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HIGHWAY TECHNICIAN PROGRAM  
TRAINING MANUAL

# Hot Mix Asphalt Paving



Revised 2013



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**This material is to be used for training purposes only. Some of the procedures, field tests, and other operating procedures as described within these pages may be different than actual on-site procedures. Therefore, application should not be made without consideration of specific circumstances and current INDOT standards and policies.**

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## Appendix A - Paving Troubleshooting Guide

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# 1 Hot Mix Asphalt Paving Inspection

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**Terminology**

**Prerequisites**

**Duties**

**Daily Tasks**

**Chain of Command**

*Local Level*

*Central Office*

*Contractor*

**Safety**

*Hazards*

*Possible Injuries*

*Safety Precautions*

**Terms/Definitions Related to Hot Mix Asphalt**

# **CHAPTER ONE:**

## ***HOT MIX ASPHALT PAVING INSPECTION***

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The purpose of this course is to teach the HMA Technician how to properly inspect Hot Mix Asphalt (HMA) paving operations. Emphasis will be on acquiring the skills and knowledge required to conduct the inspection to ensure construction of quality pavements in conformance with the plans and Specifications. The construction of smooth, durable, and safe highways requires careful planning and continuous monitoring. The manual is not to be considered part of the specifications or override the specifications or contract documents.

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### **TERMINOLOGY**

HMA has numerous synonyms. This material has been called bituminous paving mix(ture), bituminous concrete, bituminous mix(ture), asphalt paving mix(ture), asphalt mix(ture), asphaltic concrete or plain "asphalt", among other terms. This manual uses the term "hot mix asphalt" to help standardize the wording and minimize confusion. When the Standard Specifications are referenced in the manual, QC/QA HMA is used for mixtures in accordance with Section **401**, HMA is used for mixtures in accordance with Section **402**, and SMA (Stone Matrix Asphalt) is used for mixtures in accordance with Section **410**.

Asphalt materials include Performance Graded (PG) Asphalt Binders, Asphalt Emulsions, Cutback Asphalt, Utility Asphalt, and Asphalt used for coating corrugated metal pipe. Hot mix asphalt used for INDOT specified pavements requires PG binders to be used for the asphalt material. This manual uses the term "binder" when referring to this material.

### **PREREQUISITES**

A HMA Technician should have general knowledge of the following items:

- 1) INDOT Standard Specifications
- 2) Indiana Test Methods (ITM)
- 3) HMA paving processes and methods
- 4) Plans and contract Special Provisions
- 5) Profilographs
- 6) Certified Worksite Traffic Supervisor (CWTS) requirements

## **DUTIES**

The general duties of an HMA Technician are the same as for all other Technicians. These duties are defined in **Section 105.09** and summarized as follows:

- 1) Keep the Project Engineer or Project Supervisor (PE/S) informed as to the progress of the work and the manner in which the work is being done.
- 2) Report whenever the material furnished and the work conducted fails to meet the requirements of the specifications and the contract.
- 3) Be knowledgeable of and implement the maintenance of traffic plan.
- 4) Call to the attention of the Contractor, as the work progresses, any known deviation from the plans and specifications, or the Quality Control Plan (QCP) with respect to materials, methodology, and workmanship for the contract.

Technicians will be authorized to inspect all work conducted and materials furnished. They have authority to reject defective materials and to suspend any work that is being improperly done, subject to the final decision of the Project Engineer or Project Supervisor.

## **DAILY TASKS**

The Technician is required to be aware of the Contractor's planned work for each day to include what will be done, how much work will be done, and what equipment will be used. The daily reports are required to be completed and submitted to the PE/S promptly. A safety meeting is conducted with the PE/S as deemed necessary to review the potential hazards of the work for that day.

## **CHAIN OF COMMAND**

Every organization has a number of management levels, each with their own assigned authority and responsibility. The Technician is required to know the chain of command within INDOT as well as in the Contracting. Working through the chain usually minimizes problems and maintains cooperation.

### ***LOCAL LEVEL***

The HMA Technician is assigned to and reports to the PE/S.

Other levels of management in the field include:

- 1) The District Area Engineer
- 2) The District Construction Director
- 3) The District Deputy Commissioner

When there are major problems on the contract, such as equipment breakdown or non-routine questions or requests from the Contractor, the PE/S is contacted. If the problem is urgent and the PE/S is not available, the Area Engineer is contacted.

The HMA Technician and the HMA plant are required to communicate with each other to resolve any problems related to the mix. A quick means of communication, such as a radio system furnished by the Contractor or access by telephone, is needed.

### ***CENTRAL OFFICE***

Each INDOT District Construction Director has a Central Office Construction Field Engineer to provide guidance concerning HMA operations. The Field Engineer reports directly to the State Construction Engineer, Construction Management Division.

### ***CONTRACTOR***

Typical Contractor organizations include:

- 1) The crafts -- operators, carpenters, laborers
- 2) Field Quality Control Technicians
- 3) Job Foremen/Paving Foremen
- 4) HMA Field Supervisor (may hold another title in Contractor's actual organization.)
- 5) Job Superintendent
- 6) General Superintendent/Project Manager
- 7) The owner

Technicians have the most contact with the foremen and job superintendent and are required to work through these individuals, if possible, rather than the craftsmen directly. Under no circumstances does the Technician operate the Contractor's equipment.

**SAFETY**

HMA Technicians are required to be concerned with the safety of the traveling public, other INDOT employees, and the Contractor's work force, as well as their own safety. Although many safety devices and procedures have been established to provide a safe construction work zone, various hazards still exist. These hazards are required to be identified and the necessary safety precautions taken to prevent injuries and accidents.

**HAZARDS**

Safety hazards that are present every day for inspecting HMA paving include:

*Equipment*

<u>Type of Equipment</u>	<u>Potential Hazard</u>
Trucks	Dump bed and tailgate operation Climbing on side of bed to check mix Overhead power lines
Pavers	Clothing catches causing injuries Burns Being hit by paver extensions
Rollers	High center of gravity, easily tipped over Being hit or run over Being caught in the pinch points of the roller when turning
Power brooms	Flying debris and dust
Air hammers	Flying debris and dust
Hand tools	Long handles
Propane tank	Fire Explosion

Eye irritant

Vehicle and  
Equipment fires

Burns

*Materials*

Type of Material

Potential Hazard

Cleaning solvents

Fire

Hot mix material

Burns

Tack coat

Slips and falls

*Traffic*

Type of Traffic

Potential Hazard

Traveling public through or  
adjacent to the work zone

Being hit

Construction traffic

Being hit

***POSSIBLE INJURIES***

Safety hazards may result in accidents which cause injuries or death. The possible injuries that may occur are:

Part of Body

Possible Injury

Eyes

Flying debris and dust

Hands and arms

Cuts and lacerations

Bruises and abrasions

Burns

Body

Falls

Burns and bruises

Electrocution

Serious, extensive and possibly fatal injuries  
if run over

Feet

Blisters

Burns and bruises

## ***SAFETY PRECAUTIONS***

### ***Dress***

#### ***Clothing***

Regular clothing is worn. Loose fitting jackets, shirts, or pants are never worn because of the danger of getting caught in moving parts.

#### ***Shoes***

Work type leather boots with non-skid soles and steel toes are required to be worn. The soles of the shoes are required to be reasonably free of tack. Tennis shoes do not provide adequate foot protection and are not permitted.

#### ***Safety Vests***

Type III Fluorescent vests, t-shirts, and hardhats, are required to be worn at all times while engaged in operations upon or adjacent to a highway construction and public traffic.

Approved safety vests and caps are bright colored so that equipment operators and motorists are more likely to see them.

The vest may get caught on equipment and/or other projections, and should be properly adjusted to minimize snagging.

### ***Safety Equipment***

#### ***Hard Hats***

Hardhats should be worn in accordance with OSHA and Contractor safety policies.

Specifically, hard hats are required to be worn when an employee is on any worksite where overhead equipment, such as cranes, backhoes, loaders, or other large equipment (as deemed necessary by the supervisor), is considered a part of the worksite.

When bending over, the hard hat may fall off or get blown off. Care is taken in making any sudden movement to recover the hat as a safety hazard may exist. A hat strap may be attached to hold the hat on.

#### ***Seat Belts***

All operators and occupants of Contractor and INDOT vehicles are required to wear the complete seat belt assembly of the vehicle.

### Safety glasses

Safety glasses are available and worn when there is any possibility of damaging the eyes.

### Gloves

When climbing on the truck and conducting other similar tasks, gloves are worn.

### Ear plugs

Ear protection may be needed if jackhammers or other loud noises are prevalent.

### *Minimizing Exposure*

The risk of having an accident that results in injury may be minimized by following these precautions:

- 1) Never get between the paver and a hauling truck backing into the hopper.
- 2) Stay back when the truck dump bed is in motion and when the paver hopper wings are in operation.
- 3) When collecting weigh tickets from the driver's side, remember that fast moving traffic is only a step away.
- 4) When climbing onto a truck or equipment, use the steps and hand holds when they are available with 3 contact mounting and dismounting method.
- 5) Do not climb onto truck/equipment, unless absolutely necessary to do so.
- 6) Inform the driver/operator before climbing up on the truck/equipment.
- 7) Don't talk to the drivers, operators or other individuals unnecessarily.
- 8) Horse play and goofing around are not tolerated.
- 9) Be alert to changes in the conditions on the contract that affect safety hazards. One example is one-way traffic versus two-way traffic.
- 10) Park vehicles out of the way of the traffic.

*Pertinent Information*

*Fires*

Fires on the contract or in the field office are not common, but may occur. Basic fire suppression, the locations of fire extinguishers, and how to operate the fire extinguishers is required to be known.

*First Aid*

The proper treatment of minor cuts and burns not only reduces the irritation but also reduces the chance of infection and more serious complications. Basic methods of treatment and the location of the first aid kit are required to be known.

*Emergencies*

Emergency situations may arise that require contacting aid. At the start of the contract, the location and phone number or best method to contact a medical facility, an ambulance, the fire department, and the State Police are required to be identified.

*Accidents*

In the event of an accident on the contract, all available information for possible inclusion in the permanent contract records is recorded. The PE/S is given information such as the date, time, weather, people present, equipment, vehicle type and identification numbers, and the sequence of events.

## TERMS/DEFINITIONS RELATED TO HOT MIX ASPHALT

*AASHTO* - American Association of State Highway and Transportation Officials.

*ASTM* - American Society for Testing and Materials.

*Aggregate Spreaders* – Machines used for spreading aggregate evenly at a uniform rate on a surface.

*Air Voids* – Internal spaces in a compacted mix surrounded by asphalt-coated particles, expressed as a percentage by volume of the total compacted mix.

*Asphalt Emulsion* – An emulsion of asphalt and water that contains a small amount of an emulsifying agent. Emulsified asphalt droplets may be of either the anionic (negative charge), cationic (positive charge) or nonionic (neutral).

*Base Course* – The layer in the pavement system immediately below the binder and surface courses. The base course consists of crushed aggregate or other stabilized material.

*Binder* – Asphalt that is classified according to the Standard specifications for Performance Graded Asphalt Binder, AASHTO Designation MP1. The binder may be either unmodified or modified asphalt.

*Certified Material* - An aggregate product produced in accordance with the Certified Aggregate Producer Program (CAPP) for Department use.

*Certified Aggregate Producer* - A Plant/Redistribution Terminal that meets the requirements of ITM 211, continues to be under the same ownership, and is approved by the Department.

*Coarse Aggregate* - Aggregate that has a minimum of 20 percent retained on the No. 4 (4.75 mm) sieve.

*Crack and Seat* – A fractured slab technique used in the rehabilitation of PCC pavements that minimizes slab action in a jointed concrete pavement by fracturing the PCC layer into smaller segments. This reduction in slab length minimizes reflective cracking in new HMA overlays.

*Distributor* – A truck or a trailer having an insulated tank heating system and distribution system. The distributor applies asphalt to a surface at a uniform rate.

*DTE* – District Testing Engineer.

*Emulsifier* – The chemical added to the water and asphalt that keeps the asphalt in stable suspension in the water. The emulsifier determines the charge of the emulsion and controls the breaking rate.

*Equivalent Single Axle Load (ESAL)* – The effect on pavement performance of any combination of axle loads of varying magnitude equated to the number of 80-kN (18,000-lb.) single-axle loads that are required to produce an equivalent effect.

*Fine Aggregate* - Aggregate that is 100 percent passing the 3/8 in. (9.5 mm) sieve and a minimum of 80 percent passing the No. 4 (4.75 mm) sieve.

*Fog Seal* – A light application of diluted asphalt emulsion used to renew old asphalt surfaces, seal small cracks and surface voids, and inhibit raveling.

*Intermediate Course* – The hot mix asphalt course immediately below the surface course, generally consisting of larger aggregates and less asphalt (by weight) than the surface course.

*Leveling Course* – A course of hot mix asphalt of variable thickness used to eliminate irregularities in the contour of an existing surface prior to placing the subsequent course.

*Mechanical Spreaders* – Spreader boxes that are mounted on wheels and attached to and pushed by dump trucks. HMA boxes are pulled and chip spreaders are pushed.

*Maximum Particle Size* - The sieve on which 100 percent of the material will pass.

*Milling Machine* – A self-propelled unit having a cutting head equipped with carbide-tipped tools for the pulverization and removal of layers of asphalt materials from pavements.

*Nominal Maximum Particle Size* - The smallest sieve opening through which the entire amount of the aggregate is permitted to pass.

*Performance Graded (PG)* – Asphalt binder grade designation used in Superpave that is based on the binder's mechanical performance at critical temperatures and aging conditions.

*Pneumatic-Tire Roller* – A compactor with a number of tires spaced so their tracks overlap delivering a kneading type of compaction.

*Polish Resistant Aggregates* – Dolomite containing less than 10.3% elemental magnesium, crushed limestone, or gravel meeting the requirements of ITM 214. Aggregates meeting these requirements are maintained on the INDOT Approved List of Polish Resistant Aggregates.

*Power Sweeper* – A power operated rotary broom used to clean loose material from the pavement surface.

*Prime Coat* – An application of asphalt primer to an absorbent surface. The prime coat is used to prepare an untreated base for an asphalt surface. The prime penetrates or is mixed into the surface of the base and plugs the voids, hardens the top and helps bind the mixture to the overlying course.

*Quality Control Plan (QCP)* - A document written by the Contractor that is contract-specific and includes the policies, and procedures used by the Contractor.

*Qualified Technician* - An individual who has successfully completed the written and proficiency testing requirements of the Department Qualified Laboratory and Technician Program.

*Reclaimed Asphalt Pavement (RAP)* – Excavated asphalt pavement that has been pulverized, usually by milling, and is used like an aggregate in the recycling of asphalt pavements.

*Reclaimed Asphalt Shingles (RAS)* - Reclaimed asphalt shingles that has been pulverized/crushed and is used like an aggregate in the recycling of asphalt pavements.

*Rubblization* – The pulverization of a Portland cement concrete pavement into smaller particles, reducing the existing pavement layer to a sound, structural base that will be compatible to an asphalt overlay.

*Steel-Wheeled Static Rollers* – Tandem or three-wheel rollers with cylindrical steel rolls that apply their weight directly to the pavement.

*Steel-Wheel Vibratory Rollers* – A compactor having single or double cylindrical steel rolls that apply compactive effort with weight and vibration. The amount of compactive force is adjusted by changing the frequency and amplitude of vibration.

*Subbase* – The course in the asphalt pavement structure immediately below the base course. If the subgrade soil has adequate support, this course may serve as the subbase.

*Subgrade* – The soil prepared to support a pavement structure or a pavement system. The subgrade is the foundation of the pavement structure.

*Superpave* – Short for "Superior Performing Asphalt Pavement", a performance-based system for selecting and specifying asphalt binders and for designing asphalt mixtures.

*Structural Backfill* - Suitable sand, gravel, crushed stone, air-cooled blast furnace slag, or granulated blast furnace slag used to fill designated areas excavated for structures that are not occupied by permanent work.

*Tack Coat* – A relatively thin application of asphalt applied to an existing asphalt or PCC surface at a prescribed rate. Asphalt emulsion diluted with water is the preferred type. Tack coat is used to form a bond between an existing surface and the overlying course.

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## **2 Asphalt History**

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### **Asphalt**

*Source and Nature of Asphalt*  
*Performance Graded Binder*

### **Hot Mix Asphalt**

*Paving Courses*  
*Mix Grading*

### **Design Mix Formula**

### **Mixing Process**

*Batch Plants*  
*Drum Plants*

# CHAPTER TWO:

## *ASPHALT HISTORY*

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### ASPHALT

Asphalt is a black, cementing material that varies widely in consistency from solid to semisolid (soft solid) at normal air temperatures. When heated sufficiently, asphalt softens and becomes a liquid, which allows the material to coat the aggregate particles during HMA production.

Asphalt is made up largely of a hydrocarbon called bitumen. Virtually all asphalt used in the United States is produced by modern petroleum refineries and is called petroleum asphalt. The degree of control allowed by modern refinery equipment permits the production of asphalts with specific characteristics suited to specific applications. As a result, different asphalts are produced for paving, roofing and other special uses.

Paving asphalt, commonly called binder, is a highly viscous (thick), sticky material. It adheres readily to aggregate particles and is therefore an excellent cement for binding together aggregate particles in HMA. The binder is an excellent waterproofing material and is resistant to most acids, alkalis (bases) and salts. This means that a properly constructed HMA pavement is waterproof and resistant to many types of chemical damage.

Binder for paving may also contain modifiers to improve performance properties. Some of these binders require special storage and handling. The material suppliers recommendations should be followed to insure that these performance characteristics are not altered or lost before mixing and placement of the HMA.

Binder changes when the material is heated and/or aged. Binder tends to become hard and brittle and therefore lose some of its ability to adhere to aggregate particles. These changes may be minimized by understanding the properties of the binder and taking steps during construction to ensure that the finished pavement is built in a way that retards the aging process.

## ***SOURCE AND NATURE OF ASPHALT***

Because asphalt is used for many purposes, there is sometimes confusion about where asphalt comes from, how the material is refined, and how the material is classified into grades. There is similar confusion about terms related to asphalt properties and use.

### ***Petroleum Refining***

Crude petroleum is refined by distillation, a process in which various fractions (products) are separated out of the crude. Distillation is accomplished by raising the temperature of the crude petroleum in stages. As shown in Figure 2-1, different fractions separate at different temperatures.

The lighter fractions are separated by simple distillation. The heavier distillates, often referred to as gas oils, may be separated only by a combination of heating and applying a vacuum. The product which cannot be distilled under vacuum distillation is asphalt.

Figure 2-2 is a schematic illustration of a typical refinery. The schematic shows the flow of petroleum during the refining process.

### ***Asphalt Refining***

Different types of asphalt are required for different applications. To produce asphalts that meet specific requirements, refiners are required to have a way to control the properties of the asphalts they produce. This is often accomplished by blending crude petroleum of various types together before processing. Blending allows refiners to combine crudes that contain asphalts of varying characteristics in such a way that the final product has exactly the characteristics required by the asphalt user.

Once the crude petroleum have been blended together, there are two widely used processes by which asphalt may be produced from them: vacuum distillation and solvent extractions.

As discussed above, vacuum distillation involves separating the asphalt from the crude by applying heat and a vacuum. In the solvent extraction process, additional gas oils are removed from the crude, leaving residual asphalt.

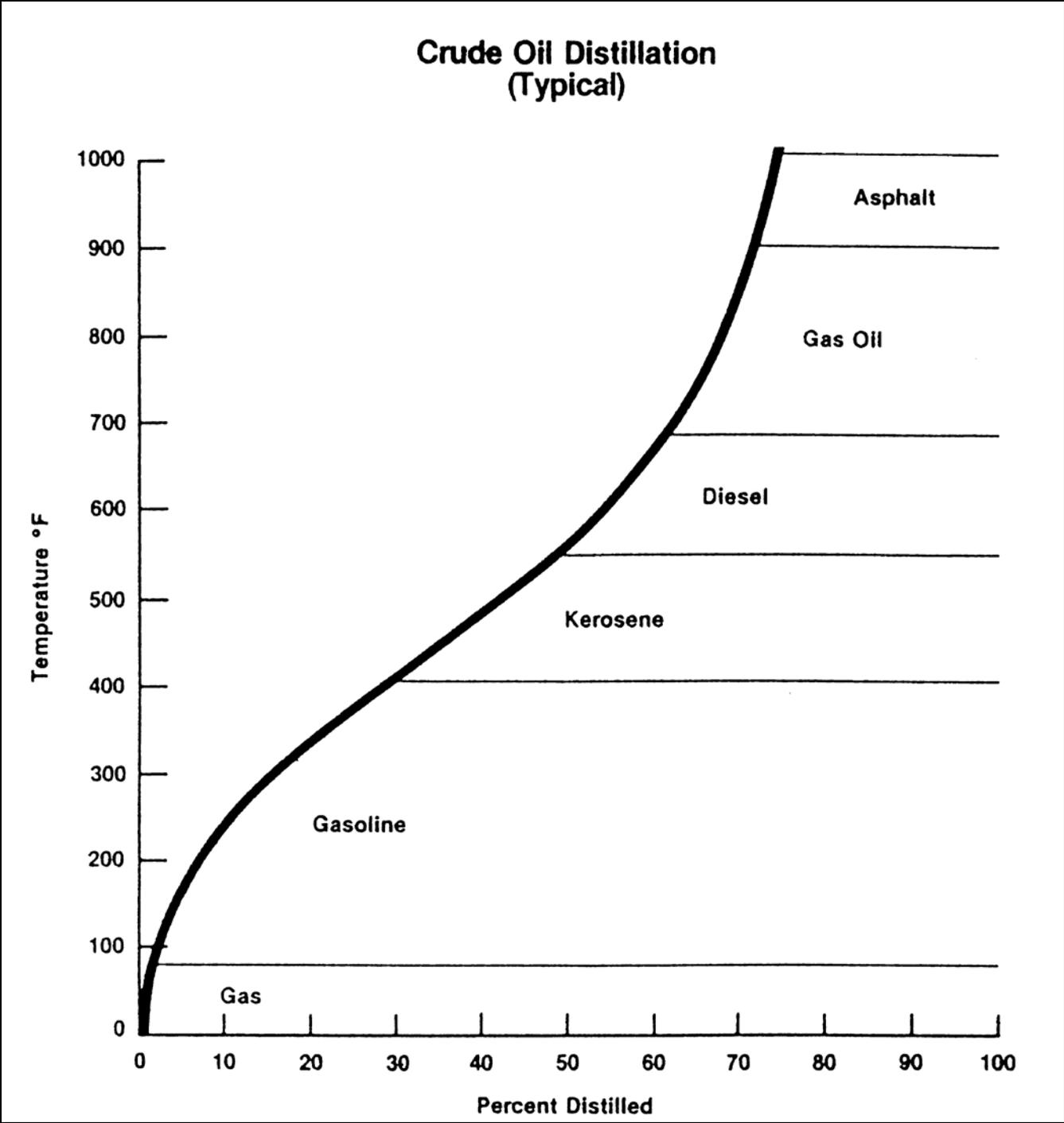


Figure 2-1. Typical Distillation Temperatures and Products

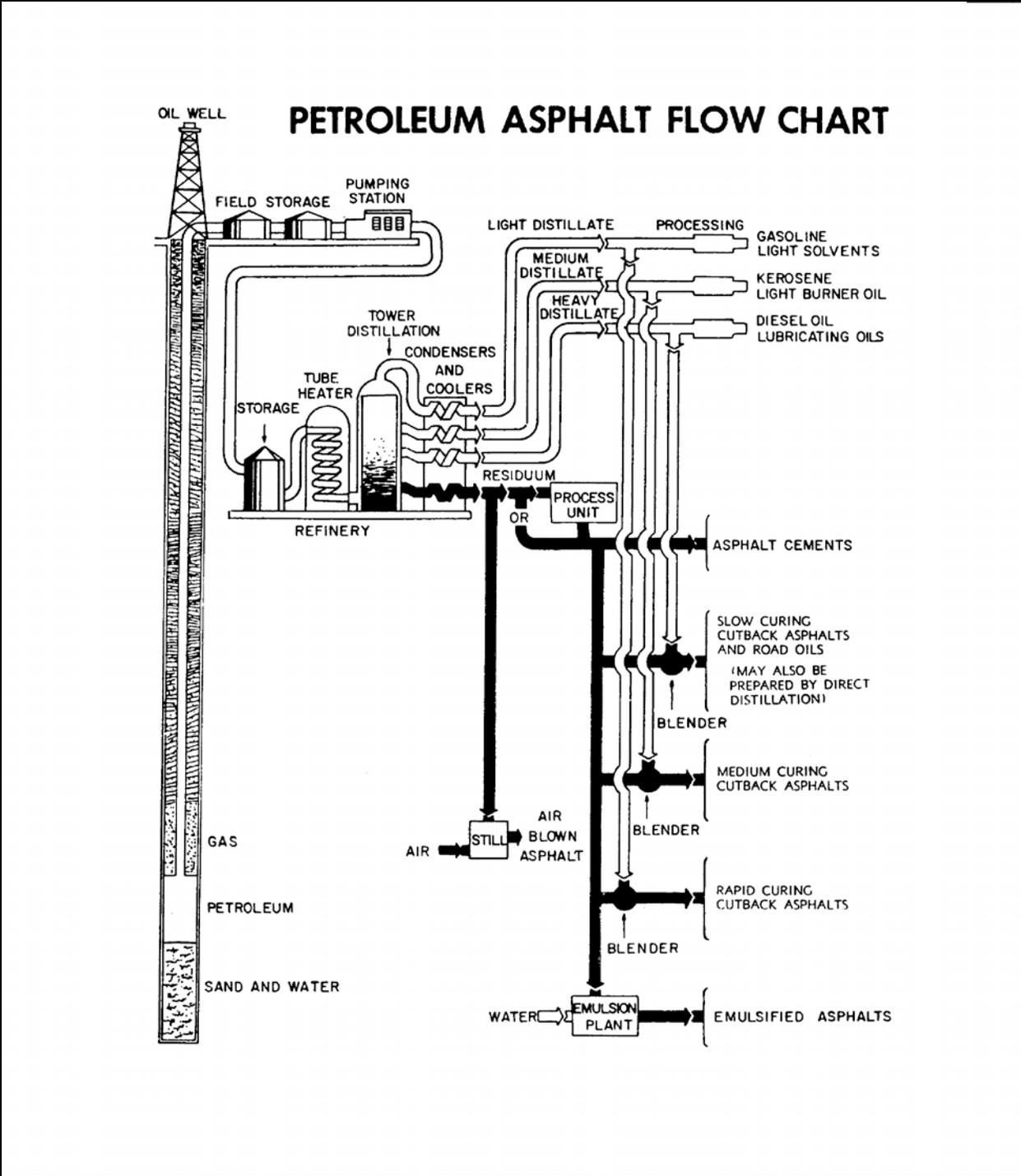
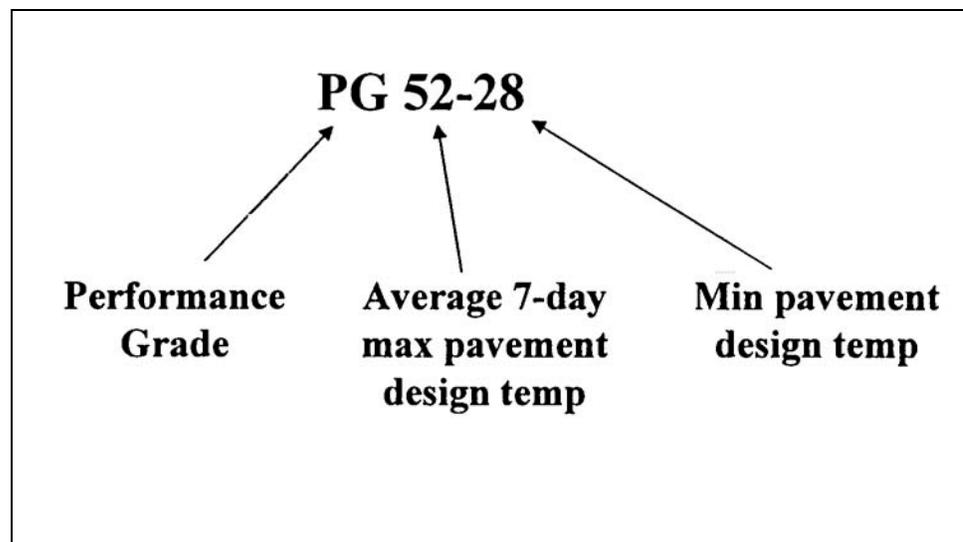


Figure 2-2. Typical Refining Process

## ***PERFORMANCE GRADED BINDER***

The binder Specifications are based on fundamental properties which are measured at actual in service temperatures where the critical distresses occur. The upper temperature extreme is designated as the average 7-day maximum pavement design temperature. This temperature is obtained by accumulating the temperature from each successive 7-day period throughout the summer, and choosing the 7-day period which yields the largest average. The lower temperature extreme is designated as the minimum pavement design temperature. An example of how this grading system works is shown in Figure 2-3. The specification limits for the PG Binders are listed in Section 902.01.



**Figure 2-3. PG Grading System**

## **HOT MIX ASPHALT**

Hot mix asphalt is a combination of two basic ingredients, asphalt and aggregates. The asphalt accounts for 3 to 8 percent of the mixture by weight while aggregates account for the remaining 92 to 97 percent.

### ***PAVING COURSES***

On typical HMA contracts there are three distinct HMA courses or layers which may be placed; base, intermediate and surface.

The base course is a foundation course consisting of larger aggregate sizes to provide stability and strength.

The intermediate course is an intermediate layer of medium-sized aggregates which act as a barrier to keep surface material from being pushed into the base material. Intermediate materials may also be used as a base or as a wedging and leveling course.

The surface course is a smooth, skid resistant layer made up of smaller aggregates.

### ***MIX GRADING***

HMA mixtures may also be open graded or dense graded mixtures.

Open graded HMA mixtures usually consist of larger aggregates with few small aggregates or fines. The open grading of the mix permits water to flow through the pavement. One use of this mix is to provide a free draining base course.

Dense graded mixtures contain more small and fine aggregates to close up any spaces between the larger aggregates. Dense graded mixtures shed water from the surface better, provide a smoother ride, and are typically used for base, intermediate, or surface courses not requiring free drainage.

### **DESIGN MIX FORMULA**

Precise proportions of asphalt and aggregates are blended together to produce HMA paving mixtures. The types of asphalts used and the proportions of each component vary among mixtures. As a result, each mix has a different set of characteristics and properties.

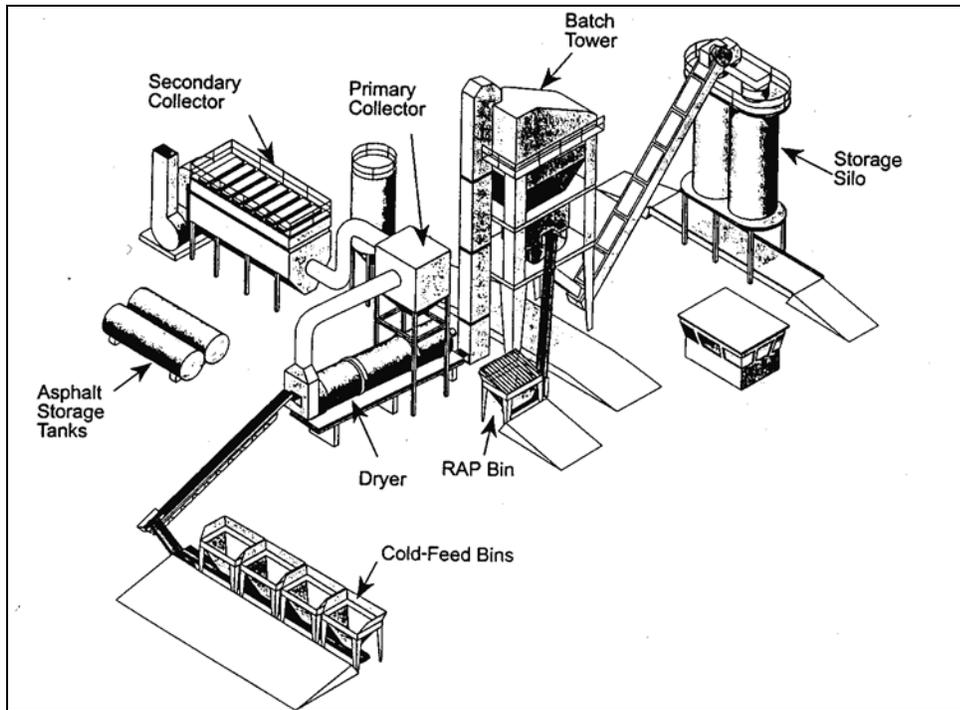
Prior to any mix production, the Contractor is required to submit a Design Mix Formula (DMF) for each mixture supplied to the contract. The DMF specifies the exact types and quantities of asphalt and aggregates to be used to produce the mix. The Contractor develops a mix design that is within the Specification guidelines regarding that particular mix. The mix design is then submitted to district Testing for approval. No mix may be used on the contract until the DMF has been approved.

The Technician is required to know what the pay item description is for each mix used. The pay item description indicates whether the mixture is QC/QA HMA in accordance with Section **401**, HMA in accordance with Section **402**, or SMA in accordance with Section **410**.

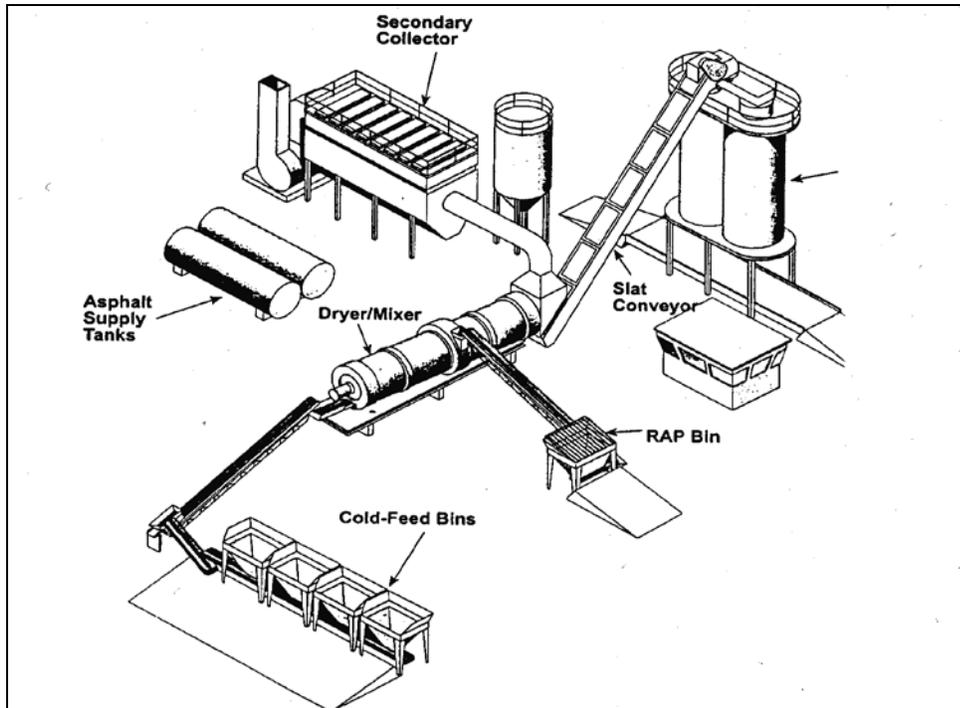
The PE/S receives a copy of the approved Design Mix Formula. The HMA Technician is required to review the Design Mix Formulas for the contract to verify what materials are to be used to produce the mix that is inspected each day.

## **MIXING PROCESS**

A HMA plant is an assembly of mechanical and electronic equipment where aggregates are blended, heated, dried, and mixed with binder to produce HMA meeting specified requirements. The plant may be stationary (located at a permanent location) or portable (moved from contract to contract). There are numerous types of plants, including batch plants, continuous mix plants, parallel-flow drum plants, counter flow drum plants, and double barrel drum plants to name a few. In general, however, the majority of plants may be categorized as either a batch plant (Figure 2-4), or a drum mix plant (Figure 2-5).



**Figure 2-4. Typical Batch Plant**



**Figure 2-5. Typical Drum Plant**

## ***BATCH PLANTS***

Batch plants obtain their name from the fact that during operation the HMA is produced in batches. The size of batch varies according to the capacity of the plant pugmill (the mixing chamber where aggregate and binder are blended together). A typical batch is approximately 6000 lb.

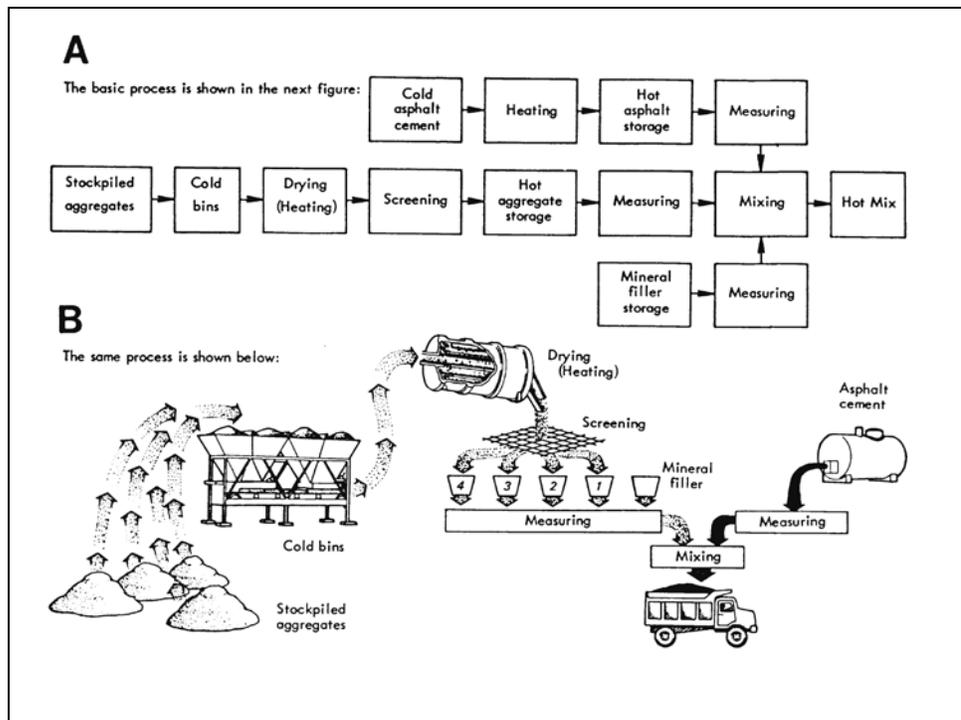
### ***Batch Plant Operations and Components***

At a batch plant, aggregates are blended, heated and dried, proportioned, and mixed with binder to produce HMA. A plant may be small or large, depending on the type and quantity of HMA being produced, and also may be stationary or portable.

