CERTIFIED HMA
FIELD SUPERVISOR

PROCEDURES and POLICIES

MANUAL

2018

INDOT
CERTIFIED HMA
FIELD SUPERVISOR

Objectives

The Indiana Department of Transportation (INDOT) has established a Quality Control/Quality Assurance Program for the purpose of properly assigning INDOT and Producer responsibilities for all aspects of the production of quality Hot Mix Asphalt. The QC/QA HMA Pavement specifications, specifically ITM 803, require that the Quality Control Plan Field Manager be a Certified HMA Field Supervisor.

The principal objective of the Certified HMA Field Supervisor Program is to provide the necessary training to field personnel so that they may administer quality control of the HMA. Knowledge of materials, HMA plants, mix delivery, compaction, smoothness, testing, specifications and other field HMA related topics are provided to enhance the Supervisor's ability to meet the program requirements.

Administration

The training program is administered by INDOT and the Asphalt Pavement Association of Indiana (APAI). Specific duties of each agency include:

<u>INDOT</u>

1. Writing and Maintenance of the Training Manual
2. Maintenance of Certified HMA Field Supervisor List
3. Recertification

<u>APAI</u>

1. Course Announcement
2. Training Facility Arrangements
3. Registration of Students
4. Refreshment Arrangements
5. Providing Training Course Materials
6. Miscellaneous Administrative Tasks

Program Committee

The Program Committee acts as the steering committee which establishes the needs for the certification program and provides technical assistance for course materials and examinations. The committee is composed of representatives from INDOT, FHWA, and APAI.

Certification Committee

The Certification Committee is responsible for revocation or suspension of certifications. Their tasks include reviewing the violations of standard policies, rendering judgement of the seriousness of the violation, and hearing any subsequent appeal. The committee is composed of the following members:

> Manager, Office of Materials Management
> 1 Representative appointed by the APAI Training Committee

Certification Requirements

An individual is required to attend the certification training course to become certified.

Recertification Requirements

The certification is valid for three years as determined from the date of initial issuance. Recertification will require attending a recertification refresher course. The recertification refresher course will include a condensed version of the certification training course. There will be no fee for the recertification refresher course.

If the certification is not renewed, the certification will expire. Renewal of the certification may be made by attending the certification training course.

Notification of the recertification procedures will be made prior to the expiration of the certification.

Fees

The fee for attending the certification training course will be established by the Program Committee. The fee will cover a training manual, course materials, and refreshments, if applicable.

Cancellation Policy

If a scheduled certification or recertification refresher course is cancelled because of insufficient class size, notification will be sent one week prior to the start of the course. The course fee for the certification course will be reimbursed.

Revocation or Suspension of Certification

Certifications awarded may be revoked or suspended at any time by the Certification Committee for just cause.

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CHAPTER ONE:
HOT MIX ASPHALT PAVING SUPERVISION

The purpose of this course is to provide information on how to properly construct Hot Mix Asphalt (HMA) pavements. Emphasis will be on acquiring the skills and knowledge that a HMA Field Supervisor will need to supervise and 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.

This manual is intended to provide the best practices for the Certified HMA Field Supervisor. Many of the techniques, procedures, and methods provided are not applicable to all pavement circumstances, and other methods may be used to meet the requirements of the specifications. The manual is not to be considered part of the specifications or override the specifications or contract documents.

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 Field Supervisor should have knowledge of the following items prior to taking this course.

1) INDOT Standard Specifications

2) Indiana Test Methods 580 and 803 (Appendix A)

3) HMA paving processes and methods

4) Paving equipment operations

5) Pavement deficiencies and how to correct these problems

6) Plans and contract Special Provisions

7) Profilographs

8) OSHA 10 or OSHA 30 training course on traffic and safety

9) Certified Worksite Traffic Supervisor (CWTS) requirements

DUTIES

The general duties of a HMA Field Supervisor are contained within **Sections 105, 304, 306** and **400.** These duties may be designated to other personnel on the project. The duties are summarized as follows:

1) Provide all work and materials in reasonably close conformance with the plans and specifications (Section **105.03**)

2) For work conducted in accordance with Sections **304, 306** and **400,** serve as the Contractors "competent superintendent" (Section **105.05**)

3) Be responsible to recognize and furnish acceptable materials and perform all work in accordance with the requirements of plans and specifications (Section **105.09**)

4) Keep the Project Engineer or Project Supervisor (PE/PS) informed as to the schedule of the work, the progress of the work and the manner in which the work is being performed (Sections **108.04, 108.05, 108.06** and **108.07**)

5) Be knowledgeable of the Construction Requirement Sections of **401, 402, 403, 404, 405, 406, 407, 408** and **410**

6) Complete the Paving Quality Control Plan (QCP) in accordance with ITM 803 (See Appendix A) and perform the work in accordance with the QCP

7) Be knowledgeable of and implement the maintenance of traffic plan in accordance with Section **801.03** for the HMA operations

8) Complete the daily project balance sheet for each activity. (See Appendix D)

9) Be responsible for road sampling in accordance with ITM 580

10) Be responsible for constructing HMA pavements meeting the plans and specifications for the contract and proactively identify and correct issues preventing such construction

CHAIN OF COMMAND

Every organization has a number of management levels, each with their own assigned authority and responsibility. The chain of command within INDOT and the Contractor should be known and followed. Working through the chain usually minimizes problems and maintains cooperation.

