Chapter 6 - Bituminous Pavements

2-601 Bituminous Concrete (HMA) Pavements

2-601A General

Hot mix asphalt (HMA) pavement consists of coarse graded or dense graded hot mixed, hot laid, bituminous paving mixtures. HMA mixtures are placed on either a prepared gravel base on new pavement structures, or an existing pavement structure for overlay projects.

HMA mixtures are composed of carefully graded coarse and fine aggregates, mineral filler when necessary, and asphaltic cement.

2-602 HMA Mixes and Applications

Superpave HMA mixes have replaced Marshall hot-mix asphalt mixes in most cases. Superpave, like Marshall, is a mix design. Marshall mix designs are designated as “Bituminous Concrete Class ( ).” Superpave mixes are designated as “HMA S*.” Where “S” indicates Superpave and * indicates the sieve related to the nominal maximum aggregate size of the mix, i.e. HMA S0.5. There are two (2) design levels for each nominal maximum aggregate size. The levels are based on the amount of traffic loading they will be exposed to during the designed life of the pavement. A local road, for example, would typically be a level 2. An interstate highway would typically be a level 3.

The design level has no bearing on the nominal maximum aggregate size. For example, a HMA S0.5 level 2 and a HMA S0.5 level 3 have the same nominal maximum aggregate size: 0.5 inch (12.5 mm).

Typical usage for Superpave HMA mixes:

- **HMA S0.25** - Leveling course, thin lift maintenance overlays, over milled surfaces, bridge membrane systems
  
  **Recommended compacted lift thickness:** 1 inch (25 mm)

- **HMA S0.375** - Ideal as a surface course for local roads and some secondary roadways, leveling course, wedge course, over milled surfaces, certain bridge membrane systems, good for some limited access highways
  
  **Recommended compacted lift thickness:** 1.5 inches (38 mm)

- **HMA S0.5** - Ideal surface course for all types of roadways including limited access highways and other higher volume roadways, also good for many wedge course applications
  
  **Recommended compacted lift thickness:** 2 inches (50 mm)

- **HMA S1** - Base course, thick leveling courses
  
  **Recommended compacted lift thickness:** 3 to 4 inches (75 to 100 mm)
Typical usage for Marshall HMA mixes:

Class 3 - Bituminous lip curbing, paved ditch

Class 2 - Temporary pavement for stage construction, i.e. leveling course, wedge course, over milled surface, transitions, etc.
Recommenad compacted lift thickness: 1.5 inches (38 mm)

Class 1 - Temporary pavement for stage construction, i.e. median cross-over, road widening, transitions, etc.
Recommended compacted lift thickness: 2 inches (50 mm)

2-603 Contract Specifications

The Standard Specifications for Roads, Bridges and Incidental Construction (commonly called the Standard Specifications) and the special provisions contain the information regarding material specification, methods of construction, methods of measurement, and bases of payment by which the contractor and the State are bound in the performance of the contract work.

2-604 Contract Plans

Contract plans provide information related to pavements for roadways. This information includes:

- The typical roadway cross sections describe the location, thickness of pavement, width of pavement and specific HMA mixture(s) to which the roadway is to be constructed.

- The plan sheets provide a visual description of the roadway. These plans also describe the roadway pavement width at specific locations by station.

- The cross sections provide information regarding finish pavement line and grade by station. The maximum thicknesses for bituminous concrete are shown on the typical cross sections.

When a HMA wearing surface is applied to a bridge deck, the slab plan and the miscellaneous details sheets in the bridge plans describe the HMA mixture and thickness of the overlay to be placed on bridge decks.

2-605 Production Responsibility

HMA mixtures consist of coarse aggregate, fine aggregate, mineral filler if necessary, and asphalt cement combined to meet composition limits by weight and other characteristics as described in Section M.04. Proportioning of the materials, within the composition limits specified, is the responsibility of the Contractor or Producer. Approval of the source of all materials is required before such materials can be used. The Contractor or Producer must submit a job mix formula for each HMA mix design to be produced to the Department’s Material Testing Laboratory for approval. When the job mix formula is approved, the Contractor is required to furnish a mixture that complies with the formula within the tolerances as described in Section 4.06.

Changes in the source of supply require approval by the Department’s Material Testing Laboratory, and may require adjustment of the job mix formula by the Contractor. The Chief Inspector, prior to any paving, must obtain copies of the approved job mix formula from the Laboratory testing representative. One copy is kept in the project files, and the other copy is kept by the Paving Inspector at the paving site.
2-606 Inspection Responsibilities

The responsibilities for acceptance inspection, sampling and testing are split between the Department’s Material Testing Laboratory and the District forces.

2-606A Material Testing Laboratory

The Assistant Manager, Division of Materials Testing, is responsible for providing the personnel required to examine and approve the Contractor's mixing plant and the trucks used for transporting the HMA mixes to the project.

2-606B District Responsibilities

The Assistant District Engineer assigns the Project Engineer and inspection personnel required to receive the bituminous materials and inspect the placement of the materials in accordance with the contract specifications at the paving site on the project.

2-606C Preliminary Inspection and Approval of Plant

Plant equipment for the production and transportation of bituminous concrete must conform to the requirements of the current Standard Specifications. Inspection, approval and certification that the plant is equipped in conformance with the requirements of the contract specifications are the function and responsibility of the Assistant Manager, Division of Materials Testing.

Upon receipt of the Contractor's report of Anticipated Source of Materials, the Assistant Manager, Division of Materials Testing, will arrange for the inspection of the equipment at the plants selected to supply HMA. Materials Testing will notify the District Engineer of the results of the inspection. Requirements for plant inspection can be found in the manual for the Division of Materials Testing.

2-607 Inspection Prior to Paving

The Paving Inspector must perform the following checks prior to the start of paving:

2-607A Paving Equipment

Before paving is started, all paving machines and rollers must be inspected and approved for conformance with specifications by the Paving Inspector or another assigned inspector. The Inspector should be sure that sufficient equipment, in good working order, is available so that once paving starts it can be continued without undue delays and shutdowns.

2-607B Paving Machines

Most HMA mixtures are placed with a paver. The paver spreads the mixture, in either a uniform layer of a desired thickness or a variable layer to a desired elevation and cross section, ready for compaction.
The paver consists of two basic units: a tractor and a screed. The tractor receives, conveys and augers the mixture to the screed and propels the screed forward. The tractor may be mounted on either rubber tires or crawlers. In addition to the engine, the tractor unit has a hopper for receiving the mix from the haul trucks, conveyors to move the mix through the flow control gates to the augers, flow gates to prevent overloading the augers, and augers to evenly spread the mix in front of the screed. Rollers are mounted on the front of the tractor to push the haul trucks during the dumping process. The rollers should turn freely so the trucks will have little effect on paver operation.  

The screed performs the actual placing of HMA material to the desired width and thickness or elevation, as shown in the sketch in Figure 2-6.3. The screed is towed by the tractor and is free to float up or down until the bottom of the screed is parallel with the grade over which it is traveling.

Figure 2-6.1 Typical Bituminous Paver- side view

Figure 2-6.2 Typical Bituminous Paver- top view

Figures 2-6.1 through 2-6.4, 2-6.7 through 2-6.11, 2-6.18, and 2-6.24 were developed from material provided by the Blaw-Knox Construction Equipment Company. Used with permission.
The relationship between the vertical movement of the screed tow point and the elevation of the screed is the key to the paver's ability to lay smooth pavements. There is an 8-to-1 ratio so that a 1 in. (25 mm) vertical movement of the tow point will result in only a \( \frac{1}{8} \) in. (3 mm) vertical corrective movement of the screed, and before that \( \frac{1}{8} \) in. (3 mm) movement is accomplished, the paver must move 5 times the length of the screed arm.

**Figure 2-6.3 Screed Details**

Because of the free-floating principle, the screed does not reflect any of the minor bumps and dips in the existing grade—resulting in a smoother pavement. An exaggerated view of the leveling action of a paver is shown in Figure 2-6.4.

Pavers must be equipped with automatic grade and slope controls as specified in the *Standard Specifications*. The automatic screed controls can be set for automatic, semiautomatic or manual automatic operation on most pavers. Automatic screed controls typically have these main components:

- Grade sensor,
- Slope sensor,
- Control station, and
- Slope control.

The grade sensor rides on a string line, a ski or a joint matcher to detect changes in elevation and transmits the information electronically to the controls. The electronic controls can be checked by varying the position of the grade sensor and observing if the screed controls react to make the correct adjustments. When the ski is used, the grade sensor should always ride on the center of the ski so that all elevation changes are averaged.

Use of the automatic controls further enhances the paver's capability to produce a smooth pavement surface regardless of irregularities in the surface being paved. Slope—crown or super-elevation—is controlled by the slope sensor or pendulum set for the desired slope. Once the screed is set for the desired mat thickness and slope, the automatic controls activate the motors or cylinders to change the screed tilt to automatically compensate for road surface irregularities.
2-607C Rollers

Four types of rollers are used to compact HMA pavements: double drum tandem (static), vibratory double drum, oscillatory/vibratory double drum and pneumatic tire. Vibratory and oscillatory rollers are capable of operating in static or dynamic modes. Vibratory and oscillatory rollers use dynamic forces to aid in the compaction of the HMA.

Rollers using the vibratory system achieve compaction through vertical amplitude forces. Rollers with this system shall be equipped with indicators that provide the operator with amplitude, frequency and speed settings/readouts to measure the impacts per foot during the compaction process.

Rollers using the oscillatory system achieve compaction through horizontal shear forces. Rollers with this system shall be equipped with frequency indicators. Rollers can operate in the dynamic mode using the oscillatory system on concrete structures such as bridges and catch basins if at the lowest frequency setting.

All rollers must have proper sprinkling systems to wet the drums or tires to prevent the mix from sticking. Scrapers are usually required on drum rollers. Rollers must be equipped with drip pans to prevent oil, grease, or fuel from dropping onto the roadway—because any petroleum product will damage bituminous pavement. Clutches must function smoothly; a roller that jerks when starting, stopping or reversing will contribute to a rough surface.

The tires on pneumatic-tire rollers are typically arranged so the gaps between the tires on one axle are covered by the tires on the other as shown in Figure 2-6.5. The Contractor is required to furnish evidence regarding tire size, pressure and loading to confirm that the proper contact pressure is being developed and that the loading and contact pressure are uniform for all wheels.
2-607D Material Transfer Vehicle (MTV)

A Material Transfer Vehicle (MTV) shall be used when placing a HMA surface course that is greater than 5,000 feet (1524 m) in length and 28 feet (8.5 m) in width. A surface course is defined as the total thickness of the same HMA mix that extends up to and includes the final wearing surface whether it is placed in a single or multiple lifts, and regardless of any time delays between lifts. See Figure 2-6.6.

A Load Factor Rating Analysis should be obtained from the Designer for all structures that the MTV may be required to traverse during the paving operation. See Form 2-6.31 for a sample letter to Design from the Project Engineer requesting the analysis.

The MTV must be a self-propelled vehicle specifically designed for the purpose of delivering the HMA mixture from the delivery truck to the paver. The MTV must have the capability to remix the HMA mixture.

The use of a MTV will be subject to the requirements stated in Section 1.07.05- Load Restrictions. The Engineer may limit the use of the vehicle if it is determined that the use of the MTV may damage highway components, utilities, or bridges. The Contractor shall submit to the Engineer at time of pre-construction the following information:

- The make and model of the MTV to be used
- The axle weights and axle spacing for each separate piece of paving equipment (haul vehicle, MTV, and paver).
- A working drawing showing the axle spacing in combination with all three pieces of equipment that will comprise the pacing echelon.
2-607E Lighting

Adequate lighting is required for night paving. The Inspector must check the lighting equipment before paving begins to ensure that it complies with specifications and is functional. Continuing checks must be made during paving to ensure that lights continue to function.

2-608 Base Preparation

HMA may be placed:

- over existing pavements, either bituminous or concrete,
- on newly constructed aggregate or bituminous base courses, or
- for widening projects, on a combination of existing pavement and base course.

The existing surface must be compact, stable, and free of all debris—sand, mud, leaves or other materials—before placing the new bituminous pavement. This may involve patching, leveling, wedging, and cleaning. Inspect the surface for potholes, base failures, dips, bumps, cracks or other defects, and arrange for corrections. Check the prepared subgrade or prepared base course for compaction and for proper line, grade and cross slope to conform to the plans and specifications. Many of the faults that eventually appear in the surface of a pavement are the result of inadequacies in the subgrade or base.