Certain basic operations are common to all batch plants:

- 1) Aggregate storage and cold feeding
- 2) Aggregate drying and heating
- 3) Screening and storage of hot aggregates
- 4) Storage and heating of binder
- 5) Measuring and mixing of binder and aggregate
- 6) Loading of finished HMA

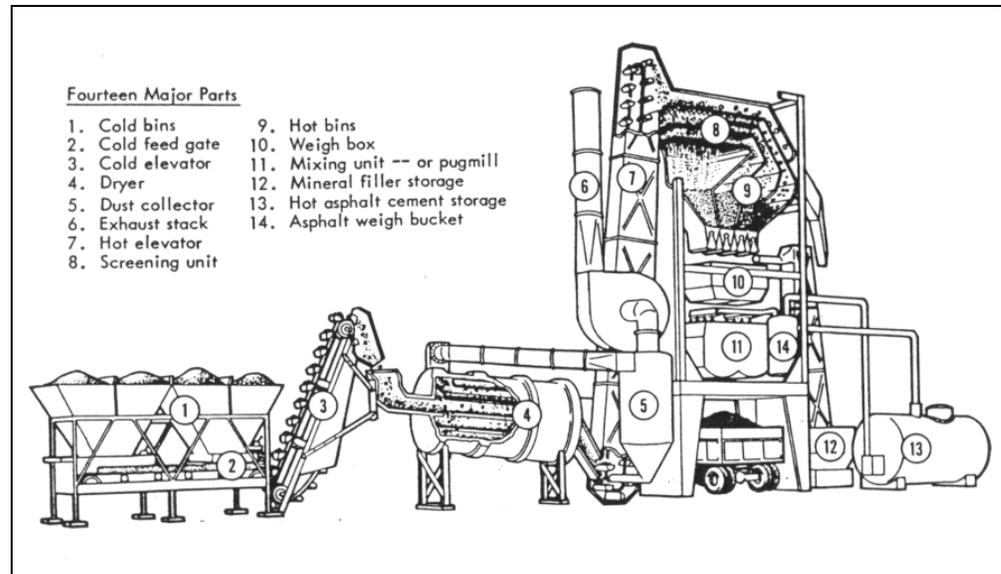
Figure 2-6. illustrates the sequence of these operations.



**Figure 2-6. Basic Batch Plant Operations Shown (A) in flow chart form and (B) schematically**

Aggregates are removed from storage or stockpiles in controlled amounts and passed through a dryer to be dried and heated. The aggregates then pass over a screening unit that separates the material into different sized fractions and deposits them into bins for hot storage. The aggregates and mineral filler (when used) are then withdrawn in controlled amounts, combined with binder, and thoroughly mixed in a batch. The HMA is loaded directly into trucks or placed in a surge bin, and hauled to the paving site.

Figure 2-7 illustrates the major components of a typical batch plant. An overview of the processes involved in plant operations as follows is intended to help the technician understand the functions and relationships of the various plant components.



**Figure 2-7. Major Batch Plant Components**  
**(Many plants also include a baghouse in addition to the dust collector shown in number 5 above.)**

Cold (unheated) aggregates stored in the cold bins (1) are proportioned by cold-feed gates (2) on to a belt conveyor or bucket elevator (3), which delivers the aggregates to the dryer (4), the aggregate is dried and heated. Dust collectors (5) remove undesirable amounts of dust from the dryer exhaust. Remaining exhaust gases are eliminated through the plant exhaust stack (6). The dried and heated aggregates are delivered by hot elevator (7) to the screening unit (8), which separates the material into different sized fractions and deposits them into separate hot bins (9) for temporary storage. When needed, the heated aggregates are measured in controlled amounts into the weigh box (10). The aggregates are then dumped into the mixing chamber or pugmill (11), along with the proper amount of mineral filler, if needed, from the mineral filler storage (12). Heated binder from the hot binder storage tank (13) is pumped into the binder weigh bucket (14) which weighs the binder prior to delivery into the mixing chamber or pugmill where the binder is combined thoroughly with the aggregates. From the mixing chamber, the HMA is deposited into a waiting truck or delivered by conveyor into a surge bin.

## **DRUM PLANTS**

Drum mixing is a relatively simple process of producing HMA. The mixing drum (Figure 2-8) is very similar in appearance to a batch plant dryer drum. The difference between drum mix plants and batch plants is that in drum mix plants the aggregate is not only dried and heated within the drum, but also mixed with the binder. There are no gradation screens, hot bins, weigh hoppers, or pugmills in a drum mix plant. Aggregate gradation is controlled at the cold feed.

As the aggregates (correctly proportioned at the cold feed) are introduced into the drum mix plant for drying, the binder is also introduced into the drum. The rotation of the drum provides the mixing action that thoroughly blends the binder and the aggregates. As the HMA is discharged from the drum, the mixture is carried to a surge bin and subsequently loaded into trucks.

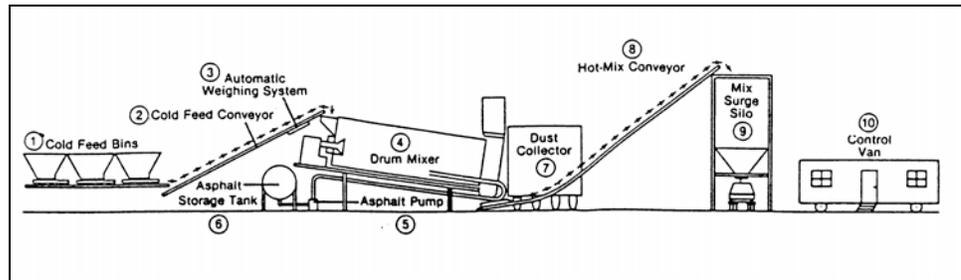


**Figure 2-8. Drum Mix Plant**

### **Drum Mix Plant Components**

The fundamental components of the drum mix plant (Figure 2-8) are:

- 1) Aggregate cold-feed bins
- 2) Conveyor and aggregate weighing system
- 3) Drum mixer
- 4) Dust collection system
- 5) Hot mix conveyor
- 6) Mix surge bin
- 7) Control van
- 8) Binder storage tank



**Figure 2-9. Basic Drum Mix Plant**

Referring to Figure 2-9 the following is a brief, general description of the sequence of processes involved in a typical drum mix plant operation: Controlled gradations of aggregates are deposited in the cold feed bins (1) from which the aggregates are fed in exact proportions onto a cold-feed conveyor (2). An automatic aggregate weighing system (3) monitors the amount of aggregate flowing into the drum mixer (4). The weighing system is interlocked with the controls on the binder storage pump (5), which draws binder from a storage tank (6) and introduces binder into the drum where binder and aggregate are thoroughly blended by the rotating action of the drum. A dust collection system (7) captures excess dust escaping from the drum. From the drum, the HMA is transported by hot mix conveyor (8) to a surge bin (9) from which the mixture is loaded into trucks and hauled to the paving site. All plant operations are monitored and controlled from instruments in the control van (10).

The mixing process is essentially similar in all drum mixing plants; however, there are several plant designs available. These include the counter-flow drum, which has the burner located near the outlet end of the drum, and the unitized counter-flow drum, which has an outer mixing drum that surrounds the dryer drum.

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# 3 Paving Equipment

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**Distributors**

**Pavers**

**Widening Machines**

**Rollers**

*Two-Axle Tandem Roller*

*Three-Wheel Roller*

*Pneumatic-Tire Roller*

*Vibratory Roller*

*Oscillatory Roller*

*Trench Roller*

**Material Transfer Vehicles**

**Haul Trucks**

**Hand Tools**

**Cleaning**

# **CHAPTER THREE:**

## ***PAVING EQUIPMENT***

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Before paving operations may be started, all of the paving equipment is required to be checked for conformance with the Specifications and the Contractor's Quality Control Plan. If the equipment functions properly, the chances of a successful paving operation are greatly increased.

The major pieces of paving equipment on a HMA contract are distributors, pavers, material transfer devices, widening machines, rollers, and hauling units (trucks). Each piece of equipment is required to be checked prior to beginning the paving operation to ensure that the equipment is in good working order and in compliance with specific requirements.

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### **DISTRIBUTOR**

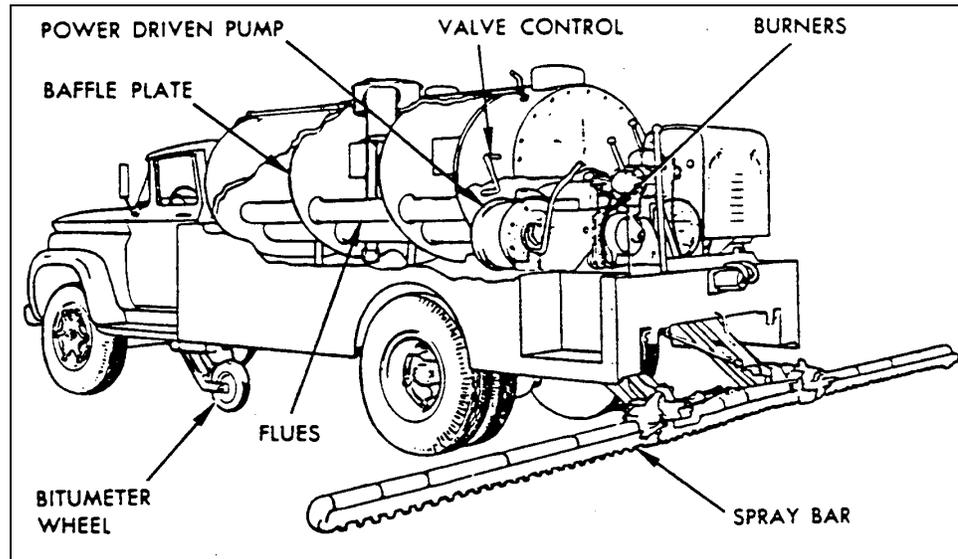
A distributor is used to apply liquid asphalt material such as prime and tack coats to surfaces to be paved. The distributor consists of an insulated tank mounted on a truck or trailer. A power-driven pump forces the asphalt through a system of spray bars and nozzles onto the construction surface. A burner, usually oil-fired with flues within the tank, is used to heat the asphalt to the proper application temperature. The major units for a typical distributor are indicated in Figure 3-1.

The distributor is required to:

- 1) Maintain the liquid asphalt at a uniform temperature
- 2) Apply material at a uniform rate
- 3) Apply material at variable widths

The distributor is required to be equipped with:

- 1) A tachometer (Bitumeter) to measure the speed during applications
- 2) Pressure gauges
- 3) Accurate volume measuring gauges or a calibrated tank
- 4) A thermometer for measuring temperatures
- 5) A power unit for the pump
- 6) Full circulating spray bars to prevent material cooling in the spray bars. The spray bars are required to be adjustable both laterally and vertically.



**Figure 3-1. Distributor**

## **PAVERS**

Most HMA mixtures are placed by a paver (Figure 3-2) or finishing machine. The HMA paver spreads the mixture in either a uniform layer of a desired thickness or a variable layer to a desired elevation and cross section. Upon placement, the HMA is ready for compaction.

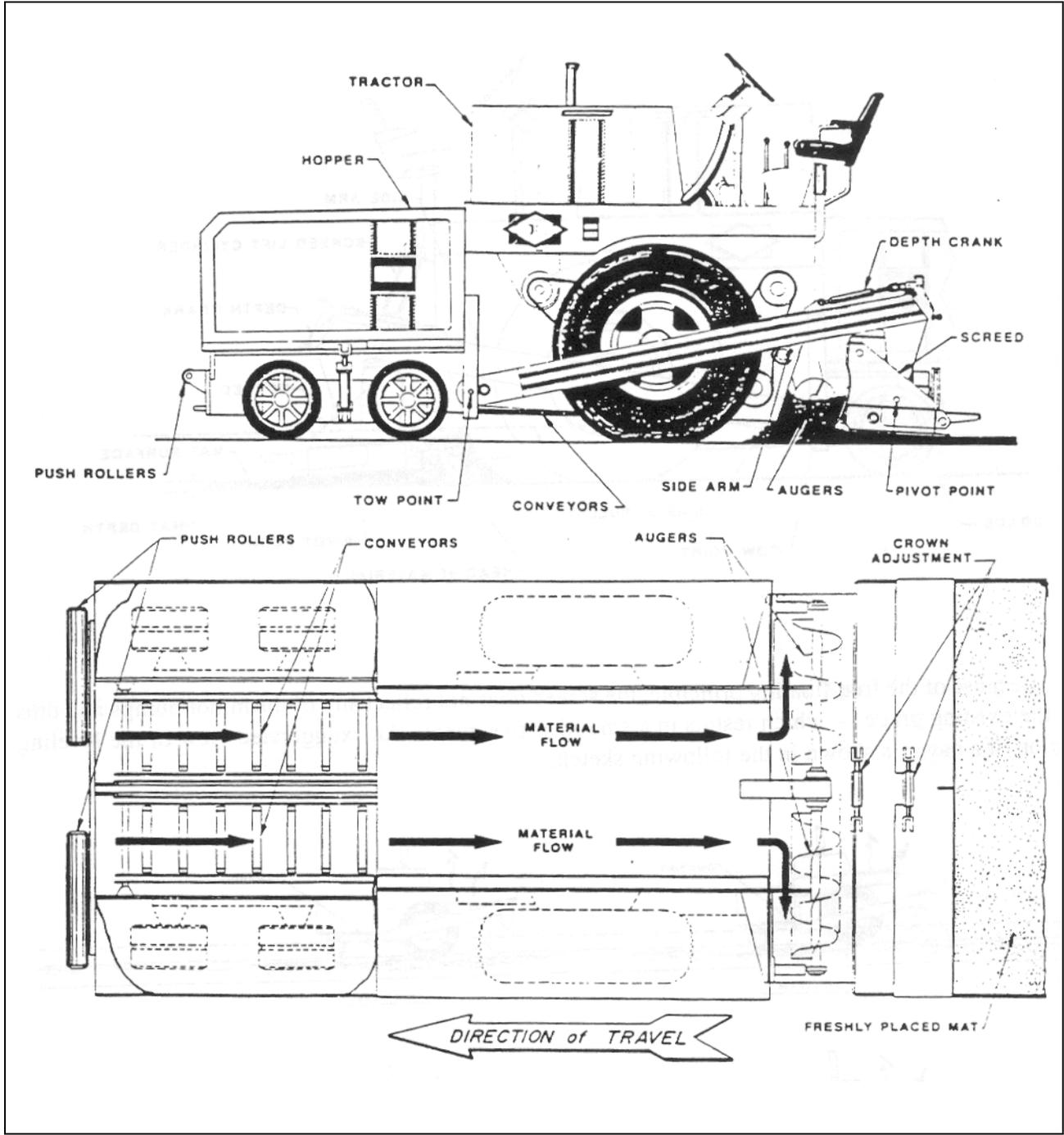
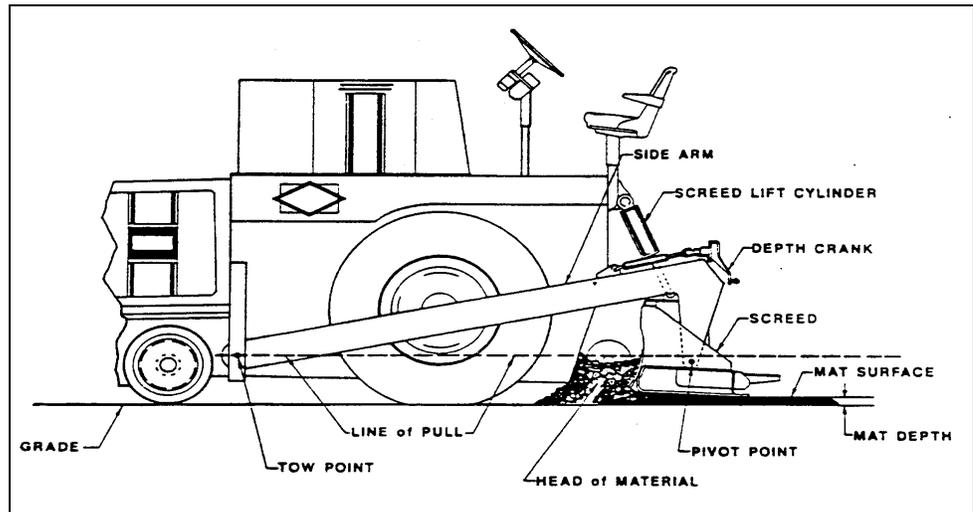


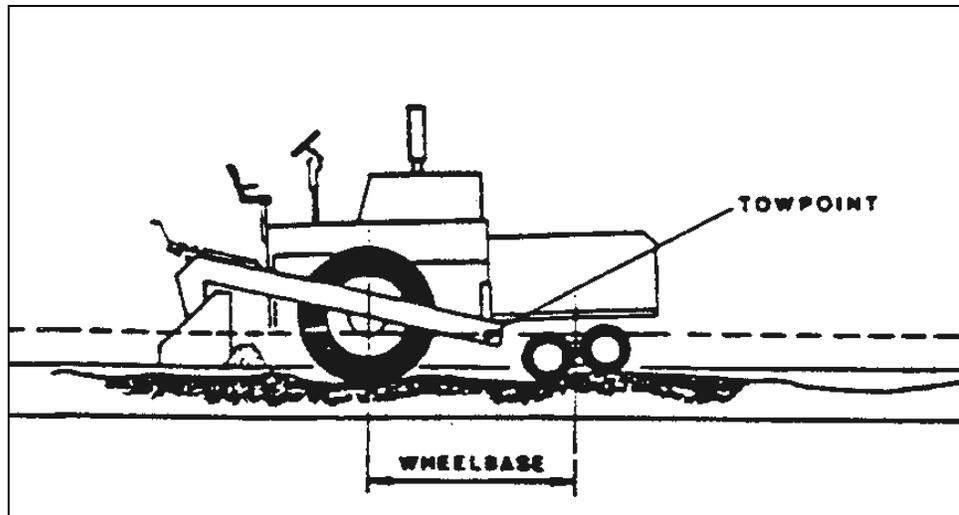
Figure 3-2. HMA Paver

The paver consists essentially of 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 mix from the haul trucks, or Material Transfer Device, conveyors to move the mix through the flow control gates to the augers, flow gates to regulate the flow of mixture to maintain uniform auger speed, and augers to evenly spread the mix in front of the screed. If haul trucks are used, rollers are mounted on the front of the tractor to push the haul trucks during the dumping process. The rollers turn freely so the trucks have little effect on paver operation. The screed conducts the actual placing of HMA to the desired width and thickness or elevation as indicated in Figure 3-3. 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 the screed is traveling.



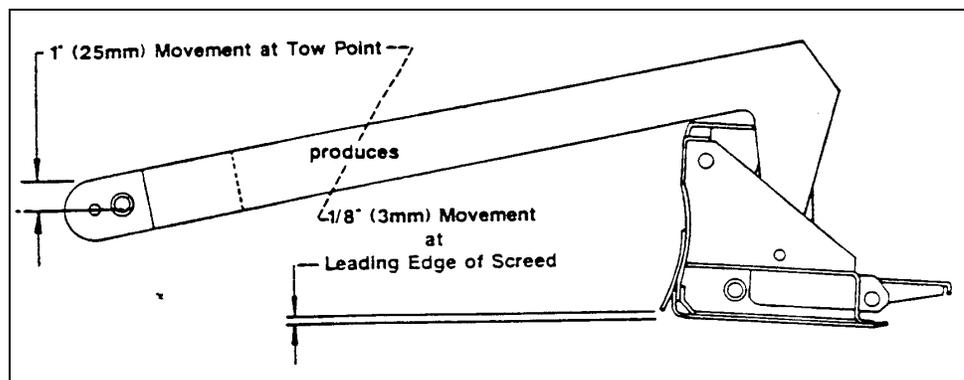
**Figure 3-3. Paver Components**

Because of the free-floating principle, the screed does not reflect any of the minor bumps and dips in the existing grade which results in a smoother pavement. An exaggerated view of the leveling action of a paver is indicated in Figure 3-4.



**Figure 3-4. Free-Floating Screed**

The relationship between the vertical movement of the screed tow point and the elevation of the screed is illustrated in Figure 3-5. There is an 8 to 1 ratio between the tow point and the elevation; therefore, a 1 in. vertical movement of the tow point results in only a 1/8 in. vertical corrective movement of the screed. Before the 1/8 in. movement is made, the paver moves five times the length of the screed side arm. This relationship is the key to the paver's ability to lay smooth pavements.

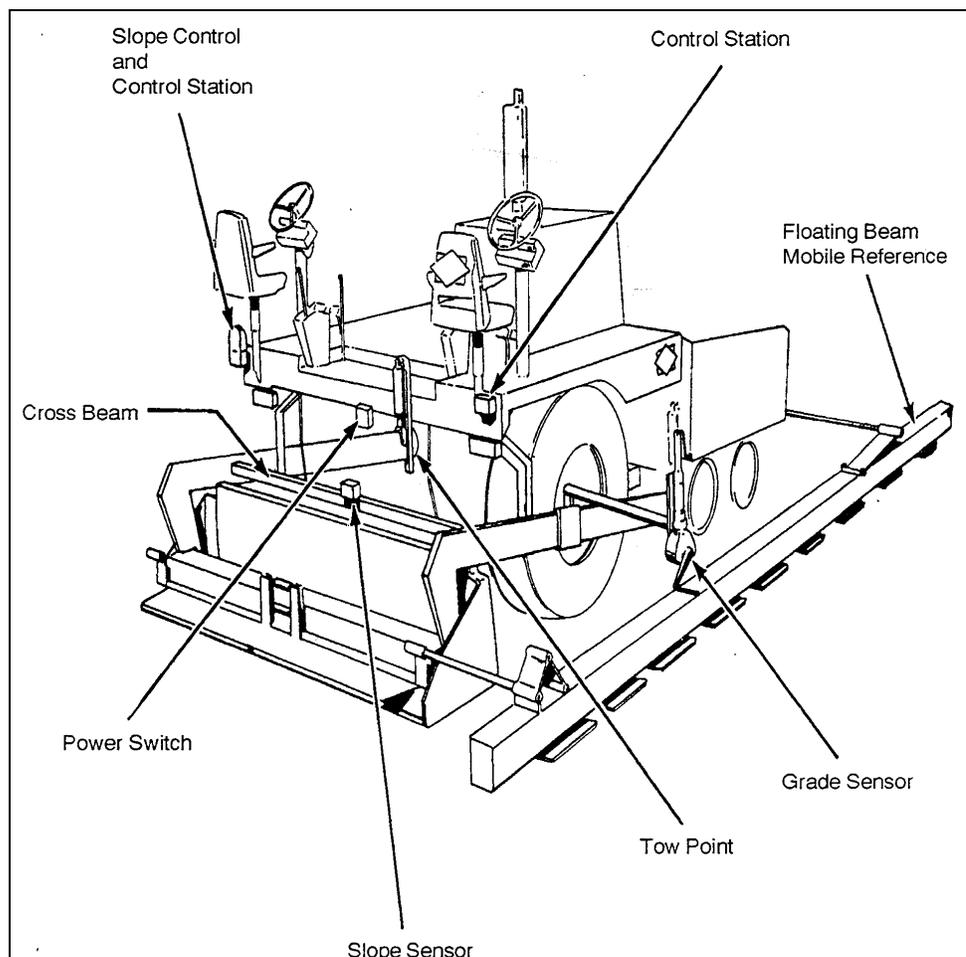


**Figure 3-5. Screed Tow Point and Elevation**

Section 409 requires that a paver (Figure 3-6):

- 1) Be a self-contained power propelled unit
- 2) Be equipped with an activated (vibratory) screed or strike-off assembly capable of being heated for the full length, including extensions

- 3) Be capable of spreading and finishing mix in lane widths indicated on the typical sections for the contract
- 4) Be equipped with automatic grade and slope controls if the width of the roadway or shoulder to be paved is 8 ft or more in width. The operator's control panel is required to have gauges that indicate compliance with the established grade and slope.
- 5) Have a grade leveler (commonly called a ski or mat reference) for attachment to the paver to activate the automatic grade control



**Figure 3-6. Paver Screed Controls**

The automatic screed controls may be set for manual, semiautomatic, or automatic operation on most pavers. Automatic screed controls typically have the following main components:

- 1) Infrared sonic grade sensor
- 2) Non-contact slope sensor
- 3) Control station
- 4) Slope control
- 5) Motors and hydraulic cylinders to change the screed tilt

The grade sensor rides on a stringline, a ski, or a joint matcher to detect changes in elevation and transmit the information electronically to the controls. The electronic controls may be checked by varying the position of the grade sensor and observing if the screed controls react to make the correct adjustment. When the ski is used, the grade sensor is required to 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. Crown or superelevation slope 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. Automatic slope and grade controls are required to be used as outlined in the Quality Control Plan (QCP).

## **WIDENING MACHINES**

Widening machines (Figure 3-7) are used when the width to be laid is too narrow or inaccessible for the regular paver. The inside 4 ft wide shoulder of a dual-lane highway is one example of when HMA may be placed separately using a widening machine.

Widening machines are required to be self-propelled and capable of placing material at variable widths. Vibrating or heated screeds and automatic grade and slope controls are not required for these machines; however, automatic grade controls for matching joints are available on some models. Self-propelled wideners are usually used for widths up to 4 ft, and wideners mounted on motor-graders are used for widths between 4 ft and 8 ft. The use of widening pavers is not allowed on widths of 8 ft or more.



**Figure 3-7. Widening Machine**

## **ROLLERS**

Six types of rollers are used for compacting HMA: two-axle tandem, three-wheeled, pneumatic tire, vibratory, oscillatory, and trench. All of the rollers have steel wheels, except for the pneumatic-tire roller which has rubber wheels.

All rollers are required to have proper sprinkling systems to wet the drums or tires to prevent the mix from sticking. Scrapers are usually required on steel-wheel rollers. Rollers are required to be equipped with drip pans to prevent oil, grease, or fuel from dropping onto the roadway. Any petroleum product damages HMA pavement. Clutches are required to function smoothly. A roller that jerks when starting, stopping, or reversing causes a rough surface.

QC/QA mixtures in accordance with Section **401** are compacted with rollers designated in the Contractor's Quality Control Plan. HMA mixtures are required to be compacted by the rollers designated in Section **409.03(d)**, and SMA mixtures are compacted with rollers in accordance with Sections **409.03(d)1**, **409.03(d)2**, or **409.03(d)6**.

### ***TWO-AXLE TANDEM ROLLER***

A two-axle tandem steel-wheel roller (Figure 3-8) is required by Section **409.03(d)1** to weigh at least 10 tons.



**Figure 3-8. Two-Axle Tandem Roller**

### ***THREE-WHEEL ROLLER***

The three-wheel roller (Figure 3-9) is required by Section **409.03(d)2** to have a compression or drive rolls that produce a bearing of at least 300 pounds per linear inch of roll width. This bearing weight is computed by dividing the weight of the drive axle by the combined width of the two rolls. A tandem roller, which has a drive wheel bearing of no less than 300 pounds per linear inch may be used in lieu of the three-wheel roller.



**Figure 3-9. Three-Wheel Roller**

***PNEUMATIC-TIRED ROLLER***

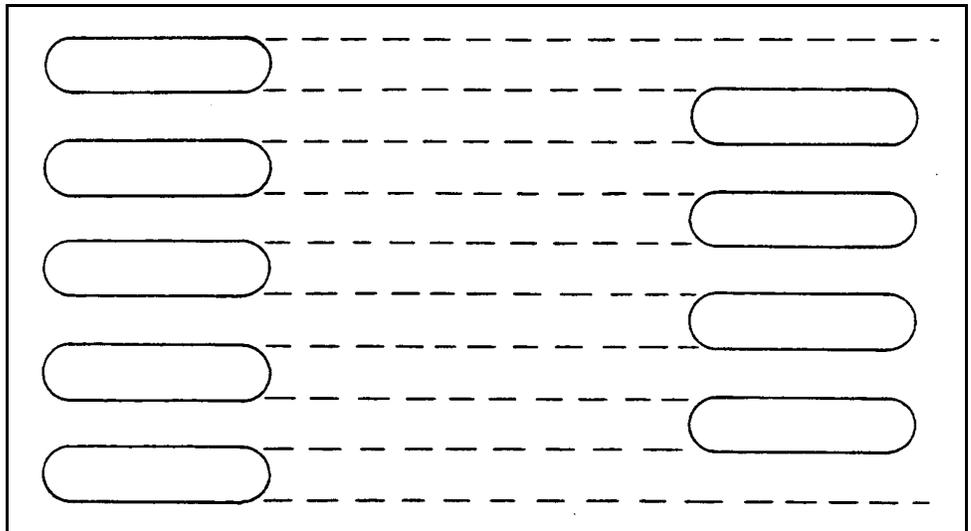
A pneumatic-tired roller (Figure 3-10) is required by Section **409.03(d)3** to:

- 1) Be self propelled
- 2) Have a minimum width of 5 ft 6 in.
- 3) Be equipped with wide-tread compaction tires, with a minimum size of 7:50 by 15
- 4) Be capable of exerting a uniform, average contact pressure from 50 to 90 pounds per square inch over the surface by adjusting ballast and tire pressure
- 5) Have wheels on at least one axle that are fully oscillating vertically and so mounted so as to prevent scuffing of the surface during rolling or turning



**Figure 3-10. Pneumatic-Tire Roller**

The tires on a pneumatic-tired roller are typically arranged so the gaps between the tires on one axle are covered by the tires of the other as shown in Figure 3-11.



**Figure 3-11. Pneumatic-Tired Roller Tires**

The Contractor is required to furnish charts and tabulations indicating the contact areas and pressures for the full range of tire inflation pressures and for the full range of tire loadings for each type and size of pneumatic-tired roller to be used.

### ***VIBRATORY ROLLER***

A vibratory roller (Figure 3-12) is a steel-wheeled roller that has the capability of oscillating one or both of the steel rollers.

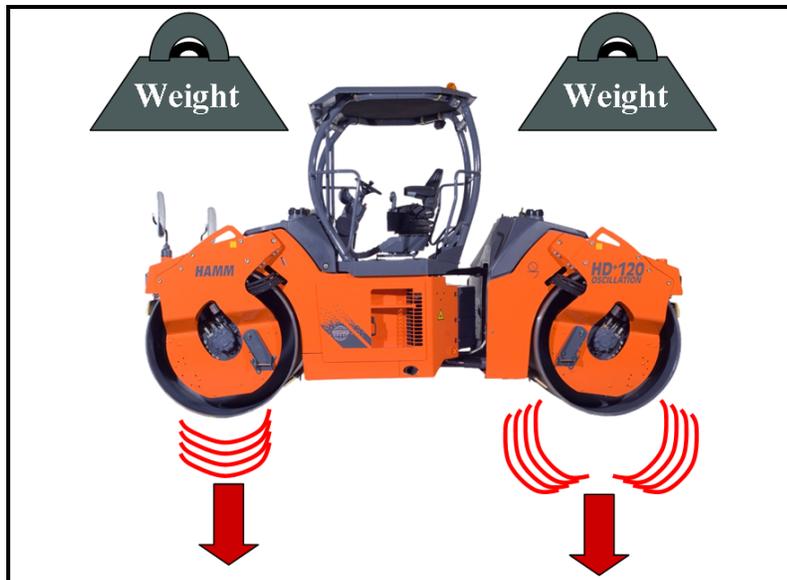


**Figure 3-12. Vibratory Roller**

Only vibratory rollers specifically designed for the compaction of HMA may be used. Vibratory rollers are required by Section **401.09(d)4** to be equipped with a variable amplitude system, a speed control device, and have a minimum vibration frequency of 2000 vibrations per minute. A reed tachometer is required to be provided by the Contractor for use in verifying the operation frequency.

### ***OSCILLATORY ROLLER***

An oscillatory roller (Figure 3-13) has dual, opposed, eccentric weights that rotate in the same direction around the drum axis. The rotation of the weights causes the drum to move in a rocking motion instead of a vertical motion that is provided by vibratory rollers. This rocking motion creates horizontal and downward shear forces. Because the drum does not bounce like a vibratory roller, the oscillatory roller provides a smoother surface of the mixture. Refer to Section **401.09(d)5** for additional information.



**Figure 3-13. Oscillatory Roller**

#### ***TRENCH ROLLER***

When the width of a trench is too narrow to accommodate a standard roller, a trench roller (Figure 3-14) is used for compaction. The trench roller is required by Section **401.09(d)6** to be of sufficient weight to exert a pressure of 300 pounds per linear inch of width for the compression wheel. The compression wheel may be either hollow or solid. Weight is added to hollow wheels by filling the wheel with water ballast. Counterweights are used for rollers with solid wheels.

To provide uniform compaction for the entire width of the compression wheel, the face of the wheel is required to be parallel to the surface being compacted. Trench rollers use a vertical adjustment on the wheel not in the trench to tilt the machine to accomplish this uniform compaction.



**Figure 3-14. Trench Roller**

### **MATERIAL TRANSFER VEHICLES**

Material Transfer Vehicles (Figure 3-15) or Shuttle Buggies are used to transfer mix from the haul trucks to the paver. The use of a Material Transfer Vehicle may greatly reduce the chances of segregation in the mixture and aid in maintaining a uniform paver speed.



**Figure 3-15. Material Transfer Vehicle**

### **HAUL TRUCKS**

Haul trucks (Figure 3-16) used to transport the HMA to the paver are required to be continuously monitored. Some checks the HMA Technician makes include:

- 1) Watch for truck beds that are leaking mix because the gates are not tight
- 2) Watch for foreign material in the mix which would indicate that the beds were not clean when loaded
- 3) Be sure the trucks are equipped with tarps and that the tarps are in place when needed to keep the material from cooling or becoming contaminated on route to the paver
- 4) Make sure the watertight tarps overlap the bed of the trucks enough to prevent rain and foreign material from getting into the mix
- 5) Have the tarps rolled back to inspect the appearance of the mix before allowing the load to be dumped
- 6) Watch for evidence of the excess use of approved anti-adhesive agent(s)
- 7) Check each truck for an easy to read identification number
- 8) Make sure there are no hydraulic or fuel leaks



**Figure 3-16. Haul Truck**

## **HAND TOOLS**

Normal hand tools used in the paving operation include shovels, lutes, ten-foot straightedges, and sixteen-foot straightedges with tolerance points (1/4, 1/2, 3/4) mounted on wheels.

## **CLEANING**

The paver hopper, conveyors, augers, and screeds are required to be cleaned at the end of each day. Any hardened mix is removed so the new mix is not contaminated when the paving is resumed.

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# 4 Mix Composition

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## **Quality Control/Quality Assurance**

*Quality Control Plan*

*Quality Assurance Procedures*

*Materials*

*Design Mix Formula/Job Mix Formula*

## **Hot Mix Asphalt (HMA)**

*Quality Control*

*Pay Item*

*Miscellaneous Mix Criteria*

*Acceptance of Mixtures*

## **Stone Mastic Asphalt (SMA)**

# CHAPTER FOUR:

## *MIX COMPOSITION*

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A HMA pavement is composed of binder and aggregate blended together to form various lifts of mixture. The individual material properties of each component may affect the overall performance of the pavement. If pavements are to perform long term and withstand specific traffic and loading, the materials making up the pavements are required to be of high quality.

This section covers the material requirements relating to HMA mixtures.

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### QUALITY CONTROL/QUALITY ASSURANCE

The Contractor is responsible for Quality Control (QC) of all phases of asphalt operations under Section **401**. This Section also includes the tolerances that are required to be met by the Contractor during the production and paving operations. To ensure that the Contractor's QC procedures provide a finished product with properties within the defined tolerances, INDOT uses Quality Assurance (QA) procedures. These procedures are designed to provide for inspection of the Contractor's QC processes and random sampling of the material placed. The QA process is completed by the testing of the mixture and core samples by District Testing personnel.

#### *QUALITY CONTROL PLAN*

The contract specific steps that the Contractor intends to use in the paving operations to ensure the construction of a quality pavement are included in the Quality Control Plan (QCP). The QCP is required to be prepared in accordance with **ITM 803** and submitted by the Contractor in accordance with Section **401.02**.

#### *QUALITY ASSURANCE PROCEDURES*

QA procedures require plate samples to be obtained from the pavement after placement by the paver. The samples are then transported to District Testing laboratory facilities for testing to determine the following volumetric properties:

- 1) Binder Content
- 2) Air Voids
- 3) Voids in Mineral Aggregate (VMA)

In addition, cores are taken to determine the in-place density of each compacted mixture.

District Testing personnel will provide QA test results for volumetric properties and density. These results will be forwarded to the PE/S and the Contractor as soon as possible after they become available.

Pavement smoothness is another parameter which requires QA review. On some contracts, longitudinal profile is measured by a profilograph. A 16 ft straightedge is used to verify the longitudinal profile for pavement segments that are exempt from profilograph measurement.

On contracts that do not include the profilograph pay item, the 16 ft long straightedge is used to verify longitudinal profile of the constructed pavement. The 16 ft straightedge shall be a rigid beam mounted on two solid wheels on axles 16 ft apart. The straightedge has a mounted push bar to facilitate propelling the device along or across the pavement. Tolerance points are located at the 1/4, 1/2, and 3/4 points and may be composed of threaded bolts capable of being adjusted to the tolerance required. At locations where the 16 ft long straightedge is used, the pavement variations shall be corrected to 1/4 inch or less.

Regardless of the instrument used to measure the longitudinal profile, a 10 ft straightedge is used to verify the slopes transverse to the mainline direction of traffic. This includes longitudinal profiles of all public road approaches and median crossovers.

## ***MATERIALS***

All QC/QA HMA mixtures are required to be produced by a certified HMA plant in accordance with **ITM 583**.

### ***Pay Item***

QC/QA HMA pay items have a standardized format that provides information about the type of material required. For example, a QC/QA HMA, 3, 70, Surface 9.5 mm pay item provides the following information:

- 1) "QC/QA HMA" represents Quality Control, Quality Assurance Hot Mix Asphalt
- 2) The "3" in the pay item reflects the ESAL category for the mixture. The ESAL category is a measure of the truck traffic that is anticipated on the roadway. There are five ESAL categories and larger numbers indicate higher anticipated truck volumes. Therefore, higher ESAL category mixtures require more durable aggregates to carry these additional anticipated loads.
- 3) The "70" in the pay item reflects the PG binder grade that is required for the mixture. Typical PG binder grades that appear in pay item descriptions include 58, 64, 70, and 76. Larger PG binder numbers indicate stiffer binders. These stiffer binders are typically

required at locations subjected to higher loads or where higher pavement temperatures are anticipated. Therefore, PG 70 and PG 76 are usually used in the upper courses of the pavement and are more common in pavements in the southern portion of the state. PG 76 binders are also used in open graded mixtures to prevent draindown of the binder.

- 4) The "Surface" in the pay item indicates the mixture type. Base, intermediate, and surface courses are the types of mixtures utilized in pavement. Base courses are usually placed on treated subgrades, but occasionally may be placed on a milled existing pavement as part of a three lift, or structural overlay. Intermediate courses are typically placed on underlying base courses or on a milled pavement as part of a two lift, or functional overlay. Surface mixtures are usually placed on underlying intermediate courses or on a milled pavement surface in a preventive maintenance overlay, sometimes referred to as a mill and fill.
- 5) The "9.5 mm" in the pay item reflects the nominal aggregate size utilized in the mixture. The available nominal aggregate sizes are 4.75 mm, 9.5 mm, 12.5 mm, 19.0 mm, and 25.0 mm. Mixtures with larger nominal aggregate size designations include larger particle sizes. However, the maximum particle size in a mixture is larger than the size noted in the nominal aggregate designation (refer to Section **401.05** for gradation range information).

