Decrease or No Change
Reconstruction	D, F	A, B, C, D, F	Any
	A, B, C	D, F	

The relative importance of any of these benefits will vary according to the type of project, location, climate, and traffic. In residential areas, for example, the ability to maintain geometric features and curb reveals will be important, whereas low noise generation will be important on higher-volume urban roads. Pavement preservation with thin asphalt overlays is recommended for pavements with low to medium levels of surface distress and should be placed before the pavement deterioration has reached a critical stage where more extensive rehabilitation is required. If designed and constructed appropriately, thin overlays can be expected to provide 10 years or more performance on asphalt surfaces and six to 10 years on concrete or composite surfaces.

Structural Overlay

When an overlay is needed to increase or restore the structural capacity of a pavement, the procedures followed in this section are recommended. In general, the thickness of the overlay will depend on the difference between the required structural capacity and the integrity of the existing pavement structure. The structural integrity of the existing pavement can be estimated based on the pavement condition.

If the existing pavement has a Cracking Grade of B or C, it may be advisable to remove the affected layers of asphalt—and possibly stabilized base, if present—by milling. If the Cracking Grade is D or F, it is recommended to mill all affected layers by milling. In some situations, the use of a geosynthetic interlayer or a stress absorbing membrane interlayer (SAMI) can be used to limit the amount of milling and reduce the occurrence of reflective cracking in overlays placed on top of cracked pavements.

Reconstruction

When a pavement is in a severe state of distress, it will be necessary to reconstruct the section after completing a new design. There are different scenarios that will require separate consideration.

1. The pavement has experienced severe cracking (Cracking Grade of D or F), but has minimal rutting (Rutting Grade of A, B, or possibly C). This is a sign that the subgrade is in good condition and has performed well with respect to rutting under the traffic it has experienced. However, the paved surface

is in good condition and has performed well with respect to rutting under the traffic it has experienced. However, the paved surface has experienced severe cracking due to traffic loading and/or environmental factors. In these situations, it is recommended to remove all of the affected asphalt layers and design a new pavement structure using the guidance provided in Section 1 (Figures 1.6 – 1.8). During the redesign process, the remaining thickness of aggregate base can be included in the new design.

2. The pavement has experienced minor cracking (Cracking Grade of A, B, or C), but has severe rutting (Rutting Grade of D or F). This is a sign that the asphalt layers are performing well, but that the subgrade has failed due to overloading or inadequate design. In this case it is necessary to remove all existing pavement layers and construct a new pavement structure based on the subgrade quality and traffic class using the guidance provided in Section 1 (Figures 1.6 – 1.8).



Milling an existing asphalt pavement.

OVERLAY THICKNESS DESIGN

The design of an asphalt overlay is based on four factors previously discussed:

1. Condition of the existing asphalt pavement
2. Structure of the existing asphalt pavement
3. Design Traffic Class (from Table 1.1)
4. Subgrade Category (from Table 1.2)

After determining the function of an asphalt overlay (preservation or structural), it is important to know the traffic demand of the pavement and quality of the subgrade over which the pavement is constructed. Refer to Section 1 of this guide to identify which Traffic Class the pavement will be exposed to (Class 1, 2, 3, or 4) from Table 1.1. Additionally, it is necessary to determine the quality of the subgrade supporting the pavement in question. Section 1 should also be referenced to determine the Subgrade Category

be referenced to determine the Subgrade Category (Poor, Medium, or Good) from Table 1.2.

The overlay thickness should be calculated using Equation 2.1 and rounded up to the nearest ¼ inch. The required structural capacity is denoted as the structural number (SN_{Req}) and is based on the design Traffic Class and Subgrade Category. The SN_{Req} values in Table 2.4 align with the pavement designs recommended in Section 1 (Figures 1.6 – 1.8) of this guide.