Gravel subbase must be dry and all defects corrected. The entire base should be compacted for a distance of 2,000 ft. (600 m) ahead of the paving operation.
2-609 Utilities

Where there are underground utilities, a determination must be made as to whether vibratory compaction equipment will damage the utility. Close coordination with the utility companies is essential. Density specifications are not automatically waived if vibratory compaction is not possible. Alternate methods of compaction, like pneumatic tire or oscillatory rollers, should be considered.

The Inspector must note all overhead obstacles such as utility power lines, guy wires, traffic signals, bridge overpasses, and overhead signs. Overhead obstacles must be clearly marked or flagged so that paving equipment operators and truck drivers will not hit them. The marking of such obstacles should be done only by the appropriate utility company. The Inspector should inform the Contractor of these obstacles to avoid any possible conflicts and to maintain safe and adequate distances between equipment and the obstacles. Dump truck drivers must be especially careful of overhead obstacles when raising truck bodies.

Utility companies that have facilities located within the highway right-of-way that will be affected by a paving project must be notified at the start of the project, well before paving is scheduled. (Agreements with the utilities for any adjustments should be obtained prior to start of construction. Utilities should be invited to attend the preconstruction meeting.)

When the utility company does not return the agreement in a reasonable period of time or fails to appear at the preconstruction meeting, a certified letter must be sent to that utility company before the paving is to commence, advising them of the start date and that the utility location will be marked. It is very important that the Department attempt, in every way possible, to have the utility companies on the site during the paving operation. Where utilities have not adjusted their facilities prior to paving, the Paving Inspector must notify the District Office before allowing paving to commence.

2-610 Preparing Meeting

A preparing meeting must be held in advance of the actual start of paving. It is always held at the project site.

The preparing meeting should be scheduled so the Contractor's paving foreman, who will supervise the actual paving operation, can attend. The paving foreman will then understand the project and can assign the proper equipment to perform the work as specified. The preparing meeting agenda is shown in Form 2-6.1 in the appendix at the end of this chapter.

Seasonal Requirements: Paving shall be divided into two seasons, In-Season and Extended Season; In-Season shall be from May 1 – September 30, and Extended Season shall be from October 1- April 30. In no case shall the final lift of HMA be placed during the extended season unless otherwise authorized or directed by the Engineer. No HMA mixes shall be placed when the air or base temperature is below 32°F. HMA for temporary pavement will be subject to the seasonal requirements unless otherwise authorized or directed by the Engineer.

Additional Requirements for Extended Season:

- The minimum mixture temperature for all HMA mixtures in the delivery truck prior to discharge into the paver or transfer vehicle hopper shall be 290°F. The temperature will be taken from the initial discharge of mixture from the truck. If found to be below the minimum requirement, the truck will not be allowed to unload remaining mixture.
- The Contractor shall use a minimum of 3 rollers with operators for paving lengths greater than 1000 feet. Two rollers must be capable of operating in the dynamic mode.
• The Contractor’s Quality Control Plan shall include a section on Extended Season Paving and address paver speed, roller patterns and balancing mixture delivery and placement operations to meet specification requirements.

2-611 Test Section
The Contractor may be required to place a test section whenever the requirements of Sections 4.06 or M.04 are not met. The Contractor shall submit the quantity of mixture to be placed and the location of the test section for review and acceptance by the Engineer. The equipment used in the construction of a passing test section shall be used throughout production.

If a test section fails to meet specifications, the Contractor shall stop production, make necessary adjustments to the job mix formula, plant operations, or procedures for placement and compaction. The Contractor shall construct test sections, as allowed by the Engineer, until all the required specifications are met. All test sections shall also be subject to removal as set forth in Section 1.06.04.

2-612 Traffic Control
Where public traffic must be maintained through a paving operation, a proper signing pattern must be in place in accordance with the contract item “Maintenance and Protection of Traffic” prior to beginning the paving. Safety is the most important factor in any construction activity.

The traffic pattern must accommodate the traveling public, Contractor personnel and inspection forces. Inspection forces include those sampling and testing material. Maintaining an uninterrupted traffic flow so the paving operation proceeds without stoppages is one of the key factors in attaining a superior quality paving project.

2-613 Inspection During Paving
2-613A The Day Before
Inspection staff must notify the District Office the day before a paving operation so arrangements can be made with the Department’s Material testing Laboratory to allow for coverage at the plant and to enable the District to schedule nuclear density assurance testing. The information required is the plant producing the material and the estimated tonnage. This information should be given to the District as far in advance as possible; however, it should be received no later than mid afternoon of the normal working day before the paving operation. The information will be relayed to the Department’s Material testing Laboratory so they can schedule their personnel.

2-613B Transportation of Mixture
Inspection of hauling equipment is the responsibility of the Contractor. The Paving Inspector, however, must check each truck when it arrives at the work site and reject the load if the truck does not conform. The mixture shall be transported from the mixing plant in trucks that have previously been cleaned of all foreign material and that have no gaps through which mixture might inadvertently escape.

Truck body coating and cleaning agents must not have a deleterious effect on the transported mixture. An excess of the cleaning agent must be avoided. The use of gasoline, kerosene, or fuel oil for cleaning the trucks is prohibited. All truck bodies should be raised prior to loading to drain excess coating materials.

Loaded trucks shall be tightly covered with waterproof covers acceptable to the Engineer. Mesh covers are prohibited.
Loaded trucks must not exceed the statutory or permitted load limits referred to as gross vehicle weight (GVW). The Contractor shall furnish a list of all vehicles and allowable weights transporting mixture.

If a truck delivers mixture to the project and the ticket indicates that the truck is overweight, the load will not be rejected but a “Measured Weight Adjustment” will be taken in accordance with Section 4.06.04.

All vendors producing HMA for the State under the terms of the contract must have their truck weighing scales, storage scales, and the mixing plant automated to provide a detailed weigh ticket to the Inspector for each batch, at the paving site for each load of material delivered.

A weigh ticket must accompany each load of mix transported to the project and must include the exact information specified in Section 4.06.03 of the current Standard Specifications and as shown in Volume 2, Section 2-632D.

2-613C Paving Inspection

At least one Paving Inspector must be present at all times that a paving operation is underway. The Contractor shall perform all quality control sampling and testing, provide inspection, and exercise management control to ensure that HMA production and placement conforms to all requirements. The Inspector provides quality assurance.

The Paving Inspector is responsible for receipt and placement of the material. Control of the shipment of materials is the responsibility of the supplier. Close liaison between the plant and Paving Inspector is essential. Use the telephone or other available and adequate means. The Paving Inspector must advise the Contractor immediately if bad weather or other unsatisfactory conditions at the job site require the suspension of paving operations. Delays in stopping the trucks may result in wasted material.

The Paving Inspector is personally responsible for collecting the weigh tickets and signing each ticket prior to unloading, to assure that the material is actually incorporated in the work. Never allow Contractor personnel to collect the tickets.

The Inspector should frequently check the temperature of the mix in the trucks and at the paver, by use of a probe type armored thermometer or an infrared thermometer. Any loads not within the temperature requirements of the specifications must be rejected. Rejection of mixture based on temperature will only be allowed if verified by means of a probe type thermometer.

The Inspector should visually check each load to determine that the load is satisfactory. Mistakes in batching and mixing can occur at the plant without being noticed by the Contractor. The Paving Inspector should be especially vigilant in watching for certain characteristic behaviors of the mix which indicate trouble:

- An overheated or burned batch will give off a cloud of blue smoke and the mix will have a brown, dead appearance.
- If the bitumen has drained off or flowed to the bottom of the truck and the aggregate on top is uncoated, it could indicate the aggregate is dirty or wet.
- Excess bitumen in the mix will flush to the surface during rolling, and will appear fat, greasy and soupy.
- Excessive bitumen will also cause the mix to lie flat in the truck rather than dome up.
- Aggregates not dried sufficiently will cause the asphalt to puddle and the mix to be flat in the truck, and drops of water may appear dripping from the tailgate.
- Ensure that each truck dumping into the paver leaves empty.

Any change in the character of the mix, either in the trucks or as it is being placed, should be reported immediately to the Contractor or paving foreman so the condition can be corrected. The Inspector should watch for segregation in the mix. Segregation can be caused by improperly stockpiling aggregate so the larger stones roll to the bottom of
the pile or by improperly loading the mix into the trucks at the paving plant. The preferred method of loading tandem-axle or tri-axle dump trucks is shown in Figure 2-6.8. About 40 percent of the mix is loaded in the center of the front half of the truck bed. The truck is then moved forward so the next 40 percent or so of the mix is deposited in the center of the back half of the bed. The truck is then moved backward so the remaining mix can be placed between the first two piles.

Figure 2-6.8 Preferred Truck Loading Sequence

The reason for rejection of any load must be recorded on the ticket and on the paving reports, so that proper deductions can be made from the pay quantities.

The HMA mixture shall not be placed whenever the surface is wet or frozen. No HMA mixes shall be placed when the air or base temperature is below 32°F.

Paving shall be divided into two seasons, In-Season and Extended Season; In-Season shall be from May 1 – September 30, and Extended Season shall be from October 1- April 30. In no case shall the final lift of HMA be placed during the extended season unless otherwise authorized or directed by the Engineer. Additional requirements for extended season:

- The minimum mixture temperature for all HMA mixtures in the delivery truck prior to discharge into the paver or transfer vehicle hopper shall be 290°F. The temperature will be taken from the initial discharge of mixture from the truck. If found to be below the minimum requirement, the truck will not be allowed to unload remaining mixture.
- The Contractor shall use a minimum of 3 rollers with operators for paving lengths greater than 1000 feet. Two rollers must be capable of operating in the dynamic mode.
- The Contractor’s Quality Control Plan shall include a section on Extended Season Paving and address paver speed, roller patterns and balancing mixture delivery and placement operations to meet specification requirements.

The Paving Inspector must be sure that all of the necessary preliminary material tests have been made and that all the tests required in the “Schedule of Minimum Requirements for Test” are submitted as paving continues. The Contractor is responsible for tests at the plant.

2-614 Tack Coat

A tack coat is the application of asphalt material to ensure a bond between newly placed HMA mixtures to varying contact surfaces. A thin uniform coating of tack coat material shall be applied immediately before overlaying and be allowed sufficient time to break (set). All surfaces that have been in place longer than three (3) calendar days shall have an application of tack coat and for those less than three (3) days it shall be at the sole discretion of the
The tack coat shall be applied by a non-gravity pressurized spray system that results in uniform overlapping coverage at a target application rate of $0.07 \pm 0.02$ gallons per square yard for a non-milled surface and a target application rate of $0.12 \pm 0.02$ gallons per square yard for a milled surface. For areas where both milled and un-milled surfaces occur, the tack coat shall be a target application rate of $0.07 \pm 0.02$ gallons per square yard. The Engineer must approve the equipment and the method of measurement prior to use. The material for tack coat shall not be heated in excess of 160°F and shall not be further diluted.

Tack shall be applied uniformly without streaking or puddling. If a nozzle is not spraying properly, stop the distributor immediately and have the nozzle cleaned or adjusted. Where streaking occurs, direct the Contractor to make the necessary adjustments to eliminate the condition. Any puddles of tack coat material must be cleaned up before placing the mix. If it is allowed to remain, it will cause bleeding into the mix creating a “fat” spot-an area with an excessive amount of asphalt.

The height of the spray bar shall be such that a double overlap is achieved, see figure 2-6.9. The effects of having the spray bar too high or too low are excessive overlap or no overlap as shown in Figure 2-6.10.

The distributor must be capable of applying the tack coat material in accurately measured quantities and the specified rate of application.

![Figure 2-6.9 Spray Bar Overlaps](image)

![Figure 2-6.10 Incorrect Spray Bar Overlaps](image)
Areas inaccessible to the spray bar should be tacked with a hand sprayer. Extreme care must be taken with a hand sprayer to get uniform coverage without puddling.

2-615 Mechanical Spreading

The basic principle of all mechanical spreaders—the paving machine—is the same. The machine consists of a self-propelled tractor and a screed unit. The tractor unit provides the motive power and includes the receiving hopper, the conveyor and spreading augers.

2-615A Screed Unit

The screed unit is attached to leveling arms that extend from the tow point on the tractor unit. See Figures 2-6.1 through 2-6.3 and 2-6.11. The tamper, screed depth cranks, crown controls, screed heater and the screed itself are all part of the screed unit. The screed rides on the finished surface. Most pavers have vibrating screeds to partially compact the mix as it is placed.

