MISSOURI ASPHALT PAVEMENT ASSOCIATION

Asphalt Parking Lot Design

A publication for owners, architects and engineers
who design and construct asphalt parking lots.

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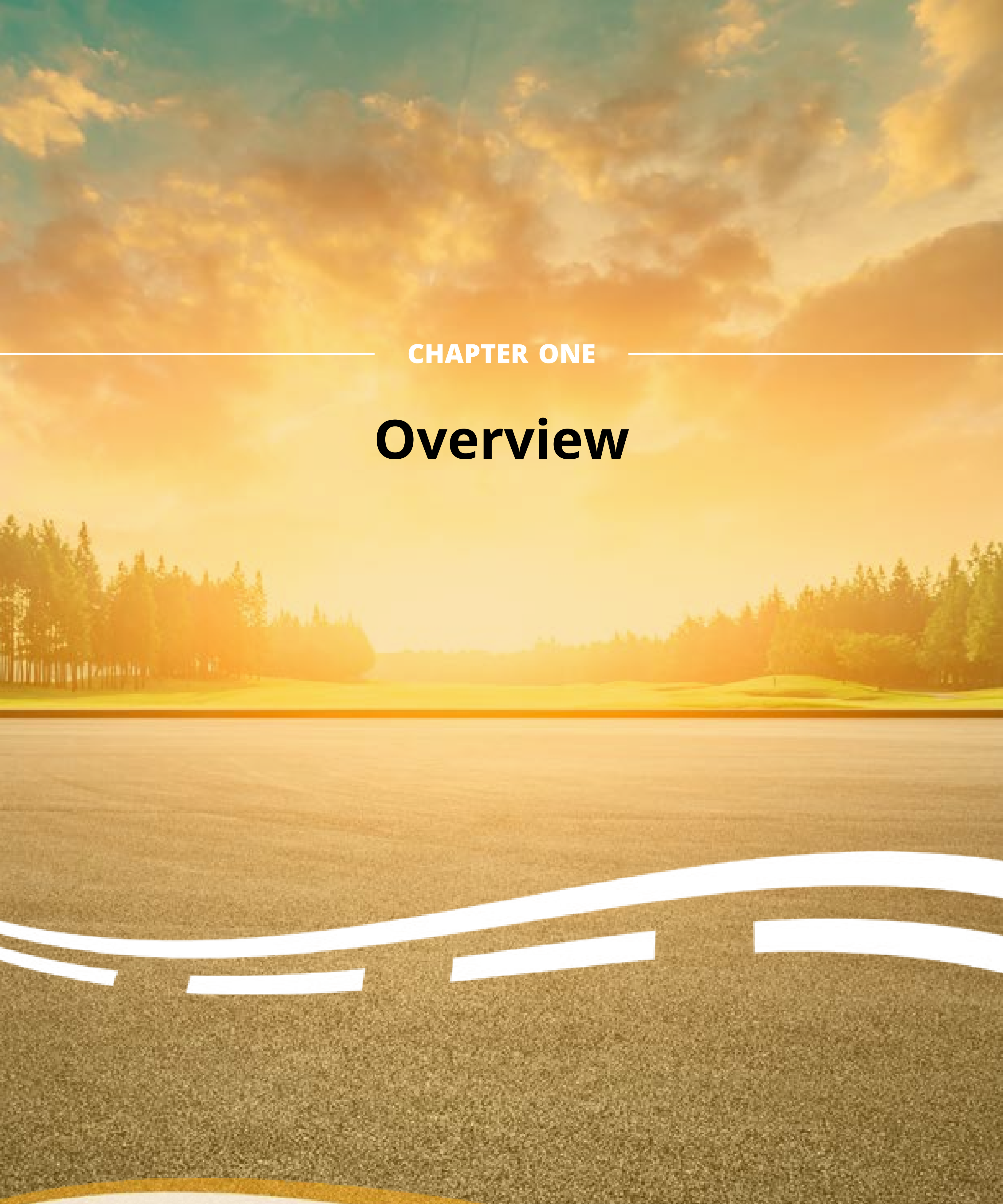
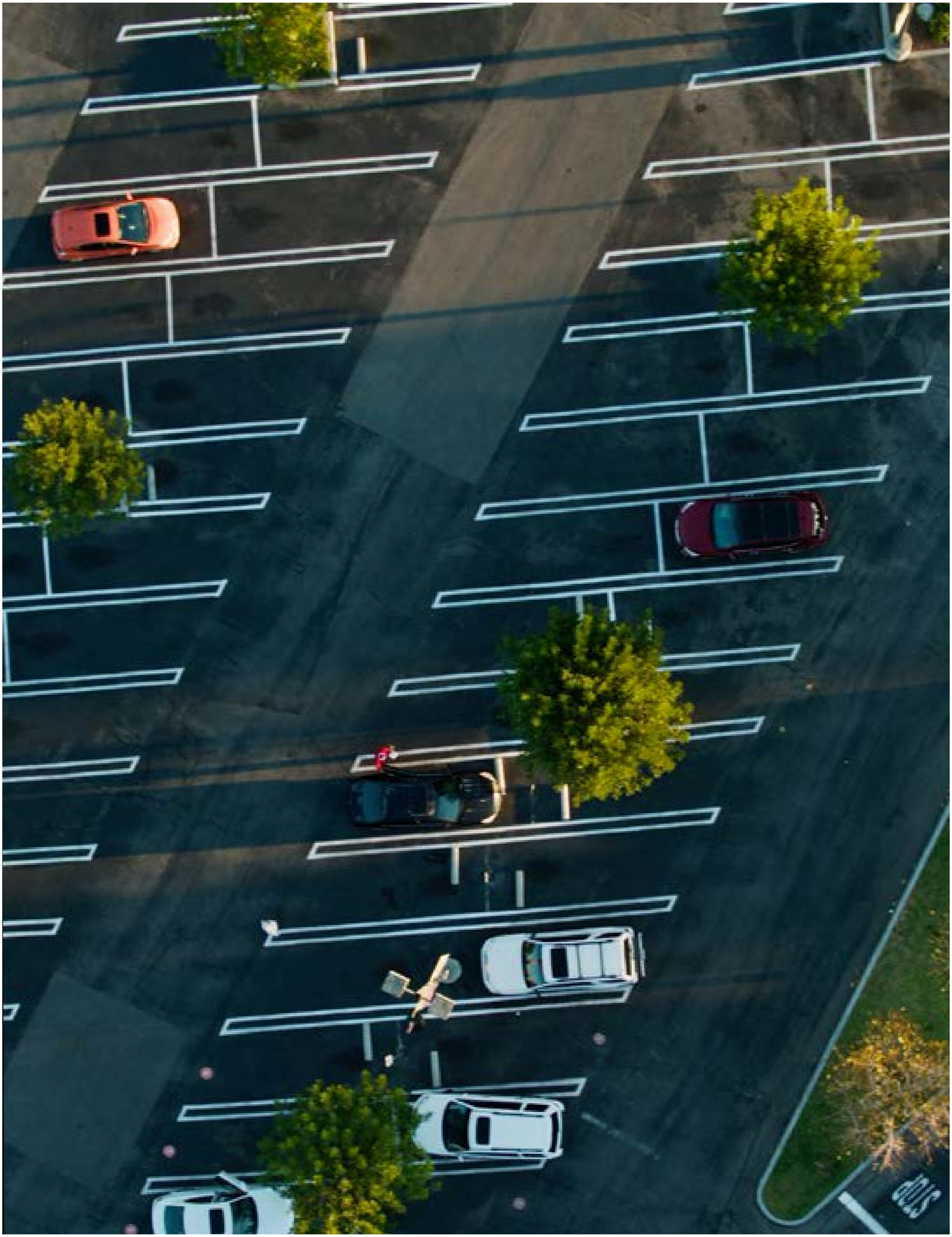
Overview





Overview

Nearly all building structures incorporate parking features to accommodate their workers and customers, as well as those providing deliveries, trash removal, and other services. Office buildings and retail stores aspire to impress existing clients and seek to attract new customers. They understand the importance of first impressions. The parking lot serves as a crucial gateway to this first impression. Make sure your parking lot is prepared with quality materials to be both eye appealing and represents your company's image.

