6-400 SURFACE TREATMENTS AND PAVEMENTS

6-400.1 GENERAL

A roadway consists of layers of various materials. These layers, called courses, provide strength and are placed on the original ground. The top layers are typically asphalt concrete or portland cement concrete. These layers add to the strength of the roadway section. The uppermost layer provides the riding surface for vehicles.

Concrete consists of coarse and fine aggregates, and a cementing agent, either asphalt or portland cement. Asphalt concrete pavements are comprised of asphalt, a byproduct of the distillation of crude oil called bitumen, and coarse and fine aggregates. Because asphalt concrete is mixed at a plant, the mixture is commonly called plantmix bituminous pavement. Pavements made with portland cement and coarse and fine aggregates are commonly called portland cement concrete pavement, PCCP. The decision to use either asphalt or portland cement concrete is based on variables such as design requirements, cost, climate, and material availability.

For existing roadways, the condition of the pavement and base significantly influences the type of pavement reconstruction, rehabilitation, or maintenance treatment used to improve the condition of the roadway. Severely distressed pavements may require removal and replacement. Less distressed pavement may only require rehabilitation by grinding, or coldmilling, the existing pavement and replacing it with new plantmix bituminous pavement.

Regardless of the surface treatment or pavement material, three operations require observation – mixing of the paving material, preparation of the roadway surface, and placement of the mixed material on the roadway. The following sections provide details for monitoring surface treatment and paving operations.

6-400.2 SAFETY

Safety is imperative throughout the entire paving process. On roadway construction projects, personnel regularly handle and move materials and equipment. Therefore, everyone on the project must be alert to all movements—equipment, people, and materials. By being aware of surroundings, you reduce the chances of being struck by a moving vehicle, construction equipment, or the traveling public. Being aware also reduces the risk of placing yourself in an unsafe situation. .

Accidents involving equipment and materials on the jobsite are not the only safety concerns. Plants that mix asphalt concrete or portland cement concrete are areas where material and processing temperatures are dangerously high, hoisting operations are ongoing, and chemicals are being used. Exercise care and awareness of activities and surroundings to improve worker safety. Federal agencies play a significant role with job-site safety. The Occupational Safety and Health Administration and the Mine Safety and Health Administration have responsibilities relating to plant operations and confined space work areas, respectively. Refer to Section 5-200, Field Safety, of this *Construction Manual* for additional information on safety.

6-401 PLANTMIX BITUMINOUS PAVEMENTS

6-401.1 GENERAL

The process of constructing a plantmix bituminous pavement consists of the following three principal operations:

- Mixing of the paving material, including aggregate preparation, storage and handling, mixing plant calibration and operation
- Preparation of the roadway surface
- Placement of the mixed material on the roadway, including equipment, paving methods, and compaction

Before construction, each of the three operations requires observation and monitoring in preparation of paving activities. During construction, the field crew continues to monitor operations at the mixing plant and paving activities operations on the roadway. The following sections provide guidance during the inspection process. The specifications describe the requirements for materials and construction methods that the contractor must follow. The Asphalt Institute publication "Construction of Hot Mix Asphalt Pavements" contains helpful information relating to bituminous pavement and other asphalt-related topics.

6-401.2 BEFORE CONSTRUCTION

6-401.2.1 MIX DESIGN DEVELOPMENT

Development of a mix design for plantmix bituminous material consists of producing and preparing aggregate, testing aggregate, obtaining asphalt samples, and transmitting aggregate and asphalt samples to the Materials Division. Using the samples submitted by the Resident Engineer, the Materials Division develops a plantmix bituminous mix design that conforms to the requirements of the specifications.

Aggregate production and stockpiling significantly influence the quality of the pavement. Although aggregate production and stockpiling are the responsibilities of the contractor, NDOT observes how these operations are performed to monitor the quality of the material. To obtain acceptable quality in the pavement, aggregate production should be uniform and stockpiling should reduce segregation.

Aggregate is commonly produced by mining, crushing, and then passing the material through a series of screens to obtain the aggregate sizes required by the specifications. Any changes in this production process, such as adjustment of crusher openings, screen changes, or equipment wear, can change the aggregate gradation.

After aggregate is screened, it is stored in stockpiles. When stockpiles are constructed, aggregate particles of similar sizes may collect at the base of the stockpile, resulting in a non-homogeneous material. This collection of similar particles, or separation of particles, is called segregation. Aggregate production and stockpiling is discussed in Section 6-100.1, Aggregate Sources.

Because the contractor is responsible for the quality of the aggregate being produced and stockpiled, the contractor conducts informational tests throughout the process. Refer to Section 106 of the specifications. A benefit of frequent testing is development of a history of each material produced. The Resident Engineer also conducts informational testing to monitor the quality of the material. While the Resident Engineer cannot tell the contractor how to produce the aggregate or store the aggregate in stockpiles, the Resident Engineer may offer input to the contractor by clarifying specifications relating to storing and stockpiling aggregate.

After the contractor has produced a quantity of aggregate representative of the material to be incorporated into the work, the contractor requests development of a mix design. At the time of the request, the contractor proposes an initial proportioning, or percentage, of aggregate from each stockpile. This proportioning is typically called "bin percentages." The specifications will state the minimum quantity of aggregate that the contractor must produce before requesting development of a mix design.

The Resident Engineer's testers then obtain and test aggregate samples from each stockpile to verify that the aggregate conforms to the specifications. The Resident Engineer compares test results with the contractor's test results. The Resident Engineer's test results and the contractor's test results should correlate. If test results do not correlate, the Resident Engineer notifies the contractor. Although the contractor is not required to make modifications, the contractor may make modifications. After the Resident Engineer confirms that test results are representative of the stockpiles and that the test results comply with the specifications, the contractor then provides asphalt samples to the Resident Engineer. The Resident Engineer confirms that the type of asphalt, as stated on the sample container, conforms to the specifications. The Resident Engineer sends the aggregate samples with the aggregate test results, and asphalt sample to the Materials Division.

The Materials Division performs tests on the aggregate and asphalt samples, confirming the Resident Engineer's aggregate test results and that the asphalt conforms to the specifications. Based on the test results and bin percentages proposed by the contractor, the Materials Division develops a mix design and sends it to the Resident Engineer. The mix design establishes the amount of asphalt that will be added to the aggregate—the "bitumen ratio."

Bitumen ratio is a percentage calculated by dividing the amount of asphalt by the dry weight of the aggregate. A similar but different term, Asphalt Content, is a percentage calculated by dividing the amount of asphalt by the total weight of the mixture (aggregate and asphalt). The terms "bitumen ratio" and "asphalt content" are often confused as having the same meaning, but they are different. In determining the mix design bitumen ratio, the Materials Division prepares several batches with varying amounts of asphalt. The Materials Division sends the mix design to the Resident Engineer. The Resident Engineer transmits the mix design to the contractor. The contractor uses the mix design to develop a proposed job mix formula, which is discussed in Section 6-401.2.2, Job Mix Formula. .

Figure 6-401.1. Aggregate Marination Plant.

After aggregate is produced and stockpiled, the aggregate may require treatment to modify its characteristics. A finely ground mineral called hydrated lime is added to the aggregate to reduce plasticity and moisture sensitivity. The most common process of mixing aggregate, water, and hydrated lime is called marination. NDOT specifications call this process the Marination Method. The marinated aggregate must be stockpiled for a minimum of 48 hours before being mixed with asphalt. The equipment used in the marination process includes a lime storage silo, aggregate bins with feeder belts, a pugmill for mixing, and a conveyor system to a stockpile or hauling truck. Figure 6-401.1 shows a typical aggregate marination plant.

The contractor must calibrate the equipment used in the marination process before materials are marinated. The inspector observes the calibration of this equipment as described in Section 6-401.2.4, Marination Plant Calibration.

In the marination process, the aggregate must be wet and have water on the surface to activate the chemical reaction with the lime. If the aggregate is not wet, the contractor adds water to the aggregate before adding lime. The appropriate amount of moisture in the aggregate allows each individual piece of aggregate to be coated with lime, whereas too much moisture has a clumping effect, causing several pieces of aggregate to stick together. The Resident Engineer visually determines the appropriate amount of moisture. The appropriate moisture content is determined using the following guidelines:

- Before the addition of hydrated lime, the coarse aggregate has a wet sheen on the surface of the aggregate particle without water dripping from it.
- Before the addition of hydrated lime, the fine aggregate holds its shape after squeezing without water dripping from it.
- After the addition of hydrated lime, the aggregate is completely coated with lime, without clumping of lime or aggregate particles.

The specifications will state the amount of hydrated lime, also referred to as mineral filler, to be used in the marination process, which is typically one percent for coarse aggregate and two percent for fine aggregate. The specifications typically state different amounts of hydrated lime for fine aggregate and coarse aggregate.

The moist aggregate is transported by conveyor belt to the pugmill for mixing. If the aggregate requires additional water to reach the appropriate moisture content, water is added to the aggregate before hydrated lime is added. This ensures that sufficient moisture is available to activate the hydrated lime. The hydrated lime is added to the moist aggregate at the pugmill. The marinated aggregate is discharged from the pugmill and transported to a stockpile.

Figure 6-401.2. Aggregate Properly Coated with Lime.

To verify the amount of lime added to the aggregate, the inspector performs periodic checks during the marination process. Periodic checks are performed hourly. During the check, flow rates of aggregate and lime are measured during a 10 minute period. Using the flow rates of aggregate and of lime during the 10 minute period, the inspector can calculate the percentage of lime added to the aggregate. Coarse and fine aggregates are marinated and monitored separately. An example of a ten-minute check for fine aggregate is as follows:

EXAMPLE:

Between 5:30 pm and 5:40 pm, total fine aggregate across the weigh belt was 50.23 tons. The daily moisture content measured by the tester was 4.1%. The hydrated lime across the weigh belt was 0.817 ton. The required amount of hydrated lime for fine aggregate, as stated in the specifications, is 2% of the dry weight of aggregate.

Calculation:

Weight of aggregate: 50.23 tons

Aggregate moisture: 4.1%

Weight of hydrated lime: 0.817 ton

$$WT_{\text{dry aggregate}} = \frac{WT_{\text{aggregate}}}{1+(\%\text{moisture})} = \frac{50.23\ \text{tons}}{1+0.041} = 48.25\ \text{tons dry aggregate}$$

$$\text{Percent of hydrated lime} = \frac{WT_{\text{hydrated lime}}}{WT_{\text{dry aggregate}}} \times 100 = \frac{0.817\ \text{ton}}{48.25\ \text{tons}} \times 100 = 1.7\%$$

In this example, the inspector would inform the contractor that corrective action is necessary because the actual hydrated lime percentage is below the required amount of 2%.

The calculated percent of hydrated lime for each ten-minute check is recorded in the marination plant inspector's daily diary. Additionally, for the day's production, the percentage of lime and total dry weight of the aggregate is recorded in the plant inspector's daily diary for each aggregate size stockpiled. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for an example of a completed marination plant inspector's daily diary.

The inspector verifies that the discharged marinated aggregate is uniformly coated with hydrated lime and that the hydrated lime is uniform throughout the marinated aggregate. Uniformly coated marinated aggregate is shown in Figure 6-401.2. To verify that the hydrated lime is uniform throughout the marinated aggregate, the inspector squirts a stream of phenolphthalein across the aggregate mix. The phenolphthalein reacts with the hydrated lime and changes from clear to a pinkish purple color. By observing the coloring of the phenolphthalein strip, the inspector can determine the uniformity of the hydrated lime distribution within the marinated aggregate. Refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* for sampling and testing requirements.

Marinated aggregate must cure for at least 48 hours before use. After the 48-hour cure time, the aggregate is approved for use up to a maximum number of days, as stated in the specifications, usually 60 days after mixing. If aggregate is cured longer than the maximum number of days specified and the contractor plans to use the aggregate in the work, the Resident Engineer should confer with the Materials Division. The Materials Division may recommend re-marinating the aggregate to ensure the effectiveness of the hydrated lime, using half the amount of lime originally specified for the marination process.

The marination inspector must document when the stockpiled material was mixed and how long each stockpile has cured. Accurate documentation reduces the contractor from introducing the wrong material into the mix. To help monitor which stockpiles are incorporated into the mix, create a diagram of the stockpiled materials, showing the location and the marination date. Provide a copy of the diagram to the NDOT plant inspector, and to the contractor's plant operator and loader operator to assist in managing the material being incorporated into the plantmix. Additionally, the marination inspector marks the stockpiled material with a lath listing the date, time, and other relevant information. Painting the date on the stockpiled aggregate is also acceptable.

On rare occasions, NDOT specifications may allow the addition of hydrated lime using a process called the Cold Feed Method. In these situations, the hydrated lime is added to modify the chemical characteristics of the mixture, not the characteristics of the aggregate. The hydrated lime is added to the aggregate prior to the addition of asphalt. A significant difference between the cold feed method and the marination method of adding hydrated lime is that the cold feed method does not have a curing period.

After an amount of marinated aggregate has been prepared, as stated in the specifications, and after an approved mix design has been received from the Materials Division, the Resident Engineer establishes a job mix formula. The purpose of the job mix formula is to produce a uniform plantmix material.

6-401.2.2 JOB MIX FORMULA

Although the Resident Engineer establishes the job mix formula, the contractor must first propose a job mix formula that is based on the mix design approved by the Materials Division. The Resident Engineer reviews the contractor's proposed job mix formula. The Resident Engineer may make minor adjustments to the contractor's proposed job mix formula. The purpose of the job mix formula is to produce a uniform plantmix material by narrowing the tolerances. The aggregate gradation specification for plantmix pavements allows a wide range of values to accommodate a variety of aggregates. The durability of the pavement is directly related to the uniformity of the mixture. If aggregate gradation or the amount of asphalt fluctuates, even though the mixture remains within specified limits, the pavement durability is reduced. The job mix formula narrows the gradation specifications to limit variability, improve uniformity, and increase durability.

In addition to the job mix formula, the contractor can do the following to improve the mixture's uniformity:

- Build stockpiles using techniques that reduce segregation
- Build two or more stockpiles of various size aggregates
- Use multiple aggregate bins at the mixing plant

Based on the job mix formula proposed by the contractor, the Resident Engineer establishes the job mix formula used on the project. The job mix formula includes the following items:

1. Mix design number, assigned by the Materials Division, on which the job mix formula is based
2. Job Mix Formula number, assigned sequentially by the Resident Engineer, commencing with JMF#1
3. Names and locations of aggregate sources
4. Percentage of each type of aggregate being used (bin percentage)
5. Percent of aggregate passing each specified sieve
6. Percent of asphalt to be added (to the 0.1%), which is the bitumen ratio
7. Asphalt type and producer
8. Actual total percent of hydrated lime, based on coarse and fine aggregate stockpiles
9. Statement of whether baghouse fines are used or not, and maximum percentage allowed
10. Temperature of mixture leaving the mixer
11. Minimum temperature of the mixture in the hopper of the paving machine

While the job mix formula sets a single value for the items listed, the specifications provide a range of tolerances within which the contractor must produce the plantmix material. Single values with tolerances provide a uniform mixture, yet allow for minor fluctuations in the production process. Throughout the life of a project, the job mix formula may be modified for various reasons. The contractor must request modifications to the job mix formula and the Resident Engineer reviews and, if reasonable, approves the request. If approved, the Resident Engineer establishes a new job mix formula. Discussions with other NDOT Resident Engineers using the same mix design may be helpful in establishing the initial job mix formula. The Resident Engineer should not revise the job mix formula in reaction to the contractor's variability, or lack of uniformity, in the aggregate. To maintain uniformity, limit changes to the job mix formula. The Resident Engineer documents the job mix formula in a letter to the contractor. . Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for an example of a job mix formula letter and explanation of the process for developing a job mix formula letter.

The Resident Engineer may modify portions of the job mix formula without contacting the Materials Division, although consultation with the Materials Division and the Construction Division Quality Assurance Section is encouraged. The Resident Engineer must contact the Materials Division before making changes to the bitumen ratio.

Bin percentages, on which the mix design is based, may only be modified within limits. The Resident Engineer may allow changes in bin percentages that do not exceed a total of six percentage points for all bins. For example, if a mix uses three bins of aggregate, the amount of Bin #1 aggregate is reduced by two percent and Bin #2 aggregate is increased by three percent. Bin #3 may be reduced by only one percent to maintain the total of 100 percent and keep the total percentage change at six percent or less. Because the bin percentages have been changed a total of six percent (2 + 3 + 1 = 6), no additional changes are allowed without Materials Division approval. Changes greater than six percent must be approved by the Materials Division. For changes greater than 10 percent total, the Materials Division may require a new mix design.

6-401.2.3 MIXING PLANT

The mixing plant combines the prepared aggregate and asphalt under conditions required by the specifications. The mixture produced at the plant is loaded into hauling trucks and transported to the paver on the roadway, where it is spread and compacted. The controlled conditions and operations at the mixing plant significantly influence the quality and durability of the plantmix placed on the roadway. The Resident Engineer's plant inspector must be knowledgeable of the specification requirements, the job mix formula, the mixing plant operations, and the materials processing and storage. The Construction Division Quality Assurance Section is available for support and guidance.

In general, two types of plants are used to mix materials for plantmix bituminous pavements: batch plant and continuous mixing plant. A batch plant produces plantmix material a single batch at a time. A continuous mixing plant produces plantmix material continuously. Another significant difference is that, in a batch plant, aggregate is proportioned after it is dried and heated. With a continuous mixing plant, the aggregate is proportioned and then dried and heated. While the plants have distinct differences, many elements of the plant components and operations are similar. Following are common elements that require a plant inspector's attention:

- Aggregate Bins – Bins store aggregate that has been processed and screened into various sizes, ready for proportioning. The partitions separating one bin from another must be solid, free of holes, and high enough to prevent the aggregate from spilling over into an adjacent bin. Fine dust may collect in the corners of the bins. Material can also stick together, forming clumps that result in aggregate segregation. An accumulation of fine dust or clumps of material may be detrimental to the mix. The inspector should observe the bins to monitor the uniformity of the aggregate. The contractor should take measures to minimize accumulation of fines in the bins.

- Aggregate Cold Feed – The aggregate cold feed belt is a conveyor belt that delivers the aggregate from the aggregate bins to the mixer. Each aggregate bin is equipped with a feed belt that delivers aggregate from the bin to the cold feed belt. The speed of each aggregate bin feed belt, as well as the aggregate bin gate setting, determines the proportion of the particular aggregate. After calibration of the aggregate cold feed, no changes in the bin gate settings are allowed. Loading of the belts can affect the uniformity of the aggregate gradation. Malfunctioning belt feeders or gates, overloading the bins, and inconsistent aggregate moisture can adversely affect the operation of the aggregate cold feed. .

- Aggregate Screens – Screens located between the aggregate bins and the mixer are commonly called scalping screens. A scalping screen vibrates and separates oversized or clumped aggregate for removal before the aggregate enters the mixer. Inspect the screen to verify that the screen size opening is correct. The correct size screen opening is slightly larger than the largest aggregate size of the mix. Production rates that exceed the capacity of any screen may alter gradation. During the screening process, the following factors can affect aggregate gradation:

  - Types and sizes of screen openings
  - Tendency for screens to plug
  - Foreign matter in the aggregate
  - Wear, holes, or breaks in screen

- Plant Scales – Plant scales weigh each component of the mixture. The completed mixture is weighed at the plant with a scale at the storage silo or with a platform scale that weighs the loaded truck. The scale that weighs the completed mixture is typically the scale used to determine payment quantities. Nevada Bureau of Weights and Measures must certify the payment scale. The Resident Engineer coordinates the certification of the scales with the contractor and the Nevada Bureau of Weights and Measures. Refer to Section 109 of the specifications. The Nevada Bureau of Weights and Measures certifies the plant scales and places a sticker on the scale indicating the certification. Allow sufficient time to schedule certification by the Nevada Bureau of Weights and Measures. The inspector must verify that the payment scale is certified.

