

Research Report

QUIETER PAVEMENTS SURVEY

by

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16. ABSTRACT This study looked at the performance of quieter pavements in use in the United States of America and Europe with specific emphasis on those states that are using open-graded mixes for both friction or porous courses on an ongoing basis. All States were contacted and 34 states responded with information on their use of open-graded mixes and stone matrix asphalt (SMA) mixes. Eleven states were able to provide an estimate of the range and average service life of their open-graded mixes and three states provided information on the service life of their SMA mixes. Specifications for open-graded mixes and SMA mixes were compiled from 20 states and compared to Washington State's open-graded friction course mix and the open-graded mix used on recent test sections built by the Washington State Department of Transportation.					
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EXECUTIVE SUMMARY

A study was conducted that looked at the relative performance of quieter pavements in Europe and the United States based on pavement management data. A phone survey was conducted to get the best response and to specifically talk to those people in the state agencies that were involved with their pavement management system (PMS). Contact was made with 35 of the 50 states on the performance of open-graded mixes and stone matrix asphalt (SMA) mixes in their respective agencies. None of the states were able to provide sufficient information to accurately estimate the service life of the different quiet pavements types to the accuracy that can usually be accomplished from the Washington State Pavement Management System (WSPMS). About half the states contacted were able to provide an estimate of the service life they were experiencing from their open-graded mixes and a few were able to estimate the service life experienced from their SMA mixes. The estimated service life for the open-graded mixes provided by the states ranged from seven to fifteen years. Where states were able to provide an estimate of service life of their dense graded mix performance, the open-graded mixes were providing about 70 percent of the service life of the dense graded mixes.

Based on the authors experience and comments from other states there is a concern with the use of open-graded mixes in areas which require snow plowing in the winter and those that experience increased pavement wear from studded tire use. The survey found that those states that have continued to use open-graded friction course (OGFC) mixes tend to be in the southern part of the country, which do not have the same maintenance issues with snow plowing and studded tire wear. Consequently, most of the

states in the northern part of the country do not appear to be using OGFC mixes as consistently as the more southern states.

As part of the state survey the current standard specifications for open-graded mixes were reviewed and summarized for those states that made them available. A collection of the state specifications for OGFC indicates that there are in general two sizes of stone gradations used in the United States. The gradation with the larger aggregate size (3/8" median) is used by states in the southeast which fit NAPA's guidelines for OGFC mixes. The rest of the states use the gradation with the smaller aggregate size (1/4" median) which originally came from the FHWA Technical Advisory for friction courses. There is no indication that the different gradings for the OGFC provide more or less service life.

Most states in the survey used a polymer modified binder (PG 76-22) with fibers to control drain-down and provide the thick asphalt film that is required for OGFC mixes. Some states used an asphalt rubber binder but these were in the minority and all tended to be located in the southern portions of the United States. There was also no indication in the survey that either binder type provided better service life. Those states that do use asphalt rubber binder are specifying a higher percentage of asphalt rubber binder compared to polymer asphalt binder. The OGFC mixes constructed at this time in Florida and Arizona with stiffer asphalt binders and thicker asphalt films (higher asphalt content) are performing better than those constructed in the 1970's and 1980's. However they are still not being used extensively by many northern states or by many states that allow the use of studded tires like Washington State. The Washington State Department of Transportation (WSDOT) can expect that the OGFC mixes constructed with stiffer

asphalt binders and thicker asphalt films will perform better than the old mixes, but it is doubtful that they will obtain comparable service lives as that reported by Arizona and Florida, given Washington's weather and studded tire use.

INTRODUCTION

PROBLEM STATEMENT

Noise produced by the tire-pavement interaction disturbs drivers and residents of neighborhoods adjacent to urban highways. Many states, including California, Arizona and Texas, have experimented with pavements that reduce the tire-pavement production of noise. Quieter pavements technologies have included rubberized asphalt friction courses, open-graded friction courses (OGFC), stone matrix asphalts (SMA) and several others. Questions concerning performance surround both the durability of the noise reduction (how much is the noise reduced initially and does that noise reduction decrease over time) and the durability of the wearing surface of the pavement (the pavement life before structural failure and required replacement).

RESEARCH OBJECTIVES

The Washington State Department of Transportation (WSDOT) wants to document, to the extent possible, the performance of these pavements from a pavement management perspective.

Specifically WSDOT wanted to:

Evaluate each state's pavement management system to determine if accurate data on a project level basis can be used to determine life cycle costs and life cycle durations (system level performance may only be considered if project level performance is unavailable). Identify the life cycles performance of the variety of quieter pavements, including:

- *The average life cycle of each type of quieter pavement*
- *The maximum average life cycle of each type of quieter pavement*
- *The minimum average life cycle of each type of quieter pavement*
- *The performance criteria used to determine those life cycles (rutting, smoothness, structural condition, etc)*
- *Compare and contrast this performance with performance of the typical life cycle of hot mix asphalt (HMA) in Western Washington State*
- *Compare and contrast the climatic differences between other states using the various quieter pavements and that of urban Western Washington. Select similar climatic zones in Arizona, California, Texas and other states using quieter pavements and examine life cycle performance*

Collect state departments of transportation specifications for pavement design, mix design and construction of the various quieter pavements. Note any specifications and any constructability issues, especially related to weather constraints.

The following discussion documents the results of the study performed to meet those goals.

REVIEW OF CURRENT PRACTICE

Typically, reduction of highway traffic noise has been accomplished through the use of noise barrier walls. However, barrier walls can be costly to build and difficult to maintain. Furthermore, noise barriers are not completely effective. Buildings located on hillsides or near any openings (driveways, intersections, etc.) will not benefit from noise reduction because the sound diffracts over the top as well as around the end of the walls.

Starting in the 1980's, European studies found that noise reduction could also be accomplished by changing the pavement surface, eliminating the noise at the source rather than building a barrier. These studies found that quiet pavements can be built by using one or more of the following approaches (Sandberg 2002):

1. A surface with a smooth surface texture using small top size aggregate
2. A porous surface, such as an OGFC with a high air void content
3. A pavement-wearing course that has an inherent low stiffness at the tire/pavement interface.

MIX TYPES

Several mix types can be considered quiet pavements due to their aggregate and binder characteristics. These include OGFC, OGFC with asphalt rubber binder, SMA and several others.

Open-Graded Friction Courses (OGFC)

An OGFC consists of an HMA mixture that is designed to have a large number of air voids (typically 18 to 22 percent). This large void content is created by using a larger percentage of coarse aggregate and a lower percentage of fine aggregate (usually less than 20 percent of the material passes the No. 8 sieve).

OGFC can reduce the noise level because the larger air void content provide a means for air trapped between the tire and the pavement surface to escape which provides for increased sound absorption.

The binder used in the OGFC can be either polymer modified asphalt (PG 76-22, PG 70-22) with fibers or rubberized asphalt. Rubberized asphalt consists of regular asphalt cement mixed with ground “crumb rubber” from used tires. Used tires are processed by separating the casings, fabric and steel. The recovered rubber then is granulated to the consistency of ground coffee. Rubberized asphalt contains between eight and 20 percent tire rubber that is blended into the liquid asphalt. When the rubberized asphalt contains over 15 percent tire rubber it is usually referred to as asphalt rubber by the Rubber Pavements Association. Details concerning asphalt rubber can be found at the Rubber Pavements Association web site at:

<http://www.rubberpavements.org/index.html>

Stone Matrix Asphalt (SMA)

SMA is a mixture of crushed coarse aggregate, crushed fine aggregate, mineral filler, asphalt binder and stabilizing agent. The stabilizing agent is used to prevent drain-down of the asphalt binder and typically consists of fibers, polymers or a combination of both.

SMA mixtures are designed to have a high coarse aggregate content (typically 70 to 80%), with stone on stone contact, a high asphalt content (typically over 6%) and high filler content (approximately 10% by weight). This produces a mix with an improved aggregate structure with thick binder films and low voids which minimizes the aging and oxidation of the binder which usually provides improved service life.

These mixes have been used for many years to provide wearing courses with improved surface properties compared to normal dense graded mixes, which are being looked at again for their potential noise reduction properties.

This report will summarize the pavement performance aspect of these mixes not their ability to reduce tire-pavement noise, since the noise reduction characterization has been a relatively recent consideration.

PAVEMENT SERVICE LIFE

European Experience (FHWA 2004)

Quieter pavement technology originated in Europe, where the systematic reduction of noise associated with roadway operations has been a critical issue for more

than 20 years. Because the preservation of historic vistas prevents the use of noise barrier walls, European countries have focused on eliminating the noise at the source.

The two main approaches to quieter pavements in Europe include the use of thin overlays with negatively textured, gap-graded mixes such as SMA mixtures, as well as single or double layers of open-graded porous surface mixes.

In 2004, a Quiet Pavements Scan Team composed of a cross section of State, Federal, academic, and industry representatives visited five European countries (Denmark, the Netherlands, France, Italy and the United Kingdom) that have successfully used pavement technologies that reduce tire/pavement noise. Findings from this study revealed that the durability of low-noise pavement systems varies from seven to 15 years depending on the pavement system and the experience level of the owner agency. Acoustical durability is about four dB(A) over the pavement life.

Pavement life is mostly affected by raveling and increased winter maintenance activities (snowplows scarring the pavement, use of studded tires, etc.). On the other hand, acoustical durability is mostly affected by clogging, especially on low-speed facilities. Some disagreements exist regarding the effective maintenance of these negatively textured and often highly porous pavements. Although some countries require pressure washing and vacuuming of the pavements at least twice a year, other countries contend that the practice may not only be useless, but perhaps even harmful. The team was unable to discover any reliable data to substantiate either claim. Winter maintenance remains a challenge, especially on the highly porous pavements. Winter maintenance relies on advanced use of prewetted salt to fight formation of black ice on the highly porous pavements, resulting in a winter maintenance cost increase of 25 to 50 percent.

Some countries have stopped using highly porous pavements in snow and ice regions, and instead are using SMA-type pavements with smaller top size aggregate.

PROCEDURES

STATE SURVEYS

In order to estimate the service life of quieter pavements, a state survey of current activity throughout the United States was performed. All 50 states were contacted by phone to determine what pavement performance data is available.

CONSTRUCTION SPECIFICATIONS

Specifications for OGFC and SMA mixes were collected from all applicable state departments of transportation. Those specifications are located in Appendix C Standard Specifications for OGFC and SMA mixes (available in the .pdf version of the report).

A summary of the more relative OGFC mix design items for each state can be found in Appendix B Summary of OGFC Materials Specifications.

FINDINGS/DISCUSSION

STATE SURVEYS

A total of 35 states responded to the survey. Of those states that responded, 28 have used either open-graded mixes or a form of SMA, but only half had information on their estimated service life. Most of the states that had some experience with open-graded mixes based that experience on the use of OGFC which were used in 1970's and later. In many cases the individuals contacted indicated that the agency now had only limited use of open-graded mixes or had discontinued that use for various reasons. None of the states contacted had detailed information in their pavement management system (PMS) that could be used to provide project specific information on the performance of these mixes. In many cases the Pavement Management staff deferred questions of service life to their Materials Engineer or their Pavement Design Engineer. It was not known if that was because of a lack of information or reflected the Agencies policy on releasing service life information. Some general information on the performance of these mixes can be developed from the results of the phone interviews but not to the level desired by WSDOT in the request for proposals for this project.

It should be noted that no other state monitors and compiles project level pavement condition data over time to the detail that WSDOT does. It has been the author's experience that many states still only collect network level condition data while others collect project level data. However, those states that collect project level data do not attempt to develop project specific trends by project with time for their entire highway system as WSDOT does. The States may collect project level pavement

condition data but they predict future pavement condition based on average or estimated deterioration trends extended from the last condition survey. Thus most states cannot provide detailed PMS information on specific mix performance. The information on service life that is presented in this report was based on either specific studies or general experience from individuals within those states.

Another issue is that many states like Arizona use ride values as their primary measure of pavement performance. Because of this, the trends that are monitored cannot be matched to trends in Washington State directly because WSDOT also defines pavement service to moderate levels of pavement cracking. States that use ride values as the primary distress indicator must experience significant changes in ride values before they take action and that can represent greater levels of crack severity and extent. As an example where Arizona would estimate pavement service life of 15 years that would represent the time to a significant change in IRI or ride values. Washington State may look at that same pavement and determine a service life of 10 to 12 years based on a specific amount of fatigue cracking (10% to 25% of the wheelpaths), which occurs well before there is significant change in ride value. Because Arizona conducts only a very limited cracking survey along with their ride survey it is unlikely one could make a good correlation between the service life in Arizona and one in Washington State. The estimate of pavement service life reported for each state was provided by the person who was interviewed. There was no attempt made to correlate those estimates to a common terminal pavement condition. The states that responded that they had used either OGFC's or SMA's are shown in Figure 1.

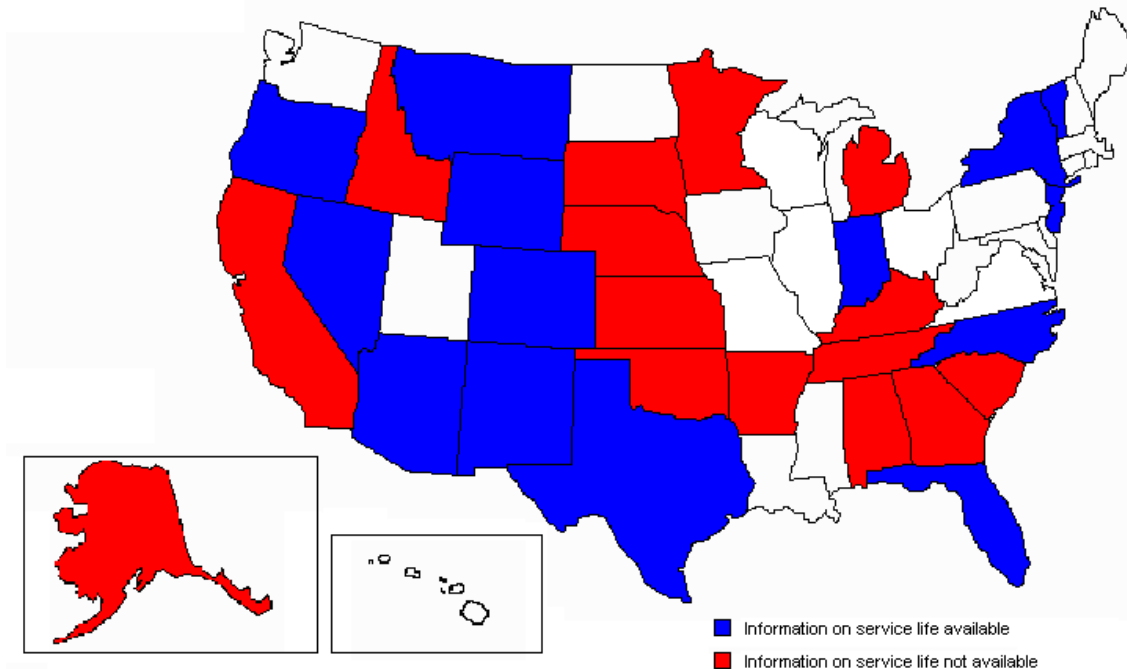


FIGURE 1 States that reported using OGFC or SMA mixes

In general, many states have used open-graded mixes and those mixes are still shown in their specifications. It appears however that the number of states that continue to actively and aggressively use open-graded mixes is limited. Many states experience with open-graded mixes is similar to Washington States. One of the authors of this report was involved with the use of open-graded mixes from the mid 1970’s through the late 1980’s. WSDOT started using OGFC in the mid 1970’s in an attempt to reduce wet skidding accidents and in response to the FHWA guidance and a technical advisory on OGFC’s. It should be noted that most states still refer to their open-graded mixes as OGFC’s. WSDOT determined that wet skidding accidents were reduced with the use of OGFC’s, but what was more apparent was that they reduced water spray from trucks and cars and were noticeably quieter and smoother. At about the same time WSDOT initiated

a significant effort in utilizing recycled HMA pavements. Due to concerns with the high percentage of recycled HMA in new HMA overlays, WSDOT placed OGFC's on all recycled HMA overlays to protect the recycled mix. Consequently there was a significant amount of OGFC placed on I-5, I-90 and SR 520 in the 1980's. All of these pavements experienced extensive raveling in the wheelpaths within five to seven years. A few sections provided up to 15 years of service on I-90 because they received light fog seals at 3 to 5 year cycles. There were also a couple of projects in Seattle and Spokane that were paved in late summer which began raveling in the wheel paths within a couple of months. The problem was traced to exceeding the high temperature limitation and increased drain-down. To minimize that risk WSDOT began placing fog seals on OGFC's after construction to improve film thicknesses. In the early 1990's WSDOT started using both a polymer modified and a rubber modified binder to improve film thickness. Because of the construction problems and relatively short service life, WSDOT has limited use of OGFC since the early to mid 1990's. Though WSDOT has all but stopped using OGFC's by the mid 1990's, the Class D OGFC remained in the Standard Specifications through 2002 and was only dropped when WSDOT implemented the Superpave specifications.

WSDOT also placed several test sections of $\frac{3}{4}$ inch OGFC using the Oregon DOT's Class F specification in the early 1990's on I-5 and on I-90. WSDOT has continued to use this OGFC mix as modified D. The WSDOT Pavements Engineer notes that WSDOT is still using modified D in Eastern Washington with good success. There are sections of I-90 where modified D is still in service from those earlier projects on the inside lanes. Modified D is also performing well on sections of SR 211, SR 904, and SR

902. Modified D was recently placed on I-90 in 2005 and 2006. Though the modified D is performing better than the standard D mix, the larger stone size may not provide the same quieter pavement benefits as the standard OGFC mix. The use of this larger stone OGFC mix is unique to Washington State and Oregon State.

Many states appear to have limited use of OGFC but continue to include them in their specifications. Other states, however, have modified their OGFC specifications and have continued to use them as a standard part of their paving program. Georgia and Florida along with other southeastern states moved to a little larger open-graded aggregate with either polymer asphalt or asphalt rubber binder. Arizona and California have used about the same sized aggregate as the old OGFC but use an asphalt rubber binder developed in Arizona. Oregon developed a large aggregate ($\frac{3}{4}$ inch) open-graded mix that they have continued to use since the early 1990's. Texas has worked with several different open-graded mix designs and has settled on a mix that is in-between the old OGFC and the new mixes used in the Southeast with polymer binder.

Figure 2 shows those states that actively use OGFC mixes as the final wearing course on either their Interstate or Principal Highways.

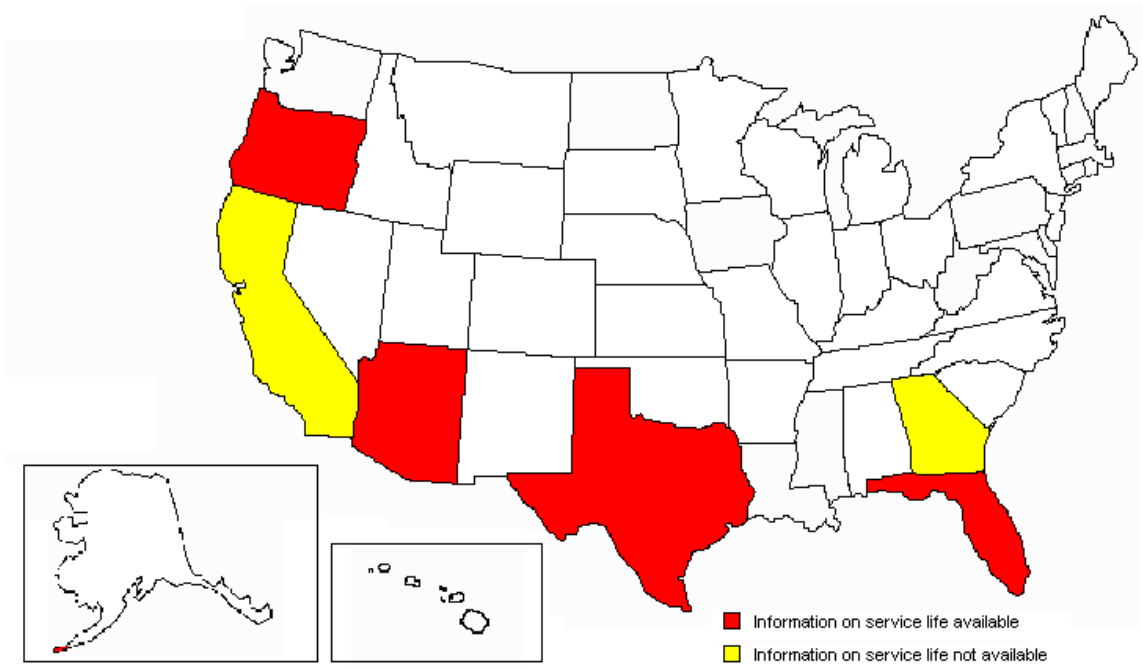


FIGURE 2 States Actively Using OGFC Mixes

In the case of SMA pavements, 11 states currently use this type of mixture, but only four of them had information on service life (Figure 3). As with OGFC mixes, SMA mixes are often placed for reasons other than noise reduction (such as increased rutting resistance). The SMA mixes are included in this survey in that they were identified in the RFP for this project as quieter pavements.

Like OGFC the SMA pavements are included in the list of potential quieter pavements. The states use of SMA pavements has been largely due to rut resistance, resistance to studded tire wear and longer service life. Consideration for use as a quieter pavement has been a recent development.

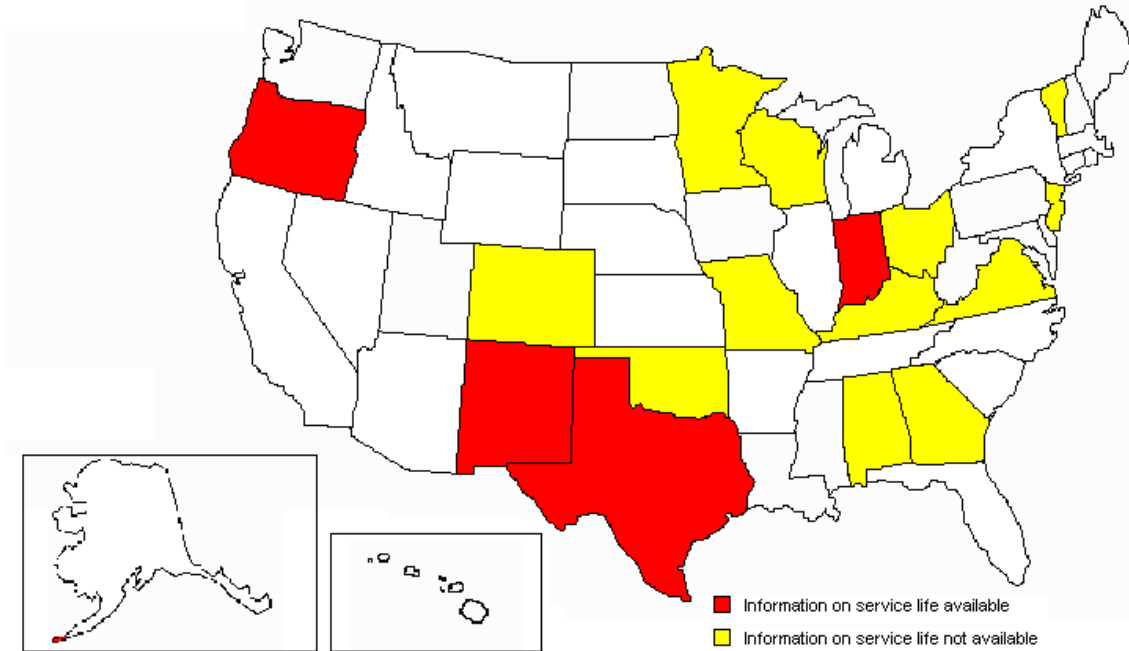


FIGURE 3 States Reported Using SMA Mixes

The general range in service life reported for all states is shown in table 1.

TABLE 1 Range in Service Lives Reported by States

Surface Type	Service Life (Years)
HMA	10-20
SMA	10-20
OGFC	7-15
Rubberized Asphalt OGFC	9-13

The full range in service life reported by the states is shown in Appendix A Summary of State Responses.

In general the states that had made improvements in their OGFC specifications and continued to use them, now report service life expectations around 10 years. That is, in general, a couple of years less service life than what they would expect from dense graded mixes. The states response on the service life of SMA's was very limited but most expected them to provide a couple of year's more service than dense graded mixes.

It should be noted that several states indicated problems with winter snow removal on OGFC. This was observed in Washington where several maintenance personnel reported to one of the authors that the OGFC seemed to hold the snow more than normal dense graded mixes and was harder to plow without damaging the pavement. Colorado reported that they had only placed one OGFC and removed it “due to increased accidents after snow fall”.

The use of OGFC appears to be limited in the more northern states because winter activities, such as snow plowing, can significantly reduce the service life of the pavement. Figure 4 shows the air-freezing index distribution for a return period of 100 years. Air temperature records can be used to gauge the severity of ground freezing by using the degree-day concept (if the daily mean air temperature is 31°F this will be one degree-day). The "Freezing Index" is simply the accumulated total of degree-days of freezing for a given winter.

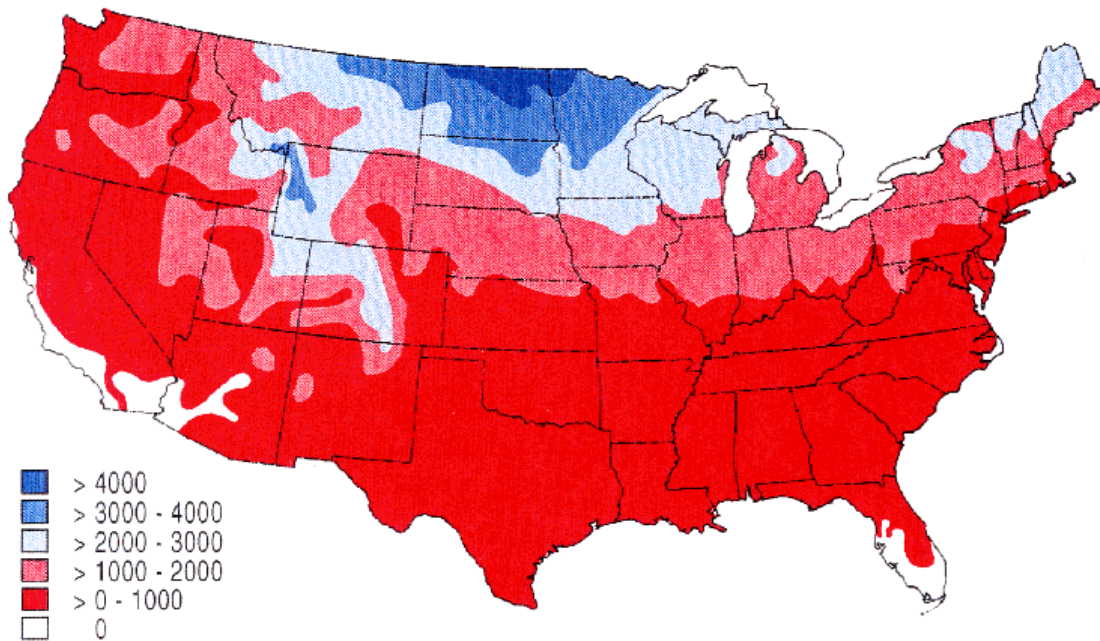


FIGURE 4 Air-Freezing Index (°F-Day) for the 100-year Return Period

As expected, the majority of states consistently using OGFC have freezing indices below 1,000 °F-Day (southern states). Those that continue to use OGFC the most (California, Arizona, Georgia, and Florida) tend to be in the warmer band of that zone.

A number of states use asphalt rubber in their OGFC pavements. Arizona and California routinely specify asphalt rubber for their OGFC pavements. The states of Florida and Texas include both polymer asphalt and asphalt rubber provisions in their specifications. A number of other states have experimented with the material. Those states that have studied and/or used rubberized asphalt include Nebraska, South Carolina, New York, New Mexico, and Washington. However, on the state survey only Arizona reported some information on the service life of these mixes. Those states that have asphalt rubber in their specifications are shown in figure 5.

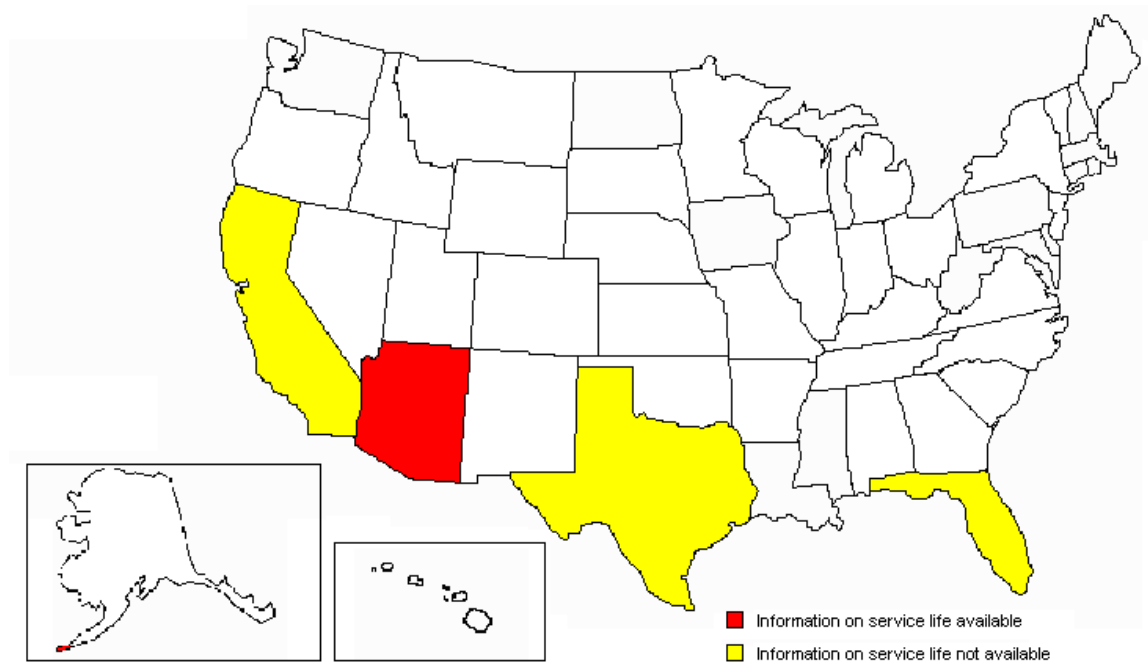


FIGURE 5 States with Specifications for Asphalt Rubber

WSDOT has used asphalt rubber as a binder in chip seals and in several early test sections of OGFC. A report in 1992 indicated that there was no difference in pavement performance between the asphalt rubber sections and polymer asphalt sections (5). However, that experience was based on using about the same percentage of polymer asphalt or asphalt rubber binder as was called for by the old FHWA Technical Advisory for OGFC which was about five percent. The OGFC that are used today in Arizona, California, Florida and Georgia use binder contents in the seven to nine percent range.

WSDOT is in the process of placing three test sections with the new generation OGFC with binder contents around nine percent. Considering that the environment in Washington is significantly different from that found in the states noted, these test sections will be critical for WSDOT to best quantify service life in their environment. WSDOT should also make an effort to record any problem with snow removal or frosting problems noted by maintenance on those sections of pavement. Based on earlier experiences with similar test sections, those who have to maintain those pavements often don't report any problem unless it is an unusual problem or a safety concern. It is recommended that annual reports on the performance of those pavement test sections should include a specific query of maintenance regarding any maintenance issues with those pavement sections.

The authors would not expect that WSDOT would experience the same service life as experienced in states like Arizona or Florida because of the use of studded tires allowed in Washington. The use of studded tires is not allowed in most states that commonly use OGFC today.

There was very limited information from the states interviewed on the service life experienced for SMA mixes. It seems that they provided longer service lives than dense graded mixes but that is based on very limited information. Some states did note that they had moved on to SMA mixes over OGFC but that trend is not clear.

CONSTRUCTION SPECIFICATIONS

As a very general statement the grading for Idaho's PMS-OG, Nevada's OGFC, New Jersey's OGFC, New Mexico's OGFC I & II, North Carolina's FC-1 and Oklahoma's OFGC are similar to WSDOT's old Class D which was adopted from the FHWA Technical Advisory for OGFC in the 1970's. The mean standard aggregate size for those mixes is about ¼ inch thick. Alabama's OGFC, Florida's FC-5, Georgia's OGFC, New Mexico's OGFC III, North Carolina's FC-2 and South Carolina's OFGC call for a larger aggregate size with the median aggregate size around 3/8 inch. The gradation used by these states matches or come close to the National Asphalt Paving Association's (NAPA) guidelines for OGFC mixes. Arizona and California's OGFC gradings fall between these sizes but are closer to the old FHWA Technical Advisory. Oregon has been using an OGFC mix with a much larger aggregate size with a median size of around ½ inch.

Most of the noise studies have been based on the smaller aggregate mix. There is some evidence that the larger aggregate mix may not be as quiet as the smaller aggregate mix (Jones 2005). Washington's test sections have utilized the Arizona mix design which falls into the smaller aggregate size group. It should be noted that several countries in Europe place a two layer open-graded system with the larger aggregate size on the

bottom and the smaller aggregate size on the top (FHWA 2004). The general mid line gradation of the two more predominate gradings for OGFC are shown in figure 6.

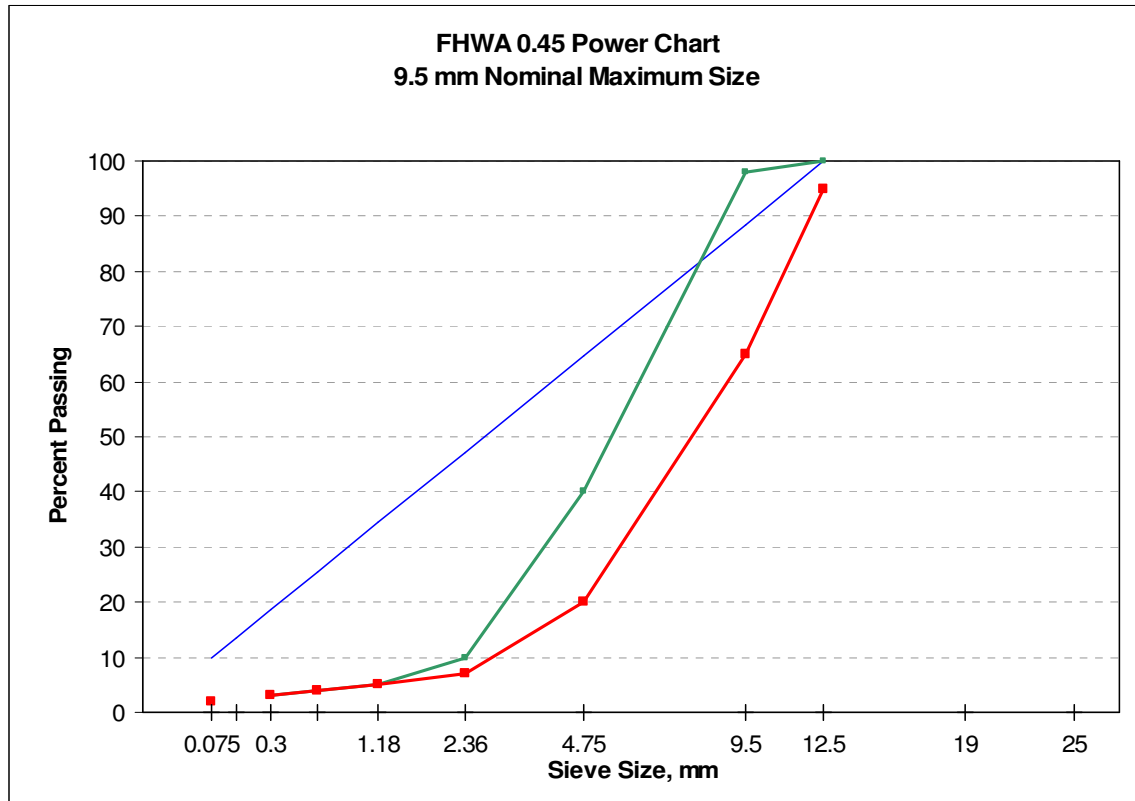


FIGURE 6 Mid-Line Grading of Smaller and Larger Aggregate OGFC

In figure 6 the straight blue line is the maximum density line for a 9.5 mm nominal maximum aggregate. The green line is the mid-line gradation for the old FHWA OGFC mix. The red line is the mid-line gradation for the OGFC used by many south eastern states.

There are two basic binder types found in use today for OGFC mixes. Most of the states are using polymer modified asphalt (PG 76-22) with fibers to control drain-down. A few states (Florida, New Mexico, and Texas) also include a provision for asphalt

rubber binder. Two states (Arizona and California) exclusively use the asphalt rubber binder.

From the state responses to the phone survey it was not clear that there was any difference between the two binder types in service life. In general the amount of binder called for seems to be a little higher for asphalt rubber binder compared to polymer asphalt binder. The study did not look at the costs of OGFC mixes in the various states. In Washington the cost of the OGFC with asphalt rubber binder at the test section on I-5 (Contract 7134) was \$130.00 per ton compared to \$90.00 per ton for the OGFC with polymer modified asphalt and fibers. On the SR 520 project (Contract 7353) the costs were \$285.00 per ton compared to \$155.00 per ton. The second project was a much smaller project with less tonnage which may account for the higher costs. To be cost effective, the OGFC with the asphalt rubber binder should provide a proportionally greater service life compared to the OGFC mix with polymer modified asphalt and fibers.

The authors are aware that ADOT has constructed test sections of both polymer modified asphalt and asphalt rubber on I-10 south of Phoenix along with sections of SMA pavement. Based on personal observations the polymer modified asphalt binder sections do not appear to be performing as well, but those sections also had about three percent less binder than the asphalt rubber sections. The sections with the higher binder content should survive longer than those with lower binder content provided that rutting does not become a problem. The performance of these sections has not been monitored or documented by ADOT at this time.

The minimum air temperature range called for by the different states ranges from 40° F to 70° F with Arizona additionally calling for an 85° F surface temperature. The 40°

F minimum is unique to one state that does not seem to place much open-graded mix. Based on the authors experience the OGFC mix tends to cool down quicker after placement than a comparable thickness of dense graded mix. For that reason, the higher minimum temperatures may reduce the construction risk associated with the placement of OGFC mixes. As a general observation, the more southern states tend to set higher minimum temperatures while the more northern states set lower minimum temperatures. That may reflect more what is practical rather than what is preferred. It is doubtful that WSDOT could use a 70° F minimum temperature requirement as is used by many southern states. The use of a 60° F minimum placement temperature is more the norm for the more northern states but that may still be fairly hard to meet with night paving in western Washington. For night paving in western Washington the 55° F minimum temperature requirement may be the only temperature practical since most night temperatures in the summer drop below 60° F. For daytime paving WSDOT should consider going to the 60° F minimum placement temperature to reduce construction risk.

One item that does not show up on the summary sheet was tack rate. For most of the states the tack rate for OGFC was about 50 percent higher than that indicated for dense graded mixes. Based on the author's experience WSDOT did experience some early raveling problem that was associated with low tack rates. Increasing the normal tack rates by 50 percent is a carryover from the early OGFC specifications which should be continued to reduce the risk of early raveling.

CONCLUSIONS AND RECOMMENDATIONS

After reviewing the data collected in this study, it is evident that there is insufficient information to accurately estimate the service life of the different quiet pavement types to the accuracy that can usually be accomplished from the WSPMS. While it is clear that climate plays an important role in the selection of the pavement type, there is not enough data to establish a relationship between service life and weather conditions. The fact that the durability of OGFC type pavements is reduced in areas that experience winter related maintenance activities is indicated based on European and North American experience. Additionally, Washington State's experience with the early OGFC mixes indicates that studded tire wear was a problem and had a significant effect on the performance of those mixes. It can be assumed that stud wear will be a continuing problem with the new generation OGFC mixes which will likely reduce the service life of those mixes in Washington State compared to other states that do not allow the use of studs.

The definition of service life is also different in various agencies. Some states allow more pavement distress before the DOT takes some form of action to rehabilitate the pavement. Arizona's PMS is largely driven by changes in pavement roughness based on ride values. Washington States PMS is primarily driven by pavement cracking and tends to rehabilitate pavements before there is a significant change in roughness. Because of this there may be several years' difference between the service life of pavements in Arizona and that in Washington State. It also should be noted that those states that have continued to use OGFC mixes tend to be in the southern part of the country, which do not

have the same maintenance issues with snow plowing and stud wear. Consequently, most of the states in the northern part of the country do not appear to be using OGFC mixes as consistently as the more southern states.

A collection of the state specifications for OGFC shows that there are in general two sizes of aggregate gradations used in the United States. The gradation with the larger aggregate size (3/8" median) is used by states in the southeast which fit NAPA's guidelines for OGFC mixes. The rest of the states use the smaller aggregate size (1/4" median) which originally came from the FHWA Technical Advisory for friction courses. There is no indication in the state responses that any of the different OGFC aggregate gradations provide more or less service life. The authors did not find any study that compared the performance of the different OGFC aggregate gradation mixes as far as service life or performance. A study by NCAT indicates that the smaller rock size may be quieter but there is no indication that they remain quieter over their service life (Jones 2005). WSDOT's current measurements are indicating that the noise reduction of the OGFC mixes they placed in two test sections may not continue over even relatively short periods of time. It would seem that the larger aggregate mix may not plug as quickly and thus it may provide better long term noise reduction capacity over time, but no studies were found that looked at that issue.

Most states in the survey used a polymer modified binder (PG 76-22) with fibers to control drain-down and provide the thick asphalt films that is required for OGFC mixes. Some states used an asphalt rubber binder but these were in the minority and all tended to be located in the southern portions of the United States. Arizona and California are the only states that use exclusively asphalt rubber binder. There was also no

indication in the survey that either binder type provided better service life. Those states that do use asphalt rubber binder are specifying a higher percentage of asphalt rubber binder compared to polymer asphalt binder. The study did not look at the costs of these mixes in the various states. In Washington the cost of the OGFC with asphalt rubber binder at the test section on I-5 was about 1/3 more costly compared to the OGFC with polymer modified asphalt and fibers. To be cost effective the OGFC on I-5 with the asphalt rubber binder will have to provide about 30 percent greater service life compared to the OGFC mix with polymer modified asphalt and fibers.

It should be noted that those states currently using OGFC mixes on an ongoing basis are all located in the southern area of the United States. There is more limited use of OGFC documented in the central or northern area of the United States. Colorado has specifically removed the one OGFC pavement it placed because of problems after snowfall. The new generation OGFC mixes clearly are performing better than those placed in the 1970's and 1980's. However, they are still not being used extensively by many northern states nor by many states that allow the use of studded tires like Washington State. WSDOT can expect that the new generation of OGFC mixes will perform better than the old mixes, but it is doubtful that they will survive as long as reported by the Arizona Department of Transportation given Washington's weather and studded tire use.

REFERENCES

- FHWA, 2004. Quiet Pavements: A Scanning Tour of Denmark, the Netherlands, France, Italy and the United Kingdom. Federal Highway Administration International Technology Exchange Program and American Association of State Highway and Transportation Officials.
- Jones, W, 2005. Quiet Pavement – Coming to a Highway Near You.
- National Center for Asphalt Technology, 2007. *Tire/Pavement Noise*.
- Swearingen, David L., Jackson, N. C, Anderson, Keith W., 1992. *Use of Recycled Materials In Highway Construction* WA-RD 252.1 Washington State DOT Olympia WA.
- Sandberg, U. and J.A. Ejsmont, 2002. *Road/Tyre Noise Reference Book*, Informex.

APPENDIX A

Summary of State Phone Survey

TABLE A1 Summary Service Life Estimates from Agency Survey

Agency	OGFC	SMA	HMA	Comments
Alabama				With new mix design (poly mod, fibers) OGFC is lasting longer.
Alaska				OGFC haven't worked in the past due to studded tire wear.
Arizona	9-13			OGFC 7-10 yrs, OGFC with rubber 9-13 yrs, no service life on HMA.
Arkansas				Crumb rubber has been used but no service life information
California				Asphalt Rubber in use but no service live provided
Colorado				OGFC removed due to increased accidents after snow.
Florida	7-15			Original OGFC's 7-15 years. Rubber since 1994 no service life.
Georgia				Have been using OGFC and SMA for 10 years, no service life.
Hawaii				No information on OGFC/SMA/gap-graded
Idaho				No info on service life
Indiana		15+		HMA service life is 15+ years, expecting 20+ from SMA's.
Iowa				Don't use SMA or OGFC layers.
Kansas				Just put down first SMA last year.
Kentucky				No service life data because of high variability.
Louisiana				No information on OGFC/SMA/gap-graded
Maine				No OGFC or SMA layers constructed in Maine.
Michigan				Using gap-graded Superpave since 2002, no service life information
Minnesota				Limited use of SMA. No service life.
Montana	10-12			Built OGFCs in the 1980's which lasted 10-12 years.
Nebraska				Just starting coming back to OGFC.
Nevada	7-10		10	OGFCs last 7-10 years in lower elevations. HMA lasts 10 years
New Hampshire				Don't use OGFCs or SMA layers.
New Jersey	10			OGFC used in the 1970s.
New Mexico	10-12	15	15-20	OGFC's 10-12 years. SMAs are 15 years old. HMA 15-20 years.
New York				Use Novachip but no study. Typical life is 5-8 years
North Carolina	12-15			Poly-mod OGFC 12-15 yrs. Old OGFC 8 years.
Oklahoma				OGFC have shorter life than typical HMA.
Oregon	8-10	10-12		OGFC 8-10 yrs (to .75" rut), SMA 10-12 (to .75" rut).
South Carolina				These are used but no service life
South Dakota				OGFC is used but no information on service life.
Tennessee				First OGFC and SMA put down last year.
Texas	12-15			Some plant mix seals in service for 12-15 years
Vermont	8-10			OGFC lasts 8-10 years and then fails very quickly.
Wyoming				Design life for OGFC averages 20 years.

APPENDIX B

Summary of State's OGFC Mix Requirements

TABLE B1 Summary of States OGFC Mix Specifications

Grading	WSDOT Class D	WSDOT OGFC Test	WSDOT OGFC- AR Test	Alabama OGFC	Arizona ARFC	California O-G RAC	Florida FC-5	Georgia OGFC 12.5mm	Idaho PMS-OG	Indiana OGFC OG19.0	Nevada OGFC
3/4"				100		100	100	100		70-98	
1/2"	100			85-100		95-100	85-100	85-100	100	40-68	100
3/8"	97-100	100	100	55-65	100	78-89	55-75	55-75	95-100	20-52	90-100
#4	30-50	35-55	30-45	10-25	30-45	28-37	15-25	15-25	30-50	10-30	35-55
#8	5-15	9-14	4-8	5-10	4-8	7-18	5-10	5-10	5-15	7-23	
#16						0-10					5-18
#200	2-5	0-2.5	0-2.5	2-4	0-3	0-3	2-4	2-4	2-5	0-8	0-4
% Asphalt	4-6	9	9	5.6-9			ARB12	5.75-7.25			
Asphalt	PG 58-22	PG 70-22	A-R	PG 76-22	A-R	A-R	PG 76-22	PG 76-22			
Min Air Temp.	55° F	55° F	55° F	40° F	70° F *	70° F	65° F	55° F	60° F	60° F	
* + 85° F Surface											
Grading	New Jersey OGFC	New Mexico OGFC I & II	New Mexico OGFC III	North Carolina OGFC FC-1 Mod	North Carolina OGFC FC-2 Mod	Oklahoma OGFC	Oregon OGM 1/2" Open	Oregon OGM 3/4" Open	South Carolina OGFC	Texas PGFC	Texas A-R
3/4"		100	100		100		99-100	85-96	100	100	100
1/2"	100	100	70-90	100	85-100	100	90-98	55-71	85-100	80-100	95-100
3/8"	80-100	90-100	40-65	75-100	55-75	90-100			55-75	35-60	50-80
#4	30-50	30-55	15-25	25-45	15-25	25-45	18-23	10-24	15-25	1-20	0-8
#8	5-15			5-15	5-10		3-15	6-16	5-10	1-10	0-4
#10		0-20	6-12			0-10					
#40		0-12	0-8								
#200	2-5	0-6	0-5	1-3	2-4	0-5	1-5	1-6	0-4	1-4	0-4
% Asphalt				5-8	5 - 8				5 - 7	5.5-7.0	8-10
Asphalt				PG 76-22	PG 76-22				PG 76-22	PG 76-22	A-R
Min Air Temp	60° F	70° F	70° F			60° F		60° F	60° F	70° F	70° F

APPENDIX C
Standard Specifications from State DOTs

Specifications for Alabama's Open-Graded Friction Course

Extracted from:

<http://www.dot.state.al.us/Docs/Bureaus/Construction/Construction+Index.htm>

ALABAMA DOT 420 POLYMER MODIFIED OPEN-GRADED FRICTION COURSE

420.01 Description.

The work covered by this Section shall consist of constructing a hot mixed, hot laid polymer modified open-graded friction course wearing layer generally placed on an existing pavement. The typical cross section and the average weight per square yard will be shown on the plans. Requirements for all hot mix asphalt pavements as specified in Section 410 are applicable to this Section, subject to any exceptions contained herein. Quality Control/Quality Assurance (QC/QA) requirements as specified in Section 106 are applicable to this Section, subject to any exceptions contained herein.

420.02 Materials.

The materials furnished for use shall comply with the requirements of Section 410 and the following:

(a) AGGREGATES.

The aggregate shall be limited to 100% crushed, virgin aggregates of the following: granite, quartzite, blast furnace slag, sandstone or manufactured lightweight aggregate, all of which shall be from approved sources and meet the appropriate requirements of Sections 801 and 802. However, if additional dust (- 200 {- 75 μ m} material) is needed, mineral filler (meeting the requirements of Section 805) or agricultural limestone may be used. If agricultural limestone is used, it shall meet the requirements of ASTM C 602, Standard Specification for Agricultural Liming Materials, for Class E agricultural limestone, so that a minimum of 80 percent of the material will pass the No. 8 {2.35 mm} sieve and 25 percent will pass the No. 60 {0.250 mm} sieve. In addition, a minimum of 5 percent will pass the No. 200 {75 μ m} sieve. No more than 10 percent agricultural limestone shall be used.

The aggregate shall be combined into a total blend that will produce an acceptable job mix within the gradation limits shown below in Table 1. No recycled asphalt pavement shall be allowed in the mix. The blend shall be made from at least two stockpiles of different gradations. At least 10% of the blend shall be taken from each stockpile.

GENERAL COMPOSITION	
SIEVE (Square Mesh Type)	PERCENT PASSING BY WEIGHT{MASS}
3/4 inch {19.0 mm}	100
1/2 inch {12.5 mm}	85 - 100
3/8 inch {9.5 mm}	55 - 65
No. 4 {4.75 mm}	10 - 25
No. 8 {2.36 mm}	5 - 10
No. 200 {75 μ m}	2 - 4

(b) LIQUID ASPHALT BINDER.

The liquid binder shall be a polymer modified PG 76-22 meeting the requirements of Section 804. The proportion of liquid asphalt binder to total sample by weight {mass} shall be 5.6 percent to 9.0 percent for Mix 1 and 4.7 percent to 9.0 percent for Mix 2. The exact proportion shall be fixed by the job mix formula.

(c) POLYMER.

The polymer additive shall meet the requirements of Section 811.

(d) FIBER.

A fiber stabilizer meeting the requirements of Subarticle 410.02(d) shall be incorporated into the mix. The fiber shall be introduced and blended into the mix according to the requirements of Subarticle 410.02(d).

(e) TENSILE STRENGTH RATIO (TSR) REQUIREMENTS.

During design and production, the Section 420 mixes shall have a TSR of at least 0.80 when tested in accordance with Section 7 of ALDOT-259. The testing frequency for both Contractor and Department testing during production shall be one test for each 5000 tons {4500 metric tons} or portion thereof.

420.03 Design

The Open-graded Friction Course shall be designed with a minimum air void content of 12% according to ALDOT-259, OPEN-GRADED ASPHALT CONCRETE FRICTION COURSE DESIGN METHOD. The contractor shall have the responsibility for the design of Section 420 mixes.

The work will be accepted on a LOT by LOT basis in accordance with the applicable requirements. Pay factors for air voids and density shall not apply.

420.04 Construction Requirements.

(a) GENERAL.

The requirements of Articles 410.03 through 410.07 shall apply except as modified hereinafter in this Article.

(b) COMPACTION EQUIPMENT.

Item 410.03(a)5 is amended to require that steel wheel tandem (7 ton {6 metric ton} minimum size) rollers shall be furnished in sufficient numbers based on the quantity of material being placed to provide effective compaction coverage within the workable time period of the mix as designated by the Engineer. Rubber-tire rollers shall not be used.

(c) WEATHER AND TEMPERATURE LIMITATIONS.

The weather, air, and surface temperature limitations for (polymerized) HMA mixes are found in Subarticle 410.03(b).

(b) DAYLIGHT, WET WEATHER AND TEMPERATURE LIMITATIONS.

1. OPERATIONS IN DAYLIGHT.

Placement and compaction operations shall be performed during daylight hours unless noted otherwise on the plans or directed otherwise by the Engineer. (The requirements for lighting for nighttime work are given in Article 104.04(a)).

2. WET WEATHER.

The mixture shall be laid only upon an approved underlying course, which is dry, and only when weather conditions are suitable. The Engineer may, however, permit work of this character to continue when overtaken by sudden rains, up to the amount which may be in transit from the plant at the time, provided the surface just ahead of the placing is swept clear of water and the mixture is within the allowable tolerances from the established delivery temperature. The layer placed under such conditions shall be at the Contractor's risk and shall be removed and replaced by him without extra compensation should it prove unsatisfactory.

3. COLD WEATHER RESTRICTIONS.

Hot mix asphalt (HMA) layers of 200 pounds per square yard { 110 kg/m² } or less shall not be placed when the surface or air temperature is below 40 °F { 4 °C }; air temperature shall be 40 °F { 4 °C } before the spreading operation is started. Spreading operations shall be stopped when the air temperature is below 45 °F { 7 °C } and falling. For HMA layers over 200 pounds per square yard { 110 kg/m² }, the above temperature may be lowered 5 °F { 2 °C }. Unless otherwise stated in the plans and specifications, polymer modified HMA layers of 200 pounds per square yard { 110 kg/m² } or less shall not be placed when the surface or air temperature is below 60 oF { 15 oC }; for layers over 200 pounds per square yard { 110 kg/m² }, the above temperature may be lowered 10 °F { 5 °C }.

The Contractor, at his discretion, may place HMA layers at temperatures lower than these cold weather limits. The contractor is warned that other factors such as wind speed and percent humidity may increase the heat loss from the HMA layers. All other requirements for the installation and quality of the HMA layers shall be applicable to the work even when the restrictions against placement of the HMA during cold weather are not followed. The layers placed under such conditions shall be at the Contractor's risk and shall be removed and replaced by him without extra compensation should they prove unsatisfactory. There will be no direct payment for additional costs associated with the placement of HMA during cold weather.

(d) COMPACTING.

Subarticle 410.03(g) is amended to require that rolling shall be as approved by the Engineer; no density tests will be required.

420.05 Method of Measurement.

The accepted quantities of polymer modified open-graded friction course will be measured as provided in Article 410.08.

420.06 Basis of Payment.

(a) UNIT PRICE COVERAGE.

Polymer Modified Open-graded Friction Course, measured as noted above, will be paid for at the contract unit price bid in accordance with Article 410.09.

(b) PAYMENT WILL BE MADE UNDER ITEM NO.:

420-A Polymer Modified Open-graded Friction Course – per ton {metric ton}

Specifications for Alabama’s Stone Matrix Asphalt

Extracted from:

<http://www.dot.state.al.us/Docs/Bureaus/Construction/Construction+Index.htm>

423 STONE MATRIX ASPHALT (SMA) (FIBER STABILIZED ASPHALT CONCRETE)

423.01 Description.

The work covered by this Section shall consist of constructing a hot mix asphalt layer of fiber stabilized stone matrix asphalt pavement on a prepared surface in accordance with these specifications and in conformity with the lines, grades, typical cross section, and the placement rate shown on the plans or as directed. The plant, equipment, and construction requirements for this pavement are specified in Sections 106 and 410, subject to any exceptions herein. All 423 mixes shall be designed and produced in accordance with the requirements given in this Section and ALDOT-395, SMA Mix Design.

423.02 Materials.

(a) AGGREGATES.

1. GENERAL.

All fine and coarse aggregate furnished shall come from an approved producer who is participating in and meeting the requirements of ALDOT-249, *Procedure for Acceptance of Coarse and Fine Aggregates*. The producer's name shall be listed in the Department's *Materials, Sources, and Devices with Special Acceptance Requirements Manual*, List I-1. The Department has established a list of qualified producers of fine and coarse aggregates. Refer to Subarticle 106.01(f) and ALDOT-355 concerning this list.

2. COARSE AGGREGATE.

Coarse aggregate shall be aggregate retained on the No. 4 {4.75 mm} sieve. The virgin coarse aggregate shall be 100% crushed granite, quartzite, limestone, sandstone, slag, or other 100% crushed manufactured stone meeting the requirements of Section 801 and Table 1.

Test Method		Minimum	Maximum
Flat & Elongated % by Count 3:1 (max to min)	ASTM D 4791 Section 8.4	0	20
Flat & Elongated % by Count 5:1 (max to min)	ASTM D 4791 Section 8.4	0	5

Aggregate Soundness.

The percent degradation of the source aggregate by the sodium sulfate soundness test (AASHTO T 104, *Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate*) after five cycles of testing shall not exceed 10 %.

Deleterious Materials and Absorption.

The amount of deleterious substances, flat or elongated particles, and absorption in the coarse aggregate shall not exceed the following limits:

(a) Coal and Lignite (Visual)	0.25 %
(b) Clay Lumps and Friable Particles (AASHTO T 112)	0.25 %
(c) Other local deleterious substances (Shale, Mica, Marcasite, etc.) (Visual)	2.0 %
(d) Absorption (Absorption on the material passing the 3/4 inch {19.0 mm} sieve and retained on the No. 4 {4.75 mm} sieve) (AASHTO T 85 *). Applies to gravel aggregates only.	2.0 %
* Section 8.1 of AASHTO T 85 modified to require a 15 minute vacuum saturation period as per Section 6.3 of AASHTO T 209 prior to the required 15-19 hour soaking period.	

Los Angeles Abrasion Criteria.

The percent loss of the coarse aggregate by the LA Abrasion test (AASHTO T 96, *Resistance to Abrasion of Small Size Aggregate by use of the Los Angeles Machine*) shall not exceed 48 % except that, for Sandstone and Blast Furnace Slag, the LA Abrasion shall not exceed 55 %.

3. FINE AGGREGATE.

Fine aggregate shall be aggregate passing the No. 4 {4.75 mm} sieve. Gravel used to manufacture fine aggregate shall have a bulk specific gravity greater than 2.550 (AASHTO T 85). The virgin fine aggregate shall be 100% crushed granite, limestone, sandstone, slag, or other 100% crushed manufactured stone meeting the requirements of Section 802 and Table 2; the parent material shall meet the requirements of Section 801.

Test Method	Minimum	Maximum
Uncompacted Voids % AASHTO T 304*	45	100
Sand Equivalent % AASHTO T 176*	50	100
Liquid Limit % AASHTO T 89	0	25
Plasticity Index AASHTO T 90	Non-plastic	
*The Sand Equivalent and Uncompacted Voids may be run on the blend of the aggregates.		

The fine aggregate shall be non-plastic when tested in accordance with AASHTO T 89, as modified by ALDOT-232, and AASHTO T 90 and shall have a maximum of 1.0 percent clay lumps and friable particles as determined by AASHTO T 112. It shall consist of hard, tough grain, free of injurious amounts of clay, loam, or other deleterious substances.

4. MINERAL FILLER.

The mineral filler shall meet the requirements of Section 805.

(b) RECYCLED ASPHALT PAVEMENT (RAP).

When RAP is used as a component of SMA, the coarse and fine aggregates contained in the RAP shall meet the respective requirements as outlined in Items 423.02 (a) 2 and 3. The total amount of RAP allowed in SMA is limited to 15% by weight {mass} of aggregate. RAP containing gravel or fine aggregate manufactured from gravel with a bulk specific gravity less than 2.550 is not allowed in SMA.

Otherwise, the use of RAP shall conform to the specifications of Article 410.02. In addition to these requirements, RAP used in a 3/8" {9.5 mm} Maximum Size Mix shall be processed so that 100.0% of the RAP shall pass the 3/8" {9.5 mm} sieve.

(c) BLEND OF AGGREGATES.

The combined aggregates shall conform to the percent passing by volume requirements of Table 3.

Sieve Size	1.5 inch {37.5 mm} Maximum Aggregate Size		1 inch {25.0 mm} Maximum Aggregate Size		3/4 inch {19.0 mm} Maximum Aggregate Size		1/2 inch {12.5 mm} Maximum Aggregate Size		3/8 inch {9.5 mm} Maximum Aggregate Size	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
1.5 inch {37.5 mm}	100	100								
1 inch {25.0 mm}	90	100	100	100						
3/4 inch {19.0 mm}	30	86	90	100	100	100				
1/2 inch {12.5 mm}	26	63	50	74	90	100	100	100		
3/8 inch {9.5 mm}	24	52	25	60	26	78	90	100	100	100
# 4 {4.75 mm}	20	28	20	28	20	28	26	60	90	100
# 8 {2.36 mm}	16	24	16	24	16	24	20	28	28	65
# 16 {1.18 mm}	13	21	13	21	13	21	13	21	22	36
# 30 {600 μm}	12	18	12	18	12	18	12	18	18	28
# 50 {300 μm}	12	15	12	15	12	15	12	15	15	22
# 200 {75 μm}	8	10	8	10	8	10	8	10	12	15

An example of how to blend aggregate based upon volume can be found in ALDOT-395, SMA Mix Design. The production tolerances for the above gradation bands are as specified in Item 410.02(b)2, except that the tolerance for the No. 4 {4.75 mm} sieve is +/- 4% and for the 3/8 inch {9.5 mm} sieve is +/- 6%.