Today's parking lots are engineered with the latest advances in sustainable materials and mechanistic-empirical design principles. While the needs of motorists in light vehicles must be met, parking lots must simultaneously hold up to the demands of regularly scheduled truck deliveries, snow removal, and occasional overloads. Asphalt parking lots enable the use of high amounts of recycled materials that can deliver exceptional smoothness and durability when properly designed and constructed.

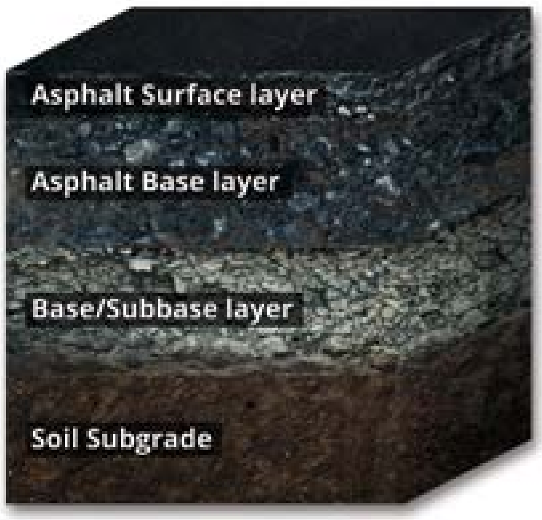
This publication provides owners, architects, and engineers guidance on the design and construction of high-quality asphalt parking lot pavements in Missouri. This guide closely mirrors the parking lot design guide developed by the Plantmix Asphalt Industry of Kentucky (PAIKY). MAPA would like to thank PAIKY for their willingness to collaborate on this project. Thickness design calculations and subsequently tabulated values were validated by researchers at the University of Missouri-Columbia using the PAVEXpress Tool (pavexpress.com), maintained by the National Asphalt Pavement Association (NAPA).

CHAPTER TWO

Pavement Thickness Design

Pavement Thickness Design

This section describes the key structural design considerations for parking lots, i.e., the layer types and thicknesses of an asphalt (or flexible) parking lot pavement. In its simplest form, the thickness of an asphalt pavement is determined by the quality and strength of the subgrade materials, as well as the volume and composition of the traffic that is expected to travel on the pavement.



Pavement Cross-Section

Asphalt pavements are typically analyzed as a layered, elastic system, where significantly different materials are utilized in each layer. Each layer contributes to the overall strength and function of the pavement structure. Most parking lots in Missouri are built on a foundation of native subgrade soils, while subbase and base aggregate (granular) layers are utilized to provide load-carrying structure and to improve the working platform for the asphalt paving materials. Following the placement and compaction of the soil and aggregate layers, two or more layers of asphalt pavement are typically added to complete the pavement structure. Paving with multiple asphalt layers helps promote good compaction and final surface smoothness.

Traffic Analysis

The weight and frequency of truck and passenger vehicle traffic over a pavement is a critical and sensitive parameter in designing the thickness of any pavement structure. Clearly, pavements designed for heavy truck traffic will require a thicker pavement section than ones that will primarily serve passenger cars. However, the challenge is to conservatively estimate future traffic loads so that a proper pavement foundation and structural layer configuration can be designed.

The effect of traffic is often expressed in terms of Equivalent Single Axle Loads (ESALs). An ESAL refers to the relative damage caused by a given axle load on a given axle type (single, tandem, tridem) in relation to the distress caused by the passage of a single 18,000-pound axle load. Heavier axle loads have ESAL factors greater than one, while the axle loads from smaller trucks and cars deliver less than one ESAL per passage. The advantage of the ESAL concept is that factors for different axles (of one truck and also of trucks of different types) may be added, and thus the cumulative effects of many trucks of different types may be evaluated. ESAL factors apply not only to trucks but also to lighter vehicles such as cars, pickups, and sport utility vehicles. However, the ESAL factor for these passenger vehicles is quite small as compared to a heavily-loaded commercial truck. Most pavement design methods will utilize ESALs as an input parameter, but that information is not always readily available. Without specific data on the number of ESALs expected for a specific pavement, designers may seek out other forms of data to help them estimate the expected traffic. One such alternate approach is to consider the number of vehicles

that will travel over the pavement each day. This information may be used to help quantify the traffic and is expressed as the Average Daily Traffic (ADT). When utilizing ADT data, the designer must also determine another key piece of data to complete the analysis. The percentage of trucks must be well defined and understood. The combination of ADT and the percentage of trucks is often sufficient information for computer programs to calculate the ESALs for a given pavement.

Since the design of an asphalt pavement is heavily influenced by the truck traffic, it is important that the designer has a firm grasp on the volume of truck traffic to utilize in the planning and design of the pavement. In this guide, traffic has been grouped into three categories for the purpose of simplifying the parking lot pavement design process.

This publication includes several schematic diagrams which should help provide some additional guidance on when and where to expect certain categories of traffic. Heavy truck traffic areas could include distribution centers, or loading and unloading areas around commercial facilities. Parking lots that are primarily used by passenger cars but do experience the occasional delivery or garbage truck would be considered moderate. Light truck traffic would generally apply to parking facilities dominated by passenger cars and sport utility vehicles with little or no opportunity for commercial truck access.

Subgrade Materials

The subgrade material for most pavements will be naturally occurring soils or rock which must be examined and well understood before designing a pavement. There are two primary methods currently being used to categorize soils (for roadways) that have similar characteristics: (1) American Association of State Highway and Transportation Officials (AASHTO) System and (2) Unified Soil Classification System (USCS). The purpose of classifying subgrade soil by soil type and strength value is to predict how the soil will perform when loaded.

The consistency, quality, and moisture conditions of the naturally occurring materials are all factors in the pavement design process. Additionally, the designers must determine if the existing site materials are suitable for the project. If deemed unsuitable, the engineers will make a determination if they should be removed and replaced with better materials, or if they should be mechanically improved, or chemically stabilized.

Through inspection and geotechnical analysis, most engineers will consider all the factors on a project and assign a relative strength value to the subgrade materials. Local conditions such as the depth to bedrock, water table, and frost depth should all be considered. A common approach to characterizing subgrade load-carrying capacity involves the California Bearing Ratio (CBR). The design engineer or geotechnical consultant will generally utilize field investigation, laboratory testing, and/or local experience to assign a CBR strength value to the subgrade. This value has been utilized in the design methodology herein and is an important variable affecting pavement cross section design.

Table 1. Relationship Between AASHTO Subgrade Soil Classification, Resilient Modulus, and CBR

Material Classification AASHTO Soil Class	Soil Description	Typical M_R (psi)	*California Bearing Ratio (CBR) (%)
A-1-a	**Stone fragments, gravel and sand**	**40,000**	**74**
A-1-b		**38,000**	**68**
A-2-4	**Silt or clayey gravel and sand**	**32,000**	**52**
A-2-5		**28,000**	**42**
A-2-6		**26,000**	**38**
A-2-7		**24,000**	**33**
A-3	**Fine sand**	**29,000**	**45**
A-4	**Silty soils**	**24,000**	**33**
A-5		**20,000**	**25**
A-6	**Clayey oils**	**17,000**	**19**
A-7-5		**12,000**	**11**
A-7-6		**8,000**	**6**

Table 2. Relationship Between Unified Soil Classification System, Resilient Modulus, and CBR

