

# 400 Flexible Pavement Design

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### 400.1 Introduction

Flexible pavement design is based on the concept of Structural Number. The Structural Number is a regression coefficient expressing the structural strength of a pavement required for given combinations of soil support ( $M_r$ ), traffic loading, and terminal serviceability. Flexible pavements can be constructed with Superpave mixes, stone mastic mixes, contractor designed mixes, or ODOT mixes; however, regardless of the mix design method used, the ODOT/AASHTO method of pavement design calculates the same required Structural Number. Once the Structural Number is determined, the flexible buildup is determined by using the appropriate structural coefficient for ODOT specification materials. Alterations to ODOT's Construction and Material Specifications (C&MS) for asphalt concrete may require adjustments to the procedures described herein.

Additional information on flexible pavement and proper construction practices can be found in the Construction Inspection Manual of Procedures published by the Office of Construction Administration.

### 401 Design Parameters

Flexible pavement design is based on relatively few input parameters. Serviceability, traffic loading (ESAL), subgrade stiffness ( $M_r$ ), reliability and overall standard deviation have all been discussed in Section 200. Structural Coefficient is the only new parameter. Structural Coefficients for ODOT asphalt concrete material specifications are found in Figure 401-1.

### 402 Structural Number Determination

All of the design input information is required prior to determination of design thickness. Structural Number (SN) is determined using the nomographs found in Figures 402-2 and 402-3. An example flexible pavement design is provided in Figure 402-1.

#### 402.1 Ramps and Interchanges

If traffic and soils data is available, ramps, collector-distributor lanes, directional roadways, etc., may be designed individually. More common is to use the same thickness as the mainline or reduce the mainline thickness by 1-inch (25 mm).

### 403 Typical Section and Buildup Considerations

#### 403.1 Typical Section Design

Regardless of the SN required, a buildup which includes an aggregate base (Item 304) will generally provide better performance than an asphalt-on-subgrade buildup. The aggregate base is less sensitive to moisture than the subgrade and it separates the pavement further from the subgrade. An aggregate base is recommended under all flexible pavements and particularly when the thickness of a full depth flexible design is very thin, approximately 5 inches (130 mm) (SN ~ 1.8) or less.

All surface and intermediate courses should be specified in 0.25 inch (5 mm) increments. Items 301 and 302 should be specified in 0.5 inch (10 mm) increments. Item 304 is typically placed at 6 inches (150 mm) thick. The minimum thickness for Item 304 is 4 inches (100 mm) and it should be specified in 1 inch (25 mm) increments.

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When designing a flexible pavement, some consideration should be given to reducing the total number of separate lifts required. This can be accomplished by keeping in mind the maximum and minimum lift thicknesses for all of the materials involved. Maximum and minimum lift thicknesses can be found in the C&MS, or Section 406 or Figure 406-1 of this Manual.

### **403.2 Shoulder Buildups**

Shoulders are used to provide an area for the accommodation of disabled vehicles, for the lateral support of the base and surface courses, to improve the safety of a highway, and for future maintenance of traffic operations during maintenance and rehabilitation work.

Shoulders for flexible pavements should be constructed of the same materials and thicknesses as the driving lanes' pavement whenever a paved shoulder is required. This provides for the ability to have a hot longitudinal joint at the pavement-shoulder interface, provides a stable temporary pavement for maintenance of traffic lane shifts, and reduces the complexity of construction. Using other types of shoulders, such as surface treated, stabilized aggregate, or turf shoulders should be in accordance with the Location & Design Manual, Volume One - Roadway Design. Regardless of the type of shoulder used, the base and subgrade should be designed to drain water away from the pavement, rather than towards it. Examples of typical sections depicting flexible pavement with different types of unpaved shoulders are located in Figure 403-1. Also refer to the Location & Design Manual, Volume 2 - Drainage Design and the Sample Plan Sheets.

### **403.3 Edge Course Design**

For proper quantity calculations, each lift of pavement and base below the intermediate course must be shown wider than the lift above, creating a stair step look. A lift is the thickness of material placed in one pass. Maximum lift thicknesses for the various materials are found in the C&MS, or Section 406 or Figure 406-1 of this Manual. When a layer of material exceeds the maximum lift thickness it will be placed in two lifts. The designer should assume the two lifts will be approximately equal thickness. If a layer requires three lifts, it should be assumed that the lifts will be approximately equal thickness.

Surface and intermediate courses should be shown ending in a vertical plane at the outside edge of the surface course. The lift immediately below the intermediate course should be shown extending 4 inches (100 mm) beyond the edge of the intermediate course or a distance equal to the combined thickness of the surface and intermediate course, whichever is greater. All other lifts of Items 301, 302, and 304 should be shown extending 6 inches (150 mm) beyond the overlying lift or extending the thickness of the overlying lift, whichever is greater.

For concrete curbed sections, the asphalt is paved to the face of the curb. Where the bottom courses of the asphalt pavement buildup lie below the depth of the curb base, those lifts should be placed as a foundation for the curb and should have the proper edge course design as discussed above.

## **404 Asphalt Concrete Acceptance**

One of the most important concepts to understand when selecting asphalt concrete materials is the acceptance method used in construction. There are three different acceptance methods hereinafter referred to as 403 acceptance, 446 acceptance and 448 acceptance. It is important that the designer understand the different acceptance methods and when they apply. In many cases, the materials required in two different pay items are identical, the only difference being the acceptance method. For example, Item 446 Asphalt Concrete Surface Course, Type 1, PG64-22 is the exact same material as Item 448 Asphalt Concrete Surface Course, Type 1, PG64-22, the only difference is the acceptance method.

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The 403 acceptance is the default acceptance for all asphalt concrete items not using 446 or 448 acceptance. It is never explicitly specified in the plans or the item descriptions as it is inherent to the specifications. The 403 acceptance is based on asphalt binder content and gradation only and does not include density. The C&MS details the method the contractor must use to compact the pavement. If the method is followed, the pavement is accepted regardless of the actual density achieved. The 403 acceptance is used for all asphalt concrete base items.