#### ***Recycled Asphalt Pavement***

QC/QA HMA mixtures may also include recycled asphalt pavement (RAP) (Figure 4-1). There are maximum RAP amounts allowed in mixtures based on the course and ESAL category. The amount of RAP included in each mixture is identified in the Contractor's Design Mix Formula (DMF) or Job Mix Formula (JMF).



**Figure 4-1. Recycled Asphalt Pavement (RAP)**

### *Recycled Asphalt Shingles*

QC/QA HMA mixtures may also include recycled asphalt shingles (RAS) (Figure 4-2) that are obtained from the waste from a shingle manufacturing or from post-consumer (tear-off) shingles. There are also maximum RAS amounts allowed in mixtures based on the course and ESAL category. The amount of RAS included in each mixture is identified in the Contractor's DMF or JMF. RAS and RAP may be used together in a HMA mixture.



**Figure 4-2. Recycled Asphalt Shingles (RAS)**

### *Dense Graded Mixtures*

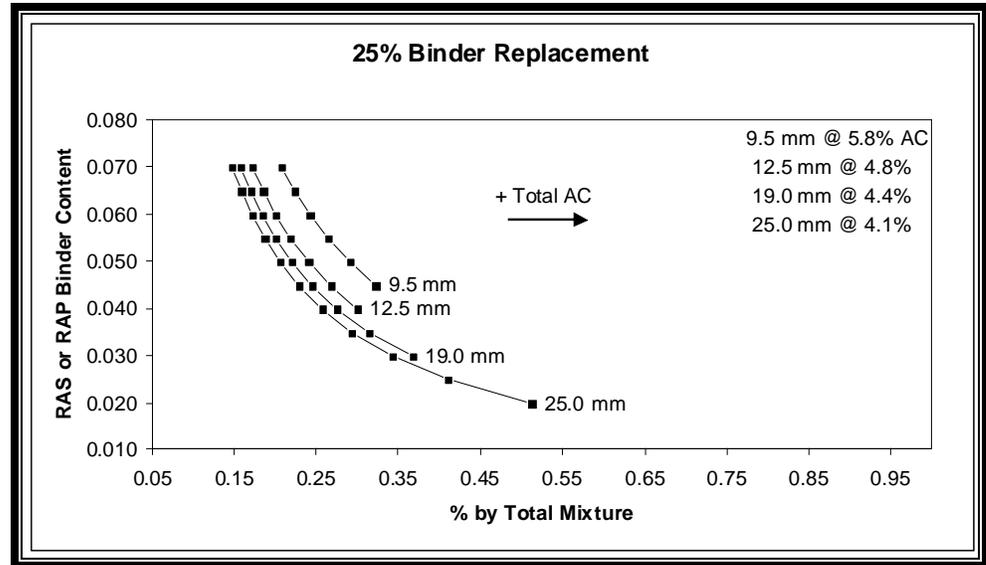
Dense graded mixtures are the structural component of the pavement. They consist of fine and coarse portions of the aggregate that are combined in the mixture. Designation of 4.75 mm, 9.5 mm, 12.5 mm, 19.0 mm, and 25.0 mm are examples of dense graded mixtures. Section **401.05** includes the gradation limits for these mixtures.

### *Open Graded Mixtures*

Open graded mixtures are used to drain the pavement structure and provide a means for water to reach the underdrain system, which is used in conjunction with these mixtures. OG 19.0 and OG 25.0 are the two open graded mixtures that are used. Section **401.05** includes the gradation requirements for these two mixtures.

**Binder Replacement**

The amount of RAP, RAS, or a combination of both that is allowed in HMA is based on the amount of binder in these recycled materials. Rather than specifying a maximum percentage of these recycled materials in the mixture, the amount of binder replacement of the virgin asphalt in the mixture is specified. The limits of the binder replacement in the mixture are specified in Section 401.06. Figure 4-3 is a graphical example of how the binder replacement requirement is applied.



**Figure 4-3. Binder Replacement**

The amount of total binder replaced by binder in the recycled material is computed as follows:

$$\text{Binder Replacement, \%} = \frac{(A \times B) + (C \times D)}{E} \times 100 \%$$

where:

- A = RAP, % Binder Content
- B = RAP, % in Mixture
- C = RAS, % Binder Content
- D = RAS, % in Mixture
- E = Total, % Binder Content in Mixture

**DESIGN MIX FORMULA/JOB MIX FORMULA**

The Design Mix Formula is the format by which the Contractor submits the design for each QC/QA HMA mixture to District Testing. **ITM 583**, Certified Hot Mix Asphalt Producer Program, is the primary document

that includes requirements related to the development of the DMF. The DMF includes the following information related to the mixture design:

- 1) Producer (Contractor)
- 2) Plant Location
- 3) Material Identification and Sources of the PG binder, coarse aggregates and fine aggregates
- 4) DMF number
- 5) Applicable ESAL Categories
- 6) Mixture Course and Nominal Aggregate Designation
- 7) Gradation Information
- 8) Specific Gravity
- 9) Lab and Plant Mixture Temperatures
- 10) RAP/RAS Content
- 11) Volumetric Properties
- 12) Mixture Adjustment Factor, MAF
- 13) Other Miscellaneous Design Information

Once a DMF is approved by the District Testing Engineer (DTE), the DMF is allowed an adjustment period each construction season that the design mix is used. The adjustment period is 5000 tons for base or intermediate mixtures; and 3000 tons for surface mixes. During the adjustment period, the gradation and volumetric properties may be adjusted by the Contractor. At the completion of the adjustment period, all adjustments are required to be noted in the resulting JMF. The JMF is required to be submitted by the Contractor to District Testing within one working day after the test results for the mixture volumetric properties are available for the adjustment period.

If the Contractor elects to use an approved JMF from the beginning of a contract, there is no adjustment period for the approved mixture.

## **HOT MIX ASPHALT (HMA)**

Hot Mix Asphalt (HMA) consists of base, intermediate, or surface mixtures placed in miscellaneous locations. These mixtures include rumble strips, wedge and level courses, temporary pavement, curbing mixtures, patching mixtures, and other mixtures in locations that the concepts of QC/QA acceptance are not practical. The requirements for HMA mixtures are specified in Section **402**.

### ***QUALITY CONTROL***

The QC requirements for HMA mixtures are identical to those required for QC/QA HMA mixtures. Additional information regarding QC may be found in Section **402.02**.

### ***PAY ITEM***

HMA mixture pay items include the design ESAL category for the mixture. For example, HMA Surface, Type A provides the following information:

The “Type A” portion of the pay item designates an ESAL category of 200,000. The ESAL categories range from Type A for the lowest anticipated truck traffic volumes to Type D for the pavements with the highest expected truck volumes. Unlike QC/QA HMA, HMA, mixture pay items do not include any reference to the PG binder required or a specific nominal aggregate size. Section **402.04** includes a minimum PG binder grade for each ESAL category and allows the Contractor to select the nominal aggregate size for each mixture.

### ***MISCELLANEOUS MIX CRITERIA***

Section **402.07** includes the specific requirements for miscellaneous mixtures. These requirements include the type of mixture, restrictions on the aggregates, and exclusions for the MAF and RAP, depending on the type of mixture used.

### ***ACCEPTANCE OF MIXTURES***

The primary difference between HMA and QC/QA HMA mixtures is the method of acceptance as specified in Section **402.09**. HMA mixes are accepted by a Type D Certification in accordance with Section **916**. The Frequency Manual designates the acceptance procedures for HMA mixtures in accordance with Section **402**. Because HMA mixtures are accepted by certification, no QA sampling or testing is required. The Producer is required to conduct QC Testing in accordance with the frequency designated in the Quality Control Plan for the HMA Producer Program/plant (**ITM 583**) and the Quality Control Plan for the contractor (**ITM 803**).

## STONE MASTIC ASPHALT

Stone Mastic Asphalt (SMA) is a tough, stable, rut-resistant mixture that relies on coarse aggregate-to-coarse aggregate contact to provide strength and a rich mortar binder to provide durability as specified in Section **410**. The coarse aggregate-to-coarse aggregate contact is obtained by designing with an aggregate skeleton that consists of a large percentage of very durable coarse aggregate. The mortar consists of asphalt binder, mineral filler (material passing the No. 200 sieve), and a stabilizing additive of either cellulose or mineral fibers.

The primary advantage of SMA is the expected extended life as compared to conventional dense-graded mixtures. This extended life is the result of providing better rut resistance and the potential to reduce reflection cracks. Other potential advantages are the reduction in tire splash and spray, and traffic noise.

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# 5 Preparation of Surface

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**Subgrade Treatment**

**Proofrolling**

**Milling**

**Patching**

**Wedge and Level**

**Base Widening**

**Cleaning**

**Tacking**

*Application*

*Curing*

# CHAPTER FIVE:

## *PREPARATION OF SURFACE*

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HMA pavements may be placed:

- 1) Over existing pavements, either HMA or concrete
- 2) On newly constructed subgrade, aggregate base or HMA base courses
- 3) For widening contracts, on a combination of existing pavement and a base course

The existing surface is required to be compacted, stable, and free from mud or other foreign matter before placing the new HMA pavement. Preparation for a HMA course may include subgrade treatment, proofrolling, milling, patching, leveling, wedging, and cleaning. The surface is required to be inspected for cross slope, potholes, base failure, dips, and bumps to determine the need for corrections.

The requirements of the Contractor for surface preparation are designated in the Quality Control Plan (QCP) for the contract, and the Technician is required to be familiar with these procedures.

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### SUBGRADE TREATMENT

Subgrade treatments on which HMA Base may be placed are specified in Section **207**. One of several Subgrade Treatment Types may be allowed and is specified in the Contract Plans and Section **207.04**. One subgrade treatment procedure is chemically modifying the soil (Figure 5-1).



**Figure 5-1. Chemically Modifying Soil**

## PROOFROLLING

In some cases the subgrade may be accepted by proofrolling according to Section **203.26**. A fully legally loaded tri-axle dump truck may be substituted for the pneumatic tire roller. Proofrolling is a visual means of determining whether or not the subgrade is compacted or stable and suitable to receive HMA base. A HMA base is required to be placed on an unyielding surface to sustain the design traffic loads when completed.

## MILLING

Milling is part of a pavement rehabilitation process where a portion of the old HMA pavement and/or PCCP is removed, or planed by a milling machine in preparation for an HMA overlay (Figure 5-2).



**Figure 5-2. Milling Machine**

Milling is done prior to repaving for many reasons including:

- 1) Removal of distressed pavement
- 2) Improve smoothness
- 3) Reshape cross slopes
- 4) Eliminate shoulder work after new layer(s) are placed (mill and fill)
- 5) Maintain curb exposure
- 6) Maintain clearances and other drainage features
- 7) Transitions to approaches or other pavement where new paving stops

- 8) Roughing the existing surface texture to remove asphalt joint material

There are several different pay items for milling depending on the application. The specific type of milling is specified in the contract. Milling is paid by the square yard (SYS) and is specified in Section **306**. The types of milling include:

- 1) Approach Milling
- 2) Asphalt Milling
- 3) Asphalt Removal
- 4) PCCP Milling
- 5) Scarification/Profile Milling
- 6) Transition Milling

The macrotexture after milling is required to be checked in accordance with **ITM 812** and Section **306.04**. Milling procedures and procedures to check macrotexture and cross slopes are required to be described in the QCP.

The millings produced become the property of the Contractor and may be transported to a HMA plant facility for use as recycled asphalt pavement (RAP). When specified, millings may be used to construct shoulders.

## **PATCHING**

Unsuitable areas are required to be identified and marked for removal by INDOT personnel. Areas to be removed include potholes, base failures, unstable mixes in place, and spots with excess asphalt. If the pavement to be patched is overlaid, the edge of the removal area is not required to be sawed. The removal area is required to conform to the marked lines to minimize over-breakage. If the patch is not overlaid, a neat edge for the patch is required to be attained by sawing. The size of the patches depends on the conditions found on the contract. The size and depth of the excavation are required to be measured and recorded for determination of the pay quantities. A typical full depth HMA patch section is illustrated in Figure 5-3.

Where unstable material is encountered below the existing pavement in the base, subbase, or subgrade, this material is removed. The sides of the excavation are required to be vertical. The HMA may not be properly compacted against sloping sides. The bottom of the removal area is compacted and the area backfilled with suitable material up to the bottom of the existing pavement. The backfill material is placed in 6 in. lifts and compacted thoroughly.

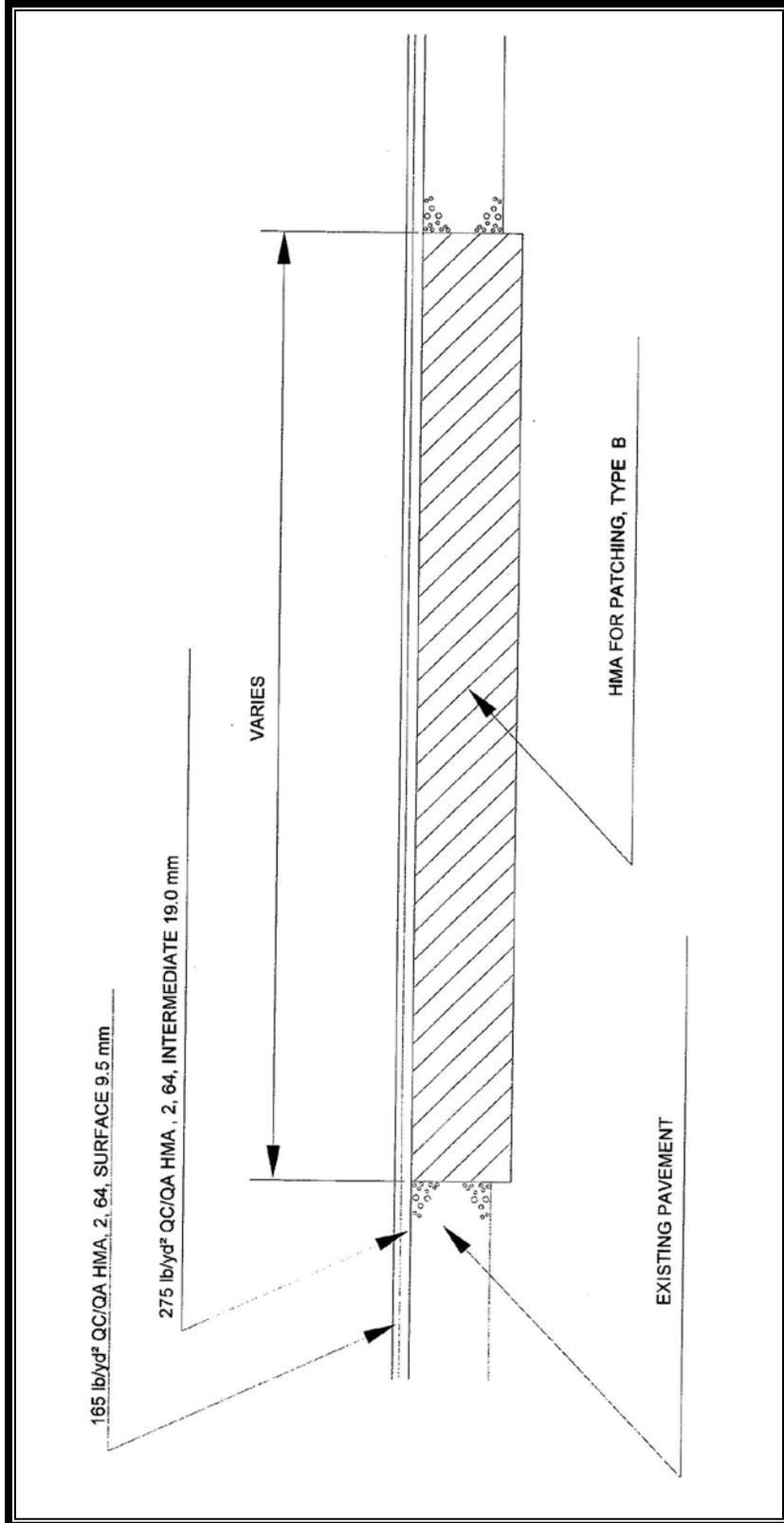


Figure 5-3. Typical Full Depth HMA Patch Section

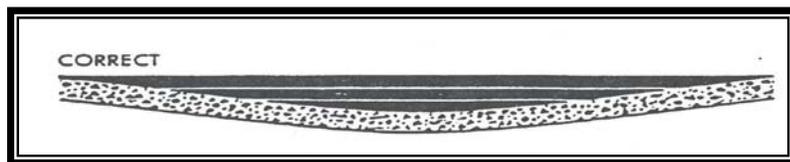
Before placing the HMA patching material, the edges of the existing mat are cleaned and tacked with asphalt to ensure a bond between the old surface and the new mix. In placing the patching mixture, the depth of each lift cannot exceed four times the maximum nominal particle size as indicated on the DMF. Each lift is required to be compacted before placing the next lift. The surface of the patch is required to be placed approximately 1/4 in. high, and be flush with the existing surface after the compaction is completed.

Patching operations are scheduled so that all removal areas opened during the day are completely patched at the close of the work day to allow opening the lane to traffic. When a patch cannot be completed, the HMA is backfilled, compacted, and a temporary surface placed to carry traffic during the night. All temporary work is at the expense of the Contractor and is avoided if at all possible.

### WEDGE AND LEVEL

When the surface of a pavement is irregular, the surface is required to be brought to a uniform grade and cross section. Normally, milling is specified to correct this problem; however, sometimes a leveling course is used. Wedge and level may not be the best practice since proper compaction is difficult when non-uniform thicknesses are placed. The HMA materials used are specified in the contract and Section 402.07(d). Wedges of HMA are used to level sags and depressions in an old pavement prior to the paving operation.

Leveling and wedging material is required to be placed in lifts to ensure compaction. The top of each lift is required to be parallel to the desired profile or cross section as shown in Figure 5-4.



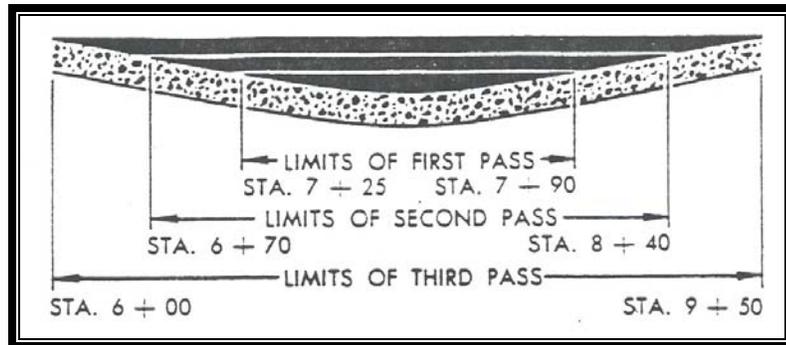
**Figure 5-4. Correct Wedge and Level**

Because of the difficulty of feathering the edges of HMA mixtures, placing the material in lifts parallel to the existing surface (Figure 5-5) usually results in rough patches that reflect to the finished surface.



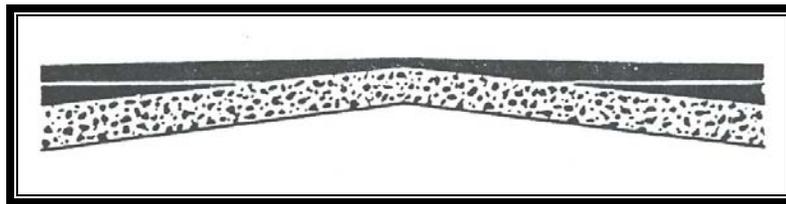
**Figure 5-5. Incorrect Wedge and Level**

The number and lengths of lifts are determined by the allowable lift thickness and the depth of the area to be leveled (Figure 5-6).



**Figure 5-6. Wedge and Level Lifts**

Wedges are also used to re-establish the crown on a tangent roadway or superelevation on a curve (Figure 5-7). 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 in the mix.



**Figure 5-7. Crown Wedge**

The finished depth of any course is required to be at least 1.5 times but not more than 6 times the maximum particle size as shown on the DMF or JMF. Feathering may be less than the minimum thickness requirements.

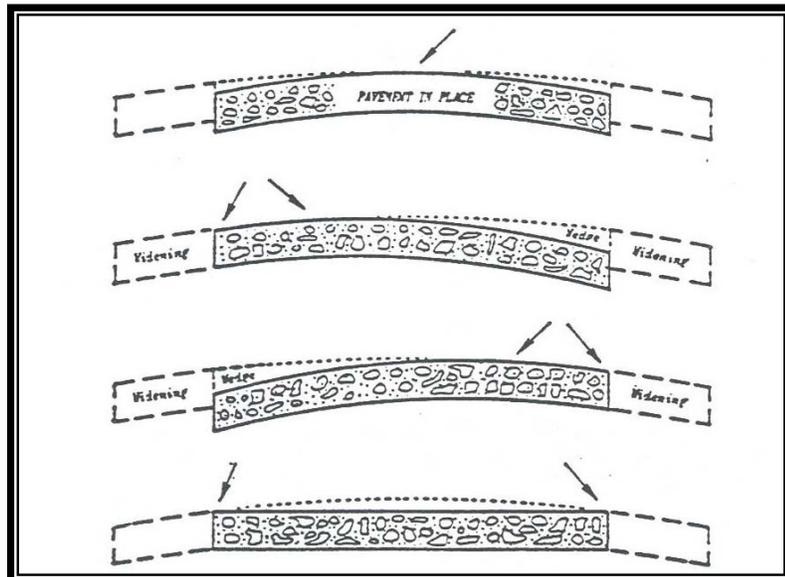
Acceptance of patching material and wedge and level is done on the basis of a Type D certification. This certification is required to be delivered to the job-site each morning before any mix may be accepted. Typically, the first truckload of material is delivered with the Type D certification. The Type D certification is required to report the air voids and binder contents of the mix. The allowable deviations from the DMF are 1.5 % for air voids and 0.7 % for the binder content. If the results do not comply with these requirements, the HMA is processed as a failed material.

## BASE WIDENING

With the increased emphasis on rehabilitation of existing roadways, more contracts require widening and resurfacing. The width of the widening, either on one or both sides of the pavement, and the type of base mixture are indicated on the plans or specified in the contract.

The area to be widened is usually excavated with a trenching machine, milling machine or motor grader, depending on the width. The subgrade is then compacted and the widened area backfilled to the planned line and grade. When the profile and alignment of the existing pavement edge is satisfactory, the edge may be used as a guide in excavating the widening trench. However, when either of these is irregular, field work and planning are required to establish line and grade before the Contractor begins work. Pavements to be surfaced are sometimes warped with variable or inverted crowns. On tangents, one edge may be higher than the surface at the centerline.

Typical examples of warped and non-uniform crowned pavements are shown in Figure 5-8. Sections needing correction may have excessive crown, one edge higher than the other, or no crown. In each instance, wedging is required. The controlling point for establishing the final profile is indicated by the arrows in Figure 5-8. The wedges are required to be placed before excavation of the widening sections is started so that a good reference for line and grade is established.



**Figure 5-8. Warped and Non-Uniform Crowned Pavements**

## CLEANING

The existing surface is required to be cleaned before applying the tack coat. Normally, cleaning may be done by sweeping, but sometimes mud or other foreign matter is required to be removed with shovels and hand brooms. Where dirt is embedded, a pressure washer or compressed air may be required for thorough cleaning. Typically power brooms are used for sweeping (Figure 5-9).

Excess asphalt material at cracks and joints is required to be removed to the elevation of the existing surface or below. Failure to remove the excess asphalt materials results in "bleeding" of the asphalt through the subsequent courses causing bumps or other irregularities in the surface.



**Figure 5-9. Power Broom**

## TACKING

A tack coat is the application of asphalt material to an existing paved surface (Figure 5-10). The primary purpose of the tack coat is to adhere the newly placed HMA to the old surface. Tack coats are covered by Section **406**. The material that is used for tacking is Asphalt Emulsion, AE-T, AE-PMT, SS-1h or AE-NT (Section **902.01(b)**).



**Figure 5-10. Tack Application**

***APPLICATION***

Tack coats are applied to have the least inconvenience to traffic and to permit one-way traffic without tracking or picking up of the material. Typically, nearly all of the tacked area is covered by mix each day. Tack coat may not be applied to a wet surface. The rate of application, temperature, and areas to be treated are required to be approved by the PE/PS before the application of tack material. In the event of rain or other circumstances where the tack coat remains uncovered, the material may be lightly sanded and provisions made for traffic safety.

The two essential requirements of a tack coat are:

- 1) The application of the asphalt material is required to be very thin
- 2) The material is required to uniformly cover the entire surface of the area to be paved without puddling or streaking

The asphalt material is required to be uniformly applied with a pressure distributor at a rate from 0.03 to 0.08 gallons per square yard unless otherwise specified or directed. The tack coat is not applied heavily. Too little tack is better than too much. The texture and absorption of the existing surface affects the desirable application rate.

The application rate depends on the speed of the truck, the length of the spray bar, the pump pressure, and the pump speed. Each distributor is equipped with charts or computerized systems for determining the correct setting for the pump and truck speed for any given spray bar length and application rate. When the Contractor cannot get uniform coverage and streaking or puddling continues despite adjustments to the distributor, the use of a burlap drag may be required. The tack coat may be mopped, broomed, or squeegeed to obtain a more even distribution or to facilitate curing.

Areas inaccessible to the spray bar are tacked with the hand spray. Extreme care is required to be taken with the hand spray to obtain uniform coverage without puddling.

### ***CURING***

Time is required to allow the asphalt emulsions to break and cure before the HMA is placed on the tack coat. The emulsion turns from brown to black and becomes sticky when the material "breaks" and the water evaporates.

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# **6 Weighman**

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**Inspection of Hauling Trucks**

**Weighing Operation**

**Weigh Tickets**

**Weighman's Daily Report**

**Truck Load Limits**

# CHAPTER SIX:

## *WEIGHMAN*

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Today the position of the weighman is not nearly as prominent as when HMA plants were not computerized and certified by the Testing Department. Currently, a weighman is only required at the HMA plant site if the weigh scales are not computerized. A Contractor's representative is responsible for recording the individual weight of the trucks when this occurs. If a weighman is not required at the HMA plant, the inspection procedures detailed herein are conducted at the paving operation.

HMA mixtures are paid for by the ton. If a weighman is required, their responsibility is to ensure that the correct weight of each truckload of mix is determined and recorded.

HMA mixtures are weighed on approved truck scales furnished by the Contractor or on public scales at the expense of the Contractor. The automatic printing systems may be used with the scale systems of automatic batching type plants instead of truck scales. This setup is required to be certified by the District Testing Department.

The duties of the weighman include:

- 1) Inspecting hauling trucks for compliance with Specifications and the Quality Control Plan (QCP)
- 2) Establishing the tare weights of the trucks twice each day (if computerized scales are not used)
- 3) Observing the weighing operation to ensure accurate measurements
- 4) Checking and signing the weigh tickets
- 5) Completing the Weighman's Daily Report

## INSPECTION OF HAULING TRUCKS

The weighman is responsible for checking the haul units for compliance with Specifications. The Contractor's plan for ensuring proper transportation and handling of the HMA is required to be addressed in the QCP. The HMA technician should be familiar with the QCP before paving operations begin and a copy of the QCP should be kept near the paving operation at all times for reference. Checks to be made include:

- 1) Truck beds are required to be tight, smooth, and clean
- 2) Trucks are required to be equipped with a watertight cover to protect the mixture from rain, dust, snow, or any other foreign material
- 3) Loads should be covered by tarps under the following conditions:
  - a. The air temperature is dropping below 65°F.
  - b. There is a possibility of rain
  - c. High wind conditions where dust or other foreign matter may collect in the mixture
  - d. Mix temperature requirements are marginal at the paver or if crusting occurs on the load
  - e. If the material is a surface mixture. These mixtures should always be tarped unless the mixing and paving operations are so close to each other that the mix temperature measured at the surface of the load is within the specified temperature range.
  - f. The QCP indicates the truck is required to be covered
  - g. Other adverse conditions exist

- 4) A minimum amount of an approved anti-adhesive agent may be used in the truck beds to prevent the mix from sticking. A list of approved anti-adhesive agents may be obtained from the Office of Materials Management (OMM). The truck bed is required to be in the raised position if a non-foaming anti-adhesive is applied and remain raised until the excess anti-adhesive has drained from the bed.
- 5) All trucks are required to have an easily identified number
- 6) Trucks should have no hydraulic or fuel leaks, as this material may damage the pavement

## **WEIGHING OPERATION**

Before a scale may be used, a seal is required on the scale indicating that the Bureau of Weights and Measures has checked the scale within the last year. Scales not sealed or having seals dated one year or older are not allowed to be used.

The balance of the scale is required to be checked twice each day. When the platform is clean, the scale should read zero. If the scale doesn't balance, the scale should not be used.

The Specifications require the Contractor to furnish an employee to perform the actual weighing of the trucks and writing of tickets. The INDOT weighman should observe the weighing operation very closely to ensure that the mix is weighed properly. Once again, these conditions are only required if the HMA plant is not a computerized and certified plant.

When batch weights are used for HMA mixtures made with asphalt emulsions, the weight of the asphalt emulsion in the batches is required to be reduced by 30 percent to correct for the weight of the water in the emulsion.

The plant scale system may include an approved automatic printer system that prints the individual or accumulative weights of the materials in each batch, provided the printer system is used in conjunction with approved automatic batching and mixing control equipment and software. The printout of the weight of each batch and the total weight of all batches in a load are required to be on one ticket. This is considered the weigh ticket for the load. If this system is used, random loads may be selected to be weighed on commercial scales as frequently as directed. However, on contracts of 5000 tons or more, a load selected at random is required to be checked during the first day of production and as frequently thereafter as directed. The gross weight of the check load, tare weight of the truck over

the same scale, and the net weight of the mixture are required to be recorded on the weigh ticket attached to the printout ticket and retained in the file of the PE/S. The net weight of mixture in the check load is required to not vary from the total weight of mixture recorded on the printout ticket by more than 200 pounds for loads up to 10 tons, 300 pounds for loads from 10 to 15 tons, or 400 pounds for loads over 15 tons. Note: Nearly all Contractors use the automatic system today, and the use of a non-computerized weigh system has become the exception rather than the norm.

## **WEIGH TICKETS**

The weigh tickets furnished by the Contractor are required to have the following information:

- 1) Ticket serial number
- 2) Date
- 3) Contract number
- 4) Source of supply
- 5) Material designation (size and type)
- 6) DMF or JMF number
- 7) Truck number
- 8) Time weighed
- 9) Gross weight
- 10) Tare weight
- 11) Net weight
- 12) Two signature lines

The space on the weigh ticket for moisture content is not used for hot mix asphalt.

The INDOT weighman is required to check the information and sign the ticket. The ticket is given to the truck driver to deliver to the HMA technician when the load is delivered to the paving site. The HMA technician signs the white copy (original). Full signatures are required for both the weighman and the HMA technician. Once again, if a computerized system is used, the technician at the paving operation

accepts the ticket and verifies that all information is on the ticket is correct.

## **WEIGHMAN'S DAILY REPORT**

The weighman's report is be completed daily. The tare weights for each truck are recorded twice each day.

Separate forms are required to be completed when the plant is supplying more than one contract. Only one form is required for each contract if more than one type of material is furnished.

## **TRUCK LOAD LIMITS**

It is a violation of State law and Section **105.12** to haul overweight loads on any public road. The INDOT weighman is responsible to ensure that overweight trucks are not sent to the contract. The weigh ticket should not be signed until the truck complies with the legal load limits. If there is a problem, the PE/S should be contacted.

The Indiana Weight Limitation Law provides that:

- 1) The total gross weight not exceed the following weights:

Tri-Axle	68,000 pounds
Quad-Axle	73,280 pounds
Tractor Trailer	80,000 pounds

- 2) The total weight from any tandem axle group not exceed 17,000 pounds per axle
- 3) An axle weight not exceed 20,000 pounds
- 4) The maximum wheel weight not exceed 800 pounds per inch width of tire as measured between the flanges of the rim

The local Indiana State Police Post should be contacted if load limit infractions become a problem on the contract.

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# 7 Mix Placement and Compaction

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## Weather Limitations

### Asphalt Materials

*Prime Coats*

*Tack Coats*

*Base Seals*

*Fog Seals*

*Joint Adhesive*

*Distributor*

### Mixture Transportation

*Haul Trucks*

*Truck Driver Responsibilities*

*Dump Person Responsibilities*

*Material Transfer Vehicles*

### Mix Temperature and Appearance

### Placement of Mixture

*Pavers*

*Paver Operation*

*Start-Up*

*Alignment*

*Grade and Slope Control*

*Transverse Joints*

*Longitudinal Joints*

*Care and Cleaning of Pavers*

*Paving Crew Responsibilities*

## **Compaction**

*Compaction of HMA*

*Specified Rollers*

*Plant Production-Number of Rollers*

*Compaction Controlled by Density*

*Widening*

*Rolling Patterns*

*Roller Operator Responsibilities*

# CHAPTER SEVEN:

## *MIX PLACEMENT AND COMPACTION*

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The procedures for mix placement and compaction are in general specified by the Contractor in the Quality Control Plan for QC/QA HMA (401), HMA (402) and SMA (410) mixtures for the contract.

The paving and compaction equipment on a HMA contract are distributors, pavers, material transfer devices, widening machines, rollers, and hauling units (trucks). Before paving operations may be started, all of the paving equipment is required to be checked for conformance with the Specifications and the Contractor's Quality Control Plan. A pre-paving meeting is a good practice to assure that all of the personnel involved in the paving and compaction operation understand the procedures to be used on the project. Pre-paving meetings should be held prior to beginning paving operations for the project, prior to phase changes in a project, and at the beginning of each construction season for multi-year projects.

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### WEATHER LIMITATIONS

Hot mix asphalt may be placed only when weather conditions are favorable. Placing the mix on a cold surface or when the air temperature is low causes the mix to cool too quickly. No mixture may be placed on a frozen subgrade. QC/QA HMA courses of less than 138 lb/yd<sup>2</sup> and SMA mixtures are required to be placed when the ambient temperature and the temperature of the surface on which the mix is to be placed is 45° F or above. For Non-QC/QA HMA, minimum temperatures have been established and are summarized in the following table:

HMA Courses	Air Temperature	Surface Temperature
Equal to or greater than 220 lb/yd <sup>2</sup>	32° F	32° F
Equal to or greater than 110 lb/yd <sup>2</sup> , but less than 220 lb/yd <sup>2</sup>	45° F	45° F
Less than 110 lb/yd <sup>2</sup>	60° F	60° F

HMA courses may be placed at lower temperatures provided the density of the HMA course is controlled by cores as indicated in Section 402.16.

Paving mixtures may not be laid on wet surfaces or when other conditions are obviously not suitable, even if air and surface temperatures are within the limits.

Mixing at the plant is required to stop when rain starts; however, material, which is on the way to the contract, may be placed if the rainfall is light enough to avoid excessive cooling or honeycombing after compaction. Since rain may be prevalent at the paving site but not at the plant, a means of rapid communication is required to be provided to prevent having several loads of material delivered which may not be used.

## **ASPHALT MATERIALS**

### ***PRIME COATS***

Prime coats are used on rubblized concrete pavements to protect the pavement from wet weather. This waterproofing layer prevents excess moisture absorbing into the pavement during rain before paving. The prime coat also allows the pavement to be used for light traffic, binds together any dust on the surface and promotes the bond between the pavement and the HMA overlay. Section **405** includes the requirements for the allowable materials, equipment, preparation of surface, and application rate of asphalt materials and cover aggregate for prime coats. The asphalt material is not allowed to be applied on a wet surface, when the ambient temperature is below 50° F, or when other unsuitable conditions exist, unless approved by the Engineer. The rubblized concrete pavement to be treated is required to be shaped to the required grade and section, free from all ruts, corrugations, or other irregularities, and uniformly compacted and approved.

### ***TACK COATS***

Tack coats are used to ensure a bond between an existing HMA mixture and the new HMA mixture. If a good bond is not formed, slippage of the overlay in a longitudinal direction by traffic may occur. Section **406** includes the allowable materials, equipment, and application rate of the asphalt material for tack coats. The existing HMA mixture to be treated is required to be free of foreign materials that may be detrimental to the purpose of the tack coat. Tack coats are not allowed to be applied to a wet surface. The rate of application and areas to be treated are required to be approved prior to application. Excessive tack coat is required to be corrected to obtain an even distribution of the material.

### ***BASE SEALS***

Base seals are used on dense graded base mixtures that are immediately below open graded mixtures within the pavement structure. The base seal prevents water carried through the open graded mixture from penetrating the dense graded base course and saturating the subgrade below. Section

**415** provides additional information on material and construction requirements.

### ***FOG SEALS***

Fog seals are used in conjunction with a joint adhesive to prevent water from penetrating the pavement structure. Because of the difficulty in compacting the asphalt mixture at the longitudinal joint, the fog seal is applied to assist in sealing the material on each side of the joint. If a milled centerline corrugation is applied, the fog seal will seal any cut aggregates that may occur because of the corrugations. Section **412** provides additional information on material and construction requirements.

### ***JOINT ADHESIVE***

Joint adhesive is required between adjacent mats to provide a waterproof seal at the joint. The joint adhesive is a hot asphalt material that is applied using a wand applicator on the joint face 1/8 in. thick at the temperature recommended by the manufacturer. The application of the adhesive is made within the same day, but at least 15 minutes prior to construction of the longitudinal joint. **RSP 401-R-581** includes the material and construction requirements for joint adhesive.

### ***DISTRIBUTOR***

A distributor is used to apply the liquid asphalt material used for the prime and tack coats. The distributor consists of an insulated tank mounted on a truck or trailer. A power-driven pump forces the asphalt through a system of spray bars and nozzles onto the construction surface. A burner, usually oil-fired with flues within the tank, is used to heat the asphalt to the proper application temperature. The major units for a typical distributor are indicated in Figure 7-1.

The distributor is required to:

- 1) Maintain the liquid asphalt at a uniform temperature
- 2) Apply material at a uniform rate
- 3) Apply material at variable widths

The distributor is required to be equipped with:

- 1) Accurate volume measuring gauges or a calibrated tank
- 2) A thermometer for measuring temperatures
- 3) A power unit for the pump

- 4) Full circulating spray bars to prevent material cooling in the spray bars. The spray bars are required to be adjustable vertically.



**Figure 7-1. Distributor**

## **MIXTURE TRANSPORTATION**

### ***HAUL TRUCKS***

Haul trucks (Figure 7-2) used to transport the HMA to the paver should be continuously monitored. Section **402.13** requires HMA in the haul trucks to be protected by tarps from adverse weather conditions or foreign materials. Adverse conditions include, but are limited to, precipitation or temperatures below 45° F. The QCP is required to include the criteria for when waterproof covers are used and designate the person responsible for directing the use of these covers. In addition, the procedures for truck unloading and for removing the remaining mixture from the truck bed and apron are required to be included in the QCP.