Unified Soil Classification System	Soil Description	Typical M_R (psi)	*California Bearing Ratio (CBR) (%)
GW	**Well-graded gravel, fine-to-coarse gravel**	**41,000**	**76**
GP	**Poorly graded gravel**	**38,000**	**68**
GM	**Silty gravel**	**38,500**	**69**
GC	**Clayey gravel**	**31,000**	**49**
GW-GM	**Well-graded gravel, silty**	**38,500**	**69**
GP-GM	**Poorly-graded gravel, silty**	**36,000**	**62**
GW-GC	**Well-graded gravel, clayey**	**34,500**	**58**
GP-GC	**Poorly-graded gravel, clayey**	**34,000**	**57**
SW	**Well-graded sand, fine-to-coarse sand**	**32,000**	**52**
SP	**Poorly-graded sand**	**28,000**	**42**
SM	**Silty sand**	**32,000**	**52**
SC	**Clayey sand**	**24,000**	**33**
SW-SM	**Well-graded sand, silty**	**28,000**	**42**
SP-SM	**Poorly-graded sand silty**	**28,000**	**42**
SW-SC	**Well-graded sand, clayey**	**25,500**	**36**
SP-SC	**Poorly-graded sand, clayey**	**25,500**	**36**
ML	**Silt**	**20,000**	**25**
CL	**Clay of low plasticity, lean clay**	**17,000**	**19**
MH	**Silt of high plasticity, elastic silt**	**11,500**	**10**
CH	**Clay of high plasticity, fat clay**	**8,000**	**6**

Types of Layered Systems

Geotechnical consultants, architects, and design consultants must make a choice regarding the type of layered system to be used on the project. Across the U.S., parking lots are typically designed in one of two ways – as conventional flexible pavements, or as full-depth asphalt pavements. However, full-depth designs are rare in Missouri because of the availability and relative costs associated with aggregate base materials versus asphalt concrete. In conventional flexible pavements, the asphalt pavement layers are placed over the granular base layers.

High Stress Areas (Loading Docks and around Trash Dumpsters)

Areas in and around truck loading docks and trash dumpsters represent severe loading conditions for the pavement and should be carefully considered when designing the parking lot. Light-duty pavement sections utilized in these areas can be prone to premature failures. The designer should take two factors into consideration: (1) the location of the loading dock and dumpster, and (2) the pavement thickness in that area.

If possible, locate the dumpster in such a way to minimize the route that the garbage truck must travel through the parking lot to and from the dumpster pad. Routine truck traffic in an otherwise light-duty section will result in a much thicker pavement design than is necessary and will increase costs. It is typically more cost effective to isolate the dumpster area and truck traffic to a small portion of the parking lot and address this area with a separate pavement design. Once the truck route to and from the loading dock and dumpster pad has been established, consider a heavy-duty pavement section to accommodate this rather severe loading condition. As a general rule, for those sections leading into the dumpster (areas where the truck will stop, load, and unload), the minimum recommended thickness is six inches of asphalt over eight inches of aggregate base.

Layer Thickness Design

When designing conventional, flexible asphalt pavements, a number of design methods and software programs are available for use. Missouri Department of Transportation (MoDOT) utilizes the "AASHTO Guide for Design of Pavement Structures," which is a document that has been updated and revised periodically over the years. While the 1993 version is still being utilized by many states, AASHTO has developed a new mechanistic-empirical approach, which is now being validated and implemented across the U.S. Due to the complex nature of this simulation-based design method, AASHTO distributes software (AASHTOWare) which includes a pavement design program entitled Pavement M-E. However, for the purpose of designing typical parking lot facilities in the U.S., most designs are currently still based on AASHTO 1993.

To simplify the use of AASHTO 1993, NAPA has developed an online tool called PAVEXpress. Using this tool, simplified thickness design tables have been developed by a number of agencies including MAPA to help simplify the job of guiding parking lot designers. These design tables have been subsequently validated by researchers at the University of Missouri-Columbia and adopted by MAPA, as presented in this guide. More details regarding the analysis conducted can be found in Appendix A.

Traffic Category

To simplify the design process for parking lots, the traffic loading category is generally selected from a relatively small number of choices. Heavy trucks (such as semi-trailers and other combination trucks), trash trucks, construction vehicles, etc., will generally dictate the eventual performance of the pavement and must therefore be properly accounted for in the design process. Three categories are used in this guide, as follows:

Light Traffic

For the purpose of this guide, light-duty traffic has been defined as a pavement that is exposed primarily to light-duty vehicles (passenger cars, SUVs, etc.), and occasional delivery trucks. These pavements typically experience fewer than 1,500 vehicles per day. The assumption for these structures is that the traffic stream will consist of 98 percent passenger vehicles and 2 percent single unit trucks.

Moderate Traffic

This table should be utilized when a moderate amount of single unit and combination truck traffic is expected (AADT from 700 to 3,000). The assumed, typical traffic stream for this traffic category is 92 percent passenger vehicles with a mixture of single unit trucks (5 percent) and combination trucks (3 percent).

Heavy Traffic

The assumed traffic mix for heavy-duty pavements is the same as the moderate traffic category (92 percent passenger vehicles with a mixture of single unit trucks (5 percent) and combination trucks (3 percent), but with AADT greater than 3,000 and less than 24,000. Design of parking facilities with traffic in excess of the heavy traffic category is beyond the scope of this guide and will require a more rigorous design. Please consult a qualified civil engineer with pavement engineering expertise.

Subgrade Strength

Three categories are also used to describe the relative subgrade strength upon which the parking facility will be built. Given the number of freeze-thaw cycles and depth of frost penetration across Missouri, choose a relatively clean, strong, crushed aggregate product for the base, with a minimal percentage of frost-susceptible fines.

Weak: CBR is greater than or equal to 3 and less than 6
Moderate: CBR is greater than or equal to 6 and less than 9
Good: CBR is greater than or equal to 9

Design Period

A design period of 15 years indicates that the designed pavement can be expected to have excellent performance over the 15-year design life, with only minor maintenance periodically required. Major rehabilitation or structural restoration, such as adding thickness to the pavement with an asphalt overlay, would only be necessary after the design life of 15 years is reached. For thicker, 30-year designs, major rehabilitation would be delayed an additional 15 years, again assuming that periodic maintenance was performed.

Asphalt Layers

In Missouri, the most common practice is to use surface-type asphalt mixtures to build up the required asphalt layer thickness. MoDOT BP-1 and BP-2 type mixtures are almost always used and are recommended for their balance of economy and durability for parking lot applications. Lift thickness between 1.5 and 3.0 inches are recommended to promote good density, which leads to good durability. The use of multiple paving lifts, when possible, can help achieve better overall surface smoothness.

Thickness Design Tables

Recommended layer thicknesses for 15-year and 30-year designs are now presented, as shown in Tables 3 and 4 respectively:

Table 3. Recommended Layer Thicknesses, 15-Year Design Life

Subgrade Strength	Layer Type	Light Traffic	Moderate Traffic	Heavy Traffic
Weak, CBR 3	**Asphalt Layers, Total (inches)**	**3**	**4.5**	**7**
	Aggregate Base, Layer (inches)	**6**	**8**	**10**
Moderate, CBR 6	**Asphalt Layers, Total (inches)**	**2.75**	**4.25**	**6.5**
	Aggregate Base, Layer (inches)	**6**	**8**	**10**
Good, CBR 9	**Asphalt Layers, Total (inches)**	**2.5**	**4**	**6**
	Aggregate Base, Layer (inches)	**6**	**8**	**10**

Table 4. Recommended Layer Thicknesses, 30-Year Design Life

Subgrade Strength	Layer Type	Light Traffic	Moderate Traffic	Heavy Traffic
Weak, CBR 3	**Asphalt Layers, Total (inches)**	**5**	**7.5**	**9**
	Aggregate Base, Layer (inches)	**6**	**8**	**10**
Moderate, CBR 6	**Asphalt Layers, Total (inches)**	**4.25**	**7**	**8**
	Aggregate Base, Layer (inches)	**6**	**8**	**10**
Good, CBR 9	**Asphalt Layers, Total (inches)**	**3.5**	**6**	**7**
	Aggregate Base, Layer (inches)	**6**	**8**	**10**

CHAPTER THREE

Site Design Considerations

Site Design Considerations

Drainage

It is often said that the three most important things to consider when designing a pavement are drainage, drainage, and drainage. It is absolutely critical that any pavement be well-designed for proper drainage. Drainage problems are frequently a major cause of parking area pavement failures and should be given special consideration during the design and construction phases.