$$T_o = \frac{SN_{Req} - (T_A \times a_A) - (T_{SB} \times a_{SB}) - (T_{GAB} \times a_{GAB})}{0.44}$$

where,

- T_o = required overlay thickness (inches)
round up to the nearest ¼ inch
- SN_{Req} = required structural number of the pavement (from Table 2.4)
- T_A = thickness of existing asphalt after milling (inches)
- T_{SB} = thickness of existing stabilized base (inches)
- T_{GAB} = thickness of existing granular aggregate base (inches)
- a_A = structural coefficient for existing asphalt (from Table 2.5)
- a_{SB} = structural coefficient for existing stabilized base (from Table 2.5)
- a_{GAB} = structural coefficient for existing granular aggregate base (from Table 2.5)

Table 2.4. Required structural number (SN_{Req}) values based on Traffic Class and Subgrade Category

Traffic Class (Table 1.1)	Subgrade Category (Table 1.2)		
	Poor	Medium	Good
1	2.12	1.92	1.73
2	2.67	2.44	2.22
3	3.75	3.46	3.19
4	4.12	3.81	3.52

Table 2.5. Structural coefficients for existing pavement layers based on pavement surface condition

Surface Condition		Pavement Material		
		Asphalt (a_A)	Stabilized Base (a_{SB})	Aggregate Base (a_{GAB})
Cracking Grade (Table 2.2)	A	0.35 - 0.40	0.20 - 0.25	
	B	0.25 - 0.35	0.15 - 0.25	
	C	0.20 - 0.30	0.15 - 0.20	
	D	0.14 - 0.20	0.10 - 0.20	
	F	0.08 - 0.15	0.08 - 0.15	
Is there evidence of pumping or contamination by fines?	No			0.10 - 0.15
	Yes			0.00 - 0.10

OVERLAY CONSTRUCTION

Patching

Before paving an overlay, it may be necessary to perform some patching of the existing asphalt pavement. In these situations, appropriate patching should be done following best practices as described in Section 1 of this guide. If milling is planned prior to resurfacing, it often beneficial to complete any full-depth patching prior to milling to improve the overall smoothness of the finished pavement.

Milling

Where it can be done, milling of the old surface will help to remove defects that could reflect through the new overlay and provide the opportunity to achieve better ride quality by paving on a smoother surface. It will help roughen the surface which will provide a greater degree of shear resistance to the pavement surface that will help strengthen the bond with the overlay with proper tack coat application. Milling around sidewalks and curbs and gutters before placing an overlay will also help maintain appropriate curb reveal and drainage. When old asphalt pavements are milled, the material (reclaimed asphalt pavement or RAP) is most commonly processed and recycled into new asphalt mixtures.

When milling is done on a project, the milling machine should be sized appropriately for the project. Once the milling is complete, the old pavement surface should be swept clean of all debris and dust prior to tack coat application to facilitate bonding.

Leveling

In some situations, an existing pavement will require leveling prior to placement of an asphalt overlay. Leveling is the process of paving a thin layer of asphalt to either fill depressions (e.g., mixture rutting, not subgrade rutting) or correct the pavement cross-slope or grade. If leveling is needed prior to an overlay, it is recommended to use a Surface Type E mixture for this purpose (Table 1.) as the fine aggregate size will allow for very thin lifts and ability to fair the transition to the existing pavement grade.

Paving (also refer to Section 1)

One of the chief concerns of overlay performance is the bond between the old pavement and the new overlay, and this means that special attention needs to be paid to the surface preparation of the old surface and the application of the tack coat. Beyond this, paving and compaction operations can proceed normally, although the screed control is critical to ensuring the proper mat thickness on thinlays.

Proper bonding between an overlay and an existing pavement can be enhanced by several factors. Because an overlay can be thin, the interface between the old and new pavement is in close proximity to the shear forces created by vehicles during braking and turning movements. The tack coat is crucial to bonding the new overlay to the old pavement. In some cases, specifications may require a heavier-than-normal application of tack coat, especially on unmilled surface. Experience has also shown the importance of removing existing pavement markings (such as thermoplastic markings) prior to placement of an overlay to ensure sufficient bonding.