The spreading augers are worm screws that uniformly spread the mix across the full width of the machine. Each side of the machine is equipped with a feeder and auger unit, which can be operated simultaneously or independently. The gates in the back of the hopper can be adjusted so there is a constant flow of material coming to the augers. The material around the augers should just cover the auger shaft.

The tamper bar is located on the front of the screed and is a vertical plate with an inclined face, facing toward the front end of the machine. The tamper bar provides the initial compaction to the mix. The vertical travel of this bar is about \( \frac{1}{8} \) in. (3 mm) at approximately 1,200 strokes per minute. The tamper in its lowest position is about \( \frac{1}{64} \) in. (0.4 mm) below the bottom of the screed. This fixes the surface elevation of the pavement just before the screed slides onto it. The real tamping is done by the front of this bar and will ensure uniform compaction.

The thickness of the course is set before the paving begins by setting the screed to the desired height. The screed should be raised an additional 10 to 20 percent of the required depth to allow for the additional compaction by rollers behind the paver. After a short run of about 20 ft. (6 m), the depth of the material being placed should be checked. Any required adjustments to the thickness are made by the Contractor turning the thickness control levers. These levers are located on the screed unit, and are turned to the right to increase the depth of the material being laid and to the left to decrease it. The most important thing to remember in adjusting thickness controls is not to move the control more than \( \frac{1}{4} \) turn at a time; otherwise the machine does not have time to act and variations in the level of the surface will result. Once the thickness of the material being laid is satisfactorily set on the machine, there should be very little reason to touch the screed depth cranks, and the Inspector should discourage workers from constantly adjusting them.

Controlling the vertical position of the free-floating screed, with respect to the grade surface over which the paver is moving, is the primary element in producing high-quality pavements. Factors such as paving speed, head of material, mix consistency, pre-compaction and screed angle all influence the vertical position of the screed. If any of these factors are varied during the paving operation, the variation will cause a change in the mat depth, density and/or texture. The three primary variable factors that influence the vertical position of the free-floating screed are listed below and shown in Figure 2-6.11.
Figure 2-6.11 Factors That Influence the Vertical Position of the Screed

- Factor F-1—angle of attack,
- Factor F-2—head of material, and
- Factor F-3—paving speed.

2-615B Angle of Attack

The angle of attack is the angle that exists between the bottom surface of the screed and grade surface over which the paver is moving. Paving over a flat, level surface with all variables held constant will produce a mat of constant profile. If the screed or tow points are vertically displaced, a change in the angle of attack occurs. The screed moves to restore the original angle as illustrated in Figure 2-6.12. The restoring action of the screed is referred to as “self-leveling.”

When the angle of attack is increased, more material is allowed to pass under the screed, causing it to rise until the screed is again moving in a plane essentially parallel to the cross slope. Conversely, decreasing the angle will reduce the amount of material allowed to pass beneath the screed, causing the screed to drop until it is again parallel to the grade.

The angle of attack is controlled by either the manual screed depth cranks or the automatic level controls. One full turn of the depth crank will raise or lower the screed ¼ in. (6 mm). However, adjustments should be made in small increments to produce a smooth-riding pavement. The change in depth begins immediately after adjusting the crank but must move approximately 5 times the length of the screed side arm before the full change in thickness is completed.
**2-615C Head of Material**

The head of material is the volume of paving material directly in front of and along the entire length of the screed. The volume and consistency of the head of material are primary factors in the amount of mix that flows under the screed and affects the mat density, texture and profile. The volume in front of the screed determines the amount of pressure or resistance to forward travel exerted on the screed.

The volume of material in front of the screed should be maintained at a near constant level, almost covering the auger shaft along the entire length of the screed. Modern pavers have automatic controls to maintain the correct level. See Figure 2-6.13 for the correct head of material.

If the head of material is too high, the resistance to forward travel is increased. The screed will rise, and may cause ripples, auger shadows, long waves, increased depth, and a less dense mat. See Figure 2-6.14. If the head is too low, the resistance to forward travel is decreased and the screed will gradually fall, resulting in a thin mat and possible voids in the mat. See Figure 2-6.15. A fluctuating head of material will result in a combination of the mat deficiencies described above plus alternating changes in the mat texture and depth.
2-615D Paving Speed

The speed of the paving operation should be determined by the rate of material delivery to the paver. The optimum speed results in the paver being in continuous operation, never stopping, and using the mixture as it is delivered, never permitting trucks to stack up waiting to unload. Continuous, uninterrupted forward travel at a constant speed, with other variables held constant, will produce a smooth riding surface. While absolute compliance with this goal is usually not possible, the fewer interruptions or changes in paving speed, the smoother the finished surface will be. The paving speed should be adjusted to that which gives a uniform texture and coordinates with plant production.

Pavers should not be operated at speeds in excess of 40 ft. (12 m) per minute under any conditions. There is a tendency of some paver operators to run the paver faster than necessary so they can get off the paver for a break periodically. This results in non-uniform surfaces.

2-615E Other Factors

In addition to the three major factors discussed above, you should be aware of other improper operating procedures that can affect the riding quality of the pavement.

- Truck bumping the paver—this is the most common cause of transverse marks and ridges in the finished mat. Drivers should stop their trucks ahead of the paver and let the paver operator pick up the truck as the paver travels forward.
- Truck driver holding brakes—this will reduce the paving speed causing an increase in mat depth. In extreme instances, it may cause the paver wheels to slip or break traction, resulting in a bump in the mat.
- Unequal or over inflation of paver drive tires can cause the drive wheel to slip or break traction, resulting in a rough, uneven mat.
Excessive hand raking (luting) behind the paver causes segregation of the mixture, and therefore is not permitted. The paver should be so adjusted that only an occasional touch-up should be necessary by hand lutes.

The vibrating screed must be kept hot at all times. The heater unit is attached to the top of the screed plate and is generally used only to keep the temperature of the screed at the temperature of the mix. It is necessary to heat the screed at the start of paving when placing HMA. The heater may be required occasionally during the day, depending on the heat of the mix and the air temperature. If paving is delayed for any length of time during the day, the heater should be lit to maintain the heat on the screed, to prevent scuffing or tearing of surface when the paving operation is resumed. Overheating the screed can cause the screed to warp, which results in poor pavement surface quality.

The screeds must be cleaned at the end of each day of paving and at other intervals at the request of the Engineer. Approved solvents, cleaners and scrapers are used for cleaning. All contact surfaces of paving equipment should be lightly oiled after cleaning. All cleaning should be performed in such a manner that the HMA in place is not damaged by the cleaning agent, and the screeds and equipment must be dry before reuse. The cleaning of the paving equipment must be done in an environmentally acceptable manner. The use of any petroleum product such as diesel or kerosene is prohibited.

A mat troubleshooting guide is shown in Table 2-6.1, in the appendix at the end of this chapter. This guide can be used to identify the causes of many problems encountered with the laid mix.

2-616 Hand Spreading

Hand spreading of HMA mixtures is discouraged. Where hand spreading is necessary, the mix should be dumped from trucks onto a platform and spread from this platform. Each shovelful should be turned as placed. Other methods acceptable to the Engineer will be permitted.

Do not allow any walking in the loose mixture, and avoid excessive luting that pulls the coarse aggregate to the surface. Pins and strings should be set to ensure the correct contour of the completed surface. The lutes, shovels and tampers should be kept hot and clean. No cleaning agent that has a deleterious effect on the mixture can be used on the hand tools. Also avoid using overheated tools, when they are cleaned with fire.

2-617 Delays or Shutdowns

Whenever the absence of loaded trucks necessitates a pause, the paver should be stopped with a substantial quantity of mix ahead of the screed. As discussed under head of material, running the paver until the mix is too low will result in a dip in the pavement. And the small mass of mix will cool faster.

When a lengthy delay in paving occurs, the screed has a tendency to settle into the fresh mat. Generally, if a delay in excess of thirty minutes should occur, the pavement should be treated the same as at the end of a normal paving day. The material in the machine should be run-out, and the fresh mat completely rolled. When paving is resumed, the end of the mat should be cut back to the point of full pavement thickness as shown on the plans. The paving machine should be reset as is done at the start of each paving day.

When unforeseen weather conditions prevent further placement of the mix, the Engineer is not obligated to accept or place the bituminous concrete mixture that is in transit from the plant. The Engineer may permit placement of material that is in transit when the paving operation is overtaken by sudden storms, provided the mixture is within the temperature limits specified, and a safety hazard does not exist. A large quantity of material can be in transit and will be either placed in less than ideal conditions or wasted. To prevent either from occurring, the Chief Inspector should be familiar with the Contractor’s Quality Control Plan and plant production to reach a decision to shut down operations because of inclement weather. This information should be obtained before the start of any paving operations. The following types of information should be obtained:

- The telephone numbers and names of quality control operators at the plant,
- The Contractor’s anticipated production rate,
The length of time required to stop production,
• The tonnage produced to clear the dryer/mixer after shutdown,
• The number of haul vehicles,
• The anticipated tonnage in transit, and
• The Contractor’s estimate of how quickly work can be secured and operations shut down.

The decision to shut down for inclement weather must remain with the paving inspection force. The items listed above must be considered in making that decision.

2-618 Thickness and Tonnage Control

The thickness and width of the pavement structure is shown on the typical sections in the project plans. The actual compacted thickness of each course of material must conform to the planned design. The design thickness is determined so the pavement structure will be strong enough to carry the anticipated traffic. A course can be a lift or multiple lifts comprised of the same HMA mixture placed as part of the pavement structure. A lift is a single HMA mixture placed at a defined thickness.

![Figure 2-6.16 HMA Course and Lift Diagram](image)

If the mat is too thin, it will likely fail prematurely. If it is too thick, the pay quantities will overrun and increase the cost of the project unnecessarily.

Adequate thickness and width measurements are to be taken and recorded on DWRs. If the depths begin to vary from the limits in Subsection 4.06.04 of the Standard Specifications, the Inspector should take additional depth measurements until the extent of the problem is identified so corrections can be made.

The thickness of the mat is checked in two ways:
• After initial rolling, make a small hole with a putty knife in the mixture, and check the depth of the course with a depth gauge.
• Check the yield of a load or series of loads actually covered against the theoretical distance that the loads should cover.

Depth variations are permissible in the specifications, and the determination above reflects the paving depth trend. Where the depth measurements indicate an adjustment of measured weight, and it is not practical to determine the limits of the area to be adjusted by normal means, cores may be taken to determine the limits.

The plans specify the thickness that the HMA material is to be placed. This is known as the “planned quantity.” The planned quantity is used in both checks.
If an adjustment for thickness of material placed is required use the Adjustment Schedule for Bituminous Concrete form, see Section 2-636.

2-619 Determining Planned Rate of Spread

Through experience as noted above, it has been found that mixes in Connecticut weigh about 115 lbs. per sq. yd. for each 1 in. of depth (2.46 kg per m² for each mm of depth) when compacted.

The formula for determining the compacted mat thickness is:

\[
\frac{\text{Planned Quantity (lbs/ yd}^2\text{)}}{\text{Estimated Weight of Mix [lbs/(yd}^2\text{ in.)]}} = \text{Desired Mat Thickness (in)}
\]

\[
\text{Planned Quantity (kg/m}^2\text{)/Estimated Weight of Mix [kg/(m}^2\text{ mm)] = Desired Mat thickness (mm)}
\]

Example 1: Planned thickness is 3 in. (75 mm).

\[
3 \times 115 = 345 \text{ lbs/yd}^2
\]

\[
75 \times 2.4 = 184 \text{ kg/m}^2
\]

2-620 Depth and Yield Checks

2-620A Depth Checks

The thickness of each lift will be checked by taking depth measurements immediately after completion of the breakdown rolling, and while the mixture retains sufficient heat to allow corrective measures to be taken. These depth measurements will be considered as applying for the full width of the lane. The intervals of width and depth measurements in any one lane will vary due to site and placement conditions, but should be taken minimally every 250 ft. (76 m). This information is to be documented in the project records. Refer to the section, "Records."

2-620B Yield Checks

Yield checks are made by comparing the area covered with the quantity placed. It is recommended that a minimum of four (4) yield checks be made per day. Spot checks for individual loads or several loads can be made at any time to ensure that the proper thickness of material is being placed. For most mixes used in Connecticut, the yield should be about 105 to 115 lbs. per square yard per inch of depth (2.24 to 2.46 kg per square meter per millimeter of depth). The mixture should be spread to a loose depth that will produce a specified finished thickness. The loose depth must be determined by experiment.
The actual rate of spread is more accurate than individual depth checks because it considers the average spread over a larger paving area.