The 446 acceptance is a density acceptance method. It requires cores be taken and measured for density. If the pavement is over or under compacted, the contractor is assessed a penalty or, in some cases, forced to remove and replace the material. Proper density is important to the long term performance of the pavement. Items with 446 acceptance give ODOT more assurance that proper density will be achieved. However, in order to give the contractor the opportunity to achieve proper density, items with 446 acceptance must be placed on a level surface and at a uniform thickness. If the surface is not level and/or the thickness not uniform, it is impossible to evenly compact the material and achieve the proper density.

The 448 acceptance includes asphalt binder content and gradation and usually density acceptance. It automatically requires density acceptance using Supplement 1055 under certain conditions. When Supplement 1055 is not required, 448 acceptance defaults to 403 acceptance.

When 448 acceptance is specified, Supplement 1055 is automatically invoked on surface and intermediate courses if the material being placed exceeds the minimum thickness and is being placed at a uniform thickness. Supplement 1055 is a less stringent density requirement than 446 acceptance. It assures the department of a minimum level of compaction but does not challenge the contractor to achieve optimum compaction or avoid over-compaction like 446 acceptance. For thin courses, variable depth courses, and courses placed on uneven surfaces, 448 acceptance does not invoke Supplement 1055. When Supplement 1055 is not required, 448 acceptance defaults to 403 acceptance.

Items with 448 acceptance, with or without Supplement 1055, are typically used in lower traffic volume situations where the risk of pavement distresses resulting from lack of density is not as great.

## 404.1 Acceptance Guidelines

The following guidelines are provided to assist in selecting materials with the proper acceptance type for all surface and intermediate courses. All surface and intermediate courses require either 446 or 448 acceptance. Thin or variable depth surface and intermediate courses specifying 448 acceptance will automatically default to 403 acceptance. The 446 acceptance should not be used with variable depth courses except as outlined below. All asphalt concrete base courses, Items 301 and 302, use 403 acceptance and the following guidelines do not apply.

- Specify items with 446 acceptance for all projects with greater than 500 cubic yards (500 cubic meters) of 12.5mm surface course or Type 1H surface course.
- Specify items with 446 acceptance for all priority system minor rehabilitation projects.
- Specify items with 446 acceptance for all projects where the surface and intermediate courses combined exceed 2000 cubic yards (1500 cubic meters).
- Specify items with 448 acceptance for all projects where 446 acceptance is not required.

For projects which require 446 acceptance, it is permissible to use variable thickness at bridges and ramps to taper down to the required elevation. ODOT construction and testing staff will test only the areas constructed as uniform thickness and skip testing the short areas with variable thickness. This

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eliminates any need for an additional pay item yet still allows the proper material with the proper acceptance to be used.

Where an item with 446 acceptance is specified for the surface course, it is recommended the intermediate course also use 446 acceptance except where a uniform lift thickness is not possible such as a variable depth course for crown correction. It is permissible to use a variable depth course with 403 acceptance below a surface and/or intermediate course with 446 acceptance. The variable depth course should specify an item with 448 acceptance as it will default to 403 acceptance.

### **405 Superpave Asphalt Concrete**

Superpave mixes are intended for use on all heavy traffic pavements, defined as greater than 1500 trucks in the opening day traffic. Superpave mixes are not necessary on lower traffic pavements although some districts have been instructed to use superpave mixes due to localized material problems.

Superpave Type A and B requirements are found in C&MS 442. They control gradation bands and aggregate angularity. Type A has higher crush requirements that may mean the importation of aggregate in some areas of the state but provides the most rut resistance. Type B has less restrictive crush requirements. Type A mixes are preferred except where superior rut resistance is not necessary and importation of aggregate would be cost-prohibitive. District testing and construction personnel knowledgeable in materials should be consulted prior to selection of Type A or B.

Pay item descriptions for superpave items contain a reference to the nominal maximum aggregate size used in the mix. Accordingly, the 9.5mm, 12.5mm, and 19mm designations are used for superpave mixes. This reference to the nominal maximum aggregate size replaces the reference to Type 1, Type 1H, and Type 2, respectively, used in non-superpave specifications, has nothing to do with any other measurement, and is used in English and metric plans.

The pay item descriptions for superpave items indicate the acceptance method by the number in parentheses. The designer should follow the guidance in Section 404 to select the proper acceptance method.

### **406 Lift Thickness and Usage Guidelines**

ODOT asphalt concrete specifications contain gradation requirements for all items. For optimum performance of the pavement system, it is important to design the various lifts of asphalt concrete items in order to achieve maximum smoothness, durability, and densification. In order to do this, some constraints are required regarding maximum and minimum lift thicknesses in relation to the gradation of the item specified. Due to lift thickness restrictions, typical sections which require heavy mix designs should avoid specifying overlay thicknesses between 2.5 inches (65 mm) and 3.25 inches (83 mm).

There are many different asphalt concrete specification items available. The differences between the items are sometimes subtle but always important. Understanding these subtleties and why they are important can help the designer select the proper item for the proper application. The specifications themselves and any designer notes should also be consulted for additional guidance.

#### **406.1 Surface Courses**

The designation of surface course refers to the layer's relative position in the pavement buildup. Surface courses are the top layer of asphalt concrete placed in a flexible pavement, with rare exceptions. In general, surface courses have the finest gradation, highest binder content, and strictest quality control requirements to provide a dense, smooth, durable surface. As a result, surface courses are typically the most expensive layer in the flexible pavement structure.

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There are two instances where a surface course is not the top layer: 7-year warranty asphalt concrete and open graded friction courses. In 7-year warranty asphalt concrete, the entire pavement structure is specified as Item 880 Asphalt Concrete (7-year Warranty) although the top layer is still generally referred to as the surface course. When using an open graded friction course, Item 803, it is placed on top of a surface course, making it the top layer.

All surface courses should be specified in 0.25-inch (5 mm) increments.

## **406.1.1 Items 446 & 448 Asphalt Concrete Surface Course, Type 1, PG64-22**

These items are for Medium or Light traffic (see PN 417 and 418). Lift thickness can be 1.25 inches (32 mm) or 1.5 inches (38 mm). A 1-inch (25 mm) lift may be used, however 1.25 inches (32 mm) is the preferred minimum. If 446 is specified a uniform thickness is required.