Aggregates that tend to polish under traffic, such as limestone, dolomite, or marble, shall be permitted only in widening as defined by Article 410.01, shoulder paving, underlying layers, and layers that are to be covered by Polymer Modified Open-graded Friction Course (Section 420) mix in this contract, except as noted in Table 4.

BPN 9 Value Of Aggregate Source *	Maximum Allowable Percentage Of Carbonate Stone
≤ 25	30
26 through 28	35
29 through 31	40
32 through 34	45
≥ 35	50

* This value, BPN 9, is made using the British Pendulum Tester on aggregate source specimen polished for 9 hours on an accelerated polishing machine known as the British Wheel as per ASTM D 3319, ASTM E 303 and BMTF-382.

In no case shall the total amount of virgin carbonate stone in the combined mixture used as actual wearing surface layers exceed the percentage shown in Table 4. When parts of the carbonate stone used in the mix are from differing strata of material or coming from multiple sources that are represented by different BPN 9 values, the lowest BPN 9 value will be used.

(d) FIBER.

A fiber stabilizer meeting the requirements of Article 410.02 shall be incorporated into the mix. The fiber shall be introduced and blended into the mix according to the requirements of Article 410.02.

(e) LIQUID ASPHALT BINDER.

Unless otherwise shown on the plans, the liquid asphalt binder shall meet the requirements of Section 804 and shall be polymer-modified to meet a PG 76-22 as specified in Section 811. Up to 15% reclaimed asphalt pavement (RAP) may be used in the mix. The minimum liquid asphalt binder content shall be as specified in Table 6.

Maximum Aggregate Size (inches) {mm}	Minimum Liquid Asphalt Binder Content (% by weight) {% by mass}
1.5 {37.5}	5.3
1.0 {25.0}	5.5
3/4 {19.0}	5.7
1/2 {12.5}	5.9
3/8 {9.5}	6.1

423.03 Design.

All SMA mixes shall be designed according to ALDOT-395, SMA Mix Design. SMA mixes shall be designed using a 50 blow Marshall design. At the design number of blows, the SMA shall have a minimum VMA of 17, a VCAMIX less than the VCADRC (calculating Voids in the Coarse Aggregate is explained in ALDOT-395 SMA Mix Design) and air voids of 4.0 percent. The SMA mix shall be designed with a minimum tensile strength ratio of 0.80 according to ALDOT-361. The dust from the mix combined with the liquid asphalt binder and fiber is the mortar. The mortar shall have a minimum unaged DSR $G^*/\sin \delta$ of 5 kPa, a minimum RTFO aged DSR $G^*/\sin \delta$ of 11 kPa, and a maximum PAV aged BBR Stiffness of 1500 MPa (Mortar Evaluation is explained in ALDOT-395, SMA Mix Design). The mix shall exhibit 4.50 mm or less rutting when

tested according to ALDOT-401, Rutting Susceptibility Determination of Asphalt Paving Mixtures Using the Asphalt Pavement Analyzer.

423.04 Hot Mix Asphalt Plant Requirements.

(a) MINERAL FILLER.

The introduction of the mineral filler shall be in accordance with Section 4.3 of AASHTO M 156 as specified in ALDOT-324 to insure accurate metering and proportioning. Adequate dry storage shall be provided for the mineral filler. In a batch plant, mineral filler shall be added directly into the weigh hopper. In a drum plant, mineral filler shall be added directly into the drum mixer near enough to the liquid asphalt binder line so that the mineral filler is captured by the liquid asphalt binder.

Note: for most SMA projects, the flow rate of the mineral filler governs the plant production rate.

(b) HOT-MIXTURE STORAGE.

SMA shall not be stored at elevated temperatures for more than three hours. SMA shall not be heated above 350 °F { 177 °C } without the approval of the Engineer.

423.05 Construction Requirements.

(a) GENERAL.

Construction requirements shall be the same as specified in Articles 410.03 through 410.07 except as noted in this Article.

(b) WEATHER AND TEMPERATURE LIMITATIONS.

The weather, air and surface temperature limitations for (polymerized) HMA mixes are found in Subarticle 410.03(b).

(c) SURFACE PREPARATION.

A thin tack coat meeting the requirements of Section 405 shall be applied to ensure uniform and complete adherence of the overlay.

(d) COMPACTION.

The mixture, when delivered to the paver, shall have a temperature of not less than 290 °F { 145 °C }.

Due to the nature of stone matrix asphalt mixture, the surface shall be rolled immediately. Rolling shall be accomplished with steel wheel rollers. Pneumatic tire rollers shall not be used on stone matrix asphalt. Rollers shall move at a uniform speed, not to exceed 3 miles per hour { 5 km/hr }, with the drive roller nearest the paver. Rolling shall be continued until all roller marks are eliminated and the required density has been obtained, but not after the mat has cooled to 240 °F { 115 °C }. The Contractor shall monitor density during the compaction process by use of nuclear density gauges to ensure that the required density is being obtained. If vibratory compaction causes aggregate breakdown or forces liquid asphalt binder to the surface, the vibratory mode shall be turned off and the roller shall operate in static mode only.

To prevent adhesion of the mixture to the rollers, it shall be necessary to keep the wheels properly moistened with water mixed with very small quantities of detergent or other approved material.

423.06 Method of Measurement.

The accepted quantities of stone matrix asphalt binder layer and stone matrix asphalt wearing layer will be measured as provided in Article 410.08. The SMA mix shall be

evaluated for liquid asphalt binder content, laboratory compacted air voids, and in-place density; pay factors will be applied.

423.07 Basis of Payment.

(a) UNIT PRICE COVERAGE.

Stone Matrix Asphalt Binder Layer and Stone Matrix Asphalt Wearing Layer, measured as noted above, will be paid for at the contract unit price bid in accordance with Article 410.09.

(b) PAYMENT WILL BE MADE UNDER ITEM NO.:

423-A Stone Matrix Asphalt Wearing Layer, * Maximum Aggregate Size - per ton {metric ton}

423-B Stone Matrix Asphalt Binder Layer, * Maximum Aggregate Size - per ton {metric ton}

* Specify Maximum Aggregate Size, either 1.5, 1, 3/4, 1/2 or 3/8 inches {37.5 mm, 25 mm, 19 mm, 12.5 mm, or 9.5 mm}

Specifications for Arizona's Asphaltic Concrete Friction Course

Extracted from:

http://www.azdot.gov/highways/ConstGrp/const_manual/TOC/c4.pdf

ARIZONA DOT

SECTION 414 ASPHALTIC CONCRETE FRICTION COURSE (ASPHALT-RUBBER):

414-1 Description:

Asphaltic Concrete Friction Course (Asphalt-Rubber), hereinafter asphaltic concrete, shall consist of furnishing all materials, mixing at a plant, hauling, and placing a mixture of aggregate materials, mineral admixture, and bituminous material (asphalt-rubber) to form a pavement course or to be used for other specified purposes, in accordance with the details shown on the project plans and the requirements of these specifications, and as directed by the Engineer.

The contractor shall be responsible for all adjustments to its equipment necessary to properly accommodate the use of asphalt-rubber as a bituminous material.

414-2 Asphaltic Concrete Mix Design Criteria:

Mix designs will be performed in accordance with Arizona Test Method 814, modified as necessary for Asphaltic Concrete Friction Course (Asphalt-Rubber). The allowable range of percent absorbed asphalt-rubber shall be 0-1.0, when tested in accordance with Arizona Test Method 806.

414-3 Materials:

For comparative purposes, quantities shown in the bidding schedule have been calculated based on the following data:

Spread Rate (lb./sq. yd.)	<u>XXX</u>
Asphalt-Rubber, %	<u>XX.X</u>
Mineral Admixture, %	1.0

The spread rate specified includes XX percent for leveling to provide a minimum XX-inch thickness above the leveling thickness. The exact spread rate will be determined by the Engineer.

414-3.01 Mineral Aggregate:

There is no Department-furnished source of mineral aggregate. The contractor shall provide a source in accordance with the requirements of Section 1001 of the specifications.

When the contractor selects a source or sources, it shall notify the Engineer. The contractor shall be solely responsible for assuring that the mineral aggregate meets all requirements and, when processed, is fully capable of providing asphaltic concrete which meets all the requirements of these specifications.

Mineral aggregate shall be separated into at least two stockpiles. No individual stockpile or hot bin usage shall be less than three percent of the total mineral aggregate.

Coarse mineral aggregate shall consist of crushed gravel, crushed rock, or other approved inert materials with similar characteristics, or a combination thereof, conforming to the requirements of these specifications.

Fine mineral aggregate or blend material shall consist of natural sand, sand prepared from rock, or other approved inert materials, or a combination thereof, conforming to the requirements of these specifications.

Mineral aggregate furnished for mix designs shall be representative of the source(s) and sampled from the material stockpiles to be utilized in asphaltic concrete production. Mix designs shall conform to the grading limits in Table 414-1, when tested in accordance with Arizona Test Method 201.

TABLE 414-1 MIX DESIGN GRADING LIMITS		
Sieve Size	Percent Passing	
	Without Admixture	With Admixture
3/8 Inch	100	100
No. 4	30 - 45	31 - 46
No. 8	4 - 8	5 - 9
No. 200	0 - 2.0	0 - 3.0

Mineral aggregate shall conform to the requirements in Table 414-2 when tested in accordance with the applicable test methods.

Tests on aggregates outlined in Table 414-2, other than abrasion, shall be performed on materials furnished for mix design purposes and composited to the mix design gradation. Abrasion shall be performed separately on samples from each source of mineral aggregate. All sources shall meet the requirements for abrasion.

TABLE 414-2 MINERAL AGGREGATE CHARACTERISTICS		
Characteristic	Test Method	Requirement
Combined Bulk Oven Dry Specific Gravity	Arizona Test Method 251	2.350 – 2.850

Combined Water Absorption	Arizona Test Method 251	0 – 2.5%
Sand Equivalent	Arizona Test Method 242 (After thoroughly sieving the sample, no additional cleaning of the fines from the plus No. 8 material is required.)	Minimum 55
Fractured Coarse Aggregate Particles	Arizona Test Method 212	Minimum 85% (at least two fractured faces) and minimum 92% (at least one fractured face)
Flakiness Index	Arizona Test Method 233	Maximum 25%
Carbonates	Arizona Test Method 238	Maximum 20%
Abrasion	AASHTO T 96	100 Rev., Max. 9% 500 Rev., Max. 40%

414-3.02 Mineral Admixture:

Mineral admixture will be required. The amount shall be 1.0 percent, by weight of the mineral aggregate. Mineral admixture shall be either Portland cement, blended hydraulic cement, or hydrated lime conforming to the requirements of Table 414-3.

TABLE 414-3 MINERAL ADMIXTURE	
Material	Requirement
Portland Cement, Type I or II	ASTM C 150
Blended Hydraulic Cement, Type IP	ASTM C 595
Hydrated Lime	ASTM C 1097

A Certificate of Analysis conforming to the requirements of Subsection 106.05 shall be submitted to the Engineer.

414-3.03 Bituminous Material:

Bituminous material shall be asphalt-rubber conforming to the requirements of Section 1009 of the specifications. The asphalt-rubber shall be Type ~~XXXXX~~. The crumb rubber gradation shall be Type B conforming to the requirements of Section 1009.

The percent of asphalt-rubber used shall be based on the weight of total mix (asphalt-rubber, mineral aggregate, and mineral admixture).

The percent of asphalt-rubber to be used will be specified by the Engineer.

In no case shall the asphalt-rubber be diluted with extender oil, kerosene, or other solvents. Any asphalt-rubber so contaminated will be rejected.

Any kerosene or other solvents used in the cleaning of equipment shall be purged from the system prior to any subsequent use of that equipment.

414-4 Mix Design:

Approximately 300 pounds of produced mineral aggregate, in proportion to the anticipated percent usage, shall be obtained by the contractor and witnessed by the Engineer so that both parties are satisfied that samples are representative of the mineral aggregate to be utilized in the asphaltic concrete production.

In addition to the mineral aggregate samples, the contractor shall also furnish the Engineer with representative samples of the following materials: a five-pound sample of the crumb rubber proposed for use, one gallon of asphalt cement from the intended supplier, three gallons of the proposed mixture of asphalt and rubber, and a one-gallon can of the proposed mineral admixture. These materials must be representative of the material which will subsequently be used in the production of asphaltic concrete.

If the mineral aggregate does not meet the requirements of Subsection 414-3.01, no mix design will be prepared. The contractor shall take the necessary steps to provide material meeting the specified requirements.

Along with the samples furnished for mix design testing, the contractor shall submit a letter explaining in detail its methods of producing mineral aggregate including wasting, washing, blending, proportioning, etc., and any special or limiting conditions it may propose. The contractor's letter shall also state the source(s) of mineral aggregate, the source and type of asphalt cement, the source and type of crumb rubber, and the source and type of mineral admixture.

Within 10 working days of receipt of all samples and the contractor's letter in the Central Laboratory, the Department will provide the contractor with a mix design containing the type and percentage of asphalt-rubber; the type and source of asphalt cement; the type and source of crumb rubber; the type, source, and percentage of mineral admixture; the source(s) of mineral aggregate and the percentage from each stockpile; the composite mineral aggregate gradation; the combined mineral aggregate and mineral admixture gradation; and any special or limiting conditions.

The contract time established for the completion of the work includes 10 working days for the required testing and the developing of the approved mix design.

Asphaltic concrete friction course production shall not begin until there is an approved mix design.

414-5 Mix Design Revisions:

At any time after production of asphaltic concrete has been started using the approved mix design, changes may be proposed by the contractor or directed by the Engineer.

The contractor shall not change its methods of crushing, screening, washing, or stockpiling from those used during production of material used for mix design purposes without approval of the Engineer, or without requesting a new mix design.

If changes are made in the source or type of bituminous material or the source(s) of mineral aggregate, or changes are made in the proportions of mineral aggregate equal to or greater than five percentage points, additional testing to the extent deemed necessary by the Engineer will be performed in order that the Engineer may be satisfied that the mix design criteria will be met.

During production of asphaltic concrete, the contractor, on the basis of field test results, may request a change to the approved mix design. The Engineer will evaluate the proposed changes and notify the contractor of the Engineer's decision within two working days of the receipt of the request.

If, at any time, unapproved changes are made by the contractor in the source or type of bituminous material, source(s) of mineral aggregate, production methods, or proportional changes in violation of approved mix design stipulations, production shall cease until a new mix design is developed at no additional cost to the Department, or the contractor complies with the approved mix design.

At any time after the mix design has been approved, the contractor may request a new mix design. The costs associated with the testing of materials in the developing of mix designs requested by the contractor after a mix design acceptable to the Department has been developed shall be borne by the contractor.

If the Engineer determines that a new mix design is necessary due to changes in mineral aggregate characteristics or gradation, costs associated with the development of the new mix design shall be borne by the contractor.

A new mix design can be developed by the Engineer at any time the Engineer deems necessary. Should such a new mix design require revisions to the contractor's operations which result in additional cost to the contractor, it will be reimbursed for these costs. However, the Engineer reserves the right to modify the asphalt-rubber content without compensation being made to the contractor involving additional operation costs.

414-6 Acceptance of Materials:

414-6.01 General:

The contractor's attention is directed to the requirements of Subsection 105.13, Removal of Unacceptable and Unauthorized Work.

If the production of asphaltic concrete is stopped either for failure to meet the requirements specified in Subsection 414-6.03 or because changes are made in the mix design, samples will be taken for calculating new consecutive averages either after production resumes or after the changes in the mix design have been made. The acceptance of the mineral aggregate gradation and the bituminous material content will be determined on the basis of the tests specified in Subsection 414-6.03. The Engineer reserves the right to increase the frequency of sampling and testing upon the resumption of asphaltic concrete production.

414-6.02 Mineral Aggregate:

Aggregate shall be free of deleterious materials, clay balls, and adhering films or other material that prevent thorough coating of the aggregate with the bituminous material.

Prior to and during asphaltic concrete production, the Engineer shall obtain and test samples of mineral aggregate for the determination of the sand equivalent, fractured coarse aggregate particles, and flakiness index. Samples shall be obtained from the cold feed belt prior to the addition of mineral admixture, or from the stockpiles when sampling from the cold feed belt is not possible. Should such testing indicate results not meeting the requirements of Table 414-2 for sand equivalent, fractured coarse aggregate particles, and flakiness index, operations shall cease and the contractor shall have the option of requesting a new mix design or correcting deficiencies in the aggregate stockpiles.

414-6.03 Asphaltic Concrete:

(A) Mineral Aggregate Gradation:

Prior to the initial startup of asphaltic concrete production, and prior to startup after any subsequent mix design revisions affecting gradation, a sample of the combined mineral aggregate shall be tested. The mineral aggregate shall meet the gradation requirements for the 3-consecutive test limits indicated below. If the mineral aggregate does not meet these requirements, production shall not begin until the mineral aggregate is in compliance with this requirement.

For each approximate 500 tons of asphaltic concrete produced, at least one sample of mineral aggregate will be taken. Samples will be taken in accordance with the requirements of Arizona Test Method 105 on a random basis. For batch plants, the sample shall be taken from the hot bins. For plants other than batch plants, the sample shall be taken from the cold feed belt. Samples will be taken by means of a sampling

device which is capable of obtaining representative samples. The device, which shall be approved by the Engineer, shall be furnished by the contractor. In any shift that the production of asphaltic concrete is less than 500 tons, at least one sample will be taken.

Samples will be tested for conformance to the mix design gradation, with or without mineral admixture as appropriate, in accordance with the requirements of Arizona Test Method 201.

The gradation will be considered to be acceptable unless the average of any three consecutive tests or the result of any single test varies from the mix design gradation percentages as follows:

Passing Sieve	Number of Tests	
	3 Consecutive	One
No. 4	± 4	± 6
No. 8	± 3	± 4
No. 200	± 1.0	± 1.5

One hundred percent of the material shall pass the 3/8-inch sieve.

At any time that test results indicate that the gradation does not fall within all of the limits indicated, the production of asphaltic concrete shall cease immediately and shall not begin again until a calibration test indicates that the gradation is within the 3-consecutive test limits indicated.

(B) Asphalt-Rubber Content:

During production of asphaltic concrete, the contractor shall maintain at the plant site a nuclear asphalt content gauge calibrated and operated in accordance with Arizona Test Method 421. At the discretion of the Engineer, the Department may choose to prepare the calibration samples for use by the contractor. Under the observation of the Engineer, the contractor shall determine the asphalt-rubber content by means of the nuclear asphalt content gauge a minimum of four times per full shift. The Engineer shall determine the times that the samples are taken. The contractor’s technicians performing the testing, including the calibration of the nuclear gauge, shall meet the technician requirements given in the Department’s System for the Evaluation of Testing Laboratories. The requirements may be obtained from ADOT Materials Group, 1221 North 21st Avenue, Phoenix, AZ 85009.

Production of asphaltic concrete shall cease immediately and the plant and/or the nuclear asphalt content gauge re-calibrated if any single test result varies by an amount greater than ± 0.60, or the average of three consecutive test results varies by an amount greater than ± 0.40, from the amount directed by the Engineer. Material that has already been produced may be used on the project if the single test value representative of that material varies by an amount from ± 0.61 to ± 0.75, inclusive, from the amount directed by the Engineer. Material that has already been produced may not be used on the project if the

single test value representative of that material varies by an amount greater than ± 0.75 from the amount directed by the Engineer unless, by retesting, the material is found to be acceptable.

414-7 Construction Requirements:

414-7.01 Quality Control:

Quality control of mineral aggregate production and asphaltic concrete production shall be the responsibility of the contractor. The contractor shall perform sufficient testing to assure that mineral aggregate and asphaltic concrete are produced which meet all specified requirements. The Engineer reserves the right to obtain samples of any portion of any material at any point of the operations for the Engineer's own use.

414-7.02 Stockpiling:

The contractor will not be allowed to feed the hot plant from stockpiles containing less than two full days of production unless only two days production remain to be done or special conditions exist where the Engineer deems this requirement waived.

Mineral aggregate shall be separated and stockpiled so that segregation is minimized. An approved divider of sufficient size to prevent intermingling of stockpiles shall be provided.

414-7.03 Proportioning, Drying, Heating, and Mixing:

The asphaltic concrete hot plant shall conform to the requirements of Section 403 of the Specifications.

Unless approved by the Engineer, no individual mineral aggregate stockpile or hot bin usage shall be less than three percent of the total mineral aggregate.

Changes in stockpile or hot bin use in excess of five percent from the approved mix design will not be permitted without the approval of the Engineer.

No fine material which has been collected in the dust collection system shall be returned to the mixture unless the collected fines are uniformly metered into the mixture.

The moisture content of the asphaltic concrete shall not exceed 0.5 percent. The moisture content will be determined in accordance with Arizona Test Method 406.

The temperature of asphaltic concrete or mineral aggregate upon discharge from the dryer shall not exceed 350 degrees F.

414-7.04 Placing and Finishing:

(A) General Requirements:

The handling of asphaltic concrete shall at all times be such as to minimize segregation. Any asphaltic concrete which displays segregation shall be removed and replaced.

All equipment surfaces shall be treated when necessary with a product approved by the Engineer in order to prevent the sticking of asphaltic concrete.

Before asphaltic concrete is placed, the surface to be paved shall be cleaned of all objectionable material and tacked with asphalt cement in accordance with the requirements of Section 404 of the specifications. The cleaning of the surface, the tacking of the surface, and the amount and grade of asphalt cement used shall be as directed by and acceptable to the Engineer.

Unless otherwise specified on the project plans, asphaltic concrete shall not be placed on the two-foot widened section where guardrail is to be installed.

(1) Placement Dates and Weather Requirements:

Asphaltic concrete shall be placed between the dates shown below for the average elevation of the project, and only when the temperature of the surface on which the asphaltic concrete is to be placed is at least 85 degrees F and the ambient temperature at the beginning of placement is at least 70 degrees F and rising. The placement shall be stopped when the ambient temperature is 75 degrees F or less and falling.

Average Elevation of Project, Feet	Beginning and Ending Dates
0 – 3499	March 15 – May 31
0 – 3499	September 1 – October 31
3500 – 4999	April 15 – October 15
5000 and over	June 1 – September 15

At any time, the Engineer may require that the work cease or that the work day be reduced in the event of weather conditions, either existing or expected, which would have an adverse effect upon the asphaltic concrete.

Prior to opening to any traffic, the Engineer may require up to three applications of lime water (a minimum of 50 pounds of lime per 2,000 gallons of water). Lime water shall be applied in a manner that uniformly covers the entire surface of the paving pass. No separate payment will be made for lime water or its application, the cost being considered as included in this contract item.

(2) Delivery to Screed Unit:

Asphaltic concrete delivered to the screed unit shall be a free flowing, homogeneous mass in which there is no segregation, crusts, lumps, or migration of the asphalt-rubber.

Should any one or more of such conditions be evident in the material delivered to the screed unit, and which cannot be eliminated by one or more of the following methods, the Engineer will order the work to be stopped until conditions are conducive to the delivery of the material in the condition as hereinbefore required:

- (a) Covering hauling units with tarpaulins.
- (b) Dumping material directly into the paver.
- (c) Moving the hot plant nearer to the point of delivery.

Other measures proposed by the contractor which will deliver asphaltic concrete meeting the above requirements will be considered by the Engineer.

(B) Loading Asphaltic Concrete into the Paving Machine:

If the asphaltic concrete is dumped directly into the paving machine from the hauling trucks, care shall be taken to avoid jarring the machine or moving it out of alignment. No vertical load shall be exerted on the paving machine by the trucks. Trucks, while dumping, shall be securely attached to the paving machine.

If the asphaltic concrete is dumped upon the surface being paved and subsequently loaded into the paving machine, it shall not be dumped at a distance greater than 150 feet in front of the paving machine. The loading equipment shall be self-supporting and shall not exert any vertical load on the paving machine. Substantially all of the asphaltic concrete shall be picked up and loaded into the paving machine.

(C) Placing and Finishing Asphaltic Concrete by Means of Self-Propelled Paving Machines:

All courses of asphaltic concrete shall be placed and finished by means of self-propelled paving machines except under certain conditions or at certain locations where the Engineer deems the use of self-propelled paving machines impractical.

In order to achieve, as far as practical, a continuous operation, the speed of the paving machine shall be coordinated with the production of the plant.

Self-propelled paving machines shall spread the mixture without segregation or tearing within the specified tolerances, true to the line, grade, and crown indicated on the project plans. Pavers shall be equipped with hoppers and augers which will distribute the mixture uniformly in front of adjustable screeds.

Screeds shall include any strike-off device operated by tamping or vibrating action which is effective without tearing, shoving or gouging the mixture and which produces a course with a uniform texture and density for the full width being paved. Screeds shall be adjustable as to height and crown and shall be equipped with a controlled heating device for use when required.

Tapered sections not exceeding eight feet in width, or widened sections not exceeding four feet in width may be placed and finished by other means approved by the Engineer.

(D) Automatically Actuated Control System:

Except under certain conditions or at certain locations where the Engineer deems the use of automatic controls impractical, asphaltic concrete shall be placed and finished by means of self-propelled paving machines equipped with an automatically actuated control system.

The control system shall control the elevation of the screed at each end by controlling the elevation of one end directly and the other end indirectly, either through controlling the transverse slope or, alternately when directed, by controlling the elevation of each end independently.

The control system shall be capable of working with the following devices which shall be furnished with the machine:

Ski-type device at least 30 feet in length, supported throughout its entire length.

Short ski.

Failure of the control system to function properly shall be cause for the suspension of the asphaltic concrete operations.

414-7.05 Joints:

Longitudinal joints shall be staggered a minimum of one foot with relation to the longitudinal joint of the immediate underlying course.

The contractor shall schedule its paving operations to minimize exposed longitudinal edges. Unless otherwise approved by the Engineer, the contractor shall limit the placement of asphaltic concrete courses, in advance of adjacent courses, to one shift of asphaltic concrete production. The contractor shall schedule its paving operations in such a manner to eliminate exposed longitudinal edges over weekends or holidays.

Longitudinal joints shall be located within one foot of the centerline between two adjacent lanes.

414-7.06 Compaction:

(A) General Requirements:

The temperature of asphaltic concrete just prior to compaction shall be at least 275 degrees F.

The wheels of compactors shall be wetted with water, or if necessary soapy water, or a product approved by the Engineer to prevent the asphaltic concrete from sticking to the steel wheels during rolling. The Engineer may change the rolling procedure if in the Engineer's judgment the change is necessary to prevent picking up of the asphaltic concrete.

(B) Equipment:

Compacting and smoothing shall be accomplished by the use of static steel wheel compactors. Vibrator compactors may be used in the static mode only. The compactors shall be self-propelled and shall be operated with the drive wheel in the forward position. A minimum of three compactors shall be provided; however, sufficient compactors shall be provided so that the drums of the compactors when staggered will cover the entire width of the paving machine during initial breakdown.

Compactors shall be operated in accordance with the manufacturer's recommendations. Compactors shall be designed and properly maintained so that they are capable of accomplishing the required compaction.

The compactors shall weigh not less than eight tons.

(C) Rolling Procedure:

A pass shall be defined as one movement of a compactor in either direction. Coverage shall be the number of passes as are necessary to cover the entire width being paved.

Compaction shall consist of the following rolling sequence:

Rolling Sequence	Number of Coverages
Initial	1
Finish	1 - 2

A sufficient number of compactors shall be used for initial breakdown so that when the compactors are staggered the entire width of the mat being laid is compacted with one forward pass of the compactors. The distance between the paving machine and the initial rolling shall not exceed 300 feet.

A separate roller(s) shall be used for final compaction. The roller(s) used for final compaction shall follow as closely behind the initial breakdown rollers as possible.

Compaction will be deemed to be acceptable on the condition that the asphaltic concrete is compacted using the type of compactors specified, ballasted and operated in accordance with the manufacturer's recommendations, and with the number of coverages of the compactors as specified.

414 -7.07 Compacting Miscellaneous Items and Surfaces:

Asphaltic concrete used in the construction of miscellaneous items and surfaces shall be compacted using compactors, hot-hand tampers, smoothing irons, mechanical vibrating hand tampers, or with other devices to the extent considered necessary by the Engineer.

414-7.08 Smoothness and Surface Tolerances:

Asphaltic concrete shall be compacted as required, smooth and true to the required lines, grades, and dimensions.

The Special Provisions may require the smoothness of the final pavement surface to be tested in accordance with Subsection 109.13.

Regardless of whether testing in accordance with Subsection 109.13 is specified or not, the following requirements shall be met:

- (1) The finished asphaltic concrete surface shall be tested and shall not vary by more than 1/8 inch from the lower edge of a ten-foot straightedge when it is placed in the longitudinal direction (including across transverse joints), and when it is placed in the transverse direction across longitudinal joints.
- (2) All deviations exceeding the specified tolerances above shall be corrected by the contractor, to the satisfaction of the Engineer.

Specifications for California's Open-Graded Friction Course

Extracted from:

http://www.dot.ca.gov/hq/esc/oe/specifications/std_specs/2006_StdSpecs/2006_StdSpecs.pdf

CALTRANS

ASPHALT CONCRETE

39-1 GENERAL

39-1.01 DESCRIPTION

- This work shall consist of furnishing and mixing aggregate and asphalt binder at a central mixing plant, spreading and compacting the mixture and furnishing and placing pavement reinforcing fabric, all as specified in these specifications and the special provisions.
- Asphalt concrete is designated as Type A, Type B or Open-graded.
- Asphalt concrete base is designated as Type A or Type B. The type of asphalt concrete or asphalt concrete base will be shown on the plans or specified in the special provisions.
- Asphalt concrete and asphalt concrete base shall be produced in a batch mixing plant, a continuous pugmill mixing plant or a drier-drum mixing plant. Proportioning shall be either by hot-feed control or cold-feed control.

39-2 MATERIALS

39-2.01 ASPHALTS

- Asphalt binder to be mixed with aggregate shall be a steam-refined paving asphalt in conformance with the provisions in Section 92, "Asphalts," and shall be of the grade designated in the special provisions or as determined by the Engineer.
- The amount of asphalt binder to be mixed with the aggregate for Open-graded asphalt concrete will be determined by the Engineer in conformance with the requirements in California Test 368, using the samples of aggregates furnished by the Contractor in conformance with the provisions in Section 39-3.03.

39-2.02 AGGREGATE

- Aggregates shall be clean and free from decomposed materials, organic material and other deleterious substances. Coarse aggregate is material retained on the No. 4 sieve; fine aggregate is material passing the No. 4 sieve; and supplemental fine aggregate is added fine material passing the No. 30 sieve, including, but not limited to, cement and stored fines from dust collectors.
- Unless otherwise specified in the special provisions, the aggregate grading of the various types of asphalt concrete shall conform to the following:

Type	Grading
A	3/4-inch maximum, coarse
B	3/4-inch maximum, medium
Open-graded	3/8-inch maximum

. The combined aggregate, prior to the addition of asphalt binder, shall conform to the requirements of this section. Conformance with the grading requirements will be determined by California Test 202, modified by California Test 105 when there is a difference in specific gravity of 0.2 or more between the coarse and fine portions of the aggregate or between blends of different aggregates.

. In the tables below, the symbol "X" is the gradation which the Contractor proposes to furnish for the specific sieve. The proposed gradation shall meet the gradation shown in the table under "Limits of Proposed Gradation." Changes from one mix design to another shall not be made during the progress of the work unless permitted by the Engineer. However, changes in proportions to conform to the approved mix design shall not be considered changes in mix design.

AGGREGATE GRADING REQUIREMENTS

Open-graded Asphalt Concrete

Percentage Passing

1/2 inch Maximum

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
3/4"	—	100	100
1/2"	—	95-100	92-100
3/8"	78-89	X±4	X±7
No. 4	28-37	X±4	X±7
No. 8	7-18	X±4	X±5
No. 16	—	0-10	0-13
No. 200	—	0-3	0-4

3/8 inch Maximum

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
1/2"	—	100	100
3/8"	—	90-100	88-100
No. 4	29-36	X±4	X±7
No. 8	7-18	X±4	X±5
No. 16	—	0-10	0-12
No. 200	—	0-3	0-4

- The combined aggregate shall conform to the following quality requirements prior to the addition of the asphalt:

Tests	California Test	Asphalt Concrete Type		Open Graded Asphalt Concrete	Asphalt Concrete Base Type	
		A	B		A	B
Percentage of Crushed Particles:	205					
Coarse Aggregate (Min.)		90%	25%	90%	90%	25%
Fine Aggregate Passing No. 4, Retained on No. 8 (Min.)		70%	20%	90%	70%	20%
Los Angeles Rattler:	211					
Loss at 100 Rev. (Max.)		10%	—	10%	10%	—
Loss at 500 Rev. (Max.)		45%	50%	40%	45%	50%
Sand Equivalent:	217					
Contract Compliance (Min.)		47	42	—	47	42
Operating Range (Min.)		50	45	—	50	45
Film Stripping (Max.) ^a	302	—	—	25%	—	—
K _C Factor (Max.)	303	1.7	1.7	—	1.7	1.7
K _f Factor (Max.)	303	1.7	1.7	—	1.7	1.7

^a After mixing with asphalt binder

- If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Operating Range" but meet the "Contract Compliance" requirements, placement of the asphalt concrete or asphalt concrete base

may be continued for the remainder of that day. However, another day's work may not be started until tests, or other information, indicate to the satisfaction of the Engineer that the next material to be used in the work will comply with the requirements specified for "Operating Range."

- . If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Contract Compliance," the asphalt concrete or asphalt concrete base which is represented by these tests shall be removed. However, if requested by the Contractor and approved by the Engineer, the asphalt concrete or asphalt concrete base may remain in place and the Contractor shall pay to the State \$1.75 per ton for the asphalt concrete or asphalt concrete base represented by these tests and left in place. The Department may deduct this amount from any moneys due, or that may become due, the Contractor under the contract. If both the aggregate grading and Sand Equivalent do not conform to the "Contract Compliance" requirements, only one adjustment shall apply.
- . No single aggregate grading or Sand Equivalent test shall represent more than 500 tons or one day's production, whichever is smaller.
- . The asphalt concrete mixture, composed of the aggregate proposed for use and the optimum amount of asphalt as determined by California Test 367, shall conform to the following quality requirements:

Tests	California Test	Asphalt Concrete Type		Open Graded Asphalt Concrete	Asphalt Concrete Base Type	
		A	B		A	B
Swell (Max.) (inch)	305	0.03	0.03	—	0.03	0.03
Moisture Vapor Susceptibility (Min.)	307	30	25	—	30	25
Stabilometer Value (Min.):						
(3/8" & No. 4 Max. AC)	366	30	30	—	—	—
All Others	366	37	35	—	37	35

39-2.03 PAVEMENT REINFORCING FABRIC

- . Pavement reinforcing fabric shall conform to the provisions in Section 88, "Engineering Fabrics."

39-3 STORING, PROPORTIONING AND MIXING MATERIALS

39-3.01 STORAGE

- . Aggregate shall be stored so that separately sized aggregates will not be intermingled, and asphalt binder shall be stored so that different grades of asphalt will not be intermingled. Any aggregate which has been intermingled with another size of aggregate shall be removed and replaced with aggregate of specified grading. As used in this specification, "cold storage" is the storing of aggregates prior to their having been

processed in a drier, and "hot storage" is the storing of aggregates after their having been processed in a drier. "Hot-feed control" and "cold-feed control" indicate the location of measuring devices or controls.

- When the Contractor adds supplemental fine aggregate, each supplemental fine aggregate used shall be stored separately and kept thoroughly dry.

- The measurement and storage requirements of this Section 39-3, shall not apply to the dust collected in skimmers and expansion chambers (knock-out boxes) or to the dust collected in centrifugal (cyclone) collectors. Dust from these collectors may be returned to the aggregate without being measured or stored separately, provided the dust is returned uniformly at a point in advance of the sampling device in batch-mixing plants or is returned at or before mixing in continuous mixing plants.

- Aggregate and asphalt binder shall also be stored in conformance with the following:

39-3.01A Cold Storage

- When aggregate contains material of which at least 20 percent will pass the No. 8 sieve, the material shall be fed from storage by means of a mechanical feeder.

- Before being fed to the drier, aggregate shall be separated into sizes and stored as follows:

39-3.01A(1) Cold Storage for Plants Utilizing Hot-Feed Control

- Aggregate for asphalt concrete base shall be separated into 4 or more sizes and stored separately. Aggregate for Type A or Type B asphalt concrete of the 3/4-inch and 1/2-inch maximum sizes shall be separated into 3 or more sizes and stored separately.

- Aggregate for Type A or Type B asphalt concrete of the 3/8-inch maximum size and the No. 4 maximum size, and aggregate for Open-graded asphalt concrete need not be separated into sizes and stored separately.

39-3.01A(2) Cold Storage for Plants Utilizing Cold-Feed Control

- When the Contractor elects to use a plant equipped with cold-feed control, aggregate for asphalt concrete base shall be separated into 4 or more sizes. Aggregate for asphalt concrete of the 3/4-inch and 1/2-inch maximum sizes shall be separated into 3 or more sizes. Aggregate for asphalt concrete of the 3/8-inch maximum size and aggregate for Open-graded asphalt concrete shall be separated into 2 or more sizes. Aggregate for asphalt concrete of No. 4 maximum size need not be separated.

- After the aggregate is separated, each size shall be stored separately.

39-3.01B Hot Storage

- Aggregate for asphalt concrete and asphalt concrete base to be mixed in batch mixing plants, after being dried, shall be stored in accordance with the following:

Aggregates for asphalt concrete base shall be separated into 4 or more sizes. Aggregates for asphalt concrete of 3/4-inch and 1/2-inch maximum sizes shall be separated into 3 or more sizes. Aggregate for asphalt concrete of 3/8-inch maximum size and aggregate for Open-graded asphalt concrete shall be separated into 2 or more sizes. Aggregate for asphalt concrete of No. 4 maximum size need not be separated.

After the aggregate is separated, each size shall be stored in a separate bin and shall be recombined in conformance with the provisions in Section 39-3.03, "Proportioning," to conform to the gradings specified in Section 39-2, "Materials."

Storage bins shall be provided with chutes to prevent overflow into adjacent bins.

39-3.01C Asphalt Binder Storage

- Asphalt to be used as a binder for asphalt concrete shall be stored in tanks accurately calibrated in uniform intervals of 100 gallon intervals and maintained to this accuracy. The storage tanks shall be accessible for measuring the volume of asphalt at any time.
- The Contractor shall provide a suitable sampling device in asphalt feed lines connecting plant storage tanks to the asphalt weighing system or spray bar. The sampling device shall consist of a valve with a nominal diameter between ½ inch or ¾ inch valve constructed in a manner that a one-quart sample may be withdrawn slowly at any time during plant operations. The valve shall be maintained in good condition, and if the valve fails to function properly, the valve shall be replaced. The sampling device shall be readily accessible and in an area free of dangerous obstructions and shall be between 24 inches and 30 inches above the platform. A drainage receptacle shall be provided for flushing the device prior to sampling.
- The discharge end of the asphalt binder circulating pipe shall be maintained below the surface of the asphalt binder in the storage tank to prevent discharging hot asphalt binder into open air.
- A temperature-sensing device shall be installed in the asphalt feed line. The device shall measure the temperature of the asphalt and shall be accurate to 10° F. The indicator shall be located and maintained at the point where the proportioning operations are controlled. When a recording type indicator is used, the recording type indicator shall be maintained in working condition and shall be serviced as required.

39-3.02 DRYING

- Aggregate shall be fed directly to a drier-drum mixer or to a drier at a uniform rate.
- Drying shall continue for a sufficient time and at a sufficiently high temperature that, at the time of spreading, the moisture content of the completed mixture shall not exceed one percent. Moisture content will be determined by California Test 310 or 370.
- The drier or drier-drum mixer shall be provided with a device which senses the temperature of the material leaving the drier or the drier-drum mixer. The temperature-sensing device shall be accurate to the nearest 10° F, and shall be installed in such a manner that changes of 10° F in temperature of the material will be shown within one minute. The indicator shall be located and maintained at the point where the proportioning operations are controlled. When a recording type indicator is used, the recording type indicator shall be maintained in working condition and shall be serviced as required.
- The burner used for heating the aggregate shall achieve complete combustion of the fuel.

39-3.03 PROPORTIONING

- Before producing asphalt concrete or asphalt concrete base, the Contractor shall submit in writing to the Engineer the gradation of the aggregate for each mix which he proposes to furnish. If the aggregate is separated into 2 or more sizes, the proposed gradation shall consist of gradations for individual sizes, and the proposed proportions of individual sizes, combined mathematically to indicate one proposed gradation. The gradation shall meet the applicable grading requirements shown in Section 39-2.02, "Aggregate," and shall show the percentage passing each of the specified sieve sizes.
- At least 2 weeks prior to their intended use, the Contractor shall furnish samples of aggregates, in the quantity requested by the Engineer, from the source the Contractor

proposes to use for the project. The samples shall have been processed in a manner representative of that for the material to be used in the work. In batch-mixing plants, these samples shall be obtained from the normal sampling area, just before the weigh hopper. In continuous mixing plants, the sample shall be obtained from the normal sampling area, after cold feed proportioning and in advance of the point where the aggregate enters the mixer. The bitumen ratio (pounds of asphalt per 100 pounds of dry aggregate including supplemental fine aggregate, if used) will be determined by the Engineer using California Test 367, or California Test 368 for Open-graded asphalt concrete.

- Should the Contractor change the source of supply, the Contractor shall furnish new samples and proposed proportions, as determined by the Engineer to be necessary, at least 2 weeks before their intended use. A change which affects any portion of the total aggregate in the mix will be considered a change in source and will require a new mix design. Up to 3 mix designs will be performed by the State at State expense when the mix design is utilized for one or more working days. The Contractor shall bear all costs involved in developing any mix design not utilized for one or more days and for all mix designs developed after the first 3 that have been so utilized. The Engineer will determine the cost to the State for the mix designs, and the Department may deduct this amount from any moneys due, or that may become due the Contractor under the contract.

- Where asphalt concrete or asphalt concrete base is to be produced from established sources and if acceptable to the Engineer, the Contractor may advise the Engineer in writing that the source, gradings and proportions of those aggregates proposed to be furnished are the same as those approved for, and used on, another prior or concurrent project. The project shall be identified by contract number. The Engineer will determine if an existing mix design is acceptable for the current project.

39-3.03A Proportioning for Batch Mixing

- When the Contractor elects to use batch mixing equipment, each aggregate storage bin shall be equipped with a suitable, safe sampling device which will provide a sample, representative of actual production, of the aggregate discharged into the weighhopper or volumetric proportioning bin. When the samples are taken from a location above ground level, a means shall be provided for lowering the aggregate samples to the ground.

- The fine material collected in dust control systems, other than centrifugal collectors or knock-out boxes, shall be proportioned as provided for supplemental fine aggregate in this Section 39-3.03A.

- When supplemental fine aggregate is used, it shall be proportioned by weight as provided in "Weight Proportioning" of Section 39-3.03A(1), "Manual Proportioning." A suitable, safe sampling device shall be installed in each feed line or surge tank preceding the weigh hopper. The delivery point of samples shall be safe and convenient.

- Aggregate and asphalt shall be proportioned by weight or by volume as follows:

39-3.03A(1) Manual Proportioning

- An automatic plant shall not be operated manually unless the automatic circuitry is disconnected to the extent that the automatic circuitry cannot be activated by the mere operation of a switch, circuit breaker or some other similar routine procedure.

- When manual proportioning is used in the production of asphalt concrete or asphalt concrete base, proportioning shall conform to the following:

Weight Proportioning

- . The zero tolerance for aggregate scales shall be 0.5-percent of the total batch weight of the aggregate. The zero tolerance for separate scales for weighing supplemental fine aggregate or asphalt binder shall be 0.05-percent of the total batch weight of the aggregate.
- . The indicated weight of material drawn from storage for any draft of material shall not vary from the preselected scale setting by more than the following percentages of the total batch weight of the aggregate:
 - (1) Aggregate shall be within one percent, except that when supplemental fine aggregate is used and is weighed cumulatively with the aggregate, the draft of aggregate drawn immediately before the supplemental fine aggregate shall be within 0.5-percent.
 - (2) Supplemental fine aggregate shall be within 0.5-percent.
 - (3) Asphalt binder shall be within 0.1-percent.
- . The asphalt binder shall be measured by a tank scale.

Volumetric Proportioning

- . Each size of aggregate, except supplemental fine aggregate, shall be proportioned in a separate bin that is adjustable in size. Each bin shall have a gate or other device so designed that the bin shall be completely filled and struck off in measuring the volume of aggregate to be used in the mix. Means shall be provided for calibrating the weight of material in each measuring bin at any time. The plant shall be operated in such a manner that the material in each aggregate bin is within 2 percent of the weight preselected for the type of mixture being produced.
- . Asphalt binder shall be proportioned by a meter or an adjustable calibrated tank. When meters are used, the asphalt lines leading to asphalt meters shall be full-circulating or shall be regulated so that, during plant stoppages, the temperature of the asphalt does not change more than 15° F from the temperature maintained while the plant is in full operation. Asphalt binder shall be proportioned to within 2 percent of the weight preselected for the mixture being produced.

39-3.03A(2) Automatic Proportioning

- . When automatic batch mixing is required by the special provisions or when the Contractor elects to use an automatic batching system, the proportioning devices shall be automatic to the extent that the only manual operation required for proportioning all materials for one batch shall be a single operation of a switch or starter.

Weight Proportioning

- . Automatic proportioning devices shall be of a type in which materials discharged from the several bins are controlled by gates or by mechanical conveyors. The batching devices shall be so interlocked that no new batch may be started until all weighhoppers are empty, the scales are at zero, and the discharge gates are closed. The means of withdrawal from the bins and of discharge from the weigh box shall be interlocked so that not more than one bin can discharge onto any given scale at one time, and that the weigh box cannot be tripped until the required quantity from each of the bins has been deposited therein. In addition, automatic proportioning devices shall be interlocked so

that the weighing cycle will be interrupted whenever the amount of material drawn from any storage varies from the preselected amount by more than the tolerances specified in Section 39-3.03A(1), "Manual Proportioning." Whenever the weighing cycle is interrupted, that specific batch shall not be used in the work unless it can be manually adjusted to meet the specified tolerances based on the total weight of the batch. When partial batches are batched automatically, the interlock tolerances, except the zero tolerance, shall apply to the total weight of the aggregate in the partial batch.

- Automatic proportioning devices shall be operated so that all weight increments required for a batch are preset on the controls at the same time. Controls shall be designed so that these settings may be changed without delay, and the order of discharge from the several bins can be changed as directed by the Engineer.
- Automatic proportioning controls shall be equipped with means for inspection of the interlock tolerance settings, and instructions for doing so shall be immediately available at the point of operation.
- In order to check the accuracy of proportioning during plant operation, the Contractor shall provide means to check the weight of various proportioned amounts on a separate scale located at the plant.

Volumetric Proportioning

- Asphalt binder shall be proportioned by an adjustable calibrated tank.
- Automatic volumetric proportioning devices shall be of a type which will not allow the bins to discharge into the mixer unless the mixer is empty and the mixer discharge gate is closed and will not operate unless the aggregate bins and asphalt binder tank are full.
- The automatic proportioning device shall operate in such a manner that the material in each aggregate bin and the asphalt binder tank is within 2 percent of the preselected weight.
- In order to check the accuracy of proportioning during plant operation, the Contractor shall provide means to check the weight of various proportioned amounts on a separate scale located at the plant.

39-3.03B Proportioning for Continuous Mixing

- Asphalt binder shall be introduced into the mixer through a meter in conformance with the provisions in Section 9-1.01, "Measurement of Quantities." The asphalt meter shall automatically compensate for changes in asphalt temperature, unless the meter is of the weight flow, coriolis effect, type. The system shall be capable of varying the rate of delivery of binder proportionate with the delivery of aggregate. During any day's run, the temperature of asphalt binder shall not vary more than 50° F. The meter and lines shall be heated and insulated. The storage for binder shall be equipped with a device for automatic plant cut-off when the level of binder is lowered sufficiently to expose the pump suction line.
- When supplemental fine aggregate is used, it shall be proportioned by weight by a method that uniformly feeds the material within 2 percent of the required amount. Supplemental fine aggregate shall be discharged from the proportioning device directly into the mixer.
- The supplemental fine aggregate proportioning system shall function with such accuracy that, when operated at between 30 percent and 100 percent of maximum operating capacity, the average difference between the indicated weight of material

delivered and the actual weight delivered will not exceed one percent of the actual weight for three 15-minute runs. For any of 3 individual 15-minute runs, the indicated weight of material delivered shall not vary from the actual weight delivered by more than 2 percent of the actual weight.

- The fine material collected in all dust control systems may be returned to the aggregate production stream without proportioning if returned at a rate commensurate with overall plant production, and if returned at or before the mixer. Any return rate of less than 100 percent of the collection rate shall be metered as specified above for supplemental fine aggregate.

- The asphalt feeder, each of the aggregate feeders, the supplemental fine aggregate feeder, if used, and the combined aggregate feeder, shall be equipped with devices by which the rate of feed can be determined while the plant is in full operation.

- The combined aggregate shall be weighed using a belt scale. The belt scale shall be of such accuracy that, when the plant is operating between 30 percent and 100 percent of belt capacity, the average difference between the indicated weight of material delivered and the actual weight delivered will not exceed one percent of the actual weight for three 3-minute runs. For any of the 3 individual 3-minute runs, the indicated weight of material delivered shall not vary from the actual weight delivered by more than 2 percent of the actual weight.

- The actual weight of material delivered for proportioning device calibrations shall be determined by a vehicle scale in conformance with the provisions in Section 9-1.01, "Measurement of Quantities." The vehicle scale shall be located at the plant and shall be sealed within 24 hours of checking the plant's proportioning devices. The plant shall be equipped so that this accuracy check can be made prior to the first operation for a project and at any other time as directed by the Engineer.

- The belt scale for the combined aggregate, the proportioning devices for supplemental fine aggregate, if used, and the asphalt proportioning meter shall be interlocked so that the rates of feed of the aggregates and asphalt will be adjusted automatically (at all production rates and production rate changes) to maintain the bitumen ratio (pounds of asphalt per 100 pounds of dry aggregate including supplemental fine aggregate, if used) designated by the Engineer. The plant shall not be operated unless this automatic system is operating and in good working condition.

- Asphalt meters and aggregate belt scales used for proportioning aggregates and asphalt shall be equipped with rate-of-flow indicators to show the rates of delivery of asphalt and aggregate, and resettable totalizers so that the total amounts of asphalt and aggregate introduced into the mixture can be determined. Rate-of-flow indicators and totalizers for like materials shall be accurate within one percent when compared directly. The asphalt cement totalizer shall not register when the asphalt metering system is not delivering material to the mixer.

- The bin or bins containing the fine aggregate and supplemental fine aggregate, if used, shall be equipped with vibrating units or other equipment which will prevent any hang-up of material while the plant is operating. Each belt feeder shall be equipped with a device to monitor the depth of aggregate between the troughing rollers. The device for monitoring depth of aggregate shall automatically shut down the plant whenever the depth of aggregate is less than 70 percent of the target depth. To avoid erroneous shutdown by normal fluctuation, a delay between sensing less than 70 percent flow and

shutdown of the plant will be permitted, as determined by the Engineer, at the time of the initial California Test 109. A second device shall be located either in the stream of aggregate beyond the belt or where it will monitor movement of the belt by detecting revolutions of the tail pulley on the belt feeder. The device for monitoring no flow or belt movement, as the case may be, shall stop the plant automatically and immediately when there is no flow. The plant shall not be operated unless both low-flow and no-flow devices are in good working condition and functioning.

- The Contractor shall determine the moisture content of the aggregate at least once during each 2 hours of production and shall adjust the moisture control equipment accordingly.

- For continuous pugmill mixing plants an aggregate sampling device which will provide a 60-pound to 80-pound sample of the combined aggregate while the plant is in full operation shall be provided in advance of the point where the aggregate enters the mixer.

- For drier-drum mixing plants an aggregate sampling device which will provide a 60-pound to 80-pound sample of the combined aggregate while the plant is in full operation shall be provided in advance of the point where the aggregate enters the drier-drum mixer.

- When the samples are taken from a location above ground level, a means shall be provided for lowering the aggregate samples to the ground.

- When supplemental fine aggregate is used, a suitable, safe sampling device shall be installed in each feed line or surge tank preceding the proportioning device for the supplemental fine aggregate.

39-3.04 MIXING

- Aggregate, supplemental fine aggregate and asphalt binder shall be mixed in a batch mixer, continuous mixing pugmill mixer or continuous mixing drier-drum mixer. The asphalt content of the asphalt mixture will be determined by extraction tests in conformance with the requirements in California Test 310 or 362, or will be determined in conformance with the requirements in California Test 379. The bitumen ratio (pounds of asphalt per 100 pounds of dry aggregate including supplemental fine aggregate if used) shall not vary by more than 0.5-pound of asphalt above or 0.5-pound of asphalt below the amount designated by the Engineer. Compliance with this requirement, except for Open-graded asphalt concrete, will be determined by testing samples taken from the mat behind the paver before initial or breakdown compaction of the mat.

- For Open-graded asphalt concrete, compliance with this requirement will be determined either by taking samples from trucks at the plant or from the mat behind the paver before initial or breakdown compaction of the mat. If the sample of Open-graded asphalt concrete is taken from the mat behind the paver, the bitumen ratio shall be not less than the amount designated by the Engineer, less 0.7-pound of asphalt per 100 pounds of dry aggregate, nor more than the amount designated by the Engineer, plus 0.5-pound of asphalt per 100 pounds of dry aggregate.

- The charge in a batch mixer, or the rate of feed to a continuous mixer, shall not exceed that which will permit complete mixing of all of the material. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected by a reduction in the volume of material or by other adjustments.

- Asphalt binder shall be at a temperature of not less than 250° F nor more than 375° F when added to the aggregate.
- The temperature of the aggregate before adding the binder, except for Open-graded mixes, shall be not more than 325° F. The temperature of the aggregate for Open-graded mixtures shall be not more than 275° F.

39-3.04A Batch Mixing

- When asphalt concrete or asphalt concrete base is produced by batch mixing, the mixer shall be equipped with a sufficient number of paddles of a type and arrangement to produce a properly mixed batch.
- The binder shall be introduced uniformly into the mixer along the center of the mixer parallel to the mixer shafts, or by pressure spraying. When a pan is used, the pan shall be equipped with movable vanes in order that the flow of binder may be directed across the width of the pan, as desired. The vanes shall be equipped with a means for quick adjustment, and a positive lock to prevent shifting.
- The mixer platform shall be of ample size to provide safe and convenient access to the mixer and other equipment. The mixer housing and weighbox housing shall be provided with gates of ample size to permit ready sampling of the discharge of aggregate from each of the plant bins and from each feed line or surge tank of supplemental fine aggregate, if used. The Contractor shall provide a sampling device capable of delivering a representative sample of sufficient size to permit the required tests.
- The mixer shall be equipped with a timing device which will indicate by a definite audible or visual signal the expiration of the mixing period. The device shall measure the time of mixing within 2 seconds.
- The time of mixing a batch shall begin on the charging stroke of the weighhopper dumping mechanism and shall end when discharge is started. Mixing shall continue until a homogeneous mixture of uniformly distributed and properly coated aggregates of unchanging appearance is produced. The time of mixing shall be not less than 30 seconds.
- When automatic proportioning or automatic batch mixing is required by the special provisions or when the Contractor elects to use an automatic batching system, an interval timer shall control the time of mixing. The interval timer shall be interlocked so that the mixer cannot be discharged until all of the materials have been mixed for the full time specified.

39-3.04B Continuous Mixing

- Continuous mixing plants shall utilize pugmill or drier-drum mixers.
- When asphalt concrete or asphalt concrete base is produced by pugmill mixing, the mixer shall be equipped with paddles of a type and arrangement to provide sufficient mixing action and movement to the mixture to produce properly mixed asphalt concrete or asphalt concrete base. The combined aggregate shall be fed directly from the drier to the mixer at a uniform and controlled rate.
- Mixing shall continue until a homogeneous mixture of thoroughly and uniformly coated aggregates of unchanging appearance is produced at discharge from the mixer.
- Temperature of the completed mixture shall not exceed 325° F at discharge from the mixer.
- The mixer shall discharge into a storage silo with a capacity of not less than that specified in Section 39-3.05, "Asphalt Concrete and Asphalt Concrete Base Storage."

The Contractor shall provide a means of diverting the flow of asphalt concrete or asphalt concrete base away from the silo to prevent incompletely mixed portions of the mixture from entering the silo.

39-3.05 ASPHALT CONCRETE AND ASPHALT CONCRETE BASE STORAGE

- . When asphalt concrete or asphalt concrete base is stored, the asphalt concrete or asphalt concrete base shall be stored only in silos. Asphalt concrete or asphalt concrete base shall not be stockpiled. The minimum quantity of asphalt concrete or asphalt concrete base in any one silo during mixing shall be 20 tons except for the period immediately following a shutdown of the plant of 2 hours or more. A means shall be provided to indicate that storage in each silo is being maintained as required.
- . Storage silos shall be equipped with a surge-batcher sized to hold a minimum of 2 tons of material. A surge-batcher consists of equipment placed at the top of the storage silo which catches the continuous delivery of the completed mix and changes it to individual batch delivery and prevents the segregation of product ingredients as the completed mix is placed into storage. The surge-batcher shall be center loading and shall be thermally insulated or heated or thermally insulated and heated to prevent material buildup. Rotary chutes shall not be used as surge-batchers.
- . The surge-batcher shall be independent and distinct from conveyors or chutes used to collect or direct the completed mixture being discharged into storage silos and shall be the last device to handle the material before it enters the silo. Multiple storage silos shall be served by an individual surge-batcher for each silo. Material handling shall be free of oblique movement between the highest elevation (conveyor outfall) and subsequent placement in the silo. Discharge gates on surge-batchers shall be automatic in operation and shall discharge only after a minimum of 2 tons of material has been collected and shall close before the last collected material leaves the device. Discharge gate design shall prevent the deflection of material during the opening and closing operation.
- . Open-graded asphalt concrete stored in excess of 2 hours, and any other asphalt concrete or asphalt concrete base stored in excess of 18 hours, shall not be used in the work.
- . Asphalt concrete or asphalt concrete base with hardened lumps in the mixture shall not be used. Any storage facility which contained the material with the hardened lumps shall not be used for further storage until the cause of the lumps is corrected.

39-3.06 ASPHALT CONCRETE PLANTS

- . Any plants, including commercial plants, that produce asphalt concrete or asphalt concrete base that is subject to these specifications shall conform to the provisions in Section 7-1.01F, "Air Pollution Control," and shall be equipped with a wet-tube dust washer or equal and other devices which will reduce the dust emission to the degree that adjacent property is not damaged. The washer and other equipment shall function efficiently at all times when the plant is in operation.
- . During production, petroleum products such as diesel fuel and kerosene shall not be used as a release agent on belts, conveyors, hoppers or hauling equipment.
- . Plants shall be equipped with an inspection dock so constructed that an inspector standing on the dock can inspect the completed mix and take samples, as necessary, from the hauling vehicle before the vehicle leaves the plant site. This inspection dock shall allow the vehicle to pull alongside and shall meet all applicable safety requirements of the California Division of Occupational Safety and Health. Drivers shall be instructed to

stop at the dock whenever an inspector is on the dock and to remain there until directed to leave by the inspector.

39-5 SPREADING AND COMPACTING EQUIPMENT

39-5.01 SPREADING EQUIPMENT

- Asphalt pavers shall be self-propelled mechanical spreading and finishing equipment, provided with a screed or strike-off assembly capable of distributing the material to not less than the full width of a traffic lane. Screed action shall include any cutting, crowding or other practical action which is effective on the mixture without tearing, shoving or gouging, and which produces a surface texture of uniform appearance. The screed shall be adjustable to the required section and thickness. The paver shall be provided with a suitable full width compacting device. Pavers that leave ridges, indentations or other marks in the surface shall not be used unless the ridges, indentations or other marks are eliminated by rolling or prevented by adjustment in operation.
- The asphalt paver shall operate independently of the vehicle being unloaded or shall be capable of propelling the vehicle being unloaded in a satisfactory manner. The load of the haul vehicle shall be limited to that which will ensure satisfactory spreading. While being unloaded the haul vehicle shall be in contact with the machine at all times, and the brakes on the haul vehicle shall not be depended upon to maintain contact between the vehicle and the machine.
- No portion of the weight of hauling or loading equipment, other than the connection, shall be supported by the asphalt paver, and no vibrations or other motions of the loader, which could have a detrimental effect on the riding quality of the completed pavement, shall be transmitted to the paver.
- When asphalt concrete is placed directly upon asphalt treated permeable base, the asphalt concrete shall be placed with a paver equipped with tracks unless the layer being placed is 0.15-foot or less in compacted thickness.

39-5.02 COMPACTING EQUIPMENT

- A minimum of one steel-tired, 2-axle tandem roller weighing not less than 8 tons nor more than 10 tons shall be used for each asphalt paver to compact Open-graded asphalt concrete, and a minimum of 3 rollers consisting of the following shall be used for each asphalt paver to compact all other asphalt concrete and asphalt concrete base:

- One steel-tired roller weighing not less than 8 tons;
- One steel-tired, 2-axle or 3-axle tandem or 3-wheel roller weighing not less than 12 tons and
- One pneumatic-tired roller.