2-620C Inspector Responsibility

It is the Paving Inspector's responsibility to ensure that the actual amount of mix placed by the Contractor complies with the plans. The Inspector collects mass slips (weigh tickets) as mix is delivered to the paving site and keeps records of the actual amount of mix placed. This record serves two purposes:

- to document the amount of mix actually placed—the *placed quantity*, and
- to serve as a basis for comparing the *placed quantity* with the *planned quantity*.

The Inspector must compute the actual rate of spread to compare with the planned rate. The planned rate is typically shown on the plans in lbs per square yard (kilograms per square meter), as mentioned above. The actual rate of spread may be computed in lbs/yd$^2$ (kg/m$^2$) or lbs per linear foot (kg per linear meter). Both the planned and actual rates must be in the same units for valid comparisons, of course.

The purpose of computing the actual rate of spread is to determine if the planned amount is being placed. If the actual rate exceeds the planned rate, too much mix is being placed, resulting in an overrun of material. If the actual rate is less than planned, too little mix is being placed and the pavement is thinner than planned. In either case, adjustments should be made to bring the actual quantity in line with that planned.

2-620D Stationing

The distance that a load or series of loads is spread can be determined by noting the station at the beginning and end, and subtracting the lower from the higher. For example:

- **Beginning**: 10 + 60.0
- **Ending**: 12 + 35.3
- **Distance**: 175.3 ft.

- **Beginning**: 4 + 250
- **Ending**: 6 + 425
- **Distance**: 2175 m

2-620E Computing Actual Rates of Spread

As stated above there are two methods of computing the actual rate of spread. The calculations are similar, differing primarily in the units in which the rates are expressed.

Examples of both methods of checking the actual rates with planned rates follow. The sketch in Figure 2-6.17, showing the amount paved and quantities used, applies to both examples.
**Method 1 (English) — Pounds per Square Yard**

The planned rate of spread is 345 lbs/yd

A 1. Total the weights of the loads placed, in lbs, to the point where the check is made.

   The total of the first five loads equals 240,304 lbs.

2. Determine the total length paved in yards.

   Loads 1 through 5 covered 191.7 yds.
3. Determine the area paved in square yards.

   Total Length × Width Paved = 191.7 yds. × 4 yds. = 766.8 yd²

4. Calculate the actual rate of spread in lbs/yd².

   \[
   \text{Actual Rate of Spread (lbs/yd²)} = \frac{240,304 \text{ lbs}}{766.8 \text{ yd}²} = 313.4 \frac{\text{lbs}}{\text{yd}²}
   \]

5. Determine relationship between the Placed Quantity and the Planned Quantity.

   If Placed Quantity = Planned Quantity: Mat thickness is okay
   If Placed Quantity > Planned Quantity: Overrun
   If Placed Quantity < Planned Quantity: Underrun

   The Placed Quantity of 313.4 lbs/yd² is less than the Planned Quantity of 345 lbs/yd².

   You are underrunning.

   B  After Load 10, you have paved 333.3 yds and have placed a total of 500,008 lbs.

   Placed Quantity = \( \frac{500,008 \text{ lbs}}{1,333.2 \text{ yd}²} = 375.0 \frac{\text{lbs}}{\text{yd}²} \)

   Area = 333.3 × 4 = 1,333.2 yd²

   The Placed Quantity of 375.0 lbs/yd² is greater than the Planned Quantity. You are overrunning.

   C  After Load 20, you have paved 756.7 yds and have placed a total of 1,044,246 lbs.

   Placed Quantity = \( \frac{1,044,246 \text{ lbs}}{3,026.8 \text{ yd}²} = 345.0 \frac{\text{lbs}}{\text{yd}²} \)

   Area = 756.7 × 4 = 3,026.8 yd²

   The Placed Quantity equals the Planned Quantity.

   Method 1(Metric) — Kilograms per square meter

   The planned rate of spread is 184 kg/m²

   A  1. Total the weights of the loads placed, in kg, to the point where the check is made.

      The total of the first five loads equals 109,000 kg.

      2. Determine the total length paved in meters.

      Loads 1 through 5 covered 175.3 m.
3. Determine the area paved in square meters.

   Total Length × Width Paved = 175.3 m × 3.7 m = 648.6 m²

4. Calculate the actual rate of spread in kg/m².

   Total Mix Placed (kg) / Area Paved (m²) = 109,000 / 648.6 = 168 kg/m²

5. Determine relationship between the Placed Quantity and the Planned Quantity.

   If Placed Quantity = Planned Quantity: Mat thickness is okay
   If Placed Quantity > Planned Quantity: Overrun
   If Placed Quantity < Planned Quantity: Underrun

   The Placed Quantity of 168 kg/m² is less than the Planned Quantity of 184 kg/m².

   Placed Quantity = 226,800 / 1127.8 = 201.1 kg/m²

   You are underrunning.

B After Load 10, you have paved 304.8 m and have placed a total of 226,800 kg.

   Area = 304.8 x 3.7 = 1127.8 m²

   Placed Quantity = 226,800 / 1127.8 = 201.1 kg/m²

   The Placed Quantity of 201.1 kg/m² is greater than the Planned Quantity. You are overrunning.

C After Load 20, you have paved 692 m and have placed a total of 472,300 kg.

   Placed Quantity = 472,300 / 2560.4 = 184.4 kg/m²

   Area = 692 x 3.7 = 2560.4 m²

   The Placed Quantity equals the Planned Quantity.

**Method 2 (English)—Pound per Linear foot**

The planned rate of spread is 345.0 lbs/yd²

A 1. Convert the Planned Quantity from lbs/yd² to lbs per linear foot.

   The paved area per linear foot is needed for the conversion. In our example the width being paved is 4 yds:
The conversion is as follows:

\[
\frac{\text{Paved Length} \times \text{Paved Width}}{\text{Paved Length}} = \frac{1 \text{ yd} \times 4 \text{ yd}}{1 \text{ yd}} \times \frac{1 \text{ yd}}{3 \text{ ft}} = 1.33 \frac{\text{yd}^2}{\text{ft}}
\]

2. Total the weights of the loads placed, in pounds, to the point where the check is made.

The total of the first five loads equals 240,304 lbs.

\[
\text{Planned Quantity} \times \text{Paved Area per linear foot} = 345.0 \frac{\text{lbs}}{\text{yd}^2} \times 1.33 \frac{\text{yd}^2}{\text{ft}} = 458.9 \frac{\text{lbs}}{\text{ft}}
\]

3. Determine the total length paved in feet.

Loads 1 through 5 covered 575.1 ft.

4. Calculate the actual rate of spread in lbs/ft

\[
\frac{\text{Total Mix Placed}}{\text{Total Length Paved}} = \frac{240,304 \text{ lbs}}{575.1 \text{ ft}} = 417.8 \frac{\text{lbs}}{\text{ft}}
\]

5. Determine relationship between the Placed Quantity and the Planned Quantity.

The Placed Quantity of 417.8 lbs/ft is less than the Planned Quantity. You are underrunning.

B After Load 10, you have paved 1,000 ft and have placed a total of 500,008 lbs.

\[
\text{Placed Quantity} = \frac{500,008 \text{ lbs}}{1,000 \text{ ft}} = 500.0 \frac{\text{lbs}}{\text{ft}}
\]

Total length = 1000 ft

The Placed Quantity of 500.0 lbs/ft is greater than the Planned Quantity. You are overrunning.

C After Load 20, you have paved 2,270 ft and have placed a total of 1044,246 lbs.

Total length = 2270 ft

The Placed Quantity is slightly more than the Planned Quantity.
The planned rate of spread is 184 kg/m²

A 1. Convert the Planned Quantity from kg/m² to kilograms per meter

   The paved area per meter is needed for the conversion. In our example the width being paved is 3.7 m:

   The conversion is as follows:

   \[
   \text{Planned Quantity} \times \text{Paved Area/meter} = 184 \text{ kg/m}^2 \times 3.7 \text{ m}^2/\text{m} = 680 \text{ kg/m}
   \]

2. Total the weight of the loads placed, in kg., to the point where the check is made.

   \[
   \text{FACTOR: paved Length} \times \text{Paved Width} / \text{Paved Length} = 1 \text{ m} \times 3.7 \text{ m}/1\text{m} = 3.7 \text{ m}^2/\text{m}
   \]

   The total of the first five loads equals 109,000 kg.

3. Determine the total length paved in meters.

   Loads 1 through 5 covered 175.3 m.

4. Calculate the actual rate of spread in kg/m

   \[
   \text{Total Mix Placed} / \text{Total Length Paved} = 109,000 / 175.3 = 621.8 \text{ kg/m}
   \]

5. Determine relationship between the Placed Quantity and the Planned Quantity.

   The Placed Quantity of 621.8 kg/m is less than the Planned Quantity. You are underrunning.

B  After Load 10, you have paved 304 m and have placed a total of 226,800 kg.

   \[
   \text{Placed Quantity} = 226,800 \text{ kg} / 304 \text{ m} = 746 \text{ kg/m}
   \]

   Total length = 304 m

   The Placed Quantity of 746 kg/m is greater than the Planned Quantity. You are overrunning.

C  After Load 20, you have paved 692 m and have placed a total of 472,300 kg.

   \[
   \text{Placed Quantity} = 472,300 \text{ kg}/692 \text{ m} = 682.5 \text{ kg/m}
   \]

   Total length = 692 m

   The Placed Quantity is slightly more than the Planned Quantity.
2-621 Compaction

2-621A Rolling

Generally, compaction is achieved by establishing rolling procedures referred to as:

- initial or breakdown rolling,
- intermediate rolling, and
- finish or final rolling.

The types of rollers used for compaction of bituminous pavements include:

- Static steel drum
- Vibratory steel drum
- Oscillatory steel drum
- Pneumatic tire

The static and vibratory steel drum rollers are most commonly used in Connecticut. The types, sizes and number of rollers must be approved by the Engineer. The rollers must be of the type appropriate for each phase of rolling. As previously stated in section 2-607, rollers must be equipped with water sprayers and scrapers on the tires and drums. The tires and drums must be kept moist during rolling to avoid picking up the material. Use only enough water to prevent pickup. The equipment must be ready, at the job site, prior to delivery of HMA and be maintained in proper operating condition throughout the paving operation.

2-621B Initial or Breakdown Rolling

Initial or breakdown rolling is normally performed with a vibratory or oscillatory roller having a weight (mass) of not less than 10 tons (9,100 kg). The number of rollers needed depends on the Contractor’s rate of production. Where only one roller is needed, a standby roller is required in case of equipment breakdown.

Rolling should begin as soon as the spread mixture will bear the weight of the roller without shoving or cracking. Flushing the pavement with water to hasten cooling is strictly prohibited.

No set rule can be given for the temperature at which the rolling should take place. In practice, rolling operations are governed by trial-and-error experience. With Superpave HMA mixes, initial or breakdown rolling should begin immediately after placement. Rolling performed after the pavement has partially cooled can cause the pavement to have a rough, uneven surface texture or make achieving specified density difficult.

Rolling should begin at the sides or low point and progress toward the center, parallel to the centerline of roadway, as shown in Figure 2-6.18. If a longitudinal joint is formed, it should be rolled first. Alternate trips of the roller should be terminated in stops at least three feet (one meter) distant from any preceding stop. All turning movements should be completed on previously compacted material. Other rolling procedures may be directed by the Engineer as conditions may require. Rolling should be discontinued if the surface shows signs of cracking and should be continued later as directed. Rolling should proceed continuously and in such a manner that all roller marks are eliminated. Rollers must be in good condition and must be operated by competent roller operators. The pavement should be rolled so that the entire surface receives substantially equal compaction.
On super elevated curves, rolling should begin at the low side and progress to the high side. All rolling should be done so that each preceding track of the roller is overlapped by at least half the width of the roller. When rolling pavement edges, the roller should extend 2 to 4 in. (50 to 100 mm) beyond the edge of the pavement.

After the required passes are completed, the roller should be moved to the outside of the lane on the cooled portion of the mat to repeat the process on the next segment.

Steel drum rollers should be operated with the drive drum forward, or the uphill direction of paving. The drive drum applies a more direct vertical load than the tiller drum and causes less shoving of the material since the turning force tends to tuck the material under the drum. Exceptions to rolling with the drive drum forward occur when the roadway longitudinal grades are excessive or the cross slope or superelevation is high. In such cases, the drive drum may chatter, displace the mixture and cause a rough surface. The recommended practice in such cases is to do the breakdown rolling with the tiller drum forward.