Where it can be done, milling of the old surface will help to remove defects that could reflect through the new overlay and provide the opportunity to achieve better ride quality by paving on a smoother surface. It will help roughen the surface which will provide a greater degree of shear resistance to the pavement surface so it will not be as likely to shove and debond. Milling will also provide material (reclaimed asphalt pavement or RAP) that can be recycled into new asphalt mixtures. The milling machine should be sized appropriately for the project. Once the milling is complete, the old pavement surface should be swept clean of all debris and dust prior to tack coat application to facilitate bonding.

The goal for compaction of a thin lift asphalt surface should be to increase the stability of the mat and to seal the voids in the material to make it as impermeable as possible. Mat density is best achieved in thin lifts using a static, steel wheel compactor. Vibratory rollers should not be used on thin lifts that are less than about one inch because they may cause roughness or tearing of the mat.

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APPENDIX A

ASPHALT PAVEMENT GLOSSARY



Asphalt.

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ASPHALT PAVEMENT GLOSSARY

Aggregate. A hard inert material of mineral composition such as sand, gravel, slag, or crushed stone, used in pavement applications either by itself or for mixing with asphalt.

Aggregate Gradation. Distribution of aggregate particle sizes.

Anti-Stripping Additive. Material added to an asphalt mixture to reduce or eliminate the moisture susceptibility of the mixture by promoting adhesion between the binder and the aggregate surface. The most common additives are hydrated lime that is added to the aggregate and amine-based liquid additives added to binders.

Asphalt Concrete. A mixture of mineral aggregate and asphalt binder. Often referred to as asphalt.

Asphalt Binder. Asphalt cement that is classified according to the Standard Specification for Performance Graded Asphalt Binder, AASHTO Designation M320. It can be either unmodified or modified asphalt cement, as long as it complies with the specifications.

Asphalt Emulsion. A combination of asphalt cement, water and a small amount of an emulsifying agent. It is a heterogeneous system (containing two normally immiscible substances: asphalt and water), in which the water forms the continuous phase of the emulsion, and the minute globules of asphalt form the discontinuous phase. Emulsified asphalt may be either anionic globules—electronegatively charged asphalt—or cationic—electropositively charged asphalt globules—depending upon the emulsifying agent.

Bleeding (or Flushing). Film of asphalt binder on the pavement surface caused by the upward migration of binder in the asphalt pavement.

Block Cracking. Interconnected cracks that divide the pavement into rectangular pieces.

California Bearing Ratio (CBR). A simple strength test comparing the bearing capacity of a material to that of a well-graded crushed stone. The test uses a 1.95 in penetration piston to measure the strength.

Compaction. The process used to densify a mass of material.

Compaction. The process used to densify a mass of material.

Core. A cylindrical specimen extracted from a pavement structure often used to measure the in-situ properties and characteristics of pavement materials.

Corrective Maintenance. Activities performed in response to a deficiency (or deficiencies) that negatively impacts the safe and efficient operations of a pavement and its future integrity.

Crack Sealing. Filling a pavement crack to prevent ingress of water or other non-compressible material (e.g., soil, rocks, weeds, etc.). Crack sealant material is typically a rubberized asphalt or sand-asphalt slurry.

Cross-slope. The slope (change in elevation over length) of the pavement surface expressed as a percent designed to promote surface drainage.

Crown. A crowned pavement section slopes from the centerline of the pavement to each edge to promote surface drainage.

Crushed Stone. Angular aggregate produced by mining a suitable rock deposit and breaking the rock down to the desired size using crushers.

Curb Reveal. The vertical dimension of the exposed portion of a curb above a pavement surface.

Drum Mix Plant. A manufacturing facility for producing asphalt paving mixtures that proportions aggregate, then dries and mixes the aggregate with a proportional amount of asphalt in the same drum. Variations of this type of plant use several types of drum modifications, separate (and smaller) mixing drums, and coating units (coater) to accomplish the mixing process.

Fatigue Cracking. Interconnected cracks forming a series of small blocks resembling an alligator's skin or chicken-wire, and caused by excessive deflection of the surface over unstable subgrade or lower courses of the pavement structure. Also referred to as alligator cracking.

Full-Depth Asphalt Pavement. An asphalt pavement in which asphalt mixtures are employed for all courses above the prepared subgrade.