Without proper drainage, stormwater can cause premature deterioration of the surface layers. In addition, moisture will penetrate into the subgrade layers, which could weaken the entire pavement structure resulting in severe distress. When designing a pavement structure, consider both surface and subsurface drainage. Similar to the approach when building a new house – pavements require both a roof and an under-drain system. The pavement surface should be sloped to enable storm water to drain from the surface. Even with the best construction practices, it is inevitable that water will get into the pavement structure and therefore should be designed to drain subsurface water laterally into swales or edge drain systems in an effort to protect moisture-susceptible subgrade soils.

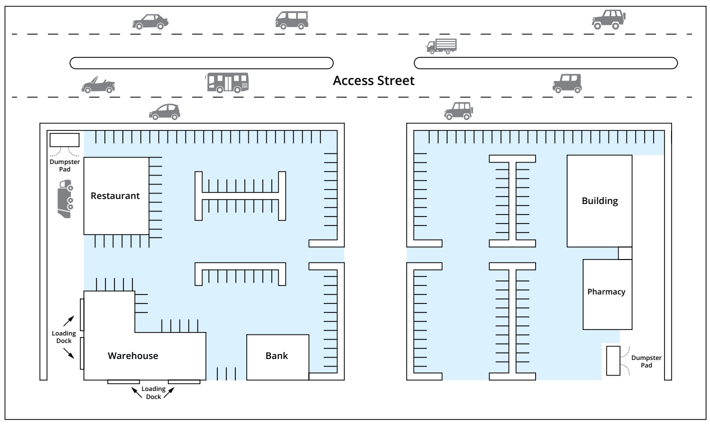
Automatic sprinkler systems have become common throughout medians in parking areas. Constant exposure to moisture can deteriorate the pavement and/or the underlying subgrade soils. Thus, caution should be taken to confine this water to the grassy areas. Precautions should also be taken to avoid planting trees in a manner that will introduce large root systems in close proximity to the asphalt pavement surface. Near-surface tree roots under a flexible pavement surface can eventually lead to a visibly heaved, rough, and possibly cracked pavement surface. Suggestions for the prevention of root infiltration can be found in the section 3.1.1.4 of the report Best Practices for Bicycle Trail Pavement Construction and Maintenance in Illinois.

Slopes

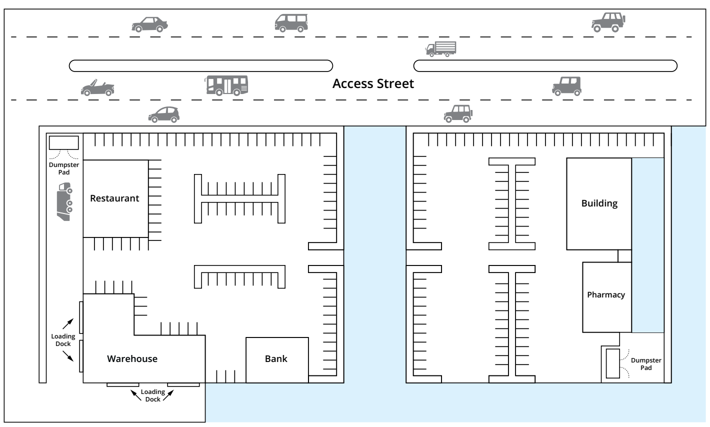
Parking areas should have a minimum slope of 2 percent to facilitate drainage. Pavement cross slopes of less than 2 percent are hard to construct without forming flat spots or depressions that can lead to ponding water (bird baths). There is a tendency among designers to overlook the need for grade information at key points in intersections, transitions between grade lines, etc.

Light Traffic Applications

For typical parking lot applications or other pavements that are likely to host passenger vehicles, Tables 3 or 4 of Thickness Design Tables will provide guidance on the thickness of the aggregate base and the layers of base and surface asphalt. Most commercial building structures have well-defined areas for passenger car parking as shown to your right. The type and condition of the subgrade soil materials are sensitive parameters in the design thickness and are important to the long-term performance of the pavement. Consult with a geotechnical engineer to assist in evaluating the site conditions and to perform testing and analysis to establish a CBR value appropriate for the project.



Typical Commercial Light Duty Parking Lot Layout

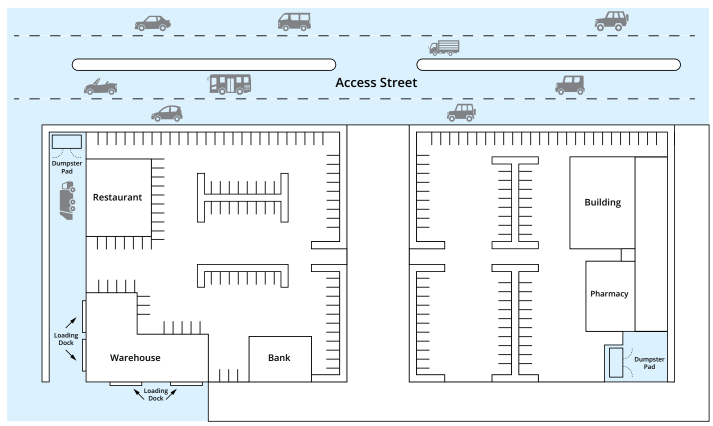


Typical Commercial Moderate Duty Parking Lot Layout

Moderate Traffic Applications

For parking lot applications, driving lanes or other pavements that are likely to experience some truck traffic along with passenger vehicles, Tables 3 or 4 of Thickness Design Tables will provide guidance on the thickness of the aggregate base, as well as the layers of base and surface asphalt. Most commercial developments will have some common driving lanes between buildings which may experience heavier truck traffic and higher volumes of passenger cars. Consult with a geotechnical engineer to assist in evaluating the site conditions and to perform testing and analysis to establish a CBR value appropriate for the project.

Heavy Traffic Applications



Typical Commercial Heavy Duty Parking Lot Layout

For heavily-traveled areas with substantial truck traffic leading into parking lots, around dumpsters and loading docks, refer to Tables 3 or 4 of Thickness Design Tables they will provide guidance on the thickness of the aggregate base, as well as the layers of base and surface asphalt. Most commercial and light industrial facilities with loading docks will have an established truck route in and out of the facility. Consult with a geotechnical engineer to assist in evaluating the site conditions and to perform testing and analysis to establish a CBR value appropriate for the project. For pavements expected to experience more than 8 million ESALs or for facilities such as truck distribution centers where the anticipated traffic stream is much different than the assumptions in this guide document, perform a detailed analysis of the anticipated traffic loading conditions. If the analysis suggests that the pavement will experience more than 8 million ESALs, consult with PAVEXpress for design.

Contractor and Calculating Tools

The National Asphalt Pavement Association (NAPA) has developed tools to assist designers and contractors in calculating asphalt pavement quantities and cooling rates for paving contractors. For additional information, visit asphaltpavement.org and go to the resources tab.

Source: National Asphalt Pavement Association

CHAPTER FOUR

Design of Asphalt Mixtures for Parking Lots

Design of Asphalt Mixtures for Parking Lots

In order to achieve optimum performance and durability of a parking lot, the asphalt mixtures should be specifically designed for individual project conditions. MoDOT has detailed specifications and nomenclature for mixtures utilized on MoDOT projects, as summarized in Appendix B. In addition, local agencies such as city and county governments may have specifications and mixtures that they prefer. Due to the availability of materials and conditions in an area, designers should consider using mixtures that have a history of proven performance.

Mix Designs and Performance Testing

Asphalt pavements are made up of three primary components: 1) aggregates; 2) liquid asphalt binder; and 3) air (or voids). The asphalt binder acts as the binding agent to glue aggregate particles into a dense mass and to waterproof the mixture. When bonded together, the mineral aggregate acts as a stone framework to impart strength and toughness to the system. Asphalt mixtures also include a small percentage of air voids which are necessary for pavement durability. The performance of the mixture is affected both by the properties of the individual components and their combined reaction in the system.