- Storage Tanks – Inspect storage tanks to verify that no material is in the tank, other than the material designated for the mix. The bituminous storage tank must be capable of uniformly heating and maintaining the asphalt at the temperature stated in the specifications. Specifications may require certain bituminous materials be continuously circulated during storage. To reduce cooling, the contractor insulates the pipe that conveys asphalt from the storage tank to the mixer. The type of burner fuel the contractor uses must be in accordance with the specifications and have required certifications. The asphalt and the burner fuel may be stored in a multi-compartment storage tank, as long as the asphalt and the burner fuel do not share a common wall.

- Bituminous Metering Device – The specifications state the tolerance allowed for the bitumen content used in the mix. One of the most common causes for bituminous paving mixture failures is incorrect amounts of asphalt. The plant inspector should frequently check and monitor the amount of asphalt used in the mixture, and communicate with the testers and the street inspector to confirm the correct amount of asphalt in the mix.

- Mixer – The mixer is a revolving drum or cylinder in which aggregate is dried and heated by burning fuel oil or gas. The cylinder walls are lined with longitudinal cups or channels called “lifters” or “lifting flights” that drop the aggregate as a veil or curtain through hot gases. The mixer slope, diameter, length, arrangement of lifters, number of lifters, and RPM control the time the aggregate is in the mixer.

Air is used to atomize the fuel oil as it is ejected from the burner nozzle to provide for complete combustion, and to provide draft or suction necessary to carry combustion gases through the mixer. If complete combustion does not occur, the fuel oil tends to deposit a black, oily residue on the hot aggregate material, making it difficult to coat the aggregate with asphalt. Black smoke coming from the mixer exhaust indicates incomplete fuel oil combustion in the mixer. Intermittent puffs of smoke at the exhaust end of the mixer, or a flame that enters the mixer at a short distance, indicate insufficient draft through the mixer. With complete combustion, the flame penetrates about one-third to one-half the length of the mixer. Overloading the mixer may prohibit sufficient heating and drying of the aggregate. In a continuous mixing plant, the drum serves as the mixer and mixes asphalt with the dry aggregate, producing the final mix.

- Dust Collector – Dust and fine aggregate particles are emitted during the mixing process. A dust collection system captures the dust that is exhausted during the heating process. Typically, mixing plants have two components to the dust collection system: Primary dust collector and secondary dust collector.

    - Primary Dust Collector - The primary dust collector is the first point of extracting dust and fine aggregate particles from the mixer exhaust system. Primary dust collectors are either a knockout box or a cyclone dust collector. Collected dust particles are returned to the mixer to be re-mixed with the aggregate and asphalt. Collected dust particles are returned to the mixture to reduce the loss of fine aggregate particles, which are integral to an acceptable mix.

- Secondary Dust Collector - Because of stringent air quality standards, secondary collectors may be required. A secondary dust collector is either a wet scrubber or a baghouse. The dust collector system serves two purposes: (1) to provide an adequate draft through the mixer, and (2) to collect and return a uniform amount of the fine material. If a baghouse is used for dust collection, and the contractor wants to reintroduce the fines back into the mix, the contractor must be able to measure and control the amount of fines being reintroduced into the mix. The inspector observes the contractor's calibration of the system that reintroduces fines to verify that the amount of fines reintroduced into the mixture is uniform and does not exceed limits stated in the specifications. If the system is not calibrated, then the contractor cannot reintroduce baghouse fines into the mixture and the job mix formula will reflect the exclusion of baghouse fines.

Thermometers determine temperatures at various locations in the mixing plant. Specifications describe temperature requirements. Specifications typically state temperature requirements of the asphalt entering the mixer and temperature requirements of the mixture exiting the mixer. An armored thermometer, capable of detecting temperature ranges expected in the asphalt entering the mix, are fixed in the asphalt feed line as the asphalt enters the mixer. The thermometer is located so that the inspector can observe the readings conveniently and safely. Plants may also be equipped with a dial scale thermometer, a mercury-actuated thermometer, an electric pyrometer, or other thermometric instrument placed at a discharge chute of the mixer to register or indicate the temperature of the heated aggregates automatically. Such a device is in full view of the plant operator and convenient to the inspector to make observations.

Any thermometers used by the inspector should be correlated with the contractor's thermometers. By correlating thermometers, disputes involving temperature readings are reduced. If unresolved questions remain, contact the Resident Engineer, who may request replacement or verification of the temperature readings.

In a mixing plant, the mixture components—aggregate, asphalt, and baghouse fines—are combined in a mixer. First, the aggregate is introduced into the mixer where it passes over a series of flights, creating a sheet of aggregate that passes in front of the hot gases from the burner. This heats the aggregate and drives off the moisture before the asphalt introduction. Then, the asphalt is introduced into the mixer. The asphalt introduction point varies, depending on the individual plant characteristics. Aggregate coating occurs through a foaming action caused by the steam driven from the aggregate. Mixer slopes affect the amount of time that mixing action occurs. Mixers typically slope between five percent and 2 1/2 percent.

Plantmix can be produced at a contractor's portable job-site plant or at a commercial plant that serves multiple customers. For job-site plants, the contractor must provide a copy of the Nevada Department of Environmental Protection permit, which addresses the plant production limitations, to the Resident Engineer at least 48 hours before beginning operations.

6-401.2.3.1 MIXING PLANT CALIBRATION

After the contractor processes and stockpiles the aggregate and assembles the mixing plant, and the Resident Engineer receives the mix design, the contractor calibrates the mixing plant. Even though the contractor calibrates the mixing plant, the NDOT inspector observes and verifies the calibration process.

Mixing plant calibration is the process of determining the accuracy of plant instruments that produce the mixture in accordance with the job mix formula. Feed rates of the component materials that make up the mixture are identified and recorded. After the contractor calibrates the plant and the inspector has observed and verified the calibration, the plant inspector uses these calibration results to monitor plant operations during plantmix production.

Calibration is a step-by-step process that is done without operating the burner or introducing asphalt to the aggregate. Components of the mixture that require calibration are aggregate, asphalt, baghouse fines. For aggregate, the contractor adjusts the aggregate bin gate opening and the aggregate feed belt speed from each aggregate bin to produce an aggregate mixture that is consistent with the job mix formula. Asphalt feed rates are measured by a flow meter, which requires calibration. Contractors use a variety of methods to introduce baghouse fines into the mix, which requires calibration methods specific to the equipment used. The calibration process includes operating the mixing plant at several speeds (tons per hour) to establish a range of production rates. The composition of the mixture depends on the proportioning of each component material, and is based on the feed rate of aggregate. The feed rates of asphalt and baghouse fines are interlocked with the aggregate feed rate to maintain consistent proportioning.

Mixing plants are calibrated and documented at least every 12 months. Recalibration is required, however, if the plant was moved or components of the plant were altered or rearranged. If a plant is shut down for an extended period, such as during the winter months, the Resident Engineer should check the plant calibration before full production begins. The Resident Engineer may require recalibration of the plant at any time if the accuracy is questioned. Even though the Resident Engineer is responsible for checking the accuracy of the plant control settings, the Resident Engineer must notify the Construction Division Quality Assurance staff before calibrating a plant. The specifications require the contractor to notify the Resident Engineer, typically 48 hours in advance, when the plant is ready to be calibrated. The Construction Division can provide technical assistance and support to the Resident Engineer during the calibration process. The plant should be operating in a consistent manner before the plant calibration is scheduled.

The following sections provide information on calibrating component parts of the mixing plant. The Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, contains NDOT form 040-038, “Hotplant Calibration Sheet.” A hot plant calibration guide is available from the Construction Division Quality Assurance Section.

6-401.2.3.1.1 Aggregate Feed Calibration

Aggregate feed calibration consists of first calibrating the individual feed belts from each aggregate bin. Second, the weigh belt that delivers aggregate from the individual aggregate feed belts into the mixer is calibrated. A configuration of a weigh belt and aggregate feed belts is shown in Figure 6-401.3.

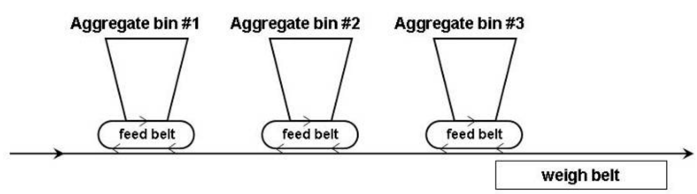

Figure 6-401.3. Configuration of Weigh Belt and Aggregate Feed Belts.

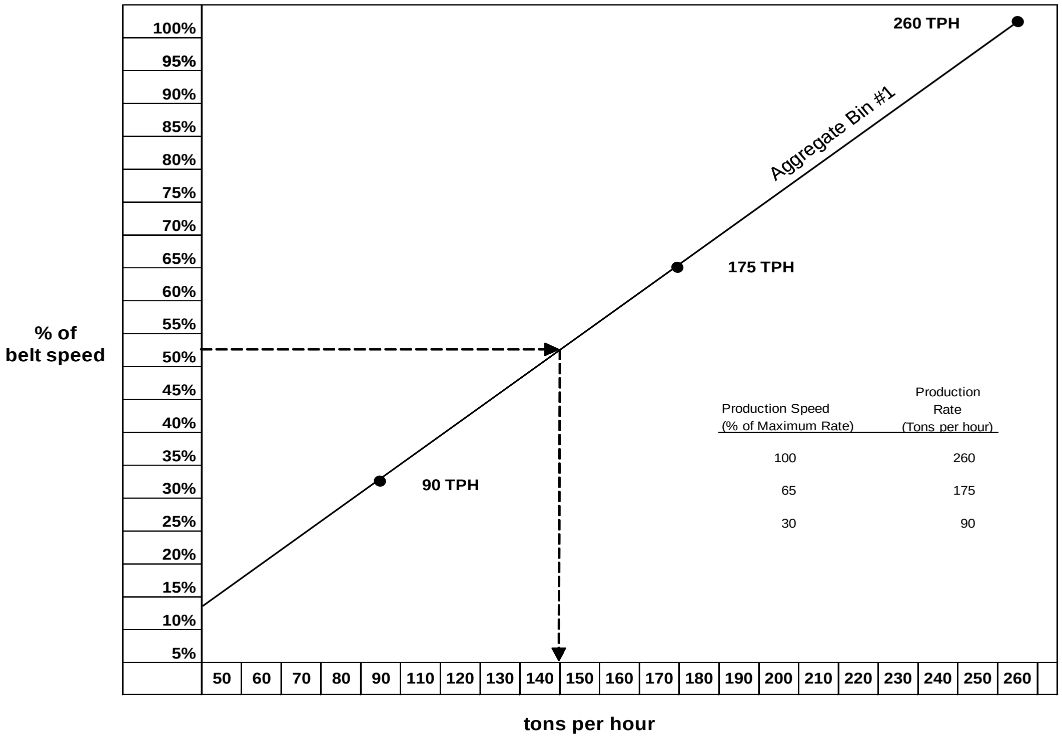

Figure 6-401.4. Example Bin Graph.

The contractor develops bin graphs for each of the aggregate feed belts. A bin graph is a plot of the relationship between aggregate feed, measured in tons per hour, and percentage of belt speed. The plant is operated at low, medium, and high production rates. For each plant production rate, the belt speed (measured as a percentage of the maximum belt speed) and aggregate feed rate (measured in tons per hour) for each bin is noted. A graph is produced for each bin. Figure 6-401.4 is an example of a bin graph developed by the contractor.

After the contractor develops the bin graphs, the weigh belt is calibrated. The weigh belt calibration determines the actual weight of aggregate introduced into the mix. A scale weighs the aggregate on the conveyor belt as it passes over the scale, commonly called a belt scale. The belt scale system sends a reading to the mixing plant control house. The reading is used to determine the weight of aggregate introduced into the mixer. When using a belt scale system, the contractor conducts a weight calibration according to the manufacturer's recommendations. The purpose of the weight calibration is to show the relationship between the actual weight of aggregate and the weight of aggregate indicated by the control house instruments. This relationship is then used to determine the actual weight of aggregate introduced into the mix.

After the contractor completes the initial weight calibration, checks are made at low, medium, and high production rates within the rated operating range of the plant. Each aggregate weigh check should be at least 10 tons. For a given production rate, the plant scale readings are compared to the certified platform scale readings. The percentage of error between the readings must be one percent or less. The percentage of error is then calculated for each of the other two production rates. Each production rate percentage of error must be one percent or less. Additionally, the range of the percentages of error between the low, medium, and high production rates must be within one percent of each other. The weight calibration should be conducted each time the belt scale is set up, and whenever the Resident Engineer questions the accuracy of the weigh system, but not less than once a year. After the weigh belt has been calibrated, the inspector notes and, if possible, marks the location of the settings of the bin gates. After the weigh belt is calibrated, verify the accuracy of one of the aggregate bin feed belts to confirm a correlation with the bin graph.

6-401.2.3.1.2 Asphalt Feed Calibration

The asphalt feed calibration determines the actual weight of asphalt introduced into the mix. Because the amount of asphalt in the mixture is directly related to the amount of dry aggregate in the mix, the asphalt feed rate is interlocked with the aggregate feed rate to maintain consistent proportioning.

A measuring device, such as an in-line flow meter or an asphalt pump revolution counter, measures the amount of asphalt introduced into the mixture from the storage tank. The measuring device should compensate for the temperature of the asphalt. The asphalt measuring device sends a reading to the mixing plant control house. The reading is used to determine the weight of asphalt introduced into the mixer.

The measuring device is calibrated to show the relationship between the actual weight of asphalt and the weight of asphalt indicated by the control house instruments. The inspector should be aware that plant control consoles may indicate a percent of asphalt that differs from the percent of asphalt required by the job mix formula because plants may utilize total weight of aggregate instead of dry weight of aggregate. The relationship between the weighed asphalt and indicated asphalt weight is then used to determine the actual weight of asphalt introduced into the mix. The metered quantity of asphalt, measured in gallons (minimum of 1,000 gallons) and converted to weight, should correlate within one-half percent of the actual weight as measured on the certified scales. Instead of gallons, the meter may read the quantity of asphalt by weight, measured in pounds or tons. Regardless of the units of measurement, a minimum of 1,000 gallons of asphalt is required for calibration. After the contractor completes the initial weight calibration, checks are made at low, medium, and high production rates within the rated operating range of the plant. The Resident Engineer can request recalibration of the asphalt meter whenever the meter's accuracy is in question.

6-401.2.3.1.3 Baghouse Fines Calibration

The contractor may introduce baghouse fines into the mix, provided the fines do not exceed two percent by dry weight of aggregate. If the contractor decides to introduce baghouse fines into the mix, the contractor must provide a positive weighing device that is interlocked with the aggregate feed system. Baghouses collect fines at varying rates. However, the fines must be introduced into the mixture at a uniform rate to produce a consistent mix. The contractor must have a system that eliminates the sporadic delivery of baghouse fines returned to the mix. The system must provide continuous uniform flow within tolerances stated within the specifications. The types of systems that measure reintroduced baghouse fines can vary. The contractor is not required to introduce fines. The contractor may dispose of the fines.

If the contractor chooses to introduce baghouse fines, the measuring system must be calibrated. Baghouse fines calibration compares plant weight readings to actual weights as determined by accurate scales. The weight readings of baghouse fines should correlate within 5 percent of the actual weight as measured on accurate scales. Because the quantity of baghouse fines is small, commonly no more than 2% of the aggregate dry weight or as stated in the specifications, baghouse fines may be weighed on a scale smaller than a platform scale used to weigh trucks.

Because baghouse fines are available only after a plant has operated for a period time, calibration procedures for commercial and jobsite plants are different. When using baghouse fines from a commercial plant, the baghouse fines must be calibrated before any plantmix is produced, including mixture for field trial mixtures or the first half day of paving. When using baghouse fines at a jobsite plant, baghouse fines are calibrated after producing field trial mixture or the first half day of paving. Calibration must be completed before any additional plantmix is produced.

6-401.2.3.1.4 Hydrated Lime (Mineral Filler) Calibration

The specifications direct the contractor to add hydrated lime by using the Marination Method or, in rare cases, by the Cold Feed Method. Regardless of which method is used, calibration of the measuring system used is the same as calibrating baghouse fines. The weight readings of hydrated lime should correlate within 5 percent of the actual weight as measured on accurate scales. Because the quantity of hydrated lime is small, commonly between 1% and 2% of the aggregate dry weight or as stated in the specifications, the hydrated lime may be weighed on a scale smaller than a platform scale used to weigh trucks.

6-401.2.4 MARINATION PLANT CALIBRATION

Marination plant calibration is the process of determining the accuracy of plant instruments that produce the marinated aggregate. Feed rates of the aggregate and hydrated lime are identified and recorded. After the contractor calibrates the marination plant and the inspector has observed and verified the calibration, the plant inspector uses these calibration results to monitor plant operations during the marination process.

The contractor adjusts the aggregate feed belt and hydrated lime feed belt speed to produce a marinated aggregate mixture that is consistent with the specifications. The calibration process includes operating the mixing plant at several speeds (tons per hour) to establish a range of production rates. The composition of the mixture depends on the proportioning of each component material, and is based on the feed rate of aggregate and hydrated lime. The feed rates of hydrated lime and water are interlocked with the aggregate feed rate to maintain consistent proportioning.

Aggregate feed calibration consists of first calibrating the aggregate weigh belt that delivers aggregate from the aggregate bin into the mixer. The weigh belt calibration determines the actual weight of aggregate introduced into the mix. A scale weighs the aggregate on the conveyor belt as it passes over the scale, commonly called a belt scale. The belt scale system sends a reading to the marination plant instruments. The reading is used to determine the weight of aggregate introduced into the mixer. When using a belt scale system, the contractor conducts a weight calibration according to the manufacturer's recommendations. The purpose of the weight calibration is to show the relationship between the actual weight of aggregate and the weight of aggregate indicated by the instruments. This relationship is then used to determine the actual weight of aggregate.

After the contractor completes the initial weight calibration, checks are made at low, medium, and high production rates within the rated operating range of the plant. Each weigh check should be at least 10 tons. For a given production rate, the plant scale readings are compared to the certified platform scale readings. The percentage of error between the readings must be one percent or less. The percentage of error is then calculated for each of the other two production rates. Each production rate percentage of error must be one percent or less. Additionally, the range of the percentages of error between the low, medium, and high production rates must be within one percent of each other. The weight calibration should be conducted each time the belt scale is set up, and whenever the Resident Engineer questions the accuracy of the weigh system.

After calibration of the aggregate weigh belt, the weigh system for the hydrated lime is calibrated. Hydrated lime calibration compares plant weight readings to actual weights as determined by accurate scales. Because the quantity of hydrated lime is small, commonly no more than 2% of the aggregate dry, hydrated lime may be weighed on a scale smaller than a platform scale used to weigh trucks. The contractor determines the amount of hydrated lime for each weigh check, typically several hundred pounds. For a given production rate, the plant readings are compared to the accurate scale readings. The percentage of error between the readings must be one percent or less. The percentage of error is then calculated for each of the other two production rates. Each production rate percentage of error must be one percent or less. Additionally, the range of the percentages of error between the low, medium, and high production rates must be within one percent of each other. The weight readings of hydrated lime should correlate within 5 percent of the actual weight as measured on accurate scales.

The water metering system does not require calibration because accurate measurement of the amount of water is not needed. The appropriate amount of water is visually determined as described in Section 6-401.2.1, Mix Design Development. Water must be added to the aggregate prior to the addition of hydrated lime. Adding water after the hydrated lime would tend to wash the hydrated lime from the aggregate.

6-401.2.5 ROADWAY

The roadway surface must be prepared prior to placing plantmix material. Preparing the roadway for paving includes the following:

- Constructing the base course
- Preparing the surface
- Conducting required tests
- Applying liquid or emulsified asphalt

The plans and specifications describe how the contractor is to prepare the roadway surface for paving. Plantmix paving can be placed on roadway surfaces such as aggregate base, coldmilled surfaces, concrete, or asphalt permeable base. After the contractor prepares the surface, the inspector determines the acceptability of the prepared surface. The surface to receive plantmix paving is acceptable when it conforms to grade, profile, and other requirements described in the plans and specifications. If testing requirements are specified, refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*. Visually inspect the surface to confirm that no surface defects exist.