**Figure 7-2. Haul Truck**

***TRUCK-DRIVER-RESPONSIBILITIES***

The truck driver responsibilities include assuring that the truck is loaded properly and that there is a consistent delivery of HMA in a homogeneous mass into the paver hopper or transfer unit without causing segregation. Specific responsibilities of the truck driver when using a dump truck include:

- 1) Load the truck using multiple drop procedures
- 2) Tarp the load as required to maintain mix temperatures
- 3) Proceed safely to the paving site and line up properly in front of the paver or transfer unit
- 4) Back into the paver or transfer unit without bumping
- 5) Open the tail gate and discharge the mixture in a mass when the paver or transfer unit makes contact with the truck
- 6) Continue to raise the bed while moving to allow the material to be discharged in a mass
- 7) Exit immediately when the truck is empty

An alternate procedure for unloading the truck into the paver is possible by raising the bed prior to releasing the tailgate. The procedure is as follows:

- 1) Back the truck into discharge position stopping short of the paver by 1 to 2 inches
- 2) Raise the bed slowly until the load shifts to the rear. The paver operator will start the paver forward when he observes the shift of material
- 3) Release the tail gate when the forward motion is detected and continue to raise the bed as directed

#### ***DUMP PERSON RESPONSIBILITIES***

The dump person responsibilities include safely directing the truck into the correct position for discharging the truck into the hopper. Specific responsibilities include the following:

- 1) Be aware of the safety in and around the paving site, especially overhead obstructions, and warn the paving crew if dangerous situations arise
- 2) Safely direct the truck into the discharge position without bumping the paver and assuring alignment of the paver and truck to make steering to reference points much easier
- 3) Watching the hopper to assure that the hopper does not run low or empty. The hopper should be at least 25% full at all times.

## ***MATERIAL TRANSFER VEHICLES***

Materials Transfer Vehicles (Figure 7-3) are often used to transfer the mixture from the trucks to the paver and provide the benefits of reduced segregation and increased smoothness. They also may reduce the number of trucks required to deliver the mixture to the paver and improve the balance of the production, paving and compaction operations. If used on a project, **ITM 803** requires that the type and size of the Material Transfer Vehicle and the plan for crossing bridges be included in the Quality Control Plan.



**Figure 7-3. Material Transfer Vehicle**

The Material Transfer Vehicle operator responsibilities include receiving the HMA from the trucks and transferring the HMA into the hopper.

## **MIX TEMPERATURE AND APPEARANCE**

The quality and temperature of the mix at the paving site should be continually monitored. This is done by visually observing each load and by periodically checking the temperature of the mix before being unloaded.

When the mix arrives at the site, the following items should be checked:

- 1) The top size of the aggregate is checked to verify that the size is correct for the mix course being placed. The mix designated on the ticket is required to match the type of mix designated for that course.
- 2) The mix is required to be of similar color throughout the load. Improper mixing at the plant may result in some parts of the mix being lighter in color than others.

- 3) All aggregates are required to be coated with asphalt. Large coarse aggregate may not be entirely coated because of the rough surface texture.
- 4) Puddles of asphalt sitting on the mix indicate insufficient mixing. These loads are not acceptable.
- 5) Blue smoke rising from the mix is an indication that the temperature of the mix is too hot. The temperature of the mix is checked to confirm this observation. A smoky load may also indicate the use of fuel oil as an anti-adhesive in the truck bed.
- 6) The aggregate particles are required to be distributed throughout the mix. If the coarse aggregates tend to roll out of the truck into the paver at the very beginning or very end of the load, the mix is segregated. Segregation is the most common mix problem.
- 7) Specifications require the maximum plant discharge temperature to be no more than 315 °F when PG 58-28, PG 64-22, PG 64-28, or PG 70-22 binders are used and not more than 325 °F when PG 70-28 or PG 76-22 binders are used. Mixture temperatures at the paver site should never be higher than these temperature limitations.

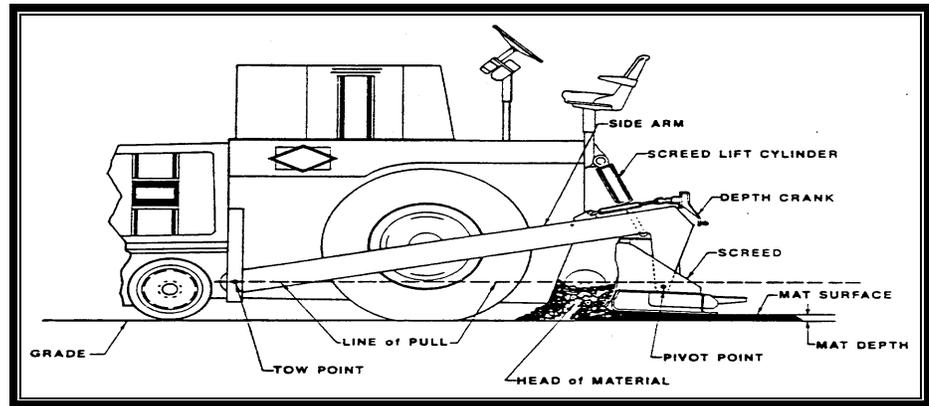
To attain the best results, HMA mixtures are required to be placed at the optimum temperature. The temperature of each mixture at the time of spreading is required to not be more than 18° F below the minimum mixing temperatures indicated on the DMF/JMF for non-QC/QA mixtures. Normally, a surface thermometer is sufficient for obtaining an accurate temperature of the mixture.

## **PLACEMENT OF MIXTURE**

### ***PAVERS***

HMA mixtures are spread and finished with the use of paver finishers and widening pavers. The HMA paver spreads the mixture in either a uniform layer of a desired thickness or a variable layer to a desired elevation and cross section. Widening pavers are used for widths of less than 8 ft where the normal paver cannot operate.

There are many types of pavers available for placing HMA mixtures. The discussion in this chapter does not include all of the variations available on all pavers. Figure 7-4 illustrates the various components that are common to many pavers.



**Figure 7-4. Paver Components**

***PAVER OPERATION***

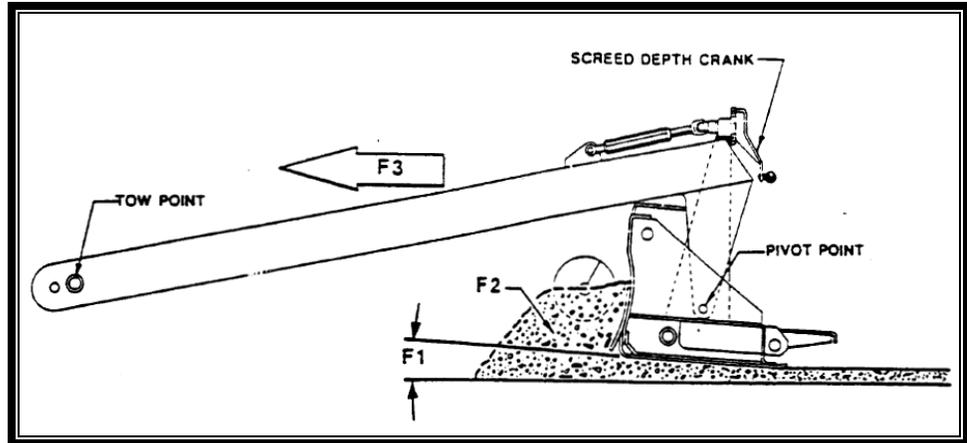
The operation of the paver is different for the various types of equipment used in the HMA Industry. The information provided in this section may or may not apply to all pavers and is intended to provide information on the general operations of a paver.

Controlling the vertical position of the free-floating screed, with respect to the grade surface over which the paver is moving, is the primary concern in producing high quality paving.

Several factors, such as the paving speed, head of material, mix consistency, pre-compaction, and screed angle of attack influence the vertical position of the screed. If any one of these factors is varied during the paving operation, the variation causes a change in the mat depth, density, and/or texture.

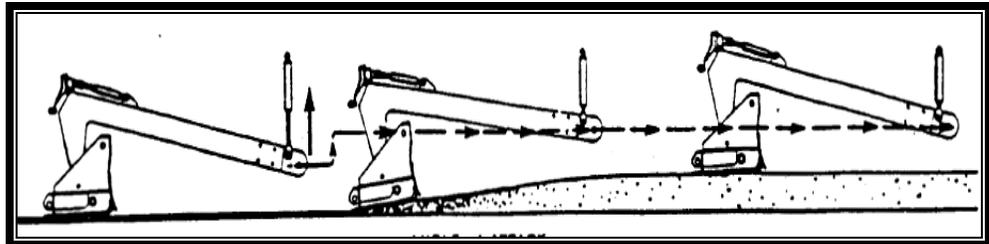
The three primary variable factors which influence the vertical position of the free-floating screed (Figure 7-5) are:

- 1) Factor F-1 -- Angle of Attack
- 2) Factor F-2 -- Head of Material
- 3) Factor F-3 -- Paving Speed



**Figure 7-5. Free Floating Screed**

The angle of attack is the angle that exists between the bottom surface of the screed and the grade surface over which the paver is moving. Paving over a flat, level surface with all variables held constant produces 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 7-6. The restoration action of the screed is referred to as self-leveling.



**Figure 7-6. Angle of Attack**

When the angle of attack is increased, more material is allowed to pass under the screed causing the screed to rise until the screed is again moving in a plane essentially parallel with the grade surface.

Decreasing the angle reduces the amount of material allowed to pass beneath the screed, causing the screed to drop until the screed is again parallel to the grade.

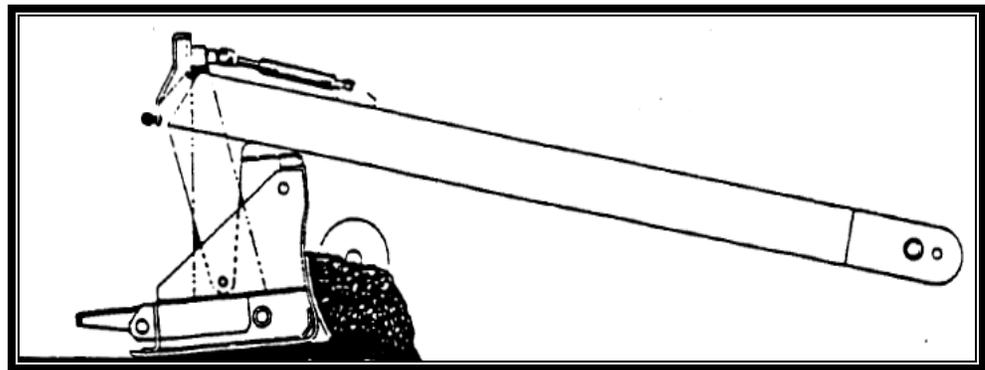
The angle of attack is controlled by either manual screed depth cranks or automatic level controls. One full turn of the depth crank raises or lowers the screed approximately 1/4 in.

Adjustments are made in small increments to produce a smooth riding pavement. The change in depth begins immediately after adjusting the crank; however, the paver is required to move approximately 5 times the

length of the screed side arm before the full change in thickness is completed. Once the paver is adjusted for the correct mat thickness very little adjustment of the depth crank is required.

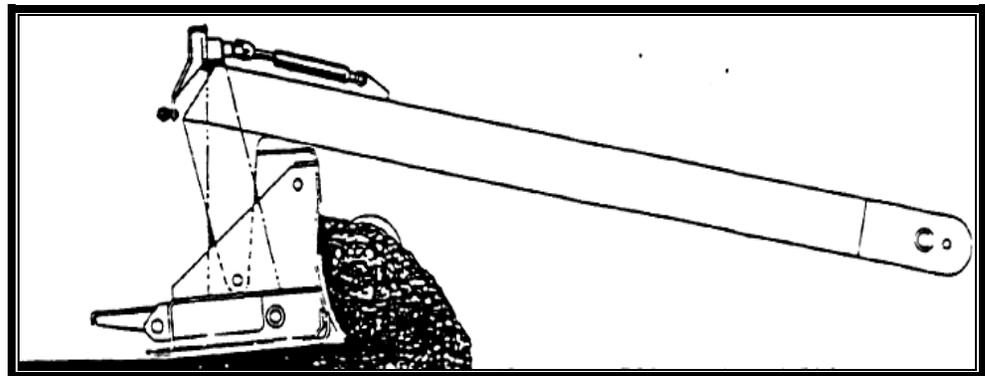
The head of material is the volume of paving material directly in front of and along the entire length of the screed. The volume and consistency of the head of material are primary factors in the amount of mix that flows under the screed that affect the mat density, texture, and profile. The volume in 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 is maintained at a near constant level from the center to almost covering the auger shaft along the entire length of the screed (Figure 7-7). Modern pavers have automatic controls to maintain the correct level.



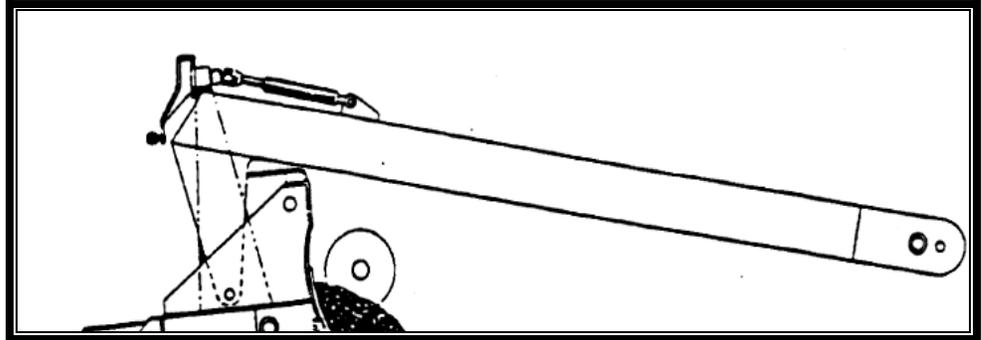
**Figure 7-7. Correct Head of Material on Screed**

If the head of material is too high (Figure 7-8), the resistance to forward travel is increased. The screed rises and may cause ripples, auger shadows, long waves, increased depth, or a less dense mat.



**Figure 7-8. Head of Material Too High on Screed**

If the head is too low (Figure 7-9), the resistance to forward travel is decreased and the screed gradually falls, resulting in a thin mat and possible voids in the mat.



**Figure 7-9. Head of Material Too Low on Screed**

A fluctuating head of material results in a combination of the mat deficiencies described above plus alternating changes in the mat texture and depth.

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

The paving speed to match the plant production may be computed for any planned quantity. The paving speed and plant production are required to match and be outlined in the Quality Control Plan.

Pavers may not operate at speeds in excess of 50 ft per minute for mixes that are not density controlled by cores. Paver speeds in excess of this speed often result in non-uniform surfaces.

Whenever the absence of loaded trucks necessitates a pause, the paver is stopped with a substantial quantity of mix ahead of the screed. Operating the paver until the mix is too low ahead of the screed results in a dip in the pavement.

In addition to the three major factors discussed, other improper operating procedures which may affect the riding quality of the pavement are:

- 1) Truck bumping the paver -- this practice is the most common cause of transverse marks and ridges in the finished mat. Drivers are required to stop their trucks ahead of the paver and let the paver operator pick up the truck as the paver travels forward.
- 2) Truck driver holding brakes -- this practice reduces the paving speed causing an increase in mat depth and may cause the paver wheels to slip or break traction. This problem causes a non-uniform edge line of the mat and a bump in the mat.
- 3) Paver engine in poor operating condition -- an improperly functioning engine may cause power and speed surges resulting in ripples, waves, or auger shadows in the mat.
- 4) Unequal or over inflation of paver tires -- this may cause the drive wheel to slip or break traction resulting in a rough, uneven mat.
- 5) Loose or unevenly tensioned traction drive chains -- this may cause power or speed surges resulting in ripples, waves, or auger shadows in the mat.

Automatic grade and slope controls are required to be outlined in the QCP for mixtures produced in accordance with Section **401**. Section **402** indicates that automatic slope and grade controls are required except when placing mixtures on roadway approaches which are less than 200 ft (60 m) in length or on miscellaneous work. The use of automatic controls on other courses where the use is impractical due to project conditions may be waived by the Engineer.

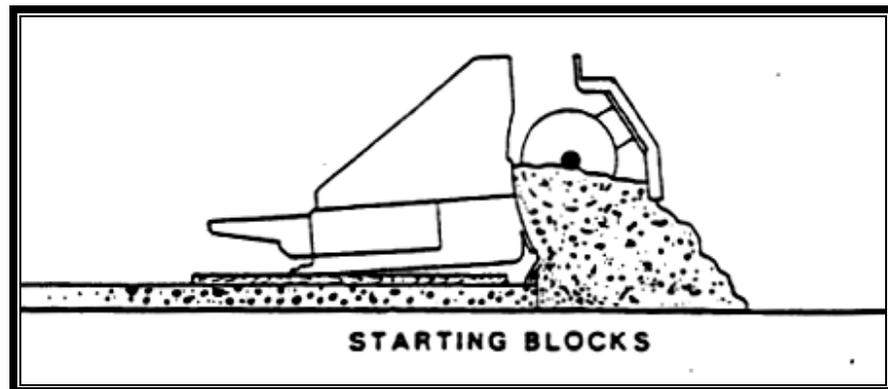
## **START-UP**

Three types of start-ups are used in hot mix asphalt paving:

- 1) Full depth
- 2) Continuing an existing lay
- 3) Feathering

A full depth start-up is used where paving is started at an intermediate point in the contract. Before starting, the screed is required to be elevated from the grade by the thickness of the mat plus an allowance for the compaction to be achieved by the rolling. Wooden blocks of the required thickness are placed under each end of the screed.

When continuing from a previously laid mat, the tapered material is removed back to the full-depth section and the joint lightly tacked. Strips of lath thick enough to allow for compaction are placed under the ends of the screed as illustrated in Figure 7-10. The front of the screed should never be placed beyond the joint.



**Figure 7-10. Continuing on Existing Lay**

When building a start-up feather joint, the screed is set directly on the existing pavement at an angle to gradually taper up to the full depth. The feathering is required to be long enough to provide a smooth transition to the driving surface. Temporary transverse joints, if constructed under traffic, are also feathered.

Paving exceptions are indicated on the plans. Bridges, except for earth-filled arches, are usually an exception from paving. Adding HMA pavement over a concrete bridge deck would cause deterioration to the deck. There may be exceptions when paving under a bridge if the added pavement would reduce the overhead clearance to an unacceptable height. Vertical clearance requirements are designated in **105.08(b)**.

With any start-up, the screed is required to be hot before any mix is processed through the paver. Screed heaters are provided on all pavers to preheat the screed. Once the screed is hot, the heaters may be turned off because the heated mixture keeps the screed hot. Screed extensions bolted on to the paver to attain the required width are also required to be heated. The heating device on the main screed does not provide heat to these extensions.

The front of the screed is required to be set slightly higher than the rear of the screed to provide what is commonly referred to as the “angle of attack”. This angle allows the screed to climb enough to equal the amount of compaction that the screed exerts on the mix. Thickness checks are made frequently during the start-up to ensure that the screed is set correctly to produce the desired thickness.

### ***ALIGNMENT***

The alignment of the edge of the pavement is critical to the appearance of the highway. When overlaying an existing pavement with a uniform edge, the paver operator may use the edge as a guide for laying the new pavement. When the edge is irregular or the lay is on a new base, an offset string line to guide the paver is recommended. The requirement for good alignment is discussed with the Contractor before starting the paving operation. Neat lines are a requirement for a good quality pavement.

Another cause of poor alignment is overloading the propulsion capabilities of the paver. On steep grades, the haul truck may be required to dump only a portion of the load and pull ahead to take the additional dead load off the paver. This may also be necessary on fresh tack where the paver is not maintaining traction. Fishtailing of the paver is usually caused by overloading, slipping of the crawlers or drive wheels, or steering clutches in poor condition.

The pointer mounted on the paver is recommended to be rigid rather than a pendulum type because the rigid type permits more control in following the string line or pavement edge.

### ***GRADE AND SLOPE CONTROL***

The paver may be equipped with an automatic grade and slope device. The automatic grade device controls the screed to adjust the thickness of the mat as the mix is placed to meet the desired grade. The automatic grade device may be guided with a string line, a grade leveler, or a joint marker, depending on the conditions of the existing pavement.

The screed may also be controlled by turning the depth crank. Once the paver is adjusted to the automatic grade device, the depth cranks are not used. One exception would be if the automatic grade device quit working. Manual controls may be used if this occurs to place the material in transit, however, stopping the operation until repairs can be made is recommended.

The slope meter is used to pre-set the paver to produce the specified cross slopes for crown and super elevation. The screed is hinged in the middle to permit crown adjustment at both the leading and trailing edges of the screed. The leading edge is required to always have slightly more crown than the trailing edge to provide a smooth flow of material under the screed. Too much crown produces an open texture along the edges of the mat. Too little crown results in an open texture in the center.

### ***TRANSVERSE JOINTS***

A transverse joint, commonly called a day joint, is normally required at the end of each day's paving to provide a smooth transitional ramp for traffic. One procedure to construct a day joint is indicated in the series of drawings in Figure 7-11; however, there are other acceptable procedures for this joint. The procedure for the construction of the transverse joint is required to be included in the QCP for the project.

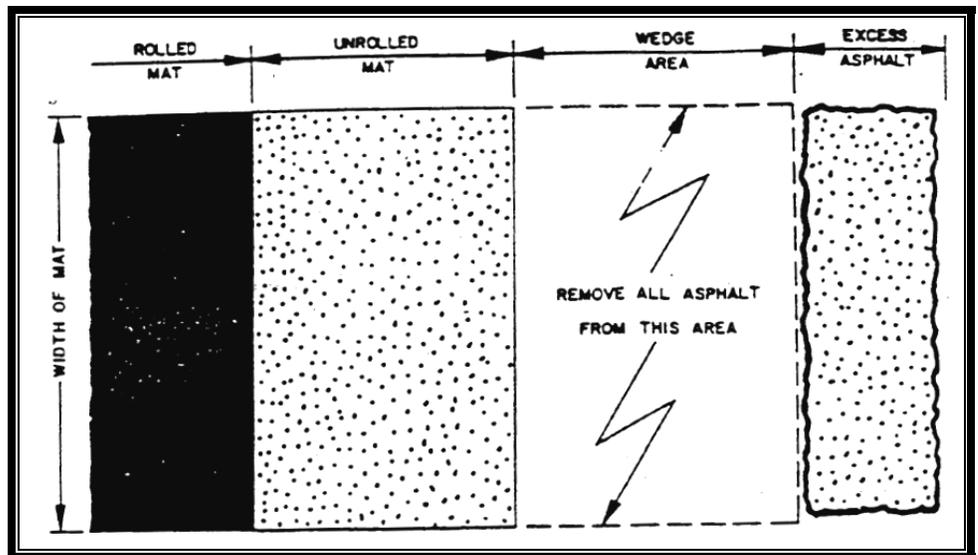
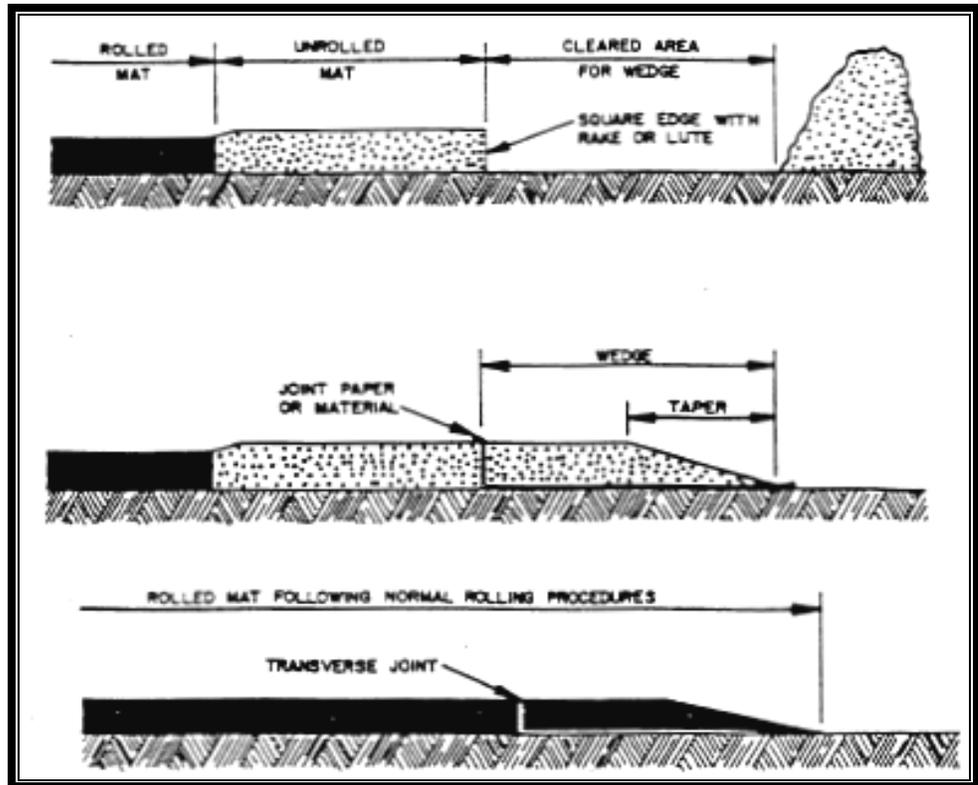


Figure 7-11. Construction of a Day Joint

The last few feet of the mat is left unrolled, the mix is cleared away from the wedge area, joint paper is laid on the existing surface and up the vertical face of the joint, the mix is shoveled over the paper to form the wedge, and the mat is rolled. The Contractor is not allowed to completely empty the paver hopper to make the day joint since some of the mix still in the hopper is too cold. 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 wooden strips as previously described. The paver is positioned with the front of the pre-heated screed over the joint line. After the hot mixture is conveyed into place, sufficient time to re-heat the joint is allowed before moving the paver forward. The paver is advanced enough to allow the workmen to conduct the necessary handwork. The straightedge is required to be used to check the joint to ensure the proper grade before allowing the roller on the surface. Once the joint has been rolled, the joint is rechecked with the straightedge. If any corrections are required there is sufficient heat remaining in the mix to make a smooth joint.

### ***LONGITUDINAL JOINTS***

Longitudinal joints are made when joining adjacent lays to make the specified width of pavement. The paver screed does not overlap the previous lay and is carried slightly higher to allow for compaction of the new lay to match the previous lay. The raker uses a lute to remove the excess material from the previous lay into the new lay to obtain a tight, smooth joint and to prevent the rollers from compacting this material into the cold mat. The paver attempts to place the material in such a way that no luting is necessary.

#### ***Joint Adhesive***

Longitudinal joint performance has been a problem with HMA pavements because of the difficulty of obtaining a tight joint that will resist the penetration of water into the pavement. This water will eventually cause stripping of the underlying layers and deterioration of the joint. A joint adhesive material placed on the joint (Figure 7-12) reduces the water penetration into the joint and improves the joint performance.

Joint adhesive material is required by **RSP 401-R-581**, the material is applied to longitudinal joints constructed in the top course of dense graded intermediate mixtures and all surface mixture courses. This includes joints within the traveled way as well as between the traveled way and an auxiliary lane, the traveled way and a paved shoulder, and an auxiliary lane and a paved shoulder.



**Figure 7-12. Joint Adhesive Material**

*Safety Edge*

A safety edge (Figure 7-13) is a wedge of asphalt mixture placed at the edge of the pavement that results in a 30 - 35° angle of mixture. The purpose of the safety edge is to provide a means for a vehicle to leave or access the edge of pavement and therefore reduce roadway departure accidents.

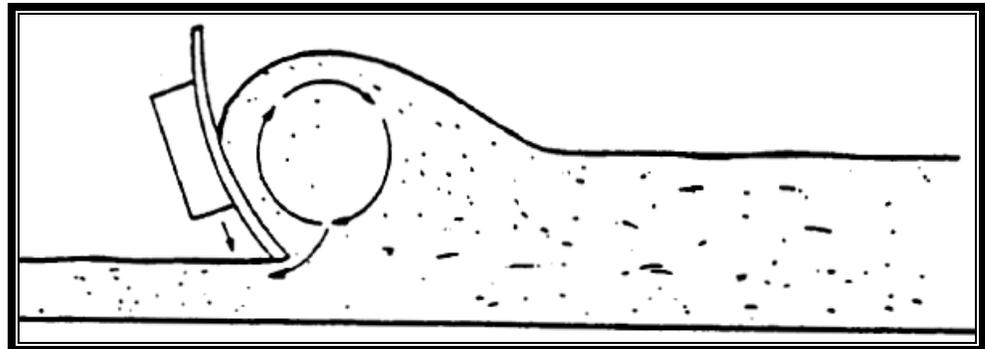


**Figure 7-13. Safety Edge**

The settings for the [paver] machine are checked before the paving operation is started. After paving a short distance, the mat is required to be checked for the following:

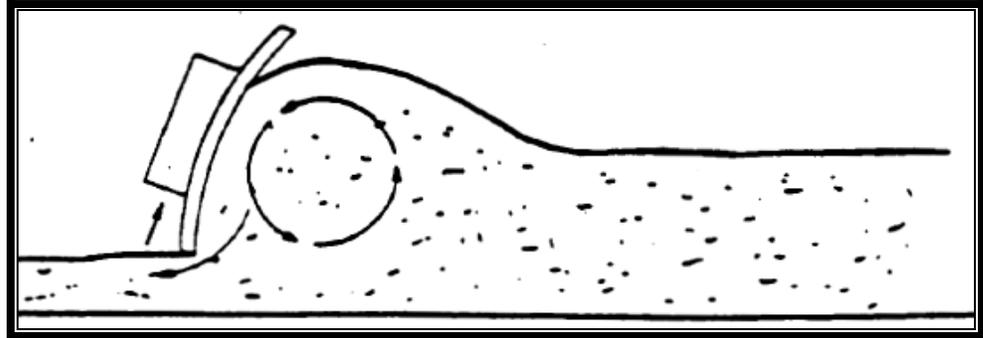
- 1) Proper width – if correction is necessary, the width is adjusted by expanding or contracting the strike-off. The outer edge plate may also need to be readjusted parallel with the road edge.
- 2) Proper elevation – adjusted by raising or lowering the inner strike-offs.
- 3) Proper slope – adjusted with the outer strike-off support. The sliding outer edger plate, may also require readjustment.
- 4) Inner edger plate – positioned to prevent paving material from piling up on the existing pavement. The inner edger plate is adjusted to be parallel to the pavement surface set in the lowest position.
- 5) Flow of material - the flow of material in front of and under the strike-off is watched. Adjustment from the vertical positions may be required.

If the top of the strike-off is tilted back (Figure 7-14), the plate rolls material up. Excessive backward tilt forces the strike-off to pull down into the material.



**Figure 7-14. Strike-Off Plate Tilted Back**

Tilting the top of the strike off plate forward (Figure 7-15) causes the strike-off to roll the material down. Excessive forward tilt forces the strike-off to ride up over the material.



**Figure 7-15. Strike-Off Plate Tilted Forward**

#### ***CARE AND CLEANING OF PAVERS***

Pavers are required to be checked for oil and fuel leaks because petroleum products damage the mix. Fuel oil, kerosene, or solvents are not allowed to be transported in open containers on any equipment. Cleaning of equipment and small tools also is not allowed on the pavement or shoulder areas.

The paver hopper, conveyors, augers, and screeds are required to be cleaned at the end of each day. Any hardened mix is removed so the mix is not contaminated when the paving is resumed.

Caution is used at paver cleanout sites because excessive fuel oil saturating the ground may lead to pollution problems. The Contractor is required to clean the areas where the paver is maintained.

#### ***PAVING CREW RESPONSIBILITIES***

##### ***Paver Operators***

The paver operator responsibilities include safely operating the paver and using the paver best practices to produce the highest quality pavement possible. Specific responsibilities include:

- 1) Selecting the paving speed that balances delivery, paver capacity and the compaction process, and paving with few if any extended stops
- 2) Working with the screed operator in establishing and maintaining the head of material within a plus or minus one-inch tolerance

- 3) Steering the paver and holding the paver to a pre-determined reference
- 4) Directing the truck driver to raise the bed and exit when empty
- 5) Utilizing rapid but smooth starting and stopping operations to help prevent end-of-load roughness
- 6) Observing the HMA being discharged into the paver hopper or insert for changes in the characteristics of the mixture
- 7) Monitoring the paver for unusual noise or vibration
- 8) Working with the dump person to make sure the truck does not bump the paver or that the hopper runs low on material

#### *Screed Operator*

The screed operator responsibilities include understanding the basic principles of paving with a free-floating screed and knowing the screed design, operation, and adjustments. An awareness of HMA mix design characteristics and what may change if the mixture varies throughout the day is valuable. Specific responsibilities include:

- 1) Setting up the screed and paving reference to match the specification requirements for width, crown, slope, and depth
- 2) Heating the screed properly
- 3) Working closely with the paver operator in establishing and maintaining the head of material within a plus or minus one-inch tolerance
- 4) Operating the grade and slope system, utilizing the designated references, and occasionally checking that the mat being laid is being held to the established references
- 5) Making screed adjustments to produce a consistent textured mat
- 6) Following the best practices for making sound longitudinal and transverse joints

***Lute Person***

The lute person (Figure 7-16) responsibilities include assuring that any mat deficiencies are corrected prior to compaction. Specific responsibilities include:

- 1) Hand working any area of the mat which cannot be placed by the paver
- 2) Repairing all pavement imperfections
- 3) Preparing transverse and longitudinal joints for compaction
- 4) Preparing end-of-pass wedges or tapers for compaction
- 5) Assisting in cleaning the paver at the end of the shift
- 6) Assuring the quality of the finished project and communicating problems to the responsible person when they arise



**Figure 7-16. Luting Transverse Joint**

## COMPACTION

### COMPACTION OF HMA

Compaction of HMA mixes is conducted with steel wheel, pneumatic tired, vibratory, or oscillatory rollers in three phases:

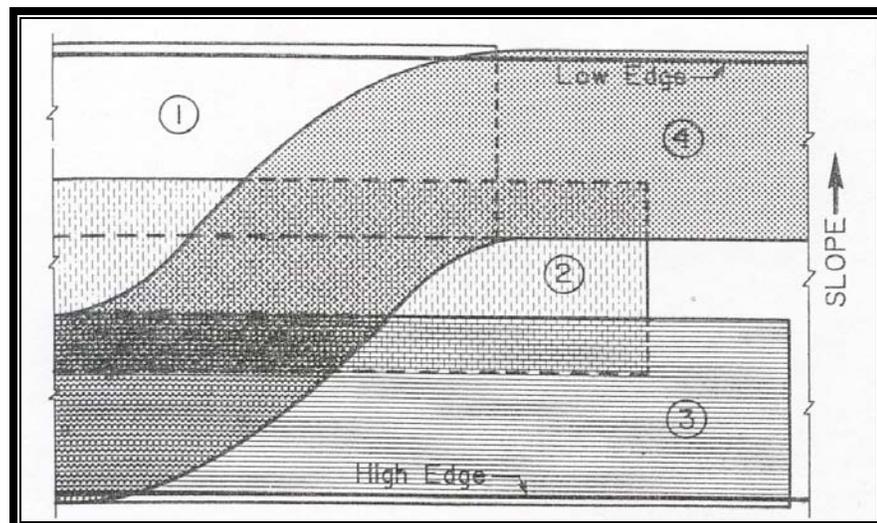
- 1) Breakdown or initial rolling
- 2) Intermediate rolling
- 3) Finish rolling

Both vibratory and tamper-type paver screeds begin the compaction of the mix as the material flows under the screed. Breakdown rolling compacts the material beyond that imparted by the paver, intermediate rolling compacts and seals the surface, and finish rolling removes the roller marks and other blemishes left from the previous rolling.

#### *Breakdown Rolling*

For example, when a single lane is being placed, the outside edge (the low side) of the lane is rolled first. When placing a new mat adjacent to the existing lay, the longitudinal joint is rolled first followed by the breakdown rolling on the low edge.

In general, the roller proceeds straight into the un-compacted mix and returns in the same path, however, when the roller stops and reverses direction the roller should be at an angle to the pavement. The turning movement is normally completed on previously compacted material. The drive wheel of the roller is toward the paver because there is less tendency for the mix to shove under the drive wheel. The recommended pattern for breakdown rolling is illustrated in Figure 7-17.



**Figure 7-17. Breakdown Rolling Pattern**

After the required passes for the breakdown rolling are completed, the roller is moved to the outside of the lane on the cooled portion of the mat to repeat the process on the next segment.

#### ***Intermediate Rolling***

Intermediate rolling is conducted immediately after the breakdown rolling while the mix is still hot and at a temperature that results in maximum density. The rolling pattern is the same pattern as done for the breakdown rolling.

Keeping the tires hot helps prevent the newly laid material from sticking to the tires for the pneumatic-tired roller. Intermediate rolling is continuous until compaction is attained. If the mixture is accepted in accordance with Section **402**, the rolling pattern is established by the specifications.

#### ***Final Rolling***

Final rolling is conducted to improve the surface texture. This rolling is completed while the mat is still warm enough so roller marks from the breakdown and intermediate compaction are removed.

### ***SPECIFIED ROLLERS***

Compaction may be controlled by the number of passes of a specified series of rollers (Section **402**) or by density (Section **401** and **410**). The QCP for the contract is required to specify the type of rollers to be used. Sufficient rollers are required to be operated to complete the compaction before the temperature of the mix has cooled to a point where the density cannot be obtained.

The rolling operation is required to obtain a fully compacted mat. If the necessary compaction is not attained, subsequent traffic may consolidate the mat further resulting in wheel ruts. Some mixtures, designated as “tender mixtures”, may have a temperature range whereby after the initial breakdown passes, rolling is required to cease until the temperature drops to an acceptable level. Otherwise, the mat may be damaged and/or any density attained by initial breakdown may be lost. Monitoring compaction during the first day of paving is critical to obtain the necessary density.

Section **402.15** for non-QC/QA mixtures allows the Contractor to designate the type of rollers used. Option No. 1 requires a three wheel roller, followed by a pneumatic tire roller and a tandem roller. Options 2, 3, 4, and 5 include different roller and roller application combinations. A roller pass is defined as one complete coverage by the roller of a given area. The various options for rolling are included in the following table. (Refer to page 3-8 for more detailed information on roller types)

Number of Roller Applications							
Rollers	Courses $\leq$ 440 lb/yd <sup>2</sup>					Courses $>$ 440 lb/yd <sup>2</sup>	
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 1	Option 2
Three Wheel	2		4			4	
Pneumatic Tire	2	4				4	
Tandem	2	2	2			4	
Vibratory				6			8
Oscillatory					6	--	--

**Note:** A roller application is defined as one pass of the roller over the entire mat

***PLANT PRODUCTION - NUMBER OF ROLLERS***

Before the contract begins, verification that there are a sufficient number of rollers and haul trucks to keep pace with the anticipated plant production is necessary. This procedure is documented in the Quality Control Plan required for the project.

***COMPACTION CONTROLLED BY DENSITY***

For all QC/QA (401) and SMA (410) mixtures, density is determined by cores obtained from the mat after all rolling is complete except for the following locations:

1. The total planned lay rate to be placed over a shoulder existing prior to the contract is less than 385 lb/yd<sup>2</sup>
2. The first lift of material placed at less than 385 lb/yd<sup>2</sup> over a shoulder existing prior to the contract award

If cold weather paving is allowed, the density is also determined by cores (Section 402.16).

Quality control procedures for density control are to be included in the QCP in accordance with ITM 803. Non-destructive density testing is required except for cores taken to correlate the density gauge and quality control cores defined in the QCP. Nuclear or non-nuclear gauges may be used. Each gauge is calibrated in accordance with the manufacturer's recommendations and correlated to the type of mixture being placed, depth of mixture, and possibly the underlying base materials. Near the beginning of the paving operation, an area may be designated for testing to determine the proper rolling patterns to achieve the target density. This area is commonly referred to as a "test strip". Non-destructive tests are

taken and cores obtained at the same locations in the test strip. The difference between the gauge readings and the measured core densities is determined and used for an "offset" for the gauge.