INDOT PROJECT/DISTRICT LEVEL

The levels of management in the field include:

1) HMA Technician/Inspector

2) Project Engineer/Project Supervisor

3) District Area Engineer

4) District Construction Engineer

5) District Deputy Commissioner

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

CENTRAL OFFICE

Each District Construction Director has a Central Office Construction Field Engineer to provide guidance concerning HMA operations. The Field Engineers are each assigned a construction specialty and work in the Construction Management Division of INDOT.

CONTRACTOR

Typical Contractor organization may 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) Executive

The HMA Field Supervisor responsible for communication occurring between HMA field operations and HMA plant per QCP.

COMMUNICATION

Construction is always a race against time. You need to beat the rain, lay the mix tomorrow, finish a certain task next week, and be done by August. You worry about contract working days, calendar date completions, hours, days, weeks, months, seasons and years.

You do so because time is money. You worry about profits, incentive/disincentive clauses, liquidated damages, possible losses and acceleration costs. You know that anything you can do to save time can save money.

Accurate communication can save time, and time is money. However, for all of these advanced technical innovations, our personal communication skills are not always that advanced as they should be.

As a construction supervisor, you spend much time communicating. You instruct your crew members, report to your supervisors, coordinate with your subcontractors, listen to your inspectors, and answer questions from the landowners. All of these activities require communication skills, and your effectiveness as a supervisor depends, to a large degree, on your effective use of these skills.

Construction supervisors face difficulties with accurate communication, however. You work in an environment which is full of barriers that affect communication. On the job, you may have scattered crew members, traffic within a few feet, and extremely high noise levels. And, let's face it, you are used to thinking more about facts, figures, costs, production, schedules, and deadlines than communication skills.

When you hear a foreman say: "They did WHAT??" "I thought I told you to do that", you know that miscommunication has occurred. You also know that time has probably been lost and costs have probably increased.

Communication is the process of sending and receiving information, thoughts, or instructions from one person to another. The process includes the sender's word choice, voice tone inflection, and body language, as well as the receiver's understanding, feed-back, and, if the process is successful, commitment. Clear and accurate communication is a learned process. No one is born with this ability. To become an effective communicator, you must learn about the process and practice its skills.

By using the information in this session, you will become a more accurate communicator and a better highway construction supervisor. You will be able to give clear instructions, accurate information, and you will know how to verify that your messages have been accurately understood, resulting in a savings of time. By learning to communicate more accurately, you will also enhance your leadership and motivational skills.

ACCURATE COMMUNICATION

Accurate communication is a two-way process: information, thoughts, or instructions are given or sent by one person and received and understood by another.

Accurate communication always involves three components: (1) a sender (2) a message, and (3) a receiver. Communication is accomplished through speaking, listening, and feedback..

Think of accurate communication as an asphalt roadway. The roadway is made up of components: subgrade, base rock, and asphalt pavement. If any of these three components fails, the roadway fails. The same is true of the three components of accurate communication.

The Sender

The sender is the person who has information (a message) to convey to someone else (a receiver). As a construction supervisor, your performance as a sender is critical to your success. Learning to be an effective sender is often considered the most important component of accurate communication.

A sender has many responsibilities in an effective communication process. These include:

1) Put the information into words which have a clear meaning and can be easily understood by the receiver. If the words are written, the message must be understood from the words alone, because there is little opportunity to add clarification to the words themselves. If the words are spoken, voice tones, inflections, facial expression and body language (gestures or position which have meaning) may be used to clarify and emphasize, not to confuse and blur, the words of the message.

2) Prepare all receivers by reducing or eliminating distractions and then causing the receiver to “tune into” the subject of the message before delivering the message

3) Monitor feedback and reactions to make sure each receiver understands the message

4) Obtain, in some cases, a commitment from each receiver to undertake an action that is contained in the message

5) Finally, and this is a bottom-line responsibility, accept full responsibility for the effectiveness of the entire process.

The Message

What is the message you are trying to communicate when you give information to someone? What response are you expecting to result from the message you are sending? Are you expecting them to just know the information? Do you expect someone to take a specific action? Is the action to be done at a specific time?

You can use the answers to certain questions, which form the essential elements of information, to be sure every message carries enough information to be understood as you intended. The questions are:

Who? What? When? Where? Why? How?