MoDOT officially adopted the Superpave Mix Design system but also allows the use of Marshall Mix Design as an option for low type mixtures (Appendix B). Local experience, knowledge, and history should be the overriding factors in selecting an asphalt mixture that is appropriate for the project.

Parking lots are much different than roadways because vehicles are not traveling at high speeds and are far more likely to experience increased turning movements. Because of these differences, care must be exercised when designing parking lot mixtures utilizing MoDOT mixtures and specifications. Parking lots may experience oxidation, aging, tire scrubbing, and some brittleness not often seen on heavily-traveled roadways, and must be designed accordingly. Generally speaking, asphalt mixtures utilized in parking lots should be higher in total liquid asphalt content than a similarly traveled roadway. To this end, lower compaction level designs (lower number of gyrations in the Superpave gyratory compactor or lower number of blows with the Marshall hammer) are generally most appropriate for all but the heaviest duty parking lots. Lower gyration designs, such as 30-50 gyration (Superpave) or 35 blow (Marshall) lead to higher asphalt content, and better durability against environmental effects. For very high traffic parking facilities - especially where heavy vehicles will be parked or where turning operations of heavy vehicles will occur - a stouter mix design would be appropriate. In this case, a 50-80 gyration (Superpave) or 50 blow (Marshall) design would provide a good tradeoff between mixture durability, and rut/shove resistance (see MoDOT Standard Specification Section 403). It is not likely that a high compaction mix (80 gyrations, or 75 blows, or above) would ever be appropriate for a parking facility. These mixtures are generally reserved for very high traffic urban arterials and interstates, are more expensive, and may lack the proper environmental durability characteristics needed for parking facilities.

Modern performance testing has begun to gain popularity as a supplement to traditional, 'volumetric' mix design. Tests such as the Hamburg Wheel Track Test can be used to evaluate and limit rutting as well as moisture sensitivity potential as part of mix design. The disk-shaped compact tension test, or DC(T), can be used to limit environmental cracking, such as thermal and block cracking, and can be used to maximize recycling content, while ensuring mix durability to the environment. DC(T) accomplishes this by assisting with binder selection (softer binders are generally required when RAP and RAS are used) and the potential use of modifiers such as rejuvenators, fibers, etc. Other cracking tests are available to limit fatigue crack development, which would be important for parking lots with higher truck traffic. These tests include the IDEAL and iFIT tests. For lower traffic designs, and when mixture economy is a key consideration, it would be unnecessary to specify these tests as part of parking lot mixture design. However, if parking lot longevity, aesthetics, and minimizing maintenance are a design goal, then it may be advantageous to require these tests as part of a premium parking lot mixture design. Please consult a qualified asphalt mix designer to add mixture performance test requirements to the specifications for your project. MAPA will be happy to assist in this regard.

Liquid Asphalt "Binder"

In most cases, the grade of binder is specified according to the climate and level of traffic for the particular application. The performance grade (PG) binder system allows the selection of asphalt cement according to the high and low service temperatures and the level of traffic. In Missouri, PG 64-22 binder is the most common binder used across the state.However, in northern and especially northwest Missouri, a softer PG 58-28 binder may provide better resistance to low-temperature cracking. In addition, softer binders (PG 58-28, PG 46-34) and/or rejuvenators may be needed when higher amounts of RAP and RAS are used in the mix design. Rutting and cracking performance tests can help the designer in arriving at innovative, sustainable, and economical mix designs that ensure sufficient rut and cracking resistance.

Aggregates

A wide variety of mineral aggregates are used to produce asphalt pavements. Missouri has many quarry operations, and most of them produce a crushed limestone product that may be used in asphalt pavements. Natural sands and gravels are available along our rivers and streams but these rounded particles are not as desirable in our modern Superpave mixtures. In areas where gravel is available, it should be crushed in order to obtain more angular and cubical particles.

Processed aggregate has been quarried, crushed, separated into distinct size fractions, washed, or otherwise processed to achieve certain performance characteristics of the finished product. Some asphalt mixtures will utilize synthetic aggregates – materials that are not mined or quarried and often are the result of an industrial byproduct such as blast furnace slag. Division 1000, Sections 1001 to 1007 of the MoDOT Standard Specifications describes the aggregate properties and requirements for different layers of the asphalt pavement structure.

Important Parameters

Asphalt mixtures that have a good track record on highways and roadways are not always desirable for parking lot applications. Mixtures that perform well under posted speed conditions may experience distresses with slow and stopped traffic. Additionally, parking lot pavements are more susceptible to brittleness caused by light and limited vehicle traffic and ongoing exposure to the elements. The following factors should be considered:

- Design air voids in the range of 3 to 4 percent – air voids provide for long-term durability of the pavement. The lower target air voids along with a lower compaction level can be used to maximize durability (by slowing down mix oxidation). This is because both factors encourage increasing the total binder content in the mix.
- Consider surface mixtures with finer gradations – mixtures designed with gradation curves that pass predominantly above the maximum density line will have a finer surface texture, which is desired on most parking lot applications.

Recycling and Mixture Sustainability

The asphalt industry reclaims about 100 million tons of Reclaimed Asphalt Pavement every year and reuses or recycles about 95 million tons. This makes it America's number one recycled product. In addition to recycling our own product, asphalt pavements may incorporate asphalt roofing shingles (tear offs and post-consumer waste), ground tire rubber, and/or blast furnace slag (MoDOT Standard Specifications Section 402.2). The use of new recycled products into asphalt is an ongoing research topic, and parking facilities provide a good opportunity to demonstrate the use of these emerging recycled mix types and to promote the movement towards a more sustainable infrastructure and circular economy. More information is provided below, and in Appendix C, which provides a summary of permeable pavement as well as low-impact design strategies and examples.

Reclaimed Asphalt Pavement

Recycling Reclaimed Asphalt Pavement (RAP) is an excellent way to reuse the asphalt pavement that has reached the end of its service life. Recycling RAP in new asphalt mixes reduces the demand for virgin materials, thereby boosting mixture sustainability. In the case of parking lots, it can stiffen the mixture which minimizes the chance for scuffing or tire scrubbing. MoDOT currently has specifications which allow the use of RAP and provide guidance on the design and testing of those mixtures. If available, RAP should be considered and allowed for all asphalt paving mixtures including the final surface. With utilization of higher RAP contents (above 15%), selection of an appropriate, softer asphalt binder grade is important in minimizing thermal cracking (Please refer to MoDOT Standard Specifications Section 401.2.2).

Recycled Asphalt Shingles

As with RAP, reusing reclaimed asphalt shingles is an attractive way to reduce the demand for virgin materials, particularly the asphalt binder. This also promotes greater mixture sustainability. "Post-manufactured Recycled Asphalt Shingles (RAS)" are processed manufacturer's shingle scrap by-product.

"Post-consumer RAS" or "tear-offs" are processed shingle scrap removed from residential structures. Both manufacturer waste and tear-offs should be considered where available. When the shingles are properly processed and the mixture is well designed, a mixture containing RAS can perform similarly to a mixture containing only virgin materials. Due to the high stiffness of RAS binder, selection of an appropriate, softer asphalt binder grade will be critically important in minimizing thermal and block cracking. RAS contents are typically in the range of 2-5% by weight of mixture, although 7% content is possible with careful mix design and very careful binder selection (MoDOT Standard Specifications Section 401.2.2.2).

Warm-Mix Asphalt

Warm-Mix Asphalt (WMA) is a technology whereby production and construction temperatures of asphalt mixtures are significantly reduced (50-100 °F) by foaming of the asphalt binder or using a chemical additive. In either case, fumes and emissions are greatly reduced and the asphalt remains workable at those lower temperatures. Warm-Mix is rapidly gaining acceptance and many states already allow these technologies to be used. Warm-Mix Asphalt should be allowed on all mixtures including the final surface layer.