- The 2-axle or 3-axle tandem or 3-wheel roller shall have rolling wheels with a diameter of 40 inches or more.
- Except when leveling or when asphalt concrete less than 0.20-foot in compacted thickness is being placed on existing surfacing, pneumatic-tired rollers will not be required when approved vibratory rollers are furnished and used as specified in Section 39-6.03, "Compacting."
- Each roller shall have a separate operator. Rolling equipment shall be self-propelled and reversible. The minimum number, weight and type of rollers required may be

reduced or modified in conformance with the provisions in Section 39-6.03, "Compacting," for low rates of production or when alternative equipment is approved by the Engineer.

- Rollers shall be equipped with pads and water systems which prevent sticking of asphalt mixtures to the pneumatic- or steel-tired wheels. A parting agent, which will not damage the asphalt mixture, as determined by the Engineer, may be used to aid in preventing the sticking of the mixture to the wheels.
- Other equipment, approved by the Engineer in conformance with the requirements in California Test 113, may be substituted for 3-wheel or tandem rollers when used as specified in Section 39-6.03, "Compacting."
- Pneumatic-tired rollers shall be the oscillating type having a width of not less than 4 feet with pneumatic tires of equal size, diameter and having treads satisfactory to the Engineer. Wobble-wheel rollers will not be permitted. The tires shall be spaced so that the gaps between adjacent tires will be covered by the following tires.
- The tires shall be inflated to 90 psi, or a lower pressure as designated by the Engineer, and maintained so that the air pressure will not vary more than 5 psi from the designated pressure. Pneumatic-tired rollers shall be constructed so that the total weight of the roller can be varied to produce an operating weight per tire of not less than 2,000 pounds. The total operating weight of the roller shall be varied as directed by the Engineer.

39-6 SPREADING AND COMPACTING

39-6.01 GENERAL REQUIREMENTS

- Placing material in a windrow, then picking it up and placing it in the asphalt paver with loading equipment, will be permitted provided:
 - A. The asphalt paver is of such design that the material will fall into a hopper which has a movable bottom conveyor to feed the screed.
 - B. The loader (pick-up machine) is constructed and operated so that substantially all of the material deposited on the roadbed is picked up and deposited in the paving machine.
 - C. The windrow is deposited only so far in advance of the paver to provide for continuous operation of the paver and not so far as to allow the temperature of the asphalt concrete in the windrow to fall below 260° F.
- Unless lower temperatures are directed by the Engineer, all mixtures, except Open-graded asphalt concrete, shall be spread, and the first coverage of initial or breakdown compaction shall be performed when the temperature of the mixture is not less than 250° F, and all breakdown compaction shall be completed before the temperature of the mixture drops below 200° F. Open-graded asphalt concrete shall be spread at a temperature of not less than 200° F, and not more than 250° F, measured in the hopper of the paving machine. Open-graded asphalt concrete shall be compacted as soon as possible after spreading.
- Type A and Type B asphalt concrete shall be placed only when the atmospheric temperature is above 50° F. Asphalt concrete base shall be placed only when the atmospheric temperature is above 40° F.

- Open-graded asphalt concrete shall be placed only when the atmospheric temperature is above 70° F and, where placement is to be on bridges or other structures when the surface temperature of the structure is above 60° F.
- Asphalt concrete and asphalt concrete base shall not be placed when the underlying layer or surface is frozen, or when, in the opinion of the Engineer, weather conditions will prevent the proper handling, finishing or compaction of the mixtures.
- Asphalt concrete shall be spread and compacted in the number of layers of the thicknesses indicated in the following table:

Total Thickness Shown on Plans ^a	No. of Layers	Top Layer Thickness (foot)		Next Lower Layer Thickness (foot)		All Other Lower Layer Thickness (foot)	
		Min.	Max.	Min.	Max.	Min.	Max.
0.20-foot or less	1	—	—	—	—	—	—
0.25-foot	2 ^b	0.12	0.13	0.12	0.13	—	—
0.30- 0.40 foot	2	0.15	0.20	0.15	0.25	—	—
0.45-foot or more	c	0.15	0.20	0.15	0.25	0.15	0.40

a When pavement reinforcing fabric is shown to be placed between layers of asphalt concrete, the thickness of asphalt concrete above the pavement reinforcing fabric shall be considered to be the "Total Thickness Shown on Plans" for the purpose of spreading and compacting the asphalt concrete above the pavement reinforcing fabric.

b At the option of the Contractor, one layer 0.25-foot thick may be placed.

c At least 2 layers shall be placed if total thickness is 0.45-foot. At least 3 layers shall be placed if total thickness is more than 0.45-foot and less than 0.90-foot. At least 4 layers shall be placed if total thickness is 0.90-foot or more.

- Asphalt concrete base shall be spread and compacted in one or more layers. Each layer of asphalt concrete base shall be not less than 0.20-foot nor more than 0.40-foot in compacted thickness, except that where the total thickness of asphalt concrete to be placed over asphalt concrete base is 0.20-foot or less, the layer of asphalt concrete base below the asphalt concrete shall not exceed 0.25-foot.
- A layer shall not be placed over a layer which exceeds 0.25-foot in compacted thickness until the temperature of the layer which exceeds 0.25-foot in compacted thickness is less than 160° F at mid depth.
- Asphalt concrete and asphalt concrete base to be placed on shoulders, and other areas off the traveled way having a width of 5 feet or more, shall be spread in the same manner as specified above. When the shoulders and other areas are less than 5 feet in width, the

material may be deposited and spread in one or more layers by any mechanical means that will produce a uniform smoothness and texture. Unless otherwise shown on the plans, asphalt mixtures shall not be handled, spread or windrowed in a manner that will stain the finished surface of any pavement or other improvements.

- The completed mixture shall be deposited on the roadbed at a uniform quantity per linear foot, as necessary to provide the required compacted thickness without resorting to spotting, picking-up or otherwise shifting the mixture.
- Segregation shall be avoided, and the surfacing shall be free from pockets of coarse or fine material. Asphalt concrete or asphalt concrete base containing hardened lumps shall not be used.
- Longitudinal joints in the top layer shall correspond with the edges of proposed traffic lanes. Longitudinal joints in all other layers shall be offset not less than 0.5-foot alternately each side of the edges of traffic lanes. The Engineer may permit other patterns of placing longitudinal joints if the Engineer considers that those patterns will not adversely affect the quality of the finished product.
- Unless otherwise provided herein or permitted by the Engineer, the top layer of asphalt concrete for shoulders, tapers, transitions, road connections, private drives, curve widenings, chain control lanes, turnouts, left turn pockets, and other such areas, shall not be spread before the top layer of asphalt concrete for the adjoining through lane has been spread and compacted. At locations where the number of lanes is changed, the top layer for the through lanes shall be paved first. When existing pavement is to be surfaced and the specified thickness of asphalt concrete to be spread and compacted on the existing pavement is 0.25-foot or less, shoulders or other adjoining areas may be spread simultaneously with the through lane provided the completed surfacing conforms to the requirements of these specifications. Tracks or wheels of spreading equipment shall not be operated on the top layer of asphalt concrete in any area until final compaction has been completed.
- At locations shown on the plans, specified in the special provisions or as directed by the Engineer, the asphalt concrete shall be tapered or feathered to conform to existing surfacing or to other highway and non-highway facilities.
- At locations where the asphalt concrete or asphalt concrete base is to be placed over areas inaccessible to spreading and rolling equipment, the asphalt concrete or asphalt concrete base shall be spread by any means to obtain the specified results and shall be compacted thoroughly to the required lines, grades and cross sections by means of pneumatic tampers, or by other methods that will produce the same degree of compaction as pneumatic tampers.

39-6.02 SPREADING

- All layers, except as otherwise provided in Section 39-6.01, “General Requirements,” and in this Section 39-6.02, shall be spread with an asphalt paver. Asphalt pavers shall be operated in such a manner as to ensure continuous and uniform movement of the paver.
- In advance of spreading asphalt concrete over an existing base, surfacing or bridge deck, if there is a contract item for asphalt concrete (leveling) or if ordered by the Engineer, asphalt concrete shall be spread by any mechanical means that will produce a uniform smoothness and texture. Asphalt concrete (leveling) shall include, but is not limited to, the filling and leveling of irregularities and ruts. Asphalt concrete used to

change the cross slope or profile of an existing surface shall not be considered as asphalt concrete (leveling).

- When directed by the Engineer, paint binder (tack coat) shall be applied to any layer in advance of spreading the next layer.
- Before placing the top layer adjacent to cold transverse construction joints, the joints shall be trimmed to a vertical face and to a neat line. Transverse joints shall be tested with a 12-foot straightedge and shall be cut back as required to conform to the provisions in Section 39-6.03, "Compacting," for surface smoothness. Connections to existing surfacing shall be feathered to conform to the provisions for smoothness. Longitudinal joints shall be trimmed to a vertical face and to a neat line if the edges of the previously laid surfacing are, in the opinion of the Engineer, in such condition that the quality of the completed joint will be affected.

39-6.03 COMPACTING

- Compacting equipment shall conform to the provisions in Section 39-5.02, "Compacting Equipment."
- A pass shall be one movement of a roller in either direction. A coverage shall be as many passes as are necessary to cover the entire width being paved. Overlap between passes during any coverage, made to ensure compaction without displacement of material in accordance with good rolling practice, shall be considered to be part of the coverage being made and not part of a subsequent coverage. Each coverage shall be completed before subsequent coverages are started.
- Rolling shall commence at the lower edge and shall progress toward the highest portion, except that when compacting layers which exceed 0.25-foot in compacted thickness, and if directed by the Engineer, rolling shall commence at the center and shall progress outwards.
- Compaction of Open-graded asphalt concrete shall consist of 2 coverages. If necessary, only one coverage of the Open-graded asphalt concrete may be ordered by the Engineer to prevent a break in the bond of asphalt between the aggregate particles.
- All other asphalt concrete and asphalt concrete base shall be compacted as follows:

Initial or breakdown compaction shall consist of 3 coverages of a layer of asphalt mixture and shall be performed with a 2-axle or 3-axle tandem or a 3-wheel roller weighing not less than 12 tons. Where the thickness of the layer of asphalt mixture is less than 0.15-foot, fewer coverages than specified above may be ordered by the Engineer if necessary to prevent damage to the layer being compacted.

The initial or breakdown compaction shall be followed immediately by additional rolling consisting of 3 coverages with a pneumatic-tired roller. Coverages with a pneumatic-tired roller shall start when the temperature of the mixture is as high as practicable, preferably above 180° F, and shall be completed while the temperature of the mixture is at or above 150° F.

Each layer of asphalt concrete and asphalt concrete base shall be compacted additionally without delay by a final rolling consisting of not less than one coverage with a steel-tired roller weighing not less than 8 tons. Except as otherwise provided for low rates of production, a separate finish roller will be required.

- Rolling shall be performed so that cracking, shoving or displacement will be avoided.

- Rolling, where 3-axle tandem rollers may be used as specified in this Section 39-6.03, shall be under the control of the Engineer, but in general, no 3-axle tandem roller shall be used in rolling over a crown or on warped sections when the center axle is in the locked position.
- Provided it is demonstrated to the satisfaction of the Engineer that one roller can perform the work, the required minimum rolling equipment specified above may be reduced to one 2-axle tandem roller, weighing at least 8 tons, for each paver under any of the following conditions:
 - A. When asphalt concrete or asphalt concrete base is placed at a rate of 50 tons, or less, per hour at any location.
 - B. When asphalt concrete or asphalt concrete base is placed at a rate of 100 tons, or less, per hour and at the locations or under the conditions as follows:
 - 1. Placed on miscellaneous areas in conformance with the provisions in Section 39-7.01, "Miscellaneous Areas."
 - 2. When the width to be placed is less than 8 feet.
 - C. When the total amount of asphalt concrete and asphalt concrete base included in the contract is 1,000 tons, or less.
- When rolling equipment is reduced as provided in this Section 39-6.03, the rolling requirements may be reduced to at least 3 complete coverages with the tandem roller.
- Alternative compacting equipment, approved by the Engineer in conformance with the requirements in California Test 113, may be used for the initial or breakdown compaction if operated according to the procedures and under the conditions designated in the approval. Except when leveling or when asphalt concrete less than 0.20-foot in compacted thickness is being placed on existing surfacing, additional compaction with pneumatic-tired rollers will not be required when approved alternative equipment has been used for the initial compaction. A vibratory roller may be used as the finish roller provided that the vibratory roller meets the requirements for a finish roller and is operated with the vibratory unit turned off.
- Upon completion of rolling operations, if ordered by the Engineer, the asphalt concrete or asphalt concrete base shall be cooled by applying water. Applying water shall conform to the provisions in Section 17, "Watering."
- The completed surfacing shall be thoroughly compacted, smooth and free from ruts, humps, depressions or irregularities. Any ridges, indentations or other objectionable marks left in the surface of the asphalt concrete by blading or other equipment shall be eliminated by rolling or other means. The use of any equipment that leaves ridges, indentations or other objectionable marks in the asphalt concrete shall be discontinued, and acceptable equipment shall be furnished by the Contractor.
- When a straightedge 12 feet long is laid on the finished surface and parallel with the center line, the surface shall not vary more than 0.01-foot from the lower edge of the straightedge. The transverse slope of the finished surface shall be uniform to a degree such that no depressions greater than 0.02-foot are present when tested with a

straightedge 12 feet long laid in a direction transverse to the center line and extending from edge to edge of a 12-foot traffic lane.

- Pavement within 50 feet of a structure or approach slab shall conform to the smoothness tolerances specified in Section 51-1.17, "Finishing Bridge Decks."

Specifications for Florida's Asphalt Concrete Friction Course

Extracted from:

<http://www.dot.state.fl.us/specificationsoffice/2007BK/337.pdf>

FLORIDA DOT

SECTION 337 ASPHALT CONCRETE FRICTION COURSES

337-1 Description.

Construct an asphalt concrete friction course pavement with the type of mixture specified in the Contract, or when offered as alternates, as selected. This Section specifies mixes designated as FC-5, FC-9.5, and FC-12.5.

Meet the plant and equipment requirements of Section 320, as modified herein. Meet the general construction requirements of Section 330, as modified herein.

337-2 Materials.

337-2.1 General Requirements: Meet the requirements specified in Division III as modified herein. The Engineer will base continuing approval of material sources on field performance.

337-2.2 Asphalt Binder: Meet the requirements of Section 336, and any additional requirements or modifications specified herein for the various mixtures. When called for in the Contract Documents, use a PG 76-22 asphalt binder meeting the requirements of 916-1. For projects with a total quantity of FC-5, FC-9.5, or FC-12.5 less than 500 tons, the Contractor may elect to substitute a PG 76-22 for the ARB-12 or ARB-5, meeting the requirements of 916-1.

337-2.3 Coarse Aggregate: Meet the requirements of Section 901, and any additional requirements or modifications specified herein for the various mixtures.

337-2.4 Fine Aggregate: Meet the requirements of Section 902, and any additional requirements or modifications specified herein for the various mixtures.

337-2.5 Hydrated Lime: Meet the requirements of AASHTO M303 Type 1. Provide certified test results for each shipment of hydrated lime indicating compliance with the specifications.

337-2.6 Fiber Stabilizing Additive (Required for FC-5 only): Use either a mineral or cellulose fiber stabilizing additive. Meet the following requirements:

337-2.6.1 Mineral Fibers: Use mineral fibers (made from virgin basalt, diabase, or slag) treated with a cationic sizing agent to enhance the disbursement of the fiber, as well as to increase adhesion of the fiber surface to the bitumen. Meet the following requirements for physical properties:

1. Size Analysis

Average fiber length: 0.25 inch (maximum)

Average fiber thickness: 0.0002 inch (maximum)

2. Shot Content (ASTM C612)

Percent passing No. 60 Sieve: 90 - 100

Percent passing No. 230 Sieve: 65 - 100

Provide certified test results for each batch of fiber material indicating compliance with the above tests.

337-2.6.2 Cellulose Fibers: Use cellulose fibers meeting the following requirements:

1. Fiber length: 0.25 inch (maximum)
2. Sieve Analysis
 - a. Alpine Sieve Method
 - Percent passing No. 100 sieve: 60-80
 - b. Ro-Tap Sieve Method
 - Percent passing No. 20 sieve: 80-95
 - Percent passing No. 40 sieve: 45-85
 - Percent passing No. 100 sieve: 5-40
3. Ash Content: 18% non-volatiles ($\pm 5\%$)
4. pH: 7.5 (± 1.0)
5. Oil Absorption: 5.0 (± 1.0) (times fiber weight)
6. Moisture Content: 5.0 (maximum)

Provide certified test results for each batch of fiber material indicating compliance with the above tests.

337-3 General Composition of Mixes.

337-3.1 General: Use a bituminous mixture composed of aggregate (coarse, fine, or a mixture thereof), asphalt rubber binder, and in some cases, fibers and/or hydrated lime. Size, uniformly grade and combine the aggregate fractions in such proportions that the resulting mix meets the requirements of this Section. The use of RAP material will not be permitted.

337-3.2 Specific Component Requirements by Mix:

337-3.2.1 FC-5:

337-3.2.1.1 Aggregates: Use an aggregate blend which consists of either 100% crushed granite or 100% crushed Oolitic limestone.

In addition to the requirements of Section 901, meet the following coarse aggregate requirements. Use either crushed granite or crushed limestone. Use crushed limestone from the Oolitic formation, which contains a minimum of 12% non-carbonate material (as determined by FM 5-510), and has been approved for this use.

In addition to the requirements of Section 902, meet the following fine aggregate requirements. Use either crushed granite screenings, or crushed Oolitic limestone screenings for the fine aggregate.

337-3.2.1.2 Asphalt Binder: Use an ARB-12 asphalt rubber binder. If called for in the Contract Documents, use a PG 76-22 asphalt binder.

337-3.2.1.3 Hydrated Lime: Add the lime at a dosage rate of 1.0% by weight of the total dry aggregate to mixes containing granite.

337-3.2.1.4 Fiber Stabilizing Additive: Add either mineral fibers at a dosage rate of 0.4% by weight of the total mix, or cellulose fibers at a dosage rate of 0.3% by weight of total mix.

337-3.2.2 FC-9.5 and FC-12.5:

337-3.2.2.1: Aggregates: In addition to the requirements of Sections 901 and 902, use coarse and fine aggregate components which also meet the aggregate requirements for an SP-9.5 or SP-12.5 Superpave mix, respectively, as specified in Section 334.

Use an aggregate blend that consists of crushed granite, crushed Oolitic limestone, or a combination of the two. (Aggregates other than those listed above may be used if approved by the Engineer for use in friction courses.) Crushed limestone from the Oolitic formation may be used if it contains a minimum of 12% non-carbonate material as determined by FM 5-510 and the Engineer grants approval of the source prior to its use. As an exception, mixes that contain a minimum of 60% crushed granite may contain up to 40% fine aggregate from other approved sources.

337-3.2.2.2: Asphalt Binder: Use an ARB-5 asphalt rubber binder. If called for in the Contract, use a PG 76-22 asphalt binder.

337-3.3 Grading Requirements:

337-3.3.1 FC-5: Use a mixture having a gradation at design within the ranges shown in Table 337-1.

Table 337-1 FC-5 Gradation Design Range									
3/4 inch	1/2 inch	3/8 inch	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
100	85- 100	55-75	15- 25	5- 10	--	--	--	--	2-4

337-3.3.2 FC-9.5: Meet the design gradation requirements for a SP-9.5 Superpave fine mix as defined in 334-3.2.2.

337-3.3.3 FC-12.5: Meet the design gradation requirements for a SP-12.5 Superpave fine mix as defined in 334-3.2.2.

337-4 Mix Design.

337-4.1 FC-5: The Department will design the FC-5 mixtures. Furnish the materials and all appropriate information (source, gradation, etc.) as specified in 334-3.2.7. The Department will have two weeks to design the mix.

The Department will establish the design binder content for FC-5 within the following ranges based on aggregate type:

Aggregate Type	Binder Content
Crushed Granite	5.5 - 7.0
Crushed Limestone (Oolitic)	6.5 - 8.0

337-4.2 FC-9.5 and FC-12.5: Provide a mix design conforming to the requirements of 334-3.2 for Traffic Level C unless otherwise designated in the plans. Develop the mix design using an ARB-5 or PG 76-22 asphalt binder if called for in the Contract Documents.

337-4.3 Revision of Mix Design: For FC-5, FC-9.5 and FC-12.5, meet the requirements of 334-3.3. For FC-5, all revisions must fall within the gradation limits defined in Table 337-1.

337-5 Contractor’s Process Control.

Provide the necessary process control of the friction course mix and construction in accordance with the applicable provisions of 330-2 and 334-4 for FC-5, and 330-2 and 334-4 for FC-9.5 and FC-12.5.

The Engineer will monitor the spread rate periodically to ensure uniform thickness. Provide quality control procedures for daily monitoring and control of spread rate variability. If the spread rate varies by more than 5% of the spread rate set by the Engineer in accordance with 337-9, immediately make all corrections necessary to bring the spread rate into the acceptable range.

337-6 Acceptance of the Mixture.

337-6.1 FC-9.5 and FC-12.5: Meet the requirements of 334-5.

337-6.2 FC-5: Meet the requirements of 334-5 with the following exceptions:

1. The mixture will be accepted with respect to gradation ($P_{-3/8}$, P_{-4} , and P_{-8}), and asphalt binder content (P_b) only.
2. Testing in accordance with AASHTO T312-04 and FM 1-T 209 (and conditioning prior to testing) will not be required as part of 334-5.1.1.
3. The standard LOT size of FC-5 will be 2,000 tons, with each LOT subdivided into four equal sublots of 500 tons each.
4. Initial production requirements of 334-5.3 do not apply.
5. The Between-Laboratory Precision Values described in Table 334-5 are modified to include ($P_{-3/8}$, P_{-4} , and P_{-8}) with a maximum difference per FM 1-T 030 (Figure 2).
6. Table 334-4 (Master Production Range) is replaced by Table 337-2.
7. The mixture will be accepted on the roadway with respect to surface tolerance in accordance with the applicable requirements of 334-5.8. No density testing will be required for these mixtures.

Table 337-2 FC-5 Master Production Range	
Characteristic	Tolerance (1)
Asphalt Binder Content (%)	Target ± 0.60
Passing 3/8 inch Sieve (%)	Target ± 7.50
Passing No. 4 Sieve (%)	Target ± 6.00
Passing No. 8 Sieve (%)	Target ± 3.50
(1) Tolerances for sample size of n = 1 from the verified mix design	

337-6.2.1 Individual Test Tolerances for FC-5 Production: In the event that an individual Quality Control test result of a subplot for gradation ($P_{-3/8}$, P_{-4} ,

and P₈), does not meet the requirements of Table 337-2, take steps to correct the situation and report them to the Engineer.

In the event that two consecutive individual Quality Control test results for gradation (P_{-3/8}, P₋₄, and P₈) or an individual test result for asphalt binder content does not meet the requirements of Table 337-2, the LOT will be automatically terminated and production of the mixture stopped until the problem is adequately resolved (to the satisfaction of the Engineer), unless it can be demonstrated to the satisfaction of the Engineer that the problem can immediately be (or already has been) resolved. Address any material represented by the failing test result in accordance with 334-5.9.5.

337-7 Special Construction Requirements.

337-7.1 Hot Storage of FC-5 Mixtures: When using surge or storage bins in the normal production of FC-5, do not leave the mixture in the surge or storage bin for more than one hour.

337-7.2 Longitudinal Grade Controls for Open-Graded Friction Courses: On FC-5, use either longitudinal grade control (skid, ski or traveling stringline) or a joint matcher.

337-7.3 Temperature Requirements for FC-5:

337-7.3.1 Air Temperature at Laydown: Spread the mixture only when the air temperature (the temperature in the shade away from artificial heat) is at or above 65°F. As an exception, place the mixture at temperatures lower than 65°F, only when approved by the Engineer based on the Contractor's demonstrated ability to achieve a satisfactory surface texture and appearance of the finished surface. In no case shall the mixture be placed at temperatures lower than 60°F.

337-7.3.2 Temperature of the Mix: Heat and combine the asphalt rubber binder and aggregate in a manner to produce a mix having a temperature, when discharged from the plant, meeting the requirements of 330-6.3. Meet all requirements of 330-9.1.2 at the roadway. The target mixing temperature shall be established at 320°F.

337-7.4 Compaction of FC-5: Provide two, static steel-wheeled rollers, with an effective compactive weight in the range of 135 to 200 PLI, determined as follows: (Any variation of this equipment requirement must be approved by the Engineer.) Establish an appropriate rolling pattern for the pavement in order to effectively seat the mixture without crushing the aggregate. In the event that the roller begins to crush the aggregate, reduce the number of coverages or the PLI of the rollers. If the rollers continue to crush the aggregate, use a tandem steel-wheel roller weighing not more than 135 lb/in (PLI) of drum width.

337-7.5 Temperature Requirements for FC-9.5 and FC-12.5:

337-7.5.1 Air Temperature at Laydown: Spread the mixture only when the air temperature (the temperature in the shade away from artificial heat) is at or above 45°F.

337-7.5.2 Temperature of the mix: Heat and combine the asphalt rubber binder and aggregate in a manner to produce a mix having a temperature, when discharged from the plant, meeting the requirements of 330-6.3. Meet all requirements of 330-9.1.2 at the roadway.

337-7.6 Prevention of Adhesion: To minimize adhesion to the drum during the rolling operations, the Contractor may add a small amount of liquid detergent to the water in the roller.

At intersections and in other areas where the pavement may be subjected to cross-traffic before it has cooled, spray the approaches with water to wet the tires of the approaching vehicles before they cross the pavement.

337-7.7 Transportation Requirements of Friction Course Mixtures: Cover all loads of friction course mixtures with a tarpaulin.

337-8 Thickness of Friction Courses.

337-8.1 FC-12.5 and FC-9.5: The thickness of the friction course layer will be the plan thickness as shown in the Contract Documents. For construction purposes, the plan thickness will be converted to spread rate as defined in 334-1.4.

Plan quantities are based on a G_{mm} of 2.540, corresponding to a spread rate of 110 lbs/yd²-in. Pay quantities will be based on the actual maximum specific gravity of the mix being used.

337-8.2 FC-5: The total thickness of the FC-5 layer will be the plan thickness as shown in the Contract Documents. For construction purposes, the plan thickness will be converted to spread rate based on the combined aggregate bulk specific gravity of the asphalt mix being used as shown in the following equation:

$$\text{Spread rate (lbs/yd}^2\text{)} = t \times G_{sb} \times 40.5$$

Where: t = Thickness (in.) (Plan thickness)

G_{sb} = Combined aggregate bulk specific gravity from the verified mix design

The weight of the mixture shall be determined as provided in 320-2.2.

Plan quantities are based on a G_{sb} of 2.635, corresponding to a spread rate of 80 lbs/yd². Pay quantities will be based on the actual combined aggregate bulk specific gravity (G_{sb}) of the mix being used.

337-9 Special Equipment Requirements for FC-5.

337-9.1 Fiber Supply System: Use a separate feed system to accurately proportion the required quantity of mineral fibers into the mixture in such a manner that uniform distribution is obtained. Interlock the proportioning device with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes. Control the proportion of fibers to within plus or minus 10% of the amount of fibers required. Provide flow indicators or sensing devices for the fiber system, interlocked with plant controls so that the mixture production will be interrupted if introduction of the fiber fails.

When a batch plant is used, add the fiber to the aggregate in the weigh hopper or as approved and directed by the Engineer. Increase the batch dry mixing time by 8 to 12 seconds, or as directed by the Engineer, from the time the aggregate is completely emptied into the pugmill. Ensure that the fibers are uniformly distributed prior to the addition of asphalt rubber into the pugmill.

When a drum-mix plant is used, add and uniformly disperse the fiber with the aggregate prior to the addition of the asphalt rubber. Add the fiber in such a manner that it will not become entrained in the exhaust system of the drier or plant.

337-9.2 Hydrated Lime Supply System: For FC-5 mixes containing granite, use a separate feed system to accurately proportion the required quantity of hydrated lime into the mixture in such a manner that uniform coating of the aggregate is obtained prior to the addition of the asphalt rubber. Add the hydrated lime in such a manner that it will not become entrained in the exhaust system of the drier or plant. Interlock the proportioning device with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes and to ensure that all mixture produced is properly treated with hydrated lime. Control the proportion of hydrated lime to within plus or minus 10% of the amount of hydrated lime required. Provide and interlock flow indicators or sensing devices for the hydrated lime system with plant controls so that the mixture production will be interrupted if introduction of the hydrated lime fails. The addition of the hydrated lime to the aggregate may be accomplished by Method (A) or (B) as follows:

337-9.2.1 Method (A) - Dry Form: Add hydrated lime in a dry form to the mixture according to the type of asphalt plant being used.

When a batch plant is used, add the hydrated lime to the aggregate in the weigh hopper or as approved and directed by the Engineer. Increase the batch dry mixing time by eight to twelve seconds, or as directed by the Engineer, from the time the aggregate is completely emptied into the pugmill. Uniformly distribute the hydrated lime prior to the addition of asphalt rubber into the pugmill.

When a drum-mix plant is used, add and uniformly disperse the hydrated lime to the aggregate prior to the addition of the asphalt rubber. Add the hydrated lime in such a manner that it will not become entrained in the exhaust system of the drier or plant.

337-9.2.2 Method (B) - Hydrated Lime/Water Slurry: Add the required quantity of hydrated lime (based on dry weight) in a hydrated lime/water slurry form to the aggregate. Provide a solution consisting of hydrated lime and water in concentrations as directed by the Engineer. Use a plant equipped to blend and maintain the hydrated lime in suspension and to mix it with the aggregates uniformly in the proportions specified.

337-9.3 Hydrated Lime Pretreatment: For FC-5 mixes containing granite, as an alternative to 337-10.2, pretreat the aggregate with hydrated lime prior to incorporating the aggregate into the mixture. Use a feed system to accurately proportion the aggregate and required quantity of hydrated lime, and mix them in such a manner that uniform coating of the aggregate is obtained. Control the proportion of hydrated lime to within $\pm 10\%$ of the amount required. Aggregate pretreated with hydrated lime in this manner shall be incorporated into the asphalt mixture within 45 days of pretreatment.

337-9.3.1 Hydrated Lime Pretreatment Methods: Pretreat the aggregate using one of the following two methods:

Pretreatment Method A – Dry Form: Add the required quantity of hydrated lime in a dry form to the aggregate. Assure that the aggregate at the time of pretreatment contains a minimum of 3% moisture over saturated surface dry (SSD) conditions. Utilize equipment to accurately proportion the aggregate and hydrated lime and mix them in such a manner as to provide a uniform coating.

Pretreatment Method B – Hydrated Lime/Water Slurry: Add the required quantity of hydrated lime (based on dry weight) in a hydrated lime/water slurry form to the aggregate. Provide a solution consisting of hydrated lime and water in a concentration to provide effective treatment. Use equipment to blend and maintain the hydrated lime in suspension, to accurately proportion the aggregate and hydrated lime/water slurry, and to mix them to provide a uniform coating.

337-9.3.2 Blending Quality Control Records: Maintain adequate Quality Control records for the Engineer's review for all pretreatment activities. Include as a minimum the following information (for each batch or day's run of pretreatment): pretreatment date, aggregate certification information, certified test results for the hydrated lime, aggregate moisture content prior to blending, as-blended quantities of aggregate and hydrated lime, project number, customer name, and shipping date.

337-9.3.3 Certification: In addition to the aggregate certification, provide a certification with each load of material delivered to the HMA plant, that the material has been pretreated in conformance with these specifications. Include also the date the material was pretreated.

337-10 Failing Material.

Meet the requirements of 334-5.9. For FC-5, use the Master Production Range defined in Table 337-2 in lieu of Table 334-4.

Specifications for Georgia’s Open-Graded Friction Course and Stone Matrix Asphalt

Extracted from:

GEORGIA DOT Section 828—Hot Mix Asphaltic Concrete Mixtures

828.1 General Description

This specification includes the requirements for hot mix asphaltic concrete mixtures, including:

- Open-graded surface mixtures
- Stone Matrix Asphalt mixtures
- Superpave asphaltic concrete mixtures
- Fine-graded mixtures

828.1.01 Definitions

Nominal Maximum Sieve Size: One standard sieve size larger than the first sieve to retain more than ten percent.

828.2 Materials

A. Requirements

All mixtures are designated based on the Nominal Maximum Sieve Size. Determine the amount finer than No. 200 (75 µm) by washing (See GDT 4) or by the correlation procedure described in GDT 125.

Use hot mix asphaltic concrete mixtures that meet the following requirements:

1. Ensure the materials used to prepare the mixtures are approved by the Engineer before incorporating into the Work.
2. Use aggregate groups and blends that meet the following pay item designations, as indicated in the Proposal and Plans:

Pay Item Designation	Allowable Aggregate Groups
Group I or II	100% of Group I, Group II, or Blend I.
Group II only	Only 100% Group II.
Blend I	Either 100% Group II material or a blend of Group I and Group II. Do not use Group I material for more than 60% by weight of the total aggregates, nor more than 50% by weight of the coarse aggregate portion.

3. Use Group I, Group II, or a blend of both aggregate groups, for patching or leveling. Mixes are listed in Subsection 828.2.03 and Subsection 828.2.04.
4. Design mixes using the Superpave System for Volumetric Design (AASHTO TP 4 and AASHTO PP 2) unless stated otherwise. Designs shall be performed by qualified and approved laboratories and technicians as specified in SOP-2 SP -

Control of Superpave Bituminous Mixture Designs.

5. Ensure individual test results meet Mixture Control Tolerances
6. Include hydrated lime in all paving courses except where noted. For a list of hydrated lime sources, see QPL 41.
 - a. Add lime to virgin aggregate mixtures at a minimum rate of 1 percent of the total dry aggregate weight.
 - b. Add lime to recycled mixtures at a minimum rate of 1 percent of the virgin aggregate portion, plus a minimum of 0.5 percent of the aggregate in the reclaimed asphalt pavement (RAP) portion.
 - c. Add more lime and an approved heat-stable, anti-stripping additive that meets the requirements of Subsection 831.2.04, "Heat Stable Anti-Stripping Additive," if necessary, to meet requirements for mixture properties. However, the Department will not pay for the additional required materials. For a list of Heat Stable Anti-Stripping Additive sources, please see QPL 26.
 - d. On PR, LARP, airport, bridge replacement, and parking lot projects designated at Mix Design Level A, asphalt cement may include an approved, heat-stable, anti-stripping additive that meets the requirements of Subsection 831.2.04, "Heat Stable Anti-Stripping Additive" instead of hydrated lime, unless specified in the Pay Item.
 - 1) Add at a minimum rate of 0.5 percent of the AC portion.
 - 2) Ensure the additive treated mix meets the minimum tensile splitting ratio:

Tensile Splitting Ratio	Type of Asphaltic Concrete
0.4	4.75 mm mix
0.6	All other mixes

7. Use performance grade PG 67-22 asphalt cement in all mixtures except as follows:
 - a. For RAP mixtures, the Engineer will determine the performance grade to be used.
 - b. On PR, LARP, airport, bridge replacement, and parking lot projects, PG 64-22 may be substituted for PG 67-22.
 - c. Use only performance grade PG 76-22 for all mixtures that specify polymer-modified asphalt in the pay item designation.
8. Use of local sand is restricted as follows:
 - a. No more than 20 percent, based on total aggregate weight, may be used in mixtures for shoulder construction and on projects designed at Mix Design Level A.
 - b. For mixtures placed on the mainline traveled way of projects designed at Mix Design Level B, C, or D (except interstate projects), local sand may be used only in the 25 mm Superpave and shall not exceed 20 percent based on total aggregate weight.
Do not use local sand in any mixture placed on the traveled way of

Interstate mainline or ramps. No more than 20 percent local sand, based on total aggregate weight, may be used in mixtures for shoulder construction.

- c. Do not use local sand that contains more than 7 percent clay.
- d. Do not use local sand that contains any clay lumps as determined by AASHTO T 112.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Ensure the mix design has been reviewed and approved by the Department prior to beginning production.

1. Rutting Susceptibility Testing

- a. Fabricate three beams or six cylindrical specimens from each asphalt mix for the test using GDT 115.
- b. Design mixtures which meet the following criteria for rutting where tested using GDT 115:
- c. Mix Design Level A – 0.3 in (7 mm) maximum
 - Mix Design Level B – 0.25 in (6 mm) maximum
 - Mix Design Level C & D – 0.2 in. (5 mm) maximum

Mixtures designed prior to July 1, 2001 which do not exceed 0.2 in (5 mm) rutting when tested at 120 °F (49 °C) using GDT 115 may be acceptable.

Tests will not be required for mixtures designed exclusively for trench widening nor for the 4.75 mm mix, nor for open-graded surface mixtures.

2. Fatigue Testing

The Department may perform the test according to AASHTO TP 8-94 or other Department approved procedure.

D. Materials Warranty

General Provisions 101 through 150.

828.2.01 Open-Graded Surface Mixture

A. Requirements

- 1. Use the information in the following table for job mix formulas and design limits:

Mixture Control Tolerance	Asphaltic Concrete	9.5 mm OGFC	12.5 mm OGFC	12.5 mm PEM
	Grading Requirements	Percent Passing		
±0.0	3/4 in (19 mm) sieve		100	100
±6.1	1/2 in (12.5 mm) sieve	100*	85-100	80-100

±5.6	3/8 in (9.5 mm) sieve	85-100	55-75	35-60
±5.7	No. 4 (4.75 mm) sieve	20-40	15-25	10-25
±4.6	No. 8 (2.36 mm) sieve	5-10	5-10	5-10
±2.0	No. 200 (75 µm) sieve	2-4	2-4	1-4
Design Requirements				
±0.4	Range for % AC	6.0-7.25	5.75-7.25	5.5-7.0
	Class of stone (Section 800)	"A" only	"A" only	"A" only
	Coating retention (GDT-56)	95	95	95
	Drain-down, AASHTO T 305 (%)	<0.3	<0.3	<0.3

* Mixture control tolerance not applicable to this sieve for this mix.

2. Use only PG 76-22 (specified in Section 820) in the 12.5 mm OGFC and 12.5 mm PEM mixtures.
3. Use a stabilizing fiber, which meets the requirements of Section 819 in 12.5 mm OGFC and 12.5 mm PEM mixtures. The dosage rate will be as recommended by the Engineer and shall be sufficient to prevent excessive drain-down.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

General Provisions 101 through 150.

828.2.02 Stone Matrix Asphalt Mixtures

A. Requirements

Use the information in the following table for the job mix formula and design limits.

Mixture Control Tolerance	Asphaltic Concrete	9.5 mm SMA	12.5 mm SMA	19 mm SMA
	Grading Requirements	Percent Passing		
±0.0	1- in (25 mm) sieve			100
±7.0	3/4 in (19 mm) sieve		100*	90-100
±6.1	1/2 in (12.5 mm) sieve	100*	85-100	44-70
±5.6	3/8 in (9.5 mm) sieve	70-100	50-75	25-60
±5.7	No. 4 (4.75 mm) sieve	28-50	20-28	20-28
±4.6	No. 8 (2.36 mm) sieve	15-30	16-24	15-22
±3.8	No. 50 (300 µm) sieve	10-17	10-20	10-20

±2.0	No. 200 (75 µm) sieve	8-13	8-12	8-12
	Design Requirements			
±0.4	Range for % AC	6.0-7.5	5.8-7.5	5.5-7.5
	Design optimum air voids (%)	3.5 ±0.5	3.5 ±0.5	3.5 ±0.5
	% aggregate voids filled with AC (VFA)	70-90	70-90	70-90
	Tensile splitting ratio after freeze-thaw cycle GDT-66	80%	80%	80%
	Drain-down AASHTO T 305 (%)	<0.3	<0.3	<0.3

* Mixture control tolerance not applicable to this sieve for this mix.

1. Compact SMA mixtures at 50 gyrations with the Superpave Gyratory compactor or 50 blows with the Marshall compactor.
2. A Tensile splitting ratio of no less than 70% may be acceptable so long as all individual test values exceed 100 psi (690 kPa).
3. Stone Matrix Asphalt mixtures shall contain asphalt cement, mineral filler, and fiber stabilizing additives which meet the following requirements:
 - a. Use asphalt cement that meets requirements of PG 76-22 of Section 820.
 - b. Use mineral filler that meets requirements of Section 883 and has been approved by the Engineer. Local sand shall not be used in lieu of mineral filler.
 - c. Treat these mixes with a fiber-stabilizing additive, which meets the requirements of Section 819. The dosage rate will be as recommended by the Engineer and shall be sufficient to prevent excessive drain-down.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

See Subsection 828.2.C.

D. Materials Warranty

General Provisions 101 through 150.

Specifications for Idaho's Plant Mix Seal

Extracted from:

http://itd.idaho.gov/manuals/Online_Manuals/Spec_04/Spec_04.htm

IDAHO TRANSPORTATION DEPARTMENT SECTION 412 - PLANT MIX SEAL

412.01 Description. This work shall consist of constructing a plant mix seal in accordance with these specifications and in reasonably close conformity with the details shown on the plans, or as established.

412.02 Materials. Plant mix seal design shall conform to the following requirements:

Type Seal	Minimum Stability	Min. Film Thickness	Min. VMA %	Air Voids %	Min. Immersion Compression %
PMS-OG	N/A	8 microns	15	9-15	50 (per T5040.31)
PMS-MG	30	7 microns	14	5-9	85
PMS-DG	30	6 microns	13	4-5	95

Mix design for PMS-OG shall conform to Technical Advisory T5040.31. Aggregate shall meet the applicable requirements of Section 703 - Aggregates.

The aggregates for PMS-OG, PMS-MG, and PMS-DG plant mix seal shall be provided in two separate stockpiles as follows:

SIEVE SIZE		PMS-1 Pct. PASS	PMS-2 Pct. PASS	PMS-3 Pct. PASS	PMS-4 Pct. PASS
1/2 in.	(12.5 mm)	100			
3/8 in.	(9.5 mm)	95-100	100	100	100
No. 4	(4.75 mm)	0-15	88-100	88-100	95-100
No. 8	(2.36 mm)	0-5	15-30	58-72	75-90
No. 30	(0.60 mm)	0-3	9-18	20-36	35-60
No. 50	(0.30 mm)	0-3	7-14	13-25	20-45
No. 200	(0.075 mm)	0-2	5-10	5-12	5-12

The stockpiles to be used to produce the various PMS classes of plant seal mix are:

PMS -- OG: Blend PMS - 1 with PMS - 2

PMS -- MG: Blend PMS - 1 with PMS - 3

PMS -- DG: Blend PMS - 1 with PMS - 4

The contract shall specify the type of plant mix seal to be used for the project.

The aggregate to be used for plant mix seal shall be screened so that not more than 10 percent of the naturally occurring minus 0.5 in. (12.5 mm) material remains in the material to be crushed. The plus 0.5 in. (12.5 mm) material thus produced shall be crushed to produce the required gradation and tonnage of each stockpile.

For approved Contractor-furnished sources, the target blend percentages and asphalt content will be specified after the source is selected.

The blend of aggregate shall have a sand equivalent of not less than 35 when the combined sample is tested prior to introduction into the dryer.

Ninety percent of the aggregate retained on or above the No. 4 (0.075 mm) sieve in each stockpile shall have a minimum of one fractured face, as determined by

AASHTO TP-61, METHOD 1; sixty percent shall have a minimum of two fractured faces. Flat and thin or elongated aggregate particles (length greater than 5 times average thickness) shall not exceed 15 percent by mass in any stockpile.

The stockpile aggregates, when blended together, shall provide a combined mix gradation according to the following table:

MASTER GRADATION RANGE TABLE FOR PLANT MIX SEAL				
PERCENT PASSING BY WEIGHT ON SQUARE MESH SIEVE				
SIEVE SIZE		PMS-OG (OPEN-GRADED)	PMS-MG (MED. GRADED)	PMS-DG (DENSE GRADED)
1/2 in.	(12.5 mm)	100	100	100
3/8 in.	(9.5 mm)	95-100	97-100	97-100
No. 4	(4.75 mm)	30-50	40-65	77-97
No. 8	(2.36 mm)	5-15	20-47	60-83
No. 30	(0.60 mm)	8-25	25-50
No. 50	(0.30 mm)	4-18	16-40
No. 200	(0.075 mm)	2-5	2-9	4-11

Aggregate will be accepted at the hot plant. Sampling and testing shall be conducted at the hot plant to assure that a uniform combined aggregate gradation is maintained.

Asphalt shall be of the type and grade called for in the contract. Asphalt furnished shall meet the applicable requirements of Section 702 - Asphalt. Asphalt will be accepted at the point of delivery.

Anti-stripping additive shall meet the requirements of Subsection 702.04. Antistripping additive will be accepted at the point of delivery.

Tests shall be made in accordance with the applicable standard methods listed in Subsection 405. 02 - Materials.

412.03 Construction Requirements.

- A. Mixing Plant. The requirements of Subsection 405.03 shall apply.
- B. Hauling Equipment. The requirements of Subsection 405.03 shall apply.
- C. Paver. The requirements of Subsection 405.03 shall apply.
- D. Rollers. The requirements of Subsection 405.03 shall apply, except as follows:

Rolling shall be accomplished with a steel wheel roller weighing not more than 12 tons (11 t). Rolling operations shall be conducted in such a manner that shoving, distortion, or stripping will not develop beneath the roller. The amount of rolling shall be confined to only that necessary for consolidating the seal and bonding it to the underlying surface course. Excessive rolling shall be avoided.

The use of vibratory compaction method is prohibited.

E. Mix Design Approval. The requirements of Subsection 405.03, Part E shall apply.

F. Mixing. The requirements of Subsection 405.03, Part F shall apply, except as follows:

PMS - OG maximum mix temperature shall be established based on asphalt viscosity. PMS - MG and PMS - DG mix temperature shall not exceed 320°F (160°C). These temperatures shall apply regardless of the type of mixing plant.

The mixtures shall be delivered for use on the roadway at a temperature not lower than 30°F (17°C) below the approved maximum temperature specified above, unless otherwise approved.

G. Spreading and Finishing. The requirements of Subsection 405.03, Part H shall apply, except as follows:

PMS - OG plant mix seal mixture shall be placed directly into the hopper of the paver. Windrowing or other methods of depositing the mixture onto the pavement ahead of the paver will not be permitted unless approved prior to commencement of work.

If windrowing is used to deposit PMS - MG or PMS - DG mixtures onto the pavement ahead of the paver, the following requirements shall apply:

The maximum allowable length of windrow ahead of the paver shall be restricted such that the temperature of the mixture, measured immediately behind the paver, shall not be less than 225°F (110°C).

Approval to deposit the mixture onto the pavement ahead of the paver will be revoked if there is evidence of segregation of asphalt cement from the mixture or if the work is deemed unsatisfactory in any other respect. Handwork during placement shall be minimized to avoid roughening of the surface.

H. Weather Limitations. Plant mix seal shall be placed in accordance with Subsection 405.03, Part I, except that the air or surface temperature must not be below 60°F (16°C).

I. Joints. The requirements of Subsection 405.03, Part J shall apply, except as follows:

All joints shall be butted rather than lapped.

The vertical edge of the milled wedge shall not exceed the plan depth of the plant mix seal.

J. Compaction. The plant mix shall be compacted with a minimum of 2 passes of a roller as quickly as possible after placement, to obtain compaction and to bond the

seal to the existing surface. Rolling shall follow the paver as closely as possible. Reduction in number of passes shall be as directed by the Engineer.

Compaction shall be completed before the mix temperature drops below 175°F (80°C).

An additional roller pass may be required below 175°F (80°C) to remove roller marks.

Unless otherwise directed, rolling shall begin at the sides and proceed longitudinally parallel to the road centerline, each pass overlapping one-half the roller width. When paving in echelon or abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular procedure. On superelevated curves, the rolling shall begin at the low side and progress to the high side by overlapping of longitudinal passes parallel to the centerline.

Care shall be exercised in rolling not to displace the line and grade of the edges of the pavement.

Along forms, curbs, headers, walls and other places not accessible to the rollers, the mixture shall be thoroughly compacted with mechanical tampers or other approved compactors. All of the mixture shall be removed from the gutter surface prior to rolling.

An acceptance test strip shall not be required

- K. Condition of Existing Surface. Surface preparation and application of tack coat shall be in accordance with Section 401 - Tack Coat.
- L. Miscellaneous Pavement. The requirements of Subsection 405. 03 shall apply.

Specifications for Indiana’s Stone Matrix Asphalt

Extracted from:

<http://www.in.gov/dot/div/contracts/standards/book/index.html>

INDIANA DOT

SECTION 410 – QUALITY CONTROL/QUALITY ASSURANCE, QC/QA, HMA SURFACE – SMA PAVEMENT

410.01 Description

This work shall consist of one course of QC/QA HMA Surface – SMA mixture constructed on prepared foundations in accordance with 105.03.

410.02 Quality Control

The SMA mixture shall be supplied from a certified HMA plant in accordance with ITM 583; Certified Volumetric Hot Mix Asphalt Producer Program. The QCP shall be modified to include the requirements for the SMA mixtures. The SMA shall be transported and placed according to a Quality Control Plan, QCP, prepared and submitted by the Contractor in accordance with ITM 803; Contractor Quality Control Plans for Hot Mix Asphalt Pavements. The QCP shall be submitted to the Engineer at least 15 days prior to commencing SMA paving operations.

MATERIAL

410.03 Materials

Materials shall be in accordance with the following:

Asphalt Materials	
PG Binder, PG 76-22, PG 70-22.....	902.01(a)
Coarse Aggregates, Class AS.....	904
Stabilizing Additive	AASHTO MP 8
Fine Aggregates (sand, mineral filler)	904

410.04 Design Mix Formula

A design mix formula, DMF, shall be prepared in accordance with 410.05 and submitted in a format acceptable to the Engineer one week prior to use. The DMF shall state the maximum particle size in the mixture. The DMF shall state the calibration factor, test temperature and absorption factors to be used for the determination of binder content using the ignition oven in accordance with ITM 586, the binder content by extraction in accordance with ITM 571, and a Mixture Adjustment Factor (MAF). The DMF shall state the source, type dosage rate of any stabilizing additives. Approval of the DMF will be based on the ESAL and mixture designation. A mixture number will be assigned by the Engineer. No mixture will be accepted until the DMF has been approved.

The ESAL category identified in the pay item correlates to the following ESAL ranges:

ESAL CATEGORY	ESAL
1	< 300,000
2	300,000 to < 3,000,000
3	3,000,000 to < 10,000,000
4	10,000,000 to < 30,000,000
5	≥ 30,000,000

410.05 SMA Mix Design

The DMF shall be determined for each mixture from a SMA mix design by a design laboratory selected from the Department’s list of approved Mix Design Laboratories. A SMA mixture shall be designed in accordance with the respective AASHTO references as listed below.

- Standard Practice for Designing
Stone Matrix Asphalt (SMA).....AASHTO PP 41
- Standard Practice for Mixture Conditioning
of Hot-Mix Asphalt (HMA).....AASHTO R 30
- Standard Specification for Designing
Stone Matrix Asphalt (SMA).....AASHTO MP 8
- Determining the Plastic Limit and Plasticity
Index of SoilsAASHTO T 90
- Maximum Specific Gravity and Density of Bituminous
Paving MixturesAASHTO T 209
- Resistance of Compacted Asphalt Mixture to
Moisture Induced Damage.....AASHTO T 283
- Determination of Draindown Characteristics
in Uncompacted Asphalt MixturesAASHTO T 305
- Method for Preparing and Determining the Density
of Hot Mix Asphalt (HMA) Specimens by
Means of the Superpave Gyrotory Compactor.....AASHTO T 312
- Method for Viscosity Determination of Asphalt Binder
Using Rotational Viscometer.....AASHTO T 316

The single percentage of aggregate passing each required sieve shall be within the limits of the following gradation table.

SMA Gradation Control Limits (Percent Passing by Volume)				
Sieve Size	Mixture Designation			
	9.5 mm		12.5 mm	
	Lower	Upper	Lower	Upper
25.0 mm				
19.0 mm			100.0	100.0
12.5 mm	100.0	100.0	90.0	99.0
9.5 mm	70.0	95.0	50.0	85.0
4.75 mm	30.0	50.0	20.0	40.0
2.36 mm	20.0	30.0	16.0	28.0
1.18 mm	---	21.0	---	---
600 μ m	---	18.0	---	---
300 μ m	---	15.0	---	---
75 μ m	8.0	12.0	8.0	11.0

The optimum binder and aggregate gradation content shall produce 4.0% air voids. The maximum specific gravity of the uncompacted mixture shall be determined in accordance with AASHTO T 209. The percent draindown for SMA surface mixture shall not exceed 0.30% in accordance with AASHTO T 305.

The MAF equals the Gmm from the mixture design divided by the following: 2.465 for 9.5 mm mixtures and 2.500 for 12.5 mm mixtures. If the MAF calculation results in a value where $0.980 \leq \text{MAF} \leq 1.020$, then the MAF shall be considered to be 1.000. If the calculated MAF is outside of the above range, then the actual calculated value shall be used.

The mixture shall be tested for moisture susceptibility in accordance with AASHTO T 283 except that the loose mixture curing shall be replaced by mixture conditioning for 2 h in accordance with AASHTO R 30. The minimum tensile strength ratio, TSR, shall be 70%. The 6 in. (150 mm) mixture specimens shall be compacted to $6.0 \pm 1.0\%$ air voids in accordance with AASHTO T 312. Specimens shall be prepared using freeze-thaw preconditioning. If anti-stripping additives are added to the mixture to be in accordance with the minimum TSR requirements, the dosage rate shall be submitted with the DMF.

The fine aggregate portion of the aggregate blend shall be non-plastic as determined in accordance with AASHTO T 90.

A change in the source or types of aggregates, change in source or type of stabilizing additives, or a change in the source of the specified binder shall require a new DMF. A new DMF shall be submitted to the District Materials and Tests Engineer for approval one week prior to use.

The specific gravity of SF and the Gsb of the aggregate blend containing SF may be adjusted once per contract upon notification by the SF source and approval by the District Materials and Tests Engineer. A new DMF is not required for this adjustment.

The mixture design compaction temperature for the specimens shall be $300 \pm 9^{\circ}\text{F}$ ($150 \pm 5^{\circ}\text{C}$).

VOIDS IN MINERAL AGGREGATE (VMA) CRITERIA	
Mixture Designation	Minimum VMA, Percent
12.5 mm	17.0
9.5 mm	17.0

410.06 Recycled Materials

Mainline surface shall not contain recycled materials.

410.07 Lots and Sublots

Lots will be defined as 2400 t (2400 Mg) of SMA surface mixture. Lots will be further sub-divided into sublots not to exceed 600 t (600 Mg) of SMA surface mixture. Partial sublots of 100 t (100 Mg) or less will be added to the previous subplot. Partial sublots greater than 100 t (100 Mg) constitute a full subplot.

410.08 Job Mix Formula

A job mix formula, JMF, shall be developed by a certified HMA producer in accordance with ITM 583. A JMF used for SMA mixture the current or previous calendar year will be allowed. The mixture compaction temperature shall be $300 \pm 9^{\circ}\text{F}$ ($150 \pm 5^{\circ}\text{C}$). The JMF for each mixture shall be submitted to the Engineer.

410.09 Acceptance of Mixtures

Acceptance of mixtures for binder content, moisture, and gradation for each lot will be based on tests performed by the Engineer. The Engineer will randomly select the location(s) within each subplot for sampling in accordance with ITM 802.

Samples from each location shall be obtained from each subplot from the pavement in accordance with ITM 580. The second sample shall be located from the random sample by offsetting 1 ft (0.3 m) transversely towards the center of the mat and will be used for the moisture sample. The test results of the sublots will be averaged and shall meet the requirements for tolerances from the JMF for each sieve and binder content.

The maximum percent of moisture in the mixture shall not exceed 0.10 from plate samples.

The Engineer's acceptance test results for each subplot will be available after the subplot and testing are complete. During the adjustment period the test results will be made available after testing is complete.

ACCEPTANCE TOLERANCE FOR MIXTURES (% Percent Mass)							
MIXTURE	NUMBER OF TESTS	SIEVE SIZE					
		*12.5 mm	*9.5 mm	*4.75 mm	2.36 μm	600 μm	75 μm
SURFACE	1				8.0	4.0	2.5
	2				5.7	2.8	2.1
	3				4.6	2.3	1.8
	4				4.0	2.0	1.5

* The acceptance tolerance for this sieve shall be the applicable composition limits specified in 410.05.

ACCEPTANCE TOLERANCE FOR BINDER				
Binder Content	Number of Tests			
	1	2	3	4
% Binder	0.7	0.5	0.4	0.3

Acceptance of mixtures for range will be determined using the results of subplot tests performed by the Engineer from each lot. If the range is not in accordance with the requirements, adjustment points will be assessed in accordance with 410.19(a).

ACCEPTANCE TOLERANCE FOR RANGE (± Percent Mass)	
SIEVE SIZE & BINDER CONTENT	PERCENTAGE POINTS
	SURFACE
2.36 mm	12.0
600 μm	6.0
75 μm	2.0
% BINDER	1.0

Acceptance tolerances for binder content and gradation will be as set out above for the number of tests performed. The acceptance tolerance for range will be as set out above for lots of more than one subplot. The range of binder shall be the difference between the highest subplot binder content and the lowest subplot binder content in one lot. The range of gradation shall be the difference between the highest subplot percent passing and the lowest subplot percent passing each required sieve in one lot.

Single test values and averages will be reported to the nearest 0.1% except moisture will be reported to the nearest 0.01%. Rounding will be in accordance with 109.01(a).

Lot adjustment points will be assessed in accordance with 410.19(a) when the average or range for binder content or gradation are not met.

The Contractor may request an appeal of the Engineer's test results in accordance with 410.20.

A binder draindown test in accordance with AASHTO T 305 shall be completed once per lot in accordance with 410.07 and shall not exceed 0.30%.

Stabilizing additives incorporated into the mixture will be accepted on the basis of a type A certification for the specified material properties for each shipment of fibers. Stabilizing additives from different manufacturers and different types of additives shall not be intermixed.

In the event than an acceptance sample is not available to represent subplot(s), all test results of the previous subplot will be used for acceptance. If the previous subplot is not available, the subsequent subplot will be used for acceptance.

CONSTRUCTION REQUIREMENTS

410.10 General

Equipment for SMA operations shall be in accordance with 409. The Contractor shall submit to the Engineer prior to use a written Certificate of Compliance that the proposed paving equipment has been modified in accordance with 401.10 or is new and includes the modifications.

Fuel oil, kerosene, or solvents shall not be transported in open containers on equipment. Cleaning of equipment and small tools shall not be accomplished on the pavement or shoulder areas.

Segregation, flushing or bleeding of SMA mixtures will not be permitted. Corrective action shall be taken to prevent continuation of these conditions. Segregated, flushed or bleeding of SMA mixtures shall be removed if directed. All areas showing an excess or deficiency of binder shall be removed and replaced.

All mixtures that become loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced.

410.11 Preparation of Surfaces to be Overlaid

Milling of an existing pavement surface shall be in accordance with 306.05. Surfaces on which a mixture is placed shall be free from objectionable or foreign materials at the time of placement.

Milled asphalt surfaces and asphalt surfaces shall be tacked in accordance with 406. Contact surfaces of curbing, gutters, manholes, and other structures shall be tacked in accordance with 406.

410.12 Process Control

The Engineer and Contractor will jointly review the operations to ensure compliance with the QCP. Continuous violations of compliance with the QCP will result in suspension of paving operations.

410.13 Weather Limitations

SMA courses shall be placed when the ambient temperature and the temperature of the surface on which it is to be placed is 45°F (7°C) or above.

410.14 Spreading and Finishing

The mixture shall be placed upon an approved surface by means of a paver or other mechanical devices in accordance with 409.03. Mixtures in areas inaccessible to mechanical devices may be placed by other methods.

Prior to paving, both the planned quantity and lay rate shall be adjusted by multiplying by the MAF. When mixture is produced from more than one DMF or JMF for a given pay item, the MAF will be applied to the applicable portion of the mixture for each.

Planned SMA courses greater than 165 lb/syd (90 kg/m²) placed under traffic, shall be brought up even with each adjacent lane at the end of each work day. Planned SMA courses less than or equal to 165 lb/syd (90 kg/m²) shall be brought forward concurrently, within practical limits, limiting the work in one lane to not more than one work day of production before moving back to bring forward the adjacent lane.

Hydraulic extensions on the paver will not be permitted for continuous paving operations. Fixed extensions or extendable screeds shall be used on courses greater than the nominal width of the paver except in areas where the paving widths vary. Hydraulic extensions may be used in tapers and added lanes less than 250 ft (75 m) in length.

Automatic slope and grade controls will be required and shall be outlined in the QCP.

SMA mainline and SMA shoulders which are 8.0 ft (2.4 m) or more in width shall be placed with automatic paving equipment.

The rollers shall be operated to avoid shoving of the SMA and at speeds not to exceed 3 mph (4.5 km/h). Rollers shall be in accordance with 409.03(d)1, 2, or 6. Vibratory rollers meeting the requirements of 409.03(d)4 may be used but shall not be operated in vibratory mode, except the vibratory mode may be used on the first pass to the paver.

The finished thickness of any course shall be at least two times but not more than four times the maximum particle size as shown on the DMF.

410.15 Joints

Longitudinal joints in the surface shall be at the lane lines of the pavement.

Transverse joints shall be constructed by exposing a near vertical full depth face of the previous course. For areas inaccessible to rollers, other mechanical devices shall be used to achieve the required density.

If constructed under traffic, temporary transverse joints shall be feathered to provide a smooth transition to the driving surface.

