Chapter 5

Parking Lot Design

GENERAL CONSIDERATIONS

The parking lot is the first - and the last - part of a building complex to be viewed by the user. It is the gateway through which all customers, visitors, and employees pass. This first impression is very important to the overall feeling and atmosphere conveyed to the user.

Developers want their new facilities to be attractive, well designed, and functional. Though many hours are spent on producing aesthetically pleasing building designs, the same design consideration for the parking area is often overlooked. Pavements in parking areas that are initially under-designed can experience excessive maintenance problems and a shortened service life.

When properly designed and constructed, parking areas can be an attractive part of the facility that is also safe, and most important, usable to the maximum degree. In addition, parking areas should be designed for low maintenance costs and easy modification for changes in use patterns.

The information in this chapter will provide a general guide to proper parking area design, construction, and facility layout. Minimum pavement thickness designs are given for various size parking lots, heavily-loaded areas, and industrial parking lots. In addition, this chapter gives comparable designs for both full depth asphalt pavements and asphalt over untreated aggregate base.

General Planning

In developing the parking area plan, several important details should be considered. First and foremost in the mind of the developer may be providing the maximum parking capacity in the available space while ensuring convenience and safety.

If the locality does not have a zoning ordinance identifying specific requirements for off-street parking, the general recommendations in Table 5-1 may be useful.

Rules have been developed for optimizing parking area space. Among them are the following:

1. Use rectangular areas where possible.
2. Make the long sides of the parking areas parallel.
3. Design so that parking stalls are located along the lot's perimeter.
4. Use traffic lanes that serve two rows of stalls.

Table 5-1. Recommended Parking Requirements

Land Use	Spaces/Unit
Residential	
Single-Family	2.0/Dwelling
Multifamily	
Efficiency	1.0/Dwelling
1 -2 Bedroom	1.5/Dwelling
Larger	2.0/Dwelling
Hospital	1.2/Bed
Auditorium/Theater/Stadium	0.3/Seat
Restaurant	0.3/Seat
Industrial	0.6/Employee
Church	0.3/Seat
College/University	0.5/Student
Retail	4.0/1000 GFA
Office	3.3/1000 GFA
Shopping Center	5.5/1000 GLA
Hotels/Motel	1.0/Room
	0.5/Employee
Senior High Schools	0.2/Student
	1.0/Staff
Other Schools	1.0/Classroom

GFA, sq. ft. of gross floor area
GLA, sq. ft. of gross leasable area

Special attention should be given to the flow of traffic in and out of the lot as well as circulating routes inside the lot. Keep entrances far away from busy street intersections and from lines of vehicles stopped at a signal or stop sign. Be sure that the entering vehicles can move into the lot on an internal aisle, thereby avoiding entering congestion caused by involvement with turning vehicles. A pedestrian traffic-flow study is important to provide information about both safety and convenience.

Parking Angle

The most popular angles for parking stalls are 60°, 45°, and 90° . The most common angle for parking is the 60° angle because of the ease of operation it provides. This angle permits reasonable traffic lane widths and eases entry and exit of the parking stall.

Where lot size restricts the dimensions available for aisles and stalls, a 45° angle may be used. The smaller change of direction required to enter and back-out of the stall space permits use of narrower aisles. The 45° angle reduces the total number of parking spaces for a given area but is the only acceptable angle for a herringbone parking lot pattern.

The 90° parking angle provides the most parking spaces for a given area. The high degree of difficulty for entering and leaving these parking stalls makes this type of parking more suited to all-day parking, such as employee parking. This angle is generally not preferred for "in and out" lots such as those of fast food restaurants and banks.

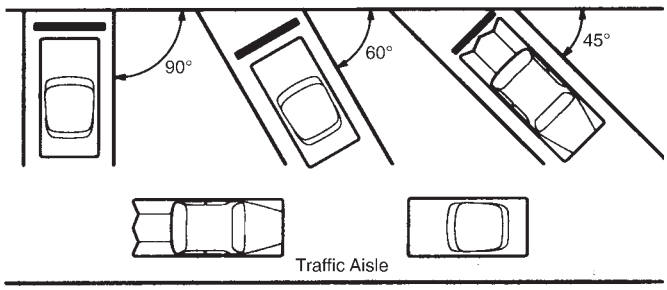


Figure 5-1. *Parking lot angles*

Parking Space Dimensions

Typical parking stall dimensions vary with the angle at which the stall is arranged in relation to the aisle. Stall widths (measured perpendicular to the vehicle when parked) range from 8-1/2 to 9-1/2 feet. The minimum width for public use parking spaces is 9 feet by 19 feet. Recommended stall dimensions for compacts and similar-sized vehicles are 7-1/2 feet by 15 feet. If a number of such spaces are to be provided, they should be grouped together in a prime area to promote their use. Stall widths for parking lots where shoppers generally have large packages, such as supermarkets and other similar parking facilities, should be 9-1/2 feet or even 10 feet wide.