For Non-QC/QA mixtures, the density is controlled by the specified rolling option (Section **402.15**).

### ***WIDENING***

HMA mixtures placed as widening and other depressed areas may be rolled with a trench roller.

### ***ROLLING PATTERNS***

Rolling of HMA mixtures may vary depending on the conditions on the project. In general, the best practice for the sequence of the rolling operations is the following:

- 1) Transverse joints
- 2) Begin the initial or breakdown rolling at the low side and proceed to the high side of the mat
- 3) Longitudinal joints – if the new mat is adjoining a previously placed lane
- 4) Intermediate rolling
- 5) Finish rolling

Any area that cannot be compacted by rollers is required to be compacted with hand tampers, plate vibrators, or other approved equipment.

Rollers, regardless of the type, are not allowed to be parked on the fresh mat.

#### ***Transverse Joints***

The ramp section and paper from the day joint are required to be removed prior to starting paving. The screed is set enough higher than the previously laid mat to allow for compaction. When the paver has moved away from the joint, any mix on the surface of the old mat is butted into the joint with a lute. The joint is first rolled transversely with the roller compacting on the old mat and extending into the uncompacted mix about 6 in. Pinching the material into the joint in this way helps attain a tight joint. Planks perpendicular to the lay are used to support the roller to prevent breaking down the edge of the mat while rolling in the transverse direction. Rolling is continued transversely until about 3 ft of the new lay has been rolled.

The roller is then turned parallel to the lay down and rolling is continued. The joint is required to be checked with a straightedge. The roller usually smoothes out a bump while the mix is still warm by rolling transversely. Additional material may be required if the straightedge indicates a dip. Material may be added by hand, leveled with a lute, and then re-rolled to correct a dip. However, adding material tends to produce poorer quality surface texture.

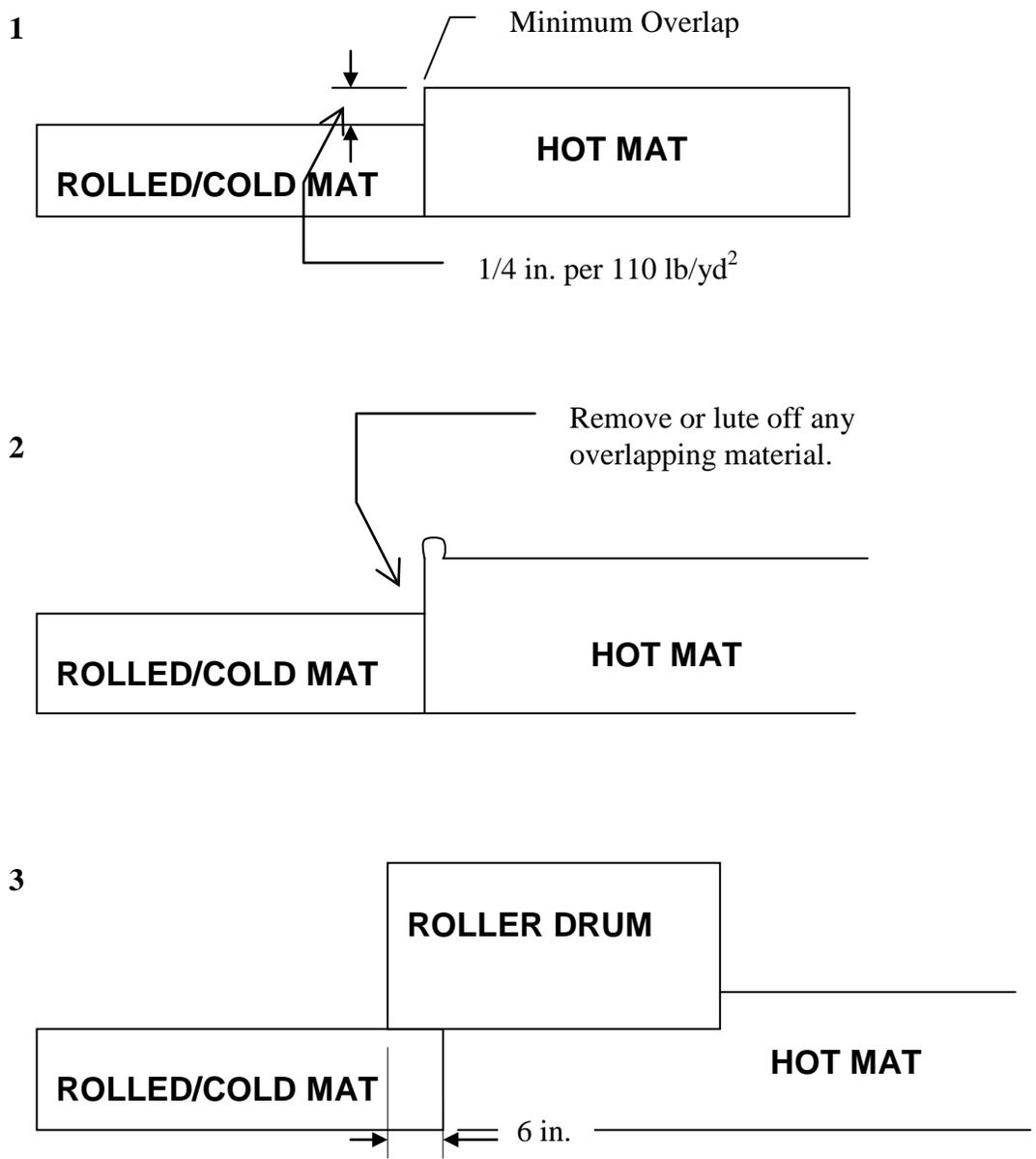
### *Longitudinal Joints*

Section **402** requires that the longitudinal joint be compacted in accordance with the following:

- For confined edges, the first pass adjacent to the confined edge, the compaction equipment shall be entirely on the hot mat 6 in. from the confined edge
- For unconfined edges, the compaction equipment shall extend 6 in. beyond the edge of the hot mat

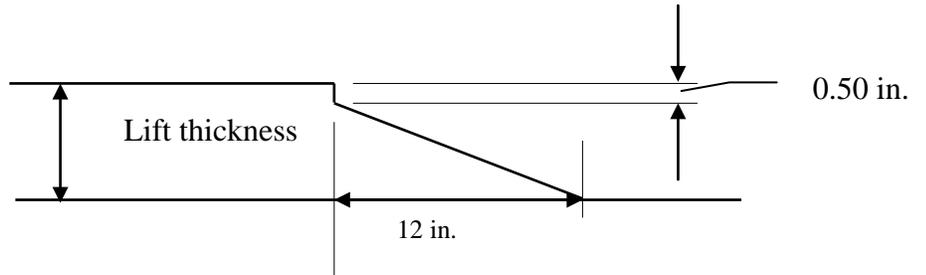
Another technique for the construction and compaction of the longitudinal joint that may be used for mixtures placed in accordance with Sections **401** and **410** is illustrated in Figure 7-18 and explained as follows:

- 1) The uncompacted HMA (hot mat) abutting a rolled/cold mat is placed 1/4 in. per 110 lb/yd<sup>2</sup> higher than the rolled/cold mat.
- 2) Any excess HMA placed on top of the rolled/cold mat is required to be removed (or lute off) from the rolled/cold mat prior to compaction.
- 3) The most efficient way to compact the longitudinal joint is to put the roller on the hot mat and overlap the joint by a distance of approximately 6 in over the cold mat. The entire width of the mat is required to receive a uniform number of passes of the compaction equipment. If the hot mat is tender with pushing and shoving during the compaction operation, the rolling operation is required to be delayed until the mat becomes stable under the roller.



**Figure 7-18. Longitudinal Joint Compaction**

The notched wedge longitudinal construction joints (Figure 7-19) is another procedure used for constructing the longitudinal joint. This type of joint has shown the potential of improving the construction of longitudinal joints by providing better compaction at the joint.



**Figure 7-19. Notched Wedge Longitudinal Construction Joint**

## ***ROLLER OPERATOR RESPONSIBILITIES***

### ***Breakdown and Intermediate Roller Responsibilities***

The breakdown and intermediate roller operator responsibilities for vibratory rollers include obtaining pavement density while the HMA is in the proper temperature range for compaction without risking aggregate damage. Rolling with the vibration toward the paver and establishing the rolling pattern with the fewest side-by-side passes as possible is required. Also, controlling the roller speed to provide proper drum impact, keeping up with the paver, and operating in the best temperature zone are additional responsibilities. If one roller cannot maintain the production rate, a second breakdown roller will be needed. Specific responsibilities include:

- 1) Communicating with the paving crew and foreman for the project requirements prior to arrival of the HMA
- 2) Doing daily maintenance on the roller and checking the water system
- 3) Determining the lift thickness
- 4) Being aware of the material temperature at delivery to the paver and behind the screed
- 5) Determining if the rolling drum mode is vibratory or static depending on the requirements to achieve density
- 6) Making the required amplitude adjustments for both drums for the mix design, material thickness, and the temperature zone
- 7) Optimizing the water system controls to avoid material pick-up and eliminate excessive water usage
- 8) Establishing the proper rolling pattern considering the paving width, roller drum width, unsupported edges, and drum overlap
- 9) Determining rolling speed to achieve the proper impact spacing and smoothness requirements

- 10) Monitoring rolling temperature and working with the optimum temperature zones
- 11) Recognizing tender mixtures and adjusting the roller pattern
- 12) Making the required rolling coverage to achieve density requirements
- 13) Adjusting rolling operations to satisfy the density, smoothness, and production rates
- 14) Maintaining consistency throughout the entire working shift

#### ***Finish Roller Responsibilities***

The finish roller operator responsibilities include removing all surface marks and blemishes from the finished pavement. The operator may be required to achieve final compaction in some cases where breakdown and intermediate rolling have not achieved the target density. Rolling at the necessary speed to maintain production is required and using vibration is rarely done. Specific responsibilities include:

- 1) Communicating with the paving crew, foreman and breakdown operator for the project requirements
- 2) Confirming maintenance and water system checks on a daily basis
- 3) Being aware of the material temperature and avoiding the tender zone
- 4) Determining if the rolling mode is vibratory or static depending on the requirements to achieve density and smoothness
- 5) Optimizing the water system controls to avoid pick-up and eliminate excessive water usage
- 6) Establishing the proper rolling pattern determined by the paving width, rolling drum width, unsupported edges, and drum overlap
- 7) Coordinating the final rolling process with QC personnel

- 8) Monitoring the rolling temperature and working within the optimum temperature zones
- 9) Making the required rolling coverage to achieve density requirements and to remove drum edge marks
- 10) Maintaining consistency throughout the entire working shift

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# 8 Thickness and Tonnage Control

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## Mixture Adjustment Factor

### Checking Mat Thickness

*Determining Mat Thickness*  
*Depth Checks*

### Actual Rate of Spread

*Stationing*  
*Weigh Tickets*  
*Computing Rates of Spread*

# CHAPTER EIGHT:

## ***THICKNESS AND TONNAGE CONTROL***

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The lay rates (thickness) and width of the paving operation are shown on the typical sections in the contract plans or the Contract Information Book. Lay rates are used to define the thickness of the layers of the pavement. The actual compacted thickness of the mat is required to conform to the planned design. The design thickness is determined so the pavement is strong enough to carry the anticipated traffic. If the mat is too thin, the pavement will likely fail prematurely. If the mat is too thick, the pay quantities will overrun and increase the cost of the contract unnecessarily.

The thickness of the mat is checked by verifying the uncompacted thickness behind the paver and by verifying the actual lay rate (sometimes call yield).

The plans specify the rate in pounds per square yard that the HMA is to be placed. This is known as the "Planned Lay Rate". The planned quantity is used in the rate of spread and verifying the design thickness.

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### **MIXTURE ADJUSTMENT FACTOR**

A Mixture Adjustment Factor (MAF) is used to adjust the mixture planned quantity and lay rate prior to paving operations, and the pay quantity upon completion of production of the mixture. The MAF is a means of adjusting lay rates to the design thickness due to materials with different densities. The MAF is calculated by dividing the maximum specific gravity ( $G_{mm}$ ) from the mixture design by the following values:

<b>Mixture</b>	<b>Maximum Specific Gravity</b>
9.5 mm	2.465
12.5 mm	2.500
19.0 mm	2.500
25.0 mm	2.500

If the calculated MAF is equal to or greater than 0.980 and equal to or less than 1.020, the MAF value is considered to be 1.000. If the calculated MAF is less than 0.980, then 0.020 is added to the value. If the calculated MAF is greater than 1.020, 0.020 is subtracted from the value. The planned quantity and lay rate are adjusted by multiplying by the MAF. The accepted quantity for payment is adjusted by dividing by the MAF.

**Example:**

Mixture	=	9.5 mm Surface
Planned Quantity	=	9750.00 tons
Placed Quantity	=	9500.00 tons
Mix Design $G_{mm}$	=	2.360
Lay Rate	=	165 lb/yd <sup>2</sup>

$$MAF = \frac{2.360}{2.465} = 0.957$$

$$MAF = 0.957 + 0.020 = 0.977$$

$$\text{Adjusted Planned Quantity} = 0.977 \times 9750.00 = 9525.75 \text{ tons}$$

$$\text{Adjusted Lay Rate} = 0.977 \times 165 \text{ lb/yd}^2 = 161 \text{ lb/yd}^2$$

$$\text{Adjusted Pay Quantity} = \frac{9500.00}{0.977} = 9723.64 \text{ tons}$$

The MAF does not apply to open graded mixtures, temporary HMA, HMA patching and widening with HMA.

**CHECKING MAT THICKNESS**

***DETERMINING MAT THICKNESS***

Before conducting any depth checks, the required thickness is obtained. Through experience, HMA mixes have indicated that 110 lb/yd<sup>2</sup> is equivalent to approximately 1 in. of compacted depth when the MAF is approximately equal to 1.0. Mixes made with some aggregates such as slag, weigh somewhat less or more depending on the type of aggregate used.

The formula for determining the compacted mat thickness is:

$$\frac{\text{Planned Lay Rate (lb/yd}^2\text{)}}{110 \text{ lb/yd}^2} = \text{Desired mat thickness in inches}$$

or

$$\frac{\text{Adjusted Lay Rate}}{MAF \times 110 \text{ lb/yd}^2} = \text{Desired mat thickness in inches}$$

**Example:**

$$\text{Planned Lay Rate} = 165 \text{ lb/yd}^2$$

$$\frac{165}{110} = 1.5 \text{ inches}$$

The mat thickness for 165 lb/yd<sup>2</sup> would be approximately 1 1/2 inches.

or

$$\begin{aligned} \text{Adjusted Lay Rate} &= 161 \text{ lb/yd}^2 \\ \text{MAF} &= 0.977 \end{aligned}$$

$$\frac{161}{110 \times .977} = 1.5 \text{ inches}$$

The mat thickness for 161 lb/yd<sup>2</sup> would be approximately 1 1/2 inches.

***DEPTH CHECKS***

The approximate thickness of the uncompacted mat is checked immediately behind the paver screed and at various points across the lane. Uncompacted mat (loose mix) is placed approximately 1/4 inch additional thickness per inch of depth placed. For example, a compacted thickness of 3 inches will be placed 3 1/4 inches behind the paver uncompacted. Depth checks are made regularly and are useful in determining if particular areas on the grade or pavement differ greatly from the typical cross sections. An excessively thin or thick mat does not compact properly. A mat too thin drags the mix aggregate. A mat too thick is difficult to compact to the required density. Adjustments to the paver may be required for the depth of mix. If the problem is extensive, the slope of the pavement or the planned thickness may need to be adjusted.

**ACTUAL RATE OF SPREAD**

The determination of the actual rate of spread is a more accurate method of determining the mixture placed than individual depth checks because the rate of spread considers the average spread over a longer paving area.

Weigh tickets are collected as the mix is delivered to the paving site and a record is kept of the actual amount of mix placed. This record is used to determine the "Placed Quantity" and compare this quantity to the "Planned Quantity".

The actual rate of spread is computed and compared this to the planned rate. The planned rate is typically shown on the plans in pounds per square yard. The actual rate of spread may be computed in pounds per linear foot, tons per linear foot, or pounds per square yard. Both the planned and actual rates are required to be in the same units for valid comparisons.

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 and there is an overrun of material. If the actual rate is less than the planned rate, too little mix is being placed and there is an underrun. In either case, adjustments are required to be made to bring the actual quantity in line with the planned quantity.

### ***STATIONING***

Highway contracts are surveyed and staked in 100 ft increments called stations. Station 1 is written as 1+00, Station 25 as 25+00, and so on. Station 25+00 would equal 2500 ft from a fixed reference point.

The use of stations makes the determination of distance paved relatively easy. If the paving started at Station 25+00 and ended at Station 60+00, there would be 3500 ft (6000 minus 2500) of mix paved. To be more precise, the distance from the actual starting or ending point to a station is determined and added or subtracted from the station referenced. For example, if the paving started 75 ft past Station 25+00, the starting point would be 25+75, or 2575 ft from the fixed reference point. If the ending point was 40 ft beyond Station 60+00, or 60+40, the distance paved would be 6040 minus 2575 or 3465 ft.

### ***WEIGH TICKETS***

A weigh ticket which shows the net weight of the material is required to be furnished for every load of mix delivered to the paving site. The weigh ticket is issued to the truck driver at the weighing site. The weigh tickets also show the cumulative tonnage delivered each day. Weigh tickets are collected from the truck driver by INDOT for each load at the same time the material is unloaded at the paving site. Upon taking the ticket, the INDOT is required to:

- 1) Write on the ticket the starting station of the load and the lane (right, left, or center) where the material is placed. A preferred method of designating lanes is EBPL (eastbound passing lane), EBDL (eastbound driving lane), etc.
- 2) Keep a running total of the mix unloaded at the paving site on the back of the ticket

- 3) Sign the original ticket after checking the appearance of the mix

At any time during the day and at any point along the roadway, the number of tons of mix that has been dumped into the paver is required to be known.

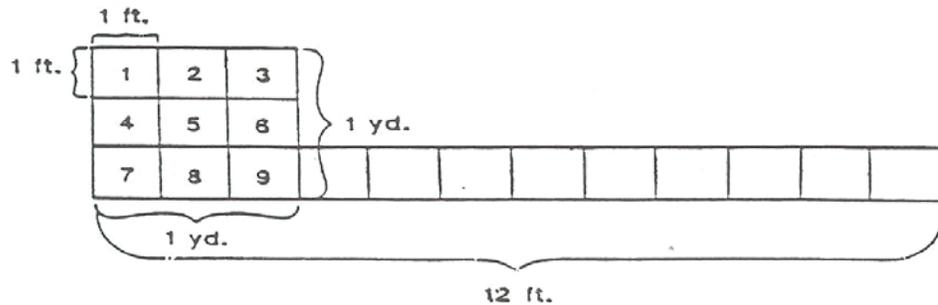
**COMPUTING RATES OF SPREAD**

As stated above, there are several methods of computing the actual rate of spread. The calculations differ primarily in the units in which the rates are expressed. The three methods are:

- 1) Method 1 – rate expressed in pounds per square yard
- 2) Method 2 – rate expressed in pounds per linear foot
- 3) Method 3 – rate expressed in tons per linear foot
- 4) Method 4 – quick method in linear feet per truck load

When the MAF is not equal to 1.000 then the adjusted lay rates and adjusted planned quantities should be used for the comparisons below.

Before starting the explanations of the rates of spread, the relationship between the areas of the three methods is required. As indicated in the diagram below, 9 ft<sup>2</sup> equals 1 yd<sup>2</sup>. The number of square yards in a linear foot depends on the width being paved.



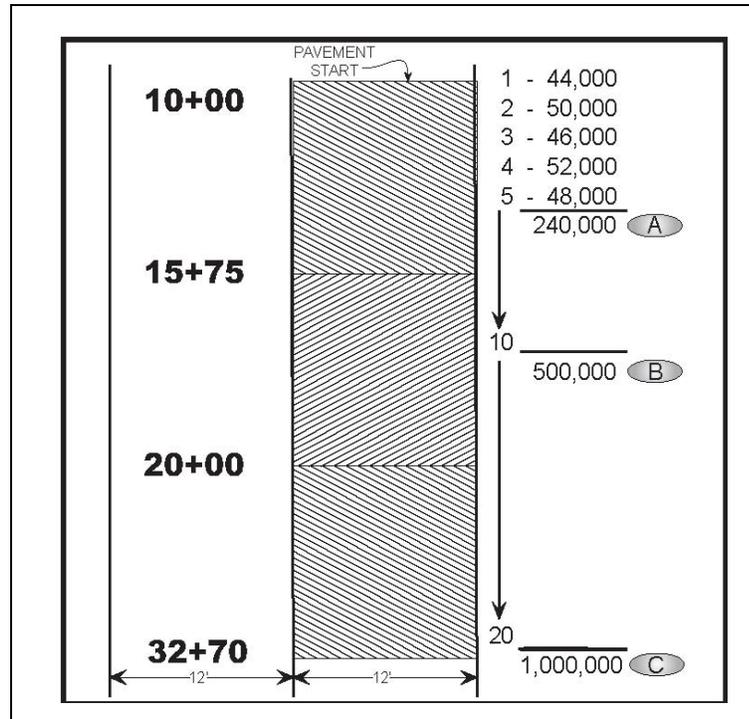
The formula for determining the relationship is:

$$\frac{1 \text{ foot} \times \text{pavement width (feet)}}{9 \text{ ft}^2/\text{yd}^2} = \frac{1 \times w}{9} = \text{yd}^2/\text{lft (linear foot)}$$

For a width of 12 ft as shown in the above diagram, the square yards per linear foot would be:

$$\frac{1 \times 12}{9} = 1.33 \text{ yd}^2/\text{lft}$$

Examples of the four methods of checking the actual rates with planned rates are as follows. The diagram below indicating the amount paved and quantities used applies to all three examples.



Not to scale:

### Method 1 – Pounds per Square Yard

The planned quantity is 330 lb/yd<sup>2</sup>. The procedure for the first 5 loads is as follows:

- 1) 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 240,000 pounds.
- 2) Determine the total length paved in linear feet. Loads 1 through 5 began at Station 10+00 and end at Station 15+75

$$(15+75) - (10+00) = 575 \text{ lft}$$

- 3) Determine the area paved in square yards.

$$\frac{\text{Total length} \times \text{width paved}}{9} = \frac{575 \times 12}{9} = 767 \text{ yd}^2$$

- 4) Calculate the actual rate of spread in lb/yd<sup>2</sup>

$$\frac{\text{Total mix placed (lb)}}{\text{Area paved (yd}^2)} = \frac{240,000 \text{ lb}}{767 \text{ yd}^2} = 313 \text{ lb/yd}^2$$

- 5) Compare the placed quantity and planned quantity

If placed quantity = planned quantity: Mat is correct  
If placed quantity > planned quantity: Overrun  
If placed quantity < planned quantity: Underrun

The planned quantity equals 330 lb/yd<sup>2</sup>. The placed quantity of 312.9 lb/yd<sup>2</sup> is less than the planned quantity indicating an underrun and a mat that is too thin. The Contractor is required to make the necessary adjustments.

After load 10, the paver is at Station 20+00 and 500,000 pounds have been placed.

$$\begin{aligned}\text{Total length} &= (20+00) - (10+00) = 1000 \text{ lft} \\ \text{Area} &= (1000 \times 12) / 9 = 1333 \text{ yd}^2 \\ \text{Placed Quantity} &= 500,000 / 1333 = 375 \text{ lb /yd}^2\end{aligned}$$

The placed quantity of 375 lb/yd<sup>2</sup> is greater than the planned quantity indicating an overrun.

After Load 20, the paver is at Station 32+70 and a total of 1,000,000 lb have been placed.

$$\begin{aligned}\text{Total length} &= (32+70) - (10+00) = 2270 \text{ lft} \\ \text{Area} &= (2270 \times 12) / 9 = 3027 \text{ yd}^2 \\ \text{Placed quantity} &= 1,000,000 / 3027 = 330.4 \text{ lb/yd}^2\end{aligned}$$

The placed quantity equals the planned quantity indicating the spread rate is correct.

## Method 2 – Pounds per Linear Foot

The planned quantity is 330 lb/yd<sup>2</sup>

- 1) Convert the planned quantity from lb/yd<sup>2</sup> to lb/lft

$$\frac{\text{length of one foot x width paved}}{9 \text{ ft}^2/\text{yd}^2} = \frac{1 \times 12}{9} = 1.33 \text{ yd}^2/\text{lft}$$

$$\text{planned quantity} \times \text{yd}^2/\text{lft} = 330 \times 1.33 = 440 \text{ lb/lft}$$

- 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 240,000 pounds

- 3) Determine the total length paved in linear feet

Loads 1 through 5 began at Station 10+00 and end at Station 15+75

$$(15+75) - (10+00) = 575 \text{ lft}$$

- 4) Calculate the actual rate of spread in lb/lft

$$\frac{\text{total mix placed}}{\text{total length paved}} = \frac{240,000 \text{ lb}}{575 \text{ lft}} = 417.4 \text{ lb/lft}$$

- 5) Compare the placed quantity and the planned quantity

The placed quantity of 417.4 lb/lft is less than the planned quantity of 440 lb/lft indicating that an underrun and a mat that is too thin.

After Load 10, the paver is at Station 20+00 and 500,000 pounds have been placed.

$$\begin{aligned} \text{Total length} &= (20+00) - (10+00) = 1,000 \text{ lft} \\ \text{Placed quantity} &= 500,000 / 1,000 = 500 \text{ lb/lft} \end{aligned}$$

The placed quantity of 500 lb/lft is greater than the planned quantity of 440 lb/lft indicating an overrun and a mat that is too thick.

After Load 20, the paver is at Station 32+70 and 1,000,000 lb have been placed.

$$\begin{aligned} \text{Total length} &= (32+70) - (10+00) = 2270 \text{ lft} \\ \text{Placed quantity} &= 1,000,000 / 2270 = 440.5 \text{ lb/lft} \end{aligned}$$

The placed quantity equals the planned quantity indicating that the spread rate is correct.

### Method 3 – Tons per Linear Foot

The planned quantity is 330 lb/yd<sup>2</sup>

- 1) Convert the planned quantity from lb/yd<sup>2</sup> to t/lft

$$\frac{\text{planned quantity (lb/yd}^2\text{)} \times \text{width of paving (ft)}}{9 \text{ (ft}^2\text{/yd}^2\text{)} \times 2000 \text{ (lb/t)}} = \frac{330 \times 12}{18,000} = 0.22 \text{ t/lft}$$

- 2) Total the weights of the loads placed in pounds to the point where the check is made and convert to tons.

The total of the first five loads equals 240,000 pounds.

Note: 2,000 pounds equals 1 ton.

$$\frac{\text{pounds placed}}{2000 \text{ lb}} = \frac{240,000}{2,000} = 120 \text{ tons}$$

- 3) Determine the total length paved in linear feet.

Loads 1 through 5 began at Station 10+00 and end at Station 15+75

$$(15+75) - (10+00) = 575 \text{ lft}$$

- 4) Calculate the theoretical quantity (tons) for the total length paved.

planned quantity (tons/lft) x total length paved (lft)

$$0.22 \text{ tons/lft} \times 575 \text{ lft} = 126.5 \text{ tons}$$

- 5) Compare the placed quantity and theoretical quantity

placed quantity – theoretical quantity = tons over/under

$$120 \text{ tons} - 126.5 \text{ tons} = -6.5 \text{ tons (Underrun)}$$

Note: If net tons is positive, there is an overrun

If net tons are negative, there is an underrun

- 6) Calculate % of underrun or overrun

$$\frac{\text{net over/under (tons)}}{\text{theoretical quantity (tons)}} \times 100 = \frac{-6.5}{126.5} \times 100 = 5.14\% \text{ underrun}$$

#### Method 4 – Linear Feet Covered per Truck Load

A typical tri-axle truck contains a net weight of 20 tons of HMA.

- 1) Convert tons to pounds

$$(20 \text{ ton}) \times (2000 \text{ lb/ton}) = 40000 \text{ lb}$$

- 2) Divide the pounds of HMA by the adjusted lay rate to determine the square yards a truckload will cover

$$\frac{40,000 \text{ lb}}{330 \text{ lb/yd}^2} = 121 \text{ yd}^2$$

- 3) Convert the square yards to square feet

$$(121.2 \text{ yd}^2) \times (9 \text{ ft}^2/\text{yd}^2) = 1090.9 \text{ ft}^2$$

- 4) Divide by the width of paving to find the length covered in feet

$$\frac{1090.9 \text{ ft}^2}{12 \text{ ft}} = 90.9 \text{ ft}$$

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# 9 Quality Assurance Procedures

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## Design Mix Formula

## Lot/Sublot -- QC/QA HMA and SMA

## Types of Samples

*Plate Samples*

*Truck Samples*

*Core Samples*

*Appeal Samples*

## Methods of Acceptance Sampling

*Random Numbers*

*Plate Samples*

*Truck Sampling*

*Core Sampling*

## Adjustment Period -- QC/QA HMA

## Mixture Acceptance

*QC/QA HMA*

*HMA*

## Pay Factor Determination/Quality Assurance Adjustments

## Mix Appeal -- QC/QA HMA

## Smoothness

*Procedures*

*Profilograph Exemptions*

*Quality Assurance Adjustments*

# CHAPTER NINE:

## ***QUALITY ASSURANCE PROCEDURES***

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The acceptance criteria for QC/QA HMA set out in the Quality Assurance Specifications are based on binder content, air voids @  $N_{des}$ , VMA @  $N_{des}$ , density and smoothness. The Specifications establish controls for temperature of the mixture, testing of aggregates for quality, and testing of binder. The acceptance criteria for HMA mixtures are based on binder content and air voids. The acceptance criteria for SMA mixtures are binder content and gradation.

This section includes the procedures for obtaining acceptance samples, minimum requirements for mixture properties in accordance with Sections **401** (QC/QA HMA), and **410** (SMA) and the procedures for determining pay factors.

### **DESIGN MIX FORMULA**

The Contractor is required to submit for the District Testing Engineer's approval a Design Mix Formula (DMF) for each mixture. All mix design information must be submitted using the INDOT approved Excel worksheet format (Figure 9-1). INDOT is required to have a signed copy of the DMF prior to production of any mixture to be used on a contract. The District Testing Engineer's signature must appear at the bottom of the worksheet and the name of the DTE must appear on the corresponding line for the contract on page 2 of 2 (Figure 9-2) of the mix design. The mix number appears on page 2 just above the 'Contracts Items' column. It is important to note that multiple mix numbers appear on page 2 of 2 due to variations in liquid grade. The complete mix number that should appear on all contract documents includes the liquid grade which is the last two digits of the mix number (i.e. 133100D-64). All of the information shown for the contract pay item line (i.e. mix type, category, size, and liquid grade) must also match all of the information shown in the approved section on page 2 of 2 the mix design worksheet.

### **LOT/SUBLOT – QC/QA HMA and SMA**

Quality Assurance Specifications consider a lot as 5000 t of Base or Intermediate QC/QA HMA, and 3000 t of Surface QC/QA HMA or SMA. The lots are divided into five sublots of equal tons. For Base and Intermediate QC/QA HMA therefore, a subplot is 1000 t, and for Surface QC/QA HMA or SMA, a subplot is 600 t. Partial sublots of 100 t or less are added to the previous subplot. Partial sublots greater than 100 t constitute a full subplot. Partial lots of four sublots or less are added to the previous lot, if applicable.

**INDIANA DEPARTMENT OF TRANSPORTATION  
MATERIALS AND TESTS DIVISION  
2013 HMA DMF/JMF per 401/402**

HMA PRODUCER :				Goode Paving				
PLANT LOCATION :				Indianapolis				
CERTIFIED PLANT NUMBER :				3000				
APPROVED DESIGN LAB :				1111				
Aggregate Size	Source	Source #	Q-Number	Ledges	DMF %	JMF %	Dolo. Test (YES/NO)?	Sample Per Tons of HMA
8 CS	Stones For You	1	Q900000	1-2	20.0%		NO	
11 CS	Stones For You	1	Q900000	1-2	16.0%		NO	
12 CS	Stones For You	1	Q900000	1-2	30.0%		NO	
24 Stone Sand	Stones For You	1	Q900000	1-2	7.0%		NO	
RAP	Goode Paving	3000			25.0%			
BHF	Goode Paving	3000			2.0%			

PG BINDER	Source	Source #		Binder % RAS	Binder Replacement %	Virgin Binder %
64-22	Binders	7777	DMF	0.0%	22.2%	3.5%
70-22	Binders	7777	JMF			
76-22	Binders	7777				
Additives/ Fibers/ Etc.	Source	Source #				%

Design Number	<b>133100 D</b>		DMF - Fine RAP/ Coarse RAP/ RAS in mixture, %		Fine	Coarse	RAS
			DMF - Fine RAP/ Coarse RAP/ RAS binder, extracted, %		25.0%		
Comments:			JMF - Fine RAP/ Coarse RAP/ RAS in mixture, %				
			JMF - Fine RAP/ Coarse RAP/ RAS binder, extracted, %				
					DMF	JMF	
			Ignition Oven Test Temperature (°F)/(°C)		900 F/ 482 C		
Base Design PG-Grade	64-22		Binder, ignition ( actual ), %		4.5%		
Mixture course	Base/Inter		Binder, extracted, %		4.1%		
Mixture designation	19.0 mm		Extraction required? Yes* or No			NO	
Maximum particle size	25.0 mm		Binder, calculated effective, %		4.3%		
	Spec	DMF Mass	JMF Mass	Volume	Gyrations Nini / Ndes / Nmax	8/100/160	
%Pass 37.5 mm		100.0			Mass gyratory pill @ Ndes, g	4500	
%Pass 25.0 mm	100	100.0			Gmm	2.500	
%Pass 19.0 mm	90-100	95.0			Gmm w/ dry back? Yes or No		NO
%Pass 12.5 mm	<90	80.0			Gmm % @ Nini / Nmax	85/90	
%Pass 9.5 mm		76.0			Gmb @ Ndes	2.375	
%Pass 4.75 mm		40.0			Air Voids @ Ndes, %	4.0%	
%Pass 2.36 mm	23-47	23.0			VMA @ Ndes, %	13.0%	
%Pass 1.18 mm		8.0			VFA @ Ndes, %	72.0%	
% Pass 600 µm		14.0			Coarse agg. ang. 1/2 face, %		90-95
% Pass 300 µm		8.0			Fine aggregate angularity		45.0
% Pass 150 µm		6.0			Sand equivalency		95.0
% Pass 75 µm	2-8	5.0			Dust/calculated effective binder	1.0	
Aggregate blend Gsb		2.600			Tensile strength ratio, %		98.0%
Plant Minimum Temp (°F)	250				Draindown, % (SMA or OG only)		
Plant Maximum Temperature (°F)	315				Date Ignition oven samples submitted		3/7/2013
Mix compaction Temp (°F)	300				VCA <sub>PRC</sub> /VCA <sub>MIX</sub> (SMA only >1)		
* Extraction Note - Written request required, submit w/ DMF					MAF by DTE for PE/PS		1.000

PRODUCER: \_\_\_\_\_ *Sam Goode* \_\_\_\_\_ DMF DATE: 03/07/13  
 \_\_\_\_\_ JMF DATE: \_\_\_\_\_

DTE SIGNATURE: \_\_\_\_\_ *Mack Donald* \_\_\_\_\_ DMF DATE: 03/08/13  
 \_\_\_\_\_ JMF DATE: \_\_\_\_\_

DTE Notes:  
 DMF reference history:  
 Producer Notes:

**Figure 9-1. Design Mix Formula/Excel Worksheet 1 of 2**



## TYPES OF SAMPLES

### *PLATE SAMPLES*

INDOT, if possible, requires samples to be obtained at the point-of-placement. For QC/QA HMA and SMA, that location is from the road. HMA samples are obtained from the road by using metal plates. One or more metal plates are positioned on the road before the mixture is placed. Once the paver paves over the plates, the plates are located and removed from the pavement before compaction. The mixture retained on the plates is placed in sample containers (Figure 9-3), marked, and shipped to an INDOT Production Lab for testing.



**Figure 9-3. HMA Sample Container**

### *TRUCK SAMPLES*

Truck samples (Figure 9-4) are HMA samples taken directly from the truck before delivery to a contract. This type of sampling is often done by the Contractor at the plant to obtain information about the HMA quickly. INDOT may obtain a truck sample for HMA (402 mixture) for verification of the Specification requirements.



**Figure 9-4. Truck Sample**

***CORE SAMPLES***

Core samples (Figure 9-5) are taken from the compacted pavement usually to obtain the density of the QC/QA HMA and SMA mixtures. The Contractor is required to obtain these samples in the presence of an INDOT representative. These samples are then shipped to an INDOT Production lab for the appropriate testing.



**Figure 9-5. Core Sample**

### *APPEAL SAMPLES*

Appeal samples are samples obtained for testing when the Contractor does not agree with the original acceptance sample test results. The Contractor submits an appeal in writing that includes test data that indicates a lesser penalty than would be assessed from the original acceptance tests. Once approved by the District Testing Engineer, appeal samples are tested. For QC/QA HMA, the appeal samples are obtained at the same time as the acceptance plate samples. For SMA, the appeal samples are cores taken after the appeal has been granted.

### **METHODS OF ACCEPTANCE SAMPLING**

The first step in acceptance sampling is determining when and where to take the sample. This process is done randomly so that all of the mixture has a chance to be sampled and so there is no bias in obtaining the sample.

### *RANDOM NUMBERS*

Sampling for mixture tests is done on a random basis using **ITM 802**. A table of Random Numbers, as shown in Figure 9-6, is used to determine the random quantity or random location. The numbers occur in this table without aim or reason and are in no particular sequence. Therefore, samples obtained by the use of this table are truly random or chance, and eliminate any bias in obtaining samples.

To use the random number table to determine the random ton to sample, select without looking one block in the table. After selecting the block, the top left number in the block is the first random number used. This number is the beginning number. Proceed down the column for additional numbers and proceed to the top of the next column on the right when the bottom of the column is reached. When the bottom of the last column on the right is reached, proceed to the top of the column at the left. If all numbers in the table are used, select a new starting number and proceed in the same manner.

To use this table to determine the location of the pavement sample, again select a block in the table and start with the top left number. This number is used to determine the test site station. The adjacent number within the block is used to determine the transverse distance to the random site. Proceed down by pairs until the bottom numbers are reached and proceed to the adjacent top block to the right, if available. When the bottom pair of numbers on the right are reached, proceed to the top block on the left in the table.

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.310	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.246
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.218	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

**Figure 9-6. Random Numbers**

## *PLATE SAMPLES*

A specific ton in each subplot is selected and the mixture from the truck containing that ton is sampled. This truck is determined by checking the weigh tickets. An example of how to determine what ton is to be sampled is indicated on form TD 452 (Figure 9-7). These random tons are not shown to the Contractor so that there is no possible influence on the construction operations.