When giving orders, instructions, or directions, you should not omit any of these six elements. The essential element most frequently omitted is why. Your crew wants to know why plans are changed, or how they fit into the big picture. By explaining why, you can help them understand the goals of the plan better and they will be more willing to commit to the plan.

Unfortunately, people often assume that some elements are already known and they leave them out of the message. But do not forget that every time you make such an assumption, you are increasing the risk of miscommunication. If you omit one of the six elements from a message, make sure you do so on purpose and only after you have asked yourself: "Could anything go wrong if I don't tell them why? or when? or how?

Messages can be complicated, and many messages simply have too much information in them. People feel confused or frustrated when they are unable to sort out a clear message from a mass of information. A complicated message contains many components and usually consists of many words plus gestures, facial expressions, tone of voice, and other body movements. Each of these components may have a meaning that must be received and understood. It is not hard to understand why it is often difficult to get the real message across if the message is surrounded by unnecessary clutter.

The Receiver

Sometimes, receivers may not be aware of the sender at the start of the communication process. They may be actively at work on the project, and therefore may be caught off guard. A receiver is not a passive party to the communication process. Like a sender, a receiver also has the following responsibilities:

1) Give attention to the sender by "tuning in" to the message as quickly as possible

2) Actively listen to the message, asking questions to clarify the meaning, i.e., provide feedback

3) Respond to the message, including any commitment that the message may contain

Accurate communication, with these three basic parts, may sound simple. If that is so, why are there so many communication problems on the job? Why aren't people better communicators?

One reason is that in a typical job site communication, you are playing out more than one role. At various points in the process, you switch back and forth, some times quickly, from sender to receiver. You instruct your crew (you're a sender); you scan their faces to see if they understand (you're a receiver); during a response from a crew member (you're a receiver), you interrupt to resend your message (you're a sender); while listening to your supervisor (you're a receiver), you ask a question (you're a sender) for clarification.

It all seems so complicated, but you can become a better communicator by improving your skills in the three activities of the communication process.

THE THREE KEY ACTIVITIES OF ACCURATE COMMUNICATION

The three key activities of building an asphalt roadway are base preparation, hot mix asphalt preparation, and placement. Just as these three activities determine the success of a roadway, accurate communication is determined by effective speaking, listening, and feedback.

Speaking

A majority of communication in our industry, especially in the field, is words spoken in person or over the phone. One of the basic rules of speaking is to let your audience (the receivers) know where you are going. In other words, help the receiver follow along while you transmit the message.

You probably know foremen or superintendents who always seem to get people to understand and follow their instructions with a minimum of problems or difficulty. The secret to their success may be the following three-step formula:

1) Tell them what you're going to tell them

2) Tell them

3) Tell them what you told them

With a particularly long message that contains several topics of instruction, this formula can be applied to each topic. Each part of the long messages is treated as a unit or building block for the complete message. This approach will avoid losing or confusing the receivers.

Another procedure that can help improve your oral communication is introduce the subject so your audience knows your objective. ("We have to switch over to the Monroe County job starting tomorrow morning"). Then after you have their attention, provide the information that supports or satisfies that objective (the message). Finally, restate anything important (summarize) to reinforce the objective.

Remember, however, that speaking is only one of three essential activities required for successful communications.

Listening

Listening is the second activity required, and the failure to listen is one of the main problems in communications. Most people think listening is another word for hearing, but that isn't true. Listening is not a passive activity, but an active process requiring your full attention and concentration.

Sometimes people cannot remember the information given in a message because they do not actively listen. A listener who is thinking of a response cannot concentrate on the sender's message. As a smart listener, first listen actively, then decide what to say in return. This is not easy; however, it is shortsighted to guess what someone is leading up to so you can interrupt them before they finish. Listen instead. Obtain all of the message and get the message right. Ask questions to clarify, if necessary. Remember, the purpose of your first response may be to provide feedback to the sender – feedback that confirms your understanding of the sender's message – without either accepting or rejecting the message itself.

Feedback

Feedback is the third activity in the communication process. This process is used to discover if the sender's message has been completely and accurately understood by the receiver. Feedback is very useful for confirming the accuracy of communication between two people or in small groups, such as crew meetings. Additional benefits are:

1) Feedback can confirm the understanding of what was said or felt by both parties

2) A sender can prompt feedback by asking a receiver to replay a message in the receiver's own words to show what level of understanding has been achieved, and to reveal if key words actually have the same meaning to both parties.

3) Feedback can be used to verify the understanding of specific elements of information in a message (who, what, where, when, why and how).

As a supervisor, you can use feedback to carry out your bottom-line responsibility for the overall effectiveness of the communications process. Often you must us feedback in self-defense to deal with receivers who have poor communications skills and to make sure your message is accurately received and acted upon.