410.16 Density

Acceptance will be based on lots and sublots in accordance with 410.07.

The Engineer's acceptance test results for each subplot will be available after the subplot and testing are complete.

Sublot and lot density values will be reported to the nearest 0.1%. Rounding will be in accordance with 109.01(a).

Density acceptance for all SMA mixtures shall be based on cores cut from the 280 compacted pavement and analysis of pavement samples obtained in accordance with ITM 580. Acceptance will be based on lots and sublots in accordance with 410.07. The Engineer will randomly select two locations in accordance with ITM 802, within each subplot for coring. The transverse core location will be located so that the edge of the core will be no closer than 3 in. (75 mm) from a confined edge or 6 in. (150 mm) from a non-confined edge of the course being placed. The maximum specific gravity will be determined from the sample obtained in 410.09.

The Contractor shall obtain cores in the presence of the Engineer with a device that shall produce a uniform 6 in. (150 mm) diameter pavement sample. Surface courses shall be cored within one work day of placement. Damaged core(s) shall be discarded and replaced with a core from a location selected by adding 1.0 ft (0.3 m) to the longitudinal location of the damaged core using the same transverse offset.

The Contractor and the Engineer shall mark the core to define the course to be tested. If the core indicates a course thickness of less than two times the maximum particle size, the core will be discarded and a core from a new random location will be selected for testing.

The Engineer will take immediate possession of the cores. If the Engineer's cores are subsequently damaged, additional coring within a specific subplot or sublots will be the responsibility of the Department. Subsequent core locations will be determined by subtracting 1.0 ft (0.3 m) from the random location using the same transverse offset.

The density of the mixture will be expressed as the percentage of maximum specific gravity (%MSG) obtained by dividing the average bulk specific gravity by the maximum specific gravity for the subplot, times 100. The Engineer will determine the BSG of the cores in accordance with AASHTO T 166. The maximum specific gravity will be determined in accordance with AASHTO T 209 from plant produced materials prepared in accordance with ITM 572. The target value for density of SMA mixtures of each subplot shall be 93.0%.

The densities of the sublots will be averaged to determine the density of the lot.

Within one work day of coring operations the Contractor shall clean, dry, and refill the core holes with SMA of similar or smaller size particles or other approved materials. The Contractor's plan for refilling core holes shall be outlined in the QCP.

410.17 Shoulder Corrugations

Shoulder corrugations shall be in accordance with 606.

410.18 Pavement Smoothness

The pavement smoothness will be evaluated and determined in accordance with 401.18.

410.19 Adjusted Points

When test results for mixture properties or density exceed the allowable tolerances, adjustment points will be assessed. The adjustment points will be used to calculate a quality assurance adjustment quantity (q) for the lot. Quality assurance adjustment points for smoothness will be in accordance with 401.19(c).

The adjustment for mixture properties and density are calculated as follows.

$$q = (1.00 \times (L \times U \times P/100)/MAF)$$

where:

q = quality assurance adjustment quantity

L = lot quantity

U = unit price for the material, \$/TON (\$/Mg)

P = total adjustment points

The total quality assurance adjustments is to be calculated as follows:

$$Q = Q_s + \sum (q_m + q_d)$$

where:

Q = total quality assurance adjustment quantity

Q_s = quality assurance adjustment for smoothness as calculated in 401.19(c)

q_m = lot adjustments for mixtures

q_d = lot adjustments for density 350

If the total adjustment points for a lot are greater than 15, the pavement will be evaluated by the Materials and Tests Division. If the Contractor is not required to remove the mixture, quality assurance adjustments of the lot will be assessed or other corrective actions as determined by the Materials and Tests Division.

(a) Mixture

When test results for the mixture furnished exceeded the allowable tolerances, adjustment points will be assessed as follows:

ADJUSTMENT POINTS FOR GRADATION						
Adjustment Points	SIEVE SIZE					
	12.5 mm	9.5 mm	4.75 mm	2.36 mm	600 μm	75 μm
For Each 0.1% up to 1.0% Out of Tolerance	0.1	0.1	0.1	0.1	0.2	0.3
For Each 0.1% > 1.0% Out of Tolerance	0.1	0.1	0.1	0.2	0.3	0.6

Gradation adjustment points for the lot shall be the sum of points calculated for up to 1% out of tolerance and the points calculated for greater than 1% out of tolerance in accordance with 410.09.

Binder content adjustment points for the lot shall be two points for each 0.1% above the tolerance or four points for each 0.1% below the tolerance in accordance with 410.09.

When test results for the mixture furnished exceed the allowable range in accordance with 410.09, adjustment points will be assessed as follows:

ADJUSTMENT POINTS FOR RANGE	
Sieve Size and Binder Content	Adjustment Points (For Each 0.1% Out of Range)
2.36 mm	0.1
600 µm	0.1
75 µm	0.1
% Binder	1.0

For mixtures produced during a certified HMA plant's adjustment period, adjustment points will not be assessed if the mixture produced is in accordance with the following.

1. The gradation complies with 410.05 with the allowable tolerance limits shown in 410.09.
2. The range for the binder content and gradation do not exceed the limits shown in 410.09.
3. The binder content is within the tolerance requirements of 410.09.

If the mixture is not in accordance with these requirements, adjustment points will be assessed in accordance with 410.09 for variations exceeding the requirements shown above.

(b) Density

When the density of the lot is outside the allowable tolerances, adjustment points will be assessed as follows:

DENSITY	
Percentages are based on %MSG	Pay Adjustments – Percent
> 97.0	Submitted to the Materials and Tests Division*
93.0 – 97.0	0.00
92.0 – 92.9	0.20 points for each 0.10% below 93.0
91.0 – 91.9	2.00 + 0.40 points for each 0.10% below 92.0
89.0 – 90.9	6.00 + 1.00 points for each 0.10% below 91.0
≤ 89.0	Submitted to the Materials and Tests Division*

* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.

410.20 Appeals

If the QC test results do not agree with the acceptance test results, a request, along with the QC test results, may be made in writing for additional testing. The basis of the appeal shall include applicable QC test results showing acceptable quality results and shall be submitted within seven calendar days of receipt of the Department's written results for that subplot. Acceptable QC test results are defined as QC test results resulting in less pay adjustment to the contract than that determined by the Department. If an appeal is granted, appeal cores shall be taken within seven calendar days after written notification unless otherwise directed. Within one work day of appeal coring operations the Contractor shall clean, dry, and refill the core holes with SMA or HMA surface materials.

The results of the appeal cores will replace the initial test results for a subplot(s) or lot and be used as the basis for acceptance.

(a) Mixture

Upon approval for the additional testing, the Contractor shall take cores in accordance with ITM 580. The core location will be within 1.0 ft (0.3 m) longitudinally of the sample tested using the same transverse offset.

(b) Density

Additional core locations will be determined by adding 1.0 ft (0.3 m) longitudinally of the cores tested using the same transverse offset. Each subplot density will be calculated using the average bulk specific gravity of the cores obtained for that subplot and the average MSG of the lot.

Specifications for Missouri's Stone Matrix Asphalt

Extracted from:

http://www.modot.org/business/standards_and_specs/highwayspecs.htm

MISSOURI DOT SECTION 403 ASPHALTIC CONCRETE PAVEMENT

403.1 Description. This work shall consist of providing a bituminous mixture to be placed in one or more courses on a prepared base or underlying course as shown on the plans or as directed by the engineer. The contractor shall be responsible for QC of the bituminous mixture, including the design, and control of the quality of the material incorporated into the project. The engineer will be responsible for QA, including testing, to assure the quality of the material incorporated into the project.

403.1.1 Naming Convention. The nomenclature of Superpave bituminous mixture names, such as SP125CLP, will be as follows. When only the aggregate size is shown, such as SP125, the specifications shall apply to all variations of that size, such as SP125B, SP125C, SP125CLP, etc. When "x" is indicated, such as SP125xLP, specifications shall apply to all variations of mixture designs. Stone Matrix Asphalt will be generally referred to as SMA.

Superpave Nomenclature	
SP	Superpave
095	9.5 mm (3/8 inch) nominal aggregate size
125	12.5 mm (1/2 inch) nominal aggregate size
190	19.0 mm (3/4 inch) nominal aggregate size
250	25.0 mm (1 inch) nominal aggregate size
x	Mixture design: B, C, E or F (as described below)
LP	Limestone porphyry (when designated)
SM	Stone Matrix Asphalt (when designated)

403.1.2 Design Levels. The following cumulative equivalent single axle loads (ESALs) shall be used for the specified mix design. The same size aggregate mix design at a higher design traffic may be substituted at the contractor's expense for the contract specified mixture design with the approval from the engineer. Substitutions shall be done uniformly and project mixing of various designs for the same work will not be permitted. For example, an SP125B mixture may be substituted for an SP125C mixture, or SP190C for SP190E, etc. Mixture design substitution will be limited to one design level higher than that specified in the contract.

Design Traffic (ESALs)	Design
< 3,000,000	E
3,000,000 to < 30,000,000	C
≥ 30,000,000	B

403.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follow:

Item	Section
Aggregate	1002
Asphalt Binder, Performance Graded (PG) ^a	1015
Fiber Additive	1071
Anti-Strip Additive	1071

^a The grade of asphalt binder will be specified in the contract.

403.2.1 Fine Aggregate Angularity. Fine aggregate angularity (FAA) shall be measured on the fine portion of the blended aggregate. When tested in accordance with AASHTO TM 304 Method A, aggregate particles passing the No. 8 (2.36 mm) sieve shall meet the following criteria for the minimum percent air voids in loosely compacted fine aggregate:

Design	FAA
E	40
C	45
B	45

403.2.2 Coarse Aggregate Angularity. Coarse aggregate angularity (CAA) shall be measured on the coarse portion of the blended aggregate. When tested in accordance with ASTM D 5821, the coarse aggregate shall meet the following criteria. Crushed limestone, dolomite, steel slag and porphyry will be considered as having 100 percent two fractured faces unless visual observations indicate an undesirable particle shape is being produced.

Design	CAA ^a
E	75/None
C	95/90
B	100/100

^aThe criteria denotes the minimum allowable percentage of the coarse aggregate with "one/two" fractured faces, such as a "95/90" requirement, means that the coarse aggregate shall have a minimum of 95 percent particles by weight (mass) with one fractured face and a minimum of 90 percent particles by weight (mass) with two fractured faces.

403.2.3 Clay Content. When tested in accordance with AASHTO TM 176, blended aggregate particles passing the No. 4 (4.75 mm) sieve shall meet the following minimum sand equivalent criteria:

Design	Sand Equivalent
E	40
C	45
B	50

403.2.4 Thin, Elongated Particles. For all mixtures except SP125xSM, the blended aggregate particles retained on the No. 4 (4.75 mm) sieve shall not exceed 10 percent, based on a ratio of 5:1 when tested for flat and elongated particles in accordance with ASTM D 4791.

403.2.5 Stone Matrix Asphalt. In addition to other requirements, material for SMA mixtures shall meet the following. Coarse aggregate shall consist of crushed limestone and either porphyry or steel slag in accordance with the quality requirements of [Sec 1002](#), except as follows. The Los Angeles (LA) abrasion, when tested in accordance with AASHTO TM 96, shall not exceed 40 percent based on initial ledge approval and source approval. The percent absorption, when tested in accordance with AASHTO TM 85, shall not exceed 3.5 percent based on the individual fractions. The amount of flat and elongated particles, measured on material retained on a No. 4 sieve (4.75 mm), of the blended aggregate shall not exceed 20 percent based on a 3:1 ratio or 5 percent based on a 5:1 ratio.

403.2.5.1 Filler Restriction. Rigden void content determined in accordance with MoDOT Test Method TM-73 shall be no greater than 50 percent.

403.2.5.2 Fibers. A fiber additive shall be used as a stabilizer. Fibers shall be uniformly distributed by the end of the plant mixing process. The dosage rate for fibers shall be no less than 0.3 percent by weight (mass) of the total mixture for cellulose and no less than 0.4 percent by weight (mass) for mineral fibers.

403.2.6 Recycled Asphalt Pavement. Recycled Asphalt Pavement (RAP) may be used in any mixture, except SMA mixtures. A maximum of 10 percent may be used in surface mixtures and a maximum of 20 percent may be used in subsurface mixtures. All RAP material, except as noted below, shall be tested in accordance with AASHTO TP 58, *Method of Resistance of Coarse Aggregate Degradation by Abrasion in the Micro-Deval Apparatus*.

Aggregate shall have the asphalt coating removed either by extraction or binder ignition. The material shall be tested in the Micro-Deval apparatus at a frequency of once per 1500 tons (Mg). The percent loss shall not exceed the Micro-Deval loss of the combined virgin material by more than five percent. Micro-Deval testing will be waived for RAP material obtained from MoDOT roadways. All RAP material shall be in accordance with [Sec 1002](#) for deleterious and other foreign material.

403.3 Composition of Mixtures.

403.3.1 Gradation. Prior to mixing with asphalt binder, the combined aggregate gradation, including filler if needed, shall meet the following gradation for the type of mixture specified in the contract. A job mix formula may be approved which permits the combined aggregate gradation during mixture production to be outside the limits of the master range when the full tolerances specified in [Sec 403.5](#) are applied.

Percent Passing by Weight					
Sieve Size	SP250	SP190	SP125	SP125xSM	SP095xSM
1 1/2 in. (37.55 mm)	100	---	---	---	---
1 in. (25.0 mm)	90 - 100	100	---	---	---
3/4 in. (19.00 mm)	90 max.	90 - 100	100	100	---
1/2 in. (12.5 mm)	---	90 max.	90 - 100	90-100	100
3/8 in. (9.5 mm)	---	---	90 max.	50-80	70-95
No. 4 (4.75 mm)	---	---	---	20 - 35	30-50
No. 8 (2.36 mm)	19 - 45	23 - 49	28 - 58	16 - 24	20-30
No. 16 (1.18 mm)	---	---	---	---	21 max.
No. 30 (600 μ m)	---	---	---	---	18 max.
No. 50 (300 μ m)	---	---	---	---	15 max.
No. 100 (150 μ m)	---	---	---	---	---
No. 200 (75 μ m)	1 - 7	2 - 8	2 - 10	8.0-11.0	8.0-12.0

403.3.2 Anti-Strip Agent. An anti-strip will be allowed by the engineer to improve resistance to stripping. Anti-strip agents and application rates shall be from a list approved in accordance with [Sec 1071](#).

403.3.3 Porphyry Mixtures. For SP125xLP and SMA mixtures, at least 50 percent by volume of the plus No. 8 (2.36 mm) material shall be from crushed porphyry in accordance with [Sec 1002](#). Depending on the actual gradation of porphyry aggregate furnished, the amount of crushed porphyry required may vary, however at least 40 percent by weight (mass) of crushed porphyry will be required. Steel slag may be substituted for porphyry in SP125xLP and SMA mixtures, except at least 45 percent by weight (mass) of crushed porphyry and/or slag will be required. The engineer may approve the use of other hard, durable aggregate in addition to porphyry and steel slag.

403.3.4 Minimum Stone Matrix Asphalt Binder. The percent asphalt binder for SMA mixtures shall not be less than 6.0 percent unless otherwise allowed by the engineer.

403.3.5 Surface Mixtures. Design level B surface mixtures, except as described in [Sec 403.15.3](#), containing limestone coarse aggregate shall contain a minimum amount of noncarbonated aggregate. The LA abrasion values, AASHTO TM 96, of the limestone will determine the type and amount of non-carbonate aggregate required as shown in the table below. The LA abrasion value will be determined from the most recent source approval sample. In lieu of the above requirements, the aggregate blend shall have an acid insoluble residue (AIR), MoDOT Test Method TM 76, meeting the plus No. 4 (4.75 mm) criteria of crushed non-carbonate material. Non-carbonate aggregate shall have an AIR of at least 85 percent insoluble residue.

Coarse Aggregate (+ No. 4)	Minimum Non-Carbonate by Volume
Limestone, LA \leq 30	30% Plus No. 4
Limestone, LA $>$ 30	20% Minus No. 4
Dolomite	No Requirement

403.4 Job Mix Formula. At least 30 days prior to placing any mixture on the project, the contractor shall submit a mix design for approval to Construction and Materials. The mixture shall be designed in accordance with AASHTO PP 28 or PP 41 and shall be tested in accordance with AASHTO TM 312 except as noted herein. A detailed description of the mix design process shall be included with the job mix formula (JMF). Representative samples of each ingredient for the mixture shall be submitted with the mix design. Aggregate fractions shall be provided in the same proportions as the proposed job mix formula. A minimum of 150 pounds (68 kg) will be required for any individual fraction. The amount of each ingredient submitted shall be as follows for each mix design to be verified:

Ingredient	Minimum Amount
Aggregate	750 Pounds (340 kg)
Hydrated Lime, Mineral Filler and/or Baghouse Fines	20 Pounds (9 kg)
Asphalt Binder	10 Gallons (38 L)

403.4.1 Proficiency Sample Program. Laboratories that participate in and achieve a score of three or greater in the AASHTO proficiency sample program for T 11, T 27, T 84, T 85, T 166, T 176, T 209, T 304 (ASTM C 1252), T 308 and T 312 will have the mixture verification process waived. The mix design shall be submitted to Construction and Materials for approval at least seven days prior to mixture production.

403.4.2 Required Information. The mix design shall include raw data from the design process and contain the following information:

- a) Source, grade and specific gravity of asphalt binder.
- b) Source, type (formation, etc.), ledge number if applicable, gradation, and deleterious content of each aggregate fraction.
- c) Bulk and apparent specific gravities and absorption of each aggregate fraction in accordance with AASHTO T 85 for coarse aggregate and AASHTO T 84 for fine aggregate including all raw data.
- d) Specific gravity of hydrated lime, mineral filler or baghouse fines, if used, in accordance with AASHTO T 100.
- e) Percentage of each aggregate component.
- f) Combined gradation of the job mix.
- g) Percent asphalt binder, by weight (mass), based on the total mixture.
- h) Bulk specific gravity (Gmb) by AASHTO T 166 Method A of a laboratory compacted mixture compacted at Ndesign gyrations.
- i) Percent air voids (Va) of the laboratory compacted specimen compacted to Ndesign gyrations.
- j) Voids in the mineral aggregate (VMA) and voids in the mineral aggregate filled with asphalt binder (VFA) at Ndesign gyrations.
- k) Theoretical maximum specific gravity (Gmm) as determined by AASHTO T 209, in accordance with [Sec 403.19.3.1](#), after the sample has been short term aged in accordance with AASHTO R 30.

- l) The tensile strength ratio as determined by AASHTO T 283 including all raw data.
- m) The gyratory sample weight (mass) to produce a 115 mm minimum height specimen.
- n) Mixing temperature and gyratory molding temperature.
- o) Number of gyrations at $N_{initial}$, N_{design} , and $N_{maximum}$.
- p) Dust proportion ratio ($-200/P_{be}$).
- q) Bulk specific gravity (G_{sb}) of the combined aggregate.
- r) Percent chert contained in each aggregate fraction.
- s) Percent of G_{mm} at $N_{initial}$ and $N_{maximum}$.
- t) Blended aggregate properties for clay content, angularity, and thin and elongated particles.
- u) Voids in coarse aggregate (VCA) for both the mixture and dry-rodded condition for SMA mixtures.
- v) Draindown for SMA mixtures.
- w) Baghouse fines added for design.
 - i. Batch and continuous mix plants – Indicate which aggregate fraction to add baghouse percentage during production.
 - ii. Drum mix plants – Provide cold feed settings with and without baghouse percentage.
 - iii.

403.4.3 Approval. No mixture will be accepted for use until the JMF for the project is approved by Construction and Materials.

403.4.4 Job Mix Formula Modification. The JMF approved for each mixture shall be in effect until modified in writing by the engineer. When unsatisfactory results occur or should a source of material be changed, a new JMF may be required.

403.4.5 Design Gyration. The number (N) of gyrations required for gyratory compaction shall be as follows:

Design	$N_{initial}$	^a N_{design}	^a $N_{maximum}$
E	7	75	115
C	8	100	160
B	9	125	205

^a SMA mixtures shall have N_{design} equal to 100 and no $N_{maximum}$ requirement.

In addition, the compaction level, as a percent of theoretical maximum specific gravity, shall be less than or equal to 91.5 percent for Design F, 90.5 percent for Design E and 89.0 percent for Designs C and B at $N_{initial}$, equal to 96.0 percent at N_{design} and less than or equal to 98.0 percent at $N_{maximum}$.

403.4.6 Mixture Characteristics. When compacted in accordance with AASHTO T 312, the mixture shall meet the following criteria.

403.4.6.1 Air Voids (V_a). Design air voids for all mixtures at all traffic levels shall be 4.0.

403.4.6.2 Voids in the Mineral Aggregate (VMA).

Mixture	VMA Minimum (percent)
SP250	12.0
SP190	13.0
SP125 (except for below)	14.0
SMA	17.0

403.4.6.3 Voids Filled With Asphalt (VFA).

Design	VFA (percent) ^a
E	65 – 78
C	65 – 75
B	65 – 75

^a SMA mixtures shall have a minimum VFA of 75 percent.

403.4.7 Dust to Binder Ratio. For all mixtures except SMA, the ratio of minus No. 200 (75 µm) material to effective asphalt binder (P_{be}) shall be between 0.8 and 1.6.

403.4.8 Moisture Susceptibility. For all mixtures except SMA, the mixture shall have a tensile strength ratio (TSR) greater than 80 percent when compacted to 95 mm (3.7 inches) with 7 ± 0.5 percent air voids and tested in accordance with AASHTO T 283. SMA mixtures shall have a TSR greater than 80 percent when compacted to 95 mm (3.7 inches) with 6 ± 0.5 percent air voids and tested in accordance with AASHTO T 283.

403.4.9 Draindown. AASHTO T 305, Draindown Test, shall be performed on all SMA mixtures prior to job mix approval. The mixture shall be stabilized in such a way that the draindown of the asphalt binder shall not exceed 0.3 percent by weight (mass) of mixture.

403.4.10 Voids in Coarse Aggregate. The percent VCAMIX of SP125xSM mixtures shall be less than or equal to the VCADRC as determined using AASHTO T 19. This may be calculated using the following equations:

$$VCA_{DRC} = 100 \times (G_{CA\gamma_w} - \gamma_s) / G_{CA\gamma_w}$$

$$VCA_{MIX} = 100 - (P_{bp} \times G_{mb} / G_{CA})$$

$$P_{bp} = P_s \times PA_{bp}$$

Where: G_{CA} = bulk specific gravity of the combined coarse aggregate (AASHTO T 85),
 γ_s = unit weight (mass) of coarse aggregate in the

dryrodded condition (DRC) (lb/ft³) (kg/m³)
(AASHTO T 19),

- γ_w = unit weight (mass) of water (62.34 lb/ft³) (1000 kg/m³),
- P_{bp} = percent aggregate by total mixture weight (mass) retained on No. 4 (4.75 mm) sieve and
- PA_{bp} = percent aggregate by total aggregate weight (mass) retained on No. 4 (4.75 mm) sieve*.

*Use No. 8 (2.36 mm) sieve for SP095xSM

403.5 Mixture Production Specification Limits.

403.5.1 Gradation and Deleterious Content Control. The gradation of the aggregate shall be determined from samples taken from the hot bins on batch-type or continuous mixing plants or from the composite cold feed belt on drum mix plants. The deleterious content of the aggregate shall be determined from samples taken from the composite cold feed belt. The RAP shall be sampled from the RAP feeding system on the asphalt plant. The contractor shall determine on a daily basis at minimum, the gradation on the aggregate reclaimed from the RAP by either extraction or binder ignition. The results shall be used to determine the daily specification compliance for the combined gradation.

403.5.1.1 Stone Matrix Asphalt Tolerances. In producing mixtures for the project, the plant shall be operated such that no intentional deviations from the job mix formula are made. The maximum deviation from the approved job mix formula shall be as follows for SMA mixtures:

Sieve	Max. Tolerance (Percent Passing by Mass)	
	SP095	SP125
3/4 in. (19.0 mm)	---	---
1/2 in. (12.5 mm)	---	±4
3/8 in. (9.5 mm)	±4	±4
No. 4 (4.75 mm)	±3	±3
No. 8 (2.36 mm)	±3	±3
No. 200 (75 µm)	±2	±2

403.5.1.2 Mixture Tolerance. For all other SP mixtures, the percent passing the first sieve size smaller than the nominal maximum size shall not exceed 92.0 percent, a tolerance not to exceed 2.0 percent on the No. 8 sieve (2.36 mm) from the table in [Sec 403.3.1](#), and within the range listed in [Sec 403.3.1](#) for the No. 200 sieve (75 µm) The deleterious content of the material retained on the No. 4 (4.75 mm) sieve shall not exceed the limits specified in Sec 1002.2..

403.5.2 Density. The final, in-place density of the mixture shall be 94.0 ± 2.0 percent of the theoretical maximum specific gravity for all mixtures except SMA. SMA mixtures shall have a minimum density of 94.0 percent of the theoretical maximum specific gravity. The theoretical maximum specific gravity shall be determined from a sample

representing the material being tested. Tests shall be taken not later than the day following placement of the mixture. The engineer will randomly determine test locations.

403.5.2.1 Shoulder Density. Density on non-integral shoulders shall be in accordance with [Sec 403.15.3](#).

403.5.2.2 Integral Shoulder. When shoulders are placed integrally with the traveled way, tests shall be taken on the traveled way.

403.5.2.3 Longitudinal Joint Density. Density along longitudinal joints shall be in accordance with [Sec 403.16.1](#).

403.5.3 Asphalt Content. The asphalt content (AC) shall be within ± 0.3 percent of the approved mix design.

403.5.4 Voids in the Mineral Aggregate. The VMA shall be within $- 0.5$ and $+ 2.0$ percent of the minimum required for each type of mixture at N_{des} gyrations.

403.5.5 Air Voids. Air voids shall be within ± 1.0 percent of the approved mix design at N_{des} gyrations.

403.5.6 Tensile Strength Ratio. The TSR shall be greater than or equal to 75 percent as determined from loose mixture taken from the roadway and tested in accordance with AASHTO T 283.

403.5.7 Aggregate Properties. Aggregate properties from [Sec 403.2](#) on the combined aggregate during production shall be no less than 2 percent below the minimum for FAA, no less than 5 percent below the minimum for CAA, no less than 5 percent below the minimum for clay content and no more than 2 percent above the maximum for thin, elongated particles.

403.5.8 Fibers. The fiber proportioning and delivery system for SMA mixtures shall have an accuracy of 10 percent by weight (mass) of the material actually being measured in any given period of time.

403.5.9 Moisture Content. The asphaltic concrete mixture, when sampled and tested in accordance with MoDOT Test Method TM 53, shall not contain more than 0.5 percent moisture by weight (mass) of the mixture.

403.5.10 Contamination. The asphaltic concrete mixture shall not be contaminated with deleterious agents such as unburned fuel, objectionable fuel residue or any other material not inherent to the job mix formula.

403.6 Field Laboratory. The contractor shall provide a Type 3 field laboratory in accordance with [Sec 601](#). The contractor shall furnish the bituminous mixture equipment to perform all required test methods for QC and QA work. The gyratory compactor shall

be evaluated in accordance with AASHTO PP 35. An approved list will be maintained by Construction and Materials. All other equipment shall be capable of performing tests in accordance with the approved test methods.

403.7 Bituminous Mixing Plants. Bituminous mixing plants and preparation of material and mixtures shall be in accordance with [Sec 404](#).

403.8 Hauling Equipment. Trucks used for hauling bituminous mixtures shall be in accordance with [Sec 404](#).

403.9 Pavers. Bituminous pavers shall be self-contained units, provided with an activated screed or strike-off assembly, heated if necessary, and capable of spreading and finishing asphaltic concrete in lane widths applicable to the specified typical sections and thicknesses shown on the plans.

403.10 Construction Requirements.

403.10.1 Weather Limitations. No mixture shall be placed on any wet or frozen surface. Temperatures shall be obtained in accordance with MoDOT Test Method TM 20.

403.10.2 Substitutions. With approval from the engineer, the contractor may substitute a smaller nominal maximum size mixture for a larger sized mixture. Specifications governing the substitute mixture shall apply. Except for a single surface layer, the total pavement thickness shall be maintained when the substitute mixture layer is reduced as allowed in Sec 403.13 by increasing the thickness of other layers or courses. The lesser of the contract unit price for the larger mixture and the substitute mixture shall be used.

403.11 Field Adjustments of Job Mix Formulas. When test results indicate the mixture produced does not meet the specification requirements, the contractor may field adjust the job mix formula as noted herein. Field adjustments may consist of changing the percentages of the aggregate fractions as listed on the approved job mix formula a maximum total of 5.0 percent and changing the percent binder as listed on the original approved job mix by no more than 0.3 percent. Additional fractions of material or new material will not be permitted as field adjustments. The engineer shall be notified immediately when any change is made in the cold feed settings, the hot bin settings or the binder content. A new Gsb shall be calculated using the new aggregate percentages. The gradation of the adjusted mixture shall meet the requirements of the mixture type specified in the contract. When the aggregate percentages are adjusted by more than a total of 5.0 percent or the binder content is adjusted more than 0.3 percent, the mixture will be considered out of specification, and a new mix design shall be established.

403.11.1 Field Mix Redesign. When a new mix design will be required, the contractor will be permitted to establish the new mix design in the field. The mixture shall be designed in accordance with AASHTO PP 28 or AASHTO PP 41 and shall meet the mix design requirements, including TSR. A representative sample of the mixture shall be submitted with the new mix design to the Central Laboratory for mixture verification.

The amount of mixture submitted for verification shall weigh (have a mass of) at least 50 pounds (24 kg).

403.11.1.1 Approval. New mix designs established in the field shall be submitted for approval to Construction and Materials. Upon approval, Construction and Materials will assign a new mix number to the mixture.

403.11.1.2 Resume Production. No mixture shall be placed on the project until the new field mix design is approved.

403.12 Application of Prime or Tack. The prime or tack coat, if specified, shall be applied in accordance with [Secs 407](#) or [408](#), whichever is applicable.

403.13 Spreading and Finishing. The base course, primed or tacked surface, or preceding course or layer shall be cleaned of all dirt, packed soil or any other foreign material prior to spreading the asphaltic mixture. If lumps are present or a crust of mixture has formed, the entire load will be rejected. The thickness and width of each course shall conform to the typical section in the contract. The contractor may elect to construct each course in multiple layers. The minimum compacted thickness shall be 1.25 inches (30 mm) for SP095, 1.75 inches (45 mm) for SP125, 2 inches (50 mm) for SP190, and 3 inches (75 mm) for SP250.

403.13.1 Paving Widths. The following shall apply for roadways constructed under traffic. For pavements having a width of 16 to 24 feet (5 to 7 m), inclusive, the asphaltic concrete pavement shall be laid in lanes approximately one half the full width of the completed pavement, and the full width shall be completed as soon as practical. Unless otherwise permitted, a single lane of any course shall not be constructed to a length that cannot be completed to full width of the pavement the succeeding operating day. For pavements greater than 24 feet (7.2 m) wide, single lane width construction shall be limited to one day's production and completion to full width shall be accomplished as soon as practical. Uneven pavement shall be left in place for no more than seven days, unless approved by the engineer. Removal of pavement to be in accordance with this specification shall be at the contractor's expense.

403.13.2 Segregation. No segregation will be permitted in handling the mixture at the plant, from the truck or during spreading operations on the roadbed. All layers shall be feathered out, by hand raking if necessary, in transitioning the depth of the surface to meet present grades at bridges or ends of projects, to provide a uniform, smooth riding surface free of irregularities. Where only the top layer of the surfacing continues across a bridge, the bottom layers shall be feathered out. In situations where there is a dispute in the existence of segregation, the area in question will be tested in accordance with MoDOT Test Method TM 75. Mixture production shall immediately cease if either criteria of MoDOT Test Method TM 75 fail. Segregated mixture shall be removed and replaced to the limits determined by the engineer.

403.13.3 Release to Traffic. If the asphaltic concrete construction consists of more than a single layer, each layer shall be compacted as specified and allowed to cool to the ambient temperature before the next layer is placed. The contractor shall keep traffic off the asphaltic concrete until the surface of the asphaltic concrete is 140 F (60 C) or below and the asphaltic concrete has cooled sufficiently to prevent flushing of the asphalt binder to the surface, marking or distorting the surface or breaking down the edges.

403.13.4 Draindown. Evidence of asphalt binder separation or draindown at delivery will be cause for rejection.

403.13.5 Shoulder Substitution. When a Sec 403 mixture is specified for traffic lanes, the same mixture may be used for the adjacent shoulder, subject to the density requirements in [Sec 403.5.2](#).

403.14 Spot Wedging and Leveling Course. The engineer will specify the locations and thickness of spot wedging and the thickness of leveling course to obtain the smoothest possible riding surface. This procedure may result in spot wedging operations over small areas with feather-edging at high points and ends of wedge areas. Rigid control of the placement thickness of the leveling course shall be required. Leveling course, consisting of a layer of asphaltic concrete of variable thickness used to superelevate curves and eliminate irregularities in the existing base, shall be spread uniformly to the specified profile grade and cross section. The mixture shall be uniformly spread and compacted, with only minor segregation as accepted by the engineer. Type SP125 mixtures, as applicable, shall be used for the spot wedging and for the leveling course.

403.15 Compaction. After the asphaltic mixture has been spread, struck off and surface irregularities adjusted, the asphaltic mixture shall be compacted thoroughly and uniformly by rolling to obtain the required compaction while the mixture is in a workable condition. Excessive rolling, to the extent of aggregate degradation, will not be permitted. A pneumatic tire roller shall be used as the initial or intermediate roller on any course placed as a wedge or leveling course. Rollers shall not be used in the vibratory mode when the mixture temperature is below 225 F (107 C). Pneumatic tire rollers shall not be used for SMA mixtures.

403.15.1 Rolling. Any displacement occurring as a result of starting, stopping or changing direction of a roller, or from other causes, shall be avoided. Excess liquid, to prevent adhesion of the mixture to the rollers, will not be permitted. Diesel fuel, fuel oil or other detrimental products shall not be used as wetting agents. Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers.

403.15.2 Defective Mixture. Any mixture that becomes loose and broken, mixed with dirt or is in any way defective shall be removed and replaced with fresh, hot mixture, which shall be compacted to conform with the surrounding area. Any area showing an excess or deficiency of asphalt binder shall be removed and replaced.

403.15.3 Non-Traffic Areas. Sec 403 mixtures used for surfacing medians and similar areas, shoulders adjacent to rigid or flexible pavement and shoulders adjacent to resurfaced pavement shall be compacted to the specified densities for the mixture. Once an established rolling pattern has been demonstrated to provide the required density for shoulders, at the engineer's discretion, the pattern may be used in lieu of density tests provided no changes in the material, typical location or temperatures are made. Regardless of the method, density will still be required and subject to testing as deemed necessary by the engineer. In lieu of roller and density requirements, temporary bypasses to be maintained at the expense of the contractor shall be thoroughly compacted. The rolling shall be performed at proper time intervals and shall be continued until there is no visible evidence of further consolidation.

403.15.4 Density Measurement. Measurements for determining the in-place density of the mixture shall be taken no later than the day following placement. Measurements not obtained within the prescribed time limits shall be subject to the requirements of [Sec 403.22](#). If a core is taken, material from underlying layers that remain adhered to the core shall be removed in a manner that does not harm the integrity of the specimen. If the contractor elects to place a lift of mixture greater than six times the nominal maximum aggregate size, cores shall be cut in half and the density of each half determined separately.

403.16 Joints. Transverse joints shall be formed by any method that will produce a dense, vertical section for use when laying is resumed. When a transverse vertical edge is to be left and opened to traffic, a temporary depth transition shall be built as approved by the engineer. The joint formed when the fresh mixture is placed shall be dense, well sealed, and the grade, line and surface texture of the succeeding surface shall conform to that of the joined surface. If directed by the engineer, the transverse joint shall be painted with a light coating of liquid asphalt. Hand manipulation of the mixture shall be minimized to avoid unsightly surface texture.

403.16.1 Joint Composition. Longitudinal joints shall be formed by the use of an edging plate fixed on both sides of the finishing machine. Care shall be taken to obtain a well bonded and sealed longitudinal joint by placing the hot mixture in a manner ensuring maximum compaction at this point. If directed by the engineer for properly sealing the longitudinal joint, a light coating of bituminous material shall be applied to the exposed edge before the joint is made. The minimum density of all traveled way pavement within 6 inches (150 mm) of a longitudinal joint, including the pavement on the traveled way side of the shoulder joint, shall not be less than 2.0 percent below the specified density when unconfined. The density of the longitudinal joint when confined will be included in the evaluation of the remainder of the mat. Each side of the joint shall be flush and along true lines.

403.16.2 Joint Offset. The longitudinal joint in any layer shall offset that in the layer immediately below by a minimum of 6 inches (150 mm); except, the joints in the completed surfacing shall be at the lane lines of the traveled way or other required

placement width outside the travel lane. The placement width shall be adjusted such that pavement marking shall not fall on a longitudinal joint.

403.17 Quality Control.

403.17.1 Quality Control Operations. The contractor shall maintain equipment and qualified personnel to perform all QC field inspection, sampling and testing as required by this specification. All contractor personnel included in the QC operation shall be qualified by the MoDOT Technician Training Program. Under no circumstances will unqualified personnel be allowed to perform QC sampling or testing. Personnel will be disqualified if acceptable methods and procedures are not followed.

403.17.1.1 Asphalt Test Results. The contractor shall record all test results and furnish a copy, including all raw data, to the engineer no later than the beginning of the day following the test. The contractor shall maintain all test results in an organized format and shall be available to the QA inspector at all times. Scale readings and other measurements not directly recorded by electronic media shall be recorded in an organized format. Printouts from gyratory compactors and asphalt content devices shall be retained as part of the testing records.

403.17.1.2 Profilograph Test Results. Profilograms and evaluations shall be furnished to the engineer no later than the end of the next working day following placement of the pavement and within two working days after corrective action.

403.17.2 Bituminous Quality Control Plan. Prior to approval of the trial mix design by the engineer, the contractor shall submit a QC Plan to Construction and Materials for approval. The QC Plan shall include:

- a) The contractor representative in charge of QC and the project level representative if different from the contractor representative. Contact information should be recorded for these individuals.
- b) Lot and subplot sizes and how they will be designated.
- c) The test method for determining asphalt content and number of cores to be cut for density determination.
- d) A proposed independent third party name, contact, address, and phone number for dispute resolution.

403.17.2.1 Third Party. The third party shall be independent of the contractor, MoDOT consultants and all project subcontractors or suppliers on each specific project. All testing of material for dispute resolution shall be performed by an approved laboratory. Approved laboratories shall be AASHTO Accreditation Program certified in the areas of the material being tested.

403.17.2.2 Plant Calibration. Plant calibration shall be performed by the contractor in accordance with [Sec 404](#), and records shall be made available to the engineer.

403.17.2.3 Retained Samples. All samples taken by the contractor, including but not limited to tested aggregate, volumetric and density samples, shall be retained for the

engineer for a minimum of seven days unless otherwise instructed. These samples shall be maintained in clean covered containers, without contamination, readily accessible to the engineer. The retained sample's identification shall consist of, but is not limited to:

- a) Time and date sampled.
- b) Product specification number.
- c) Type of sample, i.e. belt, bin, stockpile.
- d) Lot and subplot designation.
- e) Sampler/Tester.
- f) Project Job Number.

403.17.2.3.1 Gradation and Deleterious Content Samples. For each gradation and deleterious sample taken, the contractor shall retain for the engineer, the portion of the sample not tested after reducing the original sample to testing size.

403.17.2.3.2 Loose Mix Sample. All loose mix samples for determination of volumetrics, asphalt binder content and TSR shall be taken from the roadway at random locations designated by the engineer. A companion loose mix sample shall be taken, identified and retained for the engineer.

403.17.3 Quality Control Laboratory. All QC mixture testing shall be performed in an approved laboratory.

403.17.3.1 Calibration Schedule. The contractor shall calibrate or verify all significant test equipment associated with tests covered in this specification. Intervals as set by the contractor shall not exceed the following limits:

Equipment - Test Method (AASHTO)	Requirement	Interval (Month)
Gyratory Compactor - T 312	Calibrate	12 ^a
Gyratory Compactor - T 312	Verify	Daily
Gyratory Molds - T 312	Check Critical Dimensions	12
Thermometers - T 209, T 166, T 312	Calibrate	6
Vacuum System - T 209	Check Pressure	12
Pycnometer (Flask) - T 209	Calibrate	Daily
Binder Ignition Oven - T 308	Verify	12 ^b
Nuclear Content Gauge – T 287 or MoDOT TM 54	Drift & Stability – Manuf. Recommendation	1
Mechanical Shakers - T 27	Check Sieving Thoroughness	12
Sieves	Check Physical Condition	6
Weighted Foot Assembly - T 176	Check Weight	12
Mechanical Shaker - T 176	Check Rate & Length of Throw	12
Liquid Limit Device - T 89	Check Wear & Critical Dimensions	12
Grooving Tool - T 89	Check Critical Dimensions	12
Ovens	Verify Temp. Settings	4
Balances	Verify	12 ^b
Timers	Check Accuracy	6

^a Calibrate and/or verify after each move.

^b Verify after each move.

403.17.3.1.1 Inventory. An inventory of all major sampling, testing, calibration and verification equipment, including the serial number or other identifying number shall be maintained.

403.17.3.1.2 Calibration Records. Calibration and verification records shall include but are not limited to:

- a) Detailed results of the work performed (dimensions, mass, force, temperature, etc.)
- b) Description of the equipment calibrated including identifying number.
- c) Date the work was performed.
- d) Identification of the individual performing the work.
- e) Identification of the calibration or verification procedure used.
- f) The previous calibration or verification date and next due date.
- g) Identification of any in-house calibration or verification device used (including identification to establish traceability of items such as standard masses, proving rings, standard thermometers, balances, etc.).

403.17.3.2 Record Retention. Test records shall be maintained to permit verification of any test report. Records pertaining to testing, equipment calibration and verification, test reports, internal quality systems review, proficiency sample testing, test technician training and evaluation and personnel shall be retained in a secure location for a minimum of three years.

403.17.3.3 Test Method Availability. A current copy of all test methods and procedures shall be maintained in the QC laboratory at all times for reference by the technicians. Examples of report formats and procedures may be found in AASHTO R 18.

403.18 Quality Assurance. All QA field inspection, sampling and testing will be performed by a qualified MoDOT technician. The QA inspector shall have free access to any and all testing equipment used by the mixture producer and any workbooks, records or control charts maintained by the mixture producer for the QC process. The QA inspector shall also have sufficient access to the plant grounds to assure compliance with the approved QC Plan.

403.18.1 Assurance Testing. The engineer will independently sample and test the mixture from the roadway at the frequency listed in [Sec 403.19.3](#). The independent sample will be of sufficient size to retain half for possible disputes. Further testing of this sample will be under the direction of the engineer. The retained portion of the QC samples for mixture properties, gradation, and deleterious content will be tested at a frequency no less than once per week. The engineer's test results, including all raw data, will be made available to the contractor when completed and no later than the next working day.

403.18.2 Aggregate Comparison. Comparison for aggregate will be considered favorable when the contractor's QC results and the engineer's QA test results of a retained sample compare within the following limits.

403.18.2.1 Gradation.

Sieve Size	Percentage Points
3/4 inch (19 mm) and larger	5.0
1/2 inch (12.5 mm)	5.0
3/8 inch (9.5 mm)	4.0
No. 4 (4.75 mm)	4.0
No. 8 (2.36 mm)	3.0
No. 10 (2.00 mm)	3.0
No. 16 (1.18 mm)	3.0
No. 20 (850 μ m)	3.0
No. 30 (600 μ m)	3.0
No. 40 (425 μ m)	2.0
No. 50 (300 μ m)	2.0
No. 100 (150 μ m)	2.0
No. 200 (75 μ m)	1.0

403.18.2.2 Coarse Aggregate Angularity. Angular particles shall be within 5 percentage points.

403.18.2.3 Fine Aggregate Angularity. Void content shall be within 2 percentage points.

403.18.2.4 Sand Equivalent. Sand equivalency shall be within 5 percentage points.

403.18.2.5 Thin, Elongated Particles. Flat, elongated particle content shall be within one percentage point.

403.18.2.6 Deleterious. The total and individual deleterious content shall not exceed the specification limits.

403.18.3 Federal Highway Administration Requirements. Performance and acceptance of QC/QA testing under these specifications shall not eliminate any FHWA requirements for acceptance of the material.

403.19 Acceptance of Material. Acceptance of bituminous mixture will be based on lots. Material will be sampled from the roadway behind the paver in lots or sublots on a random basis through the use of a random number system and evaluated using a Quality Level Analysis (QLA). A QLA will determine payment based on a combination of the total PWL (PWLt) determined for each pay factor item for each lot of material produced.

403.19.1 Random Numbers. The engineer will generate random numbers.

403.19.2 Lots. The lot size shall be designated in the contractor's QC Plan. Each lot shall contain no less than four sublots with a maximum sublot size of 1,000 tons (1000 Mg). Sublots from incomplete lots shall be combined with the previous complete lot for determination of pay factors. When no previous lot exists, the mixture shall be treated in accordance with [Sec 403.23.7.4.1](#). A new lot shall begin when the asphalt content of a mixture is adjusted in accordance with [Sec 403.11](#).

403.19.3 Test and Pay Factor Items. As a minimum, the contractor and engineer shall test in accordance with the following table. Where multiple test methods are allowed, the contractor shall designate the test method to be used in the QC Plan. Final payment will be based on the indicated pay factor items.

Tested Property	Pay Factor	Test Method	Contractor Frequency	Engineer Frequency
Mixture temperature	No	----	1/Sublot	1/day
Temperature of base and air	No	----	As needed	As needed
Mat Density (% of theoretical maximum density) by contractor	Yes	MoDOT Test Method TM-41 or AASHTO T 166	1 Sample ^b /Sublot As needed for joints & shoulders.	1 Sample/Lot
Unconfined Joint Density	No	MoDOT Test Method TM-41 or AASHTO T 166	1 Sample ^b /Sublot	1 Sample/Lot
Cold feed or hot bin gradation and deleterious content	No	AASHTO T 27 and AASHTO T 11	2/Lot	1/day
FAA, CAA, Clay Content and Thin, Elongated Particles from material sampled from the cold feed or hot bin	No	AASHTO T 304, ASTM D 5821, AASHTO T 176 and ASTM D 4791	1/10,000 tons with a minimum of 1/project/mix type	1/project
Asphalt content	Yes	AASHTO T 164, or MoDOT Test Method TM-54, or AASHTO T 287, or AASHTO T 308	1/Sublot	1/day
Asphalt content of RAP	No	AASHTO T 164 ^d	1/Lot	1/project
VMA @ N _{des} gyrations	Yes ^a	AASHTO T 312 and PP 28	1/Sublot	1/day
V _a @ N _{des} gyrations	Yes ^a	AASHTO T 312 and PP 28	1/Sublot	1/day
VFA @ N _{des} gyrations	No ^a	AASHTO T 312 and PP 28	1/Sublot	1/day
Theo. max SG of the mixture	No	AASHTO T 209	1/Sublot	1/day
TSR of the in place mixture	No ^c	AASHTO T 283	1/10,000 Tons or fraction thereof	1/50,000 Tons or 1/project

^a Based on the average of a minimum of two compacted specimens.

^b Core samples shall consist of one core. Up to two additional cores, as stated in the QC Plan, may be obtained at the same offset within one foot (0.3 m) of the randomly selected location. If more than one core is obtained, all cores shall be combined into one sample.

^c Payment will be based on the table in [Sec 403.23.5](#).

^d Other methods may be approved by establishing correction factors for RAP from the same source.

403.19.3.1 Test Method Modification.

403.19.3.1.1 Binder Ignition Modification. Asphalt content determination in accordance with AASHTO T 308, Section 6.9.1 shall be modified by adding the following: If the calibration factor exceeds 1.0 percent, lower the test temperature to 427 ± 5 C (800 ± 8 F) and repeat test. Use the calibration factor obtained at 427 C (800 F) even if it exceeds 1.0 percent. If RAP is used, the binder ignition oven shall be calibrated in accordance with MoDOT Test Method TM 77. At the engineer's discretion, testing may be waived when production does not exceed 200 tons (200 Mg) per day. The contractor shall certify the proper proportions of a previously proven mixture were used.

403.19.3.1.2 Rice Test. When the water absorption of any aggregate fraction is greater than 2.0 percent, the test method for determining theoretical maximum specific gravity, AASHTO T 209, shall be modified as follows: After completing the procedure in accordance with Section 9.5.1 or 9.5.2, drain water from the sample. To prevent loss of fine particles, decant the water through a paper towel held over the top of the container. Spread the sample before an electric fan to remove surface moisture. Weigh at 15-minute intervals, and when the loss in mass is less than 0.05 percent for this interval, the sample may be considered to be surface dry. This procedure requires about 2 hours and shall be accompanied by intermittent stirring of the sample. Break conglomerations of mixture by hand. Take care to prevent loss of particles of mixture. Calculate the specific gravity of the sample by substituting the final surface-dry mass for A in denominator of Equations 2 or 3.

403.19.3.2 Miscellaneous Applications.

403.19.3.2.1 Small Quantities. For each separate mixture of less than 3000 tons (3000 Mg) on individual projects, including individual projects in combination contracts, the following shall apply:

- a) A field laboratory will not be required for monitoring mixtures. All required QC and QA testing shall be performed in an approved laboratory.
- b) QC tests required in [Sec 403.19.3](#) shall be performed at a frequency of no less than one per day if production does not exceed 750 tons (750 Mg) and at a frequency of no less than two per day if production exceeds 750 tons (750 Mg). Independent or retained sample QA tests shall be performed at least once per 1500 tons (1500 Mg), as indicated.

403.19.3.2.2 Base Widening and Entrances. For base widening mixture and entrance work, the following will apply:

- a) All base widening shall be constructed in accordance with [Sec 401.7.5](#) and subsections.
- b) The minimum density of these mixtures shall be attained as specified herein, except, compaction may be performed in accordance with [Sec 403.15.3](#).

403.19.4 Dispute Resolution. When there are significant discrepancies between the engineer's and the contractor's test results, dispute resolution procedures will be used.

403.19.4.1 Cease Work. The contractor's operations may be required to cease until the dispute is resolved if the test results indicate the mixture is subject to failure.

403.19.4.2 Third Party Resolution. The first step in dispute resolution will be to identify differences in procedures and correcting inappropriate procedures before moving to third party resolution. If that does not resolve the dispute, either the contractor or the engineer may request the approved QC Plan third party involvement. The recommendations of the approved third party shall be binding on both the engineer and contractor.

403.19.4.3 Third Party Payment. The contractor shall be responsible for the cost associated with the third party testing and resolution if the final result indicates the engineer's test results were correct. Likewise the Commission will be responsible for the cost associated with the third party testing and resolution when the final result indicates the contractor's results were correct.

403.19.4.4 Other Adjustments. The contractor shall not be entitled to any additional payment for costs incurred due to use of the dispute resolution procedures such as, but not limited to, those for delay, cessation of operations, costs to subcontractors, etc. The engineer may give consideration to adjustment of working days if warranted.

403.20 Surface Test. The surface of each layer shall be substantially free from waves or irregularities. The pavement surface shall be thoroughly tested for smoothness by profilographing or straightedging as indicated. The contractor in the presence of the engineer shall perform testing applicable to this specification, except straightedging. Profilographing shall be performed on the surface course on all resurfacing work containing leveling course, coldmilling or multiple course construction as an operation to improve the original riding surface prior to placing the new surface and on the surface course of all new construction.

403.20.1 Straightedging. As soon as practical, the engineer will straightedge all segments of the paved surface not profilographed, except medians and similar areas, shoulders adjacent to rigid pavement or resurfaced rigid pavement and temporary bypasses. Any variations exceeding 1/8 inch in 10 feet (3 mm in 3 m) will be marked. Areas more than 1/8 inch (3 mm) high shall be removed as specified in [Sec 502.8.6](#). At transverse construction joints, the surface of all other layers shall not vary from the 10-foot (3 m) straightedge by more than 1/4 inch (6 mm).

403.20.2 Profilographing. Profilographing shall be performed immediately behind the finish roller in accordance with [Sec 502](#), except if waived, then smoothness shall be in accordance with [Sec 403.20.1](#).

403.21 General Requirements.

403.21.1 Sequence of Operations. To reduce inconvenience to the traveling public during widening or surfacing, the contractor will not be permitted to place any final surface course until the base widening, the leveling course and the binder course have

been completed throughout the entire combination of sections, unless otherwise authorized by the engineer. The proper condition of the base widening, the leveling course and the binder course, at the time of placing the surface course, shall be the contractor's responsibility.

403.21.2 Pavement Marking. If the contractor's work has obliterated the existing pavement marking on resurfacing projects open to through traffic, the pavement marking shall be replaced in accordance with [Sec 620](#).

403.21.3 Surfaced Approaches. At locations designated in the contract or as specified by the engineer, approaches shall be primed in accordance with [Sec 408](#) and surfaced with Type SP125 asphaltic concrete. The asphaltic concrete surface shall be placed in accordance with the details shown on the plans or as specified by the engineer. Approaches shall not be surfaced until after the surface course adjacent to the entrance is completed. Any work required to condition and prepare the subgrade on the approaches will be at the contractor's expense.

403.21.4 Filling Drain Basins. If shown on the plans, existing drain basins shall be filled to the top of the lip with plant mix bituminous base course or asphaltic concrete from the pavement edge to the edge of the shoulder. Any difficulty or delay created by this requirement will be at the contractor's expense.

403.21.5 Pavement Repairs (Blow-Ups). A blow-up will be considered that area where excessive expansion has resulted in distress to the existing pavement. Blow-ups occurring prior to the application of the tack coat on the existing surface will normally be repaired by the Commission. Blow-ups occurring after the application of the tack coat shall be repaired by the contractor by removing the distressed concrete and replacing the pavement in accordance with [Sec 613](#).

403.22 Method of Measurement.

403.22.1 Weight Determination. The weight (mass) of the mixture will be determined from the batch weights (masses) if a batch-type plant is used, and will be determined by weighing (determining the mass of) each truck load on scales in accordance with [Sec 310](#) if other types of plants are used. Measurement will be made to the nearest 0.1 ton (0.1 Mg) for the total tonnage (mass) of material accepted.

403.22.2 Full Depth.

403.22.2.1 The final driving surface area, for the full depth of the pavement, will be used as the area for all underlying bituminous lifts and will not include the additional quantity needed to construct the 1:1 slope.

403.22.2.2 Final measurement of the completed pavement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, measurement of the pavement complete in place will be made to the nearest 0.1 square yard (0.1 m²). The revision or correction will be computed and added to or deducted from the contract quantity.

403.22.3 Alternate Overlay.

403.22.3.1 Field Established Quantity. When bid as an alternate to a Portland cement concrete overlay, the contractor shall establish the existing roadway profile and set the final overlay profile. The engineer may adjust the final profile as needed. The tons (Mg) of hot mix asphalt required will be determined by the engineer from the set or adjusted profile. This quantity will be the field established plan quantity.

403.22.3.2 Overlay Measurement. Final measurement of the completed pavement will be based on the field established plan quantity except for authorized changes during construction. The revision or correction will be computed and added to or deducted from the contract quantity. Measurement of the pavement complete in place will be made to the nearest 0.1 ton (0.1 Mg).

403.22.4 Pavement Testing. The finished courses shall have the nominal thickness shown on the plans. Tests will be conducted to ensure that each course is being constructed to proper thickness, composition and density. The contractor shall cut samples from any layer of the compacted mixture at locations designated by the engineer. QA samples shall be cut and delivered to the engineer no later than the end of the next day following the laydown operation. If the samples are not cut and delivered as stated, the asphaltic laydown operation may be suspended and a deduction of 5 percent per day of the contract unit price of the representative material may be applied, until samples are cut and delivered to the engineer. Samples may be obtained by either sawing or drilling 4-inch (100 mm) minimum diameter cores. Each sawed sample shall consist of a single piece of the pavement of the size designated by the engineer, but no larger than 12 inches (300 mm) square.

403.22.4.1 Pavement Thickness. Lift thickness may be determined by the average thickness of cores taken for density measurements for each lot. Total thickness samples for new full depth asphalt pavements shall be obtained after all bituminous construction is completed on the project and shall be taken at locations specified by the engineer. For the purpose of determining the constructed thickness of full depth pavement, cores shall be taken at random intervals in each traffic lane at the rate of one core per 1000 feet (300 m) or increment thereof, or at any other locations as may be determined by the engineer and measured in accordance with AASHTO T 148. Sections of any asphaltic concrete determined to be 0.5 inches or more, less than the thickness shown on the plans, shall be corrected by the contractor. No payment will be made for any costs incurred by the contractor in correcting pavement deficient in thickness. Each core is representative of the pavement thickness for a distance extending one-half the distance to the next core, measured along centerline, or in the case of a beginning or ending core, the distance will extend to the end of the pavement.

403.22.4.2 Surface Restoration. The surface from which samples have been taken, including those for density measurements, shall be restored by the contractor with the mixture then being produced no later than the next day of plant operation, if construction is still active. If bituminous construction has been completed, the surface from which

samples have been taken shall be restored within 48 hours with an approved commercial mixture or with cold patch mixtures acceptable to the engineer.

403.23 Basis of Payment.

403.23.1 Aggregate Variation. Due to possible variations in the specific gravity of the aggregates, the tonnage (quantity) of mixture used may vary from the proposal quantities. No adjustment in contract unit price will be made because of such variation.

403.23.2 Compacted Samples. Payment for obtaining and delivering samples of compacted mixture from the pavement and replacing the surface will be made per sample at the fixed price specified in [Sec 109](#). No direct payment will be made for samples taken for QC testing.

403.23.3 Payment for Pavement Repairs (Blow-ups). Payment for repairing blow-ups will be made in accordance with [Sec 104](#).

403.23.4 Smoothness Adjustment. The contract unit price for all mixes, except wedge or level course, will be adjusted in accordance with [Sec 502.15](#).

403.23.4.1 Diamond Grinding. Ground areas will not be considered marred pavement, however, they shall be sprayed with asphalt emulsion diluted with equal parts of water at a rate in accordance with [Sec 407](#) to achieve total coverage. Excess emulsion shall be blotted in accordance with [Sec 407](#).

403.23.4.2 Testing Cost. The contract unit prices for asphaltic concrete pavement will be considered full compensation for all material entering into the construction of the pavement and for the cost of the smoothness testing and correction.

403.23.4.3 Width Limitation. When paving widths are greater than the travel lane widths, payment for profiling will apply to the traffic lane design driving width only, normally 12 feet (3.6 m).

403.23.5 Tensile Strength Retained Adjustment. The contract unit price of each 10,000 tons (10,000 Mg) or fraction thereof for all mixtures shall be adjusted based on TSR according to the following:

TSR	Percent of Contract Price
>95%	105
90-94%	103
85-89%	102
75-84%	100
70-74%	98
65-69%	97
55-64%	95
<55%	Remove

403.23.6 Density Adjustment. Pay adjustments due to longitudinal joint density will apply to the full width of the lane paved. The average of joint cores from each lot will determine specification compliance. Adjustments will be in accordance with [Sec 403.23.7.4.1\(b\)](#). If payment reductions are necessary, the lower adjusted contract unit price of the PWL or unconfined joint density adjustment will apply. Adjustments due to joint density will apply to the lot from which the cores are obtained.

403.23.7 Percent Within Limits. PWL will be based on the mean, standard deviation and quality index of each lot's test results. The upper PWL (PWL_u) and lower PWL (PWL_l) is determined from the table in [Sec 502.15.8](#). Total percent within limits, PWL_t, is: $PWL_t = (PWL_u + PWL_l) - 100$.

The mean is: $x_a = (\sum x_i)/n$

Where: x_a = Average of the individual values being considered
 $\sum x_i$ = The summation of all the individual values being considered
 n = The number of individual values under consideration

The Standard Deviation is: $s = (\sum(x_i - x_a)^2/(n - 1))^{1/2}$

The Upper Quality Index is: $Q_u = (USL - x_a)/s$

The Lower Quality Index is: $Q_l = (x_a - LSL)/s$

Where: Q_u = Upper Quality Index
 Q_l = Lower Quality Index
USL = Pay Factor Item Upper Spec Limit
LSL = Pay Factor Item Lower Spec Limit

403.23.7.1 Quality Level Analysis. The engineer will make the QLA no more than 24 hours after receipt of the contractor's test results, by determining the PWL_t for each designated pay factor item.

403.23.7.1.1 Acceptance. The contractor's test results will be used when applicable to determine the PWL, provided the contractor's QC tests and the engineer's QA tests compare favorably, and provided the engineer's inspection and monitoring activities indicate the contractor is following the approved QC Plan.

403.23.7.1.1.1 Comparison. Favorable comparison will be obtained when the engineer's QA test results on a production sample are within two standard deviations, or one-half the specification tolerance, whichever is greater, from the mean of the contractor's test results for that particular lot.

403.23.7.1.1.2 Outliers. No test result shall be discarded, except individual test results on a lot basis may be checked for an outlier in accordance with the statistic T in ASTM E 178, at a significance level of 5 percent. If an outlier is found, material from the retained QA sample may be tested, in the presence of the engineer, to determine a replacement test value. The replacement test value shall be used in the PWL determination.

403.23.7.1.3 Roadway/Shoulder Lots. For the purpose of QLA, mixture placed on the traveled way and placed on the traveled way and shoulders integrally, shall be accounted for in a regular lot/sublot routine. Mixture placed on shoulders only shall be accounted for in a shoulder lot/sublot routine.

403.23.7.1.4 Random Sampling. For the purpose of QLA, all mixture placed on the roadway shall be subject to random testing, except mixture placed within 6 inches (150 mm) of an unconfined longitudinal joint shall not be subject to evaluation. Random samples taken in the same day may be separated by 200 tons (200 mg).