## **406.1.2 Item 442 Asphalt Concrete Surface Course, 9.5mm, Type A & B (446 & 448)**

This item is the superpave version of surface course Type 1 for Medium and Light traffic. This item exists for those districts required to use superpave mixes on medium and low traffic routes. The requirements of Section 406.1.1 apply.

## **406.1.3 Item 442 Asphalt Concrete Surface Course, 12.5mm, Type A & B (446 & 448)**

This item is the superpave surface course for Heavy traffic (ADTT>1500, see PN 416) applications. The 12.5mm mix is designed for maximum rut resistance at 1.5 inches (38 mm) thick. The surface course is generally the most expensive layer and an increased thickness may not be economical. In special situations where an intermediate course is not possible, the 12.5mm mix may be specified up to a maximum of 2.5 inches (65 mm). A 12.5mm mix cannot be placed properly at a thickness less than 1.5 inches (38 mm); durability and constructability problems will result. Best practice is to use 1.5 inches (38 mm).

All projects which require a quantity greater than 500 cubic yards of 12.5mm surface course should specify 446 acceptance for the surface course. Items with 446 acceptance are to be specified only in uniform thickness.

## **406.1.4 Items 446 and 448 Asphalt Concrete Surface Course, Type 1H**

These items are the non-superpave equivalents of Item 442 Asphalt Concrete Surface Course, 12.5mm. The requirements of Section 406.1.3 apply. These items are rarely used, as heavy traffic locations should use superpave items. These may be used in small quantity applications where a superpave mix is not economical.

Type 1H will not have a performance grade (PG) asphalt binder specified in the pay item. All standard Type 1H mixes are designed using PG70-22M binder with SBS or SBR polymer modifiers.

## **406.1.5 Item 443 Stone Matrix Asphalt Concrete, 12.5mm, PG70-22M & PG76-22M (446)**

Stone matrix asphalt (SMA) concrete is a highly rut-resistant mix intended as a surface course for high stress areas and is often used for Amish buggy routes. SMA uses 446 acceptance therefore a uniform lift thickness is required. The minimum lift thickness is 1.5 inches (38 mm). Maximum lift thickness is 2 inches (50 mm). SMA is not recommended for intermittent paving. The minimum recommended placement is one mile (1.6 km) of continuous paving or 250 cubic yards (250 cubic meters) however there may be situations where smaller quantities are justified.

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## 406.2 Intermediate Courses

Intermediate courses are placed on top of base courses and below surface courses. Intermediate courses provide additional structural capacity and level the base course to allow a smooth surface course. Intermediate courses can be used for extended periods of time for maintenance of traffic.

All intermediate courses should be specified in 0.25-inch (5 mm) increments.

### 406.2.1 Item 446 Asphalt Concrete Intermediate Course, Type 1, PG64-22

This item is for the intermediate course in pavement overlay situations where the total overlay thickness is less than 3 inches (75 mm). Type 1 material is required because of the thin layer. Lift thickness for this item can be as thin as 1 inch (25 mm) and as thick as 1.5 inches (38 mm). Item 446 is to be specified only in uniform thickness. Because Type 1 mixes typically exhibit less stability than Type 1H or Type 2, this item is not recommended for high stress or heavy traffic locations. Best practice is to increase the overlay thickness, with or without planing the existing surface, and use a Type 2 intermediate course.

This item is not to be used in combination with a Type 1H surface course.

### 406.2.2 Item 442 Asphalt Concrete Intermediate Course, 19mm, Type A & B (446)

This item is a superpave intermediate course. The gradation of this mix requires the lift to be at least 1.75 inches (45 mm) thick. In special circumstances it is possible to allow this lift to be as thin as 1.5 inches (38 mm), but this is discouraged. Due to the 446 acceptance, this item is to be specified only in uniform thickness.

Caution is advised when determining the use and thickness of this Item. ODOT C&MS specifies a maximum compacted lift of 3 inches (75 mm). For example, the contractor must place a 3.5-inch (90 mm) layer in two lifts of 1.75 inches (45 mm). It is best to avoid specifying layers between 3 inches (75 mm) and 3.5 inches (90 mm) due to the 1.75 inch (45 mm) minimum lift thickness requirement. For most situations, the total thickness should not exceed 4.5 inches (115 mm), as it would be better to introduce the additional thickness into the 301 or 302, or possibly the 304 base.

### 406.2.3 Item 446 Asphalt Concrete Intermediate Course, Type 2, PG64-28 & PG64-22

This item is the non-superpave equivalent of Item 446 Asphalt Concrete Intermediate Course, 19mm, Type A & B (446). The requirements of Section 406.2.2 apply.

Specify PG64-28 for projects which have a Type 1H surface mix, otherwise specify PG64-22.

### 406.2.4 Item 448 Asphalt Concrete Intermediate Course, Type 1, PG64-28 & PG64-22

This item is intended primarily as a scratch course. Uniform lift thickness for this item can be as thin as 1 inch (25 mm) and as thick as 1.5 inches (38 mm). This item can be used as a variable thickness course. For some rare occasions, when this lift is used as a leveling or wedge course, it may be practical to stretch the lift thickness past the 1.5 inch (38 mm) limit. For situations where the variability of the course thickness is excessive, say 0 inches to 2 inches (0 mm to 50 mm), consideration should be given to pavement planing to allow for the use of a Type 2 mix which provides more stability than a Type 1 mix. This item can be tapered to 0 inches (0 mm) and placed at non-uniform thickness less than the minimum lift thickness.

For projects using 446 acceptance for the surface course but need this type of a leveling or wedge, there is nothing wrong with placing an intermediate course with 448 acceptance under a surface

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course with 446 acceptance. This item is not to be used as uniform thickness layer underneath a Type 1H surface.

Specify PG64-28 for projects which have a Type 1H surface mix, otherwise specify PG64-22.