Six ways you can obtain feedback from the people you work with are:

1) Ask the receiver to repeat the message in his or her own words: "Randy, what are we supposed to do as you understand it?"
2) Watch what receivers do as they receive the message. Are they maintaining eye contact with you? Do they seem to be paying attention? Are they taking notes? Do you see understanding in their faces, or a blank, glassy-eyed look that may mean confusion and uncertainty?
3) Listen carefully to their questions about what you have said. The questions people ask often reveal more than the answers they give.
4) Ask questions and listen carefully to the answers. If you receive inappropriate answers, or stone silence, you know your message has not been completely and accurately received.
5) Share your feelings about the feedback after the message is understood, and do this whether the feedback is positive or negative. This will encourage feedback and help to make the feedback a regular part of your own communication style.
6) Monitor the receiver's actions after they receive the message. When they go back to work, do their actions show they understood the message? If the message called for a commitment and the receivers made that commitment, did they carry it out?

Sometimes it's smart to carry your bottom-line responsibility for effective communication one step further by assuming that it is *always your responsibility*, whether you are a sender or a receiver. If a sender's message is not completely and accurately communicated to a receiver, both lose. If this happens to you, it won't make any difference whether you are a sender or a receiver.

COMMUNICATING IN SPECIFIC SITUATIONS

Whether you are making a speech, instructing a new crew member, conducting a meeting, or telling your family or a friend about your day, you must be aware of your choice of words, tone, and expressions. There are times on the job when communication is social, but even "chit chat" or "small talk" tells people something about you, and you should avoid making any impression that might interfere with your effectiveness as a supervisor or leader.

In dealing with your crew, it is extremely important to insure their understanding if you are to gain their commitment. Your crew needs to know exactly what to do and when, and you must arrive at a mutual understanding so that they can commit to today's objectives and the objectives of the project.

WHEN INSTRUCTING YOUR CREW

When instructing your crew, follow these steps:

1) Plan your presentation: write down your plan

2) Choose the time and place that eliminates environmental barriers and has their attention

3) Follow the speaker's three-step formula:

    a) tell them what you're going to tell them
    b) tell them: and
    c) tell them what you told them

4) Insure understanding by obtaining feedback

5) Be patient and positive

6) If understanding is incomplete, try again with different words: or give examples, or ,if necessary, demonstrate

7) Get commitment from your crew to do what is required

MEETINGS

There is more to a meeting than just sitting around the table with other people. Meetings also require preparation and follow-up to make sure information is effectively communicated and agreed-upon actions are taken.

Preparation for a Meeting

Preparation for a meeting requires the following:

1) Before setting up a meeting, ask yourself: Is this meeting really necessary?

2) Determine the purpose of the meeting by asking yourself:

   a) Does the problem require discussion?
   b) Is it likely that a group can solve the problem?
   c) Could the discussion be handled over the phone?
   d) Are the required experts on the list of invitees?

3) Develop a list of topics to be discussed – an agenda

4) Gather information on each agenda item by listing:

   a) Your thoughts, attitudes and opinions
   b) Supporting data or rationale
   c) Your proposed plan of action
   d) Anticipated positions of others
   e) Alternative plans where required

5) Choose the time and place, establish a time limit, and eliminate distractions

6) Notify other attendees such as owners, subs, suppliers, local officials, and other supervisors.

Conducting the meeting

1) Stick to the agenda – post it on the wall along with time limits

2) Start on time and finish on time

3) Obtain everyone's ideas and opinion on each subject

4) Clarify decisions and assignments

5) Get commitment from all who must support the action

Follow-up

1) Immediately document the main ideas and decisions reached

2) Send copies of minutes to attendees

3) Check later to be sure that agreed-upon actions are taken

4) File a copy of the minutes for future reference

TELEPHONE CONVERSATIONS

Telephones have been part of your life since you can remember and are taken for granted as a time-saver in construction. Effective telephone communication, however, doesn't just happen; it is planned and improves with practice. When communicating by phone:

1) Plan what you have say

2) Plan how you are going to say it

3) Be aware of the potential effect of communication barriers

4) Be businesslike and give your full attention to the caller

5) Make your tone of voice match your objective; remember your emotions will probably show through

6) Use a serious tone for bad news or a serious problem

7) Use a friendly tone for normal discussion

8) Use a business-like tone for reprimands or complaints or use a stern or harsh tone; however, only use this tone if you think this approach will obtain the response you want.

9) Be careful in your choice of words, because there is no body language to help understanding or provide feedback

10) Obtain feedback to insure understanding - Ask!

11) Follow up with a memo or a confirming phone conversation

SAFETY

HMA Field Supervisor is required to be concerned with the safety of the traveling public, 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

Type of Equipment	Potential Hazard
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
	Bruises
	Electrocution
	Serious, extensive and possibly fatal injuries if run over
Feet	Blisters
	Burns
	Bruises

SAFETY PRECAUTIONS

Dress

Clothing

Regular clothing is worn. Loose 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 worn.

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.