Once the truck that contains the random ton is identified, the approximate total length of mixture that the truck places is determined by knowing the weight of the truck, the paving width, and the quantity placed. When placing variable depth, such as a crown correction, the average depth is used. The following relationship is used to calculate this approximate length that a truck would place.

$$\text{Length of Load} = \frac{\text{Load Weight (t)}}{\text{Avg. Planned Quantity (lb/yd}^2\text{)} \times \text{Width of Paving (ft)}} \times 18000$$

(Nearest Foot)

The length the truck places is multiplied by the first random number to obtain a longitudinal distance. This distance is measured from the location of the paver when the truck containing the random ton begins unloading into the paver or material transfer device. The transverse test site location is determined by multiplying the width of pavement by the second random number and rounding to the nearest whole ft. This distance is measured from the right edge of pavement when looking in the direction of increasing station numbers. If the transverse location is less than 1 ft from either edge of pavement, at a location where the course thickness is less than 2.0 times the maximum particle size, or within the width of the roller drum used to form shoulder corrugations, then another random location is selected to obtain an acceptable sampling location. The first 300 t of the first subplot of the first lot for each DMF/JMF is not sampled. If the random ton selected for the subplot is within the first 300 t, then 300 is added to the random ton number and the sample is obtained from the truck containing that ton.

INDIANA DEPARTMENT OF TRANSPORTATION  
DIVISION OF MATERIALS AND TESTS

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DISTRICT TESTING ENGINEER  
FILE

RANDOM SAMPLING FOR MIX ANALYSIS

Contract No. R-20396 LOT No. 4

District Greenfield Mixture 19.0 mm Intermediate

DATE SAMPLED: SUBLOT 1 6/9/01 SUBLOT 2 6/9/01 SUBLOT 3 6/10/01 SUBLOT 4 6/10/01

SUBLOT NO.	SUBLOT TONS	RANDOM NO.	RANDOM TON	RANDOM TON A x B = C	LOT TON TO BE SAMPLED	PAYING WIDTH	RANDOM NO.	TRANS. LOC.	LENGTH OF LOAD	RANDOM NO.	RANDOM DIST.	STARTING STA.*	RANDOM STATION
1	600				0								N.B. Passing
	1000	.123	123		0	12	.100	1.2 (1)	136	.259	35	10+50	10+85
2	600				625								N.P. Passing
	1000	.116	116		1000	12	.890	10.7 (11)	136	.317	43	76+90	77+33
3	600				1250								N.B. Passing
	1000	.836	836		2000	12	.523	6.3 (6)	136	.665	90	194+00	194+90
4	600				1875								N.B. Passing
	1000	.636	636		3000	12	.928	11.1 (11)	136	.404	55	247+20	247+75

\* STATION OF PAVER WHEN TRUCK CONTAINING RANDOM TON BEGINS UNLOADING.

$$\text{Length of Load} = \frac{\text{Load Weight (tons)} \times 18000}{\text{Avg. Planned Quantity} \times \text{Width of Paving (ft.)}}$$

Figure 9-7. Random Sampling for Mix

If a sample is obtained by the Contractor for the Departments' acceptance testing, the Contractor representative who obtained the sample and the Department representative who witnessed the sample being taken will be identified on the transmittal information. This required documentation is very valuable/useful when handling numerous samples.

The following example indicates how these random locations are determined.

**Example:**

Width of Pavement	=	12 ft
Load Weight	=	20 t
Mixture	=	9.5 mm Surface
Planned Quantity	=	110 lb/yd <sup>2</sup>
Ending Station of Paver of Previous Load	=	158+00
Random Numbers	=	0.256, 0.561

Test Site Station

$$\text{Length of Load} = \frac{20}{110 \times 12} \times 18000 = 273 \text{ ft}$$

$$\text{Longitudinal Distance} = 273 \times 0.256 = 70 \text{ ft}$$

$$\text{Random Station} = (158+00) + 70 = 158+70$$

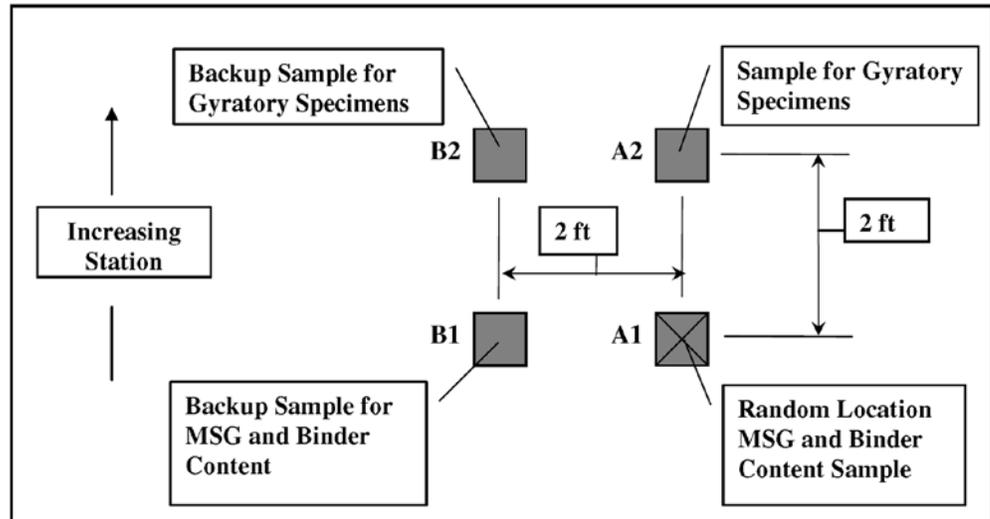
Transverse Distance

$$\text{Distance} = 12 \times 0.561 = 6.7 \text{ ft (say 7 ft)}$$

For contracts controlled by volumetrics for QC/QA HMA (401), several samples are required. The first plate (A1) sample location is determined by the random sampling procedure and this material is used for the maximum specific gravity and binder content samples. A second plate (A2) sample location is placed longitudinally 2 ft upstation from the first plate at the same transverse offset. This sample is used for the gyratory specimens.

If an appeal by the Producer of the INDOT test results is accepted, backup samples are tested. These samples are obtained at the same time as the acceptance samples. The backup sample plate (B1) for the maximum specific gravity and binder content is placed transversely 2 ft from the first plate towards the center of the mat. The backup sample plate (B2) for the gyratory specimens is placed transversely 2 ft from the second plate towards the center of the mat.

The following diagram shows an example of an arrangement of the plate samples when additional samples are required and backup samples are taken transversely from the first and second sample locations for QC/QA HMA:



An example of determining the sample locations is as follows:

**Example:**

Sublot Size	= 1000 t
Random Number	= 0.613
Random Quantity	= 1000 x 0.613 = 613 t
Width of Pavement	= 12 ft
Load Weight	= 20 t
Mixture	= 25.0 mm Base
Planned Quantity	= 250 lb/yd <sup>2</sup>
Ending Station of Paver of Previous Load	= 105+00
Random Numbers	= 0.428, 0.417

Test Site Station

$$\text{Length of Load} = \frac{20}{250 \times 12} \times 18000 = 120 \text{ ft}$$

$$\text{Longitudinal Distance} = 120 \times 0.428 = 51 \text{ ft}$$

$$\text{Random Station} = (105+00) + 51 = 105+51$$

Transverse Distance

$$\text{Distance} = 12 \times 0.417 = 5 \text{ ft}$$

If additional samples are required, the following locations are determined:

Gyratory Specimens Sample

Random Location =  $105 + 51 + 02 = 105 + 53$  (nearest foot)  
Transverse Location = 5 ft

Backup Sample for MSG and Binder Content

Random Location =  $105 + 51$   
Transverse Distance =  $5 + 2 = 7$  ft

Backup Sample for Gyratory Specimens

Random Location =  $(105 + 51) + 2$   
=  $105 + 53$  (nearest foot)  
Transverse Distance =  $5 + 2 = 7$  ft

The procedure for obtaining plate samples (Figure 9-8) once the random location is determined is as follows:

- 1) A clean metal plate with attached wire is placed on the pavement. Should conditions on the contract require stabilizing movement to avoid slipping of the plate, a nail is driven into the pavement, and the plate hole placed onto the nail. A No. 18 gage mechanics wire and masonry nail has been proven to be effective for this purpose.
- 2) The wire is extended beyond the edge of the paving width. The wire should not pass under a grade leveler attached to the paver. Trucks, pavers, or material transfer devices are allowed to cross the plate and/or wire. If a windrow elevator is used, the paving operation is stopped so that the plate may be placed between the windrow elevator and the paver.
- 3) After the mixture is placed and before any compaction from the rollers occurs, the wire is used to locate the plate.
- 4) The plate is lifted with the wire, a narrow shovel or pitchfork is inserted under the plate, and the plate is lifted from the pavement.
- 5) The sample is then placed in a container for transport to the testing facility. Enter sample information (location w/sample number) on container and verify that the minimum sample weight is met. The material remaining on the plate is required to be removed and replaced into the sample container.



**Figure 9-8. Plate Sampling**

If the depth of the mixture is such that the material may fall off the sides of the plate when lifted from the pavement, a mold may be used with the plate. Only the plate or the plate with a mold procedures are allowed for the acceptance sample. The placement and location of the plate are done using the same procedures and restrictions used for sampling when only a plate is used. Additional requirements for using a mold with a plate include:

- 1) A clean round mold, with a height greater than the mixture thickness and diameter less than the width of the plate, is pushed by means of a circular motion into the mixture directly over the plate.
- 2) The mold and plate are raised together and a pitchfork or narrow shovel is inserted under the plate.
- 3) The mold and plate are lifted from the pavement and any excess mixture on top of the plate and outside of the mold is discarded.

- 4) The sample inside the mold is placed into the sample container. Material remaining on the plate is removed and placed into the sample container.
- 5) Verify that the minimum sample weight is met.

When the pavement width is 4 ft or less, the samples are obtained from the center of the course and at least 1 ft from the edge of the course.

Plate samples will not be taken at the following location:

- 1) Less than 1 ft from the edge of the course.
- 2) A course thickness less than 2.0 times the maximum particle size.
- 3) Original pay items less than 300 t.
- 4) Areas placed by wideners, or specialty equipment approved by the Engineer. If the random location falls within an area placed by this equipment, another randomly selected location is determined. If the entire subplot falls within an area placed by this equipment, the previous is used for acceptance. If the previous subplot is not available, the subsequent subplot will be used.

The size of the plate used to obtain a sample is dependent on the test(s) conducted on the material. The following minimum sample weights are required:

Mixture Designation	Minimum Weights (g)	
	MSG and Binder Content	Gyratory Specimens
4.75 mm	3000	11000
9.5 mm	3000	11000
12.5 mm	4000	11000
19.0 mm, OG 19.0 mm	5500	11000
25.0 mm, OG 25.0 mm	7000	11000

Figure 9-9 indicates the approximate weights that may be obtained for various sizes of plates and lift thicknesses that are placed.

Figure 9-10 indicates the approximate weights that may be obtained for various sizes of molds and lift thicknesses when a mold is used with the plate for obtaining a sample.

Approximate Sample Yield for Various Lift Thickness and Plate Sizes								
Lift Thickness (inches)	Lay Rate (lb/yd <sup>2</sup> )	Plate Size, inches						
		8	9	10	11	12	14	16
Sample Weight (g)								
1.25	137.5	3100	3900	4800	5900	7000	9500	12400
1.5	165	3700	4700	5800	7000	8400	11400	14900
1.75	192.5	4300	5500	6800	8200	9800	13300	17300
2.0	220	5000	6300	7700	9400	11100	15200	19800
2.25	247.5	5600	7100	8700	10500	12500	17100	22300
2.5	275	6200	7800	9700	11700	13900	19000	27800
2.75	302.5	6800	8600	10600	12900	15300	20900	27300
3.0	330	7400	9400	11600	14100	16700	22800	29700
3.25	357.5	8100	10200	12600	15200	18100	24700	32200
3.5	385	8700	11000	13500	16400	19500	26600	34700
3.75	412.5	9300	11800	14500	17600	20900	28500	37200
4.0	440	9900	12500	15500	18700	22300	30300	39600
4.25	467.5	10500	13300	16400	19800	23600	32100	41900
4.5	495	11100	14000	17300	21000	25000	34000	44400
4.75	522.5	11700	14800	18300	22100	26400	35900	46900
5.0	550	12300	15600	19300	23300	27700	37800	49300
5.25	577.5	12900	16400	20200	24500	29100	39700	51800
5.5	605	13600	17200	21200	25600	30500	41500	54300
5.75	632.5	14200	17900	22200	26800	31900	43400	56700
6.0	660	14800	18700	23100	28000	33300	45300	59200

**Figure 9-9. Approximate Sample Yield for Various Lift Thickness and Plate Sizes**

Approximate Sample Yield for Various Lift Thicknesses and Mold Sizes						
Lift Thickness (inches)	Lay Rate (lb/yd <sup>2</sup> )	Mold Size, inches				
		8	10	12	14	16
Sample Weight (g)						
1.25	137.5	2400	3800	5400	7400	9700
1.5	165	2900	4500	6500	8900	11600
1.75	192.5	3400	5300	7600	10400	13600
2.0	220	3900	6100	8700	11900	15500
2.25	247.5	4400	6800	9800	13300	17400
2.5	275	4800	7600	10900	14800	19400
2.75	302.5	5300	8300	12000	16300	21300
3.0	330	5800	9100	13100	17800	23200
3.25	357.5	6300	9800	14200	19300	25200
3.5	385	6800	10600	15300	20800	27100
3.75	412.5	7300	11300	16300	22200	29100
4.0	440	7700	12100	17400	23700	31000
4.25	467.5	8200	12900	18500	25200	32900
4.5	495	8700	13600	19600	26700	34900
4.75	522.5	9200	14400	20700	28200	36800
5.0	550	9700	15100	21800	29700	38700
5.25	577.5	10200	15900	22900	31100	40700
5.5	605	10700	16600	24000	32600	42600
5.75	632.5	11100	17400	25100	34100	44500
6.0	660	11600	18200	26100	35600	46500

**Figure 9-10. Approximate Sample Yield for Various Lift Thicknesses and Mold Sizes**

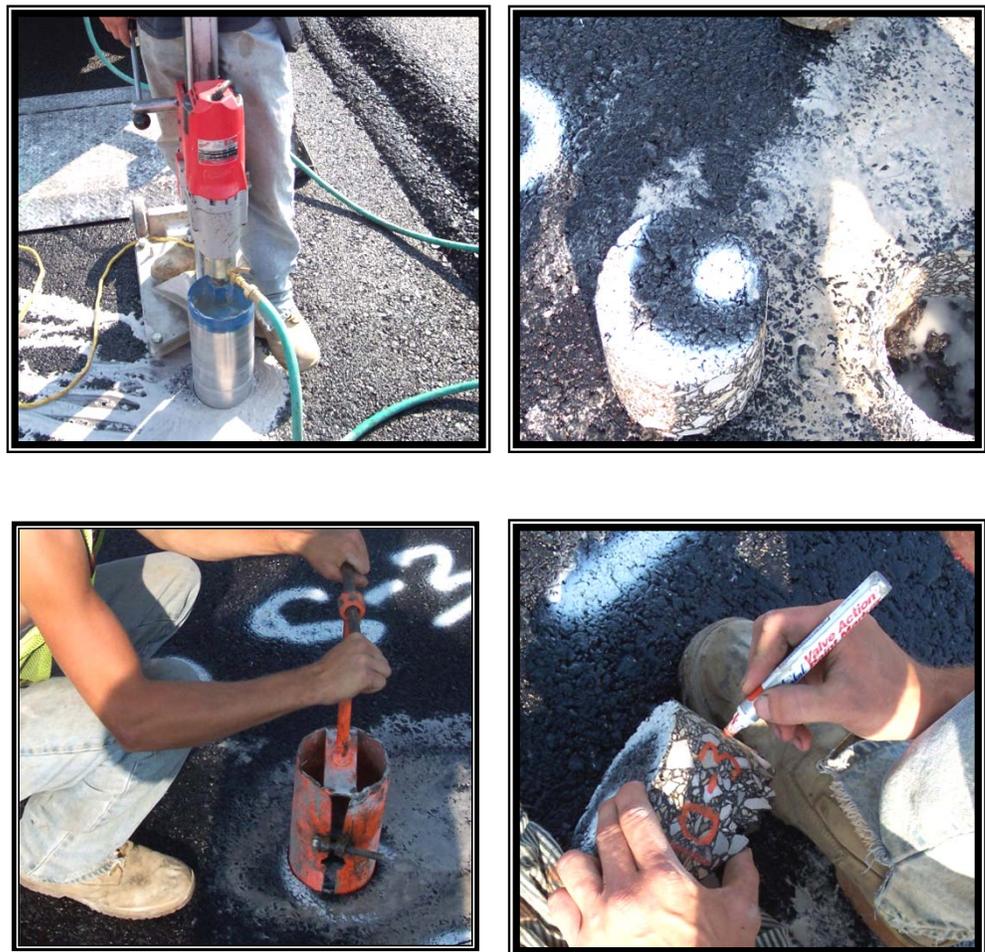
### ***TRUCK SAMPLING***

Truck sampling is conducted at the HMA Plant by taking a sample directly from a truck hauling the mixture to the contract. The random ton is determined in accordance with **ITM 802**. The truck containing that ton is then sampled. Generally, truck sampling is done by the Producer for Quality Control purposes. Truck sampling is conducted in accordance with **ITM 580**.

### ***CORE SAMPLING***

Core sampling (Figure 9-11) is done by the Contractor under the supervision of an INDOT Technician. For QC/QA HMA, two cores are obtained in each subplot for density of the mixture. The core locations are determined by **ITM 802** with each core located independently within the subplot. All core sampling is done in accordance with **ITM 580**.

A 6 in diameter core is obtained from the pavement. The sample is removed from the pavement with a device that does not damage the layer to be tested. The layer to be tested is marked with a lumber crayon or permanent marker.



**Figure 9-11. HMA Coring**

## ADJUSTMENT PERIOD -- QC/QA HMA

The Producer is allowed an adjustment period for each mix design in which the mix design is verified and changes may be made in the DMF, if necessary. A job mix formula (JMF) is submitted for approval to the Engineer one working day after the Producer receives the test results for the binder content, VMA, and air content. The adjustment period is from the beginning of production and extending until 5000 t of base or intermediate QC/QA HMA, or 3000 t of surface QC/QA HMA has been produced for each mix design. A reduced adjustment period is allowed. If production extends into the next construction season, another adjustment period is allowed.

## MIXTURE ACCEPTANCE

### *QC/QA HMA*

Acceptance of QC/QA HMA mixtures in accordance with **401** for binder content, VMA at  $N_{des}$ , and air voids at  $N_{des}$  for each lot is based on tests conducted by INDOT. INDOT randomly selects the location(s) within each subplot for sampling in accordance with the **ITM 802**. Samples from the pavement are obtained from each subplot in accordance with **ITM 580**.

A binder draindown test in accordance with **AASHTO T 305** for open graded mixtures is required once per lot and may not exceed 0.50 %.

The acceptance test results for each subplot are available after the subplot and the testing are complete.

### *HMA*

Acceptance of HMA mixtures in accordance with **402** is done on the basis of a Type D certification submitted by the Producer to the Project Engineer on a contract. Note: In accordance with Construction Memo **13-08** “there will be no **402** mixtures used on mainline pavement”. Only miscellaneous mixtures will follow **402** requirements. (An example of this certification form is shown in Figure 9-12). The certification is required to be submitted with the first truck of each type of mixture each day. If no test results are available, the Producer indicates on the form that test results are required to be obtained within the first 250 tons and each subsequent 1000 tons for base and intermediate mixtures, and the first 250 tons and each subsequent 600 tons for surface mixtures. A DMF developed for a QC/QA HMA mixture in accordance with **401** may be used for **402** mixtures and the source or grade of the binder may be changed; however, the high temperature grade of the binder is required to be in accordance with **402**.

Mixtures in **402** that require the Type D Certification include miscellaneous HMA mixtures such as patching, widening, rumble strips, wedge and leveling, approaches, temporary mixtures, etc. In general these mixtures have low quantities and are placed in locations that plate samples cannot be obtained and the random sampling procedures are not applicable.

**INDIANA DEPARTMENT OF TRANSPORTATION  
HOT MIX ASPHALT (HMA) CERTIFICATION**

CONTRACT NUMBER RS-30000 DATE 5/3/07

CERTIFIED HMA PRODUCER J. Wooden Construction

CERTIFIED HMA PLANT NUMBER 3550 DMF/JMF NUMBER 0310075

PG BINDER SOURCE 7199 PG BINDER GRADE PG 64-22

MIXTURE TYPE AND SIZE HMA Surface, 9.5 mm, Type A

DESIGN ESAL 200,000

Air Voids 4.0 (from DMF/JMF) Binder Content 5.5 (from DMF/JMF)

This is to certify that the test results for Air Voids and Binder Content represent the HMA mixture supplied to this contract.

Air Voids 4.3 ( $\pm 1.5$  % from DMF/JMF) Binder Content 5.7 ( $\pm 0.7$  % from DMF/JMF)

\* [ ] Test results are not available for submittal. A production sample shall be taken within the first 250 t (250 Mg) and each subsequent 1000 t (1000 Mg) for base and intermediate mixtures and each subsequent 600 t (600 Mg) for surface mixtures.

\*  If Applicable

\_\_\_\_\_  
Signature of HMA Producer Official

\_\_\_\_\_  
Title of Official

**FOR PE/S USE ONLY**

PAY ITEM(S) \_\_\_\_\_ BASIS FOR USE NO. C999998

**SPECIFICATION REFERENCE**

<input type="checkbox"/> 304.04 - Patching	<input type="checkbox"/> 402.07(c) - Temporary HMA	<input type="checkbox"/> 610.02 - Approaches
<input type="checkbox"/> 304.05 - Widening	<input type="checkbox"/> 503.03(e) - Terminal Joints	<input type="checkbox"/> 611.02 - Crossovers
	<input type="checkbox"/> 507.05(b) - Partial Depth Patching	<input type="checkbox"/> 718.04 - Underdrains
<input type="checkbox"/> 402.07(a) - Rumble Strips	<input type="checkbox"/> 604.07(c) - Sidewalk	<input type="checkbox"/> 801.11- Temp. Cross
<input type="checkbox"/> 402.07(b) - Wedge & Leveling	<input type="checkbox"/> 605.07(c) - Curbing	

**Figure 9-12. HMA Certification**

## PAY FACTOR DETERMINATION/QUALITY ASSURANCE ADJUSTMENTS

When a contractor produces a QC/QA HMA mixture to construct an asphalt pavement or overlay, payment for this work is made at the contract unit price per ton (Mg) of mixture delivered to the contract. In addition, these contracts include a QA Adjustment pay item which provides additional payment to the contractor or a credit to the Department based on the results of the QA testing.

The QA Adjustment may have two components. The first component is based on mixture properties and density. Secondly, if the contract includes the profilograph pay item, there will be a QA Adjustment based on the profile index measured after the full depth pavement or overlay is constructed.

For all dense graded mixtures with a pay item/DMF/JMF combination quantity greater than one lot, the pay factors are determined based on percent within limits (PWL) methodology in accordance with 401.19(a). The final PWL Acceptance Worksheets (Figure 9-13) for each pay item/DMF/JMF combination provided by District Testing includes composite pay factors for each lot based on mixture properties and density. Use this information to determine the QA Adjustment associated with mixture properties and density for each lot. Add all of the lot QA Adjustments for mixture properties and density to determine the overall QA Adjustment for mixture properties and density.

For all open graded mixtures and dense graded mixtures with pay item/DMF/JMF combination quantity less than one lot, the volumetric property/density portion of the QA Adjustment pay item is based on individual subplot QA test results in accordance with 401.19(b). The final Volumetric Acceptance Worksheets (Figure 9-15) for each pay item/DMF/JMF combination provided by District Testing includes composite pay factors for all mixture properties and density for each subplot. Use this information to determine the QA Adjustment associated with mixture properties and density for each subplot. Add all of the QA Adjustments for all mixture sublots to determine the overall QA Adjustment attributed to mixture properties and density.

Ensure that the final versions of the PWL or Volumetric Worksheets are used for determining the QA Adjustment associated with mixture properties and density. The contractor has a right to appeal QA test results and until appeals are finalized, the QA test results and pay factors are not final. Also, if the final version of either worksheet indicates a QA test failure, verify that correspondence related to disposition of this failed material has been received. If no such correspondence has been received, request a copy from District Testing.

After the total QA Adjustment for the contract has been determined, process a change order to facilitate the payment to the contractor or credit to the Department as appropriate. Attach all information used to determine the QA Adjustment to the change order as backup documentation. Refer to **ITM 588** for additional information on Percent Within Limits (PWL).

**PWL (Precent Within Limits) – Dense Graded  $\geq 1$  Lot**

Laboratory results for PWL samples are distributed in an Excel workbook (Figure 9-13). Each workbook contains all of the results for all lots for a single mix design. The final Lot Composite Pay Factor (LCPF) is found at the bottom left-hand side of the page. The total QA adjustment amount is found on the bottom right-hand side of the page. In order for the spreadsheet to calculate the QA adjustment correctly both the final lot quantity and the mix unit price must be provided to the lab by the project personnel. The QA adjustment either negative or positive is paid under the contract item “Quality Adjustments, HMA”.

A failure is indicated by the letters “RQL” or Rejectable Quality Limits in the LCPF cell (Figure 9-14). If this occurs, there is no QA adjustment shown on the spreadsheet for that lot. Failures must be resolved by a letter from the District Testing Engineer. The adjustment for the failure is a paid under the contract item “Quality Adjustments, Failed Materials”.



INDIANA DEPARTMENT OF TRANSPORTATION  
OFFICE OF MATERIAL MANAGEMENT

CY2012 PWL ACCEPTANCE WORKSHEET CY2012

ACCEPTANCE SAMPLE LOCATIONS

Factor	RANDOM LOCATION									
	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5	Sublot 6	Sublot 7	Sublot 8	Sublot 9	Sublot 10
Lab Test Number	R123982500041	R123982500042	R123982500043	R123982500044	R123424100045					
Test Date	08/24/12	08/24/12	08/28/12	08/28/12	08/28/12					
Mixture Sample No.										
Mixture Station										
Mixture Direction										
Mixture Offset ft (m)										
Mixture Offset Ref.										
Core Sample No.										
Core 1 Station										
Core 1 Direction										
Core 1 Offset ft (m)										
Core 1 Offset Ref.										
Core 2 Station										
Core 2 Direction										
Core 2 Offset ft (m)										
Core 2 Offset Ref.										

STATE - ACCEPTANCE TEST RESULTS

Sample	Factor	STATE TEST RESULTS									
		Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5	Sublot 6	Sublot 7	Sublot 8	Sublot 9	Sublot 10
Mix	% Binder	5.38	5.40	5.48	5.22	5.40					
Mix	MSG	2.456	2.448	2.452	2.478	2.461					
Pill 1	BSG	2.335	2.340	2.351	2.335	2.358					
Pill 2	BSG	2.342	2.335	2.357	2.340	2.363					
Pill Avg	BSG	2.339	2.338	2.354	2.338	2.361					
Core 1	BSG	2.224	2.262	2.261	2.280	2.259					
Core 2	BSG	2.262	2.275	2.256	2.258	2.264					

STATE - MIX PROPERTIES ACCEPTANCE RESULTS

Factor	STATE VALUES									
	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5	Sublot 6	Sublot 7	Sublot 8	Sublot 9	Sublot 10
% Binder	5.38	5.40	5.48	5.22	5.40					
% Air Voids	4.76	4.49	4.00	5.65	4.06					
% VMA	15.91	15.97	15.46	15.81	15.14					
% Density, Core 1	90.55	92.40	92.21	92.01	91.79					
% Density, Core 2	92.10	92.93	92.01	91.12	92.00					

STATE - LOT MIX PROPERTIES ACCEPTANCE PWL & PF RESULTS

Factor	PWL	Property PF
% Binder	100	1.05
% Air Voids	90	1.00
% VMA	100	1.05
% Density	92	1.01
LCPF		1.02

AQL	90 >
RQL	50 >
Sublot AV	1.00 >
FMC Review	7.00 <

NOTES:

Report Date	7/14/2011
Report	Original

CONTRACT INFORMATION	
Contract	RS-30146
Contractor	Excellent Paving
Plant Loc.	No Name City
Plant No.	1234
Plant Tech.	Rocky Road
District	Greenfield
Route	SR 95
P.E./P.S.	Dusly Roads

LOT INFORMATION	
Factor	Value
Lot Number	4
Quantity Sublot 1	600.00
Quantity Sublot 2	600.00
Quantity Sublot 3	600.00
Quantity Sublot 4	600.00
Quantity Sublot 5	600.00
Quantity Sublot 6	
Quantity Sublot 7	
Quantity Sublot 8	
Quantity Sublot 9	
Quantity Sublot 10	

DMF/JMF INFORMATION	
Factor	Value
DMF/JMF Number	123312J-70
Mix Designation	9.5mm
Course	Surface
Application	Mainline
% Binder Actual	5.5
% Air Voids @ Ndes	4.00
% VMA @ Ndes	15.50
Agg Blend Gsb	2.632
Material Code/Spec	401M34547

LOT QA ADJUSTMENT Bonus +\$	
Factor	Value
q = QA Adjustment	\$3,754.80
L = Lot Quantity	3000.00
Mix Adjust Factor (MAF)	1.000
U = Unit Price \$/Unit	\$62.58
LCPF	1.02

Signature Technician:

Signature PE/PS:

Figure 9-13. PWL ACCEPTANCE WORKSHEET



INDIANA DEPARTMENT OF TRANSPORTATION  
OFFICE OF MATERIAL MANAGEMENT

CY2012 PWL ACCEPTANCE WORKSHEET CY2012

ACCEPTANCE SAMPLE LOCATIONS

Factor	RANDOM LOCATION									
	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5	Sublot 6	Sublot 7	Sublot 8	Sublot 9	Sublot 10
Lab Test Number	R123958920011	R123958920012	R123958920013	R123958920014	R123958920015					
Test Date	05/21/12	09/18/12	09/18/12	09/18/12	09/18/12					
Mixture Sample No.										
Mixture Station										
Mixture Direction										
Mixture Offset ft (m)										
Mixture Offset Ref.										
Core Sample No.										
Core 1 Station										
Core 1 Direction										
Core 1 Offset ft (m)										
Core 1 Offset Ref.										
Core 2 Station										
Core 2 Direction										
Core 2 Offset ft (m)										
Core 2 Offset Ref.										

STATE - ACCEPTANCE TEST RESULTS

Sample	Factor	STATE TEST RESULTS									
		Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5	Sublot 6	Sublot 7	Sublot 8	Sublot 9	Sublot 10
Mix	% Binder	5.75	5.33	5.36	5.72	5.52					
Mix	MSG	2.464	2.479	2.450	2.451	2.450					
Pill 1	BSG	2.371	2.358	2.341	2.346	2.334					
Pill 2	BSG	2.391	2.359	2.340	2.351	2.332					
Pill Avg	BSG	2.381	2.359	2.341	2.349	2.333					
Core 1	BSG	2.269	2.259	2.173	2.219	2.206					
Core 2	BSG	2.289	2.161	2.248	2.170	2.220					

STATE - MIX PROPERTIES ACCEPTANCE RESULTS

Factor	STATE VALUES									
	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5	Sublot 6	Sublot 7	Sublot 8	Sublot 9	Sublot 10
% Binder	5.75	5.33	5.36	5.72	5.52					
% Air Voids	3.37	4.84	4.45	4.16	4.78					
% VMA	14.71	15.12	15.79	15.83	16.22					
% Density, Core 1	92.09	91.13	88.69	90.53	90.04					
% Density, Core 2	92.90	87.17	91.76	88.54	90.61					

STATE - LOT MIX PROPERTIES ACCEPTANCE PWL & PF RESULTS

Factor	PWL	Property PF
% Binder	89	1.00
% Air Voids	100	1.05
% VMA	90	1.00
% Density	36	RQL
LCPP		RQL

AQL	90 >
RQL	50 >
Sublot AV	1.00 >
FMC Review	7.00 <

NOTES:

Report Date	9/8/2012
Report	Original

CONTRACT INFORMATION

Contract	RS-12345
Contractor	Roads R US
Plant Loc.	No Name City
Plant No.	1234
Plant Tech.	Super Tech
District	Greenfield
Route	SR 99
P.E./P.S.	Dusty Roads

LOT INFORMATION

Factor	Value
Lot Number	1
Quantity Sublot 1	600.00
Quantity Sublot 2	600.00
Quantity Sublot 3	600.00
Quantity Sublot 4	600.00
Quantity Sublot 5	358.00
Quantity Sublot 6	
Quantity Sublot 7	
Quantity Sublot 8	
Quantity Sublot 9	
Quantity Sublot 10	

DMF/JMF INFORMATION

Factor	Value
DMF/JMF Number	123909D-64
Mix Designation	9.5mm
Course	Surface
Application	Mainline
% Binder Actual	5.7
% Air Voids @ Ndes	4.00
% VMA @ Ndes	15.10
Agg Blend Gsb	2.631
Material Code/Spec	401M34547

LOT QA ADJUSTMENT #VALUE!

Factor	Value
q = QA Adjustment	#VALUE!
L = Lot Quantity	2758.00
Mix Adjust Factor (MAF)	1.000
U = Unit Price \$/Unit	\$60.25
LCPP	RQL

Signature Technician:

Signature PE/PS:

Figure 9-14. PWL ACCEPTANCE WORKSHEET/"RQL"

## **VOLUMETRIC – Dense Graded < 1 Lot**

Laboratory results for volumetric samples are distributed in an Excel workbook (Figure 9-15). Each workbook contains the results for a single lot of a single mix design. The final Sublot Composite Pay Factor (SCPF) for each subplot is found at the bottom of each subplot column. The total QA adjustment amount for each subplot is found on the bottom right-hand side of the page. In order for the spreadsheet to calculate the QA adjustment correctly both the final subplot quantities and the mix unit price must be provided to the lab by the project personnel. The QA adjustment either negative or positive for each subplot is paid under the contract item “Quality Adjustments, HMA”.

A failure is indicated by the word “Fail” in the cell for the QA adjustment for that subplot (Figure 9-15). If this occurs, there is no QA adjustment value shown on the spreadsheet for that subplot. Failures in any subplot must be resolved by a letter from the District Testing Engineer. The adjustment for each failure is a paid under the contract item “Quality Adjustments, Failed Materials”.

INDIANA DEPARTMENT OF TRANSPORTATION  
MATERIALS AND TESTS DIVISION

CY2011 VOLUMETRIC ACCEPTANCE WORKSHEET CY2011

Sublot 1 Test Number	R132975641011
Sublot 2 Test Number	R132975641012
Sublot 3 Test Number	R132975641013
Sublot 4 Test Number	R132975641014
Sublot 5 Test Number	

Date	8/9/2013
------	----------

CONTRACT INFORMATION

Contract	IR 30889
Contractor	Roads R Us
Plant Loc.	Anytown
Plant No.	8745
Plant Tech.	Super Tech
District	Greenfield
Route	SR 99
P.E./P.S.	Sunny Day

VARIANCE OF MIXTURE PROPERTIES FROM DMF/JMF

VARIANCE FROM DMF/JMF					
	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5
FACTOR	1	2	3	4	5
% Binder	0.1	0.6	0.7	0.4	
% Air Voids	0.1	1.1	2.2	0.0	
% VMA	0.1	0.9	0.8	0.3	

LOT INFORMATION

Factor	Value
Bid Price \$/Unit	57.00
Lot Number	1
Quantity Sublot 1	1000.00
Quantity Sublot 2	1000.00
Quantity Sublot 3	1000.00
Quantity Sublot 4	648.00
Quantity Sublot 5	

STATE - ACCEPTANCE TEST RESULTS

		STATE TEST RESULTS				
		Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5
Sample	Factor	1	2	3	4	5
Mix	% Binder	3.9	3.4	3.3	4.4	
Mix	MSG	2.513	2.504	2.532	2.520	
Pill 1	BSG	2.415	2.375	2.375	2.423	
Pill 2	BSG	2.414	2.378	2.377	2.415	
Pill Avg	BSG	2.415	2.377	2.376	2.419	
Core 1	BSG	2.370	2.338	2.253	2.332	
Core 2	BSG	2.369	2.333	2.259	2.309	
Core Avg	BSG	2.370	2.336	2.256	2.321	

DMF/JMF INFORMATION

Factor	Value
DMF/JMF Number	113942-64
Mix Designation	25.0 mm
Course	Base
Application	Mainline
% Binder Actual	4.0
% Air Voids @ Ndes	4.0
% VMA @ Ndes	13.3
Agg Blend Gsb	2.675
Mix Adjust Factor	1.000
Material Code	401M34512

MIXTURE PROPERTIES FOR ACCEPTANCE

Date Results Sent	7/5/2013	7/15/2013	8/2/2013	8/2/2013	
	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5
Factor	1	2	3	4	5
% Binder	3.9	3.4	3.3	4.4	
% Air Voids	3.9	5.1	6.2	4.0	
% VMA	13.2	14.2	14.1	13.6	
% Density	94.3	93.3	89.1	92.1	

QA ADJUSTMENT\*\*

Lot/Sublot	Value
1-1	Bonus +\$ 2850.00
BFU: R132975641011	
1-2	Credit -\$ 1140.00
BFU: R132975641012	
1-3	Fail
BFU: R132975641013	
1-4	Bonus +\$ 1108.08
BFU: R132975641014	

SUBLOT COMPOSITE PAY FACTORS

Factor	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5
% Binder - P.F.	1.05	0.90	0.80	1.02	
% Air Voids - P.F.	1.05	0.98	Fail	1.05	
% VMA - P.F.	1.05	1.00	1.00	1.05	
% Density - P.F.	1.05	1.02	0.58	1.00	
SCPF	1.05	0.98	Fail	1.03	
Sublot Quantity	1000.00	1000.00	1000.00	648.00	
Revised SCPF	1.05	0.98	1.00	1.03	
Revised SL Quantity	1000.00	1000.00	1000.00	648.00	

\*\*Includes division by MAF

NOTES:

LEGEND INFORMATION

Factor	Code
Contractor Input	
State Input	
Computer Output	

Signature Technician: \_\_\_\_\_

Signature PE/PS: \_\_\_\_\_

**Figure 9-15. VOLUMETRIC ACCEPTANCE WORKSHEET**

## MIX APPEAL -- QC/QA HMA

If the Producer does not agree with the acceptance test results, a request may be submitted in writing that additional samples be tested. The written request is required to include the Producer's test results and be made within seven calendar days of receipt of the written results of the HMA tests for that lot. The appeal is not accepted if the Producer has not conducted any tests that indicate a higher Pay Factor than was determined from the test results by INDOT.

Additional tests for the appeal may be requested for the maximum specific gravity, bulk specific gravity of the gyratory specimens, binder content, or bulk specific gravity of the density cores. One or more of these tests may be requested for the subplot or entire lot. Upon approval of the appeal, the backup samples are tested as follows:

- 1) Maximum Specific Gravity -- The sample is dried in accordance with **ITM 572** and mass determined in water in accordance with **AASHTO T 209**.
- 2) Bulk Specific Gravity of the Gyratory Specimens -- New gyratory specimens are prepared and tested in accordance with **AASHTO T 312**.
- 3) Binder Content -- The binder content is tested in accordance with the test method that was used for acceptance or as directed by INDOT.
- 4) Bulk Specific Gravity of the Density Core -- Additional cores are taken within seven calendar days unless otherwise directed. The core locations are determined by adding 1.0 ft longitudinally of the cores tested for acceptance using the same transverse offset. The cores are dried in accordance with **ITM 572** and tested in accordance with **AASHTO T 166**, Method A, or **AASHTO T 275**, if required.