### **406.2.5 Item 442 Asphalt Concrete Intermediate Course, 9.5mm, Type A & B (448)**

This item is the superpave version of Item 448 Asphalt Concrete Intermediate Course, Type 1, PG64-28. The requirements of Section 406.2.4 apply.

### **406.2.6 Item 442 Asphalt Concrete Intermediate Course, 19mm, Type A & B (448)**

This item is the same as Item 442 Asphalt Concrete Intermediate Course, 19mm, Type A & B (446) (Section 406.2.2) except it can be used as a variable thickness course. The minimum and maximum lift thickness and maximum total thickness in Section 406.2.2 apply. For some rare occasions, when this lift is used as a leveling or wedge course, it may be practical to stretch the maximum recommended thickness past the 4.5 inch (115 mm) limit. This item can be tapered to 0 inches (0 mm) and placed at non-uniform thickness less than the minimum lift thickness.

For projects using 446 acceptance for the surface course but needing this type of a leveling or wedge, it is acceptable to use this item for the intermediate course. Use of this item should be avoided, if possible, for high traffic volumes to minimize pavement densification under traffic.

### **406.2.7 Item 448 Asphalt Concrete Intermediate Course, Type 2, PG64-28 & PG64-22**

This item is the non-superpave equivalent of Item 442 Asphalt Concrete Intermediate Course, 19mm, Type A & B (448). The requirements of Section 406.2.6 apply.

Specify PG64-28 for projects which have a Type 1H surface mix, otherwise specify PG64-22.

## **406.3 Base Courses**

Asphalt concrete base courses provide the majority of the structural capacity in most flexible pavement buildups. All asphalt concrete base courses should be specified in 0.5-inch (10 mm) increments.

### **406.3.1 Item 301 Asphalt Concrete Base, PG64-22**

This item is to be used in conjunction with both a surface and intermediate course. The gradation of this mix requires the lift to be at least 3 inches (75 mm) thick. For most situations, this material should have 304 underneath, and a minimum of 3 inches (75 mm) of surface and intermediate course above. In special circumstances it is possible to allow this lift to be as thin as 2.5 inches (65 mm), but this is discouraged. This item may be placed in variable thicknesses. ODOT C&MS specifies a maximum compacted lift of 6 inches (150 mm). Layers thicker than 6 inches (150 mm) will automatically be placed in multiple lifts. This material can handle traffic during construction but care should be taken to minimize high traffic volume contact. In high traffic volume situations, an intermediate course is preferred for maintenance of traffic, particularly over the winter.

### **406.3.2 Item 302 Asphalt Concrete Base, PG64-22**

This item is to be used in conjunction with both a surface and intermediate course. This mix was developed for use with thick flexible pavements where high volume truck traffic exists. When lift thicknesses and maintenance of traffic operations allow, Item 302 is preferred over Item 301. Item 302 generally costs less than Item 301 and is a more stable, rut-resistant mix but is more susceptible to

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segregation problems during construction unless good construction practices are followed. The gradation of this mix requires the lift to be at least 4 inches (100 mm) thick. ODOT C&MS specifies a maximum compacted lift of 7.75 inches (190 mm). Layers thicker than 7.75 inches (190 mm) will automatically be placed in multiple lifts. This item may be placed in variable thicknesses. For most situations, this material should have 304 underneath, and a minimum of 3 inches (75 mm) of surface and intermediate course above. It is not necessary to put a 301 course above a 302 course. Placement of 301 below 302 is illogical. Item 302 should not be used for maintenance of traffic for more than approximately 60 days and never over the winter. If it is necessary to maintain traffic for more than 60 days or over winter, the top 3 inches (75 mm) of the 302 could be changed to 301, or preferably, the project should be phased to allow the intermediate course to be used for maintenance of traffic.

### 406.4 Item 407 Tack Coat

A tack coat is used to glue an asphalt concrete layer to the layer below. Tack coats are required anytime a surface course is placed on an intermediate course (C&MS 407.06). The tack coat between a surface and a new intermediate course should be specified using Item 407 Tack Coat for Intermediate Course. All other tack coats should be specified using Item 407 Tack Coat.

Tack coat is recommended anytime a new asphalt concrete surface or intermediate course is being placed on an existing surface with one exception. Tack coat should not be used under a bondbreaker layer for an unbonded concrete overlay unless traffic will be maintained on the bondbreaker.

When tack coat is placed on concrete or brick, C&MS automatically requires the use of rubberized asphalt emulsion conforming to 702.13.

Actual application rates of tack coat are set in the field. The most common application rate used for estimating quantities is 0.075 gallons per square yard (0.34 L/m<sup>2</sup>). Estimated application rate of Tack Coat for Intermediate Course is 0.04 gallons per square yard (0.18 L/m<sup>2</sup>).

### 406.5 Item 408 Prime Coat

Prime coats are applied to Item 304 Aggregate Base to seal and protect the 304 during construction. Prime coats help control dust and damage caused by construction traffic. They can also help reduce water infiltration while the 304 is exposed. Use of a prime coat is optional. The designer should consider the construction phasing and how long the 304 will be exposed to the elements and construction traffic when determining the use of prime coat.

Estimated application rate for prime coat is always 0.4 gallons per square yard (1.8 L/m<sup>2</sup>).

## 407 Warranty Asphalt Concrete

The use of warranty does not change the asphalt concrete thickness design in any way. The same inputs are used and the same SN determined regardless of whether warranty or conventional asphalt concrete will be used. To determine the thickness of a warranty asphalt pavement, the designer should assume conventional materials and lift thickness restrictions, then apply the appropriate structural coefficients. For asphalt pavements with a 7-year warranty, the entire thickness is specified as Item 880. For 3-year warranties, conventional items are specified for each layer and Supplement 1059 is added to the surface course pay item description.

More information on asphalt pavement warranties is available in the Warranty Application Guidelines in the Innovative Contracting Manual published by the Office of Construction Administration, in the Item 880 Asphalt Concrete (7 Year Warranty) specification, and in Supplement 1059 Asphalt Concrete Surface Course Warranty Requirements.