403.23.7.2 Pay Factors. The total pay factor (PF_T) for each lot will be equal to the weighted sum of the pay factors (PF) for each pay factor item for each lot, and is determined as follows:

$$PF_T = + (0.25) PF_{\text{density}} + (0.25) PF_{AC} + (0.25) PF_{VMA} + (0.25) PF_{Va}$$

The PF_T for each lot, on the shoulder or otherwise when the density pay factor is not directly included, will be equal to the weighted sum of the PF for each pay factor item for each lot, and will be determined as follows:

$$PF_T = + (0.3333) PF_{AC} + (0.3333) PF_{VMA} + (0.3333) PF_{Va}$$

The PF for each pay factor item for each lot will be based on the PWL_t of each pay factor item of each lot and will be determined as follows:

When PWL_t is greater than or equal to 70: $PF = 0.5 PWL_t + 55$

When PWL_t is less than 70: $PF = 2 PWL_t - 50$

403.23.7.2.1 Density Pay Factor. The theoretical maximum specific gravity of the mixture, as determined for each subplot and the bulk specific gravity of no less than one core from each subplot, will be used to perform the QLA for the percent of theoretical maximum density. Thick cores required to be cut in half in accordance with [Sec 403.15.4](#) shall effectively double the number of sublots for cores. When density is not used as a pay factor, additional adjustment of the contract unit price will be based on the table in [Sec 403.23.7.4.1\(b\)](#).

403.23.7.2.2 Asphalt Content Pay Factor. The QLA will be performed using the asphalt content test results from each lot.

403.23.7.2.3 Voids in the Mineral Aggregate and Air Voids Pay Factor. Two gyratory specimens shall be compacted for each subplot and the average of the two specimens will be used to calculate the volumetrics of the subplot. The VMA, VFA, and air voids shall be determined from the gyratory compacted specimens. The VMA and air voids for the QLA shall be those calculated using the combined bulk specific gravity of the aggregate as listed on the approved job mix formula, the average bulk specific gravity of the gyratory compacted specimens and the theoretical maximum specific gravity of the

mixture determined for the subplot of material. The aggregate content used for the calculation shall be that determined from field asphalt content testing for that subplot.

403.23.7.3 Removal of Material. All lots of material with a PFT less than 50.0 shall be removed and replaced with acceptable material by the contractor. Any subplot of material with a percent of theoretical maximum density of less than 90.0 percent or greater than 98.0 percent shall be removed and replaced with acceptable material by the contractor. For SMA mixtures, any subplot of material with a percent of theoretical maximum density of less than 92.0 percent shall be removed and replaced with acceptable material by the contractor. Any subplot of material with air voids in the compacted specimens less than 2.5 percent shall be removed and replaced with acceptable material by the contractor. No additional payment will be made for such removal and replacement. The replaced material will be tested at the frequencies listed in [Sec 403.19](#). Pay for the material will be determined in accordance with the applicable portions of [Sec 403.23](#) based on the replacement material.

403.23.7.4 Miscellaneous Applications.

403.23.7.4.1 Small Quantities. For each separate mixture of less than 3000 tons (3000 Mg) on individual projects, including individual projects in combination contracts, the following shall apply:

- a) QLA and PWL will not be required.
- b) Mixtures shall be within the specified limits for VMA, Va, AC and density. In addition to any adjustments in pay due to profile, the contract unit price for the mixture represented by each set of cores will be adjusted based on actual field density above or below the specified density using the following schedule:

Field Density (Percent of Laboratory Max. Theoretical Density)			Pay Factor (Percent of Contract Unit Price)
For all SP mixtures other than SMA:			
		92.0 to 96.0 inclusive	100
96.1 to 96.5	or	91.5 to 91.9 inclusive	90
96.6 to 97.0	or	91.0 to 91.4 inclusive	85
97.1 to 97.5	or	90.5 to 90.9 inclusive	80
97.6 to 98.0	or	90.0 to 90.4 inclusive	75
Above 98.0	or	Below 90.0	Remove and Replace
For SMA mixtures:			
		>94.0	100
		93.5 to 93.9 inclusive	90
		93.0 to 93.4 inclusive	85
		92.5 to 92.9 inclusive	80
		92.0 to 92.4 inclusive	75
		Below 92.0	Remove and Replace

403.23.7.4.2 Base Widening and Entrances. For base widening mixtures and entrance work, QLA and PWL will not be required. Payment for these mixtures will be made at 100 percent of contract unit price for material that otherwise meets the specifications.

403.23.7.4.3 Single Lift or Leveling Course Work. For resurfacing projects specifying a single lift, surface mixture of 3000 tons (3000 Mg) or more, or for leveling course work, the following shall apply to the traveled way mixture. All bituminous mixture QC/QA requirements shall apply, except the density pay factor designated in Sec 403.23.7.2 will not be directly included in the total pay factor. In lieu of that, one density sample shall be taken per subplot and the pay adjustment for density will be made using the table in Sec 403.23.7.4.1(b).

Specifications for Nevada's Open-Graded Friction Course

Extracted from:

<http://www.nevadadot.com/business/contractor/standards/documents/2001StandardSpecifications.pdf>

NEVADA DOT SECTION 403 PLANTMIX BITUMINOUS OPEN-GRADED SURFACE

DESCRIPTION

403.01.01 General. This work consists of placing plantmix bituminous open-graded surface.

This work also consists of constructing milled rumble strips in the plantmix bituminous open-graded surface.

MATERIALS

705.03.02 Plantmix Bituminous Open-Graded Surface Aggregate. The aggregate shall conform to the following requirements:

Sieve Size	Percent Passing by Mass	
	12.5 mm (1/2 in.) Size	9.5 mm (3/8 in.) Size
12.5 mm (1/2 in.)	100	100
9.5 mm (3/8 in.)	90-100	95-100
4.75 mm (No. 4)	35-55	40-65
1.18 mm (No. 16)	5-18	12-22
75 µm (No. 200)	0-4	0-5

PROJECT CONTROL AND MIX DESIGN TESTS	TEST METHOD	REQUIREMENTS
Sieve Analysis	Nev. T206	Above
Sampling Aggregate	Nev. T200	—
Absorption of Coarse Aggregate	AASHTO T85	4% Max.
Fractured Faces	Nev. T230	90% Min. (2 Fractures Min.)
Plasticity Index (Blending with sand to eliminate plasticity will not be permitted)	Nev. T212	10 Max. (Individual Stockpiles, Before Marination)
Liquid Limit	Nev. T210	35 Max.

SOURCE REQUIREMENT TESTS	TEST METHOD	REQUIREMENTS
Percentage of Wear (500 Rev.)	AASHTO T96	37% Max.
Soundness (Coarse Aggregate) (5 Cycles, Sodium Sulfate)	AASHTO T104	12% Max. Loss
Soundness (Fine Aggregate) (5 Cycles, Sodium Sulfate)	AASHTO T104	15% Max. Loss
Absorption of Coarse Aggregate	AASHTO T85	4% Max.
Specific Gravity (Fine Aggregate)	AASHTO T84	2.85 Max.
Specific Gravity (Coarse Aggregate)	AASHTO T85	2.85 Max.

401.02.02 Composition of Mixtures. Compose the bituminous plantmix of a mixture of aggregate, mineral filler, and bituminous material. Size, uniformly grade, and combine the several aggregate fractions in such proportions that the resulting mixture meets the grading requirements of the job-mix formula.

Do not commence paving or coldmilling operations until the following requirements have been complied with:

- a) An approved mix design conforming to the requirements of this Subsection and Section 705 is received from the Department’s Materials Division.

Mix Design Requirements (Plantmix and Roadmix Bituminous Surface Aggregates):

TEST	TEST METHOD	REQUIREMENTS
Percent Air Voids of Compacted Bituminous Mixture (Types 2 and 3)	AASHTO T269	3 to 6%
Percent Air Voids of Compacted Bituminous Mixture (Type 2C)	AASHTO T269	4 to 7%
Percent Air Voids of Compacted Bituminous Mixture (Types 2 and 3) (Premixed)	AASHTO T269	6 to 9%
Stabilometer Value (Type 2)	Nev. T303	35 Min.
Stabilometer Value (Type 2C)	Nev. T303	37 Min.
Stabilometer Value (Type 3)	Nev. T303	30 Min.
Indirect Tensile Strength (Unconditioned) (Types 2 and 2C except with AC-10 Asphalt)	Nev. T341	448 kPa (65 psi) Min.
Indirect Tensile Strength (Unconditioned) (Type 3 except with AC-10 Asphalt)	Nev. T341	400 kPa (58 psi) Min.
Indirect Tensile Strength (Unconditioned) (With AC-10 Asphalt)	Nev. T341	345 kPa (50 psi) Min.
Indirect Tensile Strength (Retained Strength)	Nev. T341	70% Min.
Voids in Mineral Aggregate (Types 2 and 2C Plantmix Aggregate)	Nev. T338	12 to 22%

In addition, the mixture design will be evaluated per Nevada Test Method No. Nev. T760. Mixture designs not meeting this requirement may be rejected.

- b) Based upon the approved mix design, submit a written proposed job-mix formula for use by the Engineer in setting the job-mix to be used. For metric unit contracts, provide the proposed job-mix formula in metric units or both metric and English units. For English unit contracts, provide the proposed job-mix formula in English units or both English and metric units. Identify the asphalt

cement supplier in the job-mix formula. Include in the proposed formula definite single values for:

1. The percentage of aggregate passing each specified sieve.
2. The percentage of bitumen to be added (to 0.1%), by dry mass of aggregate.
3. The temperature of the mixture leaving the mixer.
4. The minimum temperature of the mixture in the hopper of the paving machine.
5. The percentage of each aggregate bin used. (Bin percentages of less than 5% will not be allowed.)

The job-mix formula with the allowable tolerances shown herein shall conform to Section 705.

A job-mix formula with single values for 1, 2, 3, 4, and 5 above will be determined and notification will be given in writing. This job-mix formula shall be in effect until modified in writing by the Engineer.

Furnish mixture conforming to the job-mix formula, within the following range of tolerances:

Aggregate passing the 4.75 mm (No. 4) and larger sieves	± 7%
Aggregate passing the 2.36 mm to 150 µm (No. 8 to No. 100) sieves	± 4%
Aggregate passing the 75 µm (No. 200) sieve.....	± 2%
Bitumen content.....	± 0.4% dry mass of aggregate
Temperature leaving the mixer.....	± 11 °C (20 °F)

Job-mix formula (1) shall reflect the asphalt percentage recommended by the approved mix design.

Consistently produce a mixture with an asphalt content at the target value. Do not use the above operational tolerance as a means to alter the asphalt content target value.

If the aggregates and asphalt cement submitted for a bituminous mix design produces a mixture exhibiting critical properties, see Note 1 below, be responsible for deciding whether a mixture can be produced which consistently meets project specification requirements, see Note 2 below.

If electing to use a mix design that yields a critical mix, proceed and place the three field trial mixture sections to be subjected to testing.

If no satisfactory recommendation can be made by the Engineer from the test results of the trial sections, a new bituminous mix design will be required and a suspension of paving operations will be required until a new mix design is approved. Working days will continue to be charged.

If the test results are satisfactory, the paving may continue, however, the mixture will be monitored to assure that the project specification requirements are consistently met, see Note 2 below.

Note 1: A critical mixture is one where there is a narrow range in the bitumen ratio in which project specification requirements are met for Stabilometer Value and Percent Air Voids of Compacted Bituminous Mixture (being a single point value or values in the acceptable range that do not allow for a ±0.4% fluctuation from the target value in bitumen content and still meet Stabilometer Value and Percent Air Voids requirements). If the range in the bitumen ratio, where

Stabilometer Value and Percent Air Voids specification requirements are met, is 0.7% or less, the mixture will be reported as “critical” and the above listed criteria shall be met before its use on the project.

Note 2: If two consecutive behind the paver samples (field samples) or 25% of the material sampled and tested, on a rolling 10 samples, fail to meet specification requirements for Stabilometer Value and/or Percent Air Voids, the paving operations will be shut down. Submit a plan outlining corrective measures to alleviate the failing material, and receive approval before any further paving. Working days will not be suspended during any such shutdown. (Rolling 10 samples indicates that only the preceding 10 samples will be counted in the analysis for consideration of failure, not the entire set of samples.)

On the first day of bituminous mix production, produce 3 trial mixtures of 450 metric tons (500 tons) of mix each. Complete production of the trial mixtures the same shift. Produce the trial mixtures at the medium speed used during the plant calibration. The trial mixtures may be placed on the shoulder of the roadway or the passing lane of four lane roadways and become a section of the completed roadway. For other roadways place at an approved location. Suspend production of the bituminous mix for a maximum of 3 working days or until all test results, except for Indirect Tensile Strength (Unconditioned) or Indirect Tensile Strength (Retained Strength), are available. Working days will not be charged during the 3 working day suspension. Production may commence without the results of the Indirect Tensile Strength (Unconditioned) or Indirect Tensile Strength (Retained Strength) tests.

Field Trial Mixture No. 1 shall conform to job-mix formula (1). Field Trial Mixture No. 2 shall conform to job-mix formula (1) except the asphalt content shall be +0.4%. Field Trial Mixture No. 3 shall conform to job-mix formula (1) except the asphalt content shall be -0.4%.

Acceptance of the plant produced trial mixtures will be based on test results meeting the requirements of this Subsection with the aggregate gradation within the job mix ranges given and the in-place densities meeting the requirements of Subsection 402.03.06.

When test results of the trial mixtures do not meet the requirements, additional plant trial mixtures may be required and the required tests performed during one additional maximum 3 working day suspension or a new mix design may be required.

Remove field trial mixtures not meeting all the requirements of the specifications from the roadway. One half the quantity of rejected trial mixtures will be paid for at the applicable unit bid prices. Also, one half of the removal quantity of rejected trial mixtures will be paid for at the applicable unit bid price or, when no removal item exists, according to Subsection 104.03. The other one half of the above quantities will not be paid for.

A revised job-mix formula (if applicable) will be provided based on the results of the tests performed on the field trial plant produced mixtures. The asphalt content will be selected, based on meeting the specifications for Hveem stability and percent air voids.

Should there be a change in sources of material, establish a new approved mix design and a new job-mix formula.

When unsatisfactory results make it necessary, the Engineer may establish a new job-mix formula and give notification in writing.

The final plantmix product placed on the roadway shall comply with the approved mixture design, and the following project control requirements:

TEST	TEST METHOD	REQUIREMENTS
Percent Air Voids of Compacted Bituminous Mixture (Types 2 and 3)	AASHTO T269	3 to 6%
Percent Air Voids of Compacted Bituminous Mixture (Type 2C)	AASHTO T269	4 to 7%
Percent Air Voids of Compacted Bituminous Mixture (Types 2 and 3)(Premixed)	AASHTO T269	6 to 9%
Stabilometer Value (Type 2)	Nev. T303	35 Min.
Stabilometer Value (Type 2C)	Nev. T303	37 Min.
Stabilometer Value (Type 3)	Nev. T303	30 Min.
Indirect Tensile Strength (Unconditioned) (Types 2 and 2C except with AC-10 Asphalt)	Nev. T341	448 kPa (65 psi) Min.
Indirect Tensile Strength (Unconditioned) (Type 3 except with AC-10 Asphalt)	Nev. T341	400 kPa (58 psi) Min.
Indirect Tensile Strength (Unconditioned) (With AC-10 Asphalt)	Nev. T341	345 kPa (50 psi) Min.
Indirect Tensile Strength (Retained Strength)	Nev. T341	70% Min.

Cease production if, two consecutive test results or 40% of the total tests taken to date for the current target percent mineral filler and target percent bitumen content, for Indirect Tensile Strength (Unconditioned) or Indirect Tensile Strength (Retained Strength) are below the required value. A change greater than or equal to 0.5% in the target percent mineral filler or target percent bitumen content or a new mix design is needed to restart the recording of the test results as stated above. Closely evaluate available information and determine the likely cause or causes of the problem, and take corrective action. Resume production when the results or other information satisfactorily indicate that the material to be produced will meet the specified values.

The temperature of the bituminous material just before mixing, and completed mixture in the hauling vehicle just before leaving the plant shall conform to the following tables:

PLANTMIX BITUMINOUS MIXTURES WITH ASPHALT CEMENT

GRADE OF ASPHALT CEMENT	BITUMINOUS MATERIAL		PLANTMIX SURFACE MIXTURES		PLANTMIX OPEN-GRADED MIXTURES	
	Minimum °C (°F)	Maximum °C (°F)	Minimum °C (°F)	Maximum °C (°F)	Minimum °C (°F)	Maximum °C (°F)
AC-2.5	121 (250)	163 (325)	104 (220)	163 (325)	104 (220)	135 (275)
AC-5	135 (275)	177 (350)	118 (245)	177 (350)	118 (245)	135 (275)
AC-10	135 (275)	177 (350)	124 (255)	177 (350)	124 (255)	143 (290)
AC-20	135 (275)	177 (350)	129 (265)	177 (350)	129 (265)	143 (290)
AC-20P	149 (300)	177 (350)	143 (290)	177 (350)	143 (290)	163 (325)
AC-30	135 (275)	177 (350)	132 (270)	177 (350)	132 (270)	143 (290)
AC-40	135 (275)	177 (350)	135 (275)	177 (350)	135 (275)	143 (290)

The minimum temperature of the completed mixture at the hopper of the paver will be a single value determined by the Engineer, which shall conform to the following table, but shall not be more than 11 °C (20 °F) lower than the temperature of the completed mixture

leaving the plant, except for AC-20P Open-Graded mixtures which shall not be more than 8 °C (15 °F) lower than the temperature of the completed mixture leaving the plant.

GRADE OF ASPHALT CEMENT	PLANTMIX BITUMINOUS SURFACE MIXTURES		PLANTMIX BITUMINOUS OPEN-GRADED MIXTURES	
	Minimum °C (°F)	Maximum °C (°F)	Minimum °C (°F)	Maximum °C (°F)
AC-2.5	93 (200)	163 (325)	93 (200)	135 (275)
AC-5	107 (225)	177 (350)	107 (225)	135 (275)
AC-10	113 (235)	177 (350)	113 (235)	143 (290)
AC-20	118 (245)	177 (350)	118 (245)	143 (290)
AC-20P	141 (285)	177 (350)	141 (285)	163 (325)
AC-30	121 (250)	177 (350)	121 (250)	143 (290)
AC-40	124 (255)	177 (350)	124 (255)	143 (290)

PLANTMIX BITUMINOUS MIXTURES WITH LIQUID ASPHALT

GRADE AND TYPE MC OR SC	BITUMINOUS MATERIAL AND MIXTURES	
	Minimum °C (°F)	Maximum °C (°F)
70	35 (95)	60 (140)
250	57 (135)	79 (175)
800	74 (165)	96 (205)
3000	93 (200)	116 (240)

The temperature of the completed mixture (when using liquid asphalts) at the hopper of the paver shall not be more than 11 °C (20 °F) below the specified completed mixing temperature in the hauling vehicle just before leaving the plant.

The temperature of the completed mixture discharged from the mixer also shall not exceed the range specified in the tables.

Furnish five 3.75 L (1 gal), samples of each grade of asphalt cement specified in the contract not less than 20 working days before starting paving operations. Furnish samples for polymerized asphalt cements in paint can type containers.

Also furnish a sample of the aggregates not less than 20 working days before starting paving operations. Do not submit samples for bituminous mix designs until a minimum of 4,500 metric tons (5,000 tons) or 25% of the required contract quantity is produced proportionately in stockpile, whichever is less. Obtain samples from the produced stockpiles, or a composite of informational belt samples taken during the production of the minimum quantity stated above, to represent each individual stockpile. The Engineer will obtain these samples or witness the Contractor obtaining them. See Subsection 106.04.

Bituminous material may be conditionally accepted at the source.

In lieu of furnishing samples of asphalt cement and aggregates for a mixture design a mix design may be submitted which has been previously approved by the Department's Materials Division.

A maximum of 1% of the material passing the 75 µm (No. 200) sieve may be removed from the combined aggregates submitted for the mix design to bring the combined gradation within specification.

If the submitted plantmix bituminous surface aggregate and asphalt cement meet the individual specification requirements, but fail to meet the mix design requirements when combined, a one time suspension of up to 10 working days may be allowed, when deemed necessary, for resubmittal and retesting for an acceptable mix design.

CONSTRUCTION

403.03.01 General. The construction requirements shall conform to Subsections 401.03.01 through 401.03.13, inclusive, with the exceptions contained in the following Subsections.

403.03.02 Rollers. Operate with each paver a breakdown and finish roller as specified in Subsection 401.03.04.

403.03.03 Joints. Construct longitudinal joints only on the shoulders, or at the edge of travel lanes.

403.03.04 Surface Tolerances. Produce completed surfacing which meets the requirements of Subsection 402.03.05 with the following additions and exceptions to the profilograph measurement. The pavement smoothness type (Type A, B, or C) will be specified in the Special Provisions.

Furnish a profilograph meeting the requirements of Subsection 402.03.03 and operate the profilograph as specified in Subsection 402.03.05, at the time and date ordered. Painted marks on the open-graded surface, as specified in Subsection 402.03.05, shall not exceed 20 cm² (4 in.²) unless otherwise directed.

Include 10 m (30 ft) of the existing pavement on each end of the project in the profile determination. Make construction joints with the existing pavement meet the requirements of this Subsection.

Repair or remove and replace all areas exceeding the profile index requirements and areas representing high points on the profiles having deviations in excess of 10 mm (0.4 in.) as measured according to Test Method No. Nev. T446. Remeasure repaired or replaced areas for conformance with the profile index and for no high points in excess of 10 mm (0.4 in.).

High points in excess of 10 mm (0.4 in.) may be allowed to remain in place, if requested and approved.

Liquidated damages of \$500.00 will be assessed for each such high point that is allowed to remain in place.

Grinding may be utilized for repair to the open-graded surface when approved. Limit grind areas to 7.6 m (25 ft) in length. The grinder and grinding operation shall conform to Subsection 402.03.05.

403.03.05 Spreading and Finishing. Place the material in a windrow in front of the spreading and finishing machine when using polymer modified bituminous material.

403.03.06 Preparation of Aggregates. Before the introduction of mineral filler, add sufficient moisture to bring the aggregates to a moisture content where enough free

surface moisture is available to thoroughly wet the aggregate and activate the lime. The actual amount of moisture required shall be as approved.

403.03.07 Milled Rumble Strips. Mill the rumble strips to the dimensions shown in the plans. Use a milling machine that produces a reasonably smooth cut surface with 2 mm (0.08 in.) maximum differentials between peaks and valleys.

The alignment of the edge of the milled pattern will be randomly checked. Locate the inside edge of rumble strips 100 mm (4 in.) \pm 50 mm (2 in.) from the edge of shoulder striping. Re-cut any rumble strip which is misaligned.

Some of the shoulders designated for receiving the rumble strips may have widths of approximately 1.2 m (4 ft) from the shoulder stripe to a vertical obstruction of concrete barrier rail or guardrail. There will be no additional compensation for any additional special milling machine necessary to install rumble strips at these locations.

Demonstrate on an initial 150 m (500 ft) test section that the equipment and method will provide the desired milled rumble strip and surface inside each depression without tearing or snagging the asphalt pavement. If the desired results are not being provided, provide new equipment, new method, or make necessary adjustments to provide the desired results. If the initial 150 m (500 ft) test section is unacceptable, repair the surface as directed, make necessary adjustments and retest.

Use a power broom or sweeper/vacuum to remove waste material resulting from the operation each day. The milled waste material may also be broomed and uniformly spread on the roadway side slopes at the end of each day's operations.

Apply a seal coat to the milled rumble strips according to Section 405. Apply the seal coat in two equal applications. Apply each application in opposite directions. Protect any adjacent permanent striping from the seal coat spray. Replace any permanent striping contaminated by the seal coat or damaged by the milling or brooming operations.

403.03.08 Compaction. Perform compactive rolling with a minimum of 2 complete coverages of the mat, by each roller, or as directed. A complete coverage is defined as a roller pass forward and back within a given area.

METHOD OF MEASUREMENT

403.04.01 Measurement. Plantmix bituminous open-graded surface aggregate, and asphalt cement will be measured as specified in Subsection 401.04.01.

Mineral filler will be measured and paid for according to Section 401.

Milled rumble strips will be measured by the kilometer (mile) longitudinally along each milled shoulder.

Seal coat applied to milled rumble strips will be measured and paid for according to Section 405.

BASIS OF PAYMENT

403.05.01 Payment. The accepted quantities, measured as provided above, will be paid for at the contract price per unit of measurement for the pay items listed below that are shown in the proposal. Payment will be full compensation for the work prescribed in this Section.

Payment will be made under:

Pay Item	Pay Unit
Plantmix Bituminous Open-Graded Surface Aggregate [*-mm (in.)]	Metric Ton (Ton)
Asphalt Cement (type)	Metric Ton (Ton)
Milled Rumble Strips	Kilometer (Mile)

* Aggregate size in Subsection 705.03.02, and as indicated in the estimate and proposal.

Specifications for New Jersey's HMA Friction Course

Extracted from:

http://www.state.nj.us/transportation/eng/specs/english/EnglishStandardSpecifications.htm#_Toc530372672

NEW JERSEY DOT SECTION 403 – HOT MIX ASPHALT FRICTION COURSE

403.01 Description.

This work shall consist of the construction of dense-graded and open-graded friction courses.

MATERIALS

403.02 Materials.

The materials and their use shall conform to [Subsection 404.02](#) except as follows:

1. Coarse aggregate for dense-graded friction course shall be crushed quartzite conforming to [Subsection 901.04](#) and yielding friction numbers equal to or exceeding the control standard when tested according to ASTM D 3319, or crushed gravel conforming to [Subsection 901.05](#) except that it need not be washed and shall not contain more than ten percent total carbonates as determined according to [Section 990](#), NJDOT A-4. The coarse aggregate for the dense-graded friction course shall be from a single source for the entire Project.
2. Stone sand used for fine aggregate in dense-graded friction course shall not be made from argillite or carbonate rock.
3. Coarse aggregate for open-graded friction course shall be broken stone of gneiss, granite, quartzite, or trap rock conforming to [Subsection 901.04](#) or shall be crushed gravel conforming to [Subsection 901.05](#) except that it need not be washed and shall not contain more than 50 percent of total carbonates (30 percent on Federally-funded Projects) as determined according to [Section 990](#), NJDOT A-4.

403.03 Composition and Preparation of Mixtures.

- A. Dense-Graded Friction Course.** The mixture for dense-graded friction course shall conform to [Section 903](#). Mix I-5 shall be used in transition (run-out) areas where directed.
- B. Open-Graded Friction Course.** The mixture for open-graded friction course shall conform to [Section 903](#) and to the following:

Sieve Size	Total Percent Passing by Weight
1/2 "	100
3/8"	80 - 100
No. 4.....	30 - 50
No. 8.....	5 - 15
No. 200.....	2 - 5
Asphalt Cement, percent by weight of dry aggregate	5.7 - 7.0

(see Note 1)

Note 1: The specific asphalt content for the job mix formula shall be determined. A minimum of three 1,000-gram trial batches having different asphalt cement contents within the specified range shall be mixed in the producer's laboratory at 250 ± 10 °F and placed on a 8 to 9 inch diameter heat resistant transparent Pyrex dish. The mixture shall be spread on the dish with a minimum of manipulation. The dish shall be placed immediately in an oven at 255 ± 5 °F for a period of one hour. After one hour the bottom of the dish shall be examined. The mixture with a slight puddle at points of contact between the aggregate and the glass dish shall be selected. Photographs of a desirable drainage condition are on file in the Department Laboratory and can be obtained upon request.

The formula selected and samples of all materials used in the final mixture design shall be submitted by the producer to the Engineer at least three weeks before the initial production date.

Sampling requirements are as follows:

Coarse Aggregate.....	35 pounds
Fine Aggregate.....	35 pounds
Mineral Filler	5 pounds
Asphalt Cement.....	2 quarts

The submitted materials will be tested for verification of the producer's mix design and for resistance to effects of water according to AASHTO T 165 and T 167.

Samples are to be molded at 255 °F using a pressure of 2,000 pounds per square inch. After four days of immersion at 120 °F, the index of retained strength must not be less than 50 percent. Should laboratory tests establish the need for a heat-stable, anti-stripping additive, the amount added shall be as directed.

The mixture shall have a minimum void content of 15 percent. Verification of the minimum void content will be made according to [Section 990](#), NJDOT B-6.

During production operations, five random samples will be taken from each lot of approximately 1,000 tons to verify mixture compliance with composition requirements. When a lot is necessarily less than 1,000 tons, samples will be taken at random at the rate of one sample for each 200 tons or fraction thereof.

Sampling and testing for mixture composition will be performed according to [Section 990](#), NJDOT B-2 and B-3.

EQUIPMENT

403.04 Equipment.

The equipment shall be as provided in [Section 404](#) except the open-graded mix shall be transported in clean vehicles with smooth dump beds that have been sprayed with a non-petroleum release agent. Mineral fillers, fine aggregates, slag dust, etc. shall not be used to dust truck beds. The mix shall be covered during transportation to prevent cooling and the formation of lumps. Long hauls, particularly those in excess of 30 miles, may result in separation of the mix and its rejection.

CONSTRUCTION

403.05 Construction Requirements.

The construction requirements shall be as specified in [Section 404](#) except as follows for open-graded mix:

1. Hand placing shall be avoided except where necessary.
2. Laying temperature of the mix shall not be less than 225 °F.
3. Ambient temperature shall be 60 °F minimum.
4. Thickness shall be $\frac{3}{4} \pm \frac{1}{4}$ inch.
5. Temperature at discharge from the plant shall be maintained from 240 to 270 °F.

Immediately after spreading and strike-off, the open-graded friction course shall be compacted by a minimum of one pass of a two-axle or three-axle tandem roller conforming to [Subsection 404.09](#). Additional rolling shall be done if and as directed to firmly set the aggregate in the surface.

Specifications for New Mexico’s Open-Graded Friction Course

Extracted from:

[http://nmshtd.state.nm.us/upload/images/Spec for Highway and Bridge](http://nmshtd.state.nm.us/upload/images/Spec%20for%20Highway%20and%20Bridge)

NEW MEXICO STATE HIGHWAY AND TRANSPORTATION DEPARTMENT SECTION 404—OPEN-GRADED FRICTION COURSE

404.1 DESCRIPTION.

404.11 This work shall consist of constructing an open-graded friction course (OGFC) on a prepared surface. OGFC shall be composed of aggregate, bituminous material, hydrated lime, and/or anti-stripping agent.

404.2 MATERIALS.

404.21 Aggregate. The aggregate shall be crushed stone or crushed gravel, composed of hard durable pebbles or fragments so as to provide a material that will meet the grading requirements of Table 404-A when tested by means of AASHTO T 11 and T 27. The OGFC type shall be as indicated in the contract. Acceptance of the aggregate for gradation purposes will be determined by testing of samples obtained from combined aggregates and lime, if used, prior to addition of asphaltic materials.

**Table 404-A
OPEN-GRADED FRICTION COURSE GRADATION REQUIREMENTS**

Sieve Size	Percent Passing		
	I	II	III
19.0 mm (3/4 in.)	100	100	100
12.0 mm (1/2 in.)	100	100	70–90
9.5 mm (3/8 in.)	90–100	95–100	40–65
4.75 mm (No. 4)	25–55	30–55	15–25
2.0 mm (No. 10)	0–12	0–20	6–12
425 µm (No. 40)	0–8	0–12	0–8
75 µm (No. 200)	0–4	0–6	0–5

- A. At least 75 percent of the material retained on the 4.75 mm (No. 4) sieve shall be particles having at least two fractured faces. Fractured faces shall be determined using NMSHTD Method FF-1, “Fractured Face Determination for Coarse Aggregate.”
- B. The aggregate shall be free from vegetable matter, lumps or balls of clay, or other material that will prevent thorough coating with bituminous material.
- C. The aggregate shall have an Aggregate Index of 20 or less when calculated in accordance with Section 910.
- D. The combining of materials from two or more sources to produce aggregate will be permitted only when each source meets all applicable quality requirements.

404.22 Bituminous Material. The type and grade of bituminous material will be specified in the contract. The bituminous material shall meet the requirements of Section 402, Bituminous Materials, Hydrated Lime and Liquid Anti-Stripping Agents.

404.23 Hydrated Lime. Hydrated lime shall meet the requirements of Section 402 Bituminous Materials, Hydrated Lime and Liquid Anti-Stripping Agents.

404.24 Liquid Anti-Stripping Agent. Liquid anti-stripping agent shall be compatible with the aggregate and bituminous material to be used on the project when evaluated by the static immersion test procedure and shall conform to the requirements of Section 402, Bituminous Materials, Hydrated Lime and Liquid Anti-Stripping Agents.

404.25 Mix Design. The Contractor shall provide a laboratory mix design developed by an approved testing laboratory. A list of approved laboratories is available from the State Materials Bureau. All costs associated with the development of the mix design shall be borne by the Contractor.

All mix designs shall be developed and tested in accordance with procedures established by the Department. The resultant job mix formula gradation shall be within the master range for the specified type of OGFC. The design shall establish whether hydrated lime, liquid anti-stripping agent, or both are required in the OGFC and the quantity to be used. When lime is to be added, it is included in the gradation for establishing the laboratory mix design. The laboratory mix design shall establish a single percentage of aggregate passing each required sieve size and a single percentage of bituminous material to be added to the aggregate.

404.3 CONSTRUCTION REQUIREMENTS.

404.31 General. The percentage of bituminous material shall be maintained within plus or minus 0.3% as determined by the binder ignition method, or other method designated by the State Materials Engineer.

Calibration and plant control shall be the Contractor's responsibility.

404.32 Preparation of Roadbed. Prior to placing OGFC, all foreign matter shall be cleaned from the existing surface.

404.33 Weather Limitations. The OGFC shall not be placed on wet surfaces or when weather conditions otherwise prevent the proper handling and finishing of the OGFC.

OGFC may be placed only when the ambient temperature and the chill factor are both 20 °C (70 °F) or above.

When the ambient temperature is 35 °C (90 °F) or above the chill factor will not be considered.

The chill factor is defined as the ambient temperature in °C) minus the wind velocity in km/h x 0.342 (°F minus wind velocity in mph). The wind velocity shall be the velocity determined by the average of the maximum and minimum wind velocity observed during a three-minute period immediately prior to or concurrent with ongoing OGFC placement operations taken at 1.5 m (5 ft) above the surface of the road.

404.34 Mixing Requirements. Hot mix plants shall conform with the requirements of Section 420, Plant Mix Bituminous Pavement, and shall be of a size and capacity commensurate with the magnitude of the work to be performed.

The mineral aggregate shall be free of oily or carbonaceous coatings before entering the mixer, and the moisture content of the mixed material shall not exceed 1% by weight of the dry aggregate.

The aggregate shall be mixed with bituminous material until all aggregate particles are thoroughly and uniformly coated.

The temperature of the mixture for placement will be established by the Project Manager, and it shall not vary more than plus or minus 10 °C (20 °F). The temperature of the OGFC mixture for placement shall not exceed 127 °C (260 °F), nor be less than 82 °C (180 °F), except that when polymer-modified asphalt cements are used, the temperature of the mixture for placement shall not exceed 150 °C (300 °F), nor be less than 100 °C (220 °F).

When hydrated lime is required, it shall be added to the aggregate in accordance with the requirements of Section 420, Plant Mix Bituminous Pavement.

When liquid anti-stripping agent is required, it shall be added to the bituminous material either by the supplier during the production process or by the use of in-line blending systems installed at the hot plant.

404.35 Placement and Finishing. The OGFC shall be placed by means of a paving machine meeting the requirements of subsection 420.323, Pavers, except that the Project Manager may require use of a 12-m (40-ft) minimum external reference to improve the rideability in any case deemed necessary.

Immediately following placement of the OGFC, the surface shall be given at least one complete rolling with a steel-wheeled, self-propelled roller of such weight as to accomplish good consolidation without excessive breakage of the aggregate.

Additional rolling shall be required at locations where the desired consolidation was not initially obtained and shall continue for the duration necessary to achieve proper consolidation.

The finished surface shall be smooth and true to the dimensions shown on the plans.

When tested by means of a 3-m (10-ft) straightedge, it shall be free of all irregularities in excess of 3 mm (1/8 in.).

All low and defective areas shall be immediately removed and replaced with fresh hot OGFC compacted to conform with the surrounding area, at the Contractor's expense.

404.351 Plan Surfacing Depths. Plan depths will be monitored and recorded throughout the surfacing operations and at intervals designated by the Project Manager.

The Department will not be liable for payment for any excess in depth of course(s). Unsatisfactory work shall be repaired, replaced, or otherwise corrected by the Contractor at no cost to the Department as directed by the Project Manager.

After initial compaction and breakdown rolling, the Department will measure the depth of the course(s) by inserting a graduated flat blade through the material to the top of the immediate underlying layer. A test will consist of the average of five measurements taken within a distance of 30 lane meters (100 lane feet). The depth will be checked at the rate of one test per 625 m² (750 yd²) for the first 2500 m² (3000 yd²) or until the Project Manager is satisfied that adjustments have been made that will consistently provide the depth of OGFC specified in the contract. After the Project Manager is satisfied that the specified depth is being provided, the frequency of checking may be reduced to one test

per 3350 m² (4000 yd²). Depth measurements made by the Department are made in order to determine acceptability of OGFC thickness. The Contractor shall not rely on the Department's measurements for process control. The Contractor shall perform measurements as required to ensure construction processes meet the requirements of the Contract.

After final compaction, if the above tests indicate a deficiency in the open-graded friction course, the Contractor shall verify thickness by taking a series of three cores, each approximately 150 mm (6 in.) in diameter, to be cut through the surface course to the top of the immediate underlying layer. Each series shall represent not more than 850 m² (1000 yd²). The first series shall be cut, one at the center and one near each edge; and the second series, one at the center and one at each quarter point.

The series shall then be alternated and continued throughout the length of the area(s) in question. The longitudinal spacing of the alternating series will be determined by the Project Manager.

Type I and Type II open-graded friction course less than 12.0 mm (1/2 in.) in depth and Type III open-graded friction course less than 19.0 mm (3/4 in.) in depth will be rejected and subsequently removed and replaced with the required thickness at no additional cost to the Department.

404.36 Contractor Process Quality Control Testing. The Contractor shall sample the stockpiled aggregate at a point agreed to by the Project Manager and shall conduct testing on those samples in accordance with applicable test procedures. This sampling and testing shall be accomplished by qualified testing personnel using equipment furnished by the Contractor that meets all applicable ASTM and AASHTO requirements.

The applicable test procedures, performed as described in the NMSHTD Technician Training and Certification Manual, are as follows:

AASHTO T 2	Sampling Aggregates
AASHTO T 11	Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 248	Reducing Samples of Aggregate to Testing Size
NMSHTD FF-1	Fractured Face Determination for Coarse Aggregate

The material shall be sampled and tested at the rate of at least one test per 225 metric tons (250 tons) of material produced for the first 1800 metric tons (2000 tons) of production, and at least one test per each 450 metric tons (500 tons) of material produced thereafter.

404.37 Suspension of Operations. If one or more properties listed in subsection [404.38](#), Department Quality Assurance Testing, fails to meet the specification requirements for a period of one day or a maximum production of 900 metric tons (1000 tons), the production will be halted by the Project Manager.

The gradation information obtained by the Contractor shall be used by the Contractor to determine causes or factors that may be a contribution to the problem and to determine the solution to the problem. The Contractor shall propose a plan to solve the problem. Approval of the plan must be obtained from the Project Manager prior to resumption of paving operations. Upon approval of the proposed plan, the Contractor may resume operations to determine if the actions taken have corrected the problem.

The Contractor shall limit production to 900 metric tons (1000 tons) which will be tested in 450-metric-ton (500-ton) increments. If that testing indicates that the problem has been corrected, the Contractor may resume full operations. If the problem has not been corrected, further trial runs and testing as described herein will be required.

The Contractor shall take corrective action to remedy any property of the mix that is out of specification. Contractors who elect to produce material that is not within the specification limits do so at their own risk. Price reductions due to out of specification material being placed will be deducted from the unit price of the item in accordance with the Department’s current Acceptance and Price Reduction Procedures.

All material that is rejected shall be removed and replaced with specification material at the Contractor’s expense. Material that is improperly graded or segregated or fails to meet the requirements herein provided, shall be corrected or removed and disposed of immediately as directed by the Project Manager at the Contractor’s expense.

404.38 Department Quality Assurance Testing. After the mix design has been issued, the Contractor shall control the mixture production on the project such that the tolerances of Table 404-B are met. The Department shall conduct quality assurance sampling, testing, and monitoring to ensure that the Contractor provides a mix that meets the tolerances. Acceptance for gradation will be based on testing of samples obtained from combined aggregates and lime, if used, prior to addition of asphaltic materials. Acceptance for asphalt content will be based on samples obtained from the windrow or paver hopper prior to laydown and tested with the Binder Ignition method, AASHTO T 308. Acceptance for lime content will be based on daily totals. The testing will be conducted in accordance with the Department’s minimum Acceptance Testing Requirements. Acceptance test results will be provided to the Contractor’s Quality Control Representative or designee by the end of the workday after the samples are taken.

**Table 404-B
ACCEPTANCE TESTING TOLERANCES**

Characteristic	Lower Spec. Limit	Upper Spec. Limit
Asphaltic Content	T.V. -0.3%	T.V. +0.3%
Lime Content	T.V. -0.3%	T.V. +0.3%
4.75 mm (No. 4)	Gradation Band	Gradation Band
2.0 mm (No. 10)	Gradation Band	Gradation Band
425 µm (No. 40)	Gradation Band	Gradation Band
75 µm (No 200)	Gradation Band	Gradation Band

Note: T.V. = Target Value from Approved Job Mix Formula.

Specifications for New Mexico’s Stone Matrix Asphalt

Extracted from:

http://nmshtd.state.nm.us/upload/images/Spec_for_Highway_and_Bridge

SECTION 424—STONE MATRIX ASPHALT 424.1 DESCRIPTION.

424.11 This work shall consist of constructing a surface course of stone matrix asphalt (SMA) pavement on a prepared surface.

SMA shall be composed of a mixture of crushed aggregate, bituminous material, mineral filler, hydrated lime if required, and stabilizing additives if required.

424.2 MATERIALS.

424.21 All materials shall be tested in accordance with applicable AASHTO methods, as modified by the Department when applicable, or other test procedures designated by the Department. All questions arising as to interpretation of test procedures shall be decided by the State Materials Bureau. Material that is improperly graded or segregated, or fails to meet the requirements herein provided, shall be corrected or removed and disposed of immediately as directed by the Project Manager, at the Contractor’s expense.

424.22 Aggregate. All coarse and fine aggregate shall be the product of a crushing operation. The combining of materials from two or more sources to produce aggregate will be permitted only when each source meets all applicable quality requirements.

The combined aggregate shall conform to the grading requirements of Table 424-A and shall have a minimum sand equivalent of 45. All material passing the 425 µm (No. 40) sieve shall be nonplastic.

424.221 Gradation and Quality Requirements.

**Table 424-A
STONE MATRIX ASPHALT AGGREGATE GRADATION**

Sieve Size	Percent Passing
19.0 mm (3/4 in.)	100
12.0 mm (1/2 in.)	85–95
9.5 mm (3/8 in.)	–75
4.75 mm (No. 4)	20–28
2.36 mm (No. 8)	16–24
600 µm (No. 30)	12–16
300 µm (No. 50)	12–15
75 µm (No. 200)	8–10

A. Coarse Aggregate. Coarse aggregate is defined as that part of the aggregate retained on a 4.75 mm (No. 4) sieve. SMA coarse aggregate shall have an Aggregate Index of 25 or less when calculated in accordance with Section 910. The amount of crushing shall be regulated so that 100%, by dry weight, of the plus 4.75 mm (No. 4) sieve material shall have at least one fractured face and a minimum of 90% shall have at

least two fractured faces when evaluated by NMSHTD Method FF-1, “Fractured Face Determination for Coarse Aggregate.”

- B.** When tested in accordance with ASTM D 4791, the plus 4.75 mm (No. 4) material shall contain no more than 20% particles with a length to thickness ratio greater than 3:1 and no more than 5% with a length to thickness ratio greater than 5:1.
- C. Fractured Faces.** A face will be considered fractured when at least one-half of the projected particle area exhibits a rough, angular, or broken texture with welldefined edges.
- D. Fine Aggregate.** Fine aggregate is defined as that part of the aggregate passing the 4.75 mm (No. 4) sieve. Fine aggregate shall consist of 100% crushed material. It shall have a soundness loss of 15 or less when tested in accordance with AASHTO T 104 using magnesium sulfate solution and a test duration of five cycles and a minimum fine aggregate angularity value of 45 as determined by AASHTO T 304.

424.222 Quality Acceptance of Aggregate. Samples will be tested in accordance with Section 910, Aggregate Index.

424.223 Production. When producing aggregates for SMA, natural fines shall be removed by screening and stockpiled separately. The Contractor shall use as a minimum, the 4.75 mm (No. 4) screen for this operation. The Contractor may use a larger screen if needed to properly control the crushing and screening operation. The aggregate retained on the scalping screen shall then be crushed, separated and stockpiled.

Crushing and stockpiling operations shall be regulated in a manner that produces material within the specified gradation band.

424.224 Stockpiling. Stockpiles shall be constructed upon prepared sites and when completed shall be neat and regular in shape and so constructed to prevent segregation of the aggregate.

Sufficient storage space shall be provided for each size of aggregate. Stockpiles of different types or sizes of aggregate shall be spaced far enough apart, or separated by suitable walls or partitions, to prevent the mixing of the aggregates. The different aggregate sizes shall be kept separated until they have been delivered to the cold feed system feeding the drier. Aggregate shall not be deposited where traffic, vehicles, or Contractor’s equipment will either run over or through the piles, or in any way cause foreign matter to become mixed with the aggregates. The storage yard shall be maintained neat and orderly and the separate stockpiles shall be readily accessible for sampling.

424.225 Acceptance of Aggregate. The plasticity index, sand equivalent, fine aggregate angularity, flat and elongated particles count, and fractured face count of SMA aggregate will be determined from representative samples taken after the aggregate materials have been blended and prior to mixing with bituminous material. The test results from these samples will be the basis for acceptance of such aggregate. The Project Manager may sample and test the aggregate at any time during production or stockpiling.

424.23 Bituminous Material. The type and grade of bituminous material will be specified in the contract. The bituminous materials shall meet the requirements of Section 402, Bituminous Materials, Hydrated Lime and Liquid Anti-Stripping Agents.

The asphalt source to be used will not be changed without written approval of the Department.

424.24 Hydrated Lime. Hydrated lime shall conform with the requirements of Section 402, Bituminous Materials, Hydrated Lime and Liquid Anti-Stripping Agents.

424.25 Mineral Filler. Mineral filler shall consist of rock or limestone dust, agricultural lime, or other suitable material. It shall be a product of crushing or other mechanical operation that results in angular shaped particles. Fly ash or other materials consisting of rounded particles will not be permitted. The filler shall be free from organic impurities, shall have a plasticity index not greater than four, and shall be essentially free from agglomerations.

424.26 Stabilizing Additives.

All stabilizing additives are to be introduced to the SMA mixture as recommended by the manufacturer of the additive. The fiber stabilizing additives are to conform to the following requirements.

A. Cellulose Fibers: Cellulose fibers shall be added at a dosage rate between 0.2% and 0.4% by weight of the total mix as determined by the mix designer. Fiber properties shall be as follows:

- | | | |
|----|---|-------------------------|
| 1. | Fiber length: | 6.0 mm (1/4 in.) |
| 2. | Sieve Analysis: | |
| | a. Alpine Sieve Method | |
| | Passing 150µm (No. 100): | 60–80% |
| | b. Ro-Tap Sieve Method | |
| | Passing 850µm (No. 20): | 75–95% |
| | Passing 425µm (No. 40): | 55–75% |
| | Passing 106µm (No. 140): | 20–40% |
| 3. | Ash Content: | 18% non-volatiles (±5%) |
| 4. | pH: | 7.5 (±1.0) |
| 5. | Oil Absorption:
(times fiber weight) | 5.0 (±1.0) |
| 6. | Moisture Content: | 5.0% (maximum) |

B. Cellulose Pellets: Cellulose pellets shall consist of a 50/50 blend of cellulose fiber and asphalt cement and shall be added at a dosage rate between 0.4% and 0.8% by weight of total mix as determined by the mix designer. The cellulose shall meet the requirements of the cellulose fibers as described above. The pellets shall have the following properties:

- | | | |
|----|--------------|--|
| 1. | Pellet size: | 6.0 mm ³ (1/4 in. ³), maximum |
| 2. | Asphalt: | 25–80 pen. |

C. Mineral Fibers: Mineral fibers shall be made from virgin basalt, diabase, or slag which is to be treated with cationic sizing agent to enhance disbursement of the fiber

as well as increase adhesion of the fiber surface to the bitumen. The fiber shall be added at a dosage rate between 0.3% and 0.5% by weight of the total mix as determined by the mix designer.

1. Size Analysis:
 - Maximum Fiber length: 6.0mm (1/4 in.)
 - Average Fiber thickness: 5 μ m (0.0002 inches), max.
2. Shot Content (ASTM C612)
 - Passing No. 60 (250 μ m): 95–100%
 - Passing No. 230 (63 μ m): 65–100%

424.27 Reclaimed Asphalt Pavement. Reclaimed asphalt pavement (RAP) shall not be used in the production of SMA.

424.28 Laboratory Mix Design. The Contractor shall provide a laboratory mix design developed by an approved testing laboratory. A list of approved testing laboratories is available from the State Materials Bureau. Under special circumstances where the Contractor is unable to obtain a mix design from an approved private testing laboratory, the State Materials Bureau laboratory will consider a request to perform the mix design. All costs associated with the development of the mix design by an approved laboratory other than the State Materials Bureau laboratory shall be borne by the Contractor. The mix design may be developed at any time after the aggregate production has been stabilized to the satisfaction of the Project Manager, and after at least 13,500 metric tons (15,000 tons) or half the estimated quantity, whichever is less, have been produced. At least five aggregate gradations must be submitted from each stockpile. If this data shows considerable variation in the material the requester may be directed to produce additional material prior to a mix design being run.

The Contractor shall provide a copy of the request to develop a mix design, along with all supporting documents, to the Project Manager and the District Laboratory Supervisor.

This submittal shall include the Contractor's suggested aggregate combination. This suggested combination will be considered in developing the mix design. Along with this submittal the Contractor shall submit copies of all stockpile test results.

If the State Materials Bureau laboratory develops a mix design, it may take more than 15 working days for the design to be issued. If the mix design is developed by an approved testing laboratory other than the State Materials Bureau laboratory, the design results shall be summarized in a format approved by the Department and submitted by the Contractor to the Project Manager for review and acceptance. The submittal shall include the results of all testing determinations for the individual mix components as well as for the mixture itself. It will take a maximum of 10 working days for the Department to review the mix design submittal.

The issuance of a mix design developed by the State Materials Bureau laboratory or acceptance by the Department of a mix design developed by another approved testing laboratory shall not relieve the Contractor of full responsibility for producing an acceptable mixture through the plant. The laboratory mix design shall be considered as a starting point only and may be adjusted as described in subsection [424.29](#).

All mix designs shall be developed and tested in accordance with procedures established by the Department. The laboratory mix design shall establish a single percentage of

aggregate passing each required sieve size and a single percentage of bituminous material to be added to the aggregate. The job mix formula gradation shall be determined in accordance with procedures described in NAPA publication QIS 122 and shall be within the master range specified in Table 424-A. At least three trial gradations shall be initially evaluated. The voids in the coarse aggregate of the SMA mixture (VCA_{MIX}) shall be less than the voids in the coarse aggregate in the dry rodded condition (VCA_{DRC}) for the selected gradation. A minimum of 1.5% hydrated lime will be required in all mix designs unless otherwise approved by the State Materials Bureau. When lime is to be added, it is included in the gradation for establishing the laboratory mix design. The laboratory mix design specimens shall be fabricated in accordance with AASHTO T 245 using 50 blows on each side of the test specimen. Specimens shall be fabricated and analyzed for at least three different binder contents when determining the optimum binder content. VTM shall be determined in accordance with AASHTO T 166, T 209, and T 269. VMA shall be determined in accordance with The Asphalt Institute Manual Series No. 2 (MS-2). Draindown shall be determined in accordance with AASHTO T 305. Retained strength shall be determined in accordance with AASHTO T 165. The resultant mix shall conform to all design parameters listed in Table 424-B.

The Contractor shall provide a mixture that meets all applicable criteria. If tests indicate the need for additives or modifiers not indicated in the Contract, more than 1.5% hydrated lime, or a change in grade or source of binder to satisfy mix design requirements, any additional cost for these items shall be borne by the Contractor.

Table 424-B
STONE MATRIX ASPHALT MIX

Mix Parameter	Requirement
Voids in Total Mix (VTM), %	4
Voids in Mineral Aggregate (VMA), Minimum, %	17.5
Stability, Minimum, N (lb)	6225 (1400)
Asphalt Content, Minimum, %	6.0*
Draindown, at Mixing Temperature, Maximum, %	0.3
Retained Strength at $7 \pm 1\%$ Air Voids, Minimum, %	85
VCA_{MIX} Shall Be Less than VCA_{DRC}	

* The minimum design asphalt content can be reduced slightly, as approved by the Project Manager, if the bulk specific gravity of the aggregate exceeds 2.75.

Factors such as durability, water resistance, and asphalt film thickness will be considered by the Department during the development or review of all mix designs. The judgment as to the significance of these factors with regard to issuing or accepting the mix design will rest with the Department.

If a change in sources of materials or crushing operations is made, the Department may require a new laboratory mix design before the new materials may be used.

When unsatisfactory results or other conditions make it necessary, the Project Manager may require that a new mix design be developed.

424.29 Mix Design Adjustment. All material incorporated into the work shall be evaluated for acceptance in accordance with the Department's current Acceptance and

Price Reduction Procedures and subsection 424.72. Material shall be evaluated for acceptance using the mix design in effect at the time the material was produced. The laboratory mix design and/or subsequent field designs may be adjusted as described herein.

424.291 Job Mix Formula. The job mix formula (JMF) is defined as the combined aggregate gradation and the percentage of each material component to be used in the mix. The JMF shall comply with all aggregate gradation requirements and shall result in a mix that meets all specified mix design requirements. The result of the laboratory mix design developed in accordance with subsection 424.28 is designated as JMF1.

424.292 Job Mix Formula Adjustment. The contractor may propose adjustments to the job mix formula in accordance with subsection 920.22, Job Mix Formula Adjustments.

424.3 CONSTRUCTION REQUIREMENTS.

424.31 General. Sufficient storage space shall be provided for each size of aggregate. The different aggregate sizes shall be kept separated until they have been delivered to the cold feed system feeding the drier. The storage yard shall be maintained neat and orderly, and the separate stockpiles shall be readily accessible for sampling.

In placing the coarse aggregate and fine aggregate in storage or moving it from storage to the cold feed bins, methods that cause segregation, degradation or the combining of materials of different gradings will not be permitted. Segregated or degraded material shall be re-screened or wasted. Should mineral filler material be required, a separate storage and bin feeder shall be provided for the filler material.

Aggregates shall not require prior preparation other than gradation control, except that those containing gravitational water shall be stockpiled and allowed to drain prior to mixing.

After the required amounts of aggregate and bituminous material have been introduced into the mixer, the materials shall be mixed until all aggregate particles are completely and uniformly coated with the bituminous material. If the Project Manager determines that excessive uncoated aggregate exists, the Contractor shall take corrective action to remedy the problem. The Moisture Content of the bituminous mixture at discharge from the mixer shall not exceed 0.5%.

424.311 Mix Temperature Requirements. The target temperature of the bituminous mixture at discharge from the mixer shall be as specified on the mix design. The temperature shall not exceed the target temperature by more than 11 °C (20 °F).

424.312 Opening to Traffic. Traffic will not be allowed on the new SMA pavement until the material has cooled sufficiently to avoid flushing of the asphalt to the surface, picking up or raveling of the surface, or any other detrimental marking or distorting of the surface. In any case, the traffic will not be allowed on the new SMA pavement until it has cooled to 60 °C (140 °F) or lower.

424.32 Equipment.

424.321 Mixing Plants.

- A. Plant Scales.** Scales shall be accurate to 0.5% of the maximum load that may be required. A licensed scale serviceman must certify scales.
- B. Equipment for Preparation of Bituminous Materials.** Tanks for storage of bituminous material shall be equipped to heat and hold the material at the required temperatures. The tank shall be provided with a capability to measure the temperature of the asphalt in the tank. The heating shall be accomplished by approved means and such that no flame shall be in contact with the tank. The circulating system for the bituminous material shall be designed to assure proper and continuous circulation during the operating period. A suitable outlet for sampling bituminous material shall be installed in the line leading from the storage tank to the plant and provisions shall be made for measuring and sampling the storage tanks.
- C. Feeder for Drier.** The plant shall be provided with accurate mechanical means for uniformly feeding the aggregate into the drier so that uniform production and uniform temperature will be obtained.
- D. Drier.** The plant shall include a system to continuously agitate the aggregate during the heating and drying process. The drier shall be capable of drying and heating aggregate in such a manner as to preclude the mineral aggregate from becoming coated with fuel oil or carbon. If it is determined that the aggregate is coated, the Contractor shall take corrective action, which may include changing type of burner fuel.
- E. Bins.** The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to assure separate and adequate storage of appropriate fractions of the mineral aggregates. When deemed necessary by the Project Manager, additional positive separation of the bins will be provided by the use of separating boards. Separate dry storage shall be provided for hydrated lime. The gates on the bins shall not leak. Bins shall be equipped with low-bin warning devices that indicate at the control panel when the bins are low.
- F. Bituminous Material Control Unit.** The Contractor shall provide satisfactory means to obtain the proper amount of bituminous material in the mix within the tolerance specified, either by weighing or metering, as approved by the Project Manager. The Contractor shall provide means for checking the quantity or rate of flow of bituminous material into the mixer.
- G. Thermometric Equipment.** An approved thermometer with a range in temperature reading from 38 to 204 °C (100 to 400 °F) shall be fixed in the bituminous feed line at a suitable location near the charging valve at the mixer unit. The plant shall also be equipped with another approved thermometric instrument so placed at the discharge chute of the drier as to register automatically the temperature of the heated aggregates or mix as applicable. The record of discharge temperatures will be provided to the Project Manager upon the completion of each week's production and when requested by the Project Manager during the course of production.
- H. Truck Scales.** The bituminous mixture shall be weighed on approved scales furnished by the Contractor or on public scales, in accordance with subsection 109.1, Measurement of Quantity.

I. Environmental Requirements.

- 1. Particulate Matter Emissions.** The following performance standards will apply to all stationary bituminous mixing plants:
 - a. Particulate matter emissions shall be limited to not more than 90 mg per dry m³ (0.4 grains per dry ft³) at standard conditions and 20% opacity.
 - b. An existing stationary bituminous mixing plant will be subject to the performance standards only if a physical change to the plant or change in the method of operating the plant causes an increase in the amount of air pollutants emitted. Routine maintenance, repair, and replacement, relocation of a portable plant, change of aggregate, and transfer of ownership are not considered modifications which will require an existing plant to comply with the standards.
- 2. Intent to Discharge.** Before commencing asphalt mixing activities, the Contractor must file a “Notice of Intent to Discharge” with the Groundwater Bureau of the New Mexico Environmental Department (NMED). The Contractor shall contact the Groundwater Bureau of the NMED and obtain a “Notice of Intent to Discharge” form and obtain the determination of Discharge Plan requirements. The NMED may approve disposal sites that are away from runoff channels and streams and are well above groundwater for small amounts of contaminants without an individual Discharge Plan.
- 3. Waiver of Intent to Discharge Requirements.** The requirements of subsection 424.321(I)(2) Intent to Discharge, will be waived if the Contractor gives written notice to the Project Manager of the intention to remove all waste oil and waste solvents, on the project, to an established commercial vendor for recycling. The Contractor can recycle the waste without coordination with the NMED, but the Contractor shall remain responsible for the proper disposition of waste materials. If the Contractor states an intention to recycle waste oil and waste solvents and then decides to discharge this waste, the Contractor shall again conform with the requirements of subsection 424.321(I)(2), Intent to Discharge.
- 4. Violation of Requirements.** If there is a violation of these requirements, the Project Manager will withhold all additional payments to the Contractor until such time as the Contractor performs a complete cleanup of the waste and it is accepted by the Department. The Department’s Environmental Section will determine the need for additional investigations and actions. All violations and fines from other state regulatory agencies shall also apply. All cleanup activities will be considered incidental to the project and no separate or additional payments will be made therefor.

J. Requirements for Batching Plants.

- 1. Weigh Box or Hopper.** The equipment shall include a means of accurately weighing each size of aggregate in a weigh box or hopper suspended on scales and of ample size to hold a full batch. The gate shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed. The scales shall be tested in accordance with subsection 109.1, Measurement of Quantity.