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/PS is given information such as the date, time, weather, people present, equipment, vehicle type and identification numbers, and the sequence of events.

TERMS 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

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.

2 Mix Composition

Quality Control/Quality Assurance

Quality Control Plan

Quality Assurance Procedures

Materials

Design Mix Formula

Hot Mix Asphalt

Quality Control

Pay Item

Design Mix Formula

Miscellaneous Mix Criteria

Acceptance of Mixtures

Stone Mastic Asphalt

CHAPTER TWO:
MIX COMPOSITION

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.

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 Testing laboratory facilities for testing to determine the following volumetric properties:

1) Air Voids

2) 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 receiving the Contractor's QC results.

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. As of 2017, Profilograph is being phased out and replaced by Inertial Profilers (IRI).

On contracts that do not include the profilograph/profiler pay item, the 16 ft straightedge is used to verify longitudinal profile of the constructed pavement.

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 three ESAL categories and larger numbers indicate higher anticipated truck volumes.

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 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 2-1). 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).

Figure 2-1. Recycled Asphalt Pavement (RAP)

Recycled Asphalt Shingles

QC/QA HMA mixtures may also include recycled asphalt shingles (RAS) (Figure 2-2) that are obtained from the waste from a shingle manufacturing (pre-consumer) or from post-consumer (tear-off) shingles. Pre-consumer and post-consumer shingles are not allowed to be blended. 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. RAS and RAP may be used together in a HMA mixture.

Figure 2-2. 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. 4.75mm, 9.5mm, 12.5mm, 19.0mm, and 25.0mm 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 9.5, OG 19.0 and OG 25.0 are the open graded mixtures that are used. Section **401.05** includes the gradation requirements for these 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 2-3 is a graphical example of how the binder replacement requirement is applied.

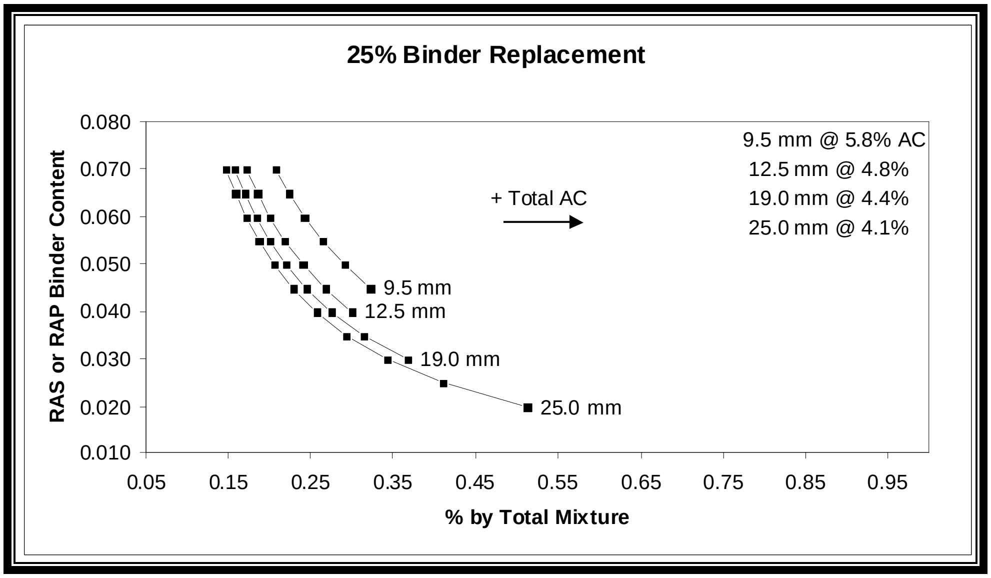

Figure 2-3. Binder Replacement

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

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

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

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

.

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 B provides the following information:

The "Type B" portion of the pay item designates a design ESAL level of less than 3,000,000. The ESAL categories range from Type B 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.

DESIGN MIX FORMULA

A DMF for a QC/QA HMA mixture in accordance with Section **401** may be used for HMA in accordance with Section **402**. The source or grade of the binder may be changed; however, the high temperature grade of the binder is required to meet the requirements of Section **402.04**.

The processing requirements for DMFs are identical to those included in Section **401** for QC/QA HMA mixes.

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. 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 plant (**ITM 583**) and the Quality Control Plan for the contract (**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. 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.

3 Quality Assurance Procedures

Design Mix Formula

Lot/Sublot -- QC/QA HMA

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 Factors -- QC/QA HMA (Dense Graded Mixture ≥ 1 Lot)

PWL - Mixture
PWL – Density
Pay Factors

Adjustment Quantity -- QC/QA HMA ≥ 1 Lot

Pay Factors -- QC/QA HMA (Dense Graded Mixture < 1 Lot and Open Graded Mixtures)

Mixture
Density

Adjustment Quantity -- QC/QA HMA < 1 Lot and Open Graded Mixures

Mix Appeal -- QC/QA HMA

Smoothness

Procedures
Profilograph Exemptions
Quality Assurance Adjustments

CHAPTER THREE:
QUALITY ASSURANCE PROCEDURES

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 **402** (HMA) and the procedures for determining pay factors.