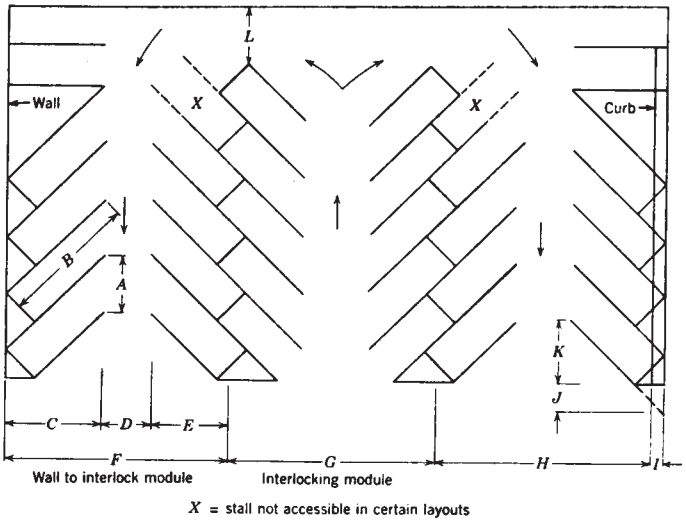


Figure 5-2.

Table 5-2. Parking layout dimensions (ft) for 9 ft stalls at various angles.

STALL LAYOUT ELEMENTS

Dimension	On diagram	45°	60°	75°	90°
Stall width parallel to aisle	A	12.7	10.4	9.3	9.0
Stall length of line	B	25.0	22.0	20.0	18.5
Stall depth to wall	C	17.5	19.0	19.5	18.5
Aisle width between stall lines	D	12.0	16.0	23.0	26.0
Stall depth, interlock	E	15.3	17.5	18.8	18.5
Module, wall to interlock	F	44.8	52.5	61.3	63.0
Module, interlocking	G	42.6	51.0	61.0	63.0
Module, interlock to curb face	H	42.8	50.2	58.8	60.5
Bumper overhang (typical)	I	2.0	2.3	2.5	2.5
Offset	J	6.3	2.7	0.5	0.0
Setback	K	11.0	8.3	5.0	0.0
Cross aisle, one-way	L	14.0	14.0	14.0	14.0
Cross aisle, two-way	M	24.0	24.0	24.0	24.0

Parking Lot Markings

Markings are a very important element of a good parking lot. The parking area should be clearly marked to designate parking spaces and to direct traffic flow. As specified in the Manual on Uniform Traffic Control Devices (MUTCD), parking on public streets should be marked out by using white traffic paint, except for dangerous areas, which should be marked in yellow.

However, yellow lines are commonly used in off-street parking lots. All pavement striping should be 4 inches in width.

New asphalt surfaces can be marked with either traffic paint or cold-applied marking tape. For best results with paint application, allow the Asphalt Concrete to cure for several days.

Construction Practices

Drainage Provisions

Drainage problems are frequently a major cause of parking area pavement failures. It is critical to keep water away from the subgrade soil. If the subgrade becomes saturated, it will lose strength and stability, making the overlying pavement structure susceptible to breakup under imposed loads.

Drainage provisions must be carefully designed and should be installed early in the construction process. Parking area surfaces should have a minimum slope of 2 percent or 1/4 inch per foot. They should be constructed so water does not accumulate at the pavement edge. Areas of high natural permeability may require an underdrain system to carry water away from the pavement substructure. Any soft or spongy area encountered during construction should be immediately evaluated for underdrain installation or for removal and replacement with suitable materials.

The use of Asphalt Concrete base (compared to use of untreated aggregate base) will greatly reduce the potential for problems related to water strength and stability.