The appeal results replace all previous test result(s) for acceptance of the mixture properties and density.

## SMOOTHNESS

Smoothness of HMA pavements is measured using a profilograph (Figure 9-16), and a profile index for a section of pavement is obtained from a profilogram recorded by the profilograph.



**Figure 9-16. Profilograph**

### *PROCEDURES*

The procedures for the operation of the profilograph are as follows:

- 1) The profilograph is operated by a Contractor Technician monitored by a Department Qualified Technician.
- 2) The profilograph is required to be certified and calibrated in accordance with **ITM 912**.
- 3) The certificate of compliance is required to be presented to the Engineer prior to use of the profilograph on the contract.
- 4) The profilograph is checked by the Engineer to verify that the band width, bump height, low pass filter, and the short segment settings on the profilograph and the tire pressure correspond with the requirements indicated on the certificate of compliance.
- 5) The profilograph is operated in an area safe from traffic hazards, protected by traffic control, and in an area approved by the Engineer.
- 6) The profilograph is operated in accordance with the manufacturer operating instructions.
- 7) The profilograph is operated manually at speeds less than or equal to 4 mph (6.7 km/h).

- 8) Prior to the operation of the profilograph, the operator is required to enter the following information into the profilograph.
  - a) Company
  - b) Operator
  - c) Contract Number
  - d) Route
  - e) Lane
  - f) Lane Direction
  - g) Collection Time and Date
  - h) Pavement Course (Surface, Intermediate or Base)
  - i) Pavement Type (HMA)
  - j) English or Metric Measurement
- 9) For lanes less than or equal to 12 ft (3.6 m) wide, the profilograph is operated in the direction of traffic and  $3.0 \pm 0.5$  ft ( $0.9144 \pm 0.152$  m) from and parallel to the right edge of the lane. If the lane may be utilized by traffic in either direction, the profilograph is operated in the direction of increasing station numbers and  $3.0 \pm 0.5$  ft ( $0.9144 \pm 0.152$  m) from and parallel to the right edge of the lane.
- 10) For lanes greater than 12 ft (3.6 m) wide, the profilograph is operated in the direction of traffic and  $3.0 \pm 0.5$  ft ( $0.9144 \pm 0.152$  m) from and parallel to both the left and the right edge of each lane. If the lane may be utilized by traffic in either direction, the profilograph is operated in the direction of increasing stations and  $3.0 \pm 0.5$  ft ( $0.9144 \pm 0.152$  m) from and parallel to both the left and the right edge of each lane.
- 11) The Contractor is required to provide the profilogram to the Department Qualified Technician at the completion of each trace. The Qualified Technician signs and dates each trace at the time of receipt.

#### ***PROFILOGRAPH EXEMPTIONS***

Areas that are exempt from profilograph measurement are:

- 1) The first and last 50 ft (15.24 m) within the paving limits
- 2) From 50 ft (15.24 m) before through 50 ft (15.24 m) after each paving exception
- 3) From 50 ft (15.24 m) before through 50 ft (15.24 m) after each curve with a centerline radius of less than 75 ft (23 m)

- 4) Vertical curves that exceed the 2 1/2 in. vertical scale measuring capacity of the profilograph
- 5) From 50 ft (15.24 m) before through 50 ft (15.24 m) after each at grade railroad crossing
- 6) From 50 ft (15.24 m) before through 50 ft (15.24 m) after each casting located within 1.0 ft (0.30 m) measured laterally from the required location for profilograph operation. The tolerances indicated for the location of the profilograph operation are excluded.

If more than one trace is required, the profile index is the average of the two traces. Partial sections that occur at the end of a run or prior to an area exempt from measurement are prorated as follows:

- 1) If the length of the partial section is less than 250 ft, the profile index calculation for the section is averaged into the previous 0.1 mile section.
- 2) If the length of the partial section is equal to or greater than 250 ft, the profile index calculation for the section is prorated to a 0.1 mile section.

#### ***QUALITY ASSURANCE ADJUSTMENTS***

A quality assurance adjustment is applied for each 0.1 mi. (0.16 km) section of each lane and the adjustment is applied to all QC/QA HMA pay items within the pavement section. The adjustment for each section is calculated as follows:

$$q_s = (PF_s - 1.00) \sum_{i=1}^n \left( A \times \frac{S}{T} \times U \right)$$

where:

- $q_s$  = quality assurance adjustments for smoothness for 1 section
- $PF_s$  = pay factor for smoothness
- $N$  = number of layers
- $A$  = area of section, sq yd ( $m^2$ )
- $S$  = planned spread rate for material, lb/sq yd ( $kg/m^2$ )
- $T$  = conversion factor: 2,000 lb/ton (1,000 kg/Mg)
- $U$  = unit price for the material, \$/ton (\$/Mg)

The quality assurance adjustment for smoothness,  $Q_s$ , for the contract is the total of the quality assurance adjustments,  $q_s$ , on each section calculated by the following formula:

$$Q_s = \sum q_s$$

Payment adjustments are made based on a zero blanking band on the final profile index in accordance with the following table. Regardless of the tabulated value, the maximum pay factor for a smoothness section where corrective action has been performed is 1.00.

<b>PAY FACTORS FOR SMOOTHNESS (PI<sub>0.0</sub>) ZERO BLANKING BAND</b>	
Design Speed Greater than 45 mph	
Profile Index in. / 0.1 mi.	Pay Factor, PF <sub>s</sub>
Over 0.00 to 1.20 in.	1.06
Over 1.20 to 1.40 in.	1.05
Over 1.40 to 1.60 in.	1.04
Over 1.60 to 1.80 in.	1.03
Over 1.80 to 2.00 in.	1.02
Over 2.00 to 2.40 in.	1.01
Over 2.40 to 3.20 in.	1.00
Over 3.20 to 3.40 in.	0.96
All pavement with a profile index (PI <sub>0.0</sub> ) greater than 3.40 in. shall be corrected to a profile index less than or equal to 3.40 in.	

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# 10 Seal Coat Placement

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## Types of Seal Coats

## Quality Control Plan

## Equipment

*Distributor*

*Chip Spreader*

*Pneumatic-Tire Roller*

*Rotary Power Broom*

## Surface Preparation

*Aggregate Surface*

*Prime Coats*

*HMA Surfaces*

## Placement

*Weather Limitations*

*Traffic Control*

*Application of Asphalt Material*

*Application of Cover Aggregate*

*Application of Fog Seal*

## Application Rate Computations

*Asphalt Material*

*Cover Aggregate*

*Fog Seal*

# CHAPTER TEN:

## *SEAL COAT PLACEMENT*

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Seal coating consists of the application of liquid asphalt material to the roadway followed immediately by the application of the aggregate. Sometimes seal coats are referred to as chip seals. Seal coat applications may include single or double coverage. Where double applications are used, the first application of asphalt material is covered with aggregate, rolled, and allowed to cure before the second coat is applied.

Seal Coats are covered in Section **404**. Seal coats may be applied to aggregate or HMA surfaces; however, the most common use by INDOT is on HMA surfaces. When a seal coat is placed on an aggregate surface, a prime coat (Section **405**) is first applied and allowed to cure.

Seal coats are applied to HMA surfaces to:

- 1) Seal out moisture and air
- 2) Rejuvenate dry weathered surfaces
- 3) Improve skid resistance of the pavement
- 4) Improve visibility of delineation between the traveled way and the shoulders

Seal coats applied directly to roadways with aggregate surfaces provide a smooth, dust-free traveled way which eliminates the need for periodic re-grading of the surface. This method of construction is normally used only for low-volume roads.

INDOT typically uses seal coats on travel lanes on low volume roads or on shoulders of roads of any traffic volume.

Fog seals are sometimes used in conjunction with seal coats. A fog seal is a light application of liquid asphalt material to a pavement surface and is commonly used on seal coated pavements to improve the cover aggregate retention, assist the curing, and improve surface appearance. INDOT most commonly uses fog seals on seal coated surfaces.

## TYPES OF SEAL COATS

Seven types of seal coats are used as indicated in the table below. The types vary by the size of cover aggregate used and the number of applications. Types 1 through 4 use single applications and types 5 through 7 are double applications.

Type	Application	Cover Aggregate Size No. and course	Rates of Application per Square Yard	
			Aggregate (lb)	Asphalt Material (Gallons at 60°F)
1 or 1P	Single	23, 24	12-15	0.12-0.16
2 or 2P	Single	12	14-17	0.29-0.33
3 or 3P	Single	11	16-20	0.36-0.40
4 or 4P	Single	9	28-32	0.63-0.68
5 or 5P	Double	Top - 12	16-19	0.33-0.37
		Bottom - 11	16-20	0.36-0.40
6 or 6P	Double	Top - 11	18-22	0.41-0.46
		Bottom - 9	28-32	0.63-0.68
7 or 7P	Double	Top - 11	18-22	0.41-0.46
		Bottom - 8	28-32	0.63-0.68

Seal coat types which include a "P" in the designation utilize a polymer based asphalt material, AE-90S. INDOT requires polymer modified emulsion on all highway mainline applications. HFRS-2 is not to be used with a Type 1 Seal Coat. Additional requirements related to allowable asphalt materials for other seal coat types are included in Sections **404.03**, **404.04**, and **902.01(b)**. Seal coat asphalt materials require a Type A certification for acceptance by INDOT.

For double applications, the larger type coarse aggregate is used for the first application. Section **904** includes the requirements for the aggregates used in seal coats. The cover aggregates are required to be produced by a CAPP approved source.

## QUALITY CONTROL PLAN

A quality control plan which outlines the proposed seal coat operation is required to be approved prior to beginning work. The QCP shall be in accordance with **ITM 803** (Appendix A).

## EQUIPMENT

Four major pieces of Contractor equipment are required for seal coating: a distributor, chip spreader, pneumatic-tired roller, and rotary power broom.

### *DISTRIBUTOR*

The asphalt distributor (Figure 10-1) is the most important piece of equipment on a seal coat operation. The uniform application of the asphalt material at the appropriate rate is essential to achieve a quality seal coat.

The distributor is required to be checked to ensure that the equipment is in good working condition and complies with the Specification requirements. The proper nozzles, nozzle angles, spray bar height, pump speed, and pump pressure are items that are required to be checked. Clogged nozzles are a common problem that prevents a uniform application of asphalt material on the pavement surface. If the distributor does not apply a uniform application of emulsion over the entire surface to be seal coated, the operation is stopped immediately until the problem is corrected.

The distributor operation is optimized to ensure that the asphalt material is applied to the pavement surface at the appropriate rate. Proper asphalt material application rates vary depending on the existing pavement condition. To achieve the required application rate, the distributor pumps and speeds are required to be coordinated properly.



**Figure 10-1. Asphalt Distributor**

### ***CHIP SPREADER***

The chip spreader (Figure 10-2) receives the aggregate from the haul trucks and deposits the material uniformly over the full width of the asphalt material applied by the distributor. The spreader is required to spread the material uniformly without segregation so that the larger particles are applied to the surface ahead of the finer material.

Chip spreaders usually are self-propelled. Tailgate spreaders that hook onto dump trucks may be used for small quantities.



**Figure 10-2. Chip Spreader**

### ***PNEUMATIC-TIRE ROLLER***

The purpose of rolling with a pneumatic-tire roller (Figure 10-3) is to seat the aggregate into the asphalt material. Care is required to be taken in rolling to avoid moving the chips during the rolling process. A smooth, uniform operation of the roller is essential. Excessive braking, fast starts, or sharp turns may dislodge the cover aggregate from the asphalt material. Pneumatic-tire rollers are required to be ballasted to the proper weight and the tires properly installed.

The chip spreader and the pneumatic-tire roller should remain as close to the distributor as possible. The intent of a seal coat operation is to place and seat the cover aggregate into the asphalt material prior to the break that occurs as water evaporates from the emulsion. Prior to the break, the asphalt material is brown in color. After the water evaporates from the emulsion, the color of the material will be black.



**Figure 10-3. Pneumatic Tire Roller**

***ROTARY POWER BROOM***

A power rotary broom (Figure 10-4) is required for cleaning the surface prior to seal coating and to remove excess cover aggregate within 24 hours after the seal coat application. Power brooms may be self-propelled, mounted on the front of tractors, or mounted on trailers pulled behind other vehicles. Some manufacturers make special machines for this purpose.



**Figure 10-4. Rotary Power Broom**

## **SURFACE PREPARATION**

Surface preparation is extremely important for successful seal coating. The surface is required to be clean, dust free, and dry to obtain proper adhesion of the seal coat. Preparation of the surface varies somewhat, depending on the type of surface.

### ***AGGREGATE SURFACE***

Aggregate surfaces are required to be brought up to the proper crown and grade and thoroughly compacted. Aggregate surfaces that have been under traffic typically have potholes and chatter bumps (wash boarding) which are required to be removed. Removal may be done by scarifying a minimum of 3 in. deep, reshaping, and re-compacting. The surface is required to be free from all ruts, corrugations, segregated material, or other irregularities.

### ***PRIME COATS***

A prime coat is the application of asphalt material to an aggregate, stabilized base, or similar absorptive base that is to be given an asphalt surface. The purpose of the prime coat is to act as a bonding agent between the base and the seal coat. Prime coat materials penetrate into the base a slight amount to help hold down the dust which would prevent the seal coat from sticking. Prime coats are only used when a chip seal is applied to an aggregate surface.

Prime coats may be applied only when the temperature is 50° F or higher, unless written permission is given by the PE/S. The existing surface is required to conform to the requirements for an aggregate pavement, as described in Section **303**, before the prime coat is applied.

The asphalt material for a prime coat is required to be applied uniformly with a distributor at the specified temperature. The rate of application may vary from 0.25 to 0.80 gallons per square yard depending on the condition of the surface and the kind, gradation, and amount of loose aggregate. Skipped areas are required to be corrected and any excess material removed from the surface. Building paper is required to be placed over the ends of previous applications and the joining application started on the paper to prevent excess material build-up. The prime coat is cured when the material ceases to be tacky, usually within 24 hours. If the prime coat does not penetrate after a reasonable time and the primed area is required to be opened to traffic, cover aggregate is spread to absorb the excess material. When traffic is required to be maintained not more than one-half of the width of the roadway may be primed at one time.

## ***HMA SURFACES***

All defective areas and broken edges of existing HMA surfaces are required to be repaired prior to sealing. The old surface is brought up to a reasonable degree of uniformity by correcting flushed or dry areas and patching potholes and dips.

Cleaning the existing surfaces may normally be done with a power rotary broom. However, mud or other foreign matter may require removal with shovels, hand brooms, or water.

## **PLACEMENT**

### ***WEATHER LIMITATIONS***

The best weather for seal coating is hot and dry, during and after the application. Sealing is never started when the surface is wet or rain is threatening. The Specifications require that both the air and surface temperatures be at least 60°F. In addition to the temperature restrictions, seal coats may only be applied to the mainline pavement between May 1 and October 1. Shoulders are not subject to these date limitations.

Special care is required to protect the traveling public from over-spray from the distributor in windy weather. Sealing is not allowed in strong winds because crosswinds disturb the flow of asphalt materials from the nozzles which may cause spray interference and streaking.

### ***TRAFFIC CONTROL***

Because seal coats are often applied to road surfaces under traffic, special traffic control measures are needed. The seal coat is required to be protected from the traffic until the material has cured enough to prevent pick-up or displacement of the cover aggregate and until the chips are firmly embedded.

Traffic control is usually done during the initial curing period by the use of flagmen and pilot cars. Later, the traffic control may be handled with signing. Traffic is piloted through the work at speeds low enough to prevent damage to the newly placed seal coat. Normally, the speed should be less than 25 miles per hour. Care is required to be taken to prevent sudden starts or stops on the new seal. When stopping traffic on a new seal coat, additional cover aggregate at the stop locations may be necessary to prevent pick-up of the cover aggregate and tracking of the asphalt material.

The length of time that traffic is controlled depends on the weather and the type of asphalt applied. During cool, damp, cloudy, or humid weather, longer control periods are necessary than when the weather is warm, dry,

and sunny. Cool, damp weather delays the evaporation of the moisture in the cover aggregate and the setting rates of the asphalt material. During very hot weather, traffic is controlled longer if there is a possibility of chips rolling or picking up under traffic. Traffic is controlled during that portion of the day when damage may occur to vehicles due to flying rocks or to the seal coat. Traffic control may be necessary during the second day after seal coat placement.

Following an unexpected rainstorm, traffic is kept off the new seal coat until the cover aggregate has dried. If this is not possible, controlling traffic at an extremely slow rate is necessary and rolling is not continued until the danger of dislodging the aggregate has passed.

Traffic control is provided and the work scheduled to handle the traffic with a minimum delay. Most extended delays, exposure of the traffic to unnecessary hazards or inconveniences, or damage to the seal coat are the result of poor planning for traffic control. Traffic is never allowed to pass a distributor which is applying asphalt material if there is any possibility of asphalt being sprayed on the vehicles.

#### ***APPLICATION OF ASPHALT MATERIAL***

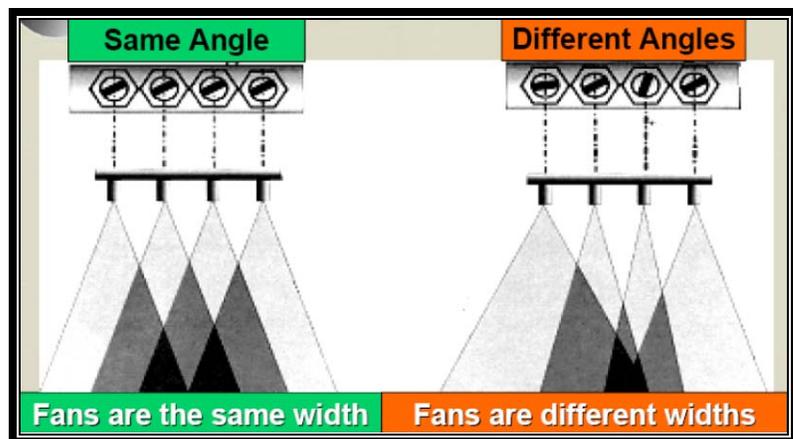
Asphalt material is applied to the roadway with a pressure distributor to obtain a uniform application. The distributor is required to heat the material to the designated temperature range. A continuous, uniform application of the asphalt material over the width to be sealed is required for a good seal coat. The distributor is tested for uniform application prior to beginning the sealing operation. The distributor is required to not be more than one minute ahead of the chip spreader.

The biggest problem in applying asphalt materials is the prevention of streaking. Streaking results in alternating areas with an excessive amount of asphalt immediately adjacent to one with insufficient asphalt and is usually caused by one of the following conditions:

- 1) Asphalt at the improper temperature
- 2) Interference of the sprayed material from one nozzle with that of adjacent nozzles
- 3) Improper pump speed
- 4) Improper spray bar height
- 5) Clogged nozzles

The required corrective actions for the above conditions are as follows:

- 1) Maintain the temperature of the asphalt material at the high end of the range suggested by the emulsion supplier.
- 2) Orient all nozzle openings in accordance with the manufacturer's recommendations. All nozzles are set at the same angle to prevent interference (Figure 10-5). Special wrenches are available to ensure that the nozzles are aligned uniformly. Generally, the smaller the nozzle opening, the more uniform the application of asphalt material. Worn or damaged nozzles are required to be replaced.



**Figure 10-5. Distributor Nozzles**

- 3) The highest possible pump speed that does not cause distortion of the spray fan is the correct speed to use. Low speed applications result in streaking and non-uniform discharge. Manufacturers provide charts and data for proper pump speed or pressure and for determining the discharge in gallons per minute for each nozzle size.
- 4) Clogged nozzles are usually the result of allowing the spray bar to cool between applications. This causes the material at the bar to harden. Circulating the hot material through the spray bar until the bar reaches the temperature of the material generally melts the obstruction. A quick test shot before starting is recommended.
- 5) Improper spray bar height is the principal cause of streaking. Visual observation while the distributor is moving does not reveal whether an exact double or triple lap is being applied. Without prior checking, only time reveals the lack of uniformity of the seal coat application.

The optimum spray bar height is also dependent on the bar's nozzle spacing. The spray bar height/nozzle spacing combination should produce either an exact double or triple overlap of the adjacent fans. Generally, closer nozzle spacings are required to achieve triple overlaps. When the proper spray bar height/nozzle spacing combination is achieved, the distributor will be able to maintain the spray bar height regardless of the amount of asphalt material in the tank.

### ***Transverse Joints***

Irregular transverse joints may be avoided by starting and stopping the application of the asphalt on building paper. The paper is placed across the lane to be treated so the forward edge is at the desired location. The distributor, traveling at the correct speed for the desired application rate, starts spraying on the paper so there is a full uniform application when the exposed surface is reached. A second placement of paper is made across the lane at the predetermined cutoff point for the distributor. This procedure gives a straight, sharp transverse joint. After the aggregate spreader has passed over the building paper, the paper is removed and discarded.

For the next application, the leading edge of the paper is placed within 1/2 in. of the cutoff line of the previously laid treatment. This procedure prevents a gap between the two spreads.

### ***Longitudinal Joints***

Full-width applications of asphalt and aggregates eliminate longitudinal joints. In most seal coat work, the joint is unavoidable because the roadway is too wide for one pass or traffic lanes are required to be maintained.

To prevent aggregate from building up on the longitudinal joints, the edge of the aggregate spread is required to coincide with the edge of the full thickness of applied asphalt. This procedure allows a width where asphalt is present in partial thickness to be overlapped when asphalt is applied to the adjacent lane. The partial thickness is the result of the outside nozzle spray being only partially overlapped. In this way there is no build up at the joint when the aggregate is spread for the full width in the next lane. The width of the asphalt strip left exposed varies depending on the nozzle spacing and whether the asphalt is a double or triple lap spray pattern.

If possible, the longitudinal joint is required to be along the centerline of the pavement being treated. An established line ensures a straight longitudinal joint.

The distributor is parked off the roadway when not in use so the spray bar or mechanism does not drip asphalt materials onto the traveled way, either before or after seal coating.

#### ***APPLICATION OF COVER AGGREGATE***

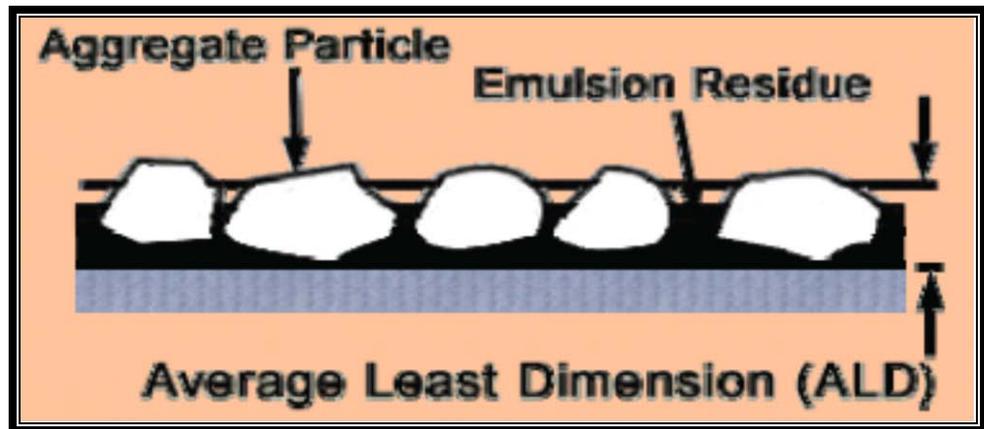
Cover aggregate is required to be clean and sufficiently dry so that a satisfactory bond with the asphalt material is obtained. If the aggregate is dusty, the material is moistened with water to eliminate or reduce the dust coating on the aggregate at least 24 hours prior to use. The moisture content should not exceed 3 %.

When the distributor moves forward, the aggregate spreader is required to follow immediately. To minimize the number of transverse joints, a sufficient number of trucks should be available to transport the cover aggregate to the job site. The cover aggregate is required to be applied within 1 min of the application of the asphalt material. The aggregate is required to be spread such that the tires of the trucks or aggregate spreader do not contact the uncovered and newly applied asphalt material. In a single application, aggregate normally does not stick to the asphalt more than one particle thick; therefore, applying aggregate at a rate greater than a single layer is wasteful.

Rolling seats the aggregate in the asphalt and promotes the bond necessary to resist traffic stresses. One pass forward, one pass back, and another pass forward again are required over each area. Pneumatic-tired rollers are required for seal coating. Steel-wheel rollers generally only compact the high spots and may crush the aggregate. Pneumatic-tired rollers apply uniform pressure over the entire area.

Immediately after the cover aggregate is spread but before rolling, any area with a deficiency or surplus of aggregate is required to be corrected. Rolling begins immediately behind the aggregate spreader and continues until at least three complete roller passes have been made. The first roller application is required to be completed within 2 min of the aggregate application. Final rolling is required to be completed within 30 min after the cover aggregate is applied.

The finished seal coat is required to exhibit a tightly knit surface one particle thick (single seal), have enough asphalt binder to seat the aggregate 50 to 65 percent of the aggregate particle, and orient the particles on the average least dimension (Figure 10-6). A common tendency is to apply both the aggregate and the asphalt at an excessive rate.



**Figure 10-6. Aggregate Average Least Dimension**

Fuel or hydraulic fluid leaks from the equipment ruin the appearance of the seal coat, cause permanent damage, and are to be avoided. Areas where leaks occur are required to be repaired as soon as possible to minimize permanent damage to the pavement.

Despite precautions, there is usually loose aggregate on the road surface after rolling is completed. The excess coarse aggregate is required to be removed from the mainline pavement surface by brooming no later than the morning after the placement of the seal coat. Care must be exercised during this brooming operation as the asphalt material may not be fully cured at this time. If the broom is allowed to put excessive force on the seal coated pavement, embedded cover aggregate may be swept from the asphalt material and the pavement may require an additional seal coat. A second brooming operation is required prior to opening to unrestricted traffic in accordance with Section **101.33**.

#### ***APPLICATION OF FOG SEAL***

When required in the contract, a fog seal is placed on top of the cover aggregate. The purpose of a fog seal is to lock the cover aggregate into the seal coat, aid the curing, and improve the surface appearance. The weather and calendar requirements associated with a seal coat also apply to the application of a fog seal.

The fog seal is required to be applied uniformly at the appropriate rate. If too little asphalt material is applied or is not applied in a uniform manner, the seal coat cover aggregate will not be locked in as intended. If too much asphalt material is applied, there will likely be friction problems with the pavement surface.

## APPLICATION RATE COMPUTATIONS

### *ASPHALT MATERIAL*

The Specification application rates for asphalt materials are based on material at 60° F. Since the material is applied at a higher temperature and expands in volume when heated, an allowance is required to be made for the increase in volume.

The formula for calculation of the volume at 60° F from a volume at an observed temperature is:

$$V = \frac{V_1}{K(T - 60) + 1}$$

where: V = volume at 60° F.

V<sub>1</sub> = volume at the observed temperature

T = observed temperature in degrees F

K = coefficient of expansion of asphalt material

The coefficient of expansion to be used in making the volume corrections for asphalt emulsion is 0.00025/° F.

Distributors are required to have a gauge for determining the gallons of material in the tank before and after each application. The difference is the amount applied. Weighing the distributor before and after the application is another acceptable method. The weight of asphalt material in the tank may be converted to a volume in gallons with the following formula:

$$G = \frac{W}{S.G \times 8.328}$$

where:

G = volume in gallons at 60° F

W = weight of asphalt material in pounds

S.G. = specific gravity of asphalt material at 60° F

8.328 = the weight of one gallon of water at 60° F

The laboratory report with the certification indicates the specific gravity and the weight per gallon at 60° F for all asphalt materials.

**Example #1** – Determine application rate

Plan rate of application of asphalt material is 0.32 gal/yd<sup>2</sup> at 60° F

Temperature of the asphalt in the distributor is 270° F

$$K = 0.00025$$

$$V_1 = V (K (T-60) + 1)$$

$$V_1 = 0.32 (0.00025 (270-60) + 1)$$

$$V_1 = 0.34 \text{ gal/yd}^2 \text{ at } 270^\circ \text{ F}$$

**Example #2** – Determine distributor speed

The speed of the distributor and length of spread are determined before spraying starts. The distributor speed may be determined by the following formula.

$$V = \frac{9Q}{WA}$$

where: V = road speed in feet per minute

Q = spray bar output in gallons per minute

W = spray bar width in feet

A = application rate in gallons per square yard at the application temperature (as computed in Example #1)

Asphalt material as in Example #1

Spray bar width = 12 feet

Pump capacity = 325 gallons per minute

$$V = \frac{9 \times 325}{12 \times 0.34} = 713 \text{ feet per minute}$$

**Example #3** – Determine actual application rate

Width of application = 12 feet

Beginning station = 10+00

Ending station = 15+75

Gallons in tank at start = 1230

Gallons in tank at end = 960

Temperature in the distributor = 270° F

$$\text{Area covered} = \frac{12(1575 - 1000)}{9 \text{ ft}^2/\text{yd}^2} = 767 \text{ yd}^2$$

$$\text{Application rate} = \frac{1230 - 960}{767} = 0.35 \text{ gal/yd}^2 \text{ at } 60^\circ \text{ F}$$

$$V = \frac{V_1}{K(T - 60) + 1} = \frac{0.35}{0.00025(270 - 60) + 1} = 0.33 \text{ gal/yd}^2 \text{ at } 60^\circ \text{ F}$$

The actual rate of application is 0.33 gal/yd<sup>2</sup> which is slightly higher than the planned rate of 0.32 gal/yd<sup>2</sup>; however, this amount is within reasonable tolerances.

**Example #4** – Convert weight to gallons

Weight of asphalt material = 14,000 lb

Specific gravity at 60° F = 0.980

$$V = \frac{14,000}{0.980 \times 8.328} = 1715 \text{ gallons at } 60^\circ \text{ F}$$

**COVER AGGREGATE**

Application rates for cover aggregate are determined in a similar manner as the application rates of asphalt material.

**Example #5** – Determine the cover aggregate application rate

Weight of cover aggregate applied = 15,200 lb. (from weigh tickets)

Use the area covered from Example #3

$$\text{Application rate} = \frac{\text{quantity used}}{\text{area covered}} = \frac{15,200}{767} = 20 \text{ lb/yd}^2$$

The actual rate is compared with the planned rate. Adjustments in the gate opening are required to reduce or increase the actual rate to conform to the planned rate.

Test runs are required to be made to check the application rates of both the asphalt and cover aggregate prior to commencing sealing operations.

## ***FOG SEAL***

The fog seal application rate adjusted for temperature is calculated in the same manner as seal coat asphalt material in Example #1. The required fog seal distributor speed calculation is made in the same manner as Example #2. The actual fog seal application rate is calculated in the same manner as Example #3.

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# 11 Quality Control Procedures

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## **Contractor Personnel**

*QCP Manager*

*QCP Field Manager*

*Quality Control Technician*

## **Milling**

*Milling Plan*

*Equipment*

*Testing*

## **Process Balance**

## **Transportation of Mixture**

*Truck Bed Cover*

*Unloading*

*Transfer Vehicles*

## **Paving**

*Paving Plan*

*Material Feed System*

*Grade and Slope*

*Joints*

*Asphalt Materials*

## **Joint Compaction**

## **Materials Sampling and Testing**

*Mixture Properties*

*Mixture Temperature at Paver*

*Density*

*Coring*

*Smoothness*

**Response to Test Results**

**Pavement Smoothness**

**Documentation**

**Quality Control Plan**

*QCP Approval*

*QCP Addenda*

# **CHAPTER ELEVEN:**

## ***QUALITY CONTROL PROCEDURES***

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The foundation for a successful Quality Assurance program is the control maintained by the Contractor to assure that all materials submitted for acceptance conform to the contract requirements. To accomplish this, the Contractor is required to have a functional Quality Control Plan (QCP) to keep the process in control, quickly determine when the process goes out of control, and respond adequately to bring the process back into control.

This chapter includes the minimum requirements for maintaining quality control during production of QC/QA Hot Mix Asphalt. Acceptance test results by INDOT are shared with the Contractor; however, results of these tests should not be used for quality control purposes.

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### **CONTRACTOR PERSONNEL**

The Contractor personnel required to provide quality control on a QC/QA Hot Mix Asphalt contract includes a QCP Manager, QCP Field Manager, and a Quality Control Technician. One quality control person may perform the duties of more than one position.

#### ***QCP MANAGER***

The QCP Manager is responsible for the overall administration of the QCP on the contract.

#### ***QCP FIELD MANAGER***

The QCP Field Manager is responsible for the execution of the QCP and is the liaison with the PE/S. This person is required to be a Certified HMA Field Supervisor and often is also the QCP Manager.

#### ***QUALITY CONTROL TECHNICIAN***

The quality control technician is responsible for the following duties:

- 1) Quality control tests for temperature, density, and smoothness
- 2) Pavement samples for quality control and INDOT acceptance
- 3) Inspection to implement the QCP

## MILLING

The Contractor is required to designate the procedures for milling the existing material to include as a minimum the general procedures, equipment, and testing that is conducted.

### *MILLING PLAN*

The general procedures for asphalt milling, asphalt removal, PCCP milling, scarification and profile milling, and transition milling are required to be designated in the QCP.

### *EQUIPMENT*

A description of the equipment required to mill, cut, and remove the existing material is required to be designated. Figure 11-1 is an example of a milling machine that is commonly used.



**Figure 11-1. Milling Machine**

### *TESTING*

The procedure for measuring the macrotexture of the milled surface in accordance with **ITM 812** is required (Figure 11-2). The purpose of this test is to measure the condition of the surface after milling in preparation for resurfacing with HMA.



**Figure 11-2. Macrotexture Test**

A minimum frequency of one macrotexture test is required. The requirements in accordance with Section **306** are as follows:

	<u>Macrotexture</u>
Asphalt Scarification & Profile Preparation	$\geq 2.2$ for single course overlays $\geq 1.8$ for multiple course overlays
Asphalt Milling	$\geq 2.2$ for single course overlays $\geq 1.8$ for multiple course overlays
PCCP Milling	$\geq 1.8$

The procedure, frequency, and equipment for measuring the cross-slope and longitudinal surface finish of the milled material is also required.

## **PROCESS BALANCE**

The procedures for balancing the HMA operation include the production, transportation, placement, and compaction of the mixture. The purpose of this balancing is to assure that there is the proper amount of HMA to provide continual operation of the paver and that there is a sufficient number of rollers to provide an effective compaction production rate approximately equal to the paver speed. The QCP is required to state the methodology for balancing the operation to include the plant production, transportation, placement, and compaction of the mixture. One procedure to determine whether the HMA operation is balanced compares the plant

production to the rate of mixture required to be delivered to the jobsite and the actual paver production rate to the effective compaction production rate (Figures 11-3 to 11-5). The following give examples of forms used by contractors to balance their operations and should be part of a good Quality Control Plan.

Example

Verify if the process is in balance for the following given information:

**Mix Delivery**

Tons to be Placed	3000 t
Hours of Paving	10 h
Plant Rating	350 t/h
Average Truck Capacity	20 t
<u>Truck Cycle (minutes)</u>	
Delay at Facility	2
Load Time	3
Ticket & Tarp	2
Haul to Job	14
Delay on Site	5
Dump/Clean Up	5
Return Haul	14

**Paving**

Pavement width:	12 ft
Paving Thickness	2 in.
Minimum density	92% MSG
In-Place Target Density	94% MSG
Reference (Target) Density	143.0 lb/ft <sup>3</sup>
Paving Efficiency Factor	0.80

**Compaction**

Breakdown roller:	Dynapac CC-42A
Drum Width	66 in.
Maximum roller speed:	2 ½ mph
Vibrations/Minute	2700 VPM
Impact Spacing	10 impacts/ft
Number of Coverages to Achieve Density (Test Strip)	2
Roller Efficiency Factor	0.80

<b><u>MIX DELIVERY PRODUCTION CALCULATION FORM</u></b>							
DATE:				PROJECT #			
PROJECT:							
<b>Tons scheduled to be placed today (MIX):</b>					<b>3,000</b>	t	
<b>Hours of paving scheduled (TIME):</b>					<b>10</b>	h	
<b>Rate of mix needed to be delivered to jobsite (H-RATE):</b>							
	= MIX / TIME =	<b>3,000</b>	/	<b>10</b>	=	<b>300</b>	tph
<b>Rate of mix available from HMA facility (F-RATE):</b>					=	<b>350</b>	tph
<b>STOP:</b> Is the H-RATE slightly greater than or equal to the F-RATE?							
<b>Average Truck Capacity (SIZE):</b>				=	<b>20</b>	net tons	
<b>Total Truck Trips Needed (TRIPS):</b>							
	= MIX / SIZE =	<b>3,000</b>	/	<b>20</b>	=	<b>150</b>	TRIPS
<b>TRUCK CYCLE ( in minutes ):</b>							
	Delay at Facility	<b>2</b>					
	Load Time	<b>3</b>					
	Ticket & Tarp	<b>2</b>					
	Haul to Job	<b>14</b>					
	Delay on site	<b>5</b>					
	Dump/clean up	<b>5</b>					
	Return Haul	<b>14</b>					
	<b>Total cycle in minutes</b>	<b>45</b>	/ 60 min / h				
	= <b>Truck Cycle (CYCLE)</b>			<b>0.75</b>	h / trip		
<b>Number of Trips per Truck (LOADS):</b>							
	= TIME / CYCLE =	<b>10</b>	h /	<b>0.75</b>	h/trip =	<b>13</b>	trips/truck
							(round down)
<b>Number of Trucks Needed (TRUCKS):</b>							
	= TRIPS / LOADS =	<b>150</b>	/	<b>13</b>	=	<b>12</b>	TRUCKS
							(round up)
<b>ARE TRUCKS x LOADS ≥ TRIPS?</b>							
		<b>12</b>	x	<b>13</b>			
	=	<b>156</b>	≥	<b>150</b>			

**Figure 11-3. Mix Delivery Production Calculation**

## PAVING PRODUCTION CALCULATION FORM

DATE: \_\_\_\_\_ PROJECT # \_\_\_\_\_

PROJECT: \_\_\_\_\_

Tons scheduled to be placed today (MIX): 3,000 t

Hours of paving scheduled (TIME): 10 h

Rate of mix needed to be delivered to jobsite (H-RATE):

$$= \text{MIX} / \text{TIME} = \frac{3,000}{10} = 300 \text{ tph}$$

Paving Width (WIDTH): 12 ft

Paving Thickness (THICK): 2 in. / 12 in./ft = 0.17 ft

Compacted Mix Density (DENSITY):

Specification limits for density: Minimum = 92 Maximum = \_\_\_\_\_

The in-place target density should be above the Minimum: Target = 94

DENSITY = Reference Density x % Target Density

$$= \frac{143}{33.33} \text{ pcf} \times 0.94 = 39.9 \text{ pcf}$$

33.33 = Conversion factor (tons to pounds & hours to minutes)

Actual Paver Production Rate (P-RATE)

$$= \text{MIX RATE} \times 33.33 / \text{WIDTH} / \text{THICK} / \text{DENSITY}$$

$$= \frac{300}{12} \times 33.33 / \frac{2}{12} / 134.4$$

$$\text{P-RATE} = 36 \text{ fpm}$$

Paving Efficiency Factor (EFF1): 0.80 (recommended: 0.75 - 0.85)

Actual Paver Speed (PAVER):

$$\text{PAVER} = \text{P-RATE} \times \text{EFF1} =$$

$$\frac{36}{1} \times 0.80 = 29 \text{ fpm}$$

**Figure 11-4. Paving Production Calculation**

## COMPACTION PRODUCTION CALCULATION FORM

DATE: \_\_\_\_\_ PROJECT # \_\_\_\_\_

PROJECT: \_\_\_\_\_

**Recommended Breakdown Rolling Speeds:**

**Static:** 2 to 3-1/2 mph; **Pneumatic:** 2 to 3-1/2 mph; **Vibratory:** 2 to 3<sup>A</sup>

Actual fpm	Speed (mph)	Reversal Factor	Effective fpm	Speed (mph)
176	(2.0)	-10%	158	(1.8)
220	(2.5)	-10%	198	(2.3)
264	(3.0)	-10%	238	(2.7)
308	(3.5)	-10%	277	(3.1)
352	(4.0)	-10%	317	(3.6)

A: Actual Speed for vibratory rollers can be based on the roller's operating frequency and an impact spacing of 10-12 impacts/ft. Use the following two lines to calculate these values.