Full-Depth Patching. Patching that extends from the pavement surface to the subgrade.

Geosynthetics. Polymeric products used in a variety of civil engineering applications. The most common geosynthetics used in pavement applications include geotextiles, geogrids, and geocomposites.

Gravel. Aggregate produced by natural processes of weathering and erosion, and typically has a rounded shape.

Hot Mix Asphalt (HMA). Asphalt mixture produced by heating the asphalt binder to decrease its viscosity, and drying the aggregate to remove moisture from it prior to mixing. Mixing is generally performed at temperatures ranging from 300-350°F depending on the mix type.

Job Mix Formula (JMF). The specific material composition, or recipe, for an asphalt mixture including the aggregate type and gradation, binder type and content, additives, and tolerances.

Layer Coefficient. Empirically based coefficient that represents the relative strength of a pavement material.

Leveling. application of a lift of asphalt applied to an existing pavement to fill in ruts and make up elevation differences. Can also be accomplished by milling.

Liquid Limit. The water content at which the behavior of a soil changes from plastic to liquid.

Longitudinal Cracking. Cracking parallel to the flow of traffic or laydown direction.

Milling. removal of layer or partial layer of asphalt from an existing pavement using a milling machine to remove distressed asphalt or create a smooth surface. Also called grinding or cold planing.

Milling Machine. Primary method used to remove old asphalt pavement surface material prior to overlay.

Overlay. Placement of a layer of asphalt over an existing pavement structure.

Oxidation. The reaction of oxygen with asphalt binder, which has a stiffening effect on the binder.

Pavement Preservation. Long-term strategy to improve overall network pavement performance using an integrated, cost-effective suite of practices that extend pavement life, improve safety, and meet user expectations.

Paver. A self-propelled formless laydown machine with a floating screed that is used to place asphalt on a roadway prior to compaction.

Performance Grade (PG). Asphalt binder grade designation used in Superpave; based on the binder's mechanical performance at critical temperatures and aging conditions. This system directly correlates laboratory testing to field performance through engineering principles.

Planned Stage Construction. Construction of roads and streets by applying successive layers of asphalt according to design and a predetermined time schedule.

Plasticity Index. Range of water contents in which a soil exhibits plastic properties.

Pneumatic Tire Roller. Self-propelled compaction device that uses pneumatic tires to compact the underlying asphalt layer.

Polished Aggregate. Areas of pavement where the aggregate extending above the asphalt binder is either very small or has no rough or angular particles.

Preventive Maintenance. Planned strategy of cost-effective treatments to an existing roadway system that preserves the system, slows future deterioration, and maintains or improves the functional condition without significantly increasing the structural capacity.

Proof Rolling. A method of ensuring that a prepared subgrade or aggregate base has no unstable areas. This is performed by driving a tandem axle truck loaded to a specific weight over the prepared area and the ground surface is observed to identify any pumping or movement, which is an indication of an unstable area.

Pumping. Pavement deflection caused by heavy loading that can result in the discharge of water and subgrade fines through cracks.

Raveling. Progressive disintegration of an asphalt layer from the surface downward resulting from dislodged particles.

Reclaimed Asphalt Pavement (RAP). Asphalt that has been removed from an old asphalt pavement. The material is typically crushed and processed and then used in new asphalt pavements.

Reconstruction. Replacement of the entire existing pavement structure by the placement of the equivalent or increased pavement structure.

Reflective Cracking. Cracks in asphalt overlays that reflect the crack pattern in the pavement structure underneath. They are caused by vertical or horizontal movements in the pavement beneath the overlay and brought on by expansion and contraction with temperature or moisture changes.

Rehabilitation. Structural enhancements that extend the service life of an existing pavement and/or improve its load-carrying capacity.

Ride Quality. Relative measure of the smoothness or roughness of the pavement.

Roller Pattern. A specific plan created by a paving contractor to consistently achieve the target pavement density. The roller pattern includes the number of passes of each specific roller used on a project.

Routine Maintenance. Work that is planned and performed on a routine basis to maintain and preserve the condition of the roadway system or to respond to specific conditions and events that restore the system to an adequate level of service.