Ground-Tire Rubber and Waste Plastic Recycling in Asphalt

The use of recycled Ground-Tire Rubber (GTR) in asphalt mixes is on the rise , driven by new technologies that deliver ease-of-construction, mixture durability, sustainability, and lower project costs. New dry-process GTR products can be easily fed into the asphalt plant via a pneumatic injection feeder system, similar to the manner in which fibers are fed into the lower portion of a drum-mix plant. Recent studies have indicated that the asphalt thickness requirement for mixes containing GTR can be reduced by 25% without sacrificing performance, which can more than offset the added cost of the GTR. At the time of this writing, the use of recycled waste plastic in asphalt is a new research topic that could lead to another important source of recycled material to be used towards increased pavement sustainability and cost reduction.

CHAPTER FIVE

Construction of Parking Lots

Construction of Parking Lots

When properly designed and constructed, parking areas become an integral part of the overall facility and will provide excellent service to the owners and their customers. In order to achieve a high-quality parking lot, 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 see those listed at the end of this publication, contact the MAPA office, or view the most up to date list of our membership from the MAPA website. See also Appendix D for a sample specification that can be used by owners and agencies to guide the construction of asphalt pavement parking lot projects.

Subgrade & 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 proof-rolling 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 or by chemical stabilization using cement, kiln dust, or hydrated lime. All debris, topsoil, vegetation, or unsuitable materials should be removed and replaced with quality materials.

All fill materials should be placed in thin lifts (12 inch maximum) 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 truck. Prior to the start of paving operations, the subgrade soils should be checked for stability, moisture content, and proper grade. For projects designed with a layer of stone between the soil subgrade and the asphalt pavement, that layer must also be placed and compacted to proper moisture content, density and grade.

Quality Workmanship

It is important that the owner or prime contractor select a local asphalt paving contractor that is familiar with the materials that perform best in that 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.

The paving contractor should utilize a self-propelled asphalt paving machine capable of producing a smooth and consistent layer of material. Through proper techniques at the asphalt plant and during trucking operations, take precautions to minimize the chances 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.

Asphalt Base Mixture 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 are characterized by larger aggregates and are typically placed in thicker layers. The base layer should be placed and compacted to the thickness indicated on the plans. The thicknesses shown on the plans represent the finished and compacted pavement thickness – not the loose thickness prior to compaction. Compaction of the asphalt base layers is critical to the performance of the pavement because it provides the structural foundation to support the weight of the traffic. In order 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, nominal maximum aggregate size (NMAS).

Tack Coat

The purpose of a tack coat is to promote the bond 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 that will receive an overlay and milled surfaces will often utilize a tack coat.

The tack coat material is typically placed just prior to paving and must be applied to a surface that is clean and free of debris or loose materials. Most tack coat products are asphalt emulsions which need some time to “break” or cure. After the tack

coat breaks, the product will dry and become sticky indicating it is ready for the next layer of asphalt. The time necessary for the tack coat to break is dependent on the weather conditions at the time of placement.

Asphalt Surface Mixture Construction

The asphalt surface layer is typically placed in one layer and compacted to the finish grade shown on the plans. The surface should not vary from the established grade by more than 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 disappear.

Conclusion

For a pavement to perform well and stand the test of time, designers must explore the site conditions and analyze the anticipated traffic. These critical parameters are necessary to the long-term performance of any pavement. Please consider experience with local conditions and materials along with the performance of projects in the area. For guidance and assistance on projects that are unique and do not fall within the guidelines set forth in this publication, please contact a MAPA member.

APPENDIX A

Thickness Design for Asphalt Parking Lots

PAVEXpress is a free, online tool based on the AASHTO 1993 to be used by architects and engineers when designing asphalt pavements and is technically considered a scoping tool rather than a design specification. However, PAVEXPress has been found to provide a rigorous implementation of the AASHTO 1993 design equations and has been verified herein to provide reliable parking lot layer/thickness designs. PAVEXPress was developed by Pavia Systems, with generous sponsorship from the National Asphalt Pavement Association (NAPA), the Asphalt Pavement Alliance (APA), and a consortium of state asphalt pavement associations.

Designers must first determine the anticipated traffic for the parking lot and utilize this information to establish which table is appropriate for the project. For this report, three reliability levels (80, 90 and 99%) were considered to design pavement structure for light, moderate and heavy-duty traffic levels. A summary of design parameters are shown in Table A1.

Table A1. Summary of Design Parameters

<table>
<tr><th colspan="12">Design Parameters</th></tr>
<tr><td colspan="6">Design Period</td><td colspan="6">15 or 30 years</td></tr>
<tr><td colspan="6">Combined Standard Error (S_0)</td><td colspan="6">0.5</td></tr>
<tr><th colspan="12">Serviceability</th></tr>
<tr><td colspan="6">Initial Serviceability Index (p_i)</td><td colspan="6">4.5</td></tr>
<tr><td colspan="6">Terminal Serviceability Index (p_t)</td><td colspan="6">2</td></tr>
<tr><td colspan="6">Change in Serviceability ($\triangle$PSI)</td><td colspan="6">2.5</td></tr>
<tr><th colspan="12">Asphalt Layers</th></tr>
<tr><td colspan="4">Layer</td><td colspan="4">Layer Coef</td><td colspan="4">Drainage</td></tr>
<tr><td colspan="4">Surface</td><td colspan="4">0.42</td><td colspan="4">1</td></tr>
<tr><th colspan="12">BaseLayers</th></tr>
<tr><td colspan="3">Layer</td><td colspan="3">Layer Coef</td><td colspan="3">Drainage</td><td colspan="3">Resilient Modulus (psi)</td></tr>
<tr><td colspan="3">Aggregate Base</td><td colspan="3">0.1</td><td colspan="3">1</td><td colspan="3">20,000</td></tr>
</table>

For the purpose of this guide, light-duty traffic has been defined as a pavement that is exposed primarily to light-duty vehicles (passenger cars, SUVs, etc.) and occasional delivery trucks. These pavements typically experience 120,000 ESALs or less and/or fewer than 1,500 vehicles per day. The assumption for these structures is that the traffic stream will consist of 98 percent passenger vehicles and 2 percent single unit trucks. In situations where more truck traffic is expected, design tables for moderate traffic levels have been established. The assumed traffic stream for these pavements is 92 percent passenger vehicles with a mixture of single unit trucks (5 percent) and combination trucks (3 percent). Table A1 should be utilized when a moderate amount of single unit and combination truck traffic is expected, producing between 250,000 to 1 million ESALs (ADT from 700 to 3,000).

For the purposes of this guide, heavy duty pavements have been defined as those exceeding 1 million ESALs and having up to 8 million ESALs (ADT greater than 3,000 and less than 24,000). The assumed traffic stream for heavy duty pavements is 92 percent passenger vehicles with a mixture of single unit trucks (5 percent) and combination trucks (3 percent). Design of parking facilities with traffic in excess of the heavy-duty pavement category is beyond the scope of this guide and will require a more rigorous design. Please consult a qualified civil engineer with pavement engineering expertise.

APPENDIX B

Overview of Asphalt Mixtures in Missouri

In order to properly identify and specify asphalt mixtures in Missouri, you must first know the nomenclature and understand a few key parameters. This information is critical in specifying or reviewing asphalt mixtures for parking lot and roadway applications.

Traffic

The anticipated traffic for a parking lot or roadway is often quantified and expressed in Equivalent Single Axle Loads (ESALs). Depending on the number of ESALs anticipated for a 45-year design life, MoDOT has established four (4) traffic levels as shown in Section 403.1.2 of the MoDOT Standard Specifications.

- Design F – Under 300,000 ESALs
- Design E – Between 300,000 and 3 Million ESALs
- Design C – Between 3 Million and 30 Million ESALs
- Design B – Greater than 30 Million ESALs

Mixture Descriptions

Asphalt mixtures categories in Missouri include base mixtures, binder mixtures, and surface mixtures. Asphalt base mixtures refer to the lower layers of the pavement structure which typically utilize larger aggregates. These are rarely, if ever, used for Missouri parking lot facilities. Asphalt binder mixtures refer to the intermediate layer between the base and surface courses but are also rarely used in Missouri parking facilities. Asphalt surface mixtures are used in the top layers of the pavement and typically utilize smaller aggregates for smoothness and finer texture.