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## 408 Smoothness Specifications

Incentive/disincentive for smoothness is specified using Proposal Note (PN) 420 Surface Smoothness Requirements for Pavements or PN 470 Thin Lift Asphalt Surface Smoothness Requirements. PN 420 is recommended for all eligible projects. The Designer Note details the eligibility requirements. For projects not eligible for PN 420, PN 470 is recommended in accordance with the Designer Note.

PN 470 is incentive only. The minimum smoothness requirements when PN 470 is used are contained in C&MS 401.19.

Smoothness incentives generally result in better attention to detail by the contractor and higher quality pavement overall. Smooth, high quality pavements are expected to perform better for a longer time, potentially resulting in cost savings to the Department.

The designer should ensure the contractor has a reasonable opportunity to achieve the incentive. Projects that may otherwise be eligible but have numerous manholes, drainage structures, business or residential driveways, etc., may not be good candidates for smoothness incentive depending on the maintenance of traffic and sequence of operations.

## 409 Special Use Asphalt Concrete Items

The following items are used for preventive maintenance, high stress areas and other situations where specialized material is desired.

### 409.1 Item 424 Fine Graded Polymer Asphalt Concrete, Type A & B

This item is intended primarily for use in preventive maintenance applications. Use of this item should be in accordance with the Pavement Preventive Maintenance Guidelines.

This item should not be placed over crack sealer that has aged less than one year. Type A should not be used in heavy traffic locations (ADTT>1500, see PN 416).

### 409.2 Item 803 Rubberized Open Graded Asphalt Friction Course

This item is intended for use in areas with poor skid resistance, where surface drainage is a concern, or where reduced tire-pavement noise is desired. Air-cooled slag is required which may not be economically available in all areas of the state. ODOT has experienced difficulty with snow and ice removal on open graded friction courses (OGFC). According to FHWA Technical Advisory T 5040.31, an OGFC "requires special snow and ice control methods and generally remains icy longer." An OGFC is effective in reducing potential for hydroplaning, reducing splash and spray, and reducing tire-pavement noise as much as 3 to 5 decibels. An OGFC does not add any structural capacity and therefore should be considered on structurally sound pavements only.

### 409.3 Item 826 AC Surface and Intermediate Course, Type 1 & 2, Fiber A or B

This item is intended primarily for high stress areas to reduce the potential for rutting. Use of this item should be coordinated with the Offices of Pavement Engineering and Materials Management.

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### **409.4 Item 857 AC with Gilsonite, Surface Course, Type 1 & 1H, and Intermediate Course, Type 2**

These items are intended primarily for high stress areas to reduce the potential for rutting. Use of these items should be coordinated with the Offices of Pavement Engineering and Materials Management.

### **409.5 Item 859 AC with Verglimit**

This item is intended as an anti-icing pavement. Verglimit is a linseed oil-coated multi-component chemical deicer additive consisting of calcium chloride flakes and other chemicals. ODOT has very limited experience with this item. Use of this item should be coordinated with the Offices of Pavement Engineering, Maintenance Administration, Materials Management, and Structural Engineering if used on bridges.

### **409.6 Item 874 Ultrathin Bonded Asphalt Concrete**

This item is intended primarily for use in preventive maintenance applications. It consists of sealing the pavement with a polymer modified emulsion followed immediately with a thin asphalt overlay. The asphalt overlay requires crushed aggregate to provide rut resistance. This item should not be placed over fresh, less than one year old, crack sealer. Placement of this item requires a special paving machine. This item should be used on structurally sound pavements only.

# 400 Flexible Pavement Design

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## List of Figures

<u>Figure</u>	<u>Date</u>	<u>Subject</u>
401-1	July 2008	Flexible Pavement Structural Coefficients
402-1	July 2008	Flexible Pavement Design Example
402-2	July 2008	Flexible Pavement Design Chart Segment 1
402-3	July 2008	Flexible Pavement Design Chart Segment 2
403-1	July 2008	Surface Treated Shoulder and Stabilized Aggregate Shoulder Typical Sections
406-1	July 2008	Asphalt Concrete Quick Reference Guide

<b>Flexible Pavement Structural Coefficients</b>	<b>401-1</b> July 2008
	<b>Reference Section 401</b>

<b>ASPHALT CONCRETE STRUCTURAL COEFFICIENTS</b>		
<b>Material</b>	<b>English Coefficient</b>	<b>Metric Coefficient</b>
Items 424, 442, 443, 446, 448, 826, 857, 859, 874 - AC Surface Courses	0.43	0.0169
Items 442, 443, 446, 448, 826, 857 - AC Intermediate Courses	0.43	0.0169
Item 880 Warranty Asphalt - top 3" (75 mm)	0.43	0.0169
Items 301, 302 - Asphalt Concrete Base Courses	0.36	0.0142
Item 880 Warranty Asphalt - below top 3" (75 mm)	0.36	0.0142
Item 321 - Cracked & Seated Plain Concrete	0.27	0.0106
Existing Asphalt Concrete - old, oxidized, & weathered	0.23	0.0092
Item 304 - Aggregate Base	0.14	0.0055
Item 320 - Rubblized Concrete	0.14	0.0055
Items 850, 851 - Free Draining Base Layers*	0.14	0.0055
Items 421, 881 - Microsurfacing	0.0	0.0
Item 803 Rubberized Open Graded Asphalt Friction Course	0.0	0.0
Items 822, 886 - Hot In Place Recycling	0.0	0.0

\* Free Draining Bases are not approved for use on ODOT projects.