DESIGN MIX FORMULA

The Contractor is required to submit for the Engineer's approval a Design Mix Formula (DMF) for each mixture. This information is recorded in a format acceptable to the Engineer. TD-451 is one format that has been used for this purpose (Figure 3-1). INDOT is required to have a signed copy of the DMF prior to production of any mixture.

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 sublot is 1000 t, and for Surface QC/QA HMA or SMA, a sublot is 600 t. Partial sublots of 100 t or less are added to the previous sublot. Partial sublots greater than 100 t constitute a full sublot. Partial lots of four sublots or less are added to the previous lot, if applicable.

INDIANA DEPARTMENT OF TRANSPORTATION
MATERIALS AND TESTS DIVISION
2016 HMA DMF/JMF per 401/402/410

v16.2 12/17/15

HMA PRODUCER :	
PLANT LOCATION :	
CERTIFIED PLANT NUMBER:	
APPROVED DESIGN LAB :	

Aggregate Size	Source	Source #	Q-Number	Ledges	Gsb	Abs %	DMF %	JMF %	Dolo. Test (YES/NO)?	___ Tons of HMA

PG BINDER	Source	Source #		Binder % RAS	Binder Replacement %	Virgin Binder %
			DMF	0.0%	0.0%	0.0%
			JMF			
Additives/ Fibers/ Etc.	Source	Source #				

			Fine	Coarse	RAS
Aggregate Design No.	**16xxxx D**	**DMF - Fine** RAP/ **Coarse** RAP/ RAS in mixture, %			
		DMF - Fine RAP/ **Coarse** RAP/ RAS binder, extracted, %			
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)		
PG Grade, Design TSR						Binder, ignition (actual), %		
Mixture course						Binder, extracted, %		
Mixture designation						Extraction required? Yes* or No		
Maximum particle size						Binder, calculated effective, %		
	Spec	DMF Mass	JMF Mass	DMF Vol	JMF Vol	Gyrations Nini / Ndes / Nmax		
%Pass 37.5 mm						Mass gyratory pill @ Ndes, g		
%Pass 25.0 mm						Gmm		
%Pass 19.0 mm						Gmm w/ dry back? Yes or No		
%Pass 12.5 mm						Gmm % @ Nini / Nmax		
%Pass 9.5 mm						Gmb @ Ndes		
%Pass 4.75 mm						Air Voids @ Ndes, %		
%Pass 2.36 mm						VMA @ Ndes, %		
%Pass 1.18 mm						VFA @ Ndes, %		
% Pass 600 µm						Coarse agg. ang. 1 / 2 face, %		
% Pass 300 µm						Fine aggregate angularity		
% Pass 150 µm						Sand equivalency		
% Pass 75 µm						Dust/calculated effective binder		
Aggregate blend Gsb					Tensile strength ratio, %			
Aggregate blend Abs, %					Draindown, % (SMA or OG only)			
					ΔPb, %			
Base PG-Plant Max Temp (°F)					VCA_{DRC}/VCA_{MIX} (SMA only >1)			
Lab compaction Temp (±9°F)					**MAF by DTE for PE/PS**		1.000	

* Extraction Note - Written request required, submit w / DMF

DMF DATE: ____________________

PRODUCER: ____

JMF DATE: ____________________

DATE DMF ASSIGNED: ______________________ DATE JMF ASSIGNED: ______________________

DTE Notes:

DMF reference history:
Ignition Oven Samples Submitted:
Producer Notes:

Figure 3-1. Design Mix Formula

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 3-2), marked, and shipped to an INDOT Lab for testing.

Figure 3-2. HMA Sample Container

TRUCK SAMPLES

Truck samples (Figure 3-3) 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 3-3. Truck Sample

CORE SAMPLES

Core samples (Figure 3-4) 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 lab for the appropriate testing.

Figure 3-4. 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 appeal procedures can be found in **401.20**. Once approved by the District Testing Engineer, appeal samples are tested.

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 3-5, 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 3-5. Random Numbers

PLATE SAMPLES

A specific ton in each sublot 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 3-6). 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.

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

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. Plate samples will not be taken at the following locations and contract requirements:

1. Less than 1 ft from the edge of the course

2. A course thickness less than 2.0 times the maximum particle size for all mixtures except 4.75 mm mixtures which shall require a course thickness of at least 1.5 times the maximum particle size.

3. Original pay item quantities less than 300t. If the random ton selected for the sublot is within the first 300t, then 300 is added to the random ton number and the sample is obtained from the truck containing that ton.