Rutting. Surface depressions in the wheelpath of a pavement.

Segregation. Non-uniform distribution of the coarse and fine aggregate components within an asphalt mix.

Shear Strength. Resistance of a material to horizontal forces.

Shoving. Permanent deformation presenting as an abrupt wave in the pavement surface perpendicular to the flow of traffic that typically occurs where asphalt adjoins a rigid object or where braking occurs.

Slippage Cracking. Crescent shaped cracks generally having two ends pointed into the direction of traffic caused by braking or turning movements.

Soil Stabilization. Permanent physical and/or chemical alteration of soils to enhance their physical properties.

Stabilized Base. Aggregate base material that has been stabilized with an additive such as Portland cement or asphalt emulsion to increase the strength and cohesion of the base material.

Steel Wheel Roller. Self-propelled compaction device that uses steel drums to compress the underlying asphalt. They can be either static or vibratory rollers.

Stripping. Breaking of the adhesive bond between the binder and aggregate in an asphalt mixture caused by water or water vapor getting between the binder film and aggregate surface.

Structural Number. Numerical expression of the overall strength of a pavement structure required to sustain the design traffic loading for a given subgrade strength. Based on the 1993 AASHTO pavement design guide.

Subgrade. The soil prepared to support a pavement structure or a pavement system. It is the foundation of the pavement structure.

Swale. A low tract of land designed to manage water runoff, filter pollutants, and increase rain-water infiltration.

Tack Coat. A low viscosity asphalt emulsion used to create a bond between an existing pavement surface and a new asphalt layer or overlay.

Thin Asphalt Overlay (Thinlay). A non-structural asphalt overlay having a thickness of ½ to 1 ½ inches typically used for pavement preservation.

Transverse Cracking. Cracking perpendicular to the flow of traffic or laydown direction caused by shrinkage of the pavement surface due to low temperatures.

Warm Mix Asphalt (WMA). Production of an asphalt mixture at significantly lower temperatures (50-100°F lower than HMA).

APPENDIX B

ASPHALT PAVEMENT DISTRESSES



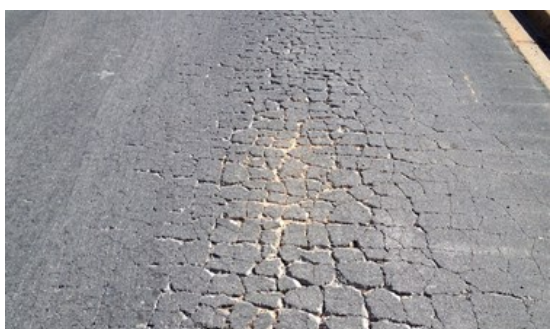
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ASPHALT PAVEMENT DISTRESSES

Cracking

Fatigue Cracking

Severity	Description	Example
Low	- An area of cracks with no or only a few connecting cracks. - Cracks are not spalled or sealed. - No evidence of pumping.	
Moderate	- An area of interconnected cracks forming a complete pattern. - Cracks may be slightly spalled. - Cracks may be sealed. - No evidence of pumping.	
High	- An area of moderately or severely spalled interconnected cracks forming a complete pattern. - Pieces may move when subjected to traffic. - Cracks may be sealed. - Pumping may be evident.	

Measure	Area of each severity level.
Problem	Structural failure, moisture infiltration through cracks, roughness, deterioration
Possible Causes	Decrease in pavement load-carrying capacity due to loss of base or subgrade support or stripping of the bottom of the asphalt layer; heavier loading than anticipated; inadequate structural design; poor construction practices.

Cracking

Block Cracking

Severity	Description	Example
Low	- Average crack width $\leq \frac{1}{4}$ inch wide or - Sealed cracks with sealant in good condition and width that cannot be determined.	
Moderate	- Average crack width between $\frac{1}{4}$ and $\frac{3}{4}$ in or - Any crack with an average width $\leq \frac{3}{4}$ in and adjacent low severity random cracking.	
High	- Average crack width $> \frac{3}{4}$ in or - Any crack with an average width $\leq \frac{3}{4}$ in and adjacent moderate to high severity random cracking.	