Rolling should proceed continuously at a rate that provides for adequate compaction and the removal of all roller marks. Rolling too fast can cause surface cracks and a rough, uneven and wavy surface. The recommended maximum speed for all non-vibratory rollers is 5 mph or 440 fpm (8 km per hour).

**2-621C Intermediate Rolling**

Intermediate rolling may be done with a static, vibratory, oscillatory or pneumatic-tire roller. If a pneumatic-tire roller is used, it should be equipped with wide tread compaction tires capable of exerting an average contact pressure from 60 to 90 psi (420 to 620 kPa) uniformly over the surface, adjusting ballast and tire inflation pressure as required.

The ground pressure developed by pneumatic-tire compactors is a function of four factors; tire size, tire ply rating, tire loads and tire inflation pressures.
2-621D Finish Rolling

Finish rolling is normally done by a static roller having a weight (mass) of not less than 10 tons (9,100 kg). Finish rolling should be done while the material is still workable enough for removal of the roller marks. A dual vibrating drum roller, operating in the static mode, may be used as the finish roller.

On certain bridge deck overlays and paving jobs where, due to physical limitations, a full roller contingent is not practical, the Engineer may, at his option, permit a lesser number of rollers provided all compaction requirements are met. The use of a vibratory roller in the dynamic or vibratory mode is prohibited on bridge decks or concrete structures. Oscillatory rollers, if used at the lowest frequency setting, may be used on structures.

In all places inaccessible to a roller, such as adjacent to curbs, gutters, bridges and manholes, the required compaction may be obtained by hand tamps. Depressions, which may develop before the completion of rolling, shall be remedied by adding new material to bring the depressions to a true surface.

2-622 Compaction Testing

The Contractor is responsible for all quality control testing. In-place nuclear density tests are taken to check the compaction of the mat. The Contractor’s Quality Control personnel make the Gyratory molds to set the standards for the nuclear gauges used on the project.

In-place densities must be taken for each lift of HMA placed. The required compaction of each lift, expressed as a percent of the theoretical density, is shown in the Standard Specifications. Theoretical densities are determined by AASHTO Test Method T209. A sample data and computation sheet for nuclear density tests for bituminous concrete is shown in Figure 2-6.19.

2-623 Transverse Joints

All transverse joints shall be formed by saw-cutting a sufficient distance back from the previous run, existing HMA pavement or bituminous concrete driveways to expose the full thickness of the lift. A brush of tack coat shall be used on any cold joint immediately prior to additional HMA mixture being placed.

2-624 Permanent Transitions

Permanent transitions are required at the beginning and ending of all paving projects. In addition, a keyway must be milled into the existing pavement for the final course to provide a tight, smooth joint. The depth of the keyway should equal the thickness of the course. A typical keyway is shown in Figure 2-6.20. All permanent transitions, leading and trailing ends, shall meet the following length requirements:

a) Roadways greater than 35 MPH = 30 feet per inch of vertical change (thickness)
b) Roadways 35 MPH or less = 15 feet per inch of vertical change (thickness).
c) Bridge Overpass and underpass transition length will be 75 feet either
   (1) Before and after the bridge expansion joint, or
   (2) Before or after the parapet face of the overpass.

Any temporary transition to be in-place over the winter shutdown period, holidays, or during extended periods of inactivity (more than 7 calendar days) shall conform to the “Permanent Transition” requirements shown above.
2-625 Permanent Transitions at Structures

Overlays must be transitioned on either side of structures. The lower lift(s) are uniformly tapered for a minimum of 150 feet on each approach to the structure. The top course is carried over the deck at the same time the course is placed on the roadway.

2-626 Temporary Transitions

When traffic must be carried over the pavement, it is necessary to form a temporary transverse joint at shutdowns and at the end of a day's work. The joint is constructed as shown in the series of drawings in Figure 2-6.21. A temporary transition is defined as a transition that does not remain a permanent part of the work. All temporary transitions shall meet the following length requirements:

a) Roadways greater than 35 MPH
   (1) Leading Transitions = 15 feet per inch of vertical change (thickness)
   (2) Trailing Transitions = 6 feet per inch of vertical change (thickness)

b) Roadways 35 MPH or less
   (1) Leading and Trailing = 4 feet per inch of vertical change (thickness)

To reduce cold joints to a minimum, the day's run of all passes shall end at the same station.

When paving is resumed, the wedge and paper are removed to provide an exposed mat that is full-depth and at the proper grade for continuing the lay. The screed is blocked up with starting blocks as shown in Figure 2-6.22. The paver should be positioned with the front of the preheated screed over the joint line. After the hot mixture is conveyed into place, sufficient time to reheat the joint should be allowed before moving the paver forward. The paver should be advanced enough to allow the workmen to perform the necessary hand work. Use the straightedge to check the joint to ensure the proper grade before permitting the roller on the surface.
Figure 2-6.21 Construction of a Day Joint
All cold joints are to be painted with liquid bitumen (tack coat) and fresh mixture rolled firmly against the joint face.

The following rolling procedures are suggested for the two transverse joint situations normally encountered.

- *Without an Abutting Lane:* A Single lane being paved, or the start of a paving operation beginning at the transverse face of an existing pavement. Abutting lanes not yet paved.

  The screed unit and hopper box of the paving machine are placed on the existing pavement. Spreading by machine commences slightly before the end of the existing pavement. Hand grading the starting edge is always required. Hand grading segregates the material, and all large aggregate should be pulled off the mat. Adding or removing materials, grading, smoothing and shaping the surface and edges must be diligently done. The surface of the spread material should be slightly higher than the proposed or existing pavement grades. As a general rule, a ¼ inch per inch of compacted thickness should be added to allow for compaction of the lift. Adjust as necessary to achieve proper thickness after compaction. Check the joint with a straightedge before and after rolling.

  Ideally, a transverse joint should be compacted transversely. The rolling equipment should operate across the width of the lane instead of longitudinally down the lane. Rolling should commence by pinching the struck edge. The roller is positioned on the existing pavement such that only 6 in. (150 mm) of the roller width will compact the material. Boards, long enough to allow the roller to move completely off the mix on both sides of the pavement, should be placed along the edge of the lane to prevent it from being rolled down. Successive passes should gradually provide for coverage by the full width of the roller drum. If the roller cannot compact the joint in the transverse direction because of site restrictions, the joint will have to be rolled in the longitudinal direction.

  When the transverse rolling is completed, longitudinal rolling of the joint can commence, starting at the lower edge of the lane. Following the breakdown rolling, the pavement surface across the joint should be checked with an approved straightedge and string lines. All inadequacies must be corrected and rolled, and the surface rechecked. When the pavement surfaces adjacent to the joint have been satisfactorily graded and compacted, rolling of the lane can commence.

- *With an Abutting Lane:* Lane being paved abuts a paved lane. Setting the paver and starting the spreading operation, including shaping and grading the material is the same as for the first situation described above.

  The first pass of the roller should be along the longitudinal joint for about 6 in. (150 mm) of the fresh material. Following the breakdown rolling, the pavement surface across the joint should be checked with an approved straightedge and string lines. All inadequacies must be corrected, rolled, and surface-checked again. When the pavement surfaces adjacent to the joint have been satisfactorily graded and compacted, rolling of the lane can commence as described in the section, “Paving Adjacent Lanes” below.
2-627 *Longitudinal Joints*

Longitudinal joints of different lifts or courses should never be constructed directly one upon the other. The longitudinal joint for the first or intermediate lift should be offset 6 to 12 in. (150 to 300 mm) from the exact centerline or lane line. The joint in the top lift should be on the exact centerline or lane line. The joint should never be located under the pavement markings; ideally it should be off-set approximately 6 inches. The Inspector and the Contractor should decide before paving is begun what the width of each lane for both the base and surface courses should be to provide the overlap between lanes. For each of the lifts placed, an offset line to the edge of the lift should be carefully staked. Paving machines are equipped with a guide bar which is lined up with this offset line, and the machine is held to this line as it proceeds.

To summarize the construction of good longitudinal joints, the following points should be emphasized:

- No joint should be over the joint in the underlying lift or course. Keep them staggered approximately 6 in. (150 mm).
- Keep the joints straight. It is impossible to get a satisfactory joint if the machine zigzags or wanders back and forth across the desired line.
- Maintain near vertical faces on all lane edges.
- Keep the joints clean and free of loose particles of material.
- Overlap the screed onto the previously laid mix enough to ensure that the lane being laid is snug against the other. If this is not done, furrows will eventually develop after traffic has been using the road for a while.
- When laying the lift adjacent to a previously compacted lane, allow sufficient thickness for compaction. Normally, the approximate excess thickness should be ¼ inch per inch of compacted thickness. For example, if the designed compacted lift thickness is 2 inches, the uncompacted lift thickness should be 2 ½ inches. If too much material is left, a ridge will develop along the line of the joint. Too little material could leave a rut or make achieving specified density impossible.
- Roll the joint as soon as possible.
- Treat the vertical face with a tack coat if it has been left long enough to cool and dry out, or if specified, use heaters.

To obtain tight and well-compacted longitudinal joints, the sequence of HMA placement operations for all courses is subject to the control of the Engineer. When two paving machines are available, practically all of the troubles arising at longitudinal joints can be eliminated by laying hot joints. This can be done by keeping one machine a short distance behind the other so that the adjacent lanes are rolled simultaneously while the material in both lanes is still hot.

2-627A *Notched Wedge Joint*

When using the Notched Wedge Joint method, the equipment and methods must first be approved by the Engineer. The Notched Wedge Joint must conform to figure 2-6.23.
2-628 Paving Adjacent Lanes

Unless otherwise specified or agreed upon, the HMA should be spread one-half width for the length decided on by conference with the Contractor. This distance will be governed by the rate at which the material cools. The initial side paved must not cool off to the extent that a line of demarcation occurs. This may be broken into four opposite sides per eight-hour day or approximately two hours for each line or lane, as directed by the Paving Inspector. For single-course construction, the inside edge of the first lane paved must be placed on the exact centerline, to give positive width and location control.

To establish a true centerline, a line is marked or a string line tacked onto the base course at a convenient offset and parallel to the exact centerline. The inner edge of the first lane should be squared up on the exact centerline using the offset line as a guide.

With this method, the first lane should be true to line and grade and have a near vertical face at the joint. (Before starting the second lane, the string line or mark should be transferred to the surface of the first lane and offset about 2 in. (50 mm) from the true centerline as a guide for the second lane.) The material being placed in the second lane is then slightly crowded against the face of the previously placed lane. The paver should be positioned so that, in spreading, the material overlaps the edge of the previous lane by no more than 1 in. (25 mm) and should have enough excess material thickness to allow for compaction. Generally, the excess material thickness should be a ¼ in. per inch of designed compacted mat thickness. No raking or luting of the joint overlap material should occur. Only the occasional ‘bumping’ back of excess or misplaced material should take place.

2-629 Surface Tolerance

The pavement surface of any lift shall meet the following requirements for smoothness and uniformity. Any irregularity of the surface exceeding these requirements shall be corrected by the Contractor.

- Smoothness- Each lift of the surface course shall not vary more than ¼ inch from a Contractor-supplied 10 foot straightedge. For all other lifts of HMA, the tolerance shall be ⅜ inch. Such tolerance will apply to all paved areas.

- Uniformity- The paved surface shall not exhibit segregation, rutting, cracking, disintegration, flushing or vary in composition as determined by the Engineer.
Irregularities exceeding the limits above must be corrected. Corrective work usually involves loosening the surface with a rake, adding additional material, grading, rolling and rechecking with a straightedge. Surfaces that look coarse can be improved at this time by the careful addition and grading of select fine material.

Portions of completed pavements that are defective in the surface tolerance, composition or compaction should be removed and replaced or overlaid with additional material, as required.

### 2-630 Pavement Smoothness (Rideability) Adjustment Overview

A limited number of contracts will contain the item and special provision for Rideability. A complete review of the special provision is advised.

The smoothness adjustment rewards smooth pavements and penalizes rough pavements. Each tenth mile section of the road is measured by the ConnDOT ARAN van and is processed by ProVAL software to determine its International Roughness Index (IRI). IRIs below 60 inches per mile result in bonuses and IRIs above 80 inches per mile result in penalties.

The smoothness adjustment applies to the surface lift of main travel lanes, climbing lanes, operational lanes, acceleration lanes, deceleration lanes, and turning roadways that are at least 0.4 miles (2,112 feet) in length.