When liquid asphalt materials are applied, such as a prime coat, tack coat, or seal coat, the sealed surface must be protected from damage. Refer to Section 6-406, Prime Coat, and Section 6-407, Seal Coat, for additional information. Prime coats protect the compacted base courses from the destructive action of traffic, minimizes moisture evaporation from base material, and reduces weather damage. A tack coat is applied to serve as an adhesive between pavement surfaces. Seal coats are applied to a finished pavement surface to serve as a moisture barrier. Theoretical application rates and types of liquid asphalts to be applied are determined by the Materials Division and are included in the plans.

Before applying a prime coat, the inspector and contractor should confer regarding the planned application rate, traffic conditions, and paving schedule. Applying too much liquid asphalt is wasteful and may cause slippage, instability, and migration of asphalt to the roadway surface, called bleeding of the pavement. Applying too little liquid asphalt may require repairs before paving operations begin.

When prime coats are not used, the placement of hot paving material may cause rapid drying of the top of the base, leaving a loose dust film that may cause slippage. If a bituminous dust palliative has been used on the base material, it may be possible and desirable to eliminate the prime coat. Tack coats are used to bind one asphalt surface to another. Refer to Sections 6-405, Tack Coat, and 6-406, Prime Coat.

In addition to the materials and condition of the roadway surface, the inspector should confer with the contractor regarding the operational aspects of the paving operation. Operational aspects are addressed during a meeting, called a pre-pave meeting. . The Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, contains a pre-pave meeting checklist. In general, operational aspects to consider are as follows:

- Equipment and labor for spreading and compacting plantmix material. By knowing the types of equipment that the contractor plans to use, the inspector can confirm that the equipment meets specifications. Knowledge of the contractor's use of equipment and personnel allows the Resident Engineer to schedule testing and inspection personnel.
- Plantmix material placement width and depth, and longitudinal and transverse joints placement. Specifications limit the depth of material that can be placed in a single pass of the paver. Specifications also restrict the location of joints. Conferring with the contractor on these issues allows the inspector to address potential problems.

After the inspector confers with the contractor on the operational aspects of paving, and after the equipment is on-site, the inspector verifies that the equipment conforms to the specifications. The inspector should also determine the adequacy of the equipment to produce the final product and report concerns of inadequacy to the Resident Engineer.

6-401.2.4.1 PAVING MACHINE

Plantmix material produced at the mixing plant is transported to the paving machine which spreads it on the roadway. Paving machines typically consist of a hopper for receiving the plantmix, augers to spread the mixture uniformly across the surface to be paved, a screed to strike off and smooth the mix, and a grade-sensing device used to raise and lower the screed to level the plantmix to the proper grade. Figure 6-401.5 shows a plantmix paving machine.

Figure 6-401.5. Plantmix Paving Machine.

Hauling trucks deliver plantmix material from the plant to the roadway. The material is unloaded from the hauling truck into a windrow in front of the paving operation or into another vehicle, called a material transfer vehicle. When the material is placed in a windrow on the roadway, a pick-up machine, attached to the front of the paver, lifts the windrowed material into the hopper. A material transfer vehicle also delivers material into the hopper. If approved by Resident Engineer, hauling trucks may deliver material directly into the hopper of the paver for areas requiring small quantities of material. The inspector must review the specifications to determine if a specific material delivery method is required. The Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, contains an asphalt paving checklist.

Material in the hopper of the paver is conveyed to the rear of the paver where augers distribute the material across the full width of the paver. Once the material is distributed, the screed strikes off excess material leaving a level, partially compacted plantmix surface. Screeds are controlled manually or automatically. When pavers begin a pass, screeds are commonly operated manually. Manual control is transferred to automatic control after the position of the screed has been stabilized. Paving operations usually begin and end at a slow speed because the paver operator may need to revert to manual control.

An important aspect of automatic screed control is the sensitivity of the controls. An overly sensitive grade sensor, or excessive manual control adjustment, frequently produces false control signals that can produce a wavy pavement surface. An under-sensitive grade sensor does not detect deviations in the grade soon enough to adjust the pavement depth. The paver operator should adjust the sensor sensitivity so that the chatter or bounce of the grade-sensing device is not transmitted for correction. Screed adjustments are not transmitted to the actual pavement until the paver has traveled a distance after the adjustment is made, typically more than 50 feet.

The inspector should discuss with the contractor which type of grade sensing device will be used. Inspect the grade-sensing device to verify that it is in good working order and that it will produce the desired finished product and conforms to the requirements of the specifications.

Grade reference devices are of two general types: (1) transverse control, used to provide cross-slope, and (2) longitudinal control, used for grade elevation. A transverse beam mounted above the screed controls the cross-slope. An external reference device controls the longitudinal grade. External reference devices include the following:

- The floating beam is a rigid beam, approximately 30 feet long, supported every 2½ feet by spring-loaded shoes. The spring-loaded shoes provide an average grade reference, or they can be locked to provide reference control similar to the long ski. When matching an adjacent, newly paved roadway on which the beam will ride, the beam may be as short as 10 feet in length.

- An electronic grade control system uses a “non-contacting” sonic sensor. The placement of the sensors must average four sensors over 20 linear feet. The system controls grade and cross slope without skis or string lines and matches joints without requiring the sensors to touch any surfaces.

- The long ski is a semi-rigid truss or a pipe with a wire-line. This assembly is loosely attached to the paver. The paver has a grade-sensing device to detect slope changes in the wire. Use a wire-line to check or control long skis (not less than 30 feet long). When matching an adjacent, newly paved pad on which the ski will ride, the ski may be as short as 10 feet in length.

- String-line or wire-line is supported above the base course and provides grade reference with a high degree of accuracy. Keeping these lightweight lines at the proper tension is important to prevent sagging.

Regardless of the type of grade-sensing device, the inspector must verify that the paver can produce a finished product that conforms to the plans and specifications.

6-401.2.4.2 ROLLERS

After the paver places the plantmix material on the roadway, rollers compact the material to the required thickness and density. Rollers come in many configurations, sizes, and weights. The two most common types of rollers are steel wheel and rubber tired pneumatic. Rollers perform the following functions: breakdown rolling (steel wheel, with or without vibration), kneading (rubber tired pneumatic), and finish rolling (steel wheel).

- Breakdown Roller – This roller immediately follows the paver and performs breakdown rolling. The breakdown roller is a tandem axle steel wheel roller, which meets the requirements of the specifications. Typically, a breakdown roller weighs at least 10 tons and is capable of vibrating.
- Pneumatic Roller – This roller follows the breakdown roller. A pneumatic roller has rubber tired wheels, typically weighs at least 10 tons, and must have skirting surrounding the tires to retain heat in the tires. The pneumatic roller aids in compacting the mix. It also kneads the mix, which can repair cracked areas in the pavement while the plantmix is still hot. Kneading the mixture with a pneumatic roller may decrease the compaction of the pavement but will allow higher compaction to be achieved. The pneumatic roller may pick up plantmix material on the wheels if the paving mat is too hot or the roller tires are too cold. Tire pressure can also affect whether a pneumatic roller picks up material. The pneumatic roller is most effective when the pavement temperature is above 185°F. Some contractors provide roller operators with an infrared hand-held thermometer. The thermometer readings help the roller operator determine appropriate optimum times to begin compactive efforts.
- Steel Wheel Roller – This roller follows the pneumatic roller, which performs the finish rolling of the mat. A finish roller typically weighs at least eight tons. Although most steel wheel rollers are equipped with a vibrator, the finish roller operator does not use the vibrator during final pass of finish rolling on the mat. The purpose of finish rolling is to remove irregularities and provide a smooth surface.

Rollers could pick up plantmix material during rolling. If this occurs, the contractor applies a release agent to the roller wheels or drum. The release agent must comply with the requirements of Section 401.03.02 of the specifications. The contractor is prohibited from using diesel or kerosene as a release agent because of the detrimental effects on the plantmix.

The inspector should confirm the availability of an appropriate number and types of rollers and verify each roller's weight before placement of the plantmix. Steel wheel rollers should be in good condition and should be checked for minimum weight. Pneumatic rollers must also comply with specifications. The inspector should report concerns of inadequacy of the equipment to the Resident Engineer. Typical rollers are shown in Figures 6-401.6 and 6-401.7.

Figure 6-401.6. Steel Wheel Roller.

Figure 6-401.7. Rubber Tired Pneumatic Roller with Skirting.

6-401.2.4.3 MISCELLANEOUS EQUIPMENT

Figure 6-401.8. Material Transfer Vehicle.

Specifications direct the contractor on the types of miscellaneous equipment to be provided and other requirements such as the specific time when the equipment must be on the project. Typical miscellaneous equipment includes a material transfer vehicle, core-drilling machine, and a profilograph.

With a material transfer vehicle, a hauling truck conveys material directly into a transfer vehicle, which continuously feeds material into the hopper, or the material transfer vehicle transfers material from a windrow into the hopper. A material transfer vehicle has advantages over other delivery methods because it allows uninterrupted delivery of material to the paver, it provides the ability to remix the material, and reduces temperature variability and segregation of the plantmix material. Figure 6-401.8 shows a material transfer vehicle.

The contractor must furnish a pavement core-drilling machine for coring samples of compacted bituminous mixtures for density testing. The inspector must verify that the drill is capable of drilling the required cores without distorting or tearing the pavement, and is of the correct size. The inspector should confirm with the contractor that the coring machine will be available on the project and operational at the time required by the specifications.

The contractor must also furnish a profilograph for checking riding tolerances of the finished roadway. The inspector must confirm that the profilograph is on the project and in good working order, including operating instructions and calibration blocks. Refer to Section 402 of the specifications.

6-401.3 DURING CONSTRUCTION

The Resident Engineer typically assigns the NDOT field crew to monitor the contractor's paving operations as follows:

- Plant inspector
- Field testers
- Street inspector
- Ticket taker

Depending on the size and complexity of the paving operation, the Resident Engineer may increase or decrease the staffing level. Materials incorporated into the plantmix are tested to determine if the material is acceptable for incorporating into the work. The Resident Engineer's field testers perform acceptance testing. Some acceptance tests, however, are performed by the Materials Division, which has specialized testing equipment. Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* identifies acceptance tests that are performed by the Materials Division.

6-401.3.1 MIXING

The plant inspector must monitor a variety of operations that affect the production and quality of the plantmix. Material and equipment, such as storage tanks for asphalt cement, burner fuel, hydrated lime, aggregate bins, baghouse, and aggregate feed belts, require inspection to ensure a uniform quality mix. After calibration and before full production begins, the contractor operates the mixing plant to verify that it produces a mixture that conforms to the job mix formula. After verification that the plant produces the specified plantmix, the plant may begin full production of plantmix. During production, whether it is preliminary or full production, the plant inspector monitors the production to verify that the specified mixture is produced. Inspecting the plant requires attention to multiple details and activities.

Before plantmix production begins, the plant inspector should have available all records and documents prepared during material preparation and equipment operation, as well as records and forms needed during construction. The plant inspector should have the following items:

- Specifications
- Special Provisions, which modify the specifications and are project-specific
- Mix design
- Job mix formula
- Calibration record (Completed calibration sheet, NDOT form 040-038)
- Aggregate marination records and sketches detailing marinated stockpiles
- Delivery records: mineral filler field book, asphalt cement field book, asphalt cement bills of lading, and samples
- Daily plant report of asphalt mixtures (NDOT form 040-011)
- Daily diary sheet
- Sample containers and transmittal sheets (NDOT form 020-016, black marking pen, masking tape, plastic bags for transmittals)
- Daily hotplant worksheet (NDOT form 040-045, if plant is a jobsite plant, not commercial), for information only
- Calibrated thermometer that has been correlated with plant thermometer
- Additionally, reference manuals such as “Hot Mix Asphalt Materials, Mixture Design and Construction” by the Center for Asphalt Technology and “Principles of Construction of Hot-Mix Asphalt Pavements” by the Asphalt Institute may be helpful.

Delivered materials, such as asphalt cement and hydrated lime, are stored on or near the jobsite. When asphalt cement is delivered, a shipping notice—commonly called a bill of lading—and a copy of the refinery material test report must accompany each delivery. Section 703 of the specifications describes the required information contained in the bill of lading and refinery test report.

If hydrated lime is not added to the aggregate using the Marination Method, hydrated lime (mineral filler) is added to the mixture during the production process. This process is called the Cold Feed Method, and is described in Section 401.03.08 of the specifications. With the Cold Feed Method, the plant inspector confirms that the lime storage silo is filled and ready for use before plantmix production begins. When the Cold Feed Method is used, the aggregate must be wet and the flow of the hydrated lime must be uniform as it is added to the aggregate. The aggregate and lime are mixed before being added to the mixer, where it is mixed with asphalt. Whether the lime is added by the Marination Method or by the Cold Feed Method, the inspector verifies that the aggregate on the conveyor belt entering the mixer is thoroughly and uniformly coated with hydrated lime.

Before starting production, discuss plant procedures with the plant operator. The discussion should include identifying inspection points to observe mixture production and where to take samples and temperatures. Sufficient notice should be given to the field tester to allow time to calibrate plantmix testing equipment. Certain testing equipment cannot be calibrated until after the mixing plant is calibrated and may require as much as a day for the calibration process. Confirm that each haul truck will have a delivery record indicating the load weight. The inspector should confirm with the contractor that the truck beds will be clean and discuss the method used to reduce plantmix from adhering to the haul truck beds. Contractors commonly apply a releasing agent to the truck bed to reduce the plantmix from adhering. Section 401.03.02 of the specifications describes releasing agent requirements.

Before full production begins, specifications require the contractor to complete a verification process showing that the plantmix complies with the job mix formula and meets specifications. The verification process includes producing a “hot drop” and completing field trial mixtures. A “hot drop” is an amount of material produced, which is representative of the plantmix produced for placement on the roadway and conforms to the job mix formula. The contractor determines the amount of material to be produced. Typically, the larger the hot drop sample, the more representative the sample is of the final product. The Resident Engineer’s tester samples the material produced from the hot drop and tests the material to verify conformance to job mix formula. After the contractor compacts the field trial mixture material using the job mix formula bitumen ratio, the Resident Engineer’s testers calibrate the nuclear thin lift density gauge. The Resident Engineer may also request samples be taken to obtain informational test results for stability and air voids.

After the Resident Engineer determines that the hot drop material meets specifications, the contractor may begin producing plantmix for the required field trial mixtures, as described in Section 401.02.02 of the specifications. Depending on the project, the specifications will require either a single field trial mixture or three field trial mixtures. The field trial mixtures determine the bitumen ratio that best meets the requirements for Stabilometer Value (Nev. Test Method T303) and Percent Air Voids of Compacted Bituminous Material (AASHTO T269). For some projects, field trial mixtures may not be required. When field trial mixtures are not required, the specifications may limit production on the first day of paving. The limitation allows NDOT to verify that the material conforms to the job mix formula and specifications, and to limit the amount of paving if the mixture is unacceptable. The inspector should review Section 401 of the specifications for details relating to field trial mixtures or limitations on the first day of paving.

Three field trial mixtures are produced, each using a different bitumen ratio, as described in the specifications. The contractor should carefully consider the test section location. If the contractor decides to place the field trial mixture material on the travel lane, the contractor may have to remove the material if it is determined to be unacceptable.

The tester takes samples of each of the three field trial mixture test sections. The samples must be large enough to allow the Resident Engineer's field testers and the Materials Division to run tests. After the trial mixtures are produced, the Resident Engineer suspends assessing working days, and the contractor cannot continue producing mixture for the project for three days while the Materials Division tests the filed trial mixture. The Materials Division forwards the results of the field trial mixtures to the Resident Engineer. The field trial mixtures' test results will either verify the mix design bitumen ratio or determine the new bitumen ratio that will be used for full production. If the bitumen ratio determined from the field trial mixture test results differs from the initial job mix formula bitumen ratio, then the Resident Engineer establishes a new job mix formula, which is assigned the next sequential job mix formula number. If field trial mixtures do not meet specifications, additional field trial mixtures may be required.

The mixing plant is now ready to run at full production. The contractor is responsible for producing plantmix that conforms to the job mix formula and specifications. The inspector reviews, observes, and monitors operations at the plant to determine if the contractor's plantmix processes are consistent with specifications. In addition, the inspector performs calculations based on information obtained from the plant instrument readings to determine if the material meets specifications. Test results are used to determine conformance with specifications.

To determine the bitumen ratio, the inspector periodically observes and notes the aggregate and asphalt cumulative totals and the production rate for the plantmix. These periodic observations are called plant checks. Plant checks are used to determine bitumen ratio analytically and to monitor consistency of the mix. During production, the inspector typically performs hourly plant checks. Each hour during production, the inspector performs a plant check, monitoring aggregate and asphalt feed rates for a ten-minute period. During the plant check, the inspector notes the plant readings at the beginning and end of the ten-minute period for aggregate and for asphalt. Using the noted plant readings, the bitumen ratio is calculated using the following formula:

$$\frac{WT_{asphalt}}{WT_{dry\ aggregate}}$$

$WT_{asphalt}$ = weight of asphalt, tons
$WT_{dry\ aggregate}$ = weight of dry aggregate, tons

Typically, plant readings are based on total aggregate weight, which includes the weight of hydrated lime and water. To calculate the dry aggregate weight, the weight of water and the weight of hydrated lime are deducted from the total weight of the aggregate. The weight of water is calculated using the plant reading for total aggregate weight, the moisture content from test results, and the total percent of lime used in the aggregate marination process. The following example illustrates how to calculate a bitumen ratio based on an hourly plant check.

EXAMPLE:

A plant inspector makes a ten-minute plant check every hour. The inspector notes the plant readings for aggregate and for asphalt at the beginning and end of the ten-minute period. The readings are as follows:

Aggregate Feed:	beginning reading – 890 tons,	end reading – 965 tons
Asphalt meter:	beginning reading – 6.00 tons,	end reading – 9.50 tons

The lime content from the job mix formula is 1.48% of the dry weight of aggregate.

The aggregate moisture obtained from a belt sample during that day's production is 3.65%.

Calculation:

Lime:	1.48%
Aggregate moisture:	3.65%
Total lime and moisture:	5.13%

Weight of aggregate:	965 tons – 890 tons = 75 tons
Weight of asphalt:	9.50 tons – 6.00 tons = 3.50 tons

$$WT_{\text{dry aggregate}} = \frac{WT_{\text{aggregate}}}{1 + (\%\,\text{lime} + \%\text{moisture})} = \frac{75\text{ tons}}{1 + 0.0513} = 71.34\text{ tons dry aggregate}$$

$$\text{Bitumen ratio} = \frac{WT_{\text{asphalt}}}{WT_{\text{dry aggregate}}} \times 100 = \frac{3.50\text{ tons}}{71.34\text{ tons}} \times 100 = 4.91\%$$

The calculated bitumen ratio for each ten-minute check is recorded in the plant inspector's daily diary. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for an example of a completed plant inspector's daily diary.

In addition to plant checks, the daily amount of asphalt used can be checked for information purposes by observing the contractor's personnel measuring the decrease in asphalt quantity in the storage tank. Contractors typically measure the depth of asphalt in a storage tank before and after production, taking into account deliveries, the difference being the volume of asphalt removed from the tank.

The moisture content of the aggregate influences the amount of asphalt added to the mix. During full production, adjustments may be required to compensate for changes in the aggregate moisture. Because aggregate moisture affects the amount of asphalt added to the mix, aggregate moisture tests should be taken twice daily—morning and afternoon.

The plant inspector records daily observations in the following two documents:

- Daily diary
- Plant Inspectors Report (part of NDOT form 040-011, "Daily Plant Report of Asphalt Mixtures")

In the daily diary, the plant inspector records the hourly bitumen ratio obtained from the plant checks. The inspector records the hourly bitumen ratio calculated throughout the day, and the average daily bitumen ratio, calculated from daily totals of mix, aggregate, and asphalt. The inspector records quantities of material delivered to the plant, plant settings, and moisture corrections. The daily diary also includes the plant production rate and plant operation times, noting any time the plant is not in operation and the reason why. An example of a completed daily diary entry is located on the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx.

The plant inspector's report is one part of a three-part form (NDOT form 040-011, "Daily Plant Report of Asphalt Mixtures"). The plant inspector records information obtained while performing inspection duties at the plant, such as bitumen ratio, stored asphalt quantities, and temperatures.