2. **Bituminous Material Control.** The equipment used to measure the bituminous material shall be accurate to plus or minus 0.3%. The bituminous material bucket shall be a non-tilting type with a loose sheet metal cover. The section of the bituminous line between the charging valve and the spray bar shall be provided with a valve and outlet for checking the meter when the metering device is substituted for a bituminous material bucket.
 3. **Mixer.** The batch mixer shall be capable of producing a uniform mixture within the specified tolerances. The mixer shall have a batch capacity of not less than 900 kg (2000 pounds).
 4. **Control of Mixing Time.** The plant shall be capable of adequately controlling mixing time. The mixer shall be equipped with an accurate timing device that will signal the completion of mixing time.
 5. **Mineral Filler.** Adequate dry storage shall be provided for the mineral filler, and provisions shall be made for proportioning the filler into the mixture uniformly and in the required quantities. Mineral filler shall be added directly into the weigh hopper. Appropriate equipment shall be provided to accurately proportion the relatively large amounts of mineral filler required for an SMA mixture.
 6. **Fiber Addition.** Adequate dry storage shall be provided for the fiber additive, and provisions shall be made for proportioning fiber into the mixture uniformly and in the desired quantities. Fiber shall be added through a separate inlet directly into the weigh hopper above the pugmill. The addition of fiber should be timed to occur during the hot aggregate charging of the hopper. Adequate dry mixing time is required to ensure proper blending of the aggregate and fiber stabilizer. Dry mixing time shall be increased 5 to 15 seconds. Wet mixing time shall be increased at least 5 seconds for cellulose fibers and up to 5 seconds for mineral fibers to ensure adequate blending with the bituminous material.
- K. Requirements for Drum Mix Plants.** The drum mixer and necessary auxiliary equipment shall be specifically designed to provide a final product conforming to specifications.
- Auxiliary equipment to the drum mix plant shall provide the following:
1. Separate cold feed controls for each material.
 2. Automatic interlocking device for cold feed, asphalt, and additive.
 3. Means for determining moisture content of aggregate so the dry weight of cold feed can be determined for proper setting of asphalt and additive flow. The Contractor shall determine the moisture content of the aggregate at least twice daily and shall adjust the moisture correction equipment accordingly.
 4. Means for sampling individual cold feeds and provisions for sequential sampling of aggregate, asphalt cement, and additives while under full production.
 5. Equipment for temperature sensing of mix at discharge and automatic burner controls.
 6. A surge storage system having a minimum capacity of 36 metric tons (40 tons) designed and equipped to prevent segregation. The surge storage system bins shall be equipped with adequate mechanical or electrical devices to

indicate when bins are less than 1/4 full. The device shall automatically provide an audible or visual warning. The plant shall not be operated unless this automatic system is in good working order.

7. The bin(s) containing fine aggregate and filler, if required, shall be equipped with a device which will prevent any hang-up of material while the plant is operating.
8. A minimum of one cold feed bin will be required for each aggregate fraction used in the mix.
9. The cold feed shall be equipped with adequate mechanical or electrical devices to indicate when the bins are empty or when the cold feed belt is not carrying the proper amount of material. The device shall automatically lock the cold feed belt and provide an audible or visual warning. The plant shall not be operated unless this automatic system is in good working order.
10. Adequate dry storage shall be provided for the mineral filler, and provisions shall be made for proportioning the filler into the mixture uniformly and in the required quantities. Mineral filler shall be added directly into the drum mixer. Appropriate equipment shall be provided to accurately proportion the relatively large amounts of mineral filler required for an SMA mixture.
11. Adequate dry storage shall be provided for the fiber additive, and provisions shall be made for proportioning fiber into the mixture uniformly and in the desired quantities. Fiber shall be added into the drum mixer to ensure complete blending of the fiber into the mix. A separate fiber feeding system shall be utilized that can accurately and uniformly introduce fiber into the drum at such a rate as not to limit the normal production of mix through the drum. At no time shall there be any evidence of fiber in the baghouse or baghouse fines.

The feeding mechanism shall include an individual belt feeder with a variable speed feeder drive controlled by electronically operated actuators.

The bituminous feed control shall be coupled with the total aggregate weight measurement device in such a manner as to automatically vary the bitumen feed rate as necessary to maintain the required proportion.

424.322 Haul Equipment. Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds that have been thinly coated with a minimum amount of Department-approved release agent to prevent the mixture from adhering to the bed. Diesel fuel shall not be used.

424.323 Pavers. Pavers shall be self-contained, self-propelled units, provided with an activated screed or a strike-off assembly, heated if necessary, and capable of spreading and finishing courses of SMA material to the widths and thickness as specified in the contract.

Pavers shall be operated at a speed no greater than 5 km/h (3 mph). Materials introduced in front of the screed shall maintain a consistent depth to avoid variation in pressure on the screed. The auger box shall be maintained at 1/3 to 2/3 full.

Pavers shall be equipped with a receiving hopper having sufficient capacity to effect a uniform spreading operation. The hopper shall be equipped with a distribution system capable of maintaining a uniform amount of mixture in front of the screed.

The paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mixture. The screed shall be adjustable for both height and crown and shall be equipped with a controlled heating device.

The screed or strike-off assembly shall produce a finished surface of an even and uniform texture for the full width being paved without tearing, shoving or gouging the mixture. Screeds shall include any strike-off device operated by tamping or vibrating action

The bituminous paver shall be equipped with an automatic leveling device controlled from an external guide. The initial pass for each course shall be made using a paver equipped with a 12-meter (40-ft) minimum external reference, except that this requirement will not apply where SMA is placed adjacent to Portland cement concrete pavement or where short lengths of SMA placement are required. Subsequent passes and passes adjacent to PCCP shall utilize a matching device of 300-mm (1-ft) minimum length riding on the adjacent lay.

A conventional bituminous paver or suitable equipment approved by the Project Manager may be used to place asphalt concrete material on shoulders depressed from the traveled lanes in order to establish a uniform typical section. Approval of the equipment used will be based upon the results obtained.

424.324 Compaction Equipment. The number, weight, and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. The selection of roller types shall provide the specified pavement density. The Project Manager, prior to use, shall approve equipment proposed for use in the compaction of SMA. All rollers shall be self-propelled, in good condition and capable of reversing without backlash. Pneumatic tire rollers shall not be used on SMA.

424.33 Addition of Hydrated Lime. The hydrated lime shall be added to the entire portion of aggregate in an enclosed pugmill immediately after leaving the cold feed and just prior to introduction into the dryer drum or aggregate dryer.

The hydrated lime shall be added to the aggregate such that loss of hydrated lime is minimal or nonexistent. Placement of the lime on an open conveyer belt will not be permitted. Placement of the lime on an enclosed belt that does not permit blowing or loss of lime is acceptable.

A vane feeder shall be located in the outfeed of the lime silo. A flow sensor shall be installed on the discharge from the vane feeder. The sensor shall activate an audible and visual signal at the control panel when lime flow is interrupted.

The lime silo shall be provided with an approved means of metering the lime being added to the mix, at typical discharge rates, to an accuracy of 3% or better by weight of the hydrated lime.

Approved means for metering lime will include load cell weighing devices placed beneath each leg of the silo, or a weighbelt feeder between the silo discharge and the pugmill. Other means of metering the addition of lime must be approved by the Project Manager prior to use. External strain gauges affixed to the legs of the silo will not be permitted. The hydrated lime content shall be controlled within $\pm 0.2\%$ of the mix design target value.

If load cell weighing devices are used for lime metering, the silo shall be supported by a cast-in-place concrete foundation pad. Grout shall be placed between the foundation and the load cells to ensure intimate contact between the load cell and the foundation.

Moisture content of the combined aggregates shall be $3.5\% \pm 0.5\%$ by weight, at the time the aggregate and lime are mixed. The Project Manager may increase the moisture content of the coarse and fine aggregates to obtain proper coating of the aggregates with hydrated lime and to eliminate dust pollution. The Contractor will provide a method to positively determine the amount of moisture added to lime-aggregate mix.

424.34 Placement Operations. The asphalt concrete mixture shall be placed on the approved surface, spread and struck off to the grade and elevation established. It shall be spread and compacted in layers as shown on the plans or as directed by the Project Manager. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable.

The subgrade, base course or bituminous-treated base (BTB) upon which the SMA is to be placed shall be cleaned of all loose material or other deleterious materials prior to placement of the SMA. These surfaces shall be free of frozen material, and the moisture and density requirements of the applicable section shall be met prior to placement of the new SMA.

The SMA may be dumped from the hauling vehicles directly into the paving machine, or it may be dumped upon the surface being paved and subsequently loaded into the paving machine; however, no SMA shall be dumped from the hauling vehicles at a distance greater than 75 m (250 ft) in front of the paving machine. When SMA is dumped upon the surface being paved, the loading equipment shall be self-supporting and shall not exert any vertical load on the paving machine. Substantially all of the SMA dumped shall be picked up and loaded into the paving machine.

The speed of the paving machine shall be coordinated with the production of the plant to achieve a continuous operation. Sufficient hauling equipment shall be available to insure continuous operation.

The control system on the paving machine shall control the elevation of the screed at each end either by controlling the elevation of one end directly and the other indirectly through controlling the transverse slope or by controlling the elevation of each end independently, including any screed attachments used for widening, etc., unless otherwise directed by the Project Manager.

Failure of the control system to achieve the desired typical section shall be cause for the suspension of the paving operations.

When dumping directly into the paving machine from trucks, care shall be taken to avoid jarring the machine or moving it out of alignment.

All courses of SMA shall be placed and finished by means of self-propelled paving machines except under certain conditions or at certain locations where the Project Manager deems the use of self-propelled paving machines impracticable.

Self-propelled paving machines shall spread the SMA without segregation or tearing within the specified tolerances, true to the line, grade, and crown indicated on the plans.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be dumped, spread, and leveled to give the required compacted thickness.

When required by the Project Manager, existing surfaces shall be cleaned and a tack coat shall be applied in accordance with Section 407, Tack Coat.

424.341 Temperature and Weather Limitations. SMA shall not be placed on wet or frozen surfaces or when weather conditions otherwise prevent the proper handling, finishing, and compacting of the SMA.

424.35 Compaction. Immediately after the bituminous mixture has been spread, struck-off and surface irregularities adjusted, it shall be thoroughly and uniformly compacted.

The sequence of rolling operations shall provide the specified pavement density.

Rolling operations shall not disturb the typical section placed by the paver.

Rollers shall be operated at speeds less than 5 km/h (3 mph) and slow enough to minimize displacement of the bituminous mixture. The use of equipment that results in excessive crushing of aggregates will not be permitted. Any roller marks resulting from use of a pneumatic roller shall be removed with additional passes using a static steel-wheel roller.

Any displacement occurring as a result of the reversing of the direction of a roller, or from other causes, shall be corrected immediately by the use of rakes and addition of fresh bituminous mixture when required. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture. To prevent adhesion of the mixture to the rollers, the wheels shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted. Diesel fuel or other petroleum diluents are not acceptable. Along forms, curbs, headers, walls and other places not accessible to the rollers, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers. On depressed areas, a trench roller or cleated compression strips under the roller may be used to transmit compression to the depressed area.

Mixtures that become loose, broken, mixed with dirt, segregated or are defective shall be removed and replaced with fresh hot bituminous mixture, and compacted to conform with the surrounding area, at the Contractor's expense. Areas showing excess or deficiency of bituminous material shall be corrected immediately as directed by the Project Manager.

424.36 Miscellaneous Paving. Construction of miscellaneous paving including guardrail pads, slope paving, ditch paving, minor turnouts, bituminous curb, and raised median paving shall be governed by Section 417, Miscellaneous Paving. Miscellaneous paving as defined in this paragraph shall be excluded from quality assurance testing as described in subsection 424.5.

424.37 Joints. Placing of the SMA shall be as continuous as possible. Rollers shall not pass over the unprotected end of a freshly laid mixture.

When SMA is placed over PMBP or bituminous-treated base, longitudinal joints shall be staggered at least 150 mm (6 in.) relative to longitudinal joints of the underlying course.

Transverse joints shall have at least a 1-m (3-ft) minimum taper, but in no case shall the taper slope be steeper than 24:1. Longitudinal joints shall have at least a 300-mm (1-ft) minimum taper, but in no case shall the taper slope be steeper than 6:1. All transverse tapers shall be cut and squared off prior to commencing new work. Tapered longitudinal

joints from previous operations shall be cleaned and tack coated unless otherwise directed by the Project Manager. All joints shall be completely bonded. The surface of each course at all joints shall be smooth and shall not show deviations in excess of 5 mm (3/16 in.) when tested with a 3-m (10-ft) straightedge in any direction.

When paving under traffic the Contractor shall plan the daily surfacing operations on a schedule so that the longitudinal joints are not left exposed longer than seven consecutive calendar days.

424.38 Surface Tolerances. The surface of each completed course shall be smooth and shall not show deviations in excess of 3 mm (1/8 in.) when tested with a 3-m (10-ft) straightedge in any direction. All humps or depressions exceeding this tolerance shall be corrected immediately as directed by the Project Manager.

424.39 Plan Surfacing Depths. When surfacing is to be paid by the square meter (square yard), plan depths will be monitored and recorded throughout the surfacing operations with methods and at intervals designated by the Project Manager.

Should a deficient plan depth become evident and corrections no longer can be applied, the Project Manager will have the alternative of accepting the in-place mixed material and reduce payment for said mixed material by the deficient quantity at contract unit bid price per m² (yd²) or rejecting the in-place mixed material and requiring subsequent replacement with new material at no additional cost to the Department.

424.4 CONTRACTOR PROCESS QUALITY CONTROL TESTING.

424.41 Contractor Quality Control for Materials. The Contractor is responsible for the quality of materials and construction. The Department reserves the right to obtain samples of any portion of any material at any point of the operation for the Department's use. The Contractor shall implement a quality control and implementation plan that will effectively monitor the operations and provide the Department with timely notice of conditions adverse to the continuous and uniform production of an acceptable product.

At the preconstruction conference the Contractor shall submit the name of the Quality Control Representative to the Project Manager. The Contractor shall also, at that time, submit a quality control and operation plan, including the procedures to be followed in developing, applying and updating the quality control charts, to the Project Manager for approval. This plan shall follow the requirements outlined by the Department.

The Contractor shall sample the stockpiled aggregate at a point agreed to by the Project Manager and the mixed material behind the laydown machine, and shall conduct testing on those samples in accordance with applicable test procedures. This sampling and testing shall be accomplished by qualified testing personnel using equipment furnished by the Contractor that meets all applicable ASTM and AASHTO requirements.

The Contractor shall establish a laboratory on the project separate and distinct from the Department's Laboratory and quality assurance facilities. The Contractor shall submit verification that all of the Contractor's equipment meets the applicable standards.

Equipment that does not meet the applicable standards shall be removed from the project. Testing for quality control shall be performed under the direct supervision of an individual certified by the Technician Training and Certification Program (TTCP) of the State Materials Bureau. The certification will be based on demonstration of abilities for

test methods and procedures, and a written test. Term and expiration date of certification and requirements for renewal of certification will be established by the TTCP Board of Directors in conjunction with the State Materials Bureau and State Construction Bureau. If a concern arises as to the competence of a certified individual, this concern must be documented in accordance with the TTCP Manual. The TTCP Manual requires a written complaint be addressed to the TTCP Lab Supervisor or State Materials Engineer. The State Materials Bureau, through the TTCP, will investigate the concern. If this investigation substantiates the concern, corrective action such as revocation or suspension of certification will be implemented in accordance with procedures established by TTCP Board of Directors.

The applicable test procedures, performed as described in the NMSHTD Technician Training and Certification Program Manual, are as follows:

AASHTO T 2	Sampling Aggregates
AASHTO T 11	Materials Finer Than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 30	Mechanical Analysis of Extracted Aggregate
AASHTO T 40	Sampling Bituminous Materials
AASHTO T 308	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
AASHTO T 87	Dry Preparation of Disturbed Soil and Soil Aggregate;
AASHTO T 89	Determining the Liquid Limit of Soils
AASHTO T 90	Determining the Plastic Limit and Plasticity Index Of Soils
AASHTO T 146	Wet Preparation of Disturbed Soil Samples for Test
AASHTO T 164	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
AASHTO T 168	Sampling Bituminous Paving Mixtures
AASHTO T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
AASHTO T 248	Reducing Field Samples of Aggregate to Testing Size
AASHTO T 304	Uncompacted Void Content of Fine Aggregate
ASTM D4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate;
NMSHTD FF-1	Fractured Face Determination for Coarse Aggregate

Using these test procedures the Contractor's Quality Control Testing shall consist of the following as a minimum:

A. Stockpile Testing. The Contractor shall perform gradation tests, sand equivalent tests, fine aggregate angularity tests, liquid limit determinations, plastic limit determinations, flat-elongated particle determinations, and fractured faces determinations on each fraction of aggregate stockpiled at the hot mix plant. The Project Manager shall approve the location for the sampling of stockpiled aggregate.

Each fraction of material shall be sampled and tested at the rate of at least one test per 230 metric tons (250 tons) of material produced for the first 1815 metric tons (2000 tons) of production and at least one test per 450 metric tons (500 tons) of material produced after that time.

B. Extracted Gradations. The Contractor shall sample the bituminous mixture from behind the laydown machine and shall determine the asphalt content and the aggregate gradation of the sample. The material shall be sampled and tested at the rate of at least one test per 900 metric tons (1000 tons) of material produced with at least two tests per day's production when production exceeds 450 metric tons (500 tons) and a minimum of one test per day when production is between 90 metric tons (100 tons) and 450 metric tons (500 tons).

C. Quality Control Test Submittals. By noon of the workday after the material has been produced or placed, the Contractor shall deliver to the Project Manager a copy of all test results that were run that day. The Contractor's Quality Control Representative shall also certify that the test results obtained are a true and accurate representation of the material sampled. Aggregate gradations shall be controlled during production of SMA by the Contractor on the project such that the maximum variation from the approved job mix formula is within the following tolerances:

Sieve Size	Percent Tolerance
9.5 mm (3/8 in.) and Larger	± 4
4.75 mm, 2.36 mm, 600 µm, 300 µm (No. 4, 8, 30, and 50)	± 3
75µm (No. 200)	± 2

If the Contractor's production testing indicates that this requirement is not being met, the Contractor shall take corrective action to ensure that the requirement is complied with.

424.42 Contractor Quality Control for Compaction. The Contractor shall monitor the compaction process by determining the density of the SMA with a portable nuclear density test device in conformity with ASTM D 2950.

Calibration of the portable nuclear device shall be established by the Contractor from cut pavement samples. The density readings of the cut pavement samples shall be determined by the Contractor in accordance with AASHTO T 166 (weight, volume 260 424—Stone Matrix Asphalt method) and the density readings of the pavement shall be determined by the portable nuclear density test device in conformity with ASTM D 2950 and shall be correlated by the Contractor. The Contractor shall conduct testing at the minimum rate of one per 270 metric tons (300 tons) and shall furnish all test results to the Project Manager.

It is intended that quality control density testing be done while the bituminous mixture is hot enough to permit further compaction if necessary. Rolling for any compactive effort will not be allowed beyond the point at which it becomes ineffective or damage begins to occur. Additionally, use of vibratory mode will not be permitted when the temperature of the mix is below 93 °C (200 °F).

424.43 Suspension of Operations. If the test results for the properties listed in subsection 424.5, Department Quality Assurance Testing, indicate that the material fails to meet the specification requirements for a period of one day or 1360 metric tons (1500

tons), the Contractor shall initiate corrective action. If the material continues to fail to meet the specifications for a total of two consecutive days or a maximum total production of 2720 metric tons (3000 tons) of SMA, the production of SMA will be halted by the Project Manager.

The gradation information obtained by the Contractor shall be used by the Contractor to determine the causes or factors that may be a contribution to the problem and to determine a solution to the problem. The Contractor shall propose a plan to solve the problem. Approval of the plan must be obtained from the Project Manager prior to resumption of paving operations. Upon approval of the proposed plan, the Contractor may resume operations to determine if the actions taken have corrected the problem.

The Contractor shall limit production to 900 metric tons (1000 tons), which will be tested in 450-metric-ton (500-ton) increments. If that testing indicates that the problem has been corrected, the Contractor may resume full operations. If the problem has not been corrected, further trial runs and testing as described herein will be required.

The Contractor shall produce material in substantial compliance with all specification requirements, regardless of whether the requirements are used for acceptance and price reduction determination. Evaluation of test results for specification compliance and treatment of material that does not meet specifications will be done in accordance with Section 920.

All material that is rejected shall be removed and replaced with specification material at the Contractor's expense. All material not meeting the Marshall Stability requirements will be rejected.

424.44 Project Assurance Testing. Project assurance sampling and testing may be performed by the Department to assure that correct and accurate procedures, and proper equipment are being used by the Contractor's field personnel. The Project assurance testing will be done by the Department's personnel on split samples furnished to the Department by the Contractor. Samples taken for assurance testing will be obtained and split by the Contractor's technicians and witnessed by Department personnel.

424.45 Test Strip. The Contractor shall construct a test strip off of the project or at a location approved by the Project Manager prior to placement on the mainline pavement. A new test strip may be required any time there is a change in the mix design, mix production operation, or mix placement operation. The test strip shall be a minimum of 150 m (500 feet) in length and the material for the test strip shall be produced and placed in accordance with these specifications. The Contractor shall not begin full production of SMA until he or she receives authorization from the Project Manager based on an evaluation of the test strip. Material placed in the test strip shall be paid for at the contract unit price.

424.5 DEPARTMENT QUALITY ASSURANCE TESTING.

424.51 Department Quality Assurance Testing for SMA Mix. Acceptance will be based on tests made from representative samples taken after the SMA has been placed on the roadbed and prior to compacting. After the mix design has been issued, the Contractor shall control the mixture production on the project such that the tolerances in Table 424-C are met.

The Department will conduct quality assurance sampling, testing, and monitoring to insure that the Contractor provides a mix that meets the tolerances. The Department will conduct this testing in accordance with its Minimum Acceptance Testing Requirements. Acceptance test results will be provided to the Contractor's Quality Control Representative or designee by the end of the following workday after the samples are taken.

**Table 424-C
ACCEPTANCE TESTING TOLERANCES**

Characteristic	Lower Spec. Limit	Upper Spec. Limit
Marshall Stability	6225 N (1400 lb)	NA
Air Voids	T.V. -1%	T.V. +1%
Asphalt Content (Binder Ignition Oven)	T.V. -0.3%	T.V. +0.3%
Hydrated Lime Content	T.V. - 0.2%	T.V. + 0.2%
Gradation:		
19.0 mm, 12.0 mm, 9.5 mm (3/4 in., 1/2 in., 3/8 in.)	T.V. -4.0%	T.V. +4.0%
4.75 mm, 2.36 mm, 600 µm, 300 µm (No 4, 8, 30, and 50)	T.V. -3.0%	T.V. +3.0%
75µm (No. 200)	T.V. -2.0%	T.V. +2.0%

Note: T.V. = Target Value

424.52 Department Quality Assurance Testing for Compaction. The bituminous pavement structure course shall be divided into acceptance sections or lots of 1360 metric tons (1500 tons) or one day's production, whichever is less, for the purpose of defining areas represented by each series of acceptance tests. The Department may use a stratified random sampling plan to enhance the quality of acceptance sampling and testing.

The density of each acceptance section or lot will be evaluated by a minimum of three cut pavement samples taken in conformity with AASHTO T 166 at randomly selected sites within the test section. The cut pavement samples shall be taken and prepared by the Contractor, for testing. The testing will be done by Department personnel. The Contractor shall core each lift of the SMA full depth in accordance with applicable AASHTO and Department procedures. All questions arising from the sampling operation, including diameter of core samples, will be decided by the Project Manager. The Contractor shall identify each core sample with a location marking and deliver all core samples to the test site within the time specified by the Project Manager.

The mean density obtained for all tests in each acceptance section or lot shall be at least 93% of the theoretical maximum density as determined from AASHTO T 209. In addition, each individual test value obtained within an acceptance section or lot shall be at least 90% of the theoretical maximum density and shall not exceed 98% of the theoretical maximum density. In the event an individual test result falls below 90% or exceeds 98% of the theoretical maximum density, the District Construction Engineer shall determine the disposition of the material represented by the test.

Specifications for North Carolina's Open-Graded Friction Course

Extracted from:

<http://www.ncdot.org/doh/preconstruct/ps/specifications/dual/>

NORTH CAROLINA DOT SECTION 650 OPEN-GRADED ASPHALT FRICTION COURSE, TYPES FC-1, FC-1 MODIFIED, AND FC-2 MODIFIED.

650-1 DESCRIPTION.

Perform the work covered by this section including but not limited to construction of a plant mixed open-graded asphalt friction course (OGAFC) properly laid upon a prepared surface in accordance with these specifications and in conformity with the lines, grades, thickness, and typical sections shown on the plans; producing, weighing, transporting, placing, and rolling the plant mix as specified in Section 610; furnishing the asphalt binder, anti-strip additive, fiber stabilizing additive, and all other materials for the plant mix; furnishing and applying tack coat as specified in Section 605; providing quality control as specified in Section 609 as modified for OGAFC; surface testing of the completed pavement; furnishing scales; making any repairs or corrections to the friction course that may become necessary, and maintaining the friction course until final acceptance of the project.

650-2 MATERIALS.

See Division 10:

Asphalt binder, Grade PG 64-22, PG 76-22	Article 1020-2
Anti-strip additive (Chemical)	Article 1020-8
Anti-strip additive (Hydrated lime).....	Article 1012-1
Coarse aggregate	Article 1012-1
Mineral filler	Article 1012-1
Stone screenings.....	Article 1012-1

Fiber Stabilizing Additives:

Use fiber stabilizing additives which are capable of stabilizing the asphalt film surrounding the aggregate particles in order to reduce drain-down of the asphalt binder. A fiber stabilizer such as cellulose or mineral fiber may be used. The selected fiber must meet the properties described below. Dosage rates given are typical ranges but the actual dosage rate used will be approved by the Engineer.

(A) MINERAL FIBERS:

Mineral fibers must be made from virgin basalt, diabase, or slag and which have been treated with a cationic sizing agent to enhance disbursement of the fiber as well as increase adhesion of the fiber surface to the asphalt binder. Add the fiber at a dosage rate between 0.2% to 0.4% by weight of total mix, as approved.

1. Size Analysis:

Average Fiber length:	0.25 inches (6.4 mm) maximum
Average Fiber thickness:	0.0002 inches (0.005 mm) maximum

- | | |
|---|---------------|
| 2. Shot Content (ASTM C 612) | |
| Passing No. 60 (0.250 mm) sieve | 90- 100% |
| Passing No. 230 (0.063 mm) sieve | 65- 100% |
| 3. Degradation (GDT-124/McNett Fractionation) | 30% (maximum) |

(B) CELLULOSE FIBERS:

Add cellulose fibers at a dosage rate between 0.2% and 0.4% by weight of total mix as approved. Fiber properties must be as follows:

- | | |
|------------------------|------------------------------|
| 1. Fiber length: | 0.25 inches (6.4 mm) maximum |
| 2. Sieve Analysis: | |
| a) Alpine Sieve Method | |
| Passing No. 100 sieve | 60-80% |
| b) Ro-Tap Sieve Method | |
| Passing No. 20 Sieve: | 80-95% |
| Passing No. 40 Sieve: | 45-85% |
| Passing No. 100 Sieve: | 5-40% |
| 3. Ash Content: | 18% non-volatiles (±5%) |
| 4. pH: | 7.5 (±1) |
| 5. Oil Absorption: | 5.0 (±1) |
| (times fiber weight) | |
| 6. Moisture Content: | 5.0 (maximum) |

(C) CELLULOSE PELLETS:

Cellulose pellets consist of a 50/50 blend of cellulose fiber and asphalt binder. Use cellulose which complies with Item (B), Cellulose Fibers, above. Add the cellulose pellets at a dosage rate between 0.4% and 0.8% by weight of total mix, as approved.

- | | |
|-----------------|---|
| 1. Pellet Size: | 1/4 cubic inch [4.1 cubic mm] (maximum) |
| 2. Asphalt: | 25 – 80 pen. |

650-3 COMPOSITION OF MIXTURE (MIX DESIGN & JOB MIX FORMULA).

(A) General:

Design the open-graded asphalt friction course utilizing a mixture of coarse and fine aggregate, asphalt binder, mineral filler, mineral fiber, fiber stabilizing additive, and other additives as required to produce a mix meeting the requirements of Table 650-1.

Submit in writing a mix design and proposed job mix formula (JMF) targets for each required mix type and combination of aggregates to the Engineer for review and approval at least 10 days prior to start of asphalt mix production. The mix design must be prepared by a mix design technician approved by the Department in an approved mix design laboratory. Perform the mix design in accordance with applicable requirements of Article 610-3 and the Department’s mix design procedures titled “DETERMINATION OF OPTIMUM ASPHALT CONTENT FOR OPEN-GRADED ASPHALT FRICTION COURSES”. A copy of these procedures can be obtained through the Department's Materials and Tests Unit. Submit the mix design and proposed job mix formula targets on forms and in a format approved by the Department.

The mix design and job mix formula target values will be established within the mix design criteria specified in Table 650-1 for the particular type mixture to be produced. The formula for each mixture will indicate the blend percentage of each aggregate fraction to be used, a single percentage of combined aggregate passing each required sieve, the percentage and grade of asphalt binder (by weight of total mixture) to be incorporated into the mixture, the percentage of anti-strip additive to be added to the asphalt binder, the percentage of fiber stabilizing additive (by weight of total mix), and the temperature at which the mixture is to be discharged from the plant.

Have on hand at the asphalt plant the approved mix design and job mix formula issued by the Department, prior to beginning the work.

The job mix formula for each mixture shall remain in effect until modified in writing, provided the results of QMS tests performed on material currently being produced conform with specification requirements.

Should a change in sources of aggregate materials to be made, a new mix design and job mix formula will be required before the new mixture is produced.

When unsatisfactory results or other conditions make it necessary, the Engineer may establish a new job mix formula.

(B) Mix Design Criteria:

Design open-graded asphalt friction course mixtures conforming to the gradation requirements and other mix design criteria in Table 650-1 for the mix type specified.

Use the asphalt binder grade shown in Table 650-1 for the mix type specified.

Use an anti-strip additive in all OG AFC mixes. It may be hydrated lime or a chemical additive or both. Add chemical anti-strip additive at a rate of 0.5% by weight of asphalt binder. Add hydrated lime at a rate of 1.0% by weight of dry aggregate. Use approved source and grade.

Incorporate a mineral fiber stabilizing additive into all OG AFC types. Add the fiber at a dosage rate by weight of the total mix as approved.

When requested, submit to the Materials & Tests Unit in Raleigh, samples of mix components. Submit sample sizes as noted below or as requested. Provide the samples at least 10 days prior to beginning placement of OG AFC mixture.

- 250 lb. (115 kg) of each coarse aggregate
- 150 lb. (70 kg) fine aggregate
- 1 gal. (4 liters) of mineral filler and/or baghouse fines
- 1 gal. (4 liters) of hydrated lime
- 1 pint (0.5 liters) of chemical anti-strip additive
- 4 lb. (1 kg) of fiber stabilizing additive

Aggregate samples when combined according to the Contractor's proposed aggregate blend percentages must be within the gradation range defined by the target values of Table 650-1 for each sieve or the samples will not be considered representative.

The mixing temperature at the asphalt plant will be established on the job mix formula.

Add the anti-strip additive to the asphalt binder in accordance with Article 620-3.

**TABLE 650-1
OGAFC MIX DESIGN CRITERIA**

Grading Requirements Sieve Designations	Total Percent Passing		
	Type FC-1	Type FC-1 Modified	Type FC-2 Modified
3/4 inch (19.0 mm)			100
1/2 inch (12.5 mm)	100	100	85-100
3/8 inch (9.5 mm)	75-100	75-100	55-75
No. 4 (4.75 mm)	25-45	25-45	15-25
No. 8 (2.36 mm)	5-15	5-15	5-10
No. 200 (0.075 mm)	1.0-3.0	1.0-3.0	2.0-4.0
Design Requirements			
Asphalt Binder, Performance Grade	PG 64-22	PG 76-22	PG 76-22
Asphalt Binder, % Range	5.0-8.0	5.0-8.0	5.0-8.0
Mixing Temperature Range (To be established by the Engineer)	200 - 275°F (93 - 135°C)	300 - 350°F (165 - 175°C)	300 - 350°F (165 - 175°C)
Retention Coating (AASHTO T 195)	95% min.	95% min.	95% min.
Draindown, Percent (AASHTO T 305)	0.3 max.	0.3 max.	0.3 max.

650-4 PLANT EQUIPMENT.

Use plant equipment in accordance with Article 610-5 and the following requirements: When fiber stabilizing additives are required as an ingredient of the mixture, utilize a separate feed system capable of accurately proportioning the required quantity into the mixture and in such a manner that uniform distribution will be obtained. Interlock the proportioning device with the aggregate feed or weigh system so as to maintain the correct proportions for all rates of production and batch sizes. Accurately control the proportion of fibers to within plus or minus 10 percent of the amount required. Provide flow indicators or sensing devices for the fiber system which are interlocked with plant controls such that mixture production will be interrupted if introduction of the fiber fails. When a batch type plant is used, add the fiber to the aggregate in the weigh hopper or as approved. Increase the batch dry mixing time by 8 to 12 seconds, or as directed, to assure the fibers are uniformly distributed prior to the injection of asphalt binder into the mixer. When a continuous mix or drier-drum type plant is used, add the fiber to the aggregate and uniformly disperse at the point of injection of asphalt binder. Add the fiber in such a manner that it will not become entrained in the exhaust system of the drier or plant.

650-5 CONSTRUCTION REQUIREMENTS.

Produce, transport to the site, and place the OGAFC in accordance with the applicable requirements of Section 610, except as otherwise provided below.

Prior to starting production of the mix, stockpile all aggregates for a sufficient period of time to facilitate the drainage of free moisture.

Produce the mixture at the asphalt plant within $\pm 15^{\circ}\text{F}$ ($\pm 8^{\circ}\text{C}$) of the temperature established on the JMF. Assure the temperature of the mix immediately prior to discharge from the hauling vehicle is within $+15^{\circ}\text{F}$ ($+8^{\circ}\text{C}$) to -25°F (-14°C) of the JMF temperature.

Add the anti-strip additive to the asphalt binder in accordance with Article 620-3.

Clean the existing surface in an acceptable manner prior to placement of any asphalt material.

Remove all existing raised pavement markers as directed and repair as approved any damaged areas caused by the removal. Use an approved dense graded mixture of similar type material for the repair.

Apply tack coat in accordance with the provisions of Section 605 and the following:

1. Use Asphalt Binder, Grade PG 64-22 tack coat material or as approved.
2. Uniformly apply the tack coat material at a rate of application 0.06 to 0.08 gal. per square yard (0.25 to 0.35 liters per square meter), as directed.

Spread and finish the friction course as specified in Article 610-8.

Roll the friction course as specified in Article 610-9.

Remove and replace any part of the finished friction course which shows nonuniform distribution of asphalt binder, aggregate or fiber at no additional cost to the Department.

Coordinate plant production, transportation, and paving operations such that uniform continuity of operation is maintained. If spreading operations are interrupted, the Engineer may require that a transverse joint be constructed any time the mixture immediately behind the paver screed cools to less than 250°F (120°C).

When OGAF C, Type FC-2 Modified mixture is specified, use OGAF C, Type FC-1 Modified on entrance and exit ramps, gore areas, and at end of project construction joints. Adjust the thickness of placement as specified below.

For end of project joints, provide a transition area consisting of one load of mixture per lane, or as directed. Taper the mixture in thickness from $3/8$ inch (9.5 mm) at the end of the project to the typical thickness (approximately $3/4$ inch (19 mm)) within the maximum distance of spread for one load of mixture. For ramps and gore areas, taper the mixture in thickness from that at the edge of the mainline, approximately $3/4$ inch (19 mm) to $3/8$ inch (9.5 mm) at the point of the ramp transverse joint. Construct the ramp transverse joint at a point specified by the plans or as directed.

650-6 QUALITY MANAGEMENT SYSTEM FOR ASPHALT PAVEMENTS.

Produce the OGAF C in accordance with the applicable provisions of Section 609 and Project Special Provisions titled "QMS for ASPHALT PAVEMENTS: (OGAF C, PAD C, and ULTRATHIN VERSION)".

650-7 METHOD OF MEASUREMENT.

The quantity of OGAF C to be paid for will be the actual number of tons (metric tons) of friction course which has been incorporated into the completed and accepted work. The friction course will be measured by being weighed in trucks on certified platform scales or other certified weighing devices.

650-8 BASIS OF PAYMENT.

The quantity of friction course, measured as provided in Section 650-7above, will be paid for at the contract unit prices per ton (metric ton) for “Open-Graded Asphalt Friction Course, Type FC-1, Type FC-1 Modified, or Type FC-2 Modified”.

Furnishing asphalt binder for the mix will be paid for as provided in Article 620-5 of the Standard Specifications for “Asphalt Binder for Plant Mix, Grade PG XX-XX”.

Adjustments in contract unit price due to asphalt binder price fluctuation will be made in accordance with Section 620.

Providing QMS for asphalt pavements will be in accordance with the project special provision entitled “QMS for Asphalt Plant Mix Pavements” contained elsewhere in this provision form.

Payment will be made under:

- Open-Graded Asphalt Friction Course, Type FC-1Ton (Metric Ton)
- Open-Graded Asphalt Friction Course, Type FC-1 ModifiedTon (Metric Ton)
- Open-Graded Asphalt Friction Course, Type FC-2 ModifiedTon (Metric Ton)

Specifications for Oklahoma's Open-Graded Friction Course

Extracted from:

<http://www.okladot.state.ok.us/construction/specbook/specbook-1999.pdf>

OKLAHOMA DOT SECTION 406 OPEN-GRADED FRICTION SURFACE COURSE

406.01 DESCRIPTION

This work shall consist of mixing, at a central plant, aggregate and bituminous materials, and then spreading and compacting the mixed material on a prepared roadbed, all in substantial compliance with the Specifications and dimensions on the Plans.

406.02 MATERIALS

Materials shall meet the requirements of Section 708.

406.03 EQUIPMENT

Equipment shall conform to the requirements of Subsection 411.03.

406.04 CONSTRUCTION METHODS

- (a) **Stockpiling Materials.** Aggregate stockpiles shall meet the requirements of Subsection 106.09.
- (b) **Preparation of Materials.** Dry and heat the mineral aggregate to a temperature not to exceed 260°F (127°C); however, when Polymer Modified Asphalt Cement (PMAC) is specified, dry and heat the mineral aggregate to a temperature not to exceed 350°F (177°C). Collect dust resulting from this operation and either waste it or return it to the mixture as deemed necessary. The mineral aggregate shall be free of oily or carbonaceous coatings prior to entering the mixer. Bituminous materials shall not exceed 280°F (138°C) when introduced into the mixer; however, when PMAC is specified, the temperature of the PMAC shall not exceed 350°F (177°C) when it is introduced into the mixer.
- (c) **Mixing.** Mix the aggregate and bituminous material as specified in Subsection 411.04.
- (d) **Loading and Hauling.** Coordinate loading and hauling of the mixture with the laydown operations so that the mixture shall be placed within the temperature range established in Subsection 406.04(g) and so that there not will be separation of the asphalt and aggregate.
- (e) **Tack Coat.** Apply a tack coat in accordance with Section 407, except that the rate of application shall be approximately 0.1 gallon per square yard (0.45 L/m²) of the surface area unless otherwise shown on the Plans or directed by the Engineer.
- (f) **Weather and Seasonal Limitations.** Construction of Open-graded Friction Surface Courses (OGFSC) will be permitted only under the following conditions:

When the surface is dry; when the mat surface on which it is to be placed is 60°F (15°C) or above when measured away from artificial heat; when the weather is not foggy, rainy or stormy; and when the wind or other conditions prevent proper leveling and consolidation.

OGFSC shall only be placed between April 1 and October 31 of each calendar year.

(g) **Spreading and Finishing.** Prior to placing the OGFSC, clean all foreign matter from the surface of the existing roadbed. The temperature of the mixture for placement on the road shall be established by the Engineer, and it shall not vary more than 25°F (14°C) above or below the target temperature for placement.

The forward movement of the pavement machine shall be continuous. If the paver has to stop, pick up the machine and clean it out, and then start anew.

(h) **Joints.** The location of the longitudinal joints shall be on the lane lines, and offset from the underlying joint a minimum of 3 inches (75 mm). All construction joints shall be tight, smooth, butt-type joints.

(i) **Compaction.** Immediately following placement of the OGFSC material, roll the surface with 2-3 passes of a static (non-vibratory) steel-wheeled, self-propelled roller of such weight as approved by the Engineer.

Finish the surface so that it is smooth and true to the dimensions shown on the Plans. Immediately correct any low or defective areas by removing them, replacing them with new material, and compacting them to conform to the remainder of the pavement. Such corrective work shall be done at the expense of the Contractor.

Trucks and all other traffic shall not be permitted on the finished OGFSC pavement until the surface temperature is within 10°F (6°C) of ambient temperature or two hours time has elapsed from final rolling.

406.05 METHOD OF MEASUREMENT

Open-graded friction surface course, including the aggregate, liquid asphalt, and other ingredients as specified in the job-mix formula - will be measured by the ton (metric ton) of combined mixture.

Tack coat will be measured and paid for in accordance with Section 407.

406.06 BASIS OF PAYMENT

Accepted quantities of open-graded friction surface course measured, as provided above, will be paid for at the contract price as follows:

OPEN-GRADED FRICTION SURFACE COURSE.....TON (METRIC TON)
OPEN-GRADED FRICTION SURFACE COURSE (MOD. AC)...TON (METRIC TON)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

Specifications for Ohio's Stone Matrix Asphalt

Extracted from:

[HTTP://WWW.DOT.STATE.OH.US/CONSTRUCTION/OCA/SPECS/2005CMS/2005_ODOT_C&MS.HTM](http://www.dot.state.oh.us/construction/OCA/SPECS/2005CMS/2005_ODOT_C&MS.HTM)

OHIO DOT

443 STONE MATRIX ASPHALT CONCRETE

443.01 Description. This work consists of constructing a stone matrix asphalt concrete (SMA) course consisting of aggregate, asphalt binder, and additives. The requirements of 442 and 446 apply except as follows.

443.02 Quality Control Program. Update the Quality Control Program meeting 403.03 to include a section for how the quality control, production and placement of SMA will meet this specification. Submit the revised program to the Laboratory with the SMA mix design to be approved.

443.03 Composition. Discuss the mix design approach with the Laboratory during the mix design and prior to submittal.

A. Design Limits. Submit a JMF to the Laboratory which meets the requirements of Table 443.03.1 and Table 443.03-2.

TABLE 443.03-1 MIX GRADATION

Sieve	Total Percent Passing
3/4 inch (19.0 mm) sieve	100
1/2 inch (12.5 mm) sieve	85 to 100
3/8 inch (9.5 mm) sieve	50 to 75
No. 4 (4.75 mm) sieve	20 to 28
No. 8 (2.36 mm) sieve	15 to 24
No. 50 (300 μ m) sieve	10 to 20
No. 200 (75 μ m) sieve	8 to 12

TABLE 443.03-2 MIX PROPERTIES

Property Description	Specification
Binder, % (1)	5.8 to 7.5
VMA, % (2)	16.0 to 19.0
Draindown Test, % (3)	0.3
Design Air Voids, %	3.5
Design Gyration (4)	65
VCA MIX / VCA DRC (5)	< 1.0
TSR (6)	0.80
F/A	NA

1. by total mix
2. based on bulk gravity
3. AASHTO T305 conducted at mix production temperature (not compaction temperature)
4. N_{ini} and N_{max} do not apply
5. VCA = Volume of Coarse Aggregate (Calculated for mix and dry rodded conditions per AASHTO PP41- 02 or newer version.)
6. Unconditioned specimens will have a minimum 65 psi (450 kPa) retained strength.

Compact specimens at 300°F (149°C) for PG 70-22M and 310°F (154°C) for PG 76-22M.

- B. Asphalt Binder. Provide asphalt binder conforming to 702.01.
- C. Coarse Aggregate. Use approved coarse aggregates. Ensure coarse aggregates meet 703.05 and Table 443.03-3.

TABLE 443.03-3 AGGREGATE REQUIREMENTS

Tests	DESCRIPTION	Specification
ASTM D 4791	% Flat & Elongated Ratio at 3:1, (max. to min.), 5:1, (max. to min.)	20 max 5 max
ASTM D 5821	% Crushed, one / two faces	100 / 90 min
AASHTO T 96	LA Abrasion (stone or gravel)	35 max

- D. Mineral Filler. Conform to 703.07. Use mineral filler in the JMF with a plasticity index (AASHTO T 90) not greater than 4 (Does not apply to hydrated lime). Reclaimed asphalt concrete pavement passing the 5/8 inch (16mm) sieve may be used as filler only. Do not account for RAP binder content. Do not use quicklime (CaO). Do not premix filler with another aggregate. Cover mineral filler piles to protect from rain.

Blend the mineral filler, asphalt binder and fiber stabilizer into a homogenous mixture and test the mortar for the following properties of Table 443.03-4.

TABLE 443.03-4 MORTAR TEST REQUIREMENTS

Tests	DESCRIPTION	Specification
AASHTO TP5-98	Unaged DSR, G*/ sin (kPa)	5 minimum
AASHTO TP5-98, T240-97	RTFO Aged DSR, G*/ sin (kPa)	11 minimum
AASHTO TP1-98, PP1-98	PAV Aged BBR, Stiffness (Mpa)	1500 maximum

E. Reclaimed Asphalt Concrete Pavement. Do not use reclaimed asphalt concrete pavement except as described in C above.

F. Fiber Stabilizer. Choose and meet the requirements of one of the following fiber stabilizers. Submit with the JMF submittal the fiber manufacturer's most recent actual test data and a certification of compliance for the fiber type to be used. Protect the fiber stabilizer from moisture or other contamination.

Cellulose Fibers. Add the fiber at a dosage rate of 0.3 - 0.4% by weight of the total mix as directed by the Engineer to control draindown in production.

Property Description	Specification
1. Fiber length (max):	0.25 inch (6.35 mm)
2. Sieve Analysis - Alpine Sieve Method	
Passing No. 100 (150µm) sieve	60-80%
Sieve Analysis - Ro-Tap Sieve Method	
Passing No. 20 (850 µm)sieve:	80-95%
Passing No. 40 (425 µm) sieve:	45-85%
Passing No. 100 (150 µm) sieve:	5-40%
3. Ash Content:	18% non-volatiles (5%)
4. pH:	7.5 (1.0)
5. Oil Absorption:(times fiber weight)	5.0 (1.0)
6. Moisture Content (max):	5.0%

Cellulose Pellets. Cellulose pellets will consist of cellulose fiber and may be blended with 0-20% asphalt binder. Meet the cellulose fiber requirements above. If no asphalt binder is used, add the pellet at a dosage rate of 0.3 - 0.4% by weight of the total mix as directed by the Engineer to control draindown in production. Adjust the fiber dosage to maintain the desired fiber amount when fiber is pre-blended with binder.

1. Pellet size: 1/4 cubic inch (maximum)
2. Binder: 25 - 80 pen.

Mineral Fiber. Use mineral fibers made from virgin basalt, diabase, or slag treated with a cationic sizing agent to enhance disbursement of the fiber as well as increase adhesion of the binder to the fiber surface. Add the fiber at a dosage rate of 0.3 - 0.4% by weight of the total mix as directed by the Engineer to control draindown in production.

1. Average Fiber length (max): 0.25 inches 6.35mm)
Average Fiber thickness (max) : 0.0002 inches(0.005mm)
2. Shot content (ASTM C612)
Passing No. 60 (250 µm) sieve: 90 - 100%
Passing No. 230 (63 µm)sieve: 65 - 100%

3. Degradation (max)*: 30%
*(GeorgiaDOT-124/McNett) - copy available from the Office of Materials Management, Asphalt section.

443.04 Mixing. Conform to the following additional requirements.

A. Fiber Stabilizer. Furnish feeder equipment specifically manufactured to uniformly feed fiber into the plant and that is automated through connection with plant controls. Include a low level and no-flow indicator and print out the feed rate of the feeder supply system and include a transparent pipe section for observing flow consistency. The Engineer will approve the fiber feed system by a trial load of SMA and inspection of the bag house collected material prior to the start of production. Conduct and document a weekly quick check of the fiber feed calibration per the Quality Control Plan. Conduct a daily check of fiber usage by calculating and documenting on the TE 199 that fiber usage is within 10% of the intended usage.

In drum plants, add the fibers in loose form, by an automated calibrated feed system, such that the fibers are coated by asphalt binder before being caught in the drum air flow.

In batch plants, distribute the fiber uniformly before injecting asphalt binder and increase mixing time a minimum of 5 seconds.

B. Mineral Filler. Filler may be fed thru a hopper if consistency of flow is achieved. If a problem in feeding consistency occurs a pneumatic system will be required. Feed filler into the weigh hopper or pugmill of a batch plant, or at a point away from the flame on a drum plant.

443.05 Storage. Do not store the SMA at the plant for more than 2 hours. Do not exceed a mix temperature of 350°F (180°C). Provide SMA at a minimum of 300°F(148°C) when it arrives at the paver, unless otherwise approved by the Laboratory. If draindown occurs shorten the storage time and increase the fiber dosage.

443.06 Quality Control. An employee of the Contractor with a Level 2 rating will be at the plant or construction site during production of the SMA for any test strips and through at least one full production day satisfactory to the District.

Perform quality control tests every 3 hours of production. The increased frequency of quality control testing may require additional quality control personnel at the plant. Determine the asphalt binder content, gradation, moisture content, air voids, VMA, and MSG of the SMA. For each test series calculate the VCAMIX / VCADRC. If the limit of 1.0 is exceeded stop production until resolved. Perform a draindown test once each day of production and raise fiber dosage 0.1% if the test limit is exceeded. Do not exceed the No. 200 (75 µm) sieve design bands by the moving average of three tests. Compact specimens at 300°F (149°C) for PG 70-22M and 310°F (154°C) for PG 76-22M. Due to sample variability with SMA, a larger than usual sample size from which material is obtained for the various tests is required.

443.07 Construction. At least 24 hours prior to beginning a test strip meet with the Engineer and DET and provide a written summary of steps taken to assure mix quality

and construction practices account for the special needs of SMA production and placement. Send a copy of the above to the Laboratory.

- A. Test Strips and JMF Adjustment. Do not begin full production of the SMA until receiving authorization from the District. This authorization will be based on the successful construction of one or more test strips. Test strips will consist of 50 to 100 tons of SMA produced and placed in accordance with these specifications. No further SMA production will occur that day unless another test strip is needed. A test strip will be one continuous mat. The test strip will be included in the first lot for determining density for payment. Test strips are incidental to the pay item.
During the construction of a test strip, perform 1 set of quality control tests as described above and obtain and test 3 random cores of the compacted pavement. Within 1 working day after a test strip is completed, the District, the Laboratory and the Contractor's Level 2 employee will determine if any changes in the SMA JMF, production, or placement procedures are needed. A redesign of the JMF or another test strip may be required. The Laboratory will notify the District of any JMF adjustments. Do not start production until notified by the District.
- B. Compaction. Start compaction immediately after the SMA has been placed by the paver. Use only steel wheel rollers. Vibratory rollers in vibratory mode, set at a high frequency and low amplitude, can be used as the breakdown roller only. Always operate the breakdown roller immediately behind the paver. If isolated, small fat spots develop, apply sand immediately during compaction. If continuous and/or large fat spots develop cease production until resolved. Do not compact SMA that is below 230°F (110°C).
- C. Hauling. Do not allow trucks to dump any mix on the project mat after delivering mix to the paver. Provide a suitable place for bed cleaning off of the mat.

443.08 Acceptance. After accepting the test strips, the Department will accept SMA according to 446.05 procedures except use the table 443.08-1,

TABLE 443.08 -1

Mean of Cores[1]	Pay Factor
98.0% or greater	[2]
97.0 to 97.9%	0.94
96.0 to 96.9%	1.00
94.0 to 95.9%	1.04
93.0 to 93.9%	1.00
92.0 to 92.9%	0.98
91.0 to 91.9%	0.90
90.0 to 90.9%	0.80
89.0 to 89.9%	[3]
Less than 89.0%	[2]

[1] Mean of cores as percent of average MSG for the production day.

[2] For surface courses, remove and replace. For other courses, the District will determine whether the material may remain in place. If the District determines the course should be removed and replaced, the Contractor shall remove and replace

this course and all courses paved on this course. The pay factor for material allowed to remain in place is 0.60.

[3] The District will determine whether the material may remain in place. If the District determines the course should be removed and replaced, the Contractor shall remove and replace this course and all courses paved on this course. The pay factor for such material allowed to remain in place is 0.70.

443.09 Basis of Payment. The Department will pay for accepted quantities of Stone Matrix Asphalt Concrete, complete in place, including test strip, at the contract price as modified above.

Item	Unit	Description
443	Cubic Yard (cubic Meter)	Stone matrix asphalt concrete, 12.5mm, PG70-22M, (446)
443	Cubic Yard (cubic Meter)	Stone matrix asphalt concrete, 12.5mm, PG76-22M, (446)

Specifications for Oregon's Open-Graded Friction Course and Stone Matrix Asphalt

Extracted from:

http://www.oregon.gov/ODOT/HWY/SPECS/2002_std_specs.shtml

OREGON DOT

Section 00745 - Hot Mixed Asphalt Concrete (HMAC)

Description

00745.00 Scope - This work consists of constructing one or more courses of hot mixed asphalt concrete (HMAC) pavement, plant mixed into a uniformly coated mass, hot laid on a prepared foundation, compacted to specified density, and finished to a specified smoothness to the lines, grades, thickness, and cross sections shown or established.

00745.01 Abbreviations:

MAMD - Moving Average Maximum Density

MDT - Maximum Density Test

MDV - Mix Design Verification

G_{mm} - Maximum Specific Gravity of Mixture

SDC - Surface Damp Condition

TSR - Tensile Strength Ratio

VFA - Voids Filled with Asphalt

VMA - Voids in Mineral Aggregate

00745.02 Definitions:

Hot Mixed Asphalt Concrete (HMAC) - A hot plant mixed, uniformly coated mixture of asphalt cement, graded aggregate and additives as required.

Level 1 HMAC - HMAC for use in applications with very low traffic and only limited exposure to trucks.

Level 2 HMAC - HMAC for use in applications with low traffic volumes and low volume truck traffic.

Level 3 HMAC - HMAC for use in applications exposed to moderate truck traffic.

Level 4 HMAC - HMAC for use in applications exposed to very heavy traffic volumes or heavy truck traffic.

Lot Size - A lot is the total quantity of material or work produced per JMF per project. The following circumstances will require a different lot:

- A new JMF is used. A JMF adjusted according to 00745.16 is not considered a new JMF
- The method for measuring compaction is changed

- A new compaction specification limit is required according to 00745.49(b-3)
- A change from one test procedure for measuring asphalt content to another test procedure for measuring asphalt content occurs

The Engineer may allow material for irregular areas not completed during the main paving operations, such as driveways or guardrail flares to be evaluated as a separate lot.

Sublot Size - A sublot is 1000 Mg (1,000 tons) of HMAC.

Surface Damp Condition (SDC) - When the outside of the aggregates are damp with moisture, but little or no free water is present.

Wearing Course - The top lift of HMAC, regardless of thickness.

00745.03 Reclaimed Asphalt Pavement (RAP) Material - Reclaimed HMAC pavement (RAP) material used in the production of new HMAC is optional. No more than 30% RAP material will be allowed in the new HMAC pavement. RAP material will not be permitted in open-graded HMAC or Level 4 dense graded HMAC wearing courses.

The amount of asphalt cement in the RAP shall be established in the mixture design phase according to ODOT TM 323 and AASHTO T 308 or other method if approved by the Engineer. Additional testing may be requested at any time by the Agency or the Contractor during the production of the RAP mixture to verify the amount of asphalt cement in the RAP. Conduct new tests by a laboratory mutually agreed upon by the Agency and the Contractor. The cost of additional testing will be paid for by the party requesting the testing.

Materials

00745.10 Aggregate - Produce and stockpile aggregate as follows:

When requested by the Engineer, supervisory personnel of the Contractor and any subcontractors who are to be involved in HMAC aggregate crushing shall meet with the Engineer at a mutually agreed upon time to discuss accomplishing all phases of the crushing work.

Produce and stockpile new aggregates and RAP aggregates according to the following requirements:

(a) General - Produce and stockpile aggregate as follows:

(1) Separated Sizes - Advise the Engineer of the separated size(s) of coarse and fine aggregate that will be used and the proposed targets for each individual sieve size for each stockpile. If the Contractor wishes to produce coarse and fine aggregates in separated sizes other than those specified, request the proposed size changes in writing, and state the proposed target value and specified tolerance for each of the individual sieve sizes of the proposed materials.

The number of fine aggregate separated sizes selected by the Contractor does not relieve the Contractor of providing a JMF and producing HMAC meeting the air voids, VMA, and VFA requirements of 00745.13(b) and 00745.16(b-1-a). Any recrushing, rescreening, or other special processing of the fine aggregates necessary to achieve the air voids, VMA, or VFA requirements will be at the expense of the Contractor.

(2) **Scalping** - Scalp the rock on a 19.0 mm (3/4 inch) sieve screen deck (after it has passed through the primary crusher if quarry rock is used). The material remaining may be accepted for use by visual inspection. The Engineer may perform verification testing of the gradation. The material shall meet the following:

Sieve Size	Percent Passing, by Mass (Weight)
200 mm (8")	95-100
19.0 mm (3/4")	5 Max.

(3) **Soundness** - Provide coarse and fine aggregate with a weighted loss not exceeding 12% when subjected to five cycles of the soundness test using sodium sulfate solution according to AASHTO T104.

(4) **Durability** - Provide aggregate not exceeding the following maximum values:

Test	Test Method		Aggregates	
	ODOT	AASHTO	Coarse	Fine
Abrasion Degradation		T 96	30.0%	
Passing 850µm (No. 20) sieve	TM 208		30.0%	30.0%
Sediment height	TM 208		75 mm (3")	100 mm (4")

(5) **Fractured Faces** - Provide crushed aggregate with not less than the minimum number of fractured faces as determined by WAQTC TM 1 as follows:

Type of Mix	Percent of Fracture (by Weight)	
	Material Retained on 1 1/2", 1", 3/4", 1/2" and No. 4 Sieve (two fractured faces)	Material Retained on No. 8 sieve (one fractured face)
All Dense Graded HMAC, ATPB	75	75
All Open Graded HMAC	90	75

(6) **Harmful substances** - Do not exceed the following values:

Test	Test Method		Aggregates	
	ODOT	AASHTO	Coarse	Fine
Lightweight pieces		T 113	1.0%	
Wood Particles	TM 225		0.10%	
Elongated Pieces (at a ratio of 5:1)	TM 229		10.0%	
Plasticity Index		T 90		0 or NP
Sand Equivalent		T176		45 min. ¹

¹ 50 min. for Level 4 HMAC

(b) Coarse Aggregate - Provide coarse aggregate meeting the following:

(1) General Requirements - Produce coarse aggregate from crushed rock or other inert material of similar characteristics.

(2) Separated Sizes - Allowable separated sizes of coarse aggregate are as follows:

Type of Asphalt Concrete Mixture	Allowable Separated Sizes (inch)			
	1 1/4 - 3/4	3/4 - No. 4	3/4 - 1/2	1/2 - No. 4
1"	Yes	Yes	Yes	Yes
3/4" Dense, Open and ATPB	-	Yes	Yes	Yes
1/2" Dense and Open	-	-	-	Yes

(3) Grading - Determine sieve analysis according to AASHTO T 27 and T 11. Establish the target values for each allowable separated size after a maximum of two shifts have been produced. Produce the aggregate within the following listed tolerances (T):

Sieve Size	Separated Sizes (inch)			
	1 1/4 - 3/4	3/4 - No. 4	3/4 - 1/2	1/2 - No. 4
	Percent Passing (by Weight)			
	T	T	T	T
1 1/2"	-1	-	-	-
1 1/4"	±5	-	-	-
1"	±10	-1	-1	-
3/4"	±5	±5	±7	-1
1/2"	-	±8	±8	±5
3/8"	-	±8	±8	±8
No. 4	±3	±8	±8	±8
No. 8	-	±5	±5	±5
No. 30	±1	±3	±3	±3
No 200	-	±1.0	±1.0	±1.0

(c) **Fine Aggregate** - Provide fine aggregate meeting the following:

(1) **General** - Produce fine aggregate from crushed rock or other inert material of similar characteristics and if permitted, blend sand.

(2) **Separated Sizes** - Allowable separated sizes for fine aggregates are:

METRIC	ENGLISH
4.75 mm - 0	No. 4 - 0
4.75 mm - 2.36 mm	No. 4 - No. 8
2.36 mm - 0	No. 8 - 0

(3) **Grading** - Determine sieve analysis according to AASHTO T 27 and T 11. Establish the target values for each allowable separate size after a maximum of two shifts have been produced. Produce the aggregate within the following listed tolerances (T):

Sieve Size	Separated Sizes		
	No. 4 - 0	No. 4 - No. 8	No. 8 - 0
	Percent passing (by Weight)		
	T	T	T
3/8"	-1	-1	-
No. 4	±7	±10	-1
No. 8	±7	±7	±10
No. 30	±7	±5	±8
No 200	±3.0	±2.0	±4.0

(4) Combination of Fine Aggregate for Testing - Blend together fine aggregate produced in two separated sizes at a 1:1 ratio when testing for fine degradation, and sand equivalent.

(5) Blend Sand - No natural or uncrushed blend sand will be allowed in Level 4 HMAC unless approved. Blend sand is permitted for Levels 1, 2, and 3 mixes. For these mixes, establish the target gradation and produce all material within the following tolerances (T):

Sieve Size		Percent Passing, by Mass (Weight)
METRIC	ENGLISH	T
9.5 mm	3/8"	-1
4.75 mm	No. 4	±5
2.36 mm	No. 8	±15
600 µm	No. 30	±20
75 µm	No. 200	±5.0

Do not blend more than 10% by mass (weight) of natural or uncrushed blend sand into the total fine aggregate to produce an allowable separated size unless approved. Provide a means of verifying and documenting the amount of blend sand added to the fine aggregate.