Subgrade Preparations

All underground utilities should be protected or relocated before grading. All topsoil should be removed. Low-quality soil may be improved by adding granular materials, lime, asphalt, or other mixtures. Laboratory tests are recommended to evaluate the load-supporting characteristics of the subgrade soil. However, designs are frequently selected after careful field evaluations based on experience and knowledge of local soil conditions.

The area to be paved should have all rock, debris, and vegetation removed. The area should be treated with a soil sterilant to inhibit future flora growth. Grading and compaction of the area should be completed so as to eliminate yielding or pumping of the soil.

The subgrade should be compacted to a uniform density of 95 percent of the maximum density. This should be determined in accordance with Standard Proctor density (Test Method 103). The compaction requirement may substitute a specified number of diskings and roller coverages of each lift. When finished, the graded subgrade should not deviate from the required grade and cross section by more than 1/2 inch in 10 feet.

Prime Coat

An application of a low-viscosity liquid asphalt may be required over untreated aggregate base before placing the Asphalt Concrete surface course. A prime coat and its benefits differ with each application, and its use often can be eliminated. Discuss requirements with the paving contractor.

Asphalt Base Construction

The asphalt base course material should be placed directly on the prepared subgrade in one or more lifts. It should be spread and compacted to the thickness indicated on the plans. Compaction of this asphalt base is one of the most important construction operations contributing to the proper performance of the completed pavement. This is why it is so important to have a properly prepared and unyielding subgrade against which to compact. The asphalt base material should meet the specifications for the mix type specified.

Untreated Aggregate Base Construction

The untreated aggregate base course should consist of one or more layers placed directly on the prepared subgrade. It should be spread and compacted to the uniform thickness and density as required on the plans. The minimum thickness of untreated aggregate is 4 inches. The aggregate material should be of a type approved and suitable for this kind of application.

It should be noted that an untreated aggregate base is sensitive to water in the subgrade. The pavement failures associated with water in the subgrade are accelerated if an untreated base allows water to enter the pavement structure.

Tack Coat

Before placing successive pavement layers, the previous course should be cleaned and a tack coat of diluted emulsified asphalt should be applied if needed. The tack coat may be eliminated if the previous course is freshly placed and thoroughly clean.

Asphalt Concrete Surface Course

Material for the surface course should be an Asphalt Concrete mix placed in one or more lifts to the true lines and grade as shown on the plans. The plant mix material should conform to specifications for Asphalt Concrete.

The asphalt surface should not vary from established grade by more than 1/4 inch in 10 feet when measured in any direction. Any irregularities in the surface of the pavement course should be corrected directly behind the paver. As soon as the material can be compacted without displacement, rolling and compaction should start and should continue until the surface is thoroughly compacted and all roller marks disappear.

THICKNESS DESIGN FOR PARKING LOTS

Design thicknesses given in this section are minimum values calculated on the volume and type of traffic that will use the facility and on the load-supporting capability of the underlying soils. For additional soil class information, refer to Chapter 3.

Special truck lanes are sometimes required to expedite traffic to loading areas, trash dumpster sites, and equipment areas. Design thicknesses for these lanes or pavement areas should be increased. Drainage problems are also a major cause of pavement failures. Their significance warrants a special section on drainage that should be reviewed before selecting a pavement design either from this guide or from any other source.

Design Procedure

Tables 5-3 through 5-6 can be used directly to select design thicknesses for a number of design input factors. To use the tables, appropriate traffic and subgrade classes must be selected as follows.

Design Steps

The following steps can be used to determine a pavement thickness.

1. Using the number of parking spaces to be marked, select the traffic class (less than 50 spaces, 50 to 500, more than 500, or industrial) to be used. Determine if any areas will receive heavy truck traffic.
2. Using soil data from the project, select a subgrade class (good, moderate, or poor) from Chapter 3. If no soil information is known, use the poor classification for the subgrade. (If the CBR value for the soil lies between the values given, use the lower classification.)
3. Using the selected traffic class and subgrade class, select a design thickness from Tables 5-3, 5-4, or 5-6. Use Table 5-5 to design heavily-loaded areas.