The inspector should be familiar with the specifications. The following suggestions may prove helpful:

- Acceptable mixing produces coated aggregate particles, with a homogenous and uniform appearance. Unacceptable plantmix material is characterized by some or all of the aggregate particles not being coated with asphalt. Aggregate particles that are not coated with asphalt are often described as "white rock."
- If unmixed material comes out of the mixer, either the pugmill or mixer, the mixer could have dead spaces, where complete mixing does not occur. The contractor periodically inspects the mixing flights or paddles for excessive wear or other problems that result in incomplete mixing.
- If unmixed material comes out of the mixer, the mixer could be overloaded. Compare the production rate with the operating capacity.
- The inspector should view the mixture before the mixture is placed in a silo or haul truck. The contractor is required to provide a viewing port in accordance with Section 401.03.09 of the specifications. View the material to verify complete mixing and uniform coating of the aggregate. Poorly mixed material or material that is not completely coated with asphalt should be rejected and the contractor must correct any problems.
- Two important elements of producing a quality mixture are bitumen ratio and a homogenous mix. Air voids and stability are sensitive to the bitumen ratio, and a homogenous mixture significantly contributes to a durable pavement.
- Observe the contractor's loader operator to confirm that the correct aggregate is supplied to the appropriate bin. Also, check the aggregate feed gates to verify that they are set at the calibrated settings.
- Inspect the hauling truck beds to see that they are clean. The truck drivers should use only an approved release agent, listed in the current Qualified Product List, on the truck beds. Observe the application of release agent, making sure that any excess material is drained from the bed of the hauling vehicle before loading with plantmix.

- If the plantmix material does not appear satisfactory, such as not being uniformly mixed or temperatures not within specification, the inspector should not allow the material to leave the plant. The inspector should discuss any problems with the mixture immediately with the plant operator and the Resident Engineer so that corrections can be made.
- The contractor issues a haul ticket (scale ticket) to each hauling vehicle before the vehicle leaves the plant and goes to the jobsite. If the loaded truck is weighed on platform scales not at the plant, the weighmaster issues the haul ticket to the truck driver.
- Haul trucks with long beds are typically loaded with three smaller batches spaced within the bed—front, back, and center—instead of a large single batch. This reduces material segregation.

Many variables affect the consistency and uniformity of plantmix. The Construction Division Quality Assurance Section is available to provide support and technical guidance.

The plant inspector, street inspector, and tester must communicate with each other. The contractor may make adjustments at the plant and at the paver. If the plant inspector detects changes in the mixture being produced, the observation should be communicated to the street inspector and tester, documented, and appropriate action taken. If the street inspector detects any changes in the delivered plantmix, the observation should be communicated to the plant inspector and tester, documented, and appropriate action taken. During mixture production, an intermittent, stop-and-go operation by the contractor may reduce the quality and consistency of the mix. Therefore, planning and constant communication between the plant and the placement operation keeps the production of plantmix at a constant pace, leading to a uniform material.

6-401.3.2 PLACEMENT

At the roadway, the street inspector is responsible for monitoring the contractor's plantmix placement and compaction operation. Haul trucks transport plantmix material from the plant to the paving operation. The plantmix is unloaded into the paver hopper, windrowed on the ground in front of the paver, or transferred into a pickup machine or material transfer vehicle. The paver spreads the plantmix to the appropriate width and depth. The plantmix is then compacted using two or more rollers.

As the plantmix is delivered to the paving operation, the inspector records the amount of material incorporated into the work. Haul tickets are used to record and document the amount of plantmix that each truck delivers to the paving operation. The truck driver receives a haul ticket after the truck is loaded with plantmix and weighed. When the truck arrives at the paving operation, the street inspector takes the ticket and records the information in the load field book. On large paving projects, a ticket taker receives the ticket and records the information in the load field book. This confirms that the truck left the plant and arrived at the project. The street inspector records daily observations in the following three documents:

- Load field book – In the load field book, the street inspector or the ticket taker records the delivery of each truck hauling plantmix to the project. The quantity of material the inspector records is used to calculate the amount of plantmix placed per station, which is the yield. The yield is a means to compare actual placed quantities to planned quantities. While the yield serves as a guide, the inspector must confirm that the actual pavement dimensions conform to those contained in the plans. Deviations from the planned quantity can cause overruns that can be costly or underruns that fail to meet structural requirements. Notify the contractor if the required depth is not being achieved. Then, notify the Resident Engineer of the deviation.

- Street inspectors report (part of NDOT form 040-011, "Daily Plant Report of Asphalt Mixtures") – The street inspector's report is one part of the three-part form. The street inspector records information collected while performing inspection duties at the paver, such as temperatures, placement information (stationing and thickness of pavement), and weather conditions..

- Daily Construction Report, NDOT form 040-056 – The street inspector uses this form to record information and observations that are not specifically recorded in the street inspector's report. Also recorded in the Daily Construction Report are straightedge readings, which the street inspector is responsible for taking. This report also includes conversations and other events or activities that may influence the final pavement.

Temperature is important for proper placement and compaction of plantmix. Not only is the temperature of the mixture important, but specifications require minimum atmospheric and surface temperatures before paving can take place. The street inspector takes the temperature of the mixture to determine if it is within specified ranges for spreading and compaction. Although the specifications do not have a temperature requirement for the mixture in front of the paver, the temperature gives an indication of the suitability of the mixture for placement in the hopper. Specifications require minimum temperatures of the material at the hopper of the paver. Behind the paver, temperatures of the plantmix must be above specified minimums for various stages of compaction.

As paver augers spread plantmix through the screed, the paver creates an unconsolidated layer of plantmix, called a mat. The inspector observes the surface of the mat for irregularities and cross slope uniformity. Typical irregularities are lumps of cold asphalt, drag marks, pockets of rock—coarse aggregates or fines. If the inspector observes irregularities, the contractor corrects the irregularities before compacting the mat. The inspector must check the depth of the uncompacted mat frequently. The uncompacted mat thickness will be greater than the design thickness to allow for compaction. As a rule of thumb, for every inch of uncompacted plantmix placed, the mat will compact ¼ inch. For example, 2½ inches of plantmix would compact to approximately a two-inch thick compacted pavement. The compacted plantmix depth should be checked to confirm pavement thickness.

Rolling the mat for compaction is an important step in the paving process. The compactive effort, which comes from rolling, increases the density of the plantmix by reducing air voids in the material. Specifications state the acceptable range of density and air voids. The first roller performs initial breakdown rolling with a steel wheel roller to set the mixture and reduce lateral displacement. The second roller is a pneumatic-tired roller. The last roller is a steel wheel tandem roller that provides a smooth finished surface. If density test results indicate that the hot mat has not achieved the required compaction, the inspector, in coordination with the tester, should work closely with the contractor. While the contractor is responsible for achieving the required density, the tester can provide testing information so that the contractor can modify rolling patterns to achieve the required results before the mat cools.

The street inspector must monitor the delivery, spreading, and compaction procedures to ensure that samples and tests are performed at the required frequencies. Ongoing communication with the testers ensures they take samples in a timely manner. Well-coordinated sampling and testing provides timely confirmation that the placement and compactive effort yields a product that conforms to specifications.

An inspector may find the following suggestions helpful:

- If a pneumatic roller causes excessive wheel marks, the contractor can correct the wheel marks by (1) reducing tire pressure, or (2) delaying rolling until the plantmix temperature decreases, but above 185°F. Although some wheel marks occur with pneumatic rollers, excessive deformation of the surface indicates decompaction of the plantmix.
- With a pneumatic roller, the roller operator warms the tires before the roller gets onto the mat. The operator proceeds slowly with rolling while the tires gain heat; and, if pickup occurs, immediately remove it from the tires. Typically, pneumatic rollers use an approved release agent, as listed on the current Qualified Product List, to reduce asphalt pickup.
- The contractor must protect longitudinal joints between traffic lanes from damage or distortion by traffic or other causes until the adjacent lane is constructed. During construction of the abutting lane, excess material that accumulates along the joint during spreading should be wasted and not cast over the surface of the uncompacted material.
- When rolling a cold transverse joint, the roller operator cross-rolls the joint, perpendicular to the paving direction, starting with the roller on the cold mat with about six-inches of the roller extending onto the new hot mat. The operator moves the roller onto the new mat in successive increments of 12 inches until the entire roller is on the new mat.
- A continuous paving operation minimizes irregularities in the finished surface caused by stopping and starting the paving equipment.
- The contractor typically uses screed heaters to heat up the paver screed until the plantmix can maintain the screed's temperature.
- When the paving operation is halted and delayed for any appreciable amount of time, the paver operator may run material out of the paver, stopping the paver as the screed begins to run out of material. Before restarting the paver, the operator augers sufficient plantmix material to the screed, and allows the paver to stand until the cooler material in front of the screed is warmed by freshly delivered plantmix.
- If end-dump trucks are used, the truck is held against the front of the paver, avoiding bumping the machine. Bumping the paver creates bumps or dips in the mat and spills material in front of the paver. The contractor must clean up any material spillage in front of the paver to prevent bump formation. The contractor should never use trucks to pull the paver.
- The operator should avoid frequent screed adjustments.
- Monitor the cross slope produced by the screed to confirm construction of the planned cross slope.
- Changes in temperature, height, and amount of material in front of the screed; the weight of the screed; and the forward speed of the paver all affect the thickness of the mat without any change of the thickness controls.
- Paving is a continuous operation during which the contractor makes adjustments to achieve the quality required by the specifications. Therefore, providing the contractor with timely test results is essential so that the contractor can make immediate decisions that produce a plantmix pavement that meets the requirements stated in the specifications. If necessary, provide the contractor with draft test results prior to completing test report forms.

- The inspector should continually verify that the project testing frequencies are consistent with the minimum frequencies listed in Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*.
- When constructing a tapered transverse joint to match an existing pavement, the operator starts the paver using manual controls. As the paver progresses, the operator adjusts the screed manually until it reaches full thickness, about 20 feet from the joint.
- The contractor must correct areas that have a non-uniform mixture or where aggregate segregation is evident.

After final rolling, the street inspector checks the pavement smoothness with a 12-foot straightedge, both longitudinally and transversely. The street inspector reports the straightedge results on NDOT form 040-056, "Daily Construction Report." The street inspector should carefully inspect all paving joints to verify compliance with specifications. If the specifications have profilograph requirements, the contractor performs profile testing of the plantmix surface before allowing traffic on the surface, typically within 48 hours of placement. Traffic could adversely affect the pavement's smoothness. The profilograph is operated to take test readings in the planned vehicle wheel path and in the direction of traffic.

The Resident Engineer assigns a person to collect, analyze, and report the data on NDOT form 040-073, "Report of Profilograph Test." Copies of the test reports are supplied to the contractor as soon as possible, but no later than the time stated in the specifications, typically seven days after the tests are taken. If the profilograph test results indicate an unacceptable pavement profile, corrective action may be required by the contractor to meet surface tolerance requirements. Excessive high points in the pavement—called "must grinds"—as described in the specifications, should be marked with paint during the profilograph testing. With timely notification, the contractor may be able to alter placement operations to reduce "must grinds" and improve the pavement smoothness.

6-401.4 MEASUREMENT AND PAYMENT

Measurement and payment for plantmix bituminous pavement is described in Section 6-402, Plantmix Bituminous Surface, Section 6-403, Plantmix Bituminous Open-Graded Surface, and Section 6-404, Cold-Recycled Bituminous Surface and Pre-Mixed Bituminous Paving Material.

6-402 PLANTMIX BITUMINOUS SURFACE

6-402.1 GENERAL

Plantmix Bituminous Surface is a layer of the roadway structural section. This layer is often called "dense-grade" because it is the densest of the bituminous pavements. In the roadway structural section, the dense-grade layer provides the greatest load-bearing capacity per inch of thickness than other elements of the structural section.

The plans designate the type of plantmix to be placed. Section 705 of the specifications describes three types of plantmix bituminous surface. The types of plantmix surface are related to the types of aggregate used in the plantmix. A description of plantmix surface types is provided below:

- Type 2 – commonly used on roadways having typical traffic loading. A Type 2 plantmix may have little or no ¾ inch aggregate.
- Type 2C – contains higher percentage of coarse aggregate than Type 2 to improve load-bearing capacity. A Type 2C plantmix has at least 5% of ¾ inch aggregate. It is typically used on roadways that carry high traffic loads, such as Interstate highways and urban arterials
- Type 3 – contains no aggregate greater than 3/8 inch and is typically used as a leveling course prior to placing a Type 2 or 2C plantmix surface

Section 6-401, Plantmix Bituminous Pavements, describes construction techniques, processes, and details that apply to plantmix bituminous surface before and during construction.

6-402.2 BEFORE CONSTRUCTION

Refer to Section 6-401, Plantmix Bituminous Pavements.

6-402.3 DURING CONSTRUCTION

Refer to Section 6-401, Plantmix Bituminous Pavements. The following sections provide additional information on compaction and surface tolerances for plantmix bituminous surface (dense-grade).

6-402.3.1 COMPACTION

Although Section 402.03.06, Compaction, of the specifications describes three methods of compaction (standard rolling pattern, test section, and control strip), the specifications will state the specific method to be used on the project. The specifications refer to the three methods of compaction as Method A, Method B, and Method C. Refer to the specifications for requirements for each compaction method. After the rollers compact the plantmix, the Resident Engineer's testers use nuclear density gauges to measure the density of the plantmix. Refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* for compaction testing requirements. Regardless of the compaction method, proper compaction and density at pavement joints is important to the life of the pavement. Poor compaction at joints may result in pavement aging by allowing moisture and air into the pavement. The following additional information is provided on the three methods of compaction:

- Standard Rolling Pattern (Method A) – The standard rolling pattern method describes the minimum rolling requirements that must be met, including the number of roller passes. The contractor is responsible for establishing the rolling pattern. The standard rolling pattern method for achieving density is typically used only for small areas.

- Test Section (Method B) – The test section compaction method specifies an acceptable density range, based on the maximum density. This method correlates nuclear density gauge readings with pavement core sample density test results taken at the same locations. The test section method is the most common compaction method used with new plantmix surface construction.
- Control Strip (Method C) – The control strip method establishes an average density using 10 nuclear density gauge readings. Density tests are not performed on core samples with this compaction method. To establish a target density value, the pavement is rolled until nuclear density gauge readings show no increase in density. Once the pavement has reached this density, nuclear density gauge tests are taken at 10 randomly selected locations to establish the average density, which is now the contractor's target value.

6-402.3.2 SURFACE TOLERANCES

The pavement surface smoothness is a measure of the contractor's ability to place the material within the tolerances specified. A smooth ride is the most important quality to the motorist. Additionally, a smooth surface reduces vehicle impact loading caused by surface irregularities. Impact loading can reduce the life of the pavement.

The specifications describe pavement smoothness requirements. Smoothness specifications include straightedge and profilograph methods of assessing pavement smoothness. The straightedge and the profilograph measure different characteristics of surface smoothness. A 12-foot straightedge is used to measure pavement irregularities longitudinally and transversely. A profilograph is an instrument that measures pavement smoothness longitudinally. The profilograph measurements are taken in the direction of traffic in the vehicle wheel path, as described in the specifications.

The inspector may use straightedge testing at any location. However, the inspector must straightedge longitudinal and transverse pavement joints. Pavement joints are seams between adjacent mats. Because construction of pavement joints requires matching an existing surface with newly placed plantmix, surface smoothness can vary. The inspector must straightedge these areas to verify that the contractor has constructed a joint with a smooth surface. The inspector records straightedge test results on NDOT form 040-056, "Daily Construction Report."

Surface smoothness tolerances measured by a profilograph must comply with tolerances listed in the specifications. A profilograph is shown in Figure 6-402.1. The specifications list three pavement smoothness types: Type A, Type B, and Type C. The specifications will state the smoothness type that the contractor must meet for the project. To measure the pavement smoothness, the contractor must furnish, maintain, and operate a profilograph. The Resident Engineer verifies that the profilograph meets specifications. The calibration of the device is important to obtain accurate and representative readings.

Figure 6-402.1. Profilograph.

The Resident Engineer assigns an inspector to observe the calibration and operation of the profilograph. The inspector must verify that the contractor has calibrated the profilograph before using it. To measure pavement smoothness, the contractor takes profilograph readings before placing traffic on the surface. Traffic can alter the smoothness of pavement. At the end of each day, the Resident Engineer receives the profilograph readings, which are depicted as a graph showing the pavement smoothness. The Resident Engineer or crew analyzes the readings and reports the results on NDOT form 040-073, "Report of Profilograph Test." The Resident Engineer provides copies of the completed Report of Profilograph Test form to the contractor as soon as possible. The contractor may use the profilograph test results to make modifications to the paving operation to improve the plantmix surface smoothness.

If the surface smoothness is unacceptable, the contractor must take corrective action to bring the pavement into the designated smoothness tolerance. Typically, the contractor will hire a specialty grinding company to grind the pavement. The equipment used to grind pavement must be capable of grinding the surface to the surface texture requirements of the specifications. After grinding, the area is profilographed again to determine if the area complies with the specification. Results are again reported on NDOT form 040-073 using a corresponding retest number.

After the grind area meets surface tolerance specifications, the contractor cleans the grind area, allows it to dry, and then seals it with emulsified asphalt (refer to Section 6-405, Tack Coat). An exception to applying emulsified asphalt after grinding is if the pavement will receive another layer of plantmix bituminous pavement within several weeks.

6-402.4 MEASUREMENT AND PAYMENT

Measurement and payment are usually by the ton, which requires accurate weighing of the material. Prior to placing material on the roadway, the material is weighed. Do not pay for material that has not been weighed. Record the placed material quantity on the proper forms. Measurement and payment are described in the specifications and the *Documentation Manual*.

When the specifications require field trial mixtures, NDOT pays the contractor for acceptable material that is placed. For unacceptable field trial mixture material, the Resident Engineer may allow the material to remain in place with concurrence from the District Engineer and the Materials Division. The Resident Engineer may allow payment for unacceptable material that remains in place. On federal-aid projects, no federal funds are used to pay for unacceptable field trial mixture material that is allowed to remain in place. If NDOT pays for unacceptable material remaining in place, NDOT pays with non-federal funds. The cost to remove unacceptable field trial mixtures is shared equally by NDOT and the contractor.

Areas that the plans designate as “miscellaneous paving areas” typically include median areas or road and driveway approaches. For miscellaneous paving areas, the contractor is paid for the weight of the material placed and for the measured surface area paved. Regardless of the number of layers placed, the measured surface area is paid only once.

6-403 PLANTMIX BITUMINOUS SURFACE – OPEN-GRADED

6-403.1 GENERAL

Plantmix Bituminous Surface – Open-Graded is the final layer of a roadway section. The open-graded surface provides a friction surface for vehicles, helps dissipate surface water, and improves the appearance and rideability of the roadway. In contrast to plantmix bituminous surface (dense-grade), open-graded plantmix is a thin layer of plantmix with a maximum size aggregate of 1/2-inch or 3/8-inch. The plans designate the open-graded aggregate size and course thickness to be placed. Open-graded provides no structural strength to the pavement section.

The open-graded course is the final wearing surface, which establishes the public perception of the quality of the project. The appearance of the open-graded surface is a reflection of the workmanship incorporated into the roadway. Because of the impact that the open-graded surface has on the traveling public, it is important to exercise care during placement of the open-graded. The freshly placed surface must be protected from damage and defects must be corrected before the material cools. Damage typically occurs from walking or driving on the hot mat.

Because the open-graded course is a thin layer, typically 3/4-inch, the placement operation can move significantly faster than placement of dense-grade. Although the paver may move at a fast pace, the progress of the paving operation is limited to the rollers producing a compacted smooth mat. Additionally, the progress of the paving operation may be limited when pavement marking tape is inlaid in the fresh surface during final rolling of the mat. If the paver is placing material far in advance of the tape placement operation, the placed open-graded may cool below the minimum temperature required by the specifications for placement of the tape. Inlaid striping, like the finished open-graded surface, is a reflection of the workmanship incorporated into the roadway.

Section 6-401, Plantmix Bituminous Pavements, describes construction techniques, processes, and details that apply to plantmix bituminous surface – open-graded before and during construction.

6-403.2 BEFORE CONSTRUCTION

Refer to Section 6-401, Plantmix Bituminous Pavements.