(d) RAP Aggregate - Use RAP aggregates in the HMAC, according to 00745.03, that are no larger than the specified maximum allowable aggregate size before entering the cold feed. Blend the RAP material with new aggregate to provide a mixture conforming to the JMF within the tolerances specified.

(e) Stockpiling - Prepare the ground for the stockpile site to prevent contamination. Prevent segregation and contamination, as much as possible, when stockpiling and removing the aggregate.

(f) Aggregate Production Quality Control - A CAgT shall perform sampling and testing of aggregates according to Section 00165 and the MFTP. Statistically evaluate the aggregates according to Section 00165. Sample before treating with hydrated lime, when lime is required.

(g) Preproduced Aggregate - Compliance of aggregates produced and stockpiled before the award date or notice to proceed of this Contract will be determined by (1) or (2) below. The material shall meet the requirements of 00745.10.

(1) Continuing production records meeting the requirements of Section 00165 and the MFTP.

(2) Sampling and testing of the entire stockpile according to Section 00165 and the MFTP.

00745.11 Asphalt Cement, Additives and Aggregate Treatment - Provide the following:

(a) Asphalt Cement - Use the grade of asphalt specified in the Contract Documents. Provide asphalt cement conforming to the requirement of ODOT's publication "Standard Specifications for Asphalt Materials". Copies of the publication are available from ODOT's Pavement Services Engineer. The applicable specifications are those contained in the current publication on the date the project is advertised.

(b) Asphalt Cement Additives - When required by the JMF, add antistripping additives meeting the requirements below and satisfying the Tensile Strength Ratio (TSR) specified in 00745.13.

Additives to prevent stripping or separation of asphalt coatings from aggregates, and admixtures used to aid in the mixing or use of asphalt mixes or for experimental purposes, shall be standard recognized products of known value for the intended purpose and approved for use on the basis of laboratory tests. They shall have no deleterious effect on the asphalt material and be completely miscible. Do not use silicones as an additive.

(c) Aggregate Treatment - When lime treated aggregate is specified in the Contract Documents or required to satisfy the TSR specified in 00745.13, treat new crushed aggregates, except those in RAP materials, with dry hydrated lime meeting the requirements of ASTM C1097. Treat aggregate as follows:

(1) General:

- a. Mix the hydrated lime, water, and aggregate thoroughly in a pug-mill.
- b. Determine the quantity of lime in aggregate for each subplot according to ODOT TM 321.

If the rates of application specified in 00745.11(c-2-b) are not met, take corrective action. Document the corrective action and notify the Engineer.

(2) Treatment During HMAC Production:

- a. Mix dry lime, water (if necessary to achieve SDC), and aggregates thoroughly in a pug-mill before they enter the paving plant dryer.
- b. Proportions of hydrated lime and aggregate moisture (percents by mass (weight) of dry aggregates):

	Dense	Open
Hydrated Lime (%)	1.0	0.7
Lime Tolerance (%)	-0.2/+0.5	-0.2/+0.5
Moisture Content of Aggregate	SDC	SDC

00745.12 Mix Type and Broadband Limits - Mix type and broadband limits shall meet the following:

(a) Mix Type - Furnish the type(s) of HMAC shown or as directed. The broadband limits for each of the mix types are specified in (b) below. When the plans allow an option of two types for a course of pavement, use only one type throughout the course.

(b) Broadband Limits - Provide a JMF for the specified mix type within the control points listed below:

Open Graded Mixes

Sieve Size	1/2" Open		3/4" Open		3/4" ATPB	
	Control Points (% passing by Weight)		Control Points (% passing by Weight)		Control Points (% passing by Weight)	
	Min.	Max.	Min.	Max.	Min.	Max.
1"			99	100	99	100
3/4"	99	100	85	96	85	95
1/2"	90	98	55	71	35	68
No. 4	18	32	10	24	2	10
No. 8	3	15	6	16	0	5
No. 200	1.0	5.0	1.0	6.0	0.0	2.0
Asphalt	*	*	*	*	2.5	3.5
Cement						

* Per JMF

00745.13 Job Mix Formula (JMF) Requirements - Do not begin production of HMAC for use on the project until the JMF is reviewed by the Engineer and written consent is provided to proceed. The JMF proposed for use on the project will be evaluated based on the criteria set forth in 00745.13(b) and (c) and the ODOT Contractor Mix Design Guidelines for Asphalt Concrete. For all mixes, complete TSR testing at least once per calendar year on mix from the first week of production of that JMF for that year. A new JMF is required if the asphalt cement grade, any additives, or the source of the aggregate or RAP change during production. A change in the source of asphalt cement requires a new JMF for open-graded HMAC, but only a new passing TSR for dense graded HMAC.

Provide a range of proposed JMF targets to the CMDT. The CMDT will select targets from within the proposed range if all of the JMF requirements set forth in 00745.13(b) are met.

(a) Contractor Provided JMF - The CMDT shall prepare, sign and submit a JMF to the Engineer for each mixture required at least 10 calendar days prior to the anticipated use in HMAC, and according to the latest copy of the ODOT Contractor Mix Design Guidelines for Asphalt Concrete. If requested, submit material samples 10 calendar days prior to use.

(b) JMF Requirements - The JMF shall meet the following mixture requirements:

Open Graded Mixture

	3/4" Open and 1/2" Open	3/4" ATPB
Design Method	ODOT	ODOT
Air Voids, %	13.5 - 16.0	-
Draindown, %	70 - 80	-
TSR *, minimum	80	-
Coating, %, minimum	-	90
VFA, %	40 - 50	

* Run the TSR for open-graded mixtures on a surrogate dense graded mixture. If a dense graded JMF has been prepared for the same material sources in the last year, the results for the most recent TSR may be applied to the open-graded mixture. If not, prepare the TSR test samples for a dense graded mix using the equivalent top size stone and materials from the same sources, which will represent the open-graded mixture.

(c) Performance Test - For dense graded Level 3 wearing course mixes and all dense graded Level 4 mixes, the mix design submittal shall include the results of performance testing as outlined in the ODOT Contractor Mix Design Guidelines for Asphalt Concrete.

00745.14 Tolerances and Limits - For gradation, measure the sieves with a weighting factor of one or more according to 00745.95. Produce and place HMAC within the following JMF tolerances and limits:

Gradation Constituent	Dense-Graded HMAC Type				Open-Graded HMAC Type		
	1 "	3/4"	1/2"	3/8"	3/4"	1/2"	ATPB
1 1/2"	JMF ±5%*						
1"	90 - 100%	JMF ±5%*			99 - 100%		99 - 100%
3/4"	JMF ±5%	90 - 100%	JMF ±5%*		85 - 96%	99 - 100%	85 - 95%
1/2"	JMF ±5%	JMF ±5%	90 - 100%	JMF ±5%*	55 - 71%	90 - 98%	35 - 68%
3/8"	-	-	-	90 - 100%	-	-	-
No. 4	JMF ±5%	JMF ±5%	JMF ±5%	JMF ±5%	JMF ±5%	JMF ±5%	JMF ±5%
No. 8	JMF ±4%	JMF ±4%	JMF ±4%	JMF ±4%	JMF ±4%	JMF ±4%	JMF ±4%
No. 30	JMF ±4%	JMF ±4%	JMF ±4%	JMF ±4%	JMF ±4%	JMF ±4%	-
No. 200	JMF ±2.0%	JMF ±2.0%	JMF ±2.0%	JMF ±2.0%	JMF ±2.0%	JMF ±2.0%	JMF ±2.0%

* Maximum not to exceed 100%

Constituent of Mixture	HMAC All Types
Asphalt Cement - ODOT TM 321 (Cold Feed/Meter)	JMF± 0.20%
Asphalt Cement - AASHTO T 308 (Ignition) and ODOT TM 323	JMF± 0.50%
RAP Content - ODOT TM 321	JMF± 2.0%
Moisture content at time of discharge from the mixing plant - WAQTC TM 6	
Open-graded *	1.10% max.
Dense-graded	0.80% max.

* Does not apply to 19 mm (3/4") ATPB

When a JMF tolerance applies to a constituent, full tolerance will be given even if it exceeds the Control Points established in 745.12(b).

Take corrective action when the RAP content exceeds the above tolerance. If the RAP content continues to be outside tolerance, stop production until a plan for corrective action is approved by the Engineer.

00745.16 HMAC Production QC/QA - The following provisions apply to all HMAC:

(a) Quality Control - Provide and maintain a quality control program as defined in Section 00165, the MFTP and according to the following:

(1) Personnel Requirements - Maintain quality control by:

- Obtaining samples under the direct supervision of a CAT-I
- Having all testing, data analysis and reporting of test results performed by a CAT-I or an assistant technician under the direct supervision of the CAT-I
- Having a CAT-II available to make necessary process adjustments

(2) Laboratory Requirements - Furnish and maintain an ODOT certified quality control laboratory. Furnish the laboratory with the necessary equipment and supplies for performing Contractor quality control testing. Calibrate all testing equipment according to the required test methods. The Engineer may inspect measuring and testing devices to confirm both calibration and condition.

The laboratory shall be operational prior to the beginning of HMAC production and be equipped with a telephone or cellular telephone, if either service is available. Provide laboratory equipment meeting the requirements of the applicable test methods identified in these Specifications and selected for use on the project.

(3) HMAC Production Sampling and Testing - Perform sampling and testing according to Section 00165 and the MFTP.

(4) Testing Frequency - Conduct the above testing program, once for each subplot, on randomly selected samples for each design mixture. (Do not obtain the first sample of the day in the first 25 Mg (25 tons) of production.) If the random number indicates that the sample is to be obtained in the first 25 Mg (25 tons), sample at 25 Mg (25 tons). In addition, test the asphalt content at least once during each day of production. This requirement may be waived by the Engineer.

After the Mix Design Verification (MDV) testing requirements of 00745.16(b) have been met, the frequency for Maximum Specific Gravity (AASHTO T209) testing may be reduced to only the first subplot produced each day, or a minimum of one test per day. Provide "QC Program" sampling and testing frequencies (random numbers) to the Engineer prior to production. Provide QC test results to the Engineer by the middle of the following work shift.

When the Statistical Evaluation Method of 00745.95 is used, stop production when the pay factor for any constituent with a weighting factor greater than one falls below 0.75. Resume production when a plan for correction is accepted by the Engineer.

(b) Mix Design Verification (MDV):

(1) MDV Quality Control:

a. General - Perform MDV testing on projects with Level 3 or Level 4 dense graded HMAC and at least once per calendar year for each JMF. If MDV testing has been completed for the JMF previously, submit verification to the Engineer.

Perform MDV tests on every subplot and as required at start up according to 00745.16(b-1-c) and the MFTP. Perform gradation and asphalt content testing with each MDV test. Calculate the following values for each MDV test.

- Air Voids
- Voids in Mineral Aggregate (VMA)
- Voids Filled with Asphalt (VFA)

MDV testing may be discontinued when at least two running averages of four MDV results are within the limits given below:

	Average of	Limit
Air Voids	4 samples	JMF Target -0.5%/+1.5%
VMA	4 samples	11.5 - 18.0 (1" Mix) 12.5 - 18.0 (3/4" Mix) 13.5 - 18.0 (1/2" Mix) 14.5 - 18.0 (3/8" Mix)
VFA	4 samples	65 - 75

Restart MDV testing when any individual Maximum Specific Gravity test deviates from the last (MAMD divided by 1000 kg/m³ (62.4 lb/ft³)) by 0.020 or more. Begin retesting according to the start-up MDV requirements of 00745.16(b-1-c). MDV testing may be discontinued again when the above criteria is met.

The CDT shall provide the results from the initial control strip to the CAT II for evaluation and comparison with the MDV results. If the MDV and density test results are contradictory, initiate an investigation. The CAT II shall recommend a plan to the Engineer for resolving the discrepancy based on the results of the investigation.

Perform a Tensile Strength Ratio (TSR) test (AASHTO T 283) on a sample obtained during the first two days of production after QC test results verify that HMAC constituents with a weighting factor greater than one according to 00745.95 are in tolerance. Provide test results to the Engineer within four working days of obtaining the sample. The TSR shall be within 20 points of the value reported on the JMF. Stop production and make adjustments if the TSR is 20 points or more lower than the design value. Restart production only after the Engineer has approved the proposed adjustments. Take corrective action when required by the MDV start-up process of 00745.16(b-1-c).

After the requirements of 00745.16(b-1-c) have been met, take corrective action if the MDV test results show that two consecutive individual samples are outside the above limits for air voids, VMA, or VFA. Document the corrective action and notify the Engineer. If test results continue to be outside the tolerance, stop production and make adjustments. Restart production only after the Engineer has approved the proposed adjustments. If the MDV test results are outside tolerance, but the mixture meets the current requirements for gradation and asphalt content, an adjustment to the JMF targets is required. Do not start a new lot as a result of the adjustment.

A request for an adjustment to the JMF targets may be made to the Engineer by the Contractor's CAT-II. The requested change will be reviewed and documented by the Engineer. If acceptable, a revised JMF will be allowed. Clearly document the subplot test for which the adjusted targets are in effect. Adjustments for gradation shall not exceed the tolerances specified for the original JMF limits. Adjustments for AC content shall be within 0.5% of the original JMF. The JMF asphalt content may only be reduced if the production VMA meets or exceeds the above requirements. Adjustments for RAP content shall be within 5% of the original JMF, but shall not exceed the requirements of 00745.03. Regardless of these tolerances, the adjusted JMF shall be within the mixture specification control points of 00745.12. If a redesign of the mixture becomes necessary, submit a new JMF according to the requirements of these Specifications.

b. Laboratory Compactor Selection - Use a Gyratory compactor for MDV when a Gyratory compactor is used to develop the JMF. For all other cases, use a Gyratory compactor or Marshall compactor, as selected by the Contractor.

c. MDV Requirements at Start-Up - Conduct gradation and asphalt content tests for each MDV test. Perform MDV testing at the start-up of the JMF production according to the following process:

- 1.** Obtain a sample during the first 100 Mg (100 tons) of production and immediately perform MDV testing.

2. If air voids and VMA are within tolerance, then continue remaining MDV testing at the established random QC subplot interval until requirements of 00745.16(b-1) are met. If not, then go to step "3".

3. If air voids and/or VMA are out of tolerance according to 00745.16(b-1-a), then make adjustments and immediately obtain another sample and perform MDV testing. Go to step "4".

4. If air voids and VMA from the MDV testing in step "3" are within tolerance, then continue remaining MDV testing at the established random QC subplot interval until requirements of 00745.16(b-1) are met. If not, go to step "5".

5. If air voids from step "3" are more than plus or minus 1.5% from the target, then stop production immediately and make adjustments. If they are not, then go to step "6". Obtain approval of the Engineer before restarting production. Begin MDV testing again at step "1".

6. If air voids from step "3" are out of tolerance and 1.5% or less from the target, or the VMA from step "3" is out of tolerance, then make adjustments and immediately obtain another sample and perform MDV testing. Go to step "4".

Use the initial MDV sample as the first random QC subplot test. Subsequent MDV samples required due to failure of start-up criteria will be used for a subplot QC test if the sample is taken within 100 Mg (100 tons) of the scheduled random QC sample location. If not, the MDV testing shall be performed separate from, and not included in, the random QC testing program. All required MDV testing will be completed at the Contractor's expense.

(2) MDV Quality Assurance - The Engineer will observe and document the Contractor's performing of MDV test procedures and calculations. Immediately correct any deviations from the specified test procedures. The Engineer may conduct MDV assurance testing at any time.

(c) Quality Assurance and Acceptance - Any quality assurance testing for Level 1 and Level 2 HMAC will be at the discretion of the Engineer. The Agency will provide quality assurance according to Section 00165 for Level 3 and Level 4 HMAC. When QA testing is performed, the Contractor's quality control results will be used for acceptance if they are within acceptable limits of the QA test results as defined by ODOT's Quality Assurance Program.

00745.17 Small Quantity Acceptance - When less than three test results are obtained on a project, the HMAC will be accepted according to the following:

(a) Within Specification Limits - If all subplot sample test results are within specification limits for all constituents (including compaction) the material will be accepted and the full bid price will be paid for the material represented by that test.

(b) Outside Specification Limits - If a subplot sample test result for any constituent is outside the specification limit the Engineer will have the backup sample tested.

(1) Backup Within Specifications - If the backup sample test results for all constituents are within specification, the material will be accepted and the full bid price will be paid for the material represented by that test.

(2) Backup Out of Specifications - If the backup sample test results are out of specification, the Contractor may choose to accept the price adjustment calculated according to 00745.95 or may choose to sample the in-place material for further testing. The price adjustments will be computed using all original test results as well as all backup test results. (If there are less than three tests, average the two tests you have and use the average as the third test result). In no case will the composite pay factor (CPF) be greater than 1.0.

(3) In-Place Samples - If the in-place material is sampled, the Engineer will select and sample from three random locations from the area represented by the lot in question. Those samples will be tested and if found to be within specification the material will be accepted and paid for at the full bid price. If the material proves to be outside of the specification limits, the material will be accepted and paid for at an adjusted price according to 00745.95. In no case will the CPF be above 1.0.

Equipment

00745.20 Lime Treated Aggregate Plant - When lime treated aggregate is specified, provide a mixing plant that includes:

(a) Pug Mill - A pug mill that mixes the aggregate and lime until the aggregate is uniformly coated and the lime is distributed throughout the aggregate.

(b) Lime Metering Device - A lime metering or weighing device that determines the amount of lime incorporated within any selected time period. Provide a device that is of sufficient accuracy to supply lime within the tolerances specified in 00745.11(c).

00745.21 HMAC Mixing Plant - Provide HMAC plants that comply with the following:

(a) DEQ Permits - Before producing HMAC for this Contract at a new or revised plant location, provide the Engineer with copies of all permits according to 00160.70.

(b) Scales - Provide required scales to assure a uniform mixture. Check and adjust scales according to 00190.30.

(c) Vibratory Scalping Devices - Provide vibratory scalping devices ahead of the mixer to reject aggregate, RAP and lumps of cemented material that are detrimental to the mix.

(d) Asphalt Antistrip Additive Metering Device - When asphalt antistrip additive is added into the asphalt at the HMAC mixing plant, provide a means to weigh or meter the additive at a specified rate that has an accuracy of plus or minus 0.5%.

(e) Thermometers - Provide the following:

- A direct reading, full operating range thermometer in the asphalt feed line near the mixer unit
- A thermometric instrument that automatically registers the temperature of the materials at the discharge of the mixer

(f) Sampling Devices - Provide and operate a device that produces a representative sample of the quantity of material required for the appropriate tests when sampling at or around crushing, screening or mixing plants.

00745.22 Hauling Equipment - Provide hauling vehicles in good operating condition with tight, clean, smooth beds. Coat the beds with a minimum amount of an approved material to keep the HMAC from sticking to the beds. Do not use diesel oil. Drain excess coating material before loading by raising the truck bed, opening belly dump gates, or operating the conveyor belt, as appropriate.

00745.23 HMAC Pavers - Pavers shall comply with the following:

(a) Power and Support - Self-contained, self-propelled, supported on tracks or wheels, none of which contact the mixture being placed.

(b) Augers and Screed - Equipped with augers and a screed or strike-off assembly, heated if necessary, which:

- Can spread and finish the HMAC to a uniform texture, in the specified widths, thicknesses, lines, grades and cross sections
- Will not segregate, tear, shove or gouge the HMAC

(c) Control System - Equipped with a paver control system which:

- Controls the HMAC placement to specified slope and grade
- Maintains the paver screed in proper position
- Provides the specified results through mechanical sensors and sensor-directed devices actuated from independent line and grade control references

(d) Illumination - Provide adequate lighting to illuminate the paver and the roadway in front of and behind the paver during the period from 30 minutes after sunset to 30 minutes before sunrise, or as deemed necessary by the Engineer. Shield lighting from adjacent traffic as necessary. Provide a minimum light level of 100 lx (10 footcandles) as measured by the Engineer on the roadway surface at a distance of 5 m (16 feet) from the front and back edges of the paver.

00745.24 Compactors - Provide the specified self-propelled rollers capable of reversing without backlash, as follows:

(a) Steel-Wheeled Rollers - Steel-wheeled rollers shall have:

- A gross static mass (weight) of at least 7 Mg (8 tons)
If steel-wheeled rollers are used for finish rolling, they shall have:
- A gross static mass (weight) of at least 5.4 Mg (6 tons)

(b) Vibratory Rollers - Vibratory rollers shall be:

- Equipped with amplitude and frequency controls
- Specifically designed to compact HMA
- Capable of at least 2000 vibrations per minute
- Have a gross static mass (weight) of at least 7 Mg (8 tons)

Do not operate in vibratory mode for lifts thinner than two times the maximum aggregate size for the type of HMA being compacted.

If vibratory rollers are used for finish rolling, they shall:

- Have a gross static mass (weight) of at least 5.4 Mg (6 tons)
- Not be operated in the vibratory mode

(c) Pneumatic-tired Rollers - Pneumatic-tired rollers shall:

- Be tandem, or multiple axle, multiple wheel type
- Have smooth-tread, pneumatic tires of equal size
- Have tires staggered on the axles, spaced and overlapped to provide uniform compacting pressure for the full compacting width
- Have a minimum total load of 1.27 Mg (2,800 pounds) per tire with tire inflation pressures of 0.31 to 0.62 MPa (45 to 90 psi)
- Be fully skirted to reduce tire heat loss and mixture pick up

(d) Illumination - Provide adequate lighting to illuminate each compactor and the roadway in front of and behind each compactor during the period 30 minutes after sunset to 30 minutes before sunrise, or as deemed necessary by the Engineer. Shield lighting from adjacent traffic as necessary. Provide a minimum light level of 100 lx (10 footcandles) as measured by the Engineer on the roadway surface at a distance of 18 m (60 feet) from the front and back edges of each compactor.

Labor

00745.30 Quality Control Personnel - Provide certified technicians in the following fields:

- CAgT
- CAT-I
- CAT-II
- CDT
- CMDT

Construction

00745.40 Season and Temperature Limitations - Place HMAC during the dates indicated, and when the temperature of the surface that is to be paved is not less than the temperature indicated:

Nominal Compacted Thickness of Individual Lifts and Courses as shown on the typical section of the plans	All Levels	Level 1 and Level 2	Level 3 and Level 4	
	Travel Lane All Courses	Wearing Course	All Other Courses	
	Surface Temperature*	From To Inclusive	From To Inclusive	From To Inclusive
Open Graded Mixes				
Less than 50 mm (2")	15 °C (60 °F)	3/15 9/30	3/15 9/30	3/15 9/30
50 mm (2") and Over	10 °C (50 °F)	3/15 9/30	3/15 9/30	3/15 9/30
ATPB	5 °C (40 °F)	All Year	NA NA	All Year
Dense Graded Mixes				
Less than 40 mm (1 1/2")	15 °C (60 °F)	All Year**	3/15 9/30	All Year**
40 to 65 mm (1 1/2" - 2 1/2")	10 °C (50 °F)	All Year**	3/15 9/30	All Year**
66 mm (2 1/2") and Over	5 °C (40 °F)	All Year**	3/15 9/30	All Year**
Temporary	5 °C (40 °F)	All Year**	All Year**	All Year**

* Do not use field burners or other devices to heat the pavement surface to the specified minimum temperature unless approved.

** If placing HMAC between March 15 and September 30, temperature requirement may be lowered 3 °C (5 °F).

00745.41 Preparing Conference - Supervisory personnel of the Contractor, including any subcontractors who are to be involved in the paving work, shall meet with the Engineer at a mutually agreed time to discuss methods of accomplishing all phases of the paving work. A representative of the Contractor responsible for quality control on the project shall also attend for all Level 3 and Level 4 mixes where quantities exceed 5000 Mg (5,000 tons).

00745.42 Preparation of Underlying Surfaces - All bases and foundations on which the pavement is to be constructed shall meet the applicable Specifications and be approved prior to the start of paving. Recondition existing bases and foundations according to Section 00610. Trim broken or ragged edges to firm material when directed.

Treat all paved surfaces on and against which HMAC is to be placed with an asphalt tack coat, according to Section 00730. Immediately before applying the tack coat, clean and dry the surface to be tacked. Remove all material, loose or otherwise, that will reduce adhesion of the tack by brooming, flushing with water, or other approved methods.

Level and compact depressed areas with HMAC as specified or directed. Perform the leveling work as a separate operation and at the locations and to the extent as shown or directed. Spread the leveling material with a paving machine, unless otherwise directed.

Protect all existing structures from the overlay operation and check and clean as necessary after the overlay.

The pavement surface shall be dry prior to the preparation work and paving. Remove existing traffic buttons prior to paving.

00745.43 Drying and Heating Aggregates for HMAC:

(a) Burner Operation - Operate the burner used to heat the aggregates to completely burn the fuel so the aggregate and asphalt are not contaminated and the asphalt is suitably aged.

(b) Heating Temperatures - Establish the allowable mixing and placement temperature ranges by the JMF. Measure the mixture temperature at the discharge of the mixer. Measure the placement temperature behind the paver. The allowable production temperatures may be adjusted based on the asphalt cement supplier’s recommendation if approved by the Engineer. The maximum mixture temperature of the HMAC and the minimum placement temperature shall be as follows:

Grading	AC Temperature, °C (°F)	
	Maximum at Mixer	Minimum Behind Paver
Dense	175 (350)	115 (240)
Open	175 (350)	95 (205)

Within the above limits, the Contractor (with approval of the Engineer) or the Engineer may adjust this temperature in 5 _C (10 _F) increments from the JMF as follows:

- **Up** - If the aggregate coating, moisture content, workability or compaction requirements are not attained.
- **Down** - If the aggregate coating, moisture content, workability and compaction requirements are attained.

00745.45 HMAC Storage - Temporary storing or holding of hot HMAC in storage silos will be permitted if the Contractor complies with the following:

(a) Flow Diverter - Provide a device to divert the flow of HMAC away from the silo when starting or stopping plant production, or at any other time necessary, so improperly proportioned mixture or incompletely mixed portions of the mixture do not enter the silo.

(b) Batcher - Equip storage silos with a batcher, rotating chute, or similar device to prevent segregation of HMAC as it enters the silo.

(c) Unheated Silos - Store HMAC in unheated silos only when the total elapsed time from the mixing to placing is less than six hours.

(d) Heated Silos - Store HMAC in heated, insulated silos no more than 72 hours only if an atmosphere is maintained in the silo at all times which prevents damage to the mixture or asphalt properties.

(e) Discharging AC and Loading Trucks - Discharge the HMAC and load trucks so segregation is prevented. If the HMAC is segregated, dispose of unsuitable HMAC at the Contractor's expense, and stop temporary storage of the HMAC.

00745.46 Control of Line and Grade - Use a floating beam device of adequate length and sensitivity to control the grade of the paver. Where this method is impractical, manual control of grade will be permitted when approved.

00745.48 Hauling, Depositing and Placing - Haul, deposit, and place HMAC as follows:

(a) Hauling - Cover HMAC if rain or cold air temperatures are encountered any time between loading and placement.

HMAC will be rejected before placing if one or more of the following is found:

- Below specified placing temperature limit
- Slumping or separating
- Solidifying or crusting
- Absorbing moisture

Dispose of rejected loads at the Contractor's expense.

Deliver the mixture to the paving machine at a rate that provides continuous operation of the paving machine, except for unavoidable delay or breakdown. If excessive stopping of the paving machine occurs during paving operations, the Engineer may suspend paving operations until the mixture delivery rate matches the paving machine operation.

(b) Depositing - Deposit HMAC from the hauling vehicles so segregation is prevented.

When HMAC is windrowed, the pick-up equipment shall:

- Pick up substantially all of the HMAC deposited on the roadway
- Be self-supporting, not exerting any vertical load on the paving machine, nor causing vibrations or other motions which could have a harmful effect on the riding quality of the completed pavement

(c) Placing - Alternative equipment and means may be allowed by the Engineer if the use of a paver is impractical.

Do not place HMAC during rain or other adverse weather conditions, unless allowed by the Engineer.

- HMAC in transit at the time adverse conditions occur may be placed if:
- It has been covered during transit
- The HMAC temperature is satisfactory
- It is placed on a foundation free from pools or flow of water
- All other requirements are met

When leveling irregular surfaces and raising low areas, do not exceed 50 mm (2 inches) actual compacted thickness of any one lift, except the actual compacted thickness of intermittent areas of 100 m² (1,000 square feet) or less may exceed 50 mm (2 inches), but not more than 100 mm (4 inches). This may require portions of the mixture to be laid in two or more lifts.

Place the mixture in the number of lifts and courses, and to the compacted thickness for each lift and course, as shown. Place each course in one lift unless otherwise specified.

Do not exceed a compacted thickness of 100 mm (4 inches) for any lift. Limit the minimum lift thickness to twice the maximum aggregate size in the mix.

Do not intermingle HMAC produced from more than one JMF. Each base course panel placed during a working shift shall conform to a single JMF. The wearing course shall conform to a single JMF, except for adjustments in the JMF according to 00745.16(b-1).

00745.49 Compaction, QC - Provide a technician certified in density testing (CDT).

(a) General - Immediately after the HMAC has been spread, struck off, and surface irregularities and other defects remedied, roll it uniformly until compacted as specified.

(1) Temperature - Complete breakdown and intermediate compaction before the HMAC temperature drops below 80 °C (180 °F), unless otherwise directed or required based on the control strip. When the rolling causes tearing, displacement, cracking or shoving, make necessary changes in compaction temperature, type of compaction equipment, and rolling procedures.

(2) Rolling - Compact the HMAC with rollers conforming to 00745.24. Provide sufficient rollers of the types appropriate to compact the mixture while it is still within the specified temperature. Do not use equipment which crushes the aggregate. Do not displace the line and grade of edges.

Moisten steel roller wheels with a minimum amount of water, or other approved material, necessary to prevent the HMAC from sticking to them and spotting or defacing the HMAC.

Operate rollers at a slow, uniform speed recommended by the manufacturer. Drive rolls or wheels shall be nearest the paver unless otherwise approved. Operate pneumatic rollers no faster than 5 km/h (3 mph). Operate vibratory rollers at frequencies of at least 2000 vibrations per minute.

Begin rolling at the sides and proceed longitudinally, parallel to the road centerline, gradually progressing to the center, unless otherwise directed. On superelevated curves, begin rolling at the low side and progress to the high side. When paving in echelon, or when abutting a previously placed lane, roll the longitudinal joint first, followed by the

regular rolling pattern. Do not make sharp turns or park rollers on hot HMAC. Stop each pass at least 1.5 m (5 feet) longitudinally from preceding stops.

Perform finish rolling with rollers meeting the requirements of 00745.24(a) or 00745.24(b), and continue until all roller marks are eliminated.

(b) Normal Pavement (Nominal Thickness 50 mm (2 Inches) or Greater):

(1) General - Compliance with the density specifications for dense graded HMAC shall be determined by random testing of the compacted road surface with calibrated nuclear gauges. Use the MAMD method of compaction measurement unless the control strip method is approved by the Engineer.

For Level 3 and Level 4 mixes, construct a control strip at the beginning of work on each JMF on the project according to ODOT TM 306. The purpose of the control strip is to determine the maximum density that can be achieved for the JMF, paving conditions, and equipment on the project, and to establish a target density when the control strip method of compaction is allowed by the Engineer.

A pneumatic tired roller is not required for Level 1 and Level 2 HMAC. The Contractor shall have at least one available pneumatic tired roller conforming to 00745.24(c) on the project and in good operating condition for Level 3 and Level 4 HMAC.

The CDT shall notify the Engineer and CAT II when the average density for a subplot exceeds 95% of MAMD. Initiate an investigation to determine if the results indicate that a problem with the mix is developing. An adjustment to the JMF will not be allowed unless MDV testing supports a required change.

(2) Random Testing - Determine the density of each subplot by averaging five QC tests performed at random locations with the nuclear gauge operated in the backscatter mode. Lots and sublots shall correspond with those defined in 00745.02. In addition, perform at least one density test each day of production. The additional testing may be waived by the Engineer.

a. Testing - After completion of the finish rolling, test according to WAQTC TM 8. Do not locate the center of a density test less than 0.3 m (1 foot) from the panel edge. Complete density testing before traffic is allowed on the new mat.

b. Core Correlation of Nuclear Gage Readings - When requested by the Contractor or Engineer, correlation of nuclear gauge readings shall be according to WAQTC TM 8. If correlations are requested, correlate each nuclear gauge used on the project. New correlations are required if the aggregate source or the asphalt cement source changes. Apply correlation factors to all nuclear gauge readings for all dense graded mixtures placed on the project. Cut the required cores and patch the core holes with dense graded HMAC.

Determine the core correlation factor according to WAQTC TM 8 and provide the results to the Engineer. Costs of the core correlation will be paid by the requesting party.

(3) Moving Average Maximum Density (MAMD) Method - The MAMD is the average of the current MDT and, if available, the four previous MDT's for the JMF used. Determine each MDT using the Gmm determined according to AASHTO T 209 and calculate the MAMD according to ODOT TM 305:

When this method is used, compact the HMAC to at least the percent of the MAMD applicable for the mix type and lift as follows:

Course of Construction	Level 1, Level 2, and Level 3 HMAC	Level 4 HMAC
First Lift	91.0 *	92.0
Single	91.0 *	92.0
All Other	92.0	92.0

* If any part of a lift requires 91.0%, the entire lift shall be 91.0%

When using the MAMD method, a new control strip will be required when there is a new JMF. The Engineer may waive the control strip for irregular areas or areas too small to establish a reasonable roller pattern.

(4) Control Strip Method - This method consists of constructing and testing a designated strip to establish optimum rolling procedures and target density. The target density is then used as a basis for acceptance of compaction of the HMAC.

a. Construction of Control Strip - When beginning work on each lift of pavement, construct one or more control strips that are:

- The length of the rolling pattern (maximum 150 m (500 feet))
- Part of the roadway
- Placed to the specified width and thickness
- Composed of the same materials as the rest of the lift
- Compacted with the same equipment as the rest of the lift

The first valid target density for each lift of pavement shall be applied to subplot density tests for previously placed pavement with the same JMF.

A target density is not valid if it is less than the percent of the MAMD in 00745.49(b-3) for the applicable mix type and lift. Construct a new control strip when:

- There is a new JMF
- 10 days of production have been accepted without construction of a new control strip
- A new lift of pavement is started

b. Establishing Target Density - Determine the target density of the control strip according to ODOT TM 306 and WAQTC TM 8 by averaging the final results of five density tests taken with a nuclear gauge at random sites within the control strip selected according to ODOT TM 306.

c. Compaction Requirement - Compact the HMAC mixture to a density of at least 98.0% of the target density.

d. Control of Operations - Stop paving if three consecutive control strips fail to achieve the target density. Take all necessary actions to resolve compaction problems. Do not resume paving without the approval of the Engineer.

(5) Test Results - Provide density results for the completed sublots to the Engineer by the middle of the following working shift.

(c) Thin Pavement:

(1) General - Compaction to a specified density will not be required for leveling, patches, or where the nominal compacted thickness of a course of dense graded mixtures will be less than 50 mm (2 inches).

(2) Projects With Less Than 1000 Mg (1,000 Tons) of HMAC - For all levels of HMAC, perform breakdown and intermediate rolling until the entire surface has been compacted by at least four coverages of the roller(s). Perform additional coverages, as directed, to obtain finish rolling of the HMAC.

(3) Projects With More Than 1000 Mg (1,000 Tons) of HMAC:

a. Level 1 HMAC - Perform breakdown and intermediate rolling until the entire surface has been compacted by at least four coverages of the roller(s). Perform additional coverages, as directed, to obtain finish rolling of the HMAC.

b. Level 2, Level 3, and Level 4 HMAC - Establish an optimum rolling pattern which results in the maximum achievable density for the JMF, paving conditions, and equipment on the project according to ODOT TM 301. In no case shall the optimum rolling pattern be less than four coverages of the roller(s).

Perform the optimum rolling pattern on all HMAC placed. Perform additional coverages as directed to obtain finish rolling of the HMAC.

(d) Open-graded HMAC - Compaction of open-graded HMAC to a specified density will not be required.

Use only steel-wheeled roller(s) for compaction. Continue the breakdown and intermediate rolling until the entire surface has been compacted with at least four coverages by the roller(s). Perform additional coverages, as directed, to obtain finish rolling of the HMAC.

(e) Other Areas:

(1) Compaction to a specified density will not be required on temporary surfacing (see 00745.50), guardrail flares, mailbox turnouts, road approaches and areas of restricted width (less than 2.4 m (8 feet) wide) or limited length, regardless of thickness.

Perform breakdown and intermediate rolling until the entire surface has been compacted with at least four coverages by the roller(s). Perform additional coverages, as directed, to obtain finish rolling of the HMAC.

(2) Along curbs and walls, on walks, irregular areas, and other areas not practically accessible to rollers conforming to 00745.24, compact the mixture with small, self-propelled rollers, mechanical tampers, hot hand tampers, or hand rollers. On depressed areas a trench roller may be used, or cleated compression strips may be used under the roller to transmit compression to the depressed area.

Temporary

00745.50 Temporary Surfacing Course - Provide HMAC for temporary surfacing that is a wellgraded, uniform, durable commercial mix. All new materials, or a combination of new materials and reclaimed materials, may be used, according to 00745.03. The Contractor is responsible for the quality of material furnished according to Section 00165. Mix used for temporary surfacing will not be eligible for price adjustment under 00745.95.

Maintenance

00745.60 Correction of Defects - Correct any defects in material and work, as directed, at the Contractor's expense. These include segregation of materials, non-uniform texture, fouled surfaces preventing full bond between successive spreads of mixture, and (a) through (d) below. No adjustment in Contract time will be made for corrective work.

(a) Boils and Slicks - Immediately remove and replace boils and slicks with suitable materials.

(b) Roller Damage to Surface - Immediately correct any displacement with the addition of fresh mixture, or by other approved methods regardless of thickness or course.

(c) Nonspecification Compaction - Immediately take corrective measures when it is determined that specified compaction density is not achieved.

(d) Other Defects - Remove and replace any HMAC that:

- Is loose, broken, or mixed with dirt
- Shows visually too much or too little asphalt
- Is defective in any way

Remove and replace HMAC defects, excesses or deficiencies at the Contractor's expense.

00745.61 Longitudinal Joints - At longitudinal joints, bond, compact and finish the new HMAC equal to the HMAC against which it is placed.

(a) Location - Place the HMAC in panel widths which hold the number of longitudinal joints to a minimum. Offset the longitudinal joints in one panel by at least 150 mm (6 inches) from the longitudinal joints in the panel immediately below.

(1) Base Course - Place base course longitudinal joints within 300 mm (12 inches) of the edge of a lane, or within 300 mm (12 inches) of the center of a lane, except in irregular areas, unless otherwise shown.

(2) Wearing Course - Longitudinal joints shall not occur within the width of a traffic lane. They shall be located at either skip lines or fog lines unless approved by the Engineer. On median lanes and on shoulder areas the joints shall occur only at lane lines or at points of change in the transverse slopes, as shown or as directed.

(b) Drop-offs:

- Provide warning signs and markings according to Section 00225 where abrupt or sloped edge drop-offs 25 mm (1 inch) or more in height occur
- Protect edges from being broken down

If unable to complete the pavement without drop-offs according to 00745.61(c) do the following:

- Construct and maintain a wedge of HMAC at a slope of 1V:10H or flatter along the exposed longitudinal joint
- Remove and dispose of the wedge before continuing paving operations
- Construct, maintain, remove and dispose of the temporary wedge at no expense to the Agency, except that HMAC for the temporary wedge will be paid for at the pay item price

(c) Placing HMAC Under Traffic - When placing HMAC pavement under traffic, schedule work for the nominal thickness being laid as follows:

(1) More Than 50 mm (2 Inches) - Schedule work so at the end of each working shift the full width of the area being paved, including shoulders, is completed to the same elevation with no longitudinal drop-offs.

(2) Less Than or equal to 50 mm (2 Inches) - Schedule work so that at the end of each working shift one panel of new travel lane pavement does not extend beyond the adjoining panel of new travel lane pavement more than the distance normally covered by each shift. At the end of each workweek complete the full width of the area to be paved, including shoulders, to the same elevation with no longitudinal drop-offs.

00745.62 Transverse Joints:

(a) Travel Lanes - Construct transverse joints on the travel lane portion of all specified pavement courses, except leveling courses, as follows:

(1) Temporary End Panel - Maintain pavement depth, line and grade at least 1.2 m (4 feet) beyond the selected transverse joint location, and from that point, wedge down on the appropriate slope until the top of the course being laid meets the underlying surface (assuming a pavement course thickness of 50 mm (2 inches)) as follows:

- For wedges that will be under traffic for less than 24 hours, construct a 2.5 m (8 foot) long wedge (1V:50H taper rate)
- For wedges that will be under traffic for 24 hours or longer, construct an 8.0 m (25 foot) long wedge (1V:160H taper rate)
- Construct, maintain, remove and dispose of the temporary wedge at no expense to the Agency. HMAC for the temporary wedge will be paid for at the pay item price.

When the pavement course thickness is different than the above 50 mm (2 inch) example, use the appropriate taper rate to compute the length of the wedge. The wedge length plus the 1.2 m (4 feet) or longer panel form the "temporary end panel".

(2) Vertical Face - After the mixture has reached the required density:

- Provide a smooth, vertical face the full depth of the course being laid at the location selected for the joint by sawing, cutting or other approved method
- Remove the HMAC material from the joint to the end of the panel. If removed before resuming paving beyond the joint, reconstruct the temporary end panel immediately by placing a bond-breaker of paper, dust, or other suitable material against the vertical face and on the surface to be occupied by the temporary end panel. Construct a full-depth panel at least 1.2 m (4 feet) long, beginning at the sawed or cut joint, and taper it on a 1V:50H slope to zero thickness.

(3) Excess HMAC - After completing a temporary end panel as specified, dispose of unused, remaining HMAC as directed. Payment will be made for the entire load of HMAC, but will be limited to only one load per joint per panel.

(4) Resume Paving - When permanent paving resumes, remove the temporary end panel and any bond-breakers. Clean the surface of all debris and apply a tack coat to the vertical edge and the surface to be paved.

(5) Joint Requirements - Compact both sides of the joint to the specified density. When tested with a straightedge placed across the joint, the joint surface shall conform to the specified surface tolerances.

(b) Abutting Bridge Ends - Compact the HMAC abutting bridge ends and other rigid type structures in the transverse and/or diagonal direction, as well as longitudinally, as directed.

(c) Bridge Deck Overlays - Saw cut the wearing course of pavement directly over the joints in bridge decks, bridge end joints and end panel end joints as soon as practical but within 48 hours of paving each stage of the wearing course, unless otherwise directed. The saw cut shall be 9 mm (3/8 inch) wide, plus or minus 3 mm (1/8 inch), and 13 mm

(1/2 inch) less than the thickness of the panel of pavement, to a maximum depth of 40 mm (1 1/2 inches).

Flush the saw cut thoroughly with a high-pressure water stream immediately after the cut has been made. Before the cut dries out, blow it free of water and debris with compressed air. Fill the joint with a poured filler from the QPL. No separate payment will be made for this work.

Finishing and Cleaning Up

00745.70 Pavement Smoothness - Furnish a 3.6 m (12 foot) straightedge and/or 3.6 m (12 foot) rolling straightedge, and test as specified. Additional testing may be required. Mark areas not meeting the surface tolerance.

(a) Level 1 and Level 2 HMAC - Test with the 3.6 m (12 foot) straightedge in travel lanes parallel to and perpendicular to the centerline, as directed. The pavement surface shall not vary by more than 6 mm (1/4 inch).

(b) Level 3 and Level 4 HMAC:

(1) Single Course Construction - Test with the 3.6 m (12 foot) straightedge in travel lanes parallel to and perpendicular to the centerline, as directed. The pavement surface shall not vary by more than 6 mm (1/4 inch).

(2) Multiple Course Construction - Test the surface of the course on which the wearing course is placed according to (a) above.

Test the wearing surface with the rolling straightedge in the designated wheel path of a 100 m strip of each travel lane per kilometer (0.1 mile of each travel lane per mile), where directed, and on each transverse joint throughout the project. Operate the rolling straightedge parallel to the centerline. The surface shall not vary more than 4 mm (0.015 foot).

Also test the wearing surface with a 3.6 m (12 foot) straightedge placed perpendicular to the centerline at least once within the above-mentioned 100 m (0.1 mile) strip. It shall not vary by more than 6 mm (1/4 inch).

If the 100 m (0.1 mile) testing strip meets the Specifications, no further testing of the kilometer represented by the testing strip will be required, except at the transverse joints. If any part of the testing strip does not meet the Specifications, test both wheel paths of the entire kilometer.

(c) Utility Appurtenances - If the Contractor is required to construct or adjust utility appurtenances, such as manhole covers and valve boxes, the tolerances stated in (a) and (b) above apply. These tolerances do not apply at utility appurtenances adjusted by others.

00745.75 Correction of Pavement Roughness - Immediately correct equipment or paving operation procedures when tests show the pavement smoothness does not comply with 00745.70. In addition, do the following:

(a) Methods - Correct surface roughness to the required tolerances, using one of the following methods as approved by the Engineer:

(1) Base Course:

- Profile to a maximum depth of 10 mm (0.4 inch) with equipment meeting the requirements of Section 00620.20
- Profile to a maximum depth of 10 mm (0.4 inch) with abrasive grinder(s) equipped with a cutting head comprised of multiple diamond blades
- Remove and replace the base lift

(2) Wearing Course:

- Remove and replace the wearing surface lift
- Profile to a maximum depth of 7 mm (0.3 inch) with abrasive grinder(s) equipped with a cutting head comprised of multiple diamond blades

(b) Time Limit - Complete correction of all surface roughness within 14 calendar days following notification, unless otherwise directed.

Measurement

00745.80 General - The accepted quantities of HMAC will be measured by the Mg (ton) according to Section 00190 with separate measurement being made for the asphalt concrete mixture and the asphalt cement contained in the mixture. No deduction will be made for lime or any other additive used in the mixture.

When RAP materials are used, measurement of the total asphalt quantity will be based on quality control tests averaged to the nearest 0.01%.

If an estimated bulk specific gravity for the aggregates is shown in the Special Provisions, determine the actual bulk specific gravity for the aggregates, recompute the quantities of HMAC to be used, and inform the Agency in writing. The quantities of HMAC will be adjusted accordingly with no adjustment in Contract unit prices. The provisions of 00140.20 and 00195.20 will apply.

00745.83 Other Items - When indicated by other pay items in the Schedule of Items, extra or additional measurement will be made for HMAC work in approaches, driveways, walks and other miscellaneous structures according to 00749.80 through 00749.83.

If there is no separate pay item for leveling work, the quantities will be included in the appropriate HMAC items.

No separate measurement will be made for lime.

Specifications for South Carolina's Open-Graded Friction Course

Extracted from:

http://www.scdot.org/doing/StandardSpecifications/pdfs/2007_full_specbook.pdf

SOUTH CAROLINA DOT SECTION 409 OPEN-GRADED FRICTION COURSE

409.1 Description

This section contains specifications for the materials, equipment, construction, measurement, and payment for an open-graded friction course (OGFC) composed of crushed mineral aggregate, polymer modified binder, stabilizing fibers, and hydrated lime mixed in an approved HMA plant. Place the OGFC on a prepared surface and in conformity with the Plans or otherwise specified by the RCE.

409.2 Materials

409.2.1 General

Use materials meeting the applicable requirements of **Subsection 401.2** except as modified in this subsection. Do not use RAP, slag, or marine limestone in the OGFC. Use a polymer modified binder of grade PG76-22 and hydrated lime in all OGFC mixtures.

409.2.2 Aggregate

Use crushed coarse aggregate having an abrasion loss of not more than 52.0% when tested in accordance with AASHTO T 96 (C Grading). If the aggregate's abrasion loss is greater than 42.0%, but less than or equal to 52.0%, test the Micro-Deval abrasion value of the material in accordance with AASHTO T 327 and ensure it does not exceed a maximum of 15.0% loss. Use Crushed coarse aggregate with two or more freshly mechanically induced fractured faces on at least 90%, based on count, in accordance with AASHTO T 61, and a Sodium Sulfate Soundness loss not greater than 15.0% when subjected to five alterations in accordance with AASHTO T 104.

409.2.3 Stabilizing Fibers

409.2.3.1 Mineral Fibers

Use mineral fibers made from virgin basalt, diabase, or slag, which is treated with a cationic sizing agent to enhance disbursement of the fiber as well as increase adhesion of the fiber to the binder. Add the mineral fiber at a dosage rate of 0.2% to 0.4% by weight of the total mix as approved by the MRE. Use mineral fibers conforming to the properties in the following tables.

Size Analysis	
Average Fiber Length	6.35 mm Max.
Average Fiber Thickness	0.005 mm Max
Shot Content (ASTM C 612)	% Passing
Passing 250 μ m sieve	90 - 100
Passing 67 μ m sieve	65 - 100
Degradation (GDT-124/McNett fraction)	30% Max.

Obtain a letter from the mineral fiber supplier certifying that the mineral fiber has been tested and complies with the required properties. Submit the certification letter to the AME and the RCE when submitting the design for verification and approval.

409.2.3.2 Cellulose Fibers

Add cellulose fibers at a dosage rate of 0.2% to 0.4% by weight of the total mix as approved by the MRE. Use cellulose fibers conforming to the properties in the following tables.

Size Analysis	
Average Fiber Length	6.35 mm max.
Sieve Analysis (AASHTO T 27)	% Passing
No. 20	80.0 – 95.0
No. 40	45.0 – 85.0
No. 100	5.0 – 40.0

Obtain a letter from the cellulose fiber supplier certifying that the cellulose fiber has been tested and complies with the above properties. Submit the certification letter to the AME and the RCE when submitting the design for verification and approval.

409.2.3.3 Recycled Polyester Fibers

Add recycled polyester fibers at a dosage rate of 0.2% to 0.4% by weight of the total mix as approved by the MRE. Use recycled polyester fibers conforming to the properties in the following tables.

Size Analysis	
Average Fiber Length	6.35 mm max.
Sieve Analysis (AASHTO T 27)	% Passing
No. 20	80.0 – 95.0
No. 40	45.0 – 85.0
No. 100	5.0 – 40.0

409.2.4 Composition of Mixture

Conduct the OGFC mix design in accordance with **SC-T-91**. Submit the mix gradation, binder content, and mineral fiber dosage rate on a form approved by the AME. The AME will review the binder content and the stabilizing fiber dosage rate for approval. Ensure a minimum retention coating of 99.5% following **SC-T-90**. Ensure that the gradation and binder content comply with the ranges shown in following table.

Sieve	% Passing
¾-inch	100
½-inch	85.0 – 100.0
⅜-inch	55.0 – 75.0
No. 4	15.0 – 25.0
No.8	5.0 – 10.0
No.200	0.00 – 4.00
Range for % Binder	5.50 – 7.00

409.3 Equipment

Provide sufficient equipment to enable prosecution of the work in accordance with the project schedule and completion of the work in the specified time.

Ensure that the equipment necessary for the proper construction of the work is on site, in acceptable working condition, and approved by the RCE as to both type and condition before the start of work under this section. Provide sufficient equipment to enable prosecution of the work in accordance with the project schedule and completion of the work in the specified time.

409.4 Construction

409.4.1 Seasonal and Ambient Air Temperatures Limitations

Place the OGFC on a clean, dry, properly tacked surface only during favorable weather conditions between March 1 and October 31 inclusive. Assure that ambient air temperature during placement of OGFC is 60°F or above when measured in the shade away from artificial heat.

409.4.2 Production

Produce the OGFC mix within a temperature range of 325°F and 350°F at discharge from the plant. Measure all temperatures following **SC-T-84**. Do not produce other mixes during OGFC production for Department projects.

409.4.3 Fiber Supply System

Ensure that the fiber supply system conforms to the requirements stated in **SC-M-401**.

409.4.4 Placement

Ensure that the temperature of the mix when placed on the roadway is not less than 320°F. Do not allow long hauling distances or excessive waiting time to off-load. Unless otherwise permitted by the RCE, place OGFC mix within 1 hour of mixing at the plant.

Apply a tack coat of approved emulsified asphalt in accordance with Subsection 401.4.18 to the surface on which the OGFC is placed. The tack rate may be reduced if the RCE deems necessary.

Spread the OGFC at the rate shown on the Plans and promptly roll with an 8 to 10 ton tandem steel-wheel roller conforming to the requirements of **Subsection 401.3.11**. Cease rolling as soon as the OGFC is properly seated to the underlying surface. It is recommended that no more than three passes of the roller be applied to the OGFC. Regardless of the number of passes of the roller, if aggregate breakdown is observed, make adjustments to eliminate the breakdown.

Do not permit non-uniform distribution of binder (flushing) and raveling in the OGFC. Remove areas in the OGFC that are flushed or raveled to the full lane width 50 feet on each side and replace at no additional expense to the Department.

409.5 Measurement

The quantity for the pay item OGFC is measured in a similar manner as HMA courses specified in **Subsection 401.5**.

409.6 Payment

Payment for Open-Graded Friction Course is determined using the contract unit price for the pay item. Payment is full compensation for constructing the OGFC as specified or directed and includes furnishing, mixing, hauling, placing, and compacting OGFC; furnishing and applying tack coat; and all other materials, labor, equipment, tools, supplies, transportation, and incidentals necessary to fulfill the requirements of the pay item in accordance with the Plans, the Specifications, and other terms of the Contract.

Payment for each item includes all direct and indirect cost and expenses necessary to complete the work.

Pay items under this section include the following:

Item No.	Pay Item	Unit
4092000	Open-Graded Friction Course	TON

Specifications for Utah's Open-Graded Surface Course

Extracted from:

www.udot.utah.gov/main/uconowner.gf?n=85101523053260369

UTAH DOT SECTION 02786 OPEN-GRADED SURFACE COURSE (OGSC)

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Materials and procedures for constructing OGSC.

1.2 RELATED SECTIONS

- A. Section 01452: Profilograph and Pavement Smoothness
- B. Section 02741: Hot Mix Asphalt (HMA)
- C. Section 02745: Asphalt Material
- D. Section 02746: Hydrated Lime
- E. Section 02748: Prime Coat/Tack Coat

1.3 REFERENCES

- AASHTO T 11: Materials Finer Than 75 μm (No. 200) Sieve in Mineral Aggregates by Washing
- AASHTO T 27: Sieve Analysis of Fine and Coarse Aggregates
- AASHTO T 30: Mechanical Analysis of Extracted Aggregate
- AASHTO T 89: Determining the Liquid Limit of Soils
- AASHTO T 90: Determining the Plastic Limit and Plasticity Index of Soils
- AASHTO T 96: Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
- AASHTO T 104: Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
- AASHTO T 112: Clay Lumps and Friable Particle in Aggregate
- AASHTO T 176: Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
- AASHTO T 278: Surface Frictional Properties Using the British Pendulum Tester
- AASHTO T 279: Accelerated Polishing of Aggregates Using the British Wheel
- AASHTO T 304: Uncompacted Void Content of Fine Aggregate
- AASHTO T 308: Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method
- ASTM D 979: Sampling Bituminous Paving Mixtures
- ASTM D 3042: Standard Test for Insoluble Residue in Carbonate Aggregate
- ASTM D 3665: Random Sampling of Construction Materials

ASTM D 4791: Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 5821: Determining the Percentage of Fractured Particles in Coarse Aggregate
UDOT Quality Management Plan
UDOT Materials Manual of Instruction
UDOT Minimum Sample and Testing Guide

1.4 ACCEPTANCE

A lot equals the number of tons placed during each production day. When daily production rates are anticipated at less than 900 tons per production day, lots may be increased to equal the number of tons placed during up to three production days as agreed upon in advance by both the Contractor and the Engineer.

Submit an engineering analysis within one week, if requesting a rejected lot remain in place.

Include in the analysis: Data and engineering principles that indicate why the pavement should remain in place.

The Engineer, Region Materials Engineer, and Region Construction Engineer review the analysis for acceptance, denial, or revision within three working days.

If the request is denied, remove the rejected material from the project within 72 hours and replace it with an acceptable material.

If rotomilling is required, agree on removal time period.

Department deducts \$15.00 per ton if a rejected lot is allowed to remain in place.

Binder Content and Gradation

Engineer takes four random samples per lot at the plant according to UDOT Materials Manual of Instruction Part 8 - 894. ASTM D 979, ASTM D 3665.

If only three samples can be taken on the production day for reasons beyond the Contractor's control; compute incentive/disincentive from the three random samples rather than four.

Add the lot to the next day's production if four random samples cannot be taken. Evaluate pay adjustment with the appropriate sample size.

Add the lot to the previous day's production for the last day's production if four random samples cannot be taken. Evaluate with the appropriate sample size.

Obtain the binder content from the ignition oven test. AASHTO T 308.

Compute Incentive/Disincentive for binder content per lot based on Table 1 using the single test result with the largest deviation from the target.

Table 1	
Binder Content	Pay Adjustment in \$/ton OGSC
Within $\pm 0.30\%$ of target	+1.00
Between $\pm 0.31\%$ and $\pm 0.45\%$ of target	0.00
Between $\pm 0.46\%$ $\pm 0.60\%$ of target	-2.00
Greater than $\pm 0.61\%$	Reject

Engineer conducts aggregate gradations tests per lot on the residue of the ignition oven test. AASHTO T 30.

Incentive/Disincentive for gradation is based on Percent Within Limits computation using Table 2, 3, 4, and 5.

The Department will reject the lot if the Percent Within Limits is less than 60 percent.

Table 2	
Gradation Upper and Lower Limit Determination	
Parameter	UL and LL
3/8" sieve	Target Value ± 6.0 percent
# 4 sieve	Target Value ± 6.0 percent
# 8 sieve	Target Value ± 5.0 percent
# 200 sieve	Target Value ± 2.0 percent

Table 3 Incentive/Disincentive for Gradation	
Gradation	
PT Based on Min. Four Samples	Incentive/Disincentive (Dollars/Ton)
> 99	0.83
96-99	0.67
92-95	0.37
88-91	0.06
84-87	-0.24
80-83	-0.54
76-79	-0.84
72-75	-1.15
68-71	-1.45
64-67	-1.75
60-63	-2.06
<60	Reject

PU/P L	n=3	n=4	n=5	n=6	n=7	n=8	n=10	n=12	n=15	n=20
100	1.16	1.50	1.75	1.91	2.06	2.15	2.29	2.35	2.47	2.56
99	1.16	1.47	1.68	1.79	1.89	1.95	2.04	2.09	2.14	2.19
98	1.15	1.44	1.61	1.70	1.77	1.80	1.86	1.89	1.93	1.97
97	1.15	1.41	1.55	1.62	1.67	1.69	1.74	1.77	1.80	1.82
96	1.15	1.38	1.49	1.55	1.59	1.61	1.64	1.66	1.69	1.70
95	1.14	1.35	1.45	1.49	1.52	1.54	1.56	1.57	1.59	1.61
94	1.13	1.32	1.40	1.44	1.46	1.47	1.49	1.50	1.51	1.53
93	1.12	1.29	1.36	1.38	1.40	1.41	1.43	1.43	1.44	1.46
92	1.11	1.26	1.31	1.33	1.35	1.36	1.37	1.37	1.38	1.39
91	1.10	1.23	1.27	1.29	1.30	1.31	1.32	1.32	1.32	1.33
90	1.09	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.27	1.27
89	1.08	1.17	1.20	1.21	1.21	1.21	1.21	1.21	1.22	1.22
88	1.07	1.14	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12	1.12	1.12	1.13	1.13	1.13	1.13	1.13
86	1.05	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.05	1.05	1.04	1.04	1.04	1.04	1.04
84	1.02	1.02	1.02	1.01	1.01	1.01	1.00	1.00	1.00	1.00
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96
82	0.98	0.96	0.95	0.94	0.94	0.93	0.93	0.92	0.92	0.92
81	0.96	0.93	0.92	0.91	0.90	0.90	0.89	0.89	0.89	0.88
80	0.94	0.90	0.88	0.87	0.86	0.86	0.85	0.85	0.85	0.85
79	0.92	0.87	0.85	0.84	0.83	0.83	0.82	0.82	0.82	0.81
78	0.89	0.84	0.82	0.81	0.80	0.79	0.79	0.78	0.78	0.78
77	0.87	0.81	0.79	0.78	0.77	0.76	0.76	0.75	0.75	0.75
76	0.84	0.78	0.76	0.75	0.74	0.73	0.72	0.72	0.72	0.72
75	0.82	0.75	0.73	0.72	0.71	0.70	0.69	0.69	0.69	0.68
74	0.79	0.72	0.70	0.68	0.67	0.67	0.66	0.66	0.66	0.65
73	0.77	0.69	0.67	0.65	0.64	0.64	0.62	0.62	0.62	0.62
72	0.74	0.66	0.64	0.62	0.61	0.61	0.60	0.59	0.59	0.59
71	0.71	0.63	0.60	0.59	0.58	0.58	0.57	0.56	0.56	0.56
70	0.68	0.60	0.58	0.56	0.55	0.55	0.54	0.54	0.54	0.53
69	0.65	0.57	0.55	0.54	0.53	0.52	0.51	0.51	0.51	0.50
68	0.62	0.54	0.52	0.51	0.50	0.50	0.48	0.48	0.48	0.48
67	0.59	0.51	0.49	0.48	0.47	0.47	0.46	0.45	0.45	0.45
66	0.56	0.48	0.46	0.45	0.44	0.44	0.43	0.42	0.42	0.42
65	0.53	0.45	0.43	0.42	0.41	0.41	0.40	0.40	0.40	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34
62	0.43	0.36	0.34	0.33	0.33	0.33	0.32	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.30	0.29	0.29	0.29	0.28
60	0.36	0.30	0.28	0.27	0.26	0.26	0.25	0.25	0.25	0.25
<60	≤ 0.35	≤ 0.29	≤ 0.27	≤ 0.26	≤ 0.25	≤ 0.25	≤ 0.24	≤ 0.24	≤ 0.24	≤ 0.24

Enter table in the appropriate sample size column and round down to the nearest value.