Design Example

- A new department store wishes to place a 350-car parking lot in front. A truck loading zone and dumpster site will be placed in back. From Chapter 3, traffic class II is selected.
- No soil data are known, so the engineer selects the poor soil classification.
- The total full-depth asphalt design thickness selected from Table 5-4 for the parking lot is 6-1/2 inches; the base course is 5 inches, and the surface course is 1-1/2 inch. The total full-depth asphalt design thickness selected from Table 5-5 for the truck loading zone and approaches is 8 inches; the base course is 6 inches and the surface course is 2 inches.

Pavement Thickness Tables

The pavement thickness for parking lots should be in accordance with the following tables:

Table 5-3. Thickness Chart: Parking Lots with Less Than 50 Spaces

A. For Asphalt Concrete Base Pavements

Design Criteria*			Thickness in Inches Asphalt Concrete		
Traffic Class (Spaces)	Subgrade Class	CBR	Base	Surface	Total
I (<50 spaces)	Good	9	3.0	1.0	4.0
	Moderate	6	3.5	1.0	4.5
	Poor	3	4.0	1.0	5.0

B. For Untreated Aggregate Base Pavements

Design Criteria*			Thickness in Inches		
Traffic Class (Spaces)	Subgrade Class	CBR	Untreated Aggregate Base	Asphalt Concrete Surface	Total
I (<50 spaces)	Good	9	4.0	3.0	7.0
	Moderate	6	4.0	3.0	7.0
	Poor	3	6.0	3.0	9.0

**See chapter 3 for traffic and soil class details*

Table 5-4. Thickness Chart: Parking Lots with More Than 50 Spaces

A. For Asphalt Concrete Base Pavements

Design Criteria*			Thickness in Inches Hot Mix Asphalt		
Traffic Class (Spaces)	Subgrade Class	CBR	Base	Surface	Total
II (50-500 spaces)	Good	9	3.0	1.0	4.0
	Moderate	6	3.5	1.5	5.0
	Poor	3	4.5	1.5	6.0
III (500 & Above spaces)	Good	9	3.5	1.5	5.0
	Moderate	6	4.5	1.5	6.0
	Poor	3	5.5	1.5	7.0

B. For Untreated Aggregate Base Pavements

Design Criteria*			Thickness in Inches		
Traffic Class (Spaces)	Subgrade Class	CBR	Untreated Aggregate Base	Asphalt Concrete Surface	Total
II (50-500 spaces)	Good	9	4.0	3.0	7.0
	Moderate	6	6.0	3.5	9.5
	Poor	3	8.0	3.5	11.5
III (500 & Above spaces)	Good	9	6.0	3.0	9.0
	Moderate	6	8.0	3.5	11.5
	Poor	3	8.0.	4.0	12.0

**See chapter 3 for traffic and soil class details*

Heavily-Loaded Areas

The pavement for entrances, frontage roads, trash dumpster sites, and delivery truck parking, as well as the approach areas to these spaces, must be increased in thickness to prevent pavement failure caused by the weight and dynamic loading. These areas should be constructed with full-depth asphalt in a thickness that will support this special type of pavement loading. Failure to provide this strengthening can result in severe pavement failure. The pavement thickness for these areas should be in accordance with the following table:

Table 5.5. Thickness Chart: Heavily-Loaded Areas in Parking Lots

Design Criteria*			Thickness in Inches Asphalt Concrete		
Traffic Class	Subgrade Class	CBR	Base	Surface	Total
I-III	Good	9	4.0	2.0	6.0
(Up to 20 heavy	Moderate	6	5.0	2.0	7.0
trucks per day)	Poor	3	6.0	2.0	8.0

**See chapter 3 for traffic and soil class details*

Note: Untreated aggregate base courses are not recommended for industrial parking lots or for parking areas for heavy trucks.

Industrial Parking Lots

Industrial parking lots and those designed primarily for trucks require a thicker design than the other lots described in this chapter. Because of heavy loads associated with trucks, it is not recommended that untreated aggregate base courses be used. The pavement thickness for truck lots should be in accordance with the following table:

Table 5.6. Thickness Chart: Heavily-Loaded Areas in Parking Lots

Design Criteria*			Thickness in Inches Asphalt Concrete		
Traffic Class (ADT	Subgrade Class	CBR	Base	Surface	Total
IV	Good	9	5.5	2.0	7.5
(20 to 200 trucks	Moderate	6	6.5	2.0	8.5
per day)	Poor	3	6.5	3.0	9.5

**See chapter 3 for traffic and soil class details*

PLANNED STAGE CONSTRUCTION

Planned stage construction is a means of providing fully adequate pavements with the effective use of funds, materials, and energy. As defined, it is the construction of an Asphalt Concrete parking lot or roadway in two or more stages, separated by a predetermined interval of time. In many situations, building pavements by stages makes good economical sense. It is a technique long used by city and highway engineers.