Nominal Maximum Aggregate Size

Asphalt mixtures are categorized based on the nominal maximum aggregate size (NMAS) which, in simplistic terms, is the largest size of aggregate utilized in that mixture. Surface mixtures in Missouri will have a NMAS size of 1/4 in. (4.375 mm) to 1/2 in. (12.5 mm), while binder mixtures utilize an aggregate size of 3/16 in. (4.75 mm) or 3/8 in. (9.5 mm). Base mixtures may range from 3/4 in. (19.0 mm) to 1 in. (25.0 mm) depending on the project and application. The specified aggregate size will influence the thickness of that lift of material. Generally, the layer thickness will be 4 times the NMAS with a minimum of 3 times the NMAS, and a maximum of 5 times the NMAS.

Base Mixtures

These are not recommended for use in routine parking lot designs, such as those specified in this guide.

Binder Mixtures

The binder mixture, which is an intermediate layer between the base and surface and for parking lots, is typically not used. If and when utilized, the most common binder mixture designations are as follows:

- Bituminous Pavement Mixture PG 64-22 (BP-2)
- Bituminous Pavement Mixture PG 64-22
- Bituminous Pavement Mixture PG 64-22 (BP-3)
- (Surface Leveling)

When selecting a binder mixture, the minimum lift thickness should be 1.5 inches per MoDOT EPG Section 450.3, but the use of a 1.5 inch minimum lift thickness is recommended to promote good density for parking lot applications.

Surface Mixtures

For the vast majority of light-duty parking lots across Missouri, the official MoDOT mixture designations for surface mixtures are as follows:

- Bituminous Pavement Mixture PG 64-22, (BP-1), commonly used for parking lot paving
- Bituminous Pavement Mixture PG 64-22, (BP-2), commonly used for parking lot paving
- Bituminous Pavement Mixture PG 64-22, (BP-3), rarely used for parking lot paving
- Bituminous Pavement Mixture PG 64-22, (Surface Leveling), rarely used for parking lot paving

The aggregate gradation requirements for these mixtures are specified in Sections 401.3 and 402.3 of the MoDOT Standard Specifications. Lift thicknesses for these mixes are specified in MoDOT EPG Sections 450.3 and 450.4, but the use of a 1.5-inch minimum lift thickness is recommended to promote good density for parking lot applications.

Asphalt Mix Design Review Checklist

Prior to the start of a paving project, the contractor is often required to submit a copy of the asphalt mixture design to the owner, owner's representative, architect, or engineer for review and approval. The following checklist outlines the key parameters that should be reviewed and considered during the mix approval process.

- Verify that the type of mixtures submitted matches the requirements set forth in the project proposal, plans or specifications (the contractor will need to submit separate designs for Base, Binder, and Surface mixtures).
  1. Confirm that the mixture designations for Base and Surface mixtures are appropriate for the project and application.
  2. Confirm the ESAL Class for the mixture.
  3. Confirm the nominal maximum aggregate size (NMAS).
  4. Verify that the plan grade (pay grade) of the mixture is PG 64-22. When using recycled materials such as RAP and RAS, the contractor may use a softer base binder (e.g. PG 58-28) to account for the stiffness contributed by the recycled materials.
  5. Check surface mixture designs versus the minimum asphalt content criteria.
- Review the proposed gradation (often called the Job Mix Formula or "JMF") for the proposed mixture to be sure these meet the gradation bands set forth by AASHTO M 323. According to Section 401.3, the following table provides the aggregate gradation for different mixtures.

Table B1. Aggregate Gradation for Asphalt Mix Types

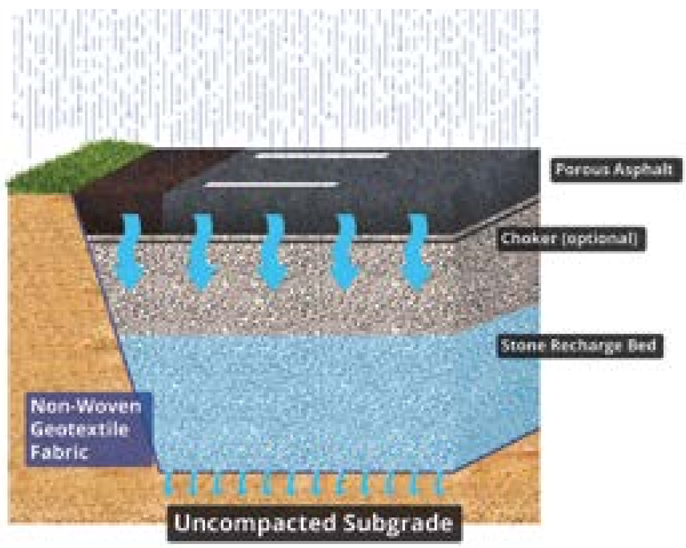
	Asphalt Mix-Type			
Sieve Size	Base	BP-1	BP-2	BP-3
1 in	100	100	100	100
3/4 in	85-100	100	100	100
1/2 in	60-90	85-100	95-100	100
3/8 in	---	---	---	100
No. 4	35-65	50-70	60-90	90-100
No. 8	25-50	30-55	40-70	---
No. 16	---	---	---	30-60
No. 30	10-35	10-30	15-35	---
No. 200	4-12	5-12	5-12	7-12

- Check to see that the design meets the minimum asphalt content criteria.
- When pavement density is required – calculate the maximum theoretical density by multiplying the average Maximum Specific Gravity (Gmm) of the mixture by 62.4 and record this number for reference. MoDOT Specification 401.7.8 requires a minimum of 92 percent in-place density; however, 94 percent is a better minimum to use for parking lots, as this will help slow down the primary deterioration modes, which are related to environmental effects.

APPENDIX C

Other Sustainable Features in Asphalt Pavement

Asphalt is a sustainable product and may provide significant benefits to owners when designing and building parking lots for building structures. The asphalt industry has been a leader in recycling and has been doing this for decades – long before green construction practices were given the consideration they are today. Through innovation and new technology, the asphalt industry is utilizing more recycled asphalt each year. Besides the recycling and other sustainability features covered in this report (RAP, RAS, WMA, GTR, and waste plastic), the industry contributes to Leadership in Energy and Environmental Design (LEED) and Low-Impact Design (LID) including porous asphalt pavements for storm water management.



Leadership in Energy & Environmental Design

The United States Green Build Council (USGBC) has developed Leadership in Energy and Environmental Design (LEED) as a certification and rating system for the design, construction, and operation of facilities which utilize sustainable features. The LEED system strives to achieve green solutions in areas such as energy savings, water efficiency, CO2 emission reductions, and stewardship of resources and environmental impact.

With decades of experience in recycling, the asphalt industry is well positioned to assist in this component of the LEED building system. More recently, the industry has made great strides and advancements in developing systems to address storm water management through porous pavement designs. Asphalt pavements can assist designers in achieving LEED credit points in a variety of categories through the use of both traditional and new features and technology.

Porous Asphalt Pavement

Porous asphalt pavements are designed to retain stormwater and, as a result, they are unique and different from conventional asphalt parking lots. These systems are comprised of a porous (open-grade) asphalt surface placed over a granular working platform on top of a reservoir of large stone. The reservoir layer is designed to have the storage capacity to hold water from storm events. Unlike a typical roadway or parking lot pavement where water is designed to be diverted away from the pavement, porous pavements allow the water to drain through. Properly designed and constructed porous asphalt pavement will provide a path and storage location for stormwater, a sustainable feature that will minimize any water discharge from the site and greatly reduce erosion and flash flooding. Projects that require LEED certification should be eligible for valuable credits when utilizing porous pavements. In addition, some local agencies may levy a stormwater fee for impervious areas that can be greatly reduced or eliminated with the use of a porous pavement system.