Table 5 Definitions, Abbreviations, and Formulas for Acceptance	
Term	Explanation
Target Value (TV)	The target values for gradation, asphalt binder content and VMA are given in the Contractor's volumetric mix design. See article 1.4, line E, for density target values.
Average (AVE)	The sum of the lot's test results for a measured characteristic divided by the number of test results; the arithmetic mean.
Standard Deviation (s)	The square root of the value formed by summing the squared difference between the individual test results of a measured characteristic and AVE, divided by the number of test results minus one. This statement does not limit the methods of calculations of s; other methods that obtain the same value may be used.
Upper Limit (UL)	The value above the TV of each measured characteristic that defines the upper limit of acceptable production. (Table 3)
Lower Limit (LL)	The value below the TV of each measured characteristic that defines the lower limit of acceptable production (Table 3)
Upper Quality Index (QU)	$QU = (UL - AVE)/s$
Lower Quality Index (QL)	$QL = (AVE - LL)/s$
Percentage of Lot Within UL (PU)	Determined by entering Table 4 with QU.
Percentage of Lot Within LL (PL)	Determined by entering Table 4 with QL.
Total Percentage of Lot (PT) Within UL and LL (PT)	$PT = (PU + PL) - 100$
Incentive/Disincentive	Determined by entering Table 1 and 2 with PT or PL.

All values for AVE, s, QU, and QL will be calculated to two decimal place accuracy which will be carried through all further calculations. Rounding to lower accuracy is not allowed.

Any lot rejected based on either gradation or binder content will not be eligible for any incentive.

Thickness

Verify the thickness with a depth probe and take corrective action if necessary.

Minimum thickness: Plan depth minus 1/4 inch.

Smoothness

Determine acceptance and correct in accordance with Section 01452.

PART 2 PRODUCTS

2.1 ASPHALT MATERIAL

- A. As specified, and following Section 02745.
- B. Sampling procedure: UDOT Quality Management Plan - 509 Asphalt Binder.

2.2 HYDRATED LIME

- A. Meet the requirements of Section 02746.

2.3 AGGREGATE MATERIALS

- A. Refer to the UDOT Minimum Sample and Testing Requirements, Section 1, Tabulation of Acceptance Sampling and Testing.
- B. Crusher processed virgin aggregate material consisting of crushed stone, gravel, or slag.
- C. Meet the following requirements, including Table 3, to determine the acceptability of the aggregate.
 - 1. Coarse aggregate:
 - a. Retained on # 4 sieve.
 - 2. Fine aggregate:
 - a. Clean, hard grained, and angular.
 - b. Passing the # 4 sieve.

Table 6		
Aggregate Properties		
Properties	Test Method	Test Requirement
One Fractured Face	ASTM D 5821	95 percent min.
Two Fractured Face	ASTM D 5821	90 percent min.
Fine Aggregate Angularity	AASHTO T 304	45 min.
Flat and Elongated (1 to 3 ratio)	ASTM D 4791 (Based on 3/8 inch and above)	10 % max.
L.A. Wear	AASHTO T 96	30 % max.
Sand Equivalent	AASHTO T 176	60 min.
Plasticity Index	AASHTO T 89 and T 90	0
Polish Test	AASHTO T 278 & T 279	31 min.
Soundness (sodium sulfate)	AASHTO T 104	12 % max. loss with five cycles
Clay Lumps and Friable Particles	AASHTO T 112	2 % max.
Standard Test Method for Insoluble Residue in Carbonate Aggregates	ASTM D 3042	30 % max.
Natural Fines	None	None

D. Meet the following gradation:

Table 7	
Aggregate Gradation (Percent Passing by Dry Weight of Aggregate - AASHTO T11, T27)	
Sieve Size	Percent
½ inch	100
3/8 inch	90 - 100
# 4	35 - 45
# 8	14 - 20
# 200	2 - 4

2.4 JOB-MIX

- A. Obtain approval for job mix gradation:
 - 1. Submit at least 10 working days before paving.
 - 2. Show definite single values for the percentage of aggregate passing each sieve based on the dry weight of aggregate.
 - 3. Stay within the single value gradation limits of Table 4.
 - 4. Add Hydrated Lime:
 - a. Method A, Lime Slurry; or Method B, Lime Slurry Marination.
 - b. Refer to Section 02746.
 - c. Incorporate minimum hydrated lime by dry weight of aggregate into all mixtures (1 percent for Method A; 1- 1/2 percent for Method B).

- B. Binder Content
 - 1. The Engineer determines the binder content and supplies samples to determine the correction factor.

- C. Changes in job mix gradation:
 - 1. Submit a written request for a change in a job-mix gradation.
 - 2. Give the Engineer 5 working days to review and approve the changes and to readjust the quantity of asphalt binder to be used.

PART 3 EXECUTION

3.1 MIXING

Mix as specified in Section 02741. The mineral aggregate coating will be considered satisfactory when all particles are coated.

3.2 SURFACE PLACEMENT

Apply the tack coat at a uniform rate of 0.10 gal/yd² undiluted emulsion or 0.15 gal/yd² 2:1 diluted emulsion. Note: 2:1 diluted emulsion represents 2 parts undiluted emulsion and 1 part water. Refer to Section 02748.

Maintain a steady paver speed

Roll sufficiently to seat without fracturing aggregate.

Bring all passes up even transversely at the end of each working day.

Construct longitudinal joints within 6 inches of lane lines.

Remove slick spots as directed by the Engineer.

3.3 LIMITATIONS

- A. Place between May 1, and September 15, and only when both the air temperature in the shade and the pavement surface temperature are above 60 degrees F and rising.
- B. Obtain written approval from the Engineer before placing OGSC after September 15.
- C. Do not place when it is determined by the Engineer that excessive moisture may be present in the pavement structure.
- D. Do not place during rain, when the surface is wet, or during other adverse weather conditions.

Specifications for Virginia's Stone Matrix Asphalt

Extracted from:

<http://www.virginiadot.org/business/const/resources/02bk.pdf>

VIRGINIA DEPARTMENT OF TRANSPORTATION SPECIAL PROVISION FOR STONE MATRIX ASPHALT (SMA)

October 25, 2005

I. DESCRIPTION

This work shall consist of furnishing a Stone Matrix Asphalt (SMA) bituminous mixture in accordance with Sections 211 and 315 of the Specifications and this Special Provision.

II. MATERIALS

(a) **Coarse Aggregate:** Coarse aggregate shall conform to the following requirements:

1. Los Angeles Abrasion	AASHTO T96	40% max.
2. Flat and Elongated Particles measured on No. 4 retained, max. to min. 3 to 1	ASTM D4791	20% max.
5 to 1		5% max.
3. Magnesium Sulfate Soundness Loss 5 cycles	AASHTO T104	15% max.
4. Particles retained on the No. 4 sieve shall have at least one fractured face	ASTM D5821	100% min.
two fractured faces		90% min.
5. Absorption	AASHTO T 85	2% max.

The aggregate properties specified are for each stockpile of coarse aggregate material designated on the job mix form (TL-127). The material contained in each stockpile shall meet the minimum or maximum criteria specified.

Use of slag will not be permitted.

(b) **Fine Aggregate:** Fine aggregate shall consist of a blend of 100 percent crushed aggregate. The magnesium sulfate soundness loss in 5 cycles shall not exceed 20 percent. In addition, the liquid limit shall not exceed 25 as determined by AASHTO T89.

(c) **Asphalt Binder:** Asphalt binders shall be Performance Graded Binder PG 70-22 or Polymer modified PG 76-22 conforming to the requirements of mix designation (M), as designated by the Department. The supplier shall certify to the Department that the binder meets all the properties of that grade as shown in AASHTO M320 (Provisional Specification MP-1) for Performance Graded Asphalt Binder. This certification shall be based on testing performed on samples of binder provided to the Contractor for

incorporation into the mixture. Certification based on testing performed on laboratory-produced binders will not be acceptable.

The Contractor shall submit to the Engineer for Department review the source, formulation, and PG grading of the binder at least 15 days prior to the production of the SMA mixture.

During mixture production, testing to determine the binder PG grade will be performed by the Department on samples taken from storage at the hot mix asphalt plant as directed by the Engineer. The Contractor shall be responsible for obtaining the sample of binder when requested. In the event that it is determined that the binder does not meet the requirements of the specified PG grade, production shall be stopped until further testing indicates that the problem has been corrected.

(d) **Mineral Filler:** Mineral filler shall consist of finely divided mineral matter such as rock or limestone dust, , or other suitable material. Hydrated lime and fly ash will not be allowed. Up to two mineral fillers may be blended to meet the mineral filler requirements. Mineral filler shall meet the requirements of Section 201 with the following modifications. The Mineral Filler or Mineral Filler blend used in surface and intermediate SMA shall have a minimum of 55% passing the No. 200 sieve. At the time of use, it shall be sufficiently dry to flow freely and be essentially free from agglomerations.

(e) **Fiber Additive:** Cellulose fiber in either loose or pelletized form shall be used. The minimum dosage rates for cellulose is 0.3 percent by weight of total mixture. During production, the Department may require the fiber additive be increased if visual inspection or draindown testing on plant produced material indicates that draindown in excess of 0.3 percent by weight of the mix is occurring as determined by VTM-100. Allowable tolerances of fiber dosage shall be ± 10 percent of the required fiber weight.

Fibers will be accepted based on the manufacturer's certification.

CELLULOSE FIBER PROPERTIES

Sieve Analysis

Method A

Alpine Sieve¹ Analysis:

Fiber Length:	0.25 inch	(maximum)
Passing No. 100 Sieve	70%	($\pm 10\%$)

Method B

Mesh Screen² Analysis:

Fiber Length:	0.25 inch	(maximum)
Passing No. 20 Sieve	85%	($\pm 10\%$)
No. 40 Sieve	65%	($\pm 10\%$)

No. 140 Sieve	30%	(± 10%)
Ash Content³	18%	(± 5%) non-volatile
pH⁴	7.5	(± 1.0)
Oil Absorption⁵	5.0	(± 1.0) (times fiber weight)
Moisture Content⁶	< 5%	

¹Method A: Alpine Sieve Analysis. This test is performed using an Alpine Air Jet Sieve (Type 200 LS). A representative five-gram sample of fiber is sieved for 14 minutes at a controlled vacuum of 22 inches (± 3 inches) of water. The portion remaining on the screen is weighed.

²Method B: Mesh Screen Analysis. This test is performed using standard Nos. 20, 40, 60, 80, 100, and 140 sieves, nylon brushes and a shaker. A representative 10-gram sample of fiber is sieved, using a shaker and two nylon brushes on each screen. The amount retained on each sieve is weighed and the percentage passing calculated.

³Ash Content: A representative 2-3 gram sample of fiber is placed in a tared crucible and heated between 1100 o F and 1200o F for not less than two hours. The crucible and ash are cooled in a desiccator and reweighed.

⁴pH Test: Five grams of fiber is added to 3.5 oz. (100 ml) of distilled water, stirred and let set for 30 minutes. The pH is determined with a probe calibrated with pH 7.0 buffer.

⁵Oil Absorption Test: Five grams of fiber is accurately weighed and suspended in an excess of mineral spirits for not less than five minutes to ensure total saturation. It is then placed in a screen mesh strainer (approximately 0.5 square millimeter hole size) and shaken on a wrist action shaker for ten minutes (approximately 1 ¼ inch motion at 20 shakes/minute). The shaken mass is then transferred without touching, to a tared container and weighed. Results are reported as the amount (number or times its own weight) the fibers are able to absorb.

⁶Moisture Content: Ten grams of fiber is weighed and placed in a 250° F forced air oven for two hours. The sample is then reweighed immediately upon removal from the oven.

NOTE: When using pelletized fiber, the dosage rate shall be adjusted to meet the specified minimum dosage rates for cellulose fiber. Pelletized fiber consists of cellulose fiber and a binder. The specified minimum dosage rates are based on fiber content only. Therefore, the amount of pelletized fiber added shall typically be higher than loose fiber.

(f) **RAP:** Use of RAP will not be permitted.

III. COMPOSITION OF SMA MIXTURE

The SMA mixture shall be designed and tested using a gyratory compactor and shall conform to the requirements listed in Table A and Table B. One percent hydrated lime will be required as an antistripping additive. An alternative antistripping additive can only be used if permitted by the Engineer.

TABLE A - SMA DESIGN RANGE
Percentage by Weight Passing Square Mesh Sieves (in)

Type# (See Note)	1	¾	1/2	3/8	No. 4	No. 8	No. 30	No. 200
Surface Mixes								
SMA 12.5	-	100	85-95	80 max	22-30	16-24	15-20	10-12
SMA 9.5	----	100	90-100	70-85	25-40	15-25	-	10-12
Intermediate Mixes								
SMA 19.0	100	85-95	50-60	30-45	----	16-24	12-16	8-10

Note - The required PG Binder will be shown in parenthesis as part of the mix type on the plans or proposal e.g. SMA 12.5 (76-22)

TABLE B - SMA MIXTURE REQUIREMENTS

Mix Type	VTM *	VMA	VMA	VCA	AC	Draindown	Design	Specimen
		Design	Production	Design and Production				
	%	Min %	Min %	%	Min %	%		Height****
SMA 9.5	2.0-4.0	18.0	17.0	<VCA _{DRC}	6.3	0.3 max	75	115
SMA 12.5	2.0-4.0	18.0	17.0	<VCA _{DRC}	6.3	0.3 max	75	115
SMA19.0	2.0-4.0	17.0	16.0	<VCA _{DRC}	5.5	0.3 max	75	115

*Asphalt content shall be selected at the midpoint of the VTM range but shall not be less than the minimum specified.

Fines-Effective Asphalt Ratio shall be 1.2-2.0.

The Voids in Coarse Aggregates (VCA) of the Dry Rodded Condition (DRC) and mix shall be determined in accordance with VTM-99.

**** Specimen height after compaction shall be between 4.25 inches to 4.75 inches (110 to 120 millimeters)

NOTE: The SUPERPAVE Gyratory Compactor (SGC) shall be from the approved list maintained by the Materials Division. Gyratory procedures shall be performed in accordance with VTM-99 Design of SMA Mixtures. Calculations for volumetrics shall be performed in accordance with VTM-57 and VTM-58, 6-inch (150mm) specimens. Draindown testing shall be in accordance with VTM-100 Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures.

IV. ACCEPTANCE

A lot will be considered acceptable for gradation and asphalt content if the mean of the test results obtained is within the tolerance allowed from the job-mix formula. The production tolerances for the control sieves and asphalt content shall be as follows:

PROCESS TOLERANCE

Tolerance on each laboratory sieve (in) and Asphalt Content – Percent Plus and Minus

No. Tests	Top Size	3/4	1/2	3/8	No. 4	No. 8	No. 30	No. 200	AC
1	0.0	8.0	8.0	8.0	6.0	6.0	6.0	4.0	0.60
2	0.0	5.7	5.7	5.7	4.3	4.3	4.3	2.8	0.43
3	0.0	4.4	4.4	4.4	3.3	3.3	3.3	2.2	0.33
4	0.0	4.0	4.0	4.0	3.0	3.0	3.0	2.0	0.30
8	0.0	2.8	2.8	2.8	2.1	2.1	2.1	1.4	0.21

The production tolerance for the specimen height after compaction is 4.25 to 4.75 inches (110 to 120 mm).

The Contractor shall check and report the Voids in Coarse Aggregates (VCA) of the mix during production for each gyratory sample. If the VCA of the mix exceeds the VCA of the Dry Rodded Condition (DRC), the Contractor shall stop production and notify the Engineer. Production shall not resume until the Contractor has taken corrective action.

V. SMA MIXING PLANT

Plants used for the preparation of the SMA mixture shall conform to the following:

(a) **Handling Mineral Filler:** Adequate dry storage shall be provided for the mineral filler, that will, at a minimum, consist of a waterproof cover that shall completely cover the stockpile at all times.

Provisions shall be made for metering of the filler into the mixture uniformly and in the desired quantities. In a batch plant, mineral filler shall be added directly into the weigh hopper. In a drum plant, mineral filler shall be added directly onto the cold feed belt. Equipment shall be capable of accurately and uniformly metering the large amounts of mineral filler up to 25 percent of the total mix.

(b) **Fiber Addition:** Adequate dry storage shall be provided for the fiber additive, and provisions shall be made for accurately and uniformly metering fiber into the mixture at plus or minus 10 percent of the desired quantities.

Introduction of loose or pelletized fiber shall require a separate system that can accurately proportion, by weight, the required quantity of fiber in such a manner as to ensure consistent, uniform blending into the mixture at all rates of production and batch sizes.

This supply system shall be interlocked with the other feeding devices of the plant system and sensing devices shall provide for interruption of mixture production if the introduction of fiber fails.

Batch Plant: Loose fiber or pelletized fiber shall be added through a separate inlet directly into the weigh hopper above the pugmill. The addition of fiber should be timed to occur during the hot aggregate charging of the hopper. Adequate dry mixing time is required to ensure proper blending of the aggregate and fiber stabilizer. Therefore, dry mixing time shall typically be increased 5 to 15 seconds. Wet mixing time shall typically be increased at least 5 seconds for cellulose fibers, to ensure adequate blending with the asphalt cement.

When fiber is used, the fiber supply system shall include low level and no flow indicators and a printout of the date, time, and net batch weight of fiber.

Drum Mix Plant: When fiber is used, the fibers shall be added in such a manner as not to be entrained into the exhaust gases of the drum plant. The fiber supply system shall include low level and no flow indicators and a printout of status of feed rate in pounds/minute.

When pelletized fibers are used, they shall be added directly into the drum mixer through the RAP inlet or a specialized fiber inlet. Operation of the drum mixer shall be such as to ensure complete blending of the pelletized fiber into the mix.

(c) **Hot Mixture Storage:** When the hot mixture is not hauled immediately to the project and placed, suitable bins for storage shall be provided. Such bins shall be either surge bins to balance production capacity with hauling and placing capacity or storage bins, which are heated and insulated and which have a controlled atmosphere around the mixture. The holding times shall be within limitations imposed by the Engineer, based on laboratory tests of the stored mixture. In no case shall the SMA mixture be kept in storage more than 8 hours.

(d) **Mixing Temperatures:** Typical plant mixing temperature shall be 3150-3400 F and at no time shall the mixing temperature exceed 350° F.

VI. WEATHER RESTRICTIONS

Weather Restrictions: Placement of the SMA mixture shall be permitted only when the ambient and surface temperatures are 50° F or above.

VII. PLACING AND FINISHING

Placing and Finishing: The mixture temperature in the truck shall not be less than 3000 F for mixtures containing PG 70-22 and 3100 F for mixtures containing PG 76-22. The temperature immediately behind the screed shall not be less than 290° F for mixtures containing PG 70-22, and shall be not less than 300 0 F for mixtures containing PG 76-22.

A continuous paving operation that provides for constant steady movement of the paver shall be maintained. In the event that excessive stop and go of the paver is occurring, production and laydown of the mixture may be stopped until the Contractor has made satisfactory changes in the production, hauling, and placement operations resulting in a constant steady movement of the paver.

A Material Transfer Vehicle (MTV) shall be used during the placement of all SMA mixes. The paving operation shall have remixing ability either in the MTV or in a paver mounted hopper. The remixing capacity shall not be less than 15 tons. In the event that breakdown occurs, paving shall be discontinued and no more material shall be shipped from the hot mix plant.

VIII. COMPACTION

Compaction: Immediately after the mixture has been spread and struck off, it shall be thoroughly and uniformly compacted by rolling. Rolling shall be accomplished with steel wheel roller(s) with a minimum weight of 10 tons. A minimum of three rollers shall be available at all times for compaction and/or finish rolling.

To minimize coarse aggregate fracture/breakage in the aggregate skeleton of SMA mixes, the use of vibratory rollers on SMA should be approached with caution. If a vibratory roller is used, the mat should receive not more than 3 vibratory passes. The roller shall use only the highest frequency and lowest amplitude setting.

Rolling procedures shall be adjusted to provide the specified pavement density. Rollers shall move at a uniform speed not to exceed 3 mph with the drive wheel nearest the paver. Rolling shall be continued until all roller marks are eliminated and the minimum density has been obtained. The Contractor shall monitor density during the compaction process by use of nuclear density gauges to assure that the minimum required compaction is being obtained. The number of passes required to obtain proper density shall be determined in accordance with VTM-76.

To prevent adhesion of the mixture to the rollers, it shall be necessary to keep the wheels properly moistened with water possibly mixed with very small quantities of detergent or other approved material.

The Contractor shall perform acceptance testing for density for each day's production by obtaining one 4 x 4 inch sawed specimen or 4 inch diameter core at 5 stratified random locations specified by the Engineer. The 5 cores or plugs shall be obtained and the in-place density determined in accordance with VTM-22. All core locations shall be numbered sequentially per roadway, marked on the pavement, and filled with compacted SMA mixture prior to completion of each day of production.

The average density of the five cores as determined by VTM-22 shall be 94 to 98 percent for 100 percent pay. All cores or plugs shall be bulked in the presence of the Department. The Department reserves the right to have the cores or plugs bulked on the project site. The payment for density will be in accordance with the following:

PAYMENT SCHEDULE	
Percent Density Achieved	Percent of Payment
More than 98.0	97
94.0 to 98.0	100
92.0 to 93.9	85
90.0 to 91.9	65
Less than 90.0	Remove and Replace

IX. TRIAL SECTION

Trial Section: Trial section(s), a maximum of 300 tons, shall be constructed at a site approved by the Engineer at least one week before, but not more than 30 days prior to, roadway construction to examine the mixing plant process control, mixture draindown characteristics, placement procedures, SMA surface appearance, compaction patterns and to calibrate the nuclear density device.

The material placed in the trial sections shall be at the specified application rate and utilize the same equipment that shall be used during production.

X. PREPAVING CONFERENCE

Prepaving Conference: the Department prior to starting production will hold a prepaving conference.

Those attending shall include the Contractor's production supervisor and laydown supervisor, a representative of the fiber supplier, and a representative of the asphalt binder supplier.

XI. MEASUREMENT AND PAYMENT

Stone matrix asphalt will be measured in tons and paid for at the contract unit price per ton, for the mix type specified, which price shall include all materials, additives, and equipment as described herein.

The initial trial section will be paid for at the contract unit price for the mix type specified. With the approval of the Engineer, up to one additional trial section of the mix type specified will be paid for at the contract unit price. The Department will only pay for a maximum of two trial sections at the contract unit price. If more than two trial sections are needed, the Department and Contractor shall negotiate the price based upon a reduced percentage of the contract unit price and the subsequent trial sections shall be constructed at sites approved by the engineer.

Payment will be as follows:

Pay Item	Pay Unit
Stone Matrix Asphalt, SMA-9.5 (70-22)	Tons
Stone Matrix Asphalt, SMA-9.5 (76-22)	Tons
Stone Matrix Asphalt, SMA-12.5 (70-22)	Tons
Stone Matrix Asphalt, SMA-12.5 (76-22)	Tons
Stone Matrix Asphalt, SMA-19.0 (70-22)	Tons
Stone Matrix Asphalt, SMA-19.0 (76-22)	Tons

Specifications for Wisconsin's Open-Graded Surface Course

Extracted from:

<http://roadwaystandards.dot.wi.gov/standards/stndspec/part4.pdf>

WISCONSIN DOT SECTION 460 HOT MIX ASPHALT PAVEMENT

460.1 Description

(1) This section describes HMA mixture design, providing and maintaining a quality management program for HMA mixtures, and constructing HMA pavement.

460.2 Materials

460.2.1 General

(1) Furnish a homogeneous mixture of coarse aggregate, fine aggregate, mineral filler if required, SMA stabilizer if required, and asphaltic material.

460.2.2 Aggregates

460.2.2.1 General.

(1) Furnish an aggregate blend consisting of hard durable particles containing no more than a combined total of one percent, by weight, of lumps of clay, loam, shale, soft particles, organic matter, adherent coatings, and other deleterious material. Ensure that the aggregate blend conforms to the percent fractured faces and flat & elongated requirements of [table 460-2](#). If the aggregate blend contains materials from different deposits or sources, ensure that material from each deposit or source has a LA wear percent loss meeting the requirements of [table 460-2](#).

(2) If the department requests, submit samples representative of the aggregate proposed for the work.

Minimum sampling frequencies are specified in the department's test method number 1559. Have an HTCP certified technician sample the aggregate. Deliver samples to the laboratory at least 14 days before using in the work. Obtain the engineer's approval of the aggregates before producing HMA mixtures.

460.2.2.2 Freeze-Thaw Soundness

(1) The department will provide freeze/thaw soundness test results based on the fraction retained on the No. 4 (4.75 mm) sieve using virgin crushed stone aggregates produced from limestone/dolomite sources in one or more of the following counties or from out of state:

Brown	Columbia	Crawford	Dane	Dodge
Fond du Lac	Grant	Green	Green Lake	Iowa
Jefferson	Lafayette	Marinette	Oconto	Outagamie
Rock	Shawano	Walworth	Winnebago	

(2) The department may waive freeze/thaw testing for existing quarries determined to be in either the Silurian system or the Prairie du Chien group of the Ordovician system of rocks.

(3) If the aggregate blend contains materials from different deposits or sources, ensure that material from each deposit or source has a freeze-thaw loss percentage meeting the requirements of [table 460-2](#).

460.2.2.3 Aggregate Gradation Master Range

Revise 460.2.2.3(1) Table 460-1 to require VMA of 16.0 for SMA 12.5 mm mixtures and VMA of 17.0 for SMA 9.5 mm mixtures.

(1) Ensure that the aggregate blend, including RAP and mineral filler, conforms to the gradation requirements in [table 460-1](#). The values listed are design limits; production values may exceed those limits.

TABLE 460-1 AGGREGATE GRADATION MASTER RANGE AND VMA REQUIREMENTS

SIEVE SIZE	PERCENTS PASSING DESIGNATED SIEVES						
	NOMINAL SIZE						
	37.5 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm	SMA 12.5 mm	SMA 9.5 mm
50.0 mm	100						
37.5 mm	90 - 100	100					
25.0 mm	90 max	90 - 100	100				
19.0 mm	___	90 max	90 - 100	100		100	
12.5 mm	___	___	90 max	90 - 100	100	90 - 97	100
9.5 mm	___	___	___	90 max	90 - 100	58 - 72	90 - 100
4.75 mm	___	___	___	___	90 max	25 - 35	35 - 45
2.36 mm	15 - 41	19 - 45	23 - 49	28 - 58	20 - 65	15 - 25	18 - 28
75 µm	0 - 6.0	1.0 - 7.0	2.0 - 8.0	2.0 - 10.0	2.0 - 10.0	8.0 - 12.0	10.0 - 14.0
PERCENT MINIMUM VMA	11.0	12.0	13.0	14.0	15.0	16.0	17.0

(2) Unless the contract designates otherwise, ensure that the nominal size of the aggregate used in the mixture conforms to the following:

PAVEMENT LAYER	NOMINAL SIZE
Lower layer pavement	19.0 mm
Upper layer pavement	12.5 mm
Stone matrix layer pavement	12.5 mm

460.2.3 Asphaltic Binders

(1) The department will designate the grade of asphaltic binder in the contract. The contractor may use virgin binder, modified binder, a blend of virgin and recovered

binder, or a blend of modified and recovered binder. Ensure that the resultant asphaltic binder conforms to the contract specifications.

460.2.4 Additives

460.2.4.1 Hydrated Lime Antistripping Agent

(1) If used in HMA mixtures, furnish hydrated lime conforming to ASTM C 977 and containing no more than 8 percent unhydrated oxides. Add one percent or more, by weight of the total dry aggregate. Do not begin production until the engineer approves the lime introduction and mixing methods.

460.2.4.2 Liquid Antistripping Agent

(1) If used in HMA mixtures, add liquid antistripping agent to the asphaltic binder before introducing the binder into the mixture. Ensure that addition of liquid antistripping agent does not alter the characteristics of the original asphaltic binder beyond the following limits:

1. A viscosity change of more than +/-400 poises.
2. A penetration change of more than -4 or +10.

460.2.4.3 Stone Matrix Asphalt Stabilizer

(1) Add an organic fiber, an inorganic fiber, a polymer-plastic, a polymer-elastomer, or approved alternate stabilizer to all SMA mixtures. If proposing an alternate, submit the proposed additive system, asphaltic binder and stabilizer additive, along with samples of the other mixture materials to the department at least 14 days before the project let date. The department will approve or reject that proposed alternate additive system no later than 48 hours before the project let date.

(2) Use a single additive system for all SMA pavement in the contract.

460.2.5 Reclaimed Asphaltic Pavement Materials

Effective with the December 2006 Letting 195 2006 Standard Specifications

(1) The contractor may use up to 35 percent RAP material in lower layer and base mixtures and up to 20 percent in upper layer mixtures. Ensure that the combined RAP and virgin aggregate conforms to aggregate requirements of [table 460-2](#).

460.2.6 Recovered Asphaltic Binders

(1) Establish the percent of recovered asphaltic binder from RAP for the mixture design according to AASHTO T 164 using the appropriate dust correction procedure. If test results indicate a change in the percent of recovered asphaltic binder from RAP, the contractor or the engineer may request a change in the design recovered asphaltic binder from RAP. Accompany that request with at least 2 recent RAP extractions from the contractor's mixture design laboratory supporting that change.

(2) The contractor may use up to 25 percent RAP for lower layers and up to 20 percent RAP for upper layers without changing the asphaltic binder grade. If using more than that amount of RAP, furnish binder with a low temperature rating one grade lower than the contract designates, unless testing indicates the resultant binder meets the grade the contract originally specified.

460.2.7 HMA Mixture Design

Revise 460.2.7(1) Table 460-2 to reduce the required gyrations for SMA at N_{des} to 65.

(1) For each HMA mixture type used under the contract, develop and submit an asphaltic mixture design according to the department's test method number 1559 and conforming to the requirements of table 460-1 and table 460-2. The values listed are design limits; production values may exceed those limits. The department will review mixture designs and report the results of that review to the designer according to the department's test method number 1559.

TABLE 460-2 MIXTURE REQUIREMENTS

Mixture type	E - 0.3	E - 1	E - 3	E - 10	E - 30	E - 30x	SMA
ESALs x 10 ⁶ (20 yr design life)	< 0.3	0.3 - < 1	1 - < 3	3 - < 10	10 - < 30	≥ 30	—
LA Wear (AASHTO T 98)							
100 revolutions(max % loss)	13	13	13	13	13	13	13
500 revolutions(max % loss)	50	50	45	45	45	45	45
Soundness (AASHTO T 104) (sodium sulfate, max % loss)	12	12	12	12	12	12	12
Freeze/Thaw (AASHTO T 103) (specified counties, max % loss)	18	18	18	18	18	18	18
Fractured Faces (ASTM 5821) (one face/2 face, % by count)	60 / —	65 / —	75 / 60	85 / 80	98 / 90	100/100	100/90
Flat and Elongated (ASTM D4791) (max %, by weight)	5 (5:1 ratio)	5 (5:1 ratio)	5 (5:1 ratio)	5 (5:1 ratio)	5 (5:1 ratio)	5 (5:1 ratio)	20 (3:1ratio)
Fine Aggregate Angularity (AASHTO T304, method A, min)	40	40	43	45	45	45	45
Sand Equivalency (AASHTO T 176, min)	40	40	40	45	45	50	50
Gyratory Compaction							
Gyrations for N_{ini}	6	7	7	8	8	9	8
Gyrations for N_{des}	40	60	75	100	100	125	65
Gyrations for N_{max}	60	75	115	160	160	205	160
Air Voids, % V_a (% G_{mm} @ N_{des})	4.0 (98.0)	4.0 (98.0)	4.0 (98.0)	4.0 (98.0)	4.0 (98.0)	4.0 (98.0)	4.0 (98.0)
% G_{mm} @ N_{ini}	≤ 91.5 ^[1]	≤ 90.5 ^[1]	≤ 89.0 ^[1]	≤ 89.0	≤ 89.0	≤ 89.0	—
% G_{mm} @ N_{max}	≤ 98.0	≤ 98.0	≤ 98.0	≤ 98.0	≤ 98.0	≤ 98.0	—
Dust to Binder Ratio ^[2] (% passing 0.075/ P_{75})	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2	1.2 - 2.0
Voids filled with Binder (VFB or VFA, %)	70 - 80 (4) (5)	65 - 78 (4)	65 - 75 (4)	65 - 75 (3) (4)	65 - 75 (3) (4)	65 - 75 (3) (4)	70 - 80
Tensile Strength Ratio (TSR) (ASTM 4867)							
no antistripping additive	0.70	0.70	0.70	0.70	0.70	0.70	0.70
with antistripping additive	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Draindown at Production Temperature (%)	—	—	—	—	—	—	0.30

^[1] The percent maximum density at initial compaction is only a guideline.

^[2] For a gradation that passes below the boundaries of the caution zone(ref. AASHTO MP3), the dust to binder ratio limits are 0.6 - 1.6.

^[3] For 9.5mm nominal maximum size mixtures, the specified VFB range is 73 - 76%.

^[4] For 37.5mm nominal maximum size mixes, the specified VFB lower limit is 67%.

^[5] For 25.0mm nominal maximum size mixes, the specified VFB lower limit is 67%.

460.2.8 Quality Management Program

460.2.8.1 General

(1) Provide and maintain a QC program defined as all activities, including mix design, process control inspection, sampling and testing, and process adjustments related to producing and placing HMA pavement conforming to the specifications. The contractor may also provide an optional CA program.

(2) The department will provide product quality verification as follows:

1. By conducting verification testing of independent samples.
2. By periodically observing contractor sampling and testing.
3. By monitoring required control charts exhibiting test results and control parameters.
4. By the engineer directing the contractor to take additional samples at any time during production.

(3) Refer to CMM 4-15-52 for detailed guidance on sampling, testing, and documentation under the QMP.

460.2.8.2 Contractor Testing

460.2.8.2.1 Required Quality Control Program

460.2.8.2.1.1 Personnel Requirements

(1) Provide HTCP certified sampling and testing personnel. Provide at least one full-time HMA technician certified at level I or higher at each plant site furnishing material to the project. Before mixture production begins, post an organizational chart in the contractor's laboratory. Include the names, telephone numbers, and current certifications of all personnel with QC or CA responsibilities. Keep the chart updated.

(2) Ensure that sampling personnel are qualified as follows^[1]:

- HMA technician certified at level I or higher.
- HMA ACT.

^[1] After informing the engineer, an uncertified person under the direct observation of an HMA technician certified at level I or higher may sample for a period not to exceed 3 calendar days.

(3) Ensure that all testing, data analysis, and data posting personnel are qualified as follows:

- HMA technician certified at level I or higher.
- HMA ACT under the direct supervision of an HMA technician certified at level I or higher.

(4) Have an HMA technician certified at level II or higher available to make necessary process adjustments.

460.2.8.2.1.2 Laboratory Requirements

(1) Conduct QC testing in a facility conforming to the department's laboratory qualification program.

(2) Ensure that the laboratory has at least 320 square feet (30 m²) of workspace and has a telephone for exclusive use by QMP personnel. Also provide a fax machine and copy machine that the contractor or the engineer can use at the plant site. Ensure that all testing equipment conforms to the equipment specifications applicable to the required testing methods.

460.2.8.2.1.3 Required Sampling and Testing

460.2.8.2.1.3.1 Contracts with 5000 Tons of Mixture or Greater

(1) Furnish and maintain a laboratory at the plant site fully equipped for performing contractor QC testing.

Have the laboratory on-site and operational before beginning mixture production.

(2) Obtain random samples and perform tests conforming to CMM 4-15-52. Obtain HMA mixture samples from trucks at the plant. Perform tests the same day taking the sample.

(3) Retain the split portion of the contractor HMA mixture and blended aggregate samples for 14 calendar days at the laboratory site in a dry, protected area. The engineer may decrease this 14-day retention period. At project completion the contractor may dispose of remaining samples if the engineer approves.

(4) Use the test methods identified below, or other methods the engineer approves, to perform the following tests at a frequency greater than or equal to that indicated:

Blended aggregate according to AASHTO T11 and T27:

Drum plants:

- Field extraction by department test method number 1560.
- Belt samples, optional for virgin mixtures, obtained from stopped belt or from the belt discharge using an engineer-approved sampling device.

Batch plants:

- Field extraction by department test method number 1560.

Asphalt content (AC) in percent:

AC by calculation.

AC by nuclear gauge reading, optional.

AC by inventory, optional.

Bulk specific gravity of the compacted mixture according to AASHTO T166.

Maximum specific gravity according to AASHTO T 209.

Air voids (V_a) by calculation according to AASHTO T 269.

VMA by calculation according to AASHTO PP 28.

(5) Test each design mixture at a frequency at or above the following:

TOTAL DAILY PLANT PRODUCTION FOR DEPARTMENT CONTRACTS in tons (Mg)	SAMPLES PER DAY ^[1]
50 to 600 (45-550)	1
601 to 1500 (551 – 1360)	2
1501 to 2700 (1361 – 2450)	3
2701 to 4200 (2451 – 3810)	4
greater than 4200 (3810)	see footnote ^[2]

^[1] Frequencies are for planned production. If production is less than planned, base the number of samples on actual production. If production is more than planned, continue sampling using that day's previously established increment. Conform to CMM 4-15-52.

^[2] Add a sample for each additional 1500 tons (1360 Mg) or fraction of 1500 tons (1360 Mg).

(6) Also conduct the following tests on the first day of production and once for every eight production samples thereafter, with a minimum of one test per production week.

- Aggregate stockpile gradations sampled from cold feed bins or stockpile according to AASHTO T 11 and T 27.
- Reclaimed or salvaged asphaltic pavement extractions sampled from the cold feed bin or stockpile according to AASHTO T 164 and T 30. The contractor may optionally perform a field extraction according to department test method number 1560.

(7) The department will waive stockpile testing of the aggregate and reclaimed or salvaged asphaltic pavement if the contractor provides data from tests conducted during stockpile production. Ensure that testing and documentation conforms to CMM 4-15-52.

(8) Also conduct field tensile strength ratio tests according to ASTM D 4867 on all mixtures containing an antistripping additive. Test each full 50,000 ton (46 000 Mg) production increment, or fraction of an increment, in the first week of production of that increment. If field tensile strength ratio values are either below the specification limit or less than the mixture design value by 20 or more, notify the engineer. The engineer and contractor will jointly determine a corrective action.

460.2.8.2.1.3.2 Contracts with Less Than 5000 Tons of Mixture

(1) Conform to [460.2.8.2.1.3.1](#) modified as follows:

- The contractor may conduct QC tests in an off-site laboratory.
- No field tensile strength ratio testing is required.

460.2.8.2.1.3.3 Contracts with Less Than 500 Tons of Mixture

(1) The engineer may waive all testing on contracts with less than 500 tons (460 Mg) of mixture.

460.2.8.2.1.3.4 Temporary Pavements

(1) The engineer may waive all testing for temporary pavements, defined as pavements that will be placed and removed before contract completion.

460.2.8.2.1.4 Documentation

460.2.8.2.1.4.1 Records

(1) Document all observations, inspection records, mixture adjustments, and test results daily. Note observations and inspection records in a permanent field record as they occur. Indicate all process adjustments and JMF changes on the air void control chart. Submit copies of the running average calculation sheet for blended aggregate, mixture, and asphalt content along with the air void chart and adjustment records to the engineer each day. Submit original testing records and control charts to the engineer in a neat and orderly manner within 10 days after paving is completed.

(2) Continue charts, records, and testing frequencies, for a mixture produced at one plant site, from contract to contract.

460.2.8.2.1.4.2 Control Charts

(1) Maintain standardized control charts at the laboratory. Record contractor test results on the charts the same day as testing. Post CA test results on the charts as data becomes available. Record data on the standardized control charts as follows:

- Blended aggregate gradation tests in percent passing. Of the following, plot those sieves the design specifications require: 37.5 mm, 25.0 mm, 19.0 mm, 12.5 mm, 9.5 mm, 2.36 mm, and 75 μ m.
- Asphalt material content in percent.
- Bulk specific gravity of the compacted mixture.
- Maximum specific gravity of the mixture.
- Air voids in percent.
- VMA in percent.

(2) Plot both the individual test point and the running average of the last 4 data points on each chart. Show QC data in black with the running average in red and CA data in blue. Draw the warning limits with a dashed green line and the JMF limits with a dashed red line. The contractor may use computer generated black-and-white printouts with a legend that clearly identifies the specified color coded components.

460.2.8.2.1.5 Control Limits

(1) Conform to the following control limits for the JMF and warning limits based on a running average of the last 4 data points:

ITEM	JMF LIMITS	WARNING LIMITS
Percent passing given sieve:		
37.5 mm	+/- 6.0	+/- 4.5
25.0 mm	+/- 6.0	+/- 4.5
19.0 mm	+/- 5.5	+/- 4.0
12.5 mm	+/- 5.5	+/- 4.0
9.5 mm	+/- 5.5	+/- 4.0
2.36 mm	+/- 5.0	+/- 4.0
75 µm	+/- 2.0	+/- 1.5
Asphaltic content in percent	+/- 0.4	+/- 0.3
Air voids in percent	+/- 1.3	+/- 1.0
VMA in percent	- 1.5	- 1.2

(2) Warning bands are defined as the area between the JMF limits and the warning limits.

460.2.8.2.1.6 Job Mix Formula Adjustment

(1) The contractor may request adjustment of the JMF according to the department's test method number 1559. Have an HMA technician certified at level II submit a written JMF adjustment request. Ensure that the resulting JMF is within specified master gradation bands. The department will have an HMA technician certified at level III review the proposed adjustment and, if acceptable, issue a revised JMF.

The department will not allow adjustments exceeding specified JMF tolerance limits. Have an HMA technician certified at level II make related process adjustments.

(2) If mixture redesign is necessary, submit a new JMF, subject to the same specification requirements as the original JMF. Do not reduce the JMF asphalt content unless the production VMA meets or exceeds the minimum VMA design requirement for the mixture produced.

460.2.8.2.1.7 Corrective Action

(1) When running average values trend toward the warning limits, consider taking corrective action.

Document all corrective actions undertaken. Include all test results in the contract files and in running average calculations.

(2) Notify the engineer if running average values exceed the warning limits. If two consecutive running average values exceed the warning limits, stop production and make adjustments. Do not restart production until after notifying the engineer of the adjustments made. Do not calculate a new running average until the fourth test after the required production stop.

(3) If the process adjustment improves the property in question so that the running average after 4 additional tests is within the warning limits, the contractor may continue production with no reduction in payment

(4) If the adjustment does not improve the properties and the running average after 4 additional tests stays inside the warning bands, the mixture is nonconforming and subject to pay adjustment.

(5) If the contractor fails to stop production and make adjustments when required, all mixture produced from the stop point to the point when the running average is back inside the warning limits is nonconforming and subject to pay adjustment.

(6) The department will reduce payment for nonconforming QMP HMA mixtures, starting from the stop point to the point when the running average is back inside the warning limits, as follows:

ITEM	PAYMENT FOR MIXTURE ⁽¹⁾	
	PRODUCED WITHIN WARNING BANDS	PRODUCED OUTSIDE JMF LIMITS
Gradation	90%	75%
Asphalt Content	85%	75%
Air Voids	70%	50%
VMA	90%	75%

⁽¹⁾ Payment is in percent of the contract unit price for both the HMA Pavement and Asphaltic Material bid items. The department will reduce pay based on the nonconforming property with lowest percent pay. The asphaltic material quantity is based on the JMF asphalt content. The department will administer pay reduction under the Nonconforming QMP Asphaltic Material and the Nonconforming QMP HMA Mixture administrative items.

(7) If the running average values exceed the JMF limits, stop production and make adjustments. Do not restart production until after notifying the engineer of the adjustments made. Continue calculating the running average after the production stop.

(8) If the air voids running average of 4 exceeds the JMF limits, the material is nonconforming. Remove and replace unacceptable material at no additional expense to the department. The engineer will determine the quantity of material to replace based on the testing data using the methods in CMM 4-15-52 and an inspection of the completed pavement. If the engineer allows the mixture to remain in place, the department will pay for the mixture and asphaltic material at 50 percent of the contract price.

(9) If the running average of 4 exceeds the JMF limits for other properties, the department will pay 75 percent of the contract price for mixture and asphaltic material if the engineer allows the mixture to remain in place. The engineer will determine the quantity of material subject to pay reduction based on the testing data and an inspection of the completed pavement.

(10) The department may also apply pay adjustments, as specified in [460.2.8.2.1.7\(6\)](#) through (9), for special circumstances as follows:

1. For plants where the total season production of a mixture requires less than 4 tests, the department will assess the material by comparing single data points to 1.5 times the warning and JMF limits.
2. At contract completion, the department will assess the material by evaluating the last 3 tests as single tests and comparing to 1.5 times the warning and JMF limits.
3. If the contractor's test results prove incorrect.

460.2.8.2.2 Optional Contractor Assurance

460.2.8.2.2.1 General

(1) CA testing is optional and is conducted to further validate production testing. The contractor may offer CA data to provide an additional piece of information for the following:

1. Process control decisions.
2. Troubleshooting possible sampling, splitting, or equipment problems.
3. Limiting liability, as defined in CMM 4-15-52, for nonconforming product as a result of department verification testing. These provisions do not supercede department's rights under [107.16](#).

460.2.8.2.2.2 Personnel Requirements

(1) Ensure that an HMA technician certified under HTCP at level I or higher performs all CA testing and data analysis. Personnel performing CA testing can not perform QC testing for the same materials.

460.2.8.2.2.3 Laboratory Requirements

(1) Conduct CA testing in a facility conforming to the department's laboratory qualification program. Furnish and maintain a laboratory fully equipped for performing selected CA tests. If the a single laboratory is providing CA and QC data for the same materials, ensure that a separate set of equipment is used to prepare CA samples and run CA tests.

460.2.8.2.2.4 Testing

(1) For the CA program, use the test methods enumerated here in 460.2.8.2.2.4, other engineer-approved methods, or other methods the industry and department HMA technical team recognizes. The contractor may select tests at its option. If using tests in limiting liability, as provided in CMM 4-15-52, data must exist for the property in question.

(2) Perform selected testing as follows:

- Bulk specific gravity (Gmb) of the compacted mixture according to AASHTO T 166 based on the average of 2 specimens.
- Maximum specific gravity (Gmm) according to AASHTO T 209.
- Air voids (Va) by calculation according to AASHTO T 269.
- VMA by calculation according to AASHTO PP 28.

- Stockpile gradation according to AASHTO T 11 and T 27^[1].
- Blended aggregate gradation on plant mix according to department test method number 1560.
- Fine aggregate angularity (FAA) according to AASHTO T 304, method A.

^[1] As modified in CMM 4.

(3) There is no specified frequency for CA testing.

(4) The department will compare CA samples to QC samples. Obtain CA samples by retaining a QC split portion conforming to the "rule of retained" requirements, as provided in CMM 4-15-52. Alternatively the contractor may have CA personnel take an additional sample during production. If taking an additional sample, the contractor may, with the engineer's approval, replace one of the required random QC tests for that day with the CA sample.

460.2.8.2.2.5 Documentation

(1) Report CA test results to the engineer and the contractor's field staff within 2 business days after receiving the samples.

460.2.8.2.2.6 Allowable Differences

(1) Differences between the QC and CA split sample test results are acceptable in limiting liability, as provided in CMM 4-15-52, if within the following limits:

ITEM	ALLOWABLE DIFFERENCES
Percent passing 12.5 mm sieve	6.0
Percent passing 9.5 mm sieve	6.0
Percent passing 4.75 mm sieve	5.0
Percent passing 2.36 mm sieve	4.0
Percent passing 600 µm sieve	3.5
Percent passing 75 µm sieve	2.0
Bulk specific gravity of the compacted mixture	0.030
Maximum specific gravity	0.020

460.2.8.3 Department Testing

460.2.8.3.1 Quality Verification Program

460.2.8.3.1.1 General

(1) The engineer will conduct QV tests to determine the quality of the final product and measure characteristics that predict relative performance.

460.2.8.3.1.2 Personnel Requirements

(1) The department will provide at least one HMA technician, certified under HTCP at level I or higher, to observe QV sampling of project mixtures. An HMA technician certified at level I or higher, or an HMA ACT under the direct supervision of an HMA technician certified at level I or higher, will split, test, analyze data, and post data. The department will make an organizational chart available at the testing laboratory and to the contractor before mixture production begins. The department's chart will include names,

telephone numbers, and current certifications of all QV testing personnel. The department will update the chart with appropriate changes, as they become effective.

460.2.8.3.1.3 Laboratory Requirements

(1) The department will furnish and maintain a facility for QV testing conforming to the department's laboratory qualification program requirements and fully equipped to perform QV testing. In all cases, the department will conduct testing in a separate laboratory from the contractor's laboratory.

460.2.8.3.1.4 Department Verification Testing Requirements

(1) HTCP certified department personnel will obtain random samples by directly supervising HTCP certified contractor personnel sampling from trucks at the plant. The department will sample conforming to CMM 4-15-52. Sample size must be adequate to run the appropriate required tests in addition to one set of duplicate tests that may be required for dispute resolution. The engineer will split the sample for testing and retain the remaining portion for additional testing if needed.

(2) The department will verify product quality using the test methods enumerated here in 460.2.8.3.1.4(2), other engineer-approved methods, or other methods the industry and department HMA technical team recognizes. The department will identify test methods before construction starts and use only those methods during production of that material unless the engineer and contractor mutually agree otherwise.

(3) The department will perform all testing conforming to the following standards: Bulk specific gravity (Gmb) of the compacted mixture according to AASHTO T 166. Maximum specific gravity (Gmm) according to AASHTO T 209.

Air voids (Va) by calculation according to AASHTO T 269.

VMA by calculation according to AASHTO PP 28.

(4) The department will test each design mixture at the following minimum frequency:

FOR TONNAGES TOTALING:

Less than 501 tons (455 Mg)no tests required

From 501 (455 Mg) to 30,000 tons(27 215 Mg)one test

More than 30,000 tons (27 215 Mg).....add one test for each additional 30,000-ton (27 215 Mg) increment

460.2.8.3.1.5 Documentation

(1) The engineer will document all observations during QV sampling, and review QC mixture adjustments and QC/CA test results daily. The engineer will note results of observations and inspection records in a permanent field record as they occur.

460.2.8.3.1.6 Acceptable Verification Parameters

(1) The engineer will provide test results to the contractor within 2 mixture-production days after obtaining the sample. The quality of the product is acceptably verified if it meets the following limits:

- Va is within a range of 2.7 to 5.3 percent.
- VMA is within minus 1.5 of the minimum requirement for the mix design nominal maximum aggregate size.

(2) If QV test results are outside the specified limits, the engineer will investigate immediately through dispute resolution procedures. The engineer may stop production while the investigation is in progress if the potential for a pavement failure is present.

(3) If production continues, the engineer will provide additional CA testing at the frequency provided for in CMM 4-15-52. This supplemental testing will continue until the material meets the acceptable limits or as the engineer and contractor mutually agree.

460.2.8.3.1.7 Dispute Resolution

(1) When QV test results do not meet the specified limits, the bureau's AASHTO accredited laboratory and certified personnel will referee test the retained portion of the QV sample and the retained portion of the nearest available previous QC sample.

(2) The department will notify the contractor of the referee test results within 2 business days after receipt of the samples.

(3) The department will determine mixture conformance and acceptability by analyzing referee test results, reviewing mixture project data, and inspecting the completed pavement all conforming to CMM 4-15-52.

460.2.8.3.1.8 Corrective Action

(1) Remove and replace unacceptable material at no additional expense to the department.

(2) The department will reduce pay for the tonnage of nonconforming mixture, as determined during QV dispute resolution, if the engineer allows that mixture to remain in place. If production continued during the investigation, the department will also adjust pay for that mixture forward to the next conforming QV or QC/CA point. The department will pay for the affected mixture at 50 percent of the contract price. The department will adjust pay for both the mixture and the asphaltic material.

460.2.8.3.2 Independent Assurance Testing

(1) The department will evaluate both the contractor and department testing personnel and equipment as specified in [106.3.4.3.6](#).

460.3 Construction

460.3.1 General

(1) Construct HMA pavement conforming to the general provisions of [450.3](#).

460.3.2 Thickness

(1) Provide the plan thickness for lower and upper layers limited as follows:

NOMINAL SIZE	MINIMUM LAYER THICKNESS	MAXIMUM LOWER LAYER THICKNESS	MAXIMUM UPPER LAYER THICKNESS
	in inches (mm)	in inches (mm)	in inches (mm)
37.5 mm	3.5 (89)	5 (127)	4.5 (114)
25.0 mm	3.25 (83)	5 (127)	4 (102)
19.0 mm	2.25 (57)	4 (102)	3 (76)
12.5 mm ^[1]	1.75 (44)	3 (76) ^[2]	2.5 (64)
9.5 mm ^[1]	1.5 (38)	3 (76) ^[2]	2 (51)

^[1] SMA mixtures use nominal size 12.5 mm or 9.5 mm.

^[2] SMA mixtures with nominal sizes of 12.5 mm and 9.5 mm have no maximum lower layer thickness specified.

460.3.3 HMA Pavement Density Maximum Density Method

Effective with the December 2006 Letting 204 2006 Standard Specifications

460.3.3.1 Minimum Required Density

(1) Compact all layers of HMA mixture to the density [table 460-3](#) shows for the applicable mixture, location, and layer.

TABLE 460-3 MINIMUM REQUIRED DENSITY^[1]

LOCATION	LAYER	PERCENT OF TARGET MAXIMUM DENSITY		
		MIXTURE TYPE		
		E-0.3, E-1, and E-3	E-10, E-30, and E-30x	SMA
TRAFFIC LANES ^[2]	LOWER	91.5 ^[3]	92.0 ^[3]	94.0
	UPPER	91.5	92.0	94.0
SIDE ROADS, CROSSOVERS, TURN LANES, AND RAMPS	LOWER	91.5 ^[3]	92.0 ^[3]	94.0
	UPPER	91.5	92.0	94.0
SHOULDERS AND APPURTENANCES	LOWER	89.5	89.5	91.0
	UPPER	90.5	90.5	91.0

^[1] The table values are for average lot density. If any individual density test result falls below 87% of the target maximum density, the engineer may investigate the acceptability of that material.

^[2] Includes parking lanes as determined by the engineer.

^[3] Minimum reduced by 2 percent for < 3 million ESALs and one percent for > 3 million ESALs, for that lower layer constructed directly on crushed aggregate or recycled base courses.

460.3.3.2 Pavement Density Determination

(1) The engineer will determine the target maximum density using department procedures. The engineer will measure pavement density for either nuclear density or the density of sawed or cored samples. The engineer and contractor will decide which method to use before paving. A change to the method requires agreement between the engineer, contractor, and the department's quality management section. The engineer will determine density as soon as it is practical after compaction and before placement of

subsequent layers. Cut pavement samples as the engineer directs and restore the surface with new, well compacted mixture.

(2) Do not re-roll compacted mixtures with deficient density test results. Do not operate continuously below the specified minimum density. Stop production, identify the source of the problem, and make corrections to produce work meeting the specification requirements.

(3) A lot represents 750 tons (680 Mg) of a mixture placed within a single layer for each location and target maximum density category indicated in [table 460-3](#).

(4) For nuclear density, the department will test 5 random samples on each lot. A nuclear density technician certified at level I will perform the testing. For the density of sawed or cored samples, the department will test 3 random samples, each at least 28 square inches (18 000 mm²) in area, from each lot. The lot density is the average of all samples taken for that lot. The department will provide density results to the contractor weekly. The number of nuclear density tests required for legs of side roads at intersections, crossovers, turn lanes, and ramps with less than 750 tons per lift are specified in CMM 4-5-90.

460.3.3.3 Waiving Density Testing

(1) The engineer may waive density testing for one or more of the following reasons:

1. It is not practical to determine density by the lot system.
2. The contract contains less than 750 tons (680 Mg) of a given mixture type placed within the same layer and target maximum density category.

(2) If the department waives density testing, the department will accept the mixture by the ordinary compaction procedure as specified in [450.3.2.6.2](#).

460.4 Measurement

Effective with the December 2006 Letting 205 2006 Standard Specifications

(1) The department will measure the HMA Pavement bid items acceptably completed by the ton as specified in [450.4](#).

(2) The department will not measure QMP HMA Mixture for material if the engineer waives the QMP testing requirements.

460.5 Payment

460.5.1 General

(1) The department will pay for measured quantities at the contract unit price under the following bid items:

<u>ITEM NUMBER</u>	<u>DESCRIPTION</u>	<u>UNIT</u>
460.1100	HMA Pavement Type E-0.3	TON
460.1101	HMA Pavement Type E-1	TON
460.1103	HMA Pavement Type E-3	TON
460.1110	HMA Pavement Type E-10	TON
460.1130	HMA Pavement Type E-30	TON
460.1132	HMA Pavement Type E-30X	TON
460.1700	HMA Pavement Type SMA	TON
460.2000	Incentive Density HMA Pavement	DOL
460.3000	QMP HMA Mixture	TON

460.5.2 HMA Pavement

460.5.2.1 General

(1) The department will pay for the HMA Pavement bid items at the contract unit price subject to one or more of the following adjustments:

1. Disincentive for density of HMA pavement as specified in [460.5.2.2](#).
2. Incentive for density of HMA pavement as specified in or [460.5.2.3](#).
3. Reduced payment for nonconforming smoothness as specified in [450.3.2.9](#).
4. Reduced payment for nonconforming QMP HMA mixtures as specified in [460.2.8.2.1.7](#).

(2) Payment for HMA Pavement Type E-0.3, E-1, E-3, E-10, E-30, and E-30x is full compensation for providing HMA mixture designs; for preparing foundation; and for furnishing, preparing, hauling, mixing, placing, and compacting mixture; for all materials except asphaltic materials.

(3) Payment for HMA Pavement Type SMA, is full compensation for providing HMA mixture designs; for preparing foundation; and for furnishing, preparing, hauling, mixing, placing, and compacting the mixture; for all materials including asphaltic materials; for stabilizer, hydrated lime, and liquid antistripping agent if required.

(4) If provided for in the plan quantities, the department will pay for a leveling layer, placed to correct irregularities in an existing paved surface before overlaying, under the pertinent paving bid item. Absent a plan quantity, the department will pay for a leveling layer as extra work.

(5) Except for SMA mixes, the department will pay for asphaltic materials separately under the Asphaltic Materials bid items as specified in [455.5](#). Except for SMA mixes, hydrated lime or liquid antistripping agent, when required, is included in the contract price for the asphaltic material.

(6) If the department waives density testing under [460.3.3.3](#), the department will not adjust pay under either [460.5.2.2](#) or [460.5.2.3](#).

(7) Restore the surface after cutting density samples as specified in [460.3.3.2\(1\)](#) at no additional cost to the department.

460.5.2.2 Disincentive for HMA Pavement Density

(1) The department will administer density disincentives under the Disincentive Density HMA Pavement and the Disincentive Density Asphaltic Material administrative items. If the lot density is less than the specified minimum in [table 460-3](#), the department will reduce pay based on the contract unit price for both the HMA Pavement and Asphaltic Material bid items for that lot as follows:

DISINCENTIVE PAY REDUCTION FOR HMA PAVEMENT DENSITY

PERCENT LOT DENSITY BELOW SPECIFIED MINIMUM	PAYMENT FACTOR (percent of contract price)
From 0.5 to 1.0 inclusive	98
From 1.1 to 1.5 inclusive	95
From 1.6 to 2.0 inclusive	91
From 2.1 to 2.5 inclusive	85
From 2.6 to 3.0 inclusive	70
More than 3.0 ^[1]	—

^[1] Remove and replace the lot with a mixture at the specified density. When acceptably replaced, the department will pay for the replaced work at the contract unit price. Alternatively the engineer may allow the nonconforming material to remain in place with a 50 percent payment factor.

(2) If the engineer directs placing HMA mixtures between October 15 and May 1 for department convenience as specified in [450.3.2.1\(5\)](#), the department will not assess a density disincentive on pavement the department orders the contractor to place when the temperature, as defined in [450.3.2.1\(2\)](#), is less than 36 F (2 C).

460.5.2.3 Incentive for HMA Pavement Density

(1) If the lot density is greater than the minimum specified in [table 460-3](#) and all individual air voids test results for that mixture placed during the same day are within +1.0 percent or - 0.5 percent of the design target in [table 460-2](#), the department will adjust pay for that lot as follows:

INCENTIVE PAY ADJUSTMENT FOR HMA PAVEMENT DENSITY

PERCENT LOT DENSITY ABOVE SPECIFIED MINIMUM	PAY ADJUSTMENT PER LOT ^[1]
From -0.4 to 1.0 inclusive	\$0
From 1.1 to 1.8 inclusive	\$300
More than 1.8	\$600

^[1] The department will prorate the pay adjustment for a partial lot.

(2) The department will adjust pay under the Incentive Density HMA Pavement bid item. Adjustment under this item is not limited, either up or down, to the bid amount shown on the schedule of items.

(3) The department will restrict incentive payment as follows:

1. For shoulders paved integrally with the traffic lane, if the traffic lane does not meet incentive requirements, the department will not pay incentive on the integrally paved shoulder.
2. If part of a lot is started or finished on a day when an individual air void test does not meet the air void criteria of [460.5.2.3\(1\)](#), the entire lot is not eligible for incentive.

460.5.3 QMP HMA Mixture

(1) Payment for QMP HMA Mixture is full compensation for sampling, testing, and documenting all contractor activities required under the department's QMP. The department will not pay for QMP HMA Mixture for material if the engineer waives the QMP testing requirements.