Stage Construction is not maintenance. It is the placement of a minimum depth of pavement during initial construction, and a final surface course placed at a planned future date. Asphalt Concrete lends itself to this kind of construction.

As an example, the owner of a new department store with a 350-car parking lot, for financial reasons, decides to stage construct the 6-1/2" full-depth asphalt parking lot. Stage 1 is constructed at the time the store is built. A total depth of 5" of asphalt concrete is placed. Stage 2, consisting of the final surface course of 1-1/2", will be placed at a set time in the future. The truck loading zone and dumpster site are paved the full depth during initial construction.

Stage construction has the advantage of providing a thoroughly adequate, all-weather pavement for the initial development of an area. Any damage to the Stage 1 pavement caused by traffic, settlements, or utility tearups can be repaired prior to placement of the final surface. With a proper asphalt tack coat, where needed, the Stage 2 pavement bonds to the old surface and becomes an integral part of the entire pavement structure.

ASPHALT CONCRETE CURB

Asphalt curbs have become increasingly popular as accessories to paving because they are: (1) economical and easy to construct; (2) can be built much faster than other types; (3) are not affected by ice- and snow-melting chemicals; and (4) can be laid on an existing pavement using a slip form paver.

Many parking facilities have some form of curbing around the perimeter for both functional and aesthetic reasons. The curbs control drainage, delineate the pavement edge, prevent vehicular encroachment on adjacent areas, and enhance the parking lot.

Curb Mixture

The method of mixing the Asphalt Concrete and the composition of the mixture must conform with IDOT Specification 2303, 2304, or an approved commercial mix. The bitumen content should be modified as necessary to produce a suitable mixture for Asphalt Concrete curb construction. Curb mixes that are proportioned using the mixture sizes of 3/8- or 1/2-inch have proven to be most satisfactory and are recommended for curb construction in Iowa.

The addition of 10 to 25 pounds of powdered asphalt per ton of mix will produce an exceptionally tough and durable curb. The asphalt cement used in the mix should be reduced on a pound-for-pound basis when powdered asphalt is added to the mixture. The temperature of the mixture at the time of mixing and laying should range from 250° F to a maximum of 300° F.

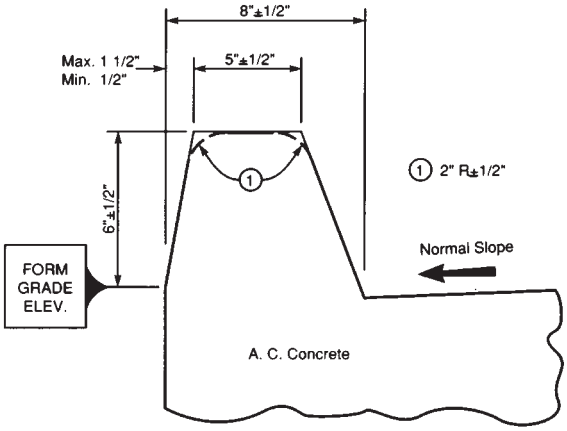
Curb Construction

Before curb construction begins, the placement area must be cleaned thoroughly. A tack coat must be applied to the pavement surface at a maximum rate of 0.10 gallons per square yard.

The Asphalt Concrete curb must be laid true to the specified line, profile, and cross section with an approved self-propelled curb-laying machine. The mixture must be fed to the hopper of the machine directly from the truck with a chute or conveyor, or it should be shoveled by hand into the hopper.

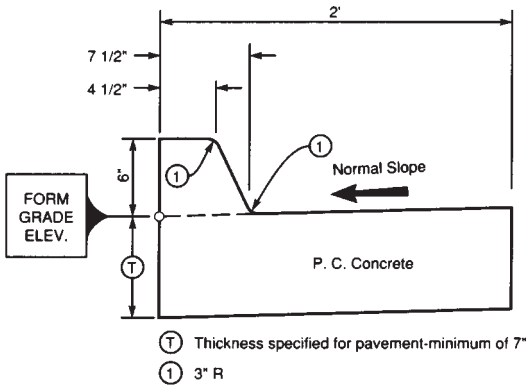
Asphalt Concrete curbs should be backed with earth fill or by constructing a double line of curb and filling the median with compacted asphalt mix.