6-403.3 DURING CONSTRUCTION

Refer to Section 6-401, Plantmix Bituminous Pavements. Because plantmix bituminous surface – open-graded is the final surface on which vehicles ride, surface smoothness is important. To reduce the amount of ridges and ruts, the contractor should minimize the number of transverse joints. The following sections provide additional information on compaction and surface tolerances for plantmix bituminous surface—open-graded.

6-403.3.1 COMPACTION

Although specifications do not require density testing of open-graded, it is still compacted using at least two rollers meeting the requirements of the specifications. The first roller, commonly called a breakdown roller, is a tandem axle roller, typically weighing at least 10 tons. The second roller, the finish roller, has a typical minimum weight of eight tons. Although not required to have vibratory capability, most rollers are so equipped. Consult the specifications to determine if vibration is prohibited. Each roller must complete two coverages of the open-graded mat. The breakdown roller should start compacting immediately after open-graded is spread. The finish roller will be close behind the breakdown roller, while the open-graded is still warm. The finish roller removes wrinkles or ridges left by the breakdown roller. Vibratory rollers must turn off the vibrator on the final pass of finish rolling. Pneumatic rollers are not used on open-graded surfaces.

6-403.3.2 SURFACE TOLERANCES

Coordinating production, delivery, and placement of open-graded material improves the riding surface quality. Repeated starting and stopping of the paver reduces the pavement smoothness. The pavement smoothness requirements of open-graded are similar to those of dense-grade. Refer to Section 6-402.3.2, Surface Tolerances of Plantmix Bituminous Surface, for additional information. For open-graded that does not meet surface tolerance requirements, the contractor must repair, or remove and replace the material as described in the specifications. The contractor may request to leave the non-conforming material in-place. If the District Engineer approves the request, the Resident Engineer may allow the contractor to repair the non-conforming surface or the Resident Engineer will assess the contractor liquidated damages. Because open-graded paving is the final surface course, grinding is kept to a minimum because it detracts from the appearance. Because the decision to grind open-graded is significant, the District Engineer, in consultation with the Resident Engineer, makes the decision to grind. The specifications describe the terms of assessing liquidated damages for open-graded that does not conform to surface tolerances.

6-403.4 MEASUREMENT AND PAYMENT

Unlike plantmix bituminous surface, miscellaneous paving areas are not measured for surface area payment for open-graded. Payment is only made for the weight of the material placed. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-404 COLD-RECYCLED BITUMINOUS SURFACE AND PRE-MIXED BITUMINOUS PAVING MATERIAL

6-404.1 GENERAL

Existing roadways that have distressed surfaces but acceptable structural strength may only require rehabilitation of the pavement surface. A common rehabilitation method is to remove the existing bituminous surface by coldmilling, mix the milled material with emulsified asphalt and other additives, and place the material back onto the roadway. This process is called cold recycling of bituminous surfaces. The equipment used to perform cold recycling is commonly called a “recycle train.” Section 404 of the specifications describes requirements of the recycle train and other equipment needed for cold recycling. The recycle train is subject to a required calibration procedure described in the specifications. The Construction Division Quality Assurance Section can assist in the calibration process. The recycle train produces a windrow of cold recycled material that is spread and compacted as described in Section 6-401.3.2, Placement, of Plantmix Bituminous Pavements.

6-404.2 BEFORE CONSTRUCTION

6-404.2.1 COMPOSITION OF MATERIALS

The specifications describe the recycled material requirements. Typically, materials include reclaimed asphalt pavement, a recycling agent, and lime. Dry lime is called quicklime. After water is added, the lime is called hydrated lime slurry. After the pavement is milled, a recycling agent, approved by the Materials Division, and dry lime, or quicklime, are mixed with the milled material. All ingredients are blended to produce a homogeneous mixture. Water, used to activate the lime in the cold recycle process, is also subject to the Materials Division pre-approval because certain minerals in water can be detrimental to the cold recycle material. Based on the material requirements contained in the specifications, the contractor, in consultation with the Resident Engineer and the Materials Division, may make adjustments based on field conditions.

6-404.2.2 EQUIPMENT

The specifications describe the requirements of the recycle equipment. A typical recycle train consists of a coldmilling machine, where a hydrated lime slurry and additional water is added. Included in the train is a crusher that reduces oversize recycled materials, as well as a portable plant pugmill mixer for the addition of emulsified asphalt, and water, if required. A paver is also part of the recycle train and places the recycled material on the roadway. Figure 6-404.1 shows a typical recycle train.

Figure 6-404.1. Recycle Train.

The Resident Engineer must confirm that the equipment is interlocked and functioning properly. The contractor selects the paver size based on the width and depth of the cold recycle mat shown in the plans. A paver used for pavement recycling requires more horsepower than would typically be used for plantmix paving. In contrast to plantmix paving in which the paving material is hot and flowable, cold recycled material does not flow well. Rollers are subject to minimum weight limits unique to recycle projects and are described in the specifications. Typically, two pneumatic rollers weighing no less than 25 tons each, and a steel wheel roller weighing at least 10 tons are required. The inspector verifies the roller weights before use.

6-404.3 DURING CONSTRUCTION

The inspector or tester observes the contractor take samples of the emulsified asphalt from each load delivered. The emulsified asphalt is tested for viscosity before it is applied to the roadway.

6-404.3.1 WEATHER LIMITATIONS

Cold recycle operations are best performed in the summer months when hot, dry weather is expected. Cold recycling requires overnight low temperatures above 35º F. During paving, the surface temperature must be at least 60º F and rising. Because warm, dry weather is required for proper curing, the success of the recycling operation and the quality of the pavement are influenced by weather. Suspend work during rain. If work is suspended because of rain, verify that the maximum moisture content in the recycled pavement conforms to the specifications.

6-404.3.2 SPREADING, COMPACTING, AND FINISHING

During cold recycling, unsuitable material or conditions may be encountered. The specifications describe how to address these situations and corrective actions. The quality of the pavement improves if the paver places the recycled material continuously. If the contractor excessively stops and starts the paver, the quality of the pavement is diminished and the Resident Engineer may suspend the recycling operation. If the forward progress of the recycle train is halted after emulsified asphalt is added to the aggregate, the delay may allow the emulsified asphalt to break before the mixture is placed on the roadway. If this occurs, placing and compacting the material may be difficult. The contractor must synchronize the "recycle train" and the paver to maintain a continuous placement operation.

Compacting a recycled plantmix mat is different from compacting a plantmix bituminous surface mat. Because recycled material contains moisture, the recycled material must be given time for some moisture to dissipate. Specifications typically require a one to two-hour delay between spreading and compacting. Performing compaction during early morning or late evening hours, when atmospheric temperatures are low, is undesirable. Recycling operations must be scheduled to accomplish compaction during warmer hours. In the heat of the day, the time between spreading and initial compaction may be reduced. As a guide, the roller may begin compacting the mat when the mat changes color. By recording the rate of placement, the Resident Engineer can determine the optimal time that the material may sit before compaction begins. Monitoring the compaction, timing, and effort is a significant part of the inspector's duties during this operation. The Construction Division Quality Assurance Section can provide guidance when the recycle operation begins.

The control strip compaction method (Method C) is used for cold recycle projects. Refer to Section 402.03.06, Compaction, of the specifications and Section 6-402.3.1, Compaction of Plantmix Bituminous Surface, for additional information. Cold recycle operations are comprised of an initial compactive effort, followed by recompactive effort several days later and the moisture has dissipated, after traffic has used the recycled roadway. The Resident Engineer may require additional control strips if atmospheric temperatures vary significantly throughout the day. Refer to Section 404.03.07, Spreading, Compacting, and Finishing, of the specifications for additional information.

To seal the surface, the contractor applies an application of emulsified asphalt to the compacted recycled surface. The emulsified asphalt sealer applied to the surface is typically the same type of emulsified asphalt used in the recycling operation. After a significant amount of water in the emulsified asphalt dissipates, sand blotter is applied to reduce the amount of asphalt picked up by traffic. The recycled pavement must cure for a minimum number of days, as stated in the specifications, before it is overlain with another plantmix material. Before placing the plantmix overlay, the recycled pavement must be recompacted with a pneumatic roller and a steel wheel roller. After the final rolling, the inspector uses a 12-foot straightedge to check the surface of the cold-recycled pavement to verify conformance with surface tolerance requirements.

6-404.3.3 CONDITIONS OF ACCEPTANCE

As long as all materials incorporated into the work meet specifications, final acceptance is based on visual inspection. If the mat has areas of raveling, rutting, or areas that are under or over emulsified, the contractor must repair the areas before the plantmix overlay. An acceptable cold recycled pavement is the product of NDOT and the contractor acting as a team.

6-404.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-405 TACK COAT

6-405.1 GENERAL

A tack coat is typically a light application of emulsified asphalt that creates a bond between pavement surfaces. The tack coat primarily helps to prevent development of a slip plane between an existing surface and another course to be placed on it. The contractor applies the tack coat at an application rate as stated in the plans or as otherwise directed by the Resident Engineer, covering the entire area uniformly. If the tack coat is applied too heavily, the tack coat no longer bonds—it becomes a lubricant, creating a slip plane on which the overlying course may creep or push. A tack coat may not be required if the previous plantmix layer is still warm and has not been contaminated with dirt or other debris.

6-405.2 BEFORE CONSTRUCTION

The tack coat is an emulsified asphalt that is diluted (mixed) with water. The project plans state the type of emulsified asphalt to be used as the tack coat. The specifications allow the contractor to substitute other types of emulsified asphalt for the type stated in the plans. Section 405 of the specifications lists the types of emulsified asphalt that may be substituted. The emulsified asphalt is diluted at the rate of 40 percent water by weight of emulsified asphalt. The following is an example calculation:

10 tons	Emulsified Asphalt (SS-1h)
+ 4 tons	water added (10 tons x 40% = 4 tons)
14 tons	SS-1h (Diluted)

The water is added to the emulsified asphalt in the distributor truck. A portion of water is added first, then the emulsified asphalt, and then the remaining water. When all materials are combined in the distributor truck, the materials are circulated in the truck until thoroughly mixed. Because water is added based on the weight of the emulsified asphalt, the contractor must provide an acceptable method of weighing diluted emulsified asphalt.

As material is delivered to the jobsite and before it is placed in storage tanks, the inspector must verify that the grade and type of emulsified asphalt meets specifications.

6-405.3 DURING CONSTRUCTION

When emulsified asphalt is delivered, it must arrive with three copies of a shipping notice—commonly called a bill of lading—and a refinery material certification must be received for the delivery. Section 703 of the specifications describes the required information contained in the shipping notice and refinery test report.

The inspector should refer to Section 106 of the specifications for sampling frequencies. Typically, a sample is taken for each load of emulsified asphalt delivered. The inspector marks the sample container using a marking pen, showing the sample number, type of material, contract number, and date. The inspector completes and attaches NDOT form 020-016, “Transmittal for Asphalt Sample,” to the sample container.

Number each sample sequentially, beginning with the number one. The inspector also numbers each bill of lading sequentially, beginning with the number one. Record the bill of lading and sample number in the liquid asphalt field book. Refer to the *Documentation Manual* for documentation details.

The contractor should notify the Resident Engineer when deliveries will take place so an inspector can be available to observe the delivery and sampling. The inspector observes the contractor taking samples of the emulsified asphalt. Emulsified asphalt samples should be stored in plastic sample containers supplied by NDOT. NDOT reserves the right to require the contractor to provide a sample of undiluted emulsified asphalt at any time.

6-405.3.1 APPLICATION

The plans state the theoretical application rate for the different types of bituminous materials used on the project. The application rate is based on the material being applied, the purpose of the material, and the surface on which it is applied. The Resident Engineer adjusts the application rate based on field conditions.

Figure 6-405.1. Distributor Truck.

The contractor applies the emulsified asphalt using a distributor truck, as shown in Figure 6-405.1. The distributor truck must conform to the specifications. The distributor truck must evenly heat the material, maintaining the material at the required temperature. The distributor truck must apply the emulsified asphalt in an even and uniform pattern. Figure 6-405.2 shows acceptable and unacceptable spray patterns. The distributor truck must not leak engine fuel, lubricants, or hydraulic fluid that may contaminate the emulsified asphalt. After the emulsified asphalt has been diluted, the distributor truck is weighed using certified scales. Before applying the material to the roadway, the distributor truck operator provides the inspector with weigh tickets showing the weight of the undiluted material and the weight of the diluted material (after water is added). From the weights on the weigh tickets, the inspector can determine the actual dilution rate.

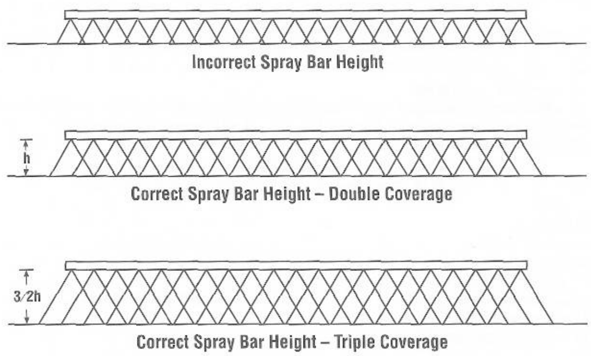

Figure 6-405.2. Distributor Truck Spray Bar Patterns.

To determine the amount of diluted emulsified asphalt applied to the roadway, weights are obtained before and after application. The weight obtained before applying the diluted material is commonly called the “weigh-in.” After application of the material, the truck is weighed again to obtain a “weigh-back.” The difference between the weigh-in and the weigh-back is the amount of emulsified asphalt applied to the roadway. If a distributor truck is equipped with a meter that shows the quantity of material applied, and when weighing the truck is not feasible, the quantity of emulsified asphalt applied can be determined using meter readings. Refer to the *Documentation Manual* for additional information.

The surface to receive the application of emulsified asphalt must be clean, dry, and free of foreign material. The inspector verifies that the surface does not contain unacceptable material such as diesel fuel, oil, or other petroleum products that would degrade the effectiveness of the emulsified asphalt.

The inspector should confer with the contractor and the distributor truck operator to clarify the limits of the application, temperature requirements, application rate, distributor truck ingress and egress, and weigh-in and weigh-back of the distributor truck. The contractor should limit the application area to that which can be paved with plantmix the same day. If the tacked surface is not covered with plantmix, a light application of tack coat may be applied the next day. During tack coat application, the inspector should confirm uniform application of the emulsified asphalt. The distributor truck must evenly coat the entire surface. The contractor must remove excess material using squeegees or brooms.

Immediately after application, the tack coat will have a dull, brown appearance. As the moisture dissipates from the tack coat, the appearance changes to shiny black and the material becomes sticky or tacky. When the water dissipates and the tack coat becomes sticky, it is said to “break.” The amount of time that a tack coat takes to break depends upon weather conditions. During the heat of the summer, the tack coat may break in minutes; but when temperatures are cooler, breaking takes longer. Do not place the plantmix over the tacked surface until the tack coat breaks. If plantmix is placed on the tack coat before it breaks, the emulsified asphalt could migrate into the mix, causing bleeding of the compacted material. After the tack coat is applied, the inspector calculates the application rate using the surface area that received the tack coat and the amount of material applied (the difference between the weigh-in and the weigh-back). Record the application rate in the Liquid Asphalt field book.

6-405.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-406 PRIME COAT

6-406.1 GENERAL

A prime coat consists of applying a liquid asphalt material to an untreated aggregate base course. The prime coat bonds the loose aggregate particles, acts as a moisture barrier, and promotes adhesion between the base and the overlying course. A prime coat is a low viscosity liquid asphalt applied directly to the surface of a base, upon which a plantmix bituminous mat is placed. Cutback asphalt (asphalt cement diluted with petroleum products) is an asphalt commonly used for prime coats.

6-406.2 BEFORE CONSTRUCTION

Before applying a prime coat, the base course must be approved by the Resident Engineer. The base course must have the appropriate number of passing compaction tests. Additionally, the base course must have sufficient moisture to maintain compaction and to promote penetration of the prime coat. The compacted base must be smooth and uniform, meeting the established grades and cross slopes. The prime coat should be applied soon after acceptance of the base course to preserve the base course and to provide the longest cure time possible. Specifications typically require a minimum cure time of 48 hours. Traffic control limitations may require shorter cure times. As the cure time increases, the stickiness of the prime coat surface reduces, which reduces the potential for picking the prime coat up by paving equipment or traffic.

6-406.3 DURING CONSTRUCTION

6-406.3.1 APPLICATION

The project plans contain the theoretical application rate for prime coats as well as the type of material to be used. The application rate may be adjusted based on the field conditions. Typically, a sufficient amount of prime coat is applied to obtain full penetration, leaving minimum puddles on the surface.

The construction details of a prime coat are similar to those of a tack coat. Details describing the materials and application process for tack coats apply to prime coats. Refer to Section 6-405, Tack Coat, for additional information. The application rate for a prime coat is typically heavier than a tack coat application rate, but the Resident Engineer determines the application rate based on the surface conditions and the amount of time that will lapse between applying the prime coat and placing a surface course. The application rate is typically decreased when the time lapse is 72 hours or less. Immediately before applying prime coat the contractor moistens the surface to be primed. Moistening the surface improves the ability of the prime coat to penetrate the surface.

After applying the prime coat, the contractor protects the area until the material breaks. If traffic needs to use the primed area, sand blotter conforming to the specifications is applied after the material breaks. If conditions allow, avoid using sand blotter. Excess sand blotter might create a slip plane between the layers; therefore, it is removed by sweeping before paving. If sand blotter is used, the contractor should apply a tack coat before paving.

6-406.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-407 SEAL COAT

6-407.1 GENERAL

A seal coat is an application of bituminous material that is placed on a plantmix bituminous surface or a rehabilitated roadbed to seal the surface. Seal coats provide a non-skid surface as an interim step during staged construction, or preserve and upgrade existing pavement. Seal coats are applied for the following reasons:

- Prevent moisture from entering the pavement
- Reduce oxidation of the pavement
- Rejuvenate a dry, weathered surface
- Reduce raveling of the pavement surface
- Retain moisture during a roadbed modification process
- Provide a temporary surface for traffic

Emulsified asphalts (asphalt cement diluted with water) or cutback asphalts (asphalt cement diluted with petroleum products) are asphalts commonly used for seal coats. On projects having small quantities of seal coat, emulsified asphalts may be substituted for cutback asphalt. In urban areas, air quality regulations may prohibit the use of cutback asphalt.

6-407.2 BEFORE CONSTRUCTION

The plans contain the application rate for seal coats as well as the type of material to be used. The Resident Engineer typically adjusts the application rate based on the field conditions.

6-407.3 DURING CONSTRUCTION

Details describing the materials and application process for tack coats apply to seal coats. Refer to Section 6-405, Tack Coat, for additional information. The application rate for a seal coat is typically heavier than a tack coat application rate, but the Resident Engineer determines this based on the surface conditions. After applying the seal coat, protect the area until the material breaks. If traffic needs to use the sealed area, apply sand blotter conforming to the specifications after the material breaks. If conditions allow, avoid using sand blotter.

6-407.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-408 SURFACE TREATMENT

6-408.1 GENERAL

A surface treatment rehabilitates, preserves, and extends the life of bituminous plantmix pavements. A common type of surface treatment is a chip seal. A chip seal keeps water from penetrating the pavement and improves skid resistance. A chip seal is performed by spraying a thin layer of asphalt, typically an emulsified asphalt, onto an existing distressed pavement and then applying a single size aggregate. The aggregate is evenly distributed over the asphalt material, and then rolled into a smooth surface. The rolled aggregate is then coated with a layer of emulsified asphalt called a fog seal. A fog seal improves aggregate retention on the roadway.

Variable local conditions and environmental factors influence the success of a chip seal operation. Successful chip seal operations require judgment that incorporates knowledge of materials, construction methods, and the effect of environmental factors. The experience of the contractor, construction crew, familiarity with the local materials, and suitable equipment usage improves the probability of a successful chip seal project.