It **does not apply** to sections shorter than this or to:

- ramps
- shoulders
- gore areas
- pavement on horizontal curves which have a 900 foot or less centerline radius of curvature
- pavement within the superelevation transition of these curves

Bridge decks shall be included if they are paved as part of the project and have an asphaltic plug or similar product for the bridge joints. Structures with exposed concrete, elastomeric concrete or steel joint systems shall be excluded.

Before the surface lift is paved, ConnDOT will make a test run of the IRI and provide this information to the Contractor. This helps the Contractor identify any problem areas so he can address them before paving the surface lift. Within 30 days of paving the surface lift ConnDOT will measure the IRI to determine smoothness. The Chief Inspector requests the ARAN van to measure the smoothness, by sending an email to dot.MatTesting@ct.gov , with a Subject of “ARAN/Photolog Van Request”. This request should include the CORE-CT Project code and be made 72 hours before the ARAN van is needed.

Work should be organized to minimize the number of times the ARAN van is needed. The “trial” evaluation shall be limited to one (1) test lane in each direction. Typically, the ARAN van should be called only twice per project - once for testing before the surface lift and once for after the surface lift has been constructed. Final evaluations for payment shall measure all lanes of interest in each direction of travel.

It is generally expected that all paving of the lift under the surface lift in both directions of travel will be completed before calling the ARAN van. Likewise, work should be organized so that the ARAN van is called only once for the surface lift. Exceptions may be made for limited access highways and unusual circumstances, such as paving that extends beyond one paving season. The special provision states that the contractor is responsible for ensuring that the pavement is clean and dry when the IRI measurements are performed.

The IRI results will be provided to the Chief Inspector with guidance how to apply the item payment or deduction.
2-631 Semi-final and Final Pavement Inspections

Semi-final pavement inspections and final pavement evaluations are required on all projects that have 2,500 tons or more of final course, which include final courses made up of multiple lifts of the same HMA material. These inspections can, however, be performed on any project the District deems appropriate. The Pavement Advisory Team (PAT) will perform the semi-final pavement inspections and final pavement evaluations with the assistance of the Project Engineer and/or the Chief inspector.

All required corrections are the contractor's responsibility, and no payment should be made for the material, labor and equipment used.

See Figure 2-6.25 for sample Final Pavement Evaluation Report

2-631A Opening to Traffic

Traffic is not permitted on the newly laid pavement until the material has cooled and hardened to the satisfaction of the Paving Inspector. Flushing with water to hasten the cooling is prohibited. Vertical pavement edges must be protected to prevent damage before opening the roadway to traffic.

2-632 Records

2-632A Form MAT-100

A MAT-100 must be prepared for each production day to provide testing coverage for HMA material placed. These forms are a permanent part of the field and laboratory records, and therefore must be kept current, accurate and neat. Refer to Volume 1, Chapter 4 – Materials Testing.

The MAT-100 is completed by the Inspector at the end of production for that day. A hard copy is sent to the Department’s Material Testing Laboratory. Where there are multiple vendors on a project within a production day, separate MAT-100’s must be prepared.

2-632B Weekly HMA Production Report

Each District should forward to the Department’s Material Testing Laboratory a weekly HMA Production Report showing HMA material placed on District administered contracts. Form 2-6.26 is a sample Weekly HMA Production Report.

2-632C Inspectors’ Reports

The Paving Inspector must keep accurate records of the stations worked, locations, areas covered in square yards and tons used, and record all batches condemned or wasted with an explanation for the reason for rejection. The information will be included on the Base & Bituminous Concrete Inspection Report (Form CON-136). A sample Base & Bituminous Concrete Inspection Report (Form CON-136) is shown in Form 2-6.27. A Form CON-136 must be completed for every day that paving is performed.

Items to be recorded on Form CON-136 include:

- The project number,
- Weather and temperature readings,
• The item number and class of paving,
• The location of the paving and quantities placed,
• Width and depth checks,
• Any loads rejected and the reasons for rejection,
• The hours worked by the contractor,
• The work force and equipment assigned by the contractor, and
• The inspection personnel assigned.

Thickness checks and yield computations should appear on the Form CON-136, and any significant discrepancy should be explained (i.e. Contractor paved too wide, etc.).

Information for depth checks shown on the Form CON-136 includes:
• The station and offset where the check was made, and
• The depth of each course at that location.

Sample Recording:

<table>
<thead>
<tr>
<th>Station</th>
<th>Offset</th>
<th>Course #1</th>
<th>Course #2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 + 00.00</td>
<td>7.9 ft. Rt.</td>
<td>1-5/8 in. (41.3 mm)</td>
<td>1-1/2 in. (18.2 mm)</td>
<td>3-1/8 in. (79.4 mm)</td>
</tr>
</tbody>
</table>

**2-632D Weigh Tickets**

As previously noted Paving Inspectors are personally responsible for collecting the weigh tickets and signing each ticket as the load is dumped. Project supervisors should check daily to ensure compliance with this directive.

Weigh tickets should be checked for adequate information. The minimum information that should be shown on a weigh ticket includes:
• State of Connecticut printed on ticket
• Name of producer, identification of plant and specific storage bin (silo) if used
• Date and time of day
• Mixture Designation (If RAP is used, the plant printouts shall include RAP dry weight, percentage and daily moisture content.) Class 3 mixtures for machine-placed curbing must state "curb mix only".
• Net weight of material loaded into truck (When RAP is used, RAP moisture shall be excluded from mixture net weight).
• Gross weight (Either equal to the net weight plus the tare weight or the loaded scale weight).
• Tare weight of truck- daily scale weight.
• Project number, purchase order number, name of contractor (if name of contractor other than producer)
Truck number for specific identification of truck

Individual aggregate, RAP, and virgin asphalt high/target/low weights shall be printed on batch plant tickets
(For drum plants and silo loadings, the plant printouts shall be printed out at 5 minute intervals maintained by the vendor for a period of three years after the completion of the project).

The net weight of mixture loaded into the truck must be equal to the cumulative measured weight of its components. In addition, any deficiencies or special conditions should be noted on the ticket.

The Inspector should make the following checks:

- Where computerized weigh tickets are provided for the delivery of HMA, verify at least twice a day the accuracy of the individual batch weights that comprise the total. Add the weights of the aggregate and check the total weight on the ticket. Any discrepancies on individual tickets should be reported immediately to the Department’s Material Testing Laboratory.

- Truck weigh tickets should include gross, tare and net weights. Mathematically check the net weight several times each day.

- Note on the ticket when a mathematical check is made and the results of the check.

- If inconsistencies are found on any ticket, all tickets for the day must be mathematically checked.

Temperatures of the mix are to be recorded, with the time taken, on both the weigh tickets and DWRs.

For partially used loads, document how the amount used was determined (measurements), where the remainder went, and the use for the remainder. This information should appear on both the DWR and batch/weigh ticket.

If any HMA is used for an unusual purpose, document the purpose it was used for, reason for use and how the material was paid for. Again, information should appear on both the DWR and batch ticket.

2-632E HMA Density Reporting Procedure

1. **State personnel density test reports:**

   - Scan daily QA test report(s) for each lot at the project’s field office the same day/night tests taken so that the Chief Inspector (C.I.) has a copy, when possible.
   - If daily QA test report(s) is processed at the District, the staff responsible shall scan report the following morning and e-mail it to the C.I. of the project. The C.I. should place a printed copy of the report (or summary sheet of the average test results) in a folder accessible to the Contractor for their information.
   - The density technician (or District staff responsible) shall enter average density for the mat and joint of each lot into Pavetrack the same day/night or at the latest the following morning. There is no need to wait for the actual production test results because the average density will be automatically adjusted when the DMT enters those results.

2. **Consultant personnel density reports:**

   - Make a printed copy of the daily QA test report (or summary sheet of the average test results) and place into a folder accessible to the Contractor for their information.
   - The density technician shall enter the average density for the mat and joint of each lot into Pavetrack the same day/night or at the latest the following morning.

**Note:** the QA test report, whether scanned the same day/night or e-mailed the following day shall be for “informational purposes only” as the results may be adjusted based on the actual production test results (Gmm) from the DMT.
3. **State and Consultant Technicians:**

- When performing QA density testing, the technician must announce their arrival to the Contractor QC representative or paving foreman. This shall be done for safety reasons. Likewise, it must be announced when they have completed their testing or are leaving the work zone.

### 2-633 Test Frequencies

Refer to the section “Minimum Testing Requirements—Acceptance and Assurance” in the “Schedule of Minimum Requirements for Sampling Materials for Test” for the minimum requirements for acceptance and assurance samples. Sampling and testing for bituminous concrete must be in accordance with those requirements.

If the frequency of assurance tests is found to be insufficient during periodic analyses of projects, it is to be addressed in the preliminary reports and, if not resolved during the project, the final Materials Certificate would list that item as an exception.

### 2-634 District Monitoring

All projects involving bituminous concrete pavement are monitored by District Record Examiners for compliance with the specifications and policies concerning receipt of and payment for bituminous items.

### 2-635 Legal Load Limits and Oversize/Overweight Permit Regulations

Inspectors must be aware of the contract requirements concerning load restrictions, legal weight limits for vehicles, and oversize/overweight permit regulations. Refer to the various published documents pertaining to load restrictions that apply to construction vehicles.

If an adjustment is required use the Adjustment Schedule for Bituminous Concrete form, see Section 2-636.

### 2-636 Asphalt (HMA) Adjustment Procedures

There are several different types of adjustments that may have to be made for HMA items that have been placed on a project.

Some of the adjustments cannot be made by using original contract items. Depending on the Special Provision date, the adjustments shall be calculated in the following ways:

#### 2-636A Asphalt (HMA) Adjustment Procedures for Provisions dated before 1/13/09

Within Site Manager, three adjustment items have been added at the project line item level under Category 01 to standardize the way the adjustments are made. When the inspector determines that an HMA adjustment is required, a DWR must be created identifying the appropriate HMA Adjustment Item.

It is important that the DWR documents why the adjustment applies, date(s) the adjustment is for, how it was calculated, and any associated references to the Project’s Volume 3.

**Adjustment Items:**

1. **HMA Material Deficiency Adjustment**, unit = Est., price = $1.00. This adjustment is monetary and is always a negative value. Item Code will be HMAM001, Line Item 5005
2. **HMA Density Adjustment**, unit = Est., price = $1.00. This adjustment is monetary and can be either a positive or a negative value. Item Code will be HMAD001, Line Item 5006
3. **Rideability Adjustment**, unit = Est., price = $1.00. This adjustment typically occurs only once during the project. However, some larger projects that are staged may require multiple adjustments throughout the course of the project life. This adjustment is monetary and can either be a positive or a negative value. Item Code will be HMAR001, Line item 5007.

A sample form for all asphalt adjustments along with a directions page is shown in Form 2-6.28.

### 2-636A.1 HMA Overweight Adjustment (tons)

Net weight adjustment will be made when a truck delivers material to the project and the truck exceeds the allowable gross weight for that vehicle type. The quantity of overage, in tons, will be deducted from the total delivered tons measured for payment. This adjustment may be applied even after the material has been incorporated into the project. See Form 2-6.28, Adjustment Schedule Form.

### 2-636A.2 HMA Material Deficiency Adjustment (dollars)

Ten percent of the total quantity of material that exceeds one or more of the mix tolerances will be used to determine the Material Deficiency Adjustment. The job mix formula adjustment tolerances can be found in Table 3 (Job Mix Formula Tolerances for Consecutive Tests) in Subsection 4.06.04 of the Standard Specifications, Form 816. See Form 2-6.28, Adjustment Schedule Form.

### 2-636A.3 HMA Density Adjustment (dollars)

The average of theoretical maximum specific gravity calculations for the material placed in a continuous paving operation will be used to establish the average percent density. (The paving of bridges will be treated as a separate continuous paving operation per bridge.) This average percent density will then be used for any adjustment according to Table 6 in Subsection 4.06.04 of the Standard Specifications, Form 816. See Form 2-6.28, Adjustment Schedule Form.

### 2-636A.4 Measured Weight Adjustment (tons)

The material in all courses of HMA, except lifts of designed non-uniform thickness, i.e. wedge or shim course will be subject to adjustment for thickness and width. The averages of the thicknesses or widths of each lift will be determined by measurements taken by the Engineer. When the total thickness or width exceeds the theoretical yield, an adjustment will be applied to the installed HMA pavement. When a deficiency in thickness or width is found, with the approval of the Engineer, the Contractor shall take corrective action. Areas that are corrected will be measured as though originally constructed. No payment will be made for material removed and disposed of, or for the restoration of affected base or adjusted construction, for the purpose of corrective work. See Form 2-6.28, Adjustment Schedule Form.