ACTUAL SPEED = VPM  $\frac{2,700}{270}$  / (  $\frac{10}{270}$  ) impacts/ft  $\frac{270}{243}$  fpm/88 = 3.1 mph  
 EFF-SPEED = Actual - 10% =  $\frac{2,700}{270}$  - 10% (  $\frac{10}{270}$  ) impacts/ft  $\frac{243}{243}$  fpm/88 = 2.8 mph

Actual Roller Drum Width (DRUM): 66 in.

Effective Drum Width (EFF-DRUM): (To account for drum overlap, 6 in. is normally used)

EFF-DRUM = DRUM - 6 in. / 12 in./ft = 66 - 6 /12 in./ft = 5 ft

Paving Width (WIDTH): 12 ft

# of Passes to Cover Mat Width Once (PASS): = WIDTH / EFF-DRUM

PASS = 12 / 5 = (Round up to whole number) 3

# of Repeat Coverages to Achieve Density (COVERAGE): 2 (From test strip)

Total # of Passes (T-PASS): = PASS x COVERAGE = 3 x 2 = 6

(Note: If T-PASS is an even number, add 1 to T-PASS for make up pass)

Is T-PASS an even number? If Yes >>>> New T-PASS = T-PASS + 1 = 7

Roller Efficiency Factor (EFF2): 0.8 (recommended 0.75 - .080)

Effective Compaction Production Rate (C-RATE):

C-RATE = EFF-SPEED x EFF2 / T-PASS = 243 x 0.80 / 7 = 28

Compare: F-RATE 350 tph to H-RATE 300.0 tph: P-RATE 36 fpm to C-RATE 28 fpm

- F-RATE FACILITY (RATE OF MIX AVAILABLE FROM PLANT)
- H-RATE HAUL (RATE OF MIX NEEDED TO BE DELIVERED)
- P-RATE PAVER (PRODUCTION RATE)
- C-RATE COMPACTION (PRODUCTION RATE)

**Figure 11-5. Compaction Production Calculation**

## **TRANSPORTATION OF MIXTURE**

The Contractor is required to designate the procedures for transportation of the HMA from the plant to the paver.

### ***TRUCK BED COVER***

The procedure for when waterproof covers are used and the person that directs their use is required.

### ***UNLOADING***

The procedures for unloading trucks and removing the remaining mixture from the truck bed and bed apron are required.

### ***TRANSFER VEHICLES***

The procedures for the use of Material Transfer Devices or Windrow Elevators, and the pans for crossing bridges with these devices is required.

## **PAVING**

The Contractor is required to designate the procedures for placement of the HMA.

### ***PAVING PLAN***

The general sequence, the widths and depths of paving for each of the major courses, and the planned date for paving to begin and to be completed on the contract are required.

### ***MATERIAL FEED SYSTEM***

The procedure for processing the mixture through the paver is required.

### ***GRADE AND SLOPE***

The procedure for controlling the grade and slope, including a description of placing wedge and level courses, if applicable, is required.

### ***JOINTS***

The procedure for the construction of the longitudinal and transverse joints is required. The starting and stopping procedures of the paver for transverse joints is also required to be included.

### ***ASPHALT MATERIALS***

The source, source numbers, type, and grade of materials that are planned for use for the tack coat, prime coat, or seal coat are required.

### **JOINT COMPACTION**

The Contractor is required to designate the procedures for compaction of the longitudinal and transverse joints.

### **MATERIALS SAMPLING and TESTING**

The Contractor is required to designate the procedures for sampling and testing HMA and the frequency of tests. The sampling locations and procedures are not required to be the same procedures used for the acceptance samples.

### ***MIXTURE PROPERTIES***

The HMA plant is required to be a HMA Certified Plant in accordance with **ITM 583**. The location of the plant, owner, Producer name and plant number is required.

The laboratory, procedures done for quality control testing of the mixture, and the minimum frequency of samples is required.

### ***MIXTURE TEMPERATURE at PAVER***

The procedure for measuring the temperature of the mixture at the paver is required. The temperature is required to be taken immediately behind the paver prior to compaction at a minimum frequency of one test for each 1 hour of paving.

### ***DENSITY***

The procedure for measuring the density of the mixture utilizing a non-destructive technique is required. Density tests are required to be taken on the mainline and shoulders. The minimum frequency of tests is one test each 1000 yd<sup>2</sup>. A nuclear test device, if used, is required to be calibrated in accordance with **ASTM D 2950** at a minimum frequency of once each 12 months. The nuclear gauge is required to be properly calibrated to the mixture being placed.

The procedure for monitoring the temperature of the mix during compaction to optimize the rolling pattern is also required.

### ***CORING***

The plan for when cores are taken and the procedure for refilling the core holes are required.

## ***SMOOTHNESS***

The procedure for measuring the smoothness of the pavement is required. The annual certification of the profilograph in accordance with **ITM 901** is also required to be included.

## **RESPONSE TO TEST RESULTS**

The Contractor is required to take corrective action when quality control test results exceed the established limits. The corrective actions are required to be designated in the QCP. As a minimum, corrective actions are required for the mixture tests from the pavement, the temperature measurements, and the density.

## **PAVEMENT SMOOTHNESS**

The Contractor is required to designate the procedures for correcting the profile of non-complying pavement. Areas outside of the allowable tolerance of Section **401.18** are required to be corrected.

## **DOCUMENTATION**

The test results for quality control and documentation of equipment are required to be maintained by the Contractor for a period of three years upon completion of the contract. The records, either electronic and/or hard copies, are required to be maintained at a readily accessible location for review by INDOT at any time. As a minimum, the documentation is required to include test results for the mixture, temperature, density, and smoothness tests of the HMA pavement. In addition, documentation of the manufacture, model, and type of paver and rollers used each day of paving is required. Any modifications to this equipment are required to be noted.

## **QUALITY CONTROL PLAN**

The Contractor is required to submit a QCP that is contract specific and states how the process control of materials, equipment, and operations are maintained. As a minimum, the QCP is required to include the following information for each contract.

- 1) The name, telephone number, duties, and employer of all quality control personnel necessary to implement the QCP. The minimum number of quality control personnel is required to include a QCP Manager, QCP Field Manager, and Quality Control Technician.

- 2) The procedure for milling to include the general procedures, equipment, testing for macrotexture, and testing for smoothness.
- 3) The procedure for balancing the HMA process to include plant production, number of trucks, paver speed, and compaction production rate procedure.
- 4) The procedure for transportation of the HMA to include the use of truck bed covers, truck unloading procedures, procedure for removal of mixture from the truck, and the use of material transfer vehicles.
- 5) The procedure for paving to include a paving plan, the material feed system, grade and slope control, joint construction, and use of asphalt materials.
- 6) The procedure for compacting longitudinal and transverse joints.
- 7) The procedures and frequency for sampling and testing the HMA, to include the mixture behind the paver, the temperature of the mixture at the paver, the density of the mixture, the coring procedure, and the procedure for measuring the smoothness.
- 8) The response to process control tests not within the established requirements for mixture, density, and smoothness tests.
- 9) The procedure for documentation of quality control tests and the equipment used on the contract.

#### ***QCP APPROVAL***

The QCP is required to be submitted to the PE/S for review at least 15 calendar days prior to commencing HMA operations. The Contractor is required to sign and date the QCP at the time of submittal to the PE/S. The PE/S signs and dates the QCP if the contents of the QCP are in compliance with the above-noted requirements. HMA operations are not allowed to begin before the QCP has been accepted.

#### ***QCP ADDENDA***

The QCP is required to be maintained to reflect the current status of the operations, and revisions are required to be provided in writing prior to initiating the change. The change may not be implemented until the revision has been accepted.

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# Appendix A - Paving Troubleshooting

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## Problems Observed of the Mixture in the Trucks

*Free Asphalt on Mix*

*Free Dust on Mix*

*Large Aggregate Uncoated*

*Mixture Not Uniform*

*Mixture Fat on One Side*

*Mixture Flattens*

*Mixture Burned*

*Mixture Brown or Gray*

*Mixture Too Fat*

*Mixture Smokes*

*Mixture Steams*

*Mixture Appears Dull*

## Problems Observed During Paving

*Bleeding*

*Transverse Joints – Improper Elevation Across Joint*

*Transverse Joints – Rough Uneven Joint*

*Screed Marks*

*Surface Texture Fluctuation*

*Tearing of Mat – Full Width*

*Tearing of Mat – Center*

*Tearing of Mat – Edge*

*Thickness and Mat Quality Variations*

*Wavy Surface – Long Waves*

*Wavy Surface – Ripples, Short Waves*

## **Problems Observed During Compaction**

*Checking Under Roller*

*Mat Shoving Ahead of Roller*

*Roller Marks*

*Unsatisfactory Compaction*

# APPENDIX A:

## *PAVING TROUBLESHOOTING*

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Long-term pavement performance is the result of the smoothness and mat quality of the HMA mixture. Smoothness affects the transportation costs of the road user to include vehicle maintenance costs, fuel consumption, speed, passenger comfort, safety, and vehicle noise. Poor mat quality also affects the pavement performance and may be caused by cracks, segregation, poor joints, and other defects. Furthermore, low density may cause the mix to deform, make the mix more susceptible to moisture, prematurely harden the asphalt, decrease the fatigue resistance, or reduce the structural strength of the pavement.

This chapter will discuss the problems that affect the smoothness and quality of the pavement mat and the possible solutions for correcting these deficiencies. Problems may be detected by observing the mixture in the truck or Material Transfer Vehicle (MTV) during the transfer of the mixture to the paver, by observing the mixture after the paving operations, and by observing the mixture during the compaction process.

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### PROBLEMS OBSERVED OF THE MIXTURE IN THE TRUCKS

As the HMA is transferred to the paver from the truck or MTV, the operator should observe the mixture for any obvious problems. Problems may be caused by the mixture materials or operations of the plant. The following discussion lists the more common problems observed of the mixture in the trucks or MTV, the type of plant associated with the problem, and the causes of the problems.



**FREE ASPHALT ON MIX**

***Batch and Drum Plants***

1. Too much asphalt
2. Faulty distribution of asphalt to aggregates

***Batch Plant***

1. Aggregate scales out of adjustment
2. Improper weighing
3. Asphalt scales out of adjustment
4. Undersize or oversize batch
5. Improperly set or worn paddles

***Drum Plant***

1. Asphalt meter out of adjustment
2. Asphalt and aggregate feed not synchronized

**FREE DUST ON MIX**

***Batch Plant***

1. Improper weighing sequence
2. Faulty dump gate

**LARGE AGGREGATE UNCOATED**

***Batch and Drum Plants***

1. Insufficient asphalt
2. Faulty distribution of asphalt to aggregates
3. Irregular plant operation

***Batch Plant***

1. Asphalt scales out of adjustment
2. Undersize or oversize batch
3. Mixing time not proper
4. Improperly set or worn paddles

***Drum Plant***

1. Asphalt meter out of adjustment
2. Asphalt and aggregate feed not synchronized

***MIXTURE NOT UNIFORM***



**Figure A-1. End of Truck Segregation**

***Batch and Drum Plants***

1. Leaky bins
2. Segregation of aggregates in bins
3. Carryover in bins due to overloading screens
4. Insufficient aggregates in hot bins
5. Faulty distribution of asphalt to aggregates
6. Irregular plant operation

***Batch Plant***

1. Faulty screen operation
2. Bin overflows not functioning
3. Aggregate scales out of adjustment
4. Improper weighing
5. Feed of mineral filler not uniform
6. Improper weighing sequence
7. Asphalt scales out of adjustment
8. Mixing time not proper
9. Improperly set or worn paddles
10. Faulty dump gate
11. Occasional dust shakedown in bins

***Drum Plant***

1. Asphalt meter out of adjustment
2. Irregular plant operation

***MIXTURE FAT ON ONE SIDE***

***Batch and Drum Plants***

1. Faulty distribution of asphalt to aggregates
2. Irregular plant operation

***Batch Plant***

1. Improper weighing
2. Undersize or oversize batch
3. Mixing time not proper
4. Improperly set or worn paddles

***MIXTURE FLATTENS***

***Batch and Drum Plants***

1. Too much asphalt
2. Faulty distribution of asphalt to aggregates
3. Irregular plant operation

***Batch Plant***

1. Aggregate scales out of adjustment
2. Undersize or oversize batch

***Drum Plant***

1. Asphalt meter out of adjustment
2. Asphalt and aggregate feed not synchronized

***MIXTURE BURNED***

***Batch and Drum Plants***

1. Aggregate feed gates not properly set
2. Improper dryer operation
3. Temperature indicator out of adjustment
4. Aggregate temperature too high
5. Irregular plant operation

***MIXTURE BROWN OR GRAY***

***Batch and Drum Plants***

1. Aggregates too wet
2. Over-rated dryer capacity
3. Dryer set too steep
4. Improper dryer operation
5. Temperature indicator out of adjustment
6. Insufficient asphalt
7. Irregular plant operation

***Batch Plant***

1. Faulty screen operation

***Drum Plant***

1. Asphalt meter out of adjustment
2. Asphalt and aggregate feed not synchronized

***MIXTURE TOO FAT***

***Batch and Drum Plants***

1. Insufficient aggregates in hot bins
2. Too much asphalt
3. Faulty distribution of asphalt to aggregates
4. Irregular plant operation

***Batch Plant***

1. Aggregate scales out of adjustment
2. Improper weighing
3. Feed of mineral filler not uniform
4. Asphalt scales out of adjustment
5. Undersize or oversize batch

***Drum Plant***

1. Asphalt meter out of adjustment
2. Asphalt and aggregate feed not synchronized

***MIXTURE SMOKES***

***Batch and Drum Plants***

1. Improper dryer operation
2. Temperature indicator out of adjustment
3. Aggregate temperature too high
4. Irregular plant operation

## ***MIXTURE STEAMS***

### ***Batch and Drum Plants***

1. Aggregates too wet
2. Over-rated dryer capacity
3. Dryer set too steep
4. Improper dryer operation
5. Temperature indicator out of adjustment
6. Irregular plant operation

## ***MIXTURE APPEARS DULL***

### ***Batch and Drum Plants***

1. Improper dryer operation
2. Temperature indicator out of adjustment
3. Aggregate temperature too high

## ***PROBLEMS OBSERVED DURING PAVING***

During the paving operations, the paving crew should observe the mixture behind the screed prior to compaction for obvious problems. Problems may be caused by mix designs, plant operations, existing pavement conditions, or operations of the paver. The following discussion lists the more common problems, the probable causes, and possible solutions.



***BLEEDING (FIGURE A-2)***



**Figure A-2. Bleeding**

***Probable Cause-Possible Solution***

1. Prime or tack coat too heavy (Figure A-3)
  - a. Use correct prime or tack coat application rates



**Figure A-3. Tack Too Heavy**

2. Poor prime penetration
  - a. If granular base is too moist, allow drying period or re-work base material
3. Segregation of HMA
  - a. Can be due to many factors including materials handling, mix gradation, operation and condition of storage bins, paver operations, etc.
4. Moisture

## ***TRANSVERSE JOINTS – IMPROPER ELEVATION ACROSS JOINT***

### ***Probable Cause-Possible Solution***

1. Differential compaction
  - a. Set screed on blocks
  - b. Allow for compaction of about ¼ in. per 1 in. layer thickness
2. Poor joint preparation
  - a. Remove tapered area from previous paving
  - b. Prepare well-defined vertical face

## ***TRANSVERSE JOINTS – ROUGH UNEVEN JOINT***

### ***Probable Cause-Possible Solution***

1. Poor compaction technique
  - a. Roll joint transversely
  - b. Use correct compaction technique
2. Poor raking technique or excessive raking (Figure A-4)
  - a. Minimize raking
  - b. Trim and remove any excess from cold side of joint



**Figure A-4. Poor Raking at Joint**

3. Segregation of HMA at mat edge
  - a. Can be due to many factors including materials handling, mix gradation, operation and condition of storage bins, paver operations, etc.

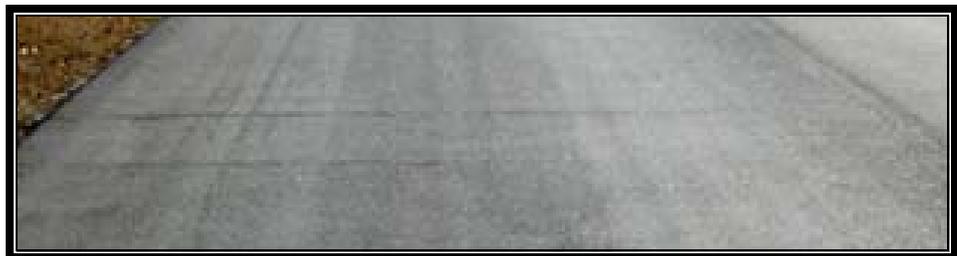
**SCREED MARKS (FIGURE A-5)**



**Figure A-5. Screed Marks**

***Probable Cause – Possible Solution***

1. Thickness control screws in poor mechanical condition
  - a. Replace control screws
2. Variable material level in front of screed
  - a. Adjust hopper gates and/or feed conveyor/spreading screw speeds
  - b. Adjust depth sensor
3. Improper operation of paver
  - a. Use proper paving procedures
  - b. Release brakes on truck
4. Truck bumps paver or is not square with paver (Figure A-6)
  - a. Allow paver to approach truck
  - b. Make sure all rear wheels of truck are in contact with roller bar on paver



**Figure A-6. Marks Due to Truck Bumping Paver**

5. Over-sensitive automatic controls or tender mix
  - a. Check mix proportions and aggregate quality
  - b. Revise design if excess sand, low filler content, or high asphalt content
  - c. Check and correct if moisture in mix
  - d. Check asphalt grade and temperature-viscosity characteristics
6. Excessive play in screed mechanical connection
  - a. See operation and maintenance manual

***SURFACE TEXTURE FLUCTUATION***

***Probable Cause – Possible Solution***

1. Too much raking and sanding behind machine
  - a. Use proper raking procedure
2. Variable HMA quality
  - a. Check mix proportions and sampling procedures
  - b. Correct at mixing plant
3. Poor temperature control of HMA
  - a. Correct temperature at mixing plant according to asphalt temperature-viscosity characteristics
  - b. Cover load during hauling and waiting
4. Poor asphalt quality
  - a. Check for asphalt overheating
  - b. Check with asphalt supplier
  - c. Test asphalt properties
5. Segregation of HMA
  - a. Could be due to many factors including stockpiling procedures, mix gradation, operation and condition of storage bins, paver operations, etc.
6. Stone size too large for layer thickness
  - a. Reduce stone size to maximum of one-half of layer thickness
  - b. Revise mix design
7. Worn screed plates - stone degradation
  - a. Replace screed plates
  - b. Check stone quality and rolling techniques
  - c. Mix too coarse or too cold
8. Variable forward speed of paver
  - a. Maintain constant forward speed

***TEARING OF MAT – FULL WIDTH (FIGURE A-7)***



**Figure A-7. Mat Tearing Full Width**

***Probable Cause – Possible Solution***

1. Stone size too large for layer thickness
  - a. Reduce stone size to a maximum of half of the layer thickness
  - b. Revise mix design
2. Tender Mix
  - a. Check mix proportions
  - b. Revise design if excess sand, low filler content, or high asphalt content
  - c. Check and correct if moisture in mix
  - d. Check asphalt grade and temperature-viscosity characteristics
3. Forward speed of paver too fast
  - a. Reduce paver speed
4. Worn out screed plate
  - a. Replace screed plate
5. Mix too dry or too harsh
  - a. Check if mix may be too coarse or aggregates too dirty
  - b. Increase VMA and asphalt content
  - c. Consider addition of natural sand

6. Mix temperature too low
  - a. Increase mix temperature at plant according to temperature-viscosity characteristics or in accordance with asphalt supplier recommendations
  - b. Cover load during hauling and waiting
7. Rapid cooling of mat surface
  - a. Check air temperature and wind chill effects
  - b. Increase number of rollers
  - c. Reduce forward speed of paver
8. Cold paver speed
  - a. Heat screed

***TEARING OF MAT – CENTER (FIGURE A-8)***



**Figure A-8. Tearing of Mat – Center**

***Probable Cause – Possible Solution***

1. Not enough lead crown
  - a. Increase lead crown
2. Mix temperature too low
  - a. Increase mix temperature at plant according to temperature-viscosity characteristics or in accordance with asphalt supplier recommendations
  - b. Cover load during hauling and waiting
3. Worn screed plate
  - a. Replace screed plate

4. Incorrect feeder gate setting
  - a. Correct feeder gate setting
5. Kicker screws worn out or mounted incorrectly
  - a. Replace or adjust kicker screws
6. Segregation of HMA at centerline (Figure A-9)
  - a. Could be due to many factors including stockpiling procedures, mix gradation, operation and condition of storage bins, paver operations, etc.



**Figure A-9. Centerline Segregation**

***TEARING OF MAT – EDGE***

***Probable Cause – Possible Solution***

1. Mix temperature too low
  - a. Increase mix temperature at plant according to temperature-viscosity characteristics or in accordance with asphalt supplier recommendations
  - b. Cover load during hauling and waiting
2. End plates not square
  - a. Check position of end plates

3. Too much lead crown in screed
  - a. Reduce lead crown
  - b. Check for improper strike-off position
4. Worn screed plate
  - a. Replace screed plate
5. Excessive overlap
  - a. Ensure no more than 3 in. overlap
6. Cold Screed
  - a. Heat screed
7. Incorrect feeder gate setting
  - a. Correct feeder gate setting
8. Screed extensions installed incorrectly
  - a. Refer to manufacturer's manual for correct installation
9. Segregation of HMA at mat edge
  - a. Could be due to many factors including stockpiling procedures, mix gradation, operation and condition of storage bins, paver operations, etc.

#### ***THICKNESS AND MAT QUALITY VARIATIONS***

##### ***Probable Cause – Possible Solution***

1. Poor control of material in front of screed
  - a. Adjust hopper gates and/or conveyer/spreading screw speed
  - b. Check location and operation of feed sensors to ensure consistent auger and feeder spread
2. Screed pull point set at improper height
  - a. Raise screed pull point. Check line of pull (draw line from bottom of tow point cylinder to pivot point of screed) and check that this line is parallel with grade
3. Improper operation of paver
  - a. Use proper procedures
4. Out-of specification HMA
  - a. Check mix proportions and sampling procedures
  - b. Correct at mixing facility
5. Poor temperature control
  - a. Correct at mix plant according to temperature-viscosity characteristics or in accordance with asphalt supplier recommendations
  - b. Cover load during hauling and waiting
  - c. Consider remixing material at paving site if temperature differential is more than 25°F across width of mat behind screed

6. Poor asphalt content control
  - a. Evaluate sampling and testing procedures
  - b. Use Quality Control charts
  - c. Check asphalt meters or weigh buckets
  - d. Check belt scales
7. Over-controlling of screed
  - a. Adjust automatic controls to more closely meet mat thickness
  - b. Make sure automatics are adjusted to correct sensitivity as recommended by manufacturer
  - c. Check for smooth uniform movement of tow point cylinders
8. Unstable or tender HMA (Figure 8-10)
  - a. Check mix proportions and aggregate quality
  - b. Revise design if excess sand, low filler content, or high asphalt content
  - c. Check and correct if moisture in mix
  - d. Check asphalt grade and temperature-viscosity characteristics



**Figure A-10. Unstable HMA**

9. Poorly graded surface of base
  - a. Use proper base preparation
  - b. Use stringline or laser reference for grade control
  - c. Use longer averaging ski or an inline-averaging ski if grade is unacceptable outside of paver end gates
10. Hydraulic screed lift is not released
  - a. Release hydraulics
  - b. Check for improper or impaired operation of hydraulics

11. Yielding underlayer – granular bases (Figure A-11)

- a. Improve or modify
- b. Check density
- c. Do not lay HMA over a saturated base
- d. Check drainage



**Figure A-11. Yielding Granular Base**

12. Yielding underlayer – overlays

- a. Cut out and patch weak areas
- b. Maintain constant forward speed
- c. Match paver speed to plant output

13. Material on existing pavement (Figure A-12)

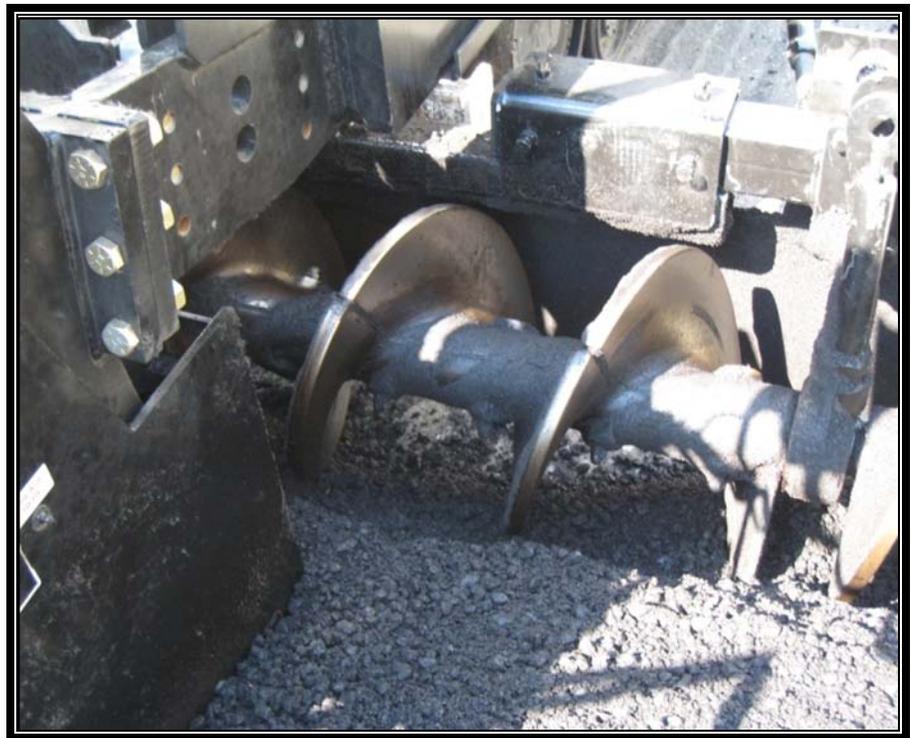


**Figure A-12. Dumped Material on Pavement**

## **WAVY SURFACE – LONG WAVES**

### ***Probable Cause – Possible Solution***

1. Poor temperature control of HMA
  - a. Correct temperature at mixing plant according to asphalt temperature-viscosity characteristics
  - b. Cover load during hauling and waiting
2. Over-controlling screed
  - a. Adjust automatics to match mat thickness
3. Brakes set on truck
  - a. Release brakes
4. Hydraulic screed lift not released
  - a. Release hydraulics
  - b. Check for improper or impaired operation of hydraulics
5. Variable material level in front of screed (Figure 8-13)
  - a. Adjust hopper gates and/or feed conveyor/spreading screw speed
  - b. Adjust depth sensor



**Figure A-13. Auger Material Too Low**

**WAVY SURFACE – RIPPLES, SHORT WAVES (FIGURE A-14)**



**Figure A-14. Wavy Surface – Short Waves**

***Probable Cause – Possible Solution***

1. Variable HMA quality
  - a. Maintain job mix within specification limits
2. Unstable or tender HMA
  - a. Check mix proportions and aggregate quality
  - b. Revise design if excess sand, low filler content, or high asphalt content
  - c. Check moisture content of mix
  - d. Check asphalt grade and temperature-viscosity characteristics
3. Loading screws too heavy
  - a. Adjust hopper gates, and/or feed conveyor/spreading screw speeds
  - b. Adjust depth sensor
4. Too much slack in roller drives
  - a. Adjust roller drives
5. Poor temperature control of HMA
  - a. Control temperature at mixing plant according to asphalt temperature-viscosity characteristics
  - b. Cover load during hauling or waiting
6. Screed pull point too low on tractor
  - a. Raise pull points
7. Improper operation of paver
  - a. Use proper paving procedures

## PROBLEMS OBSERVED DURING COMPACTION

### *CHECKING UNDER ROLLER (FIGURE. A-15)*



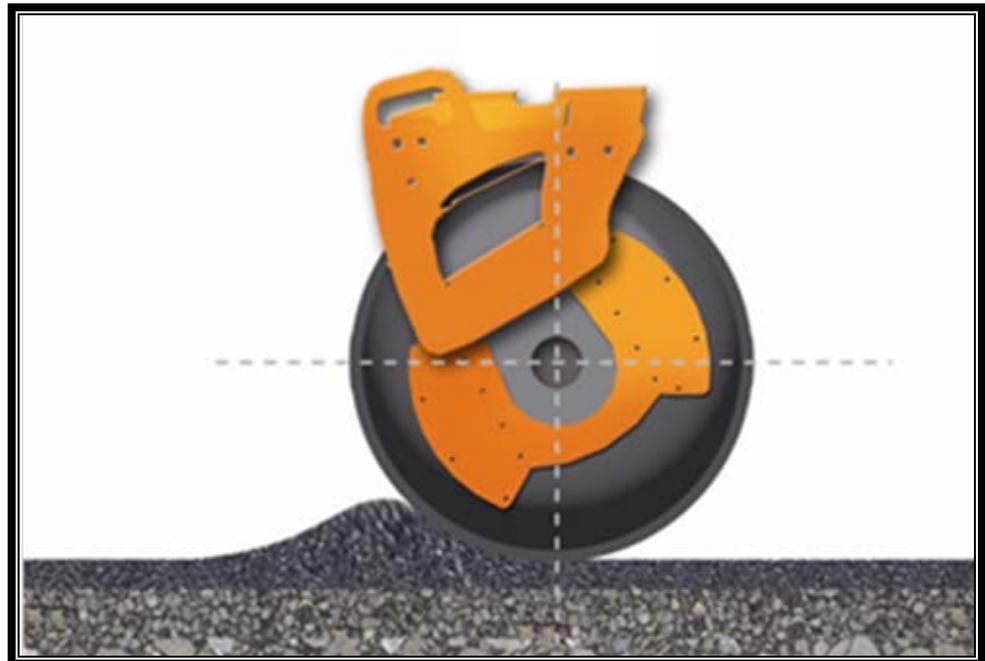
**Figure A-15. Checking Under Roller**

#### *Probable Cause – Possible Solution*

1. Yielding underlayer – granular bases
  - a. Check density
  - b. Do not lay HMA over a saturated base
  - c. Check drainage
2. Yielding underlayer – overlays
  - a. Cut out and patch weak areas
3. Tender mix
  - a. Check mix proportions and aggregate quality
  - b. Revise design if excess sand, low filler content, or high asphalt content
  - c. Check and correct if moisture is in mix
  - d. Check asphalt grade and temperature-viscosity characteristics
  - e. Change position of roller in the pattern (vibratory to intermediate, static to breakdown, etc.)
4. Poor asphalt quality
  - a. Check that asphalt has not been overheated or contaminated with harder grade
  - b. Check with supplier
  - c. Test asphalt properties

5. Asphalt content too low
  - a. Revise mix design
  - b. Increase asphalt content
  - c. If necessary, increase VMA
6. Excess filler and/or fine aggregate
  - a. Reduce and revise mix design
  - b. Check fines metering system at plant
7. Segregation of HMA
  - a. Could be due to many factors including stockpiling procedures, mix gradation, operation and condition of storage bins, paver operations, etc.
8. Too much rolling
  - a. Use correct rolling procedure
9. Mix too hot
  - a. Correct at mixing facility
  - b. Delay rolling
  - c. Reduce compaction temperatures according to aggregate properties and viscosity of asphalt
  - d. Assure large drive drum is in the direction of forward travel
10. Rapid cooling of mat surface
  - a. Check air temperature and wind chill effects
  - b. Increase lift thickness to reduce heat loss, if possible
  - c. Increase number of rollers
  - d. Reduce forward speed of paver

***MAT SHOVING AHEAD OF ROLLER (FIGURE A-16)***



**Figure A-16. Mat Shoving Ahead of Roller**

*Probable Cause – Possible Solution*

1. Roller reversing or turning too abruptly
  - a. Gradually slow and reverse
  - b. Make wide radius turns
2. Tire pressure of rubber tire roller too high
  - a. Reduce tire pressures
3. Roller on fresh surface too soon
  - a. Delay rolling
  - b. Reduce compaction temperatures according to aggregate properties and viscosity of asphalt
4. Asphalt content too high
  - a. Revise mix design
  - b. If necessary, reduce VMA
5. Yielding underlayer – granular bases
  - a. Check density
  - b. Do not lay HMA over a saturated base
  - c. Check drainage
6. Yielding underlayer – overlays
  - a. Cut out and patch weak area
7. Aggregate gradation
  - a. Check mix proportions
  - b. Reduce fines and uncrushed aggregates
8. Moisture in mix
  - a. Reduce moisture in material stockpiles, if possible
  - b. Increase proper drying time
9. Dusty or dirty base
  - a. Clean with motorized broom
10. Mix temperature too high
  - a. Reduce at mixing facility according to asphalt temperature-viscosity characteristics or in accordance with asphalt supplier's recommendations
11. Un-combusted fuel in mix
  - a. Ensure fuel is at correct viscosity for burning
  - b. Ensure that there is not too little or too much excess air
  - c. Inspect and, if necessary, adjust burner
  - d. Check fuel quality
12. Poor asphalt cement quality
  - a. Check asphalt temperature for overheating
  - b. Test asphalt properties
13. Moisture accumulation due to condensation
  - a. Check mix design temperature and storage time in surge bins
14. Tender zone
  - a. Check temperature ranges for tender zone
  - b. Compact above or below tender zone
15. Excessive mat thickness relative to aggregate size
  - a. Reduce individual lift thicknesses, if possible

16. Incorrect amplitude or frequency settings
  - a. Adjust according to actual site conditions
17. Prime or tack coat too heavy or too light (Figure A-17)
  - a. Use correct application rates
  - b. Check sprayer calibration



**Figure A-17. Incorrect Tack Coats**

***ROLLER MARKS***

***Probable Cause – Possible Solution***

1. Tender mix
  - a. Check mix proportions and aggregate quality
  - b. Revise design if excess sand, low filler content, or high asphalt content
  - c. Check and correct if excess moisture in mix
  - d. Check asphalt grade and temperature-viscosity characteristics
  - e. Check temperature ranges for tender zone.
  - f. Compact above or below tender zone
2. Bump/indentation due to reversing or turning roller too abruptly
  - a. Gradually slow and reverse
  - b. Make wide radius turns especially for vibratory rollers
  - c. Shut off vibration of vibratory roller before reaching the end of the rolling zone
  - d. Run straight in and out on successive passes and not make wide radius turns on hot HMA
  - e. Stop rollers at an angle (Figure A-18)



**Figure A-18. Stopping Roller at an Angle**

3. Bump/indentation caused by faulty drive system
  - a. Check complete drive system of roller including hydrostatic pumps and motors
4. Edge marks from weight shift when rolling superelevated curve
  - a. Roll uphill. Start at bottom of superelevation and roll into elevation, picking up the overlap on successive passes
5. Rough, uneven pavement due to material pick-up on pneumatic, rollers
  - a. Allow mix to cool and tires to reach mat temperature
6. Rough, uneven pavement due to material pick-up on steel or vibratory steel rollers
  - a. Ensure water spray nozzles operating and the water tank is full
  - b. Properly adjust rubber scrappers, cocoa mats, and steel scrapers
7. Bump/indentation from parked roller
  - a. Don't park roller on mat or vibrate drum when roller is stationary
  - b. Park roller on cool compacted HMA transverse to the direction of paving
8. Bump/indentation from vibratory roller
  - a. Reduce roller passes
  - b. Reduce amplitude
  - c. Do not vibrate on cold HMA surface
9. Flat spot or dent on roller drum
  - a. Replace roller
10. Gap too wide between halve or split drum
  - a. Keep roller drums and tires clean
  - b. Ensure scraper and mats are properly adjusted
11. Tender zone
  - a. Stay out of tender zone
  - b. Adjust rolling procedures

## ***UNSATISFACTORY COMPACTION***

### ***Probable Cause – Possible Solution***

1. Poor temperature control of HMA (mix temperature too cold or too hot)
  - a. Correct temperature at plant according to temperature-viscosity characteristics or in accordance with asphalt supplier's recommendations
  - b. Cover load during hauling and waiting
2. Poor asphalt quality
  - a. Check that asphalt has not been overheated
  - b. Check with supplier
  - c. Test asphalt properties
3. Asphalt content too low
  - a. Revise mix design to increase asphalt content, if possible
4. Hydraulic screed lift not released
  - a. Release hydraulics
  - b. Check for proper or impaired operation of hydraulics
5. Rapid cooling of mat surface
  - a. Check air temperature and wind chill effects using temperature sensors
  - b. Increase lift thickness, if possible
  - c. Run two breakdown rollers in echelon
  - d. Reduce forward speed of paver
6. Mix too dry or too harsh
  - a. Revise mix design to increase VMA and asphalt content
  - b. Consider adding natural sand
  - c. Check fines return system at plant
7. Rolling too fast
  - a. Slow down rollers
  - b. For vibratory rollers, maintain frequency and speed that results in a minimum of 10 impacts per foot
8. Roller too light, compactive effort too low
  - a. Use heavier roller
  - b. For static rollers, increase roller ballast
  - c. For vibratory rollers, set amplitude to match lift thickness and type of material
9. Inadequate rolling compaction or too few rollers/improper rolling pattern
  - a. Establish test strip to determine type and number of rollers required to maintain specified density and smoothness. And maintain production capability of plant, trucking, and paver
  - b. Slow paver to maintain proper rolling pattern
10. Out-of-specification HMA
  - a. Check that mix proportions and sampling procedures are correct at mixing facility

11. Segregation of HMA

- a. Could be due to many factors (Figure A-19)



**Figure A-19. End of Truck Segregation**

- 12. Yielding underlayer – granular bases
  - a. Check density
  - b. Do not lay HMA over a saturated base
  - c. Check drainage
- 13. Yielding underlayer – overlays
  - a. Cut out and patch weak area
- 14. Rolling zones
  - a. Work roller as close to the paver as possible
  - b. Determine mat surface temperatures for rolling zones
  - c. Maintain effective rollers in zones
- 15. Vibrator not operating
  - a. Check for electric or hydraulic system malfunction
- 16. Improper frequency (VPM) and amplitude settings on vibratory roller
  - a. Set frequency and amplitude in relation to lift thickness, material, travel speed, and density requirement