Asphalt Concrete Drainage Factor = 1.0

Given:

- Number of Lanes: 4
- Functional Classification: Rural Principal Arterial
- 2009 Traffic: 15,800 ADT
- 2029 Traffic: 22,450 ADT
- 24 hour truck %: 18%
- Design Period: 20 years (see Pavement Design Policy 20-007(P))
- Open to Traffic: 2010
- Subgrade CBR: 5 (provided by Office of Geotechnical Engineering or District Geotechnical Engineer)

Problem: Solve for the Structural Number and determine an acceptable flexible buildup

Solution:

Step 1 - Determine the 18 Kip Equivalent Single Axle Loading (ESAL)

Since the project is expected to open to traffic in 2010, the ESAL projection should be for 2010 to 2030. Calculate the mid-year (2020) ADT, rounded to the nearest ten:

$$2020 \text{ ADT} = 15,800 + (22,450 - 15,800)(11/20)$$
$$2020 \text{ ADT} = 19,460$$

Directional Distribution,  $D = 50\%$  (Figure 202-1)

Lane Factor =  $90\%$  (Figure 202-1)

B:C Ratio =  $5:1$  (Figure 202-1)

ESAL Conversion Factor for B trucks =  $1.45$  (Figure 202-1)

ESAL Conversion Factor for C trucks =  $0.58$  (Figure 202-1)

Using the equations given in Section 202.2:

$$\text{ESAL's from B trucks} = 19,460(0.18)(0.50)(0.90)(5/6)(1.45) = 1905$$

$$\text{ESAL's from C trucks} = 19,460(0.18)(0.50)(0.90)(1/6)(0.58) = 152$$

$$\text{Total Daily ESAL's} = 1905 + 152 = 2057 \text{ ESAL/day}$$

$$\text{Design Period ESAL's} = 2057 \text{ ESAL/day} * 365.25 \text{ days/yr.} * 20 \text{ years} = 15,026,385$$

use  $15.0 \times 10^6$  ESAL

Step 2 - Determine the Subgrade Resilient Modulus ( $M_r$ ) using the formula given in Section 203.1.

$$M_r = 1200 * \text{CBR}$$

$$M_r = 1200 * 5$$

$$M_r = 6000 \text{ psi}$$

Step 3 - Determine the Design Structural Number (SN) using Figures 402-2 and 402-3. In Figure 402-2, solve for the Match Line Number using the following information:

Reliability = 85% (Figure 201-1)  
Overall Standard Deviation = 0.49 (Figure 201-1)  
18-kip Single Axle Loads =  $15.0 \times 10^6$  ESAL (Step 1)  
Subgrade Resilient Modulus = 6,000 psi (Step 2)

The resulting Match Line Number is then used in Figure 402-3, along with the Design Serviceability Loss of 2.0 (Figure 201-1), to solve for the Design Structural Number (SN).

Therefore: Design Structural Number (SN) = 5.25

Step 4 - Design the typical section using the layer coefficients found in Figure 401-1. The total SN for the pavement buildup must equal or exceed the Design Structural Number (SN) = 5.25 (Step 3).

Check for Heavy traffic (see Proposal Note 416) by calculating opening day (2010) truck traffic.

$$2010 \text{ ADTT} = (15,800 + (22,450 - 15,800)(1/20)) * 0.18$$
$$2010 \text{ ADTT} = 2900$$

Since the opening day truck traffic is greater than 1500, a 12.5mm or Type 1H mix is required.

The following buildup is not the only solution, but will satisfy the required SN:

Material	Thickness	Coefficient	SN
442 AC Surface Course, 12.5mm, Type A (446)	1.5"	0.43	0.65
442 AC Intermediate Course, 19mm, Type A (446)	1.75"	0.43	0.75
302 Asphalt Concrete Base, PG64-22	8.5"	0.36	3.06
304 Aggregate Base	6"	0.14	0.84
		Total SN =	5.30

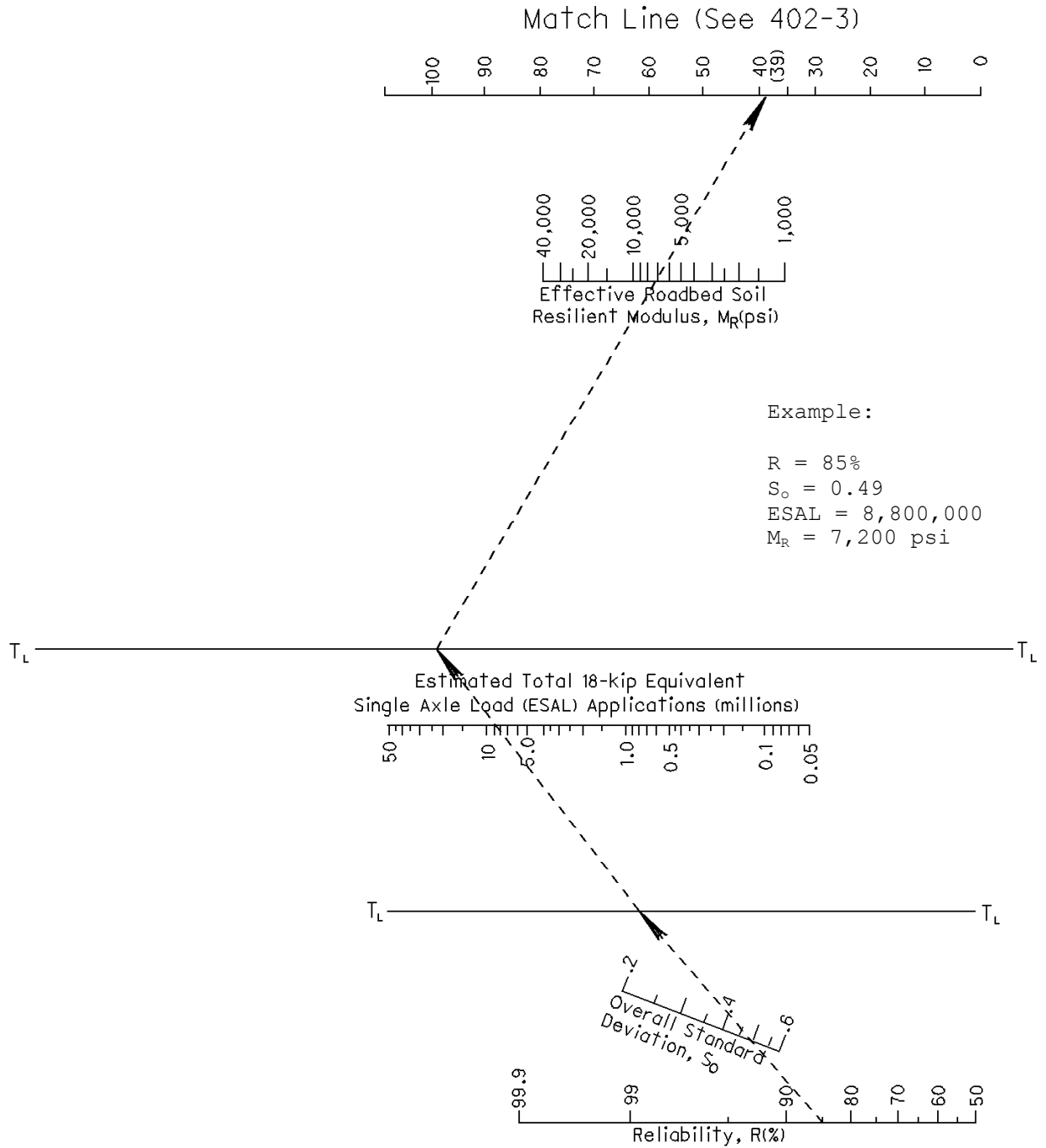
Since the total SN equal to 5.30 of the proposed buildup is greater than the required SN of 5.25, the design is acceptable.