The following illustrates two basic types of systems – Asphalt Concrete curbs and Portland Cement Concrete curb and gutter.



Details of 6" Extruded Curb
(A. C. Concrete)

Figure 5-3.



Details of 2' P. C. Concrete
Curb and Gutter Unit
Adjacent to ACC Pavement

Figure 5-4. *Typical curb sections*

ASPHALT MAT-PLATFORM FOR BUILDING CONSTRUCTION AND SITE PAVING

Site paving is the recommended first step in many types of building construction projects. It offers several advantages as a working mat or platform before building construction begins for shopping centers, schools, manufacturing concerns, warehouses, and similar facilities.

In this technique, an Asphalt Concrete base course is constructed on a prepared subgrade over the entire area that will become parking areas, service roadways, and buildings. When building construction is completed, a final Asphalt Concrete surface course is placed on the asphalt base.

Advantages

Paving a building site before construction is completed has several benefits. These include the following:

1. It ensures constant accessibility and provides a firm platform upon which people and machines can operate efficiently, speeding construction.

2. It provides a dry, mud-free area for construction offices, materials storage, and worker parking, eliminating dust control expenditures.

3. It eliminates the need for costly select material—the asphalt subfloor ensures a floor slab that is dry and waterproof.

4. Steel-erection costs can be reduced because a smooth, unyielding surface results in greater mobility for cranes and hoists.

5. The engineer can set nails in the asphalt pavement as vertical- and horizontal-control points, effectively avoiding the risk of loss or disturbance of this necessary survey work.

6. Excavation for footings and foundations and trenching for grade beams can be accomplished without regard for the asphalt base.

Construction Practices

Subgrade Preparation

All vegetation (including root systems), rocks, debris, and topsoil should be removed from the area to be paved. To prevent future growth, the subgrade should be treated with an approved soil sterilant. Install drainage and utility facilities; backfill and compact. Adjustments in utilities or underground facilities can be readily accomplished through the asphalt base should changes occur.

The subgrade must be properly shaped to meet true lines and elevations. It must be compacted to not less than 95 percent of maximum laboratory density. The surface of the compacted subgrade must not deviate by more than 3/4 inch from the established grade. A minimum slope of about 2 percent or 1/4 inch per foot should be maintained to provide adequate drainage of surface water from the finished pavement.

Areas that show pronounced deflection under construction traffic indicate instability in the subgrade. If reworking and additional rolling do not correct the situation, the area soil must be removed, replaced with suitable material, and compacted. The use of asphalt-treated base or coarse granular material is recommended.

Base-Platform Construction

Asphalt Concrete Base Material must be placed on the prepared subgrade. A base of 4 inches or less in depth should be placed in one lift. A base of a total thickness of more than 4 inches may be placed in two or more lifts with the bottom lift being a minimum of 3 inches. The material must be spread and compacted to the required thickness and density as specified and in the grades and dimensions shown on the plans.

The surface of the base must not deviate more than 1/2 inch when measured with a 10-foot straight edge.

Surface Course Construction

After building construction is essentially completed, and all building materials and offices have been removed from the previously paved base, preparation for placement of the final surface course of Asphalt Concrete can begin. Should building operations or winter weather delay placement of the final surface, the Asphalt Concrete base will adequately serve traffic needs during the interim.

Preparation for the surface course requires thorough cleaning and sometimes washing of the asphalt base to remove tracked-on dirt and foreign particles. After cleaning, any cracked or broken areas in the base should be removed, replaced with bituminous mix, and thoroughly compacted. All manholes, valve boxes, and other pavement fixtures should be brought to finished grade.

The hot mix asphalt surface course consists of one or more layers placed on the previously constructed Asphalt Concrete base course. The material must be spread and compacted to the required thickness and in the grades and dimensions shown on the plans.

The finished surface must not deviate more than 1/4 inch when measured with a 10-foot straight edge.

Tack Coat

Before placing the surface course, the base course should be cleaned thoroughly. If needed, a tack coat of diluted emulsified asphalt may be applied for bonding.