Factors that affect the success of a chip seal are:

- Aggregate and emulsified asphalt spread rates
- Surface preparation
- Construction techniques
- Weather
- Materials

6-408.1.1 AGGREGATE AND EMULSIFIED ASPHALT SPREAD RATES

Spread rates must be tailored to each project. Spread rates are determined based on source and gradation of the aggregate, the pavement surface condition, and the amount of traffic. The ideal aggregate spread rate will result in a mat that is one aggregate piece deep, uniformly covering the road surface. Typically, aggregate is embedded in the emulsified asphalt to about 70 percent of its height after rolling. If the aggregate spread rate is too high, vehicle tires will dislodge aggregate pieces. If the aggregate spread rate is too low, sufficient coverage is not obtained and excess emulsified asphalt may flush onto the aggregate surface.

The emulsified asphalt rate is adjusted based on the road surface condition. Absorbent, weathered, or flushed surface conditions may require different application rates. Too little emulsified asphalt prevents the aggregate from embedding properly, and the aggregate will be dislodged and lost. Too much emulsified asphalt drowns the aggregate in emulsified asphalt, resulting in flushing and a reduction of skid resistance.

6-408.1.2 SURFACE PREPARATION

Before chip sealing a paved surface, the roadway surface is repaired and cleaned—potholes are filled, ruts are leveled, cracks are sealed, and broken edges are repaired.

6-408.1.3 CONSTRUCTION TECHNIQUES

Emulsified asphalt is applied to the roadway with a distributor truck equipped with spray bars. Even though the emulsified asphalt application rate is as directed by the Resident Engineer, an improperly adjusted spray bar can cause a non-uniform application or streaking of the emulsified asphalt. Streaks can result where emulsified asphalt is applied too heavily, causing bleeding. Between streaks, the emulsified asphalt can be too light, causing the aggregate to strip from the emulsified asphalt. Proper adjustments of the spray bar height, nozzle angles, and spray pattern help achieve a uniform distribution.

Aggregate must be spread on the emulsified asphalt within the first few minutes after application. Teamwork among the distributor truck, chip spreader, and truck drivers is essential. If the aggregate is spread too late, it will not adequately adhere to the emulsified asphalt and stripping will result. Another critical activity is rolling, which seats the aggregate in the emulsified asphalt, enhancing a good bond. The aggregate is rolled with a pneumatic tired roller immediately after spreading. A steel wheel roller is not used because it will ride on the high spots, crushing the aggregate, and pass over the low spots, failing to adequately seat the aggregate.

After spreading and rolling the aggregate, light brooming removes loose aggregate. If the sweeping operation is begun too soon, before the emulsified asphalt sets, it will strip away properly seated aggregate. To prevent this problem, brooming should occur after the aggregate application and after the emulsified asphalt sets, typically one to three hours after rolling for light brooming and 12 to 24 hours for heavy brooming. During hot weather, delay sweeping operations until the pavement cools, which typically occurs in the early morning. If sweeping is delayed until early morning hours, traffic control is maintained until sweeping is completed.

6-408.1.4 WEATHER

Hot, dry weather is crucial to the success of a chip seal project. It must be hot and dry for proper emulsified asphalt setting and curing. The best time for chip sealing is during warm weather months—May, June, July, August, and September. Cool daytime temperatures can cause aggregate loss. Monitor weather forecasts to work around potential weather problems. When the atmospheric temperature exceeds 110°F, chip seals should not be applied because the emulsified asphalt tends to flush.

6-408.1.5 MATERIALS

Dirty aggregate is detrimental to the success of a chip seal project. Emulsified asphalt does not adhere to aggregate that is covered with fines, is too dusty, or is too wet. Dirty aggregate leads to stripping, which is dislodging of aggregate from the emulsified asphalt. The ideal solution is to use washed aggregate. The specifications contain requirements for aggregate cleanliness. Refer to Section 705.03.04 of the specifications for aggregate requirements. Aggregate used for chip seals should not be too soft. Soft aggregate crushes during rolling and under traffic. Soft aggregate also breaks down rapidly after freeze-thaw cycles.

6-408.2 BEFORE CONSTRUCTION

6-408.2.1 REPAIRS

Pavement surface deficiencies must be repaired before applying a chip seal to the roadway. District maintenance forces typically repair roadway deficiencies before chip seals are applied. The following activities are examples of repairing deficiencies:

- Repair all holes and depressions
- Fill and seal all cracks
- Level all bumps, waves, and corrugations that will impair riding qualities
- Remove all excess material on patches and joints
- Clean full width of the surface to be treated

Common repair activities completed before a chip seal are hot-mix and cold-mix patching and crack sealing. In addition to preventing water from entering the base, crack sealing reduces loss of emulsified asphalt into existing cracks. Patching levels the pavement surface and corrects areas of isolated pavement distress. The type of material used for the various repairs is important and can affect the quality and longevity of the chip seal. Patching materials and crack sealant need time to cure before placing a chip seal. Patching and crack sealing should be completed several months before the chip seal construction to allow crack sealant and paving materials to cure. As a rule, patching should be completed at least six months before construction and crack sealing should be applied at least three months before the application of chip seals.

6-408.2.2 MATERIALS

Materials must meet specification requirements. The contractor must submit samples of emulsified asphalt and aggregate to the Resident Engineer for testing and transmittal to the Materials Division at least two weeks before the chip seal operation begins.

The contractor should stockpile a sufficient quantity of aggregate to ensure a continuous chip seal operation. To be ready for use, the stockpiled aggregate must be tested for acceptance and be clean and moist, as required by the specifications. The specifications also contain atmospheric and material temperature requirements that must be verified by the inspector.

6-408.2.3 SWEEPING

Prior to placing a chip seal, the contractor sweeps the pavement surface to remove dirt, dust, or debris. The specifications may require the type of sweeping equipment to be used. In certain areas of the state, air quality regulations may require dustless sweepers to be used. Adequate sweeping provides a clean surface that allows good adhesion between the pavement surface and the emulsified asphalt. It is important that the full width of the existing surface be swept to remove all foreign material to provide a clean surface before the emulsified asphalt is applied. If the surface is swept too far in advance, it may need to be swept again on the day of construction.

Sweeping with rotary broom sweepers often creates dust. If dust poses a danger to the traveling public, a water truck may be used to reduce dust. A water truck is also used when the roadway surface is excessively dirty. When a water truck is used, the sweeping should be completed the day before the chip seal operation begins to allow the pavement to dry.

6-408.2.4 EQUIPMENT

Before the chip seal operation begins, the distributor truck, the aggregate (chip) spreader, roller, and broom must be inspected to confirm compliance with specifications and to verify that the equipment is capable of performing the operation in compliance with the specifications.

6-408.3 DURING CONSTRUCTION

The field inspector or tester observes the contractor take samples of the emulsified asphalt from each load delivered. The emulsified asphalt is tested for viscosity before it is applied to the roadway. After the Resident Engineer accepts the emulsified asphalt and before it is applied to the roadway, temporary lane line markers are installed. After installation of the lane line markers, additional sweeping may be required to remove debris and dirt from the roadway surface. Care must be exercised to protect the lane line markers from being removed.

The distributor truck does not begin spraying the emulsified asphalt until it has been calibrated. The distributor truck is calibrated by spraying emulsified asphalt on a test area, noting the gallons of emulsified asphalt sprayed, measuring the area sprayed, and calculating the application rate in gallons per square yard. The aggregate chip spreader is calibrated to confirm the amount of aggregate spread (spread rate, pounds per square yard) is consistent with the specifications. The spread rate is typically verified by operating the spreader over a pan of a known area, weighing the aggregate, and calculating the spread rate in pounds per square yard.

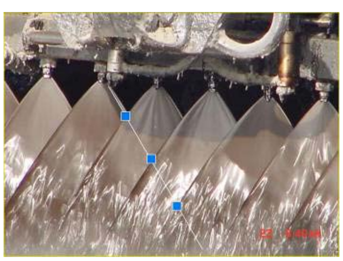

Figure 6-408.1. Emulsified Asphalt Spray Application Pattern.

After the distributor truck and chip spreader are calibrated, all equipment must be in position to begin their functions. The distributor truck operator ensures that the distributor truck's spray bar is perpendicular to centerline before the emulsified asphalt application begins. The emulsified asphalt application should appear as a uniform sheet across the entire width of the spread. Figure 6-408.1 shows a typical emulsified asphalt application spray pattern. The inspector observes each application to verify that all nozzles are spraying correctly. Observing the emulsified asphalt distribution allows early correction of spraying problems—such as a clogged nozzle, nonparallel nozzles, or improper application temperature.

Paper is placed on the roadway surface at the beginning of each spread to allow the distributor truck to attain the proper application speed as the distributor truck crosses the paper, providing a neat line and avoiding a double application of emulsified asphalt at the construction joint. In addition to the beginning of the spread, if the spreader stops for more than three minutes, a transverse paper joint is constructed to provide a neat line for a subsequent application of emulsified asphalt.

Regarding longitudinal joints, each day's spread must be completed to the full-width of the roadway. For a two-lane roadway, a longitudinal joint is constructed by applying emulsified asphalt six inches wider than the aggregate spread on the first pass of the distributor truck. After half of the day's anticipated aggregate tonnage is applied, the operation returns to the starting point to begin the second pass of spreading aggregate. When emulsified asphalt is applied adjacent to the first spread, the distributor truck operator rotates the end nozzle at the longitudinal joint, effectively creating a straight edge, commonly called a "knife edge."

The distributor truck and the aggregate spreader must be aligned perpendicular to the roadway before starting the spread. The emulsified asphalt is applied at the rate stated in the specifications. The aggregate is spread immediately after the emulsified asphalt is applied and before the emulsified asphalt begins to break. (Refer to Section 6-405.3.1, Application, for a discussion of the breaking of emulsified asphalt.) Typically, the spreader is no more than one hundred yards behind the distributor truck. If the weather is hot and windy, the distance between the distributor truck and the spreader is reduced to ensure aggregate placement before the emulsified asphalt breaks. To allow for timely aggregate spreading on the sprayed emulsified asphalt, two or three loaded trucks should be in queue behind the aggregate spreader and before the rollers. Haul truck wheel paths should be staggered so that the compactive effort from the haul trucks is evenly distributed across the width of the mat. If the emulsified asphalt breaks before the aggregate is spread, the spreading operation stops and corrective action is taken. In most situations, a paper joint is installed and the emulsified asphalt that has broken receives an additional application of emulsified asphalt. The aggregate spreading operation resumes after the second emulsified asphalt application. The second emulsified asphalt application rate is typically reduced to minimize bleeding or flushing of the emulsified asphalt.

A self-propelled aggregate chip spreader pulls the dump trucks through the aggregate spread area. As each dump truck is emptied, the aggregate spreader operator releases that truck, and the next truck in queue is attached to the aggregate spreader. (Figures 6-408.3.2 and 6-408.3.3.) Aggregate spreading greater than the specified rate (1) can increase the risk of windshield damage because of dislodged aggregate, (2) is not cost effective, and (3) requires additional sweeping efforts. Aggregate that is spread at a rate less than the specified rate creates areas of uncovered emulsified asphalt. Sparsely applied aggregate results in aggregate loss because the space between the aggregate particles does not allow the emulsified asphalt to rise high enough to hold the aggregate particles securely.

Figure 6-408.2. Emulsion Distributor Truck.

Figure 6-408.3. Chip Spreader and Hauling Trucks.

As the chip seal operation progresses, problems that may occur are as follows:

- Tires Picking Up Emulsified Asphalt – If aggregate is applied at the specified rate and tires pick up emulsified asphalt, then the emulsified asphalt application rate is either too high, causing the aggregate to roll over on contact with the emulsified asphalt, or the aggregate is too wet.
- Aggregate Rollover – If the aggregate spreader is proceeding too fast or if the emulsified asphalt is too viscous, the aggregate may roll over, altering the uniformity of the spread.
- Minor Aggregate Spread Deficiencies – Corrugation or missed areas can be corrected with the use of a drag broom or hand rake. Drag brooms are typically attached to the roller doing the initial rolling and assists in redistributing minor spread deficiencies. If the aggregate is uneven, non-uniform, or irregular for any reason, it should be drag-broomed or hand-raked immediately after spreading and before initial rolling.

The Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, contains a checklist of items that the inspector should review prior to and during the chip seal operation.

6-408.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications. Contact the Construction Division Administrative Section for measurement and payment documentation details.

6-409 PORTLAND CEMENT CONCRETE PAVEMENT

6-409.1 GENERAL

Portland cement concrete pavement (PCCP) is the top layer of the roadway structural section. PCCP is constructed, or placed, on a prepared roadbed. In the structural section, the PCCP layer provides the greatest load-bearing capacity per inch of thickness than any other element of the structural section. Although the initial cost of PCCP is greater than that of plantmix bituminous pavements, the useful life of PCCP is much greater than plantmix, and PCCP has lower annual maintenance costs. The cost of PCCP warrants its use principally on roadways that have high traffic loadings, such as urban interstate highways.

In addition to curbs, gutters, and sidewalks, the principal uses of portland cement concrete are structures and pavement. The characteristics of concrete used for structures or for pavements differ in two distinct ways: strength and coarse aggregate size. Concrete used for structures has a greater compressive strength than that used for pavements. Concrete used for pavements has larger coarse aggregate particle sizes. The remaining attributes relating to materials, proportioning, mixing, and curing are substantially the same for both types of concrete. Refer to Section 6-501, Portland Cement Concrete, for additional information.

During construction, the following weather related environmental factors could influence the quality of the PCCP. Construction practices may require adjustment to reduce the effect of these factors:

- Atmospheric and surface temperatures
- Surface moisture
- Humidity
- Wind

Each step of the PCCP construction process—production, transporting, placement, and curing—may require modifications to reduce the effects of weather. Refer to Section 6-501.5, Weather Limitations, for additional information relating to weather and portland cement concrete.

PCCP is placed monolithically (in large slabs). To allow the PCCP to shrink or contract during cold weather, longitudinal and transverse joints are constructed. The joints are saw-cut to control the location of the cracking in the PCCP. Although cracking occurs, vehicle loading must be transferred from any slab to adjacent slabs for the pavement to perform as designed. The loads are transferred by dowel bars and tie bars. Dowel bars are located along transverse joints and tie bars are located along longitudinal joints. Dowel bars are placed during the paving operation, where saw-cut joints will be constructed. For the pavement to perform as designed, the location and alignment of dowel bars is critical. Tie bars are used to transfer loads across joints with no movement.

6-409.2 BEFORE CONSTRUCTION

Before PCCP is produced at a mixing plant, the contractor must submit a mix design to the Resident Engineer, who forwards it to the Materials Division for review and approval. Aggregates used in the PCCP must be from an approved source. Refer to Section 6-300.2, Aggregate Sources, for information regarding acceptance of aggregate sources. Before mixture production and paving begins, the plant inspector should obtain a copy of the approved portland cement concrete pavement mix design. The contractor must have at least a one-week supply of aggregate, in SSD condition, stockpiled before mixing begins.

6-409.2.1 MIXING

The mixing plant, as shown in Figure 6-409.1, combines the aggregate, portland cement, water, and admixtures as required by the specifications. The PCCP mixture from the plant is loaded into hauling trucks and transported to the paver on the roadway, where it is spread, shaped, and consolidated. Material handling and storage, and operation of the mixing plant influence the quality of the PCCP. The Resident Engineer's plant inspector must be familiar with the specifications, handling and storage of materials, and the operation of the plant.

Figure 6-409.1. Concrete Mixing Plant.

NDOT requires concrete mixing plants and transit mix trucks to be certified by the National Ready Mixed Concrete Association (NRMCA). The NRMCA is a national association of ready mixed concrete producers and plant operators. NRMCA certification of concrete production facilities provides a system for establishing that production facilities of ready-mixed concrete plants are satisfactory. To receive certification, a plant is inspected to assess compliance with an industry checklist. Certifications are valid for a specific period. The inspector must check that the NRMCA certification is current for the plant producing the PCCP material. NDOT also requires that scales must be certified by the Nevada Bureau of Weights and Measures.

After mixing, the portland cement concrete is placed in hauling trucks. Testers must obtain samples before the hauling trucks leave the plant area. The testers use a platform to access the hauling truck, obtain the sample, and perform tests. The specifications require the contractor to provide a platform that the testers use to obtain samples and perform tests.

Portland cement concrete is commonly produced at a job-site plant or at a commercial plant. While the plants have distinct differences, many elements of the plant components and operations are similar. PCCP mixes produced in a commercial plant are transported to the jobsite with transit mixing trucks that have a rotating drum or hauling trucks. Hauling trucks cannot perform additional mixing when transporting the PCCP mixture to the paver. The plant inspector should monitor the following items:

- Water – The amount of water in the mixture significantly influences the strength and durability of PCCP. Too much water reduces the durability by reducing the strength and increasing shrinkage cracks. The plant inspector monitors the amount of water added to the mix.
- Admixtures – Often, chemicals are added to a mixture to alter the physical or chemical characteristics of the PCCP. These added chemicals are called admixtures. Admixtures are commonly added to the mixture at the plant through an automated dispenser. The inspector monitors the admixture amount added to each batch. Admixtures can affect when and where testers obtain samples. The specifications describe sampling and related requirements for admixtures.
- Mixing – A plate attached to the mixer must show the manufacturer's mixing drum capacity and speed. The inspector monitors the plant operation to verify that the capacity and speed do not exceed the manufacturer's recommendations. Additionally, the inspector must observe the material emptied from the mixer, confirming that the material is well mixed with no segregation.
- Aggregates – Before mixing PCCP at the plant, the plant inspector obtains aggregate gradation and moisture test results from the NDOT field testers to verify the material meets specifications. The moisture test results confirm that the aggregate from the stockpile is in SSD condition and determines the amount of water that may be added to the mix.
- Batch Weights – Concrete mix designs state the proportion or quantity of each component of the mix: course aggregate, fine aggregate, water, cement, and admixtures. The proportion of materials is based on an aggregate moisture condition in which the aggregate is saturated with a dry surface (saturated surface dry, SSD), which is the condition assumed for the mix design. The component batch weights must be adjusted to reflect the condition of the moisture content of the aggregate in the field. Because the aggregate moisture content is variable, the batch weights must be adjusted to reflect the current moisture content. Refer to Section 6-501.5, Mixing Plant, for additional information on adjusting batch weights.

Communication among the plant inspector, street inspector, and tester is important to monitor the quality of the PCCP being produced. The contractor may make adjustments at the plant and at the paver. Because the contractor's adjustment at one location can affect the PCCP quality and operations at other locations, better decisions are made when the plant inspector and street inspector share information.

6-409.2.2 ROADWAY

As with plantmix paving, the roadway surface must be prepared prior to placing PCCP. While the aggregate is being prepared and the Materials Division is reviewing the mix design for approval, the contractor prepares the roadway surface.

The plans and specifications describe how the contractor is to prepare the roadway surface for paving. PCCP is usually placed on plantmix, or other suitable base course surfaces. Before PCCP is placed, the base material must be finished and in an acceptable condition. The base is acceptable when required testing has been successfully completed, and grades and surface tolerance requirements conform to the plans and specifications. For testing requirements, refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*. To determine if the grade and surface tolerances are acceptable, confer with the survey crew. Inspect the surface of the base to confirm that no defects exist. Finally, if a prime coat is applied, it must be properly cured. If PCCP is placed on plantmix bituminous base, a curing seal is applied and must properly cure before PCCP placement. The base is then ready to receive the PCCP.

In reviewing the plans and specifications, the inspector should focus on the following areas:

- Concrete mix design
- Mixing requirements
- Placement requirements
- Dowel bars and tie bars
- Spreading and consolidating
- Joints
- Finishing
- Curing
- Surface tolerances
- Protection of the surface
- Method of measurement and payment

After the contractor describes the method of automated grade control to be used, the survey crew chief should determine the survey control point requirements. The contractor uses the established grade controls for the automated grade control operation. Before placement, the Resident Engineer schedules a pre-pave meeting with the contractor. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for a PCCP pre-pave meeting checklist. At the pre-pave meeting, the contractor describes the equipment to be used for placing, spreading, and consolidating the PCCP. Verify that the equipment conforms to specifications.

The contractor may place dowel bars by inserting them into the PCCP with an automatic dowel bar inserter attached to the paver, or by placing them in baskets in front of the paver and paving over the bars. Both methods require approval by the Resident Engineer before paving begins. The specifications provide direction on the submittal process to be followed by the contractor. The inspector must confirm that the Resident Engineer has approved the contractor's dowel bar placement method.