# Flexible Pavement Design Chart Segment 1

402-2

July 2008

Reference Section & Figure  
402, 402-1(step 3)

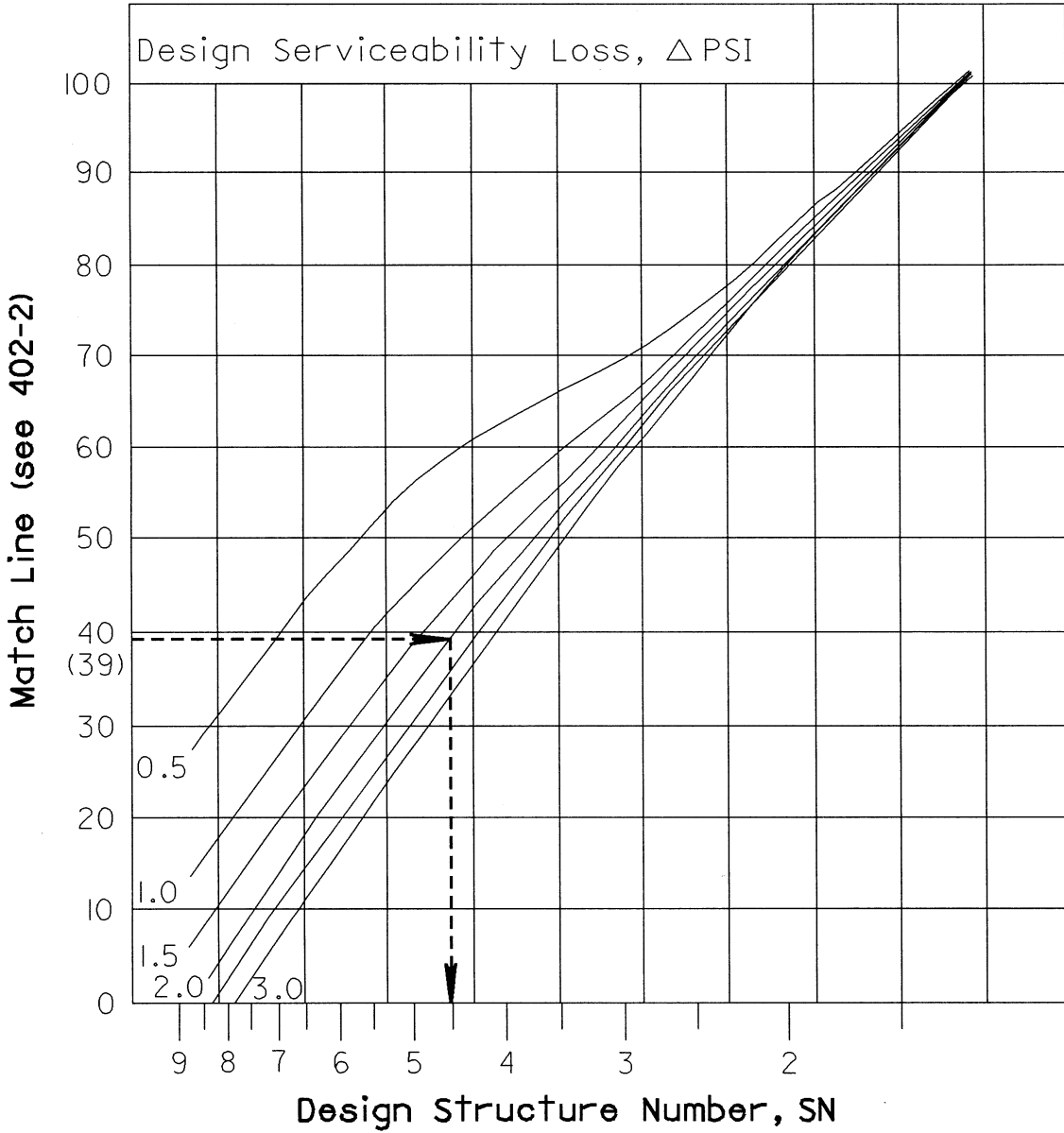


# Flexible Pavement Design Chart Segment 2

402-3

July 2008

Reference Section & Figure  
402, 402-1(step 3)