### 2-636A.5 Liquid Asphalt Adjustment (dollars)

This adjustment is associated with the price of performance-graded binder component of HMA mixtures. The asphalt price adjustment will only be applied to HMA mixtures such as Class 1, 2 and 4, Superpave 0.375 in. (9.5mm), 0.5 in. (12.5mm) and 1.5 in. (37.5mm). The adjustment will be applied on a monthly or semi-monthly basis in accordance with the payment estimate schedule of the HMA pay items. Asphalt adjustment will be made upward or downward only when the asphalt period price varies more than $5.00 from the asphalt base price. The Connecticut Department of Transportation will provide the Asphalt Price of the performance-graded binder. See Figure 2-6.30, Liquid Asphalt Adjustment Form.
2-636B HMA Adjustment Procedures for Special Provisions dated 1/13/09 or Later

2-636B.1 HMA Overweight Adjustment (tons)

Net weight adjustment will be made when a truck delivers material to the project and the truck exceeds the allowable gross weight for that vehicle type. The quantity of overage, in tons, will be deducted from the total delivered tons measured for payment. This adjustment may be applied even after the material has been incorporated into the project. See Form 2-6.28, Adjustment Schedule Form.

\[
\text{Tons Adjusted for Weight (T}_W\text{)} = \text{GVW} – \text{DGW} = (-) \text{Tons}
\]

Where: DGW = Delivered gross weight as shown on the delivery ticket or measured on a certified scale.

2-636B.2 HMA Material Deficiency Adjustment (dollars)

Ten percent of the total quantity of material that exceeds one or more of the mix tolerances will be used to determine the Material Deficiency Adjustment. The job mix formula adjustment tolerances can be found on Table 3, 3A and 3B (Job Mix Formula Tolerances for Consecutive Tests) in Subsection 4.06.04 of the Standard Specifications, Form 816. See Figure 2-6.28, Adjustment Schedule Form.

\[
\text{Tons Adjusted for Marshall Design (T}_{MD}\text{)} = M \times 0.10
\]

Where: M= Tons of bituminous concrete mixture exceeding tolerances in Table 3

\[
\text{Tons Adjusted for Superpave Design (T}_{SD}\text{)} = (AV_a + AP_b) \times \text{Tons}
\]

\[
\text{Adjustment for Air Void} = AV_a = [(Va_1 + Va_2 + Va_3 + \ldots + Va_n)] / n
\]

Where: \(Va_1\) = Total air void adjustment value for the lot
\(Va_2\) = Adjustment value from Table 3A resulting from each sub lot
\(n\) = number of air void tests in a production lot

\[
\text{Adjustment for Liquid Binder} = AP_b = [(AP_{b1} + AP_{b2} + AP_{b3} + \ldots + AP_{bn})] / n
\]

Where: \(AP_{b1}\) = Total liquid binder adjustment value for the lot
\(AP_{b2}\) = Adjustment value from Table 3B resulting from each sub lot
\(n\) = number of binder tests in a production lot

2-636B.3 HMA Density Adjustment (dollars)

The average of theoretical maximum specific gravity calculations for the material placed in a continuous paving operation will be used to establish the average percent density. (The paving of bridges will be treated as a separate continuous paving operation per bridge.) This average percent density will then be used for any adjustment according to Table 4 (Adjustment Values for Pavement Density) in Subsection 4.06.04 of the Standard Specifications, Form 816. See Figure 2-6.28, Adjustment Schedule Form.

\[
\text{Tons Adjusted for Density (T}_D\text{)} = \{[PA_M \times .40] + [PA_J \times .60]\} \times \text{Tons accepted}
\]

Where: \(T_D\) = Total tons adjusted for density for each lot
\(PA_M\) = Mat density percent adjustment from Table 4
\(PA_J\) = Joint density percent adjustment from Table 4
2-636B.4 Measured Area and Thickness Adjustment (tons)

The material in all courses of HMA, except lifts of designed non-uniform thickness, i.e. wedge or shim course will be subject to adjustment for thickness and width. The averages of the thicknesses or widths of each lift will be determined by measurements taken by the Engineer. When the total thickness or width exceeds the theoretical yield, an adjustment will be applied to the installed HMA pavement. When a deficiency in thickness or width is found, with the approval of the Engineer, the Contractor shall take corrective action. Areas that are corrected will be measured as though originally constructed. No payment will be made for material removed and disposed of, or for the restoration of affected base or adjusted construction, for the purpose of corrective work. See Figure 2-6.28, Adjustment Schedule Form.

\[
\text{Tons Adjusted for Area (T_A)} = \left( \frac{L \times W_{adj}}{9} \right) \times (t) \times 0.0575 \text{Tons/SY/inch} = (-) \text{Tons}
\]

Where:  
- \( L \) = Length (ft)  
- \((t)\) = Actual thickness (inches)  
- \( W_{adj} \) = (Designed width (ft) + tolerance /12) - Measured Width

\[
\text{Tons Adjusted for Thickness (T_T)} = A \times t_{adj} \times 0.0575 = (-) \text{Tons}
\]

Where:  
- \( A \) = Area = \( \left\{ \frac{L \times (\text{Designed width + tolerance (lift thickness)/12})}{9} \right\} \)
- \( t_{adj} \) = Adjusted thickness = \( \left( \frac{Dt + \text{tolerance}}{\text{Actual thickness}} \right) \)
- \( Dt \) = Designed thickness (inches)

2-636B.5 Asphalt Adjustment Cost (dollars)

This adjustment is associated with the price of performance-graded binder component of HMA mixtures. The asphalt price adjustment will only be applied to HMA mixtures such as Class 1, 2 and 4, HMA S0.25, HMA S0.375, HMA S0.5 and HMA S1. The adjustment will be applied to the material on the period on which it was placed in accordance with the payment schedule of the HMA pay items. Asphalt adjustment will be made upward or downward only when the asphalt period price varies more than $5.00 from the asphalt base price. The Connecticut Department of Transportation will provide the Asphalt Price of the performance-graded binder. See Figure 2-6.30, Liquid Asphalt Adjustment Form.

2-636C Rideability Adjustment (dollars)

The rideability of the section of roadway will be taken after all the paving has been completed. This will produce a figure that will be used only once to adjust the payment for the complete roadway. See 2-630 for more information.

2-637 Pavement Rehabilitation

2-637A General

Pavement rehabilitation projects may involve drainage improvements, excavation or borrow material, sedimentation control, traffic control, or upgrading of guardrail and other safety devices. Work involved on rehabilitation projects must be of the same quality as new construction. Refer to the appropriate section in this Construction Manual for inspection guidelines for the item being inspected.

2-637B Inspection of Work Site Before Work Commences

Rehabilitation projects are often in built-up areas. Changes or improvements, such as buildings on adjacent properties, additional driveways, utility installations, and maintenance projects, completed since the original work was constructed, may not show on the plans. The designers may not have had time to check existing topography and site conditions while designing the rehabilitation project. Therefore, the Chief Inspector and project inspectors must anticipate these problems through pre-inspection to prevent conflicts during rehabilitation.
The following items should be completed before construction begins:

- Measuring of removal items before work commences is very important. Measure all removal items, guide rails, catch basin tops, HMA, granite or concrete curb, and the like, and record the measurements in the Volume III book for future payment on the Inspector's DWR.

- The pavement type and the extent of deterioration should be noted and the type of restoration agreed upon between the Chief Inspector and Contractor. Elevations may have to be taken for drainage or rideability purposes. Check for humps, dips and correct cross slope with string line or Locke level shots to determine if leveling courses will be necessary before beginning the main paving.

- Original ledge and earth sections should be checked and verified in the field and on the cross sections for correctness. It may also be necessary to take additional intermediate cross sections where the plan sections do not show actual field conditions.

- Check the elevations and condition of catch basin tops, manhole frames, and water and gas main gates to determine if they can be raised or must be reconstructed. Drainage structures may also have to be extended or rebuilt.

- Check for overhead clearances of utility lines, traffic and illumination lights, bridges, and signing structures. Allow for the increased elevation of the roadway due to any leveling and the overlay in determining if there will be insufficient clearance when the project is completed.

- Check for fixed objects versus the deflection rate for new guide rail. The railing may have to be beefed up or the type of rail changed. For example, a utility pole or other fixed object may be so close to the guide rail that the rail would deflect enough under impact for a vehicle to hit the pole.

- A tree meeting must be held at the project site, to review any tree removal and site clearing of vegetation. Make sure to invite Department project personnel, the designer (either Department or consultant), a roadside development representative, the Town or City Tree Warden and/or other municipal representative, a representative from the Department of Maintenance, and the District Construction Environmental Coordinator. Trees to be removed must be flagged for a minimum of five days before removal.

- The Contractor is required to submit a sedimentation and erosion control plan for the Engineer's approval. This plan must show the type of erosion control and proposed location of each item, as well as a maintenance schedule. Although placement of controls is depicted on plan sheets, adjustment may be needed to meet actual field conditions.

- After approval of the plan, installation of the controls will be done prior to any construction activities that will cause a disturbance of the surface and possible erosion problems.

- The profiles of the approaches to bridges must be checked for rideability and proper transitions. Overlaying the bridge may not be done in conjunction with the roadway overlay project. When bridge decks are not paved, milling the approaches is necessary to provide proper rideability. If the bridge and the approaches are on a vertical curve, milling for a greater distance from the bridge may be necessary to provide good rideability.

- Pedestrian and vehicle traffic normally must be carried through rehabilitation project work zones. The Inspector and Contractor should follow the traffic controls in the plans.
2-637C Inspection of HMA Prior to Overlay

The existing pavement must be repaired before a HMA overlay can be placed.

2-637D Repairs to Existing Bituminous Pavement

Defects in bituminous pavements that require repairs prior to overlaying include:

- Cracks,
- Alligator cracking,
- Potholes,
- Sags, dips, traffic ruts, and
- Bumps.

The methods of repairing these are detailed below.

2-637D.1 Crack Sealing

Any areas that will be milled should be delineated so these areas will not be crack sealed, as this would be a waste of time and money. Cracks are first cleaned of dirt, vegetation, and the like with compressed air. Only joints and cracks greater than \(\frac{1}{8}\) in. (3 mm) wide are cleaned and sealed. Where possible, fill the cracks with paper rope to a level of 1 in. below the riding surface. Place the joint-seal material through a nozzle. The level of the sealer should not be greater than \(\frac{1}{8}\) in. (3 mm) below the pavement surface.

Cracks over 1 in. (25 mm) wide are repaired using HMA S0.25, compacted into the crack.

2-637D.2 Alligator Cracking Pavement Repairs

Where the pavement has an area in which cracks are too numerous (alligator cracking) to repair, a thin overlay of HMA S0.25 will be necessary. These areas are usually in shoulder areas where the existing pavement thickness is thinner than the travel lanes. Truck climbing lanes are also susceptible to this.

2-637D.3 Pothole Repairs

Repairs to potholes, utility crossings or any depressions should be made at this time. Use a tack coat on all surfaces of the existing pavement to be repaired before placing the repair material.

2-637D.4 Leveling

After crack sealing repairs are made, check the existing pavement for depressions, rises or bumps that may require corrective work. Depressions may require leveling courses and rises or bumps may require milling to achieve a smooth and uniform pavement surface.

The self-leveling capability of paving machines does not eliminate the need for quality grading and preparation of the surface prior to placing the HMA.
Locating areas to be shimmed or milled requires some experience. First, visually check the pavement for areas where shims may be needed. Then utilize hand (Locke) levels, straightedges, rulers, and string lines to determine the type of repair needed—shimming or milling. Checking the existing pavement surface after a rain will make depressions that require corrective leveling easier to spot. The limits of these repair areas should be delineated with paint or keel and be noted on the IR with the depth and HMA mix to be used in the repair.

Depending on the depth of the shim courses, different HMA mixes may be utilized. Base, intermediate or surface material may be used for leveling. Agreements on the HMA mix to be used should be made beforehand between the Paving Inspector and the Contractor. A tack coat must be used prior to leveling.

When the surface of an existing pavement or old base is irregular, it must be brought to a uniform grade and cross section. A leveling course is used when the road surface is so irregular that it cannot be corrected with the normal leveling capabilities of the paver. Leveling wedges of HMA mix are used to level sags and depressions in an old pavement prior to the surface course paving operation. Leveling and wedging are normally used to correct short profile and cross section problems. They may also be used to change the profile of a roadway or cover a milled surface.