Designers should carefully consider porous pavements when stormwater management issues are critical and site conditions are conducive. These projects generally require fill and more material (stone aggregate base) and are therefore more expensive than a conventional parking lot pavement. The designer should also be aware of the soil types, site conditions, topography, and traffic to be certain that a porous pavement will perform in the given application. Because of the soil types common to Missouri, porous pavement will require a system to facilitate subsurface drainage.

NAPA has published a thorough and authoritative guide on the design of porous asphalt pavements. The Information Series 131 (IS-131) publication from NAPA will be beneficial for anyone involved in the design and construction of a porous pavement system. An excellent example of a highly sustainable parking lot design can be found on the American Society of Civil Engineering (ASCE) Foundation website. The ASCE Sustainable Parking Lot project involved a significant overhaul of the ASCE headquarters parking lot in Reston, VA, which was renovated in 2020 using low-impact development (LID) practices to reduce outflow and to improve stormwater quality discharged to the watershed. A sustainable asphalt mixture design provided by the Mizzou Asphalt Pavement and Innovation Laboratory (MAPIL) using recycled, Engineered Crumb Rubber (ECR) and RAP was also featured.

APPENDIX D

ASPHALT PAVING SAMPLE SPECIFICATION FOR LOW-VOLUME APPLICATIONS

PART 1 - GENERAL

1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 100

B. Specification Sections, apply to this Section.

2. SUMMARY

A. Related Sections include the following:

1. Division 200 Section "Earthwork" for aggregate subbase and base courses and for aggregate pavement shoulders.

3. SYSTEM DESCRIPTION

A. Provide asphalt paving according to materials, workmanship, and other applicable requirements of standard specifications of the Missouri Department of Transportation (MoDOT), except as modified herein.

1. Standard Specification: MoDOT Standard Specifications for Highway Construction, latest edition, and Supplemental Specifications to the Standard Specifications.
2. Additional Reference: Asphalt Institute MS-2
3. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

4. SUBMITTALS

A. Job-Mix Designs: For each job mix proposed for the Work.

5. QUALITY ASSURANCE

A. Asphalt Producer Qualifications: Engage a firm experienced in producing asphalt similar to that indicated for this project and with a record of successful in-service performance.

1. Producer firms shall be qualified through the MoDOT as an approved Asphalt Mix Producing Firm.

B. Testing and inspection: The owner shall retain a qualified testing laboratory for testing and inspection.

6. PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or frozen. Comply with the provisions of MoDOT Standard Specifications Section 401.7.1 for temperature requirements. Asphalt Pavement may be placed between November 15th and April 1st if the ambient temperature requirements are met or if approved by the architect/engineer.

PART 2 - PRODUCTS

1. AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: Sound, angular crushed stone, or crushed gravel, complying with MoDOT Standard Specifications Section 1004.2.

C. Fine Aggregate: Natural sand or sand prepared from stone, gravel, properly cured blast-furnace slag, or combinations there of complying with MoDOT Standard Specifications Section 1002.3.

D. Recycled (Reclaimed) Asphalt Pavement (RAP): milled or removed asphalt pavement may be utilized in accordance with MoDOT Standard Specifications Section 401.2.2.

2. ASPHALT MATERIALS.

A. Asphalt Binder: AASHTO MP 1, Performance Graded Binder PG 64-22 for general applications.

B. Tack Coat: Comply with provisions in MoDOT Standard Specifications Section 407.

3. MIXES

A. Asphalt: Hot-laid, asphalt plant mixes meeting the requirements of the Standard Specifications of (MoDOT) or Asphalt Institute (AI) MS-2 and complying with the following requirements:

1. Base Course: Produce MoDOT mixture designation Base (MoDOT Standard Specifications Section 401) or a Marshall mixture from AI MS-2. There shall be no restrictions on polish resistant aggregates. Recycled Asphalt Pavement (RAP) may be utilized in accordance with MoDOT Standard Specifications Section 401.2.2.
2. Surface Course: MoDOT mixture designation BP-1, BP-2, or BP-3 (MoDOT Standard Specifications Section 401) or a Marshall mixture from AI MS-2. There shall be no restriction on polish resistant aggregates. Recycled Asphalt Pavement (RAP) may be utilized in accordance with MoDOT Standard Specifications Section 401.2.2.

B. Asphalt: Hot-laid, asphalt plant mixes designed according to procedures established by (MoDOT) or Asphalt Institute (AI) MS-2 and complying with the following requirements.

1. Provide mixes complying with composition, grading, and tolerance requirements in MoDOT Standard Specifications or AI MS-2 for the following nominal, maximum aggregate sizes:
   a. Base Course: Mixture with a nominal maximum aggregate size of .75 inch (19 mm) with a minimum Voids in the Mineral Aggregate (VMA) of 12 percent.
   b. Surface Course: Mixture with a nominal maximum aggregate size of 0.38 inch (9.5 mm) with a minimum Voids in the Mineral Aggregate (VMA) of 14 percent.

PART 3 - EXECUTION

1. EXAMINATION

A. Verify that subgrade is dry and in suitable condition to support paving and imposed loads.

B. Proof-roll subbase using loaded dump trucks or heavy rubber-tired construction equipment to locate areas that are unstable or that require further compaction.

C. Proceed with paving only after unsatisfactory conditions have been corrected.

D. Repairs to Base Course: Fill excavated pavements with asphalt base mix and, while still hot, compact flush with adjacent surface.

E. Patching: Partially fill excavated pavements with asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, surface layer finished flush with adjacent surfaces.

2. SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

1. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.

B. Tack Coat: Comply with provisions in MoDOT Standard Specifications Section 407.

3. ASPHALT PLACING

A. Machine place asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Comply with applicable provisions of MoDOT Standard Specifications Section 401 for delivery, placement, spreading and compaction of the mixture.

1. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041 (MoDOT Specification 401.7.8).

4. INSTALLATION TOLERANCES

A. Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch (13 mm).
2. Surface Course: Plus or minus 1/2 inch (13 mm).
3. Design for a minimum fall of 1 percent to facilitate drainage (2 percent recommended).

Missouri Asphalt Pavement Association

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Jefferson City, MO 65110

https://moasphalt.org | Email: info@moasphalt.org | (573) 635-6071 | Fax: (573) 635-6134

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1208 S Kingshighway St, PO Box 637
Cape Girardeau, MO 63703
p: 573-331-7561
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Emery Sapp & Sons, Inc.
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www.emerysapp.com

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St. Joseph, MO 64502
p: 816-901-4081
www.herzog.com

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p: 816-364-3970
www.ideker.net

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www.nbwest.com

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Ottumwa, IA 52501
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www.norrisasphalt.com

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1620 Woodson Rd
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www.paceconstructionstl.com

Simpson Materials Company
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www.superiorbowen.com

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Lebanon, MO 65536
www.willardasphalt.com

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Fenton, MO 63026
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www.accuratepaving.com

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Pacific, MO 63069
p: 314-581-0462
www.availableasphalt.com

BuildPro STL Construction, Inc.
9921 Holtwick Lane
St. Ann, MO 63074
p: 314-499-8181
www.buildprostl.com

C&B Paving Co.
139 Brown Rd
St. Peters, MO 63376
p: 314-393-5844
www.cbasphaltpaving.org

Diversified Contractors
301 E Marceau St
St. Louis, MO 63111
p: 314-737-8327
www.diversifiedcontractorsinc.com

E. Meier Contracting
860 Westwood Industrial Court
Weldon Spring, MO 63368
p: 636-489-8064
www.emeier.com

Ford Asphalt Company
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Bridgeton, MO 63044
p: 314-291-2600
www.fordasphalt.com

Gevers Paving Company, Inc.
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O'Fallon, MO 63368
p: 314-393-0359
www.geverspaving.com

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Union, MO 63084
p: 636-584-7283
www.hotshotasphalt.com

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www.leritzbusybee.com

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www.lkeeley.com

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Seal-O-Matic Paving
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PO Box 9037
Riverside, MO 64168
p: 816-741-2646
www.sompaving.com

Tramar Contracting, Inc.
3051 Mercantile Industrial Dr.
St. Charles, MO 63301
p: 636-288-6213
www.tramarcontracting.com

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