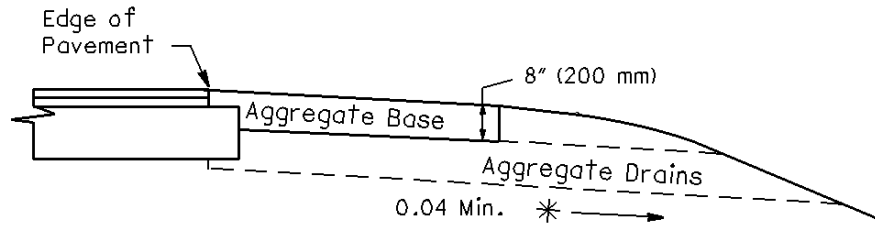
Example:  $\Delta PSI = 2.0$

Solution: SN = 4.5

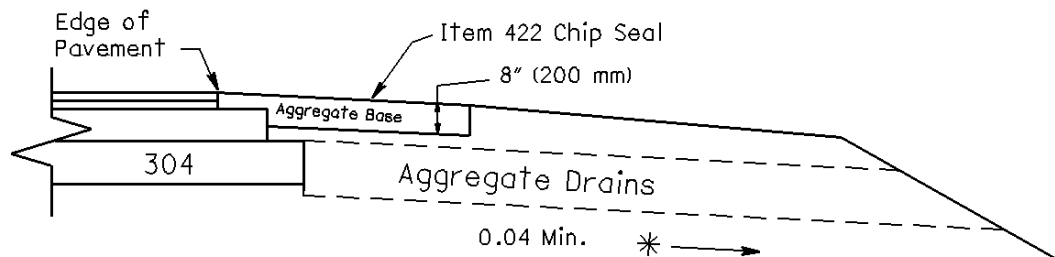
# Surface Treated Shoulder and Stabilized Aggregate Shoulder Typical Sections

**403-1**  
July 2008  
Reference Section  
205.1, 403.3 & 403.4

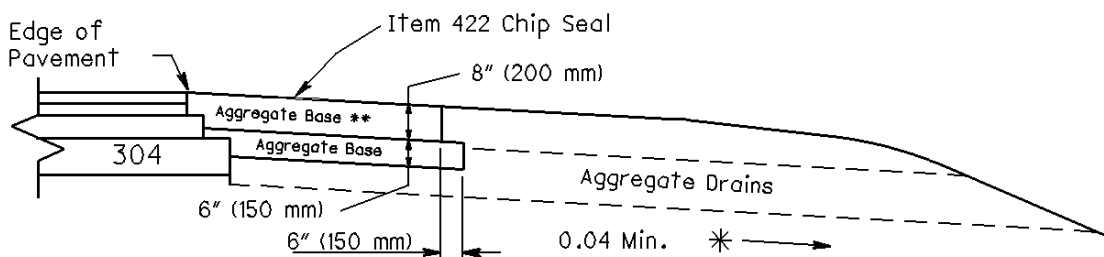
## AGGREGATE SHOULDER



## SURFACE TREATED



## SURFACE TREATED (Greater than 500 trucks in Design Year ADT)



### Notes:

The bottom of the aggregate drains shall be at or below the bottom of the pavement's aggregate base at the point of contact. The top of the aggregate drains shall be no higher than the bottom of the shoulder's aggregate base at the point of contact.

- \* 0.08 Desirable
- \*\* A flexible shoulder (Item 301) could be used in lieu of the Surface Treatment

# Asphalt Concrete Quick Reference Guide

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**406-1**

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Reference Section

**406**

Item	Minimum Lift	Maximum Lift	Taper to 0"	Uniform Thickness Required
301 Asphalt Concrete Base	3"	6"	No	No
302 Asphalt Concrete Base	4"	7.75"	No	No
424 Fine Graded Polymer Asphalt Concrete, Type A	0.625" (5/8")	0.625" (5/8")	No	Yes
424 Fine Graded Polymer Asphalt Concrete, Type B	0.75"	1.25"	No	Yes
442 AC Surface Course, 12.5mm, Type A or B (446)	1.5"	2.5"	No	Yes
442 AC Surface Course, 9.5mm, Type A or B (446)	1"	1.5"	No	Yes
442 AC Surface Course, 12.5mm, Type A or B (448)	1.5"	2.5"	No	No
442 AC Surface Course, 9.5mm, Type A or B (448)	1"	1.5"	No	No
442 AC Intermediate Course, 19mm, Type A or B (446)	1.75"	3"	No	Yes
442 AC Intermediate Course, 19mm, Type A or B (448)	1.25"	3"	Yes	No
442 AC Intermediate Course, 9.5mm, Type A or B (448)	1"	1.5"	Yes	No
443 Stone Matrix Asphalt Concrete, 12.5mm (446)	1.5"	2"	No	Yes
446 AC Surface Course, Type 1H	1.5"	2.5"	No	Yes
446 AC Surface Course, Type 1	1"	1.5"	No	Yes
446 AC Intermediate Course, Type 1	1"	1.5"	No	Yes
446 AC Intermediate Course, Type 2	1.75"	3"	No	Yes
448 AC Surface Course, Type 1H	1.5"	2.5"	No	No
448 AC Surface Course, Type 1	1"	1.5"	No	No
448 AC Intermediate Course, Type 1	1"	1.5"	Yes	No
448 AC Intermediate Course, Type 2	1.75"	3"	Yes	No

# Asphalt Concrete Quick Reference Guide

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**406-1**

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Reference Section

**406**

Item	Minimum Lift	Maximum Lift	Taper to 0"	Uniform Thickness Required
803 Rubberized Open Graded Asphalt Friction Course	0.75"	0.75"	No	Yes
826 AC Surface Course, Type 1, Fiber A or B	1"	1.5"	No	No
826 AC Surface Course, Type 2, Fiber A or B	1.75"	3"	No	No
826 AC Intermediate Course, Type 1, Fiber A or B	1"	1.5"	Yes	No
826 AC Intermediate Course, Type 2, Fiber A or B	1.75"	3"	Yes	No
857 AC with Gilsonite, Surface Course, Type 1	1"	1.5"	No	*
857 AC with Gilsonite, Surface Course, Type 1H	1.5"	2.5"	No	*
857 AC with Gilsonite, Intermediate Course, Type 2	1.75"	3"	No	*
859 AC with Verglimit (designed for medium traffic)	1"	1.5"	No	Yes
859 AC with Verglimit (designed for heavy traffic)	1.5"	2.5"	No	Yes
874 Ultrathin Bonded AC	0.625" (5/8")	1.5"	No	No

\* Acceptance and the need for a uniform lift thickness for Item 857 depends on the total quantity of material used. If the total quantity is 250 tons (250 metric tons) or greater, 446 acceptance is used and a uniform lift thickness is required. Less than 250 tons (250 metric tons), 448 acceptance is used and a variable lift thickness is allowed.