Measure	Area of each severity level.
Problem	Moisture infiltration; roughness
Possible Causes	Asphalt layer contraction and daily temperature cycling that is typically exacerbated by binder aging or binder grade or content selection in the mix design.
Notes	An occurrence should be at least 50 ft long to be considered block cracking. Otherwise, it is considered transverse and longitudinal cracks.

Cracking

Longitudinal Cracking

Severity	Description	Example
Low	- Average crack width $\leq \frac{1}{4}$ inch wide or - Sealed cracks with sealant in good condition and width that cannot be determined.	
Moderate	- Average crack width between $\frac{1}{4}$ and $\frac{3}{4}$ in or - Any crack with an average width $\leq \frac{3}{4}$ in and adjacent low severity random cracking.	
High	- Average crack width $> \frac{3}{4}$ in or - Any crack with an average width $\leq \frac{3}{4}$ in and adjacent moderate to high severity random cracking.	

Measure	Length of each severity level.
Problem	Moisture infiltration through cracks, roughness, and may indicate possible onset of fatigue cracking and structural failure.
Possible Causes	Poor longitudinal joint construction; reflective crack from the underlying layer; pavement fatigue; top-down cracking.
Notes	Any longitudinal cracking located in the wheel path that meanders or has associated random cracking is considered fatigue cracking.

Cracking

Transverse Cracking

Severity	Description	Example
Low	- Average crack width $\leq \frac{1}{4}$ inch wide or - Sealed cracks with sealant in good condition and width that cannot be determined.	
Moderate	- Average crack width between $\frac{1}{4}$ and $\frac{3}{4}$ in or - Any crack with an average width $\leq \frac{3}{4}$ in and adjacent low severity random cracking.	
High	- Average crack width $> \frac{3}{4}$ in or - Any crack with an average width $\leq \frac{3}{4}$ in and adjacent moderate to high severity random cracking.	

Measure	Length of each severity level.
Problem	Moisture infiltration; roughness.
Possible Causes	Contraction of the asphalt surface due to low pavement temperatures; reflective crack from the underlying layer; top-down cracking.
Notes	Cracks less than 12 in long are not recorded.

Surface Defects

Raveling

Severity	Description	Example
Not Applicable	Wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder. Raveling ranges from loss of fines to loss of some coarse aggregate and ultimately to a very rough and pitted surface with obvious loss of aggregate.	

Measure	Area of affected surface.
Problem	Loose debris on the pavement, roughness, water ponding, and possible loss of
Possible Causes	Loss of bond between the aggregate particles and binder or mechanical dislodging due to traffic.

Surface Defects

Bleeding

Severity	Description	Example
Not Applicable	- Excess binder accumulating on the pavement surface, usually found in the wheel paths. - May range from a surface discolored relative to the remainder of the pavement, to a surface that is losing or has lost surface texture because of excess asphalt binder.	

Measure	Area of affected surface.
Problem	Decreased skid resistance.
Possible Causes	Excessive asphalt binder in the asphalt mix; excessive application of binder during application of bituminous surface treatment; low air void content of the asphalt mix.

Surface Defects

Polished Aggregate

Severity	Description	Example
Not Applicable	▪ Surface binder has been worn away to expose coarse aggregate. ▪ Is an issue if aggregate polishing results in a reduction in surface friction.	

Measure	Area of affected surface.
Problem	Decreased skid resistance.
Possible Causes	Repeated traffic applications can occur more quickly with aggregates that are susceptible to abrasion.

Surface Deformation

Rutting

Severity	Description	Example
Not Applicable	▪ Longitudinal surface depression in the wheel path. ▪ May include pavement uplift, or shearing along the sides of the rut.	

Measure	Maximum rut depth every 50 feet in each wheel path.
Problem	Ruts can fill with water and cause hydroplaning. Deep ruts may also have a
Possible Causes	Consolidation or lateral movement of any of the pavement materials due to traffic loading. Specific causes include: ▪ Insufficient compaction of the asphalt layers during construction. ▪ Subgrade rutting due to inadequate pavement structure, insufficient compaction of the subgrade. ▪ Improper mix design or production (e.g., high asphalt binder content, rounded aggregate particles, high fines content).