Leveling and wedging material must be placed in lifts to ensure compaction. The top of each lift should be parallel to the desired profile or cross section as shown in the top drawing in Figure 2-6.29. Determine the number and lengths of lifts by the allowable lift thickness and the depth of the area to be leveled. To prevent the edges of each leveling pass from reflecting through to the finished surface, it is very important to properly lute (or feather) the ends of each pass. Large aggregate should be removed and discarded.

Wedges are also used to reestablish crown on a tangent roadway or superelevation on a curve, as shown in the bottom drawing of Figure 2-6.29. The number of wedge courses necessary to rebuild the crown or superelevation depends on the total depth to be placed and the maximum aggregate size of the mix. As a rule of thumb, the minimum lift to be placed is four times the nominal maximum aggregate size of the mix. The nominal maximum aggregate size of a mix is in the mix designation. For example, HMA S0.5 level 3 has a nominal maximum aggregate size of ½ inch or 0.5 inches.
Figure 2-6.29 Leveling and Wedging Examples

Correct Leveling

LIMITS OF FIRST PASS

LIMITS OF SECOND PASS

LIMITS OF THIRD PASS

Incorrect Leveling

Correct Wedging
2-637D.5 Milling (Cold Plane Pavement Removal)

Cold plane pavement removal of HMA is the operation of removing an HMA overlay from a roadway surface or a structure to prepare it for a new surface treatment. This surface treatment is most likely an HMA overlay.

Contractors shall use self-propelled planning machines capable of loosening pavement material, accurately establishing profile grades within a tolerance of a ¼ inch. These machines shall have a positive means for controlling cross-slope elevations in order to allow placement of the overlay pavement to a uniform thickness. Bridges and other structures may require alternate methods of surface removal, it is recommended to remove HMA overlays from bridge decks by using fine milling equipment capable of uniformly removing the existing surface to depths required. This should be performed after a pre-survey of the overlay thickness has been determined. A pre-survey will limit damage to the bridge deck surface should a cold plane milling machine be used for overlay removal.

Always check contract plans and specifications to review any weight limits for the structures in question. When in doubt, contact the designer of record for clarification. The designer may want to review the catalog cut sheet for the equipment in question.

In response to the availability of different milling items the below delineate specialized milling practices with the intention of designating appropriate milling surfaces prior to resurfacing. It is recommended inspectors review plans against field conditions to assure the proper milling types are utilized.

**MILLING OF HOT MIX ASPHALT (HMA) – (0- 4 INCHES) (0 TO 100 MM)**

**MILLING OF HOT MIX ASPHALT (HMA) – (OVER 4 TO 8 INCHES) (OVER 100 MM TO 200 MM)**

**MILLING OF HOT MIX ASPHALT (HMA) – (GREATER THAN 8 INCHES) (GREATER THAN 200 MM)**

Milling should only be used for the following conditions where an overlay of 2 inch (50mm) or more of HMA overlay is proposed:

- Adjust cross slopes to improved storm event runoff
- To completely remove HMA over Portland Concrete Pavement
- Removal of HMA in excess of 4 inch depth

**FINE MILLING (0 TO 4 INCHES) (0 TO 100 MM)**

Fine milling should only be used for the following conditions where an overlay of 2 inch (50mm) or less of HMA overlay is proposed in order to limit the reflection of milled surface through the proposed overlay:

- To smooth heaved or rutted HMA (wash boarding)
- To plane off texture or seal coats
- The restoration of rideability to a roadway
- Adjust cross slopes to improved storm event runoff

**MICRO-MILLING (0 TO 2 INCHES) (0 TO 50 MM)**

Micro-milling should only be used for the following conditions, where an overlay is not anticipated:

- To smooth heaved or rutted HMA (wash boarding)
- To plane off texture or seal coats
- The restoration of rideability to a roadway
- Improvement of roadway friction coefficient

It is not the intention of this type of milling to be used for the complete removal of a HMA lift or course from a roadway or structure surface. Also, it is not recommended for HMA surface layer of less than 1.25 inch (32 mm) thick and for shoulders with an asphalt layer of 2 inches (50 mm) or less.
2-637E Repairs to Existing Concrete Pavements

Repairs to concrete pavements may be partial-depth patches or full-depth pavement replacement.

2-637E.1 Partial-Depth Patch Repairs

Partial-depth patch repairs are made with HMA. Only spalled areas in concrete pavements will be repaired. The area to be patched will be squared up by saw cutting to a depth of 1 in. (25 mm). The cuts will be made parallel and perpendicular to the direction of travel. The area within the saw cuts is then removed to solid concrete. Tack coat material must be brushed or sprayed into the patch area. HMA material is then compacted into the repair area. Delaminated areas are not repaired prior to overlays, so chain dragging, sounding, or any other means of detecting delaminated areas is not used.

Again, only visually spalled areas are to be repaired.

2-637E.1a Preparations

Before any existing concrete is removed, the Engineer will perform a visual inspection of the concrete pavement and designate areas where concrete removal is required. The Engineer will identify only the areas where surface distress is evident. Where several areas to be repaired are very close together, the Engineer may combine these individual patches into one large patch area. The minimum size area requiring preparatory work will be as specified in the contract documents. Smaller spalls are cleaned and filled with HMA S0.25.

The limits of each area to be repaired will be defined by the Engineer and suitably marked. All loose and severely deteriorated concrete must be removed within the limits designated by the Engineer. All materials will be satisfactorily disposed of by the Contractor.

The removal of deteriorated concrete will be accomplished by individual blunt-nosed pneumatic hammers, approved by the Engineer. Chisel-point pneumatic hammers are not permitted. The angle from the horizontal of the pneumatic hammers should not exceed 45 degrees. A chipping hammer may only be used for removing deteriorated concrete or existing poor-quality HMA patches. Pneumatic tools should not be placed in direct contact with reinforcing steel. Fillets at inside corners of intersecting limit lines must be carefully removed.

All deteriorated, loose or otherwise poor-quality concrete and HMA patch material must be removed. All exposed surfaces in the repair areas should be thoroughly cleaned of loose and foreign material by air blasting, water blasting, sandblasting, or other acceptable methods. All blasting operations should be performed using techniques approved by the Engineer. Blowing debris into the travel portion of the roadway is not permitted. The resulting surfaces should be free of loose particles, dust, oil, excess moisture, or any other substances. The Engineer will then visually inspect the hole to ensure that all of the loose or poor-quality materials have been removed. Any existing HMA patches that are in good condition should remain in place. Existing reinforcing steel that is damaged and/or corroded, or has insufficient cover, will be removed as directed by the Engineer. This steel will not be replaced.

Sound reinforcing steel, which is in the proper position in the slab, should be left in place. It must be cleaned of any dirt, oil, paint, grease and loose or thick rust before the area is patched.

2-637E.1b Tacking

A light overlapping spray of tack coat should be applied to the prepared area prior to placement of the HMA material. The tack coat should be placed in accordance with Article 4.06.03 of the Standard Specifications.
2-637E.1c Repairs

Prepared partial-depth areas should be filled and thoroughly compacted with HMA S0.25. HMA S0.25 should be placed in accordance with Section 4.06 of the Standard Specifications. The surface elevation of the HMA patch should be slightly higher than the surrounding concrete after compaction to allow for additional compaction under traffic.

In areas where joints or cracks require patching, the loose or deteriorated concrete or HMA should be removed as previously described and replaced with HMA S0.25. The remaining portion of the joint or crack should receive the following treatment:

- Thoroughly clean the crack, in conformance to Section 4.06 of the Standard Specifications.
- Place paper rope or backer rod in joints as specified in the contract documents.
- Any joint or crack with an opening 1 in. (25 mm) or greater should be filled and compacted with HMA S0.25 in accordance with Section M.04 of the Standard Specifications.
- Any joint or crack with an opening less than 1 in. (25 mm) should be filled with sealant material conforming to Section 4.06 of the Standard Specifications.

2-637E.2 Full-Depth Concrete Pavement Replacement

If, during the removal operation, the Engineer determines that the pavement has severely deteriorated or faulted to a point where full-depth repair is required, the specification entitled “Concrete Pavement Replacement for Roadway (Full Depth)” should be used. The Contractor may submit an alternate concrete removal method for approval by the Engineer. Milling the deteriorated surface in combination with pneumatic hammers is one such alternative. Carbide-tooth routing machines or diamond-blade grinders may be used.

Refer to the discussion and guidelines in Volume 2, Chapter 7 “Concrete Pavements.”

2-637E.2a Subbase and Subgrade Preparation

Preparation and repair of the subbase or subgrade is usually needed prior to full-depth concrete pavement replacement. Refer to Volume 2, Chapter 5 “Base Courses.”

2-637F HMA Overlay

When the surface of the existing pavement has been repaired and approved by the Engineer, the HMA overlay is placed. The HMA overlay is placed in accordance with Section 4.06 of the Standard Specifications. Refer to the section on HMA pavement beginning on Page 2-6.1 for the inspection procedures.

2-638 Bituminous Lip Curbing

2-638A General

The procedure for submittal of the mix formula for bituminous lip curbing by the Contractor or Producer and approval by the Department’s Material Testing Laboratory is the same as that for HMA pavement. Prior to the start of any curb work, the Paving Inspector should receive from the Laboratory an approved job mix formula for “Curb and Paved Ditch” construction.
Bituminous lip curbing should be machine-formed to the dimensions and shape indicated in the standard drawings. The Engineer may permit hand-laid curbing where machine work is impractical. Hand-laid curbing must conform to the same details as machine-formed curbing.

Before placing the curb, the pavement surface must be cleaned of all loose and foreign material. An offset string line should be established on the pavement at a distance from the face of curb recommended for the machine to be used. If it is necessary for the outside wheels to operate in the area behind the shoulder, the area is to be graded and compacted to a smooth surface. A light application of tack coat is to be applied to the pavement area under the curb base. Do not apply the tack material too wide or heavy since it may result in poor curb alignment or inadequate adhesion to the base.

Curbing should be installed as soon as possible after the roadway is overlayed to prevent the pavement being washed out during a rainstorm.

The curb should be backed up with borrow soon after the curb is placed. This borrow shoulder should be seeded as soon as possible to prevent erosion.

2-638B Machine Construction

The curbing machine should be inspected before the operation begins. Most lip curb machines consist of a hopper into which the mix is placed, a motorized worm gear or screw, and the curb mold form. The worm gear pushes the mixture out through the form under pressure. It is this pressure which provides the compaction required by the specifications. If the compaction is inadequate, the Inspector should check with the plant to determine that the mix is correct. The temperature of the mix should also be checked. A mix with a low temperature cannot be adequately compacted. If the temperature is too high, the curb may slough off during placing. The temperature specified on the design mix must be within the master range of 265 to 325 °F (129 to 163 °C). It may be possible to obtain additional compaction by placing additional weights on the machine, or holding back on the machine. Worn screws or dirty molds result in open-textured, scored curb surfaces. Bituminous lip curbing is subject to the same weather and temperature restrictions as HMA paving mixes. Each load of material should be checked several times while the material is being discharged.

The placing of the curbing should be as continuous as possible so as to avoid the need for curb joints. In forming joints, the contact surface of previously constructed curbs should be painted with a thin tack coat just prior to placing the fresh curb mix.

The machine should never be left running while waiting for the trucks. The vibrations from the machine can cause the curb already placed to slough and form a dip in the curb.

The alignment must be parallel to the edge of the pavement, and breaks in the alignment are not permitted. Care must be exercised when hand finishing at obstructions, such as catch basins, and also at the end of the curb, to see that the connection is smooth with good alignment and grade.

2-638C Hand Construction

If curbs are to be placed by hand, the curb mix must be placed immediately upon arrival, or it must be placed on platforms outside the area on which it is to be spread and then distributed into place. The mix should be shaped to the required cross section and compacted by iron tampers weighing not less than 12 lbs. (5 kg) and having a bearing area not exceeding 50 sq. in. (32,260 mm²).
2-638D Bituminous Concrete Driveway Aprons

Where the plans provide for bituminous driveway aprons with bituminous lip curbing, the lip curbing turn-ins should be paved first. This way when the driveway is paved, the roll of the driveway will meet the top of the curb as the design standards show.

The lip of the driveway at the gutter line should be as shown in the applicable standard detail.

2-638E Precautions

The surface of the curbing should be tested with a 10 ft. (3 m) straightedge laid parallel with the centerline of the road, and any variation exceeding ¼ in. (6 mm) will be corrected.

After completion of the curbing, traffic will be kept at a safe distance for a period of not less than 24 hours, and until the curbing has set sufficiently to prevent injury to the work.