4. Areas placed with 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 sublot falls within an area placed by this equipment, the previous sublot is used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

TD-452 State Form 36667 (R3/3-95)

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INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

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	LOT TON TO BE SAMPLED		PAVING WIDTH	RANDOM NO.	TRANS. LOC.	LENGTH OF LOAD	RANDOM NO.	RANDOM DIST.	STARTING STA.*	RANDOM STATION
	A	B	A × B = C	D	C + D	E	F	E × F	G	H	G × H = I	J	I + J
1	600			0									N.B. Passing
	1000	.123	123	0	123	12	.100	1.2 (1)	136	.259	35	10+50	10+85
2	600			625									N.P. Passing
	1000	.116	116	1000	1116	12	.890	10.7 (11)	136	.317	43	76+90	77+33
3	600			1250									N.B. Passing
	1000	.836	836	2000	2836	12	.523	6.3 (6)	136	.665	90	194+00	194+90
4	600			1875									N.B. Passing
	1000	.636	636	3000	3636	12	.928	11.1 (11)	136	.404	55	247+20	247+75

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

$$\textit{Length of Load (Nearest Foot)} = \frac{\text{Load Weight (tons)}}{\text{Avg. Planned Quantity (lb./sq. yd.)} \times \text{Width of Paving (ft.)}} \times 18000$$

Figure 3-6. Random Sampling for Mix

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^2
Ending Station of Paver of Previous Load	=	158+00
Random Numbers	=	256, .561

Test Site Station

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

Longitudinal Distance = 273 x .256 = 70 ft

Random Station = (158+00) + 70 = 158+70

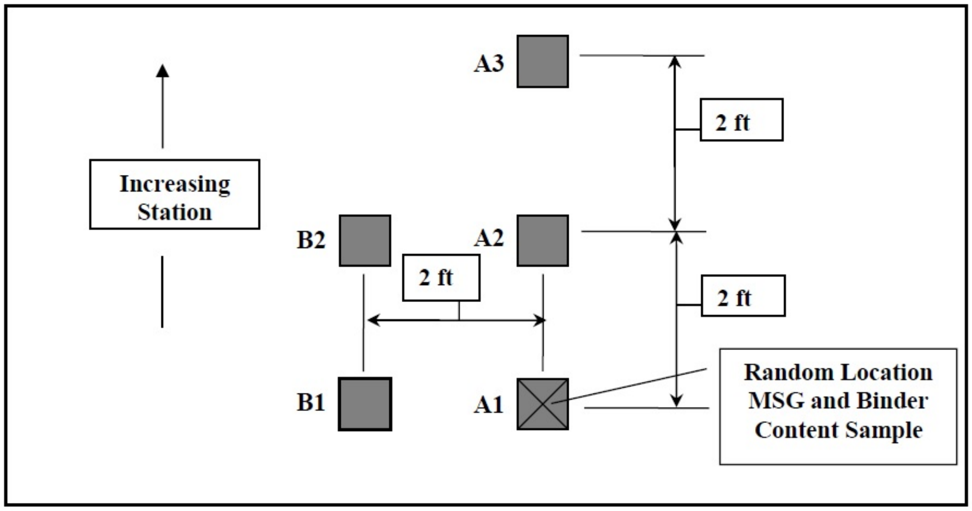
Transverse Distance

Distance = 12 x .561 = 6.7 ft (say 7 ft)

For contracts controlled by volumetrics for QC/QA HMA (**401)**, several samples are required. The first plate sample location is determined by the random sampling procedure and this material is used for the maximum specific gravity and binder content samples. This plate is designated A1. A second plate sample is placed longitudinally 2 ft upstation from the first plate at the same transverse offset. This sample is used for the gyratory specimens and is designated A2. A third plate is placed longitudinally 2 ft upstation from the second plate at the same transverse offset. This sample is used to determine the aggregate bulk specific gravity within the mixture. This plate sample will be designated A3.

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 for the maximum specific gravity and binder content is placed transversely 2 ft from the first plate towards the center of the mat and is designated B1. The backup sample for the gyratory specimens is placed transversely 2 ft from the second plate towards the center of the mat and is designated B2.

The following diagram indicates an example of an arrangement of the plate samples when samples are required for QC/QA HMA:



An example of determining the sample locations is as follows:

Example:

Width of Pavement	= 12 ft
Load Weight	= 20 t
Mixture	= 9.5 mm Surface
Planned Quantity	= 165 lb/yd^2
Ending Station of Paver of Previous Load	= 158+00
Random Numbers	= 256, .561

Test Site Station

$$\text{Length of Load} = \frac{20}{165 \times 12} \times 18000 = 182 \text{ ft}$$

Longitudinal Distance = 182 x .256 = 47 ft

Random Station = (158+00) + 47 = 158+47

Transverse Distance

Distance = 12 x .561 = 6.7 ft (say 7 ft)

MSG and Binder Content Sample

Random Location = 158 + 47
Transverse Distance = 7 ft

Gyratory Specimens Sample

Random Location = (158 + 47) + 02
= 158 + 49

Transverse Location = 7 ft

Backup Sample for MSG and Binder Content

Random Location = 158 + 47
Transverse Distance = 7-2
= 5 ft

Backup Sample for Gyratory Specimens

Random Location = (158 + 47) + 2
= 158 + 49
Transverse Distance = 7-2
= 5 ft

The procedure for obtaining plate samples (Figure 3-7) 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. Material remaining on the plate is required to be removed and replaced into the sample container.