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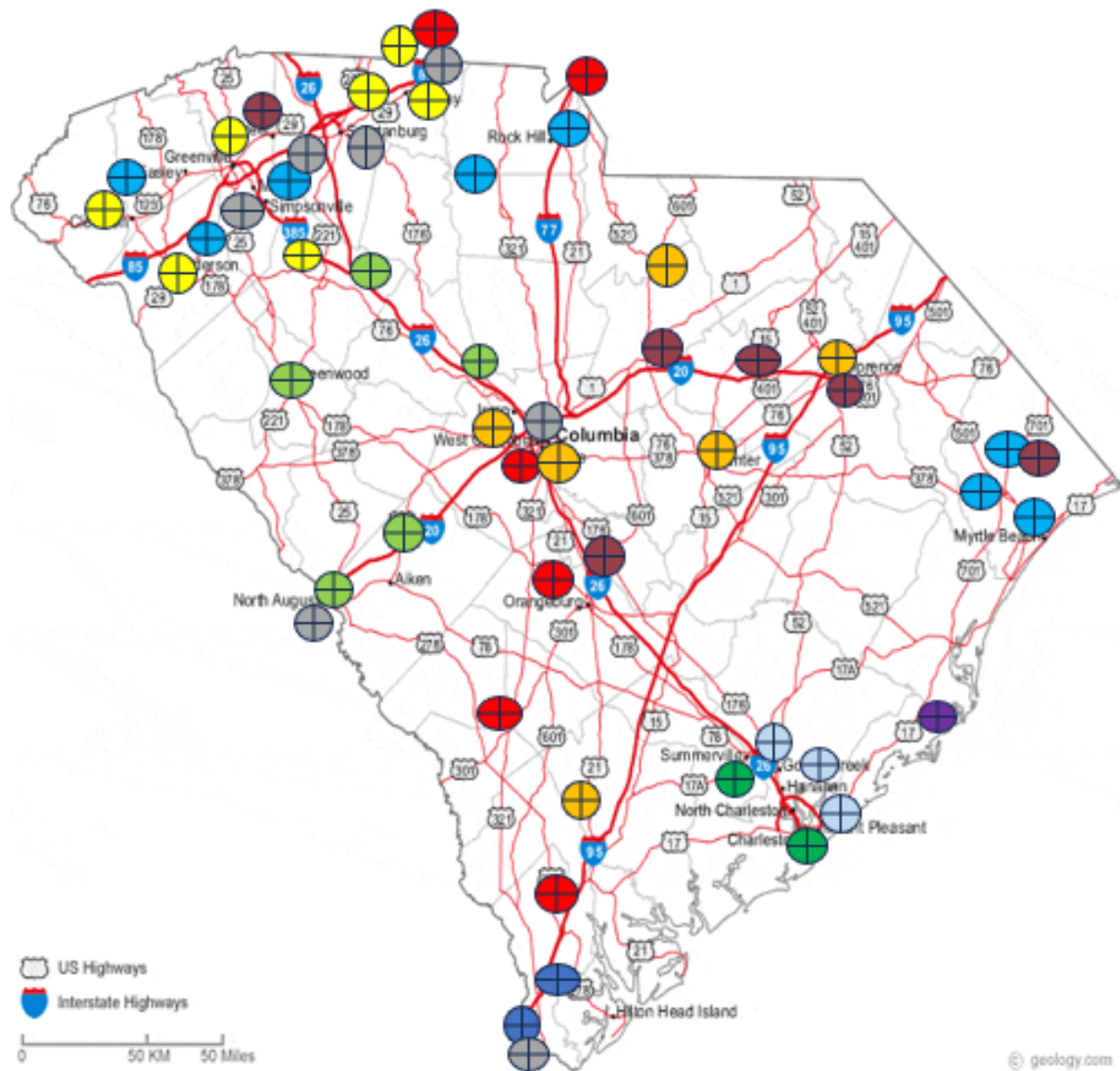
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