If the contractor uses the wire basket method of bar placement, the baskets are placed in advance of the paver, typically 200 feet. Placing the baskets in advance of the paver allows the inspector to verify that the contractor has installed and anchored the baskets according to the approved shop drawings. Baskets that are not securely anchored can shift or move during the paving operation, causing the dowel bars to become misaligned. The inspector confirms the correct size dowel bars are accurately positioned in the baskets. Incorrectly placed or misaligned dowel bars do not allow the pavement to transfer loads or allow the joint to move, as designed.

Similar to dowel bars, tie bars transfer loads at longitudinal joints. Tie bars have smaller diameters than dowel bars, typically 1/2-inch diameter.

Immediately before placing PCCP on the base surface, the contractor must moisten surfaces that will contact the mix. The surfaces should be moist enough to preclude water demand on the mix. The contractor should not place the concrete on a base where pools of water have formed. When PCCP is placed on plantmix bituminous pavement having a surface temperature greater than 90°, water is applied to cool the surface, which reduces the water demand on the mix. Trucks delivering concrete should not disturb the base surface.

Additionally, coordinate with the contractor about the planned sequence of operations so that inspection and testing can be performed effectively and efficiently. Before concrete production begins, the inspector should coordinate with the tester to ensure that required testing is scheduled. .

6-409.3 DURING CONSTRUCTION

The Resident Engineer typically assigns the NDOT field crew to monitor the contractor's paving operations as follows:

- Plant inspector
- Field testers
- Street inspector
- Tining and curing inspector
- Sawed joint cutting inspector

Depending on the size and complexity of the PCCP paving operation, the Resident Engineer may increase or decrease the staffing level. Regarding materials testing, materials incorporated into the PCCP are tested to determine if the material is acceptable for incorporating into the work. Such testing is called "acceptance testing." The Resident Engineer's field testers perform acceptance testing. Some acceptance tests, however, are performed by the Materials Division, which has specialized testing equipment. Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* identifies acceptance tests that are performed by the Materials Division.

During construction, grade-sensing control, placement of dowel bars and tie bars, surface finishing, and curing of the PCCP are significant aspects of the construction phase. For grade control, a wire line is a common technique in which a wire is set along the roadway shoulder. Placement equipment electronically senses the wire elevation and adjusts the grade of the PCCP being placed. When required by the specifications, dowel bars are placed in the PCCP to transfer vehicle loads to adjacent PCCP slabs. The plans show placement configurations, and the specifications describe the requirements and tolerances of the dowel bar placement. Proper placement of the dowel bars steel is critical. Misaligned bars may cause damage or failure of the PCCP.

Finishing is the process of creating a uniform PCCP surface with a texture that establishes sufficient friction between the pavement surface and vehicle tires. Hand finishing is discouraged because it may bring excess paste to the surface, causing irregularities in the surface smoothness. Acceptable finishing balances a uniform surface, measured with a straightedge or profilograph, and texturing with a moist burlap drag and tining. Deep grooves from tining can create areas in which water can accumulate or weak ridges that can break under traffic loading. PCCP consistency is important for proper tining. Specifications require texturing the surface using a moist burlap drag before tining. The timing of texturing with the burlap drag and tining is important because PCCP that is either too soft or too hard will not achieve or retain the proper texture. The specifications prohibit tining across transverse and longitudinal joints. Refer to Section 409.03.10, Finishing, of the specifications for tining requirements.

Instead of tining, the PCCP surface may be finished by grooving with grinding equipment. If PCCP grooving is specified, the inspector must verify that the pavement to be grooved meets surface tolerance specifications. The inspector must also be aware of pavement grooving time limitations. The inspector should periodically check the location, alignment, depth, and spacing of the finished grooves to assess conformance with specifications. The inspector should observe and document damage caused by the grooving operation. The contractor must repair damage caused by the grooving equipment or its operation.

For proper curing of the PCCP, the contractor applies curing compound immediately after final finishing or after free water leaves the PCCP surface. If the contractor cannot apply the curing compound immediately, the contractor fogs the surface with water or an approved evaporation retarder. Maintaining moisture in the concrete reduces shrinkage cracking. Curing prevents the loss of moisture. Moisture is required to hydrate the cement so that the concrete cures. Curing compound must completely cover the PCCP to seal the exposed pavement surface. The specifications require two applications of curing compound, the direction of each application being opposite to the other. The curing compound must have a white pigment, which allows the inspector to determine if uniform and complete coverage is achieved.

Because concrete expands and contracts under various load conditions and with variations in temperature, cracking may occur. Joints are constructed to allow for the controlled release of stresses created by traffic loads and temperature changes. Joints are weakened planes that direct cracking to a planned location. The joints are constructed by sawing at locations designated in the plans. The contractor saws joints when concrete has hardened but before random cracks develop. The contractor must prepare a joint sawing schedule that considers the unique conditions of the project. The specifications contain detailed requirements on the timing of sawcutting joints.

PCCP is constructed with two types of joints: Weakened plane joints and contact joints. A weakened plane joint is a sawcut across the PCCP, which weakens the PCCP, allowing the pavement to purposely crack at the joint. A contact joint is the surface where fresh concrete is placed against hardened concrete. Each type of joint may be aligned perpendicular or nearly perpendicular to the direction of travel (transverse joint), or parallel to the direction of travel (longitudinal joint). Prior to sawcutting joints, the contractor must mark the location of the joints on the PCCP, as detailed in the plans. The contractor must perform sawcutting in conformance with the plans, specifications, and the approved joint sawing schedule. The inspector observes the contractor’s joint marking and sawing operation and verifies that it complies with specifications.

Placement of PCCP is commonly done with either side-forms or a slipform paver. The specifications describe the equipment and process requirements for each PCCP paving method. The following sections provide additional information on side-form and slipform paving.

6-409.3.1 SIDE-FORM PAVING

Placing PCCP within stationary side forms is called side-form paving. A side form paver is shown in Figure 6-409.2. The contractor uses side-form paving when the area to be paved has irregular dimensions, small PCCP quantities, or limited working space. With side-form paving, the contractor places and secures forms on the prepared base course. Equipment rides on the forms to spread and finish the concrete. The specifications describe equipment requirements for side-form paving. When using side-form paving to place PCCP, the inspector should consider the following:

Figure 6-409.2. Side Form PCCP Paver.

- Type of finishing equipment
- Verify forms conform to specifications
- Check that the paver path is clear of debris and excess material
- Check location, elevation, cross slope, and grade of forms
- Verify that forms will not deflect during the paving and finishing operation
- Check that forms are secured, checking for movement in all directions
- Forms must be clean from debris and coated with an approved release agent
- Require resetting of misaligned forms
- Require forms to remain in place until PCCP has set sufficiently to hold the edge

6-409.3.2 SLIPFORM PAVING

With slipform paving, PCCP is placed using a self-propelled machine with attached side forms. A slipform paver is shown in Figure 6-409.3. The machine operates on the prepared base. A wire guide controls the alignment and thickness of the PCCP placement. The slipform paver spreads, screeds, consolidates, and finishes the concrete in a single pass. The specifications describe equipment requirements for slipform paving. When using a slipform paver to place PCCP, the inspector should consider the following:

Figure 6-409.3. Slipform PCCP Paver.

- Material Delivery – When PCCP is delivered to the paver, the contractor should ensure the material is evenly distributed in front of the paver without mounding. The paver should operate with a full head of material in front of it to prevent an abrupt reduction in slab thickness.
- Edge Slump – Monitor edges to confirm that slumping does not occur after the forms have passed. Edge slump of unsupported sides behind the paver is one of the major problems with slipform paving.
- Trailing Forms – Forms that extend beyond the paver are called trailing forms. Trailing forms may be used to address edge slump problems. However, using trailing forms may cause problems, because drag resistance from the form may pull down edges of the PCCP or vibration from the paver may alter the freshly placed PCCP.
- Water – Water may only be applied to the PCCP surface as a fog. Applying water to the PCCP surface can wash the surface, weaken the surface of the concrete, or result in surface scaling.
- Vibration Equipment – The contractor uses vibration units inserted into the wet concrete to consolidate the wet concrete uniformly. Vibration equipment must comply with the requirements of the specifications.

6-409.3.3 PROTECTION OF PAVEMENT

In areas where vehicle, pedestrian, or animal traffic can be reasonably expected, the contractor must protect the new concrete pavement from damage. Contractors use the following methods and devices to protect new PCCP:

- Barricades
- Windrows
- Proper signing
- Fences, temporary or permanent

In addition to protecting new PCCP from traffic, the contractor must also protect it from adverse weather conditions. As described in the specifications, the PCCP must be protected from freezing, typically by placing thermal blankets on the pavement. In unique situations, heaters may be used. Protection from rain before the initial set may require covering the surface to protect it from washing of the aggregate by the rain.

6-409.3.4 RIDING TOLERANCES

Before public traffic is allowed on the PCCP, the inspector checks the pavement smoothness with a 12-foot straightedge, both longitudinally and transversely. The inspector reports the straightedge results on NDOT form 040-056, "Daily Construction Report." If the specifications have profilograph requirements, the contractor performs profile testing of the PCCP surface. The profilograph is operated to take two test readings in the planned vehicle wheel paths in each land and in the direction of traffic.

The Resident Engineer assigns a person to collect, analyze, and report the data on NDOT form 040-073, "Report of Profilograph Test." Copies of the test reports are supplied to the contractor as soon as possible, but no later than the time stated in the specifications, typically seven days after the tests are taken. If the profilograph test results indicate an unacceptable pavement profile, corrective action may be required by the contractor to meet surface tolerance requirements. Excessive high points in the pavement—called "must grinds"—as described in the specifications, should be marked with paint during the profilograph testing. With timely notification, the contractor may be able to alter placement operations to reduce "must grinds" and improve the pavement smoothness. If the contractor is required to grind to meet specification requirements, the grinding must be completed before the Materials Division cores the pavement to determine the average pavement thickness.

6-409.3.5 SAW AND SEAL JOINTS

Sawing of joints must not cause damage to existing joints. A clean joint is required for the sealant to perform properly. After sawing the joint, the contractor cleans the joint, usually with water or sandblasting. The contractor must recover and dispose of the residue from the cleaning operation. If residue remains on the walls of the joint, the sealant material will not adhere properly.

After sawing and cleaning the joint, the contractor installs the size and type of closed cell backer rod specified in the plans. The inspector confirms that the contractor uses the correct diameter and type of backer rod for each width of joint. Backer rod is typically installed with a tool that places the backer rod at the required depth.

The installation must comply with the specifications and details shown in the plans to function as intended. The function of the joint is sensitive to the proper sealant recess depth. If the depth of the material is too shallow (too close to the surface), traffic could pull out the sealant. If the material is too deep, the joint could collect dirt and other debris that could cause spalling. In either case, incorrect installation will diminish the design life of the concrete pavement. The inspector observes sealing operation to verify conformance with the specifications.

6-409.3.6 OPENING TO TRAFFIC

Before allowing traffic to use the new PCCP surface, the pavement must meet strength requirements, be free of debris, and have appropriate pavement markings or traffic control devices. Debris to be removed typically consists of curing compound, residual debris from joint sawing and sealing, and dust. This material, if not removed from the roadway, can create driving hazards and environmental problems. The specifications describe the strength requirement. If the roadway is to be opened to traffic before it meets minimum compressive strength requirements, the Resident Engineer must consult with the Materials Division.

6-409.4 MEASUREMENT AND PAYMENT

PCCP is measured and paid by the square yard. Because of the importance of pavement thickness to strength and durability of the PCCP, the specifications provide for reduction in payment to the contractor when pavement thicknesses are deficient. The specifications describe the method for determining the reduction in payment, or liquidated damages.

The Resident Engineer coordinates with the Materials Division to schedule pavement coring. Coring must be done after the contractor completes required grinding to meet riding tolerance requirements. Cores are taken at the frequency listed in Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*. The thickness of each core is measured and compared to the thickness required by the plans. If the thickness of any individual core is deficient by more than 0.6-inch, secondary cores are taken to identify the limits of the deficiency. The area of the deficiency is called the "secondary unit area," while the original area is called the "primary unit area". The Materials Division summarizes the test results and distributes copies to the Resident Engineer, the District Engineer, and the Construction Division. Secondary unit areas are either removed and replaced, or left in place with no payment to the contractor, following discussion among the Resident Engineer, the District Engineer, and the Construction Division. In the remaining primary unit area, liquidated damages are determined based on the average pavement thickness as described in the specifications.

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-410 CONCRETE PAVEMENT RESURFACING

6-410.1 GENERAL

Concrete pavement resurfacing includes a variety of construction techniques and methods. Concrete pavement resurfacing extends the life of portland cement concrete pavement. The type of resurfacing or rehabilitation used in a specific situation depends on the type of distress exhibited by the pavement and the constraints presented by maintaining traffic through the work zone. When the condition of the concrete pavement is unacceptable but the base is in acceptable condition, resurfacing and rehabilitation is a cost-efficient means to extend the life of the pavement.

Following are various concrete resurfacing or rehabilitation techniques:

- Rubblizing
- Cracking and seating
- Spall and joint repair
- Slab replacement
- Profile grinding
- Saw and seal joints
- Dowel bar retrofit

Depending on the pavement condition, the techniques listed above may be used independently or in combination. The Design Division prepares the plans and specifications in coordination with the Materials Division. If the Resident Engineer observes the roadway to be significantly different than that shown in the plans, the Resident Engineer should describe the current condition to the District Engineer, Materials Division, and the Design Division. .

6-410.2 BEFORE CONSTRUCTION

The Resident Engineer must thoroughly understand the specifications and scope of work. A unique characteristic of PCCP resurfacing and rehabilitation projects is that construction methods and field experience, strongly influence the success of the repair. The Resident Engineer should review the field conditions to assess the following issues:

- Scope and objective of work
- Equipment to be used and trial runs
- Sequence of operations
- Traffic control
- Constraints
- Testing requirements
- Rehabilitation techniques
- Concrete pavement grinding
- Sawcutting and joint sealing
- Random crack repair

If the Resident Engineer determines that field conditions changed significantly to warrant modification of the repair strategy, the Resident Engineer should contact the District Engineer, Materials Division, and the Design Division. Prior to the contractor starting work, the Resident Engineer schedules a pre-operations meeting or workshop to discuss the planned activities and other critical aspects of the work. The Resident Engineer should develop an agenda with input from the Materials Division and the Construction Division Quality Assurance Section.

6-410.2.1 RUBBLIZING

The intent of pulverizing the existing concrete pavement by rubblizing is to produce a structurally sound base that reduces reflective cracking by obliterating the existing pavement distresses and joints. Rubblizing produces demolished particles that are the size of large aggregate, typically smaller than 12 inches. The pulverized layer provides a foundation for the pavement overlay.

Although the rubblizing specifications contain a gradation requirement, producing small particles can reduce the structural strength of the roadway. If the subgrade is weak, the rubblizing pattern can be altered to produce larger particle sizes that maintain more of the existing concrete pavement's structural support.

Density testing can not be performed on rubblized concrete pavement because of the large particle sizes. Therefore, the compaction process is monitored to determine the stability of the pulverized layer. After compaction, if concerns exist regarding the sufficiency of the compactive effort, a quick and effective way to determine the stability of the pulverized layer is to roll it with a loaded tandem-axle truck, such as a loaded water truck, and look for deflection of the pulverized pavement. After pulverization and compaction, a bituminous plantmix pavement is constructed on the compacted surface.

The contractor should perform and complete a rubblizing operation in the same construction season. If the Resident Engineer expects the project to carry into the winter months or the next construction season, the Resident Engineer should confer with the contractor to identify options that preclude leaving open, unpaved sections of pulverized concrete exposed to the elements.

6-410.2.2 CRACK AND SEAT

Crack and seat is a process that is similar to rubblizing, with the difference being the size of the pulverized concrete pavement. A crack and seat operation produces particles that are approximately 20 inches across. The intent of pulverizing the existing concrete pavement is to produce a structurally sound base that reduces reflective cracking by obliterating the existing pavement distresses and joints. The pulverized layer provides a foundation for the pavement overlay.

Concrete pavement that has been pulverized by the crack and seat process prohibits density testing. The compaction process is monitored to determine the stability of the cracked pavement. After compaction, if concerns exist regarding the sufficiency of the compactive effort, a quick and effective way to determine the stability of the cracked pavement is to roll it with a loaded tandem-axle truck, such as a loaded water truck, and look for deflection of the cracked pavement. After cracking and seating the concrete pavement, a bituminous plantmix pavement is constructed on the compacted surface.

The contractor should perform and complete a crack and seat operation in the same construction season. If the Resident Engineer expects the project to carry into the winter months or the next construction season, the Resident Engineer should confer with the contractor to identify options that preclude leaving open, unpaved sections of cracked concrete exposed to the elements.

6-410.2.3 SPALL REPAIR

Concrete spalling occurs when small pieces of concrete separate from the slab. Spalling typically occurs at slab joints and corners. Spall repairs can be made to existing or to new concrete pavement.

The Resident Engineer should assess the actual pavement condition to confirm that the scope of work described in the plans and specifications is still appropriate. Before beginning repairs, the contactor provides the Resident Engineer with the product information for the proposed repair material, including Material Safety Data Sheets. The material must be listed in the specifications or in the Qualified Product List. If the proposed material does not conform to the specifications or is not in the Qualified Product List, the Resident Engineer must request and receive approval from the Materials Division before using the material.

The quantity for spall repairs is difficult to establish during design. Also, during the period between design and construction, additional spalling may take place. Because the quantity of spall repair will likely change from the amount listed in the plans, the Resident Engineer should conduct a field review to determine if the amount of spall repair within the project limits is consistent with the design scope and budget. The Resident Engineer should discuss warranted changes with the Construction Division, District Engineer, and Design Division. The inspector marks the spalls to be repaired by the contractor.

6-410.2.4 SLAB REPLACEMENT

At times, an isolated slab of concrete pavement may require removal and replacement. When a slab is removed, it must be removed so that it does not disturb adjacent slabs or the underlying base. Slab removal is often done by sawcutting the perimeter of the slab, inserting lifting pins into the slab, and removing the slab by lifting. Other methods may be used for removing a slab, none of which should disturb adjacent slabs and the underlying base.

As with spall repairs, the Resident Engineer should assess the actual pavement condition to confirm that the number of slabs identified in the plans for replacement is still appropriate. If, after a field review, the Resident Engineer determines significant quantity or scope changes are warranted, the Resident Engineer should discuss the changes with the Construction Division, District Engineer, Design Division, and Materials Division.

Before beginning slab replacement, the contactor notifies the Resident Engineer of the proposed slab removal method. Depending on the requirements of the specifications, the contractor may be required to submit a formal plan. Before work begins, the Resident Engineer and contractor should discuss contingencies if the slab removal operation exposes unacceptable base material. The Resident Engineer may need to consult with the Materials Division on the proposed contingency plan. Because the specifications may limit work hours, a contingency plan is critical to returning traffic to the roadway by the time stated in the specifications. Additionally, the contractor must submit a concrete mix design to the Resident Engineer for review. The Resident Engineer submits the contractor’s concrete mix design to the Materials Division for approval. The contractor must receive approval of the mix design before removing slabs. The inspector will mark the slabs to be replaced.

6-410.2.5 PROFILE GRINDING

When a concrete pavement exhibits minor distresses such as uneven surfaces at joints, inadequate surface drainage, or poor riding characteristics, the pavement surface may undergo grinding to improve the problem areas. Grinding may also be needed to improve skid resistance. The pavement is ground full width to reestablish an acceptable profile and cross slope as detailed in the plans.

The Resident Engineer should meet with the contractor to clarify the specifications and review the equipment to be used. After the Resident Engineer is satisfied that the contractor’s equipment will achieve the desired results, the inspector will mark the area to be ground. The specifications will describe the required surface texture and surface smoothness.

6-410.2.6 SAW AND SEAL JOINTS

Concrete pavements contain joints that are created by sawing. Once sawed, the joints are sealed to keep incompressible particles and water out of the joint. Over time, seals deteriorate or break down, exposing the joint, which allows particles to enter the joint and cause cracking of the pavement. To correct this problem, joints are re-sawed and re-sealed.

If the contractor proposes to use sealing material that is not listed in the Qualified Product List, the contractor submits a certificate showing conformance with the specifications to the Resident Engineer. The Resident Engineer submits the certificate to the Research Division for approval before operations commence. The contractor must install the joint sealer material according to the manufacturer's recommendations. The Resident Engineer may require the contractor to have a manufacturer's representative present to verify proper installation. The Resident Engineer should discuss the saw and seal procedure with the contractor before beginning work. Additionally, the Resident Engineer and the contractor should discuss the traffic control plan for sawing and sealing operations to confirm compliance with specifications.

6-410.3 DURING CONSTRUCTION

6-410.3.1 RUBBLIZING

Rubblizing demolishes the existing concrete pavement. Rubblizing produces demolished particles that are the size of large aggregate, typically smaller than 12 inches. Pavement demolishing equipment must have sufficient capacity to demolish the existing pavement to full depth. Two types of machines are commonly used. One is the resonant breaker, which produces low amplitude, high frequency blows by vibrating a large steel beam. The other machine is a multi-head breaker with drop hammers that provide continuous breaking up to 13 feet wide. The multi-head breaker rubblizes a full lane width in a single pass.

Although other rubblizing equipment exists, the specifications prohibit certain types of equipment. Therefore, the specifications should be consulted regarding acceptable equipment. The equipment proposed by the contractor is tested to determine if it produces the desired results. The Resident Engineer designates a test strip location where the equipment is tested, as required by the specifications. Once the equipment demonstrates that it produces the desired results, the contractor must use the same equipment and method of operation for the remainder of the work.

For rubblization, the approved equipment and rubblization method are used on the roadway to be rehabilitated. During the rubblizing operation, the contractor must protect traffic passing by the work area from flying debris created by the operation. A full depth test hole measuring 3 feet by 13 feet is excavated for each day's rubblizing operation to verify that the equipment is achieving full depth rubblization. The test hole allows the inspector to verify that the particle size conforms to the specifications or the size recommended by the Materials Division. Test holes are backfilled with aggregate base. After rubblizing and backfilling of test holes, the rubblized surface is compacted with vibratory steel wheel rollers and a pneumatic rubber tired roller. The compacted surface then receives a prime coat, followed by a plantmix leveling course. The leveling course is then followed by a plantmix bituminous overlay. The specifications contain detailed requirements for the rubblizing operation. Refer to Section 410 of the specifications.

6-410.3.2 CRACK AND SEAT

Crack and seat operations demolish the existing concrete pavement by producing demolished pieces that are approximately 20 inches across. Pavement demolishing equipment must have sufficient capacity to demolish the existing pavement to full depth.

Crack and seat operations typically use a guillotine-type impact hammer. Although other crack and seat equipment exists, the specifications prohibit certain types of equipment. Therefore, the specifications should be consulted regarding acceptable equipment.

The equipment proposed by the contractor is tested to determine if it produces the desired results. The Resident Engineer designates a test strip location where the equipment is tested, as required by the specifications. Once the equipment demonstrates that it produces the desired results, the contractor must use the same equipment and method of operation for the remainder of the work.

Before the contractor begins cracking the concrete, the pavement is flooded with water to check for existing cracks. As the pavement dries, cracks will retain moisture after the pavement surface has dried, making cracks easy to see. By identifying the extent of existing cracking, the effectiveness of the pavement breaking operation can be determined. After the pavement cracking operation, the pavement is flooded again to verify that the contractor has achieved the required crack spacing of the pavement. If traffic is to be returned to the roadway, the contractor must sweep the surface of the roadway to remove debris and dust. Following the cracking of the pavement, the cracked concrete is seated by operating a pneumatic roller over the surface for three complete passes. The contractor removes loose debris from the cracks and joints. The contractor then places a plantmix stress relief course within 24 hours of the cleaning. The stress relief course is then followed by a plantmix bituminous overlay. The specifications contain detailed requirements for the crack and seat operation. Refer to Section 410 of the specifications.

6-410.3.3 SPALL REPAIR

On concrete surface rehabilitation projects that include spall repair and grinding, the contractor completes the spall repair before grinding. Specifications describe the size of the spall to be repaired. Although the size of the spalls may vary, the plans typically show a uniform size for the repair. Loose or delaminated material is typically removed from the spall area using a lightweight jackhammer or mechanical chipping hammer. Heavy-duty jackhammers are not used because the energy can cause micro-cracking in the surrounding concrete. After removing loose material, the contractor sandblasts the area clean.

Most spall repair products are sensitive to weather conditions. Manufacture’s recommendations must be followed to achieve the desired results. In addition, specifications typically require the product manufacturer’s representative to be present during placement of the material.

The manufacturer’s representative determines the appropriate method of perpetuating any joints in the spall repair material. The spall repair material should be flush with the surrounding surface. Repair any surface irregularity. If grinding is included as part of the project, the spall repair may be left slightly higher than the surrounding surface to allow for grinding.

6-410.3.4 SLAB REPLACEMENT

The inspector observes the contractor's slab removal operations to confirm that the base is not damaged. If the contractor damages the underlying base, the base must be repaired at the contractor's expense, using a method approved by the Resident Engineer. If the underlying base requires repair unrelated to the contractor's operations, the base is repaired on a force account basis. The Resident Engineer consults with the Materials Division to determine an appropriate repair method.

After the excavated slab area is cleaned and inspected, the contractor installs dowel bars or tie bars as detailed in the plans and specifications. After preparing the underlying base, the contractor applies a bond breaker to the base and vertical sides, then places the new concrete pavement in the excavated area. If re-opening traffic lanes is critical, a high strength, early setting concrete mixture should be considered. Refer to Section 6-409, Portland Cement Concrete Pavement, for construction details relating to PCCP.

6-410.3.5 PROFILE GRINDING

Concrete pavement grinding is combined with other concrete rehabilitation operations, such as spall and joint repair. The sequence of repair activities is important to achieve the rehabilitation objectives. Grinding takes place after spall repairs and slab replacement but before joints are sawed and sealed.

Perform grinding in a longitudinal direction. After the initial grind, the inspector checks the surface to confirm that the requirements of the specifications are met. The grinder makes a corduroy-type texture with grooves on the surface. The inspector checks the initial grind using a 12-foot straightedge. The contractor must perpetuate the existing profile grade, cross-slope, and surface drainage.

If the existing surface has deep ruts in the wheel paths, the contractor may need to adjust the depth of the grinding to achieve the requirements of the specifications. The contractor should be aware that the depth of the grind could cause cross-slope drainage problems. To correct cross-slope drainage problems, the shoulder may require grinding to taper the edge of the roadway to allow drainage.

After profile grinding, the inspector checks the pavement smoothness with a 12-foot straightedge, both longitudinally and transversely. The inspector reports the straightedge results on NDOT form 040-056, "Daily Construction Report." The contractor performs profilograph testing to determine if the ground pavement surface complies with the specifications. The profilograph is operated to test the pavement surface in the planned vehicle wheel path and in the direction of traffic.

After the profilograph testing is complete, the Resident Engineer assigns a person to collect, analyze, and report the data on NDOT form 040-073, "Report of Profilograph Test." Copies of the test reports are supplied to the contractor as soon as possible, but no later than the time stated in the specifications. If the profilograph testing results indicate an unacceptable pavement profile, corrective action may be required by the contractor to meet surface tolerance requirements.

6-410.3.6 SAW AND SEAL JOINTS

Sawing of joints must not cause damage to existing joints. A clean joint is required for the sealant to perform properly. After sawing the joint, the contractor cleans the joint, usually with water or sandblasting. The contractor must recover and dispose of the residue from the cleaning operation. If residue remains on the walls of the joint, the sealant material will not adhere properly.

After sawing and cleaning the joint, the contractor installs the size and type of backer rod specified in the plans for the size and width of joint. The inspector confirms that the contractor uses the correct diameter and type of backer rod for each width of joint. Backer rod is typically installed with a tool that places the backer rod at the required depth.

The installation must comply with the specifications and details shown in the plans. The function of the joint is sensitive to the proper sealant recess depth. If the depth of the sealant is too shallow (too close to the surface), traffic could pull out the sealant. If the sealant is too deep, the joint could collect dirt and other debris that could cause spalling. In either case, incorrect installation will diminish the design life of the concrete pavement. The inspector observes the sealing operation to verify the installation conforms with the plans and specifications. The inspector performs sealant testing after installation. The specifications describe the required tests. The contractor must remove and replace unacceptable sealant material.

6-410.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*. To complete full-width grinding that complies with specifications, multiple passes of the grinding equipment may be needed. If the grinder passes over pavement that was previously ground, such as an overlap or regrind, no payment is made for the re-ground area.

Rubblized, and crack and seat surfaces are measured and paid by the square yard. Measure the area to be demolished before pavement demolition.

6-496 BRIDGE DECK SEAL CONCRETE

6-496.1 GENERAL

Concrete bridge decks are often sealed to create a barrier to prevent salt and other corrosive chemicals from entering the concrete. A common method of sealing bridge decks is applying a liquid chemical, such as methacrylate, to the existing bridge deck. Another means to seal the deck is to seal the deck with a sealant, such as methacrylate, and then overlay the bridge deck with a polymer concrete or an epoxy material. Deck overlays can also be used to restore a riding surface or repair a severely cracked or delaminated bridge deck. In some situations, a bituminous pavement wearing surface may be constructed on the polymer concrete or epoxy overlay. Because the most common overlay material is polymer concrete, Section 6-496 discusses only polymer concrete. Polymer concrete consists of graded aggregate, that is pre-bagged, and a liquid polymer resin, which acts as a binder. The typical placement depth of polymer concrete is ¾ inch. If thicknesses exceed 1½ inches, multiple lifts may be necessary because of the high temperatures generated by polymer concrete during curing.

Because polymer concrete is a specialized material, the Resident Engineer should be knowledgeable of the specification requirements. The specifications provide detailed information on the required experience of the contractor, materials, and construction details of polymer concrete.

6-496.2 SAFETY

Materials used in bridge deck sealing and overlays require special handling and safety procedures because of the chemicals used. All personnel working, handling, or transporting the materials, as well as inspectors and material testers, must attend safety training before materials arrive at the jobsite. Because of the volatile nature of the chemicals used in making polymer concrete, strict adherence to handling and safety procedures is required to avoid violent chemical reactions.

The inspector should carefully review and understand the Material Safety Data Sheets (MSDS) that the contractor provides. If chemicals are not shipped, handled, and combined precisely as required by the MSDS and the specifications, the combined chemicals, including chemical vapors, can cause an explosion.

6-496.3 BEFORE CONSTRUCTION

Because of the highly specialized nature of polymer concrete, the specifications contain requirements relating to the contractor qualifications and experience, materials, on-site skilled technical support from the material supplier, testing of the materials, and safety and handling of the materials. Before work can begin, the contractor must complete all submittal requirements contained in the specifications.

Before the contractor begins operations with the materials, the contractor must address several safety issues. Because of the hazards associated with the materials used in polymer concrete overlays, the manufacturer’s recommendations for personal protective equipment should be followed. Also, the contractor must provide MSDS that are maintained on site. The inspector should review the information contained in the MSDS, paying special attention to safety considerations. The contractor must have an on site wash station for workers in case of chemical accidents. The contractor must also provide health and safety training for all personnel who will be working with the materials.

Polymer concrete is mixed on the jobsite either in a mechanical mixer operated manually or in a truck-mounted mixer, commonly called a volumetric mixing vehicle. When polymer concrete is mixed manually, the aggregate is pre-bagged and delivered to the site. The manual mixing process includes adding coarse and fine aggregate, measured by the bag, with a polymer resin and a chemical hardener, measured in ounces. When a volumetric mixing vehicle is used, the equipment must bear a rating plate from the Volumetric Mixer Manufacturer Bureau (VMMB). The VMMB rating plate identifies the capacity and performance of the mixer. In a volumetric mixing vehicle, raw ingredients are stored in separate compartments on the truck and metered out for incorporation into the mix. Regardless of the units of measurement used by the vehicle—weight or volume, the quantity of polymer concrete must be consistent with the unit of measurement for payment. This may require a correlation between volume and weight of the ingredients to be incorporated into the polymer concrete. Figure 6-496.1 shows a volumetric mixing vehicle and Figure 6-496.2 shows a typical measurement display on a volumetric mixing vehicle.

Figure 6-496.1. Volumetric Mixing Vehicle.

Figure 6-496.2. Display on Volumetric Mixing Vehicle.

The contractor must construct a trial overlay as required by the specifications. The purpose of constructing a trial overlay is too mimic the conditions and operations that will occur during the placement of the polymer concrete overlay. The trial overlay verifies that the materials will perform as desired and that the contractor’s operations will yield acceptable results. The trial overlay must be constructed under the same conditions that would likely occur during construction. This includes atmospheric temperature and the temperature of the existing overlay surface. Also, if the polymer concrete placement will occur at night, then the trial overlay must be constructed at night. A skilled technical representative from the material supplier must be present during the trial slab placement. The technical representative adjusts the resin content as required to achieve the desired results.

The specifications require the contractor to construct an overlay that meets surface tolerances. The Resident Engineer should obtain initial profilograph readings of the bridge deck before the contractor places the polymer concrete. The initial profilograph readings provide a baseline in case disputes arise regarding final surface tolerance readings.

The bridge deck must be prepared before receiving a prime coat and polymer concrete overlay. Preparation includes the following:

- Identifying and repairing any areas within the bridge deck that are delaminated or require repair
- Roughening the deck to remove oil, asphalt, and dirt
- Grinding epoxy paint and deeply soiled areas
- Removing loose debris

After preparing the deck and before applying the prime coat, the inspector coordinates with the survey crew to establish a grid of deck elevations. The survey crew takes elevations again after placing the polymer concrete. The contractor establishes the finish grade using survey information and a string line to maintain elevation. After establishing finish grades, the contractor will use placement equipment that will consolidate, vibrate, and finish the material to the required grade.

The Resident Engineer identifies areas within the bridge deck that require repair. To identify areas of delamination, refer to test method ASTM D4580, "Measuring Delaminations in Concrete Bridge Decks by Sounding." The Materials and Structures Divisions can provide assistance with equipment and training needed to perform bridge deck delamination testing. The contractor must make bridge deck repairs in accordance with Section 502.03.15 of the specifications.

In preparing the deck, the objective is to remove the cement paste and expose the deck aggregate, providing a clean, sound concrete surface. After the deck is cleaned, traffic is prohibited from using the deck until the placement of the polymer concrete is complete.

The contractor may use several methods for roughening or scarifying the bridge deck. Shot blasting is similar to sandblasting, except that small metal beads impact the concrete surface instead of sand. Shot blasting produces a scarified surface texture and has a good production rate. Shot blasting typically requires two passes to produce the desired surface texture. Hydroblasting, also similar to sandblasting, uses water under high pressure to impact the concrete surface. Hydroblasting produces an acceptable surface texture but requires a water management plan and additional time to remove the moisture from the deck. Hydroblasting may not be practical on projects that have limitations on working hours, such as night projects that must be open for traffic in the morning. A scabbler is a piece of equipment that uses compressed air to hammer piston-mounted bits into the concrete surface. Because a scabbler impacts the concrete surface, it can produce cracks. Small cracks are acceptable. When a scabbler is used, sandblasting is commonly required to complete the preparation of the surface. Typically, sandblasting is not used to prepare the deck. Sandblasting alone will not produce the required texture, and is not allowed in most urban areas due to air quality regulations.

Some bridge decks may have waterproof membranes that contain bituminous materials. Shot blasters are ineffective because the hot metal shot melts the membrane, gumming up the shot blaster. When waterproof membranes are encountered, hydroblasting is typically effective in removing the waterproof membrane and preparing the bridge deck.

Areas that are heavily soiled and epoxy striping are removed by grinding. Because grinding can produce variable results, the inspector must closely monitor the grinding operation.

6-496.4 DURING CONSTRUCTION

After the bridge deck has been prepared in accordance with the specifications, the inspector confirms that all materials to be incorporated into the work meet the requirements of the specifications and are on site. All material certifications and tests required by the specifications must be received and approved by the Resident Engineer before the contractor begins using the materials.

The contractor should isolate expansion joints to protect the joints from polymer concrete entering the joint. The contractor has the option to sawcut joints after placement of the polymer concrete. If the contractor elects to sawcut joints, sawcutting must occur within four hours of placement of the polymer concrete.

After joints are marked or isolated, the deck should be cleaned with compressed air to remove residual debris. After cleaning, a deck moisture test must be conducted. Refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* for required tests and frequencies.

With the deck cleaned and the deck moisture content within the acceptable range required by the specifications, the contractor applies the prime coat, typically methacrylate. A prime coat is used to bond the polymer concrete to the bridge deck. The application of the prime coat must be uniform and it must cover the deck completely. A uniform prime coat reduces variable adhesion between the deck and the polymer concrete. Complete coverage provides a barrier between the deck and the polymer concrete. If polymer concrete contacts the concrete deck, a chemical reaction can occur, which significantly decreases the bond between the polymer concrete and the deck. Therefore, the coverage of the prime coat is important.

The prime coat is flooded onto the bridge deck and evenly applied using squeegees and brooms. Placement of the prime coat should be done expeditiously to reduce the potential for contamination from dust and other debris. Prime coat is also placed quickly to maintain workability and reduce the potential for uneven application. Monitor the prime coat application, checking that the contractor corrects ponding and uneven distribution of the prime coat on the scarified bridge deck. Because the materials used for prime coat have relatively low flash point temperatures, prime coats can be hazardous. The inspector must be aware of the safety requirements contained in the MSDS. If the prime coat is contaminated or unevenly applied, the inspector may reject the prime coat, in which case the contractor cleans the surface and reapplies the prime coat. After the prime coat has set or hardened, polymer concrete placement can begin. Except for the contractor’s construction equipment, vehicle and foot traffic, equipment, and materials are not allowed on the prime coat, because of the risk of introducing contaminants that can cause debonding of the overlay.

Batching the polymer concrete takes place manually with a mechanical mixer or on a truck-mounted mixer. In either case, a skilled technical representative of the polymer concrete and prime coat supplier must be present when the initial batching begins. The contractor must thoroughly blend the resin before adding the aggregates to the resin. Refer to the specifications for detailed requirements. The contractor batches the polymer concrete using the appropriate mix formula based on the results of the trial overlay. The material supplier technical representative may recommend adjustments to the formula based on atmospheric and surface temperatures. The contractor must place and finish the batched polymer concrete within 15 minutes of mixing, or before it gels. Polymer concrete not placed within this time frame must be discarded.

Prior to placement of the polymer concrete, calculate the approximate quantity of polymer using the bridge deck surface area, the planned thickness of the overlay, and the contractor's mix formula. Confirm that the contractor has enough material on the project to complete the work. During placement of the polymer concrete, observe that the screed of the paver is adequately finishing the surface, but not over working the material. A small amount of resin coming to the surface is normal. Verify that the grade control equipment is functioning correctly. During the placement operation, the inspector monitors and documents material quantities. The polymer concrete must be placed and finished within 15 minutes or before gelling. Any material not used within these limits must be discarded. Immediately after the contractor finishes the material, and before it gels, the contractor mechanically broadcasts sand uniformly onto the surface. Typically, polymer concrete begins to harden within 30 to 120 minutes after it is mixed. The polymer concrete commonly hardens completely within four hours of mixing. After placement, the contractor must protect the surface from moisture, equipment, and traffic for at least four hours. Prior to opening to traffic, the polymer concrete overlay is tested to detect delaminations. Refer to the specifications for required tests.

6-496.5 MEASUREMENT AND PAYMENT

Bridge Deck Preparation and Concrete Placement is typically paid by the square yard, which includes all work associated with preparing the bridge deck surface, furnishing and placing the prime coat, and placing the polymer concrete.

The contractor is also paid for aggregates and resins used in the polymer concrete. The method of measurement for aggregate and resin is by the pound. The contractor is paid for the actual amount of aggregate and resin used in the polymer concrete placed. The quantity may vary significantly from the plan quantity contained in the estimate because of the profile variations on the existing bridge deck. Measurement and payment are described in the specifications and the *Documentation Manual*.