Figure 3-7. 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 procedure 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.

Areas placed with wideners or other specialty paving equipment are not subject to plate sampling. If a random sampling location falls within an area placed by this equipment, another randomly selected location is determined. If an entire sublot falls within an area placed by this equipment, the previous sublot is used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

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	11000	11000
12.5 mm	11000	11000
19.0 mm, OG 19.0 mm	11000	11000
25.0 mm, OG 25.0 mm	11000	11000

Figure 3-8 indicates the approximate weights that may be obtained for various sizes of plates and lift thicknesses that are placed.

Figure 3-9 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/syd)**	**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 3-8. 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/yd²)	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 3-9. 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 3-10) is done by the Conractor under the supervision of an INDOT Technician. For QC/QA HMA, two cores are obtained in each sublot for density of the mixture. The core locations are determined by **ITM 802** with each core located independently within the sublot. All core sampling is done in accordance with **ITM 580**.

Areas placed with wideners or specialty equipment approved by the Engineer are locations where cores are not taken. If the random core location falls within an area placed by this equipment, another randomly selected location is determined. If the entire sublot falls within an area placed by this equipment, the previous sublot is used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

A 6 in diameter core is obtained from the pavement for the random sample. 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 then marked with a lumber crayon or permanent marker.

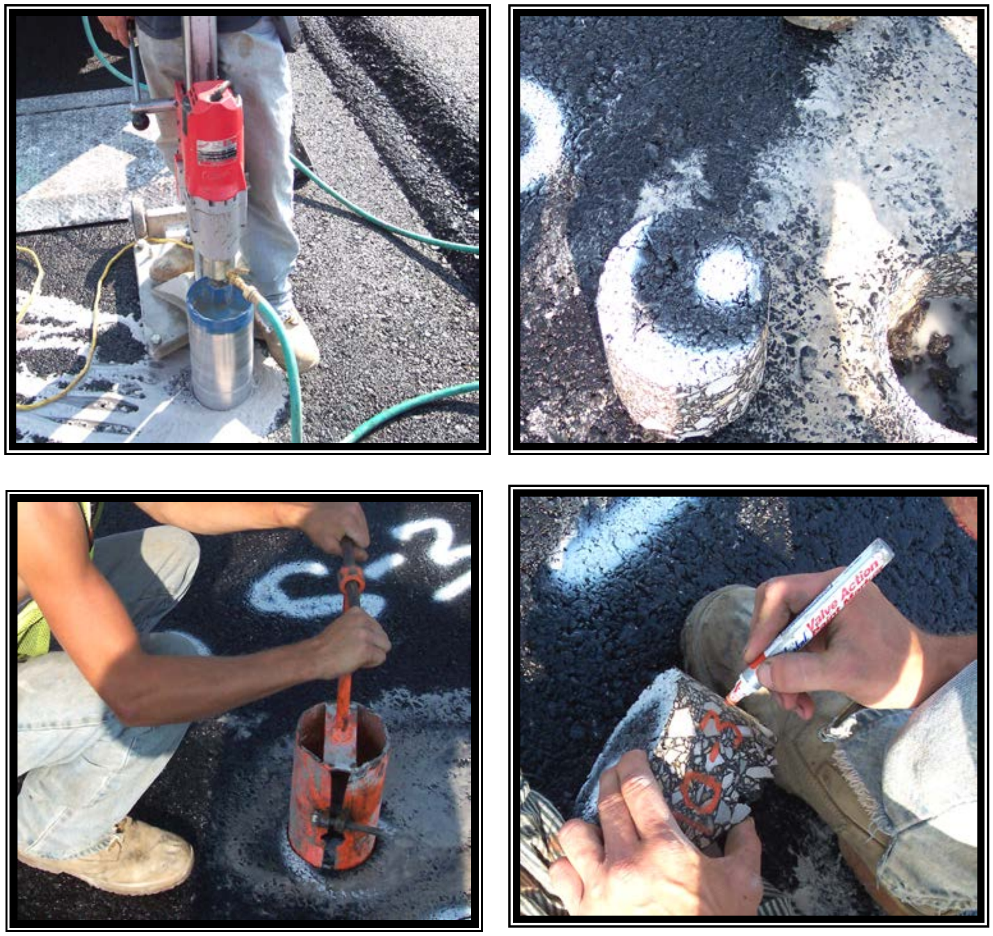


Figure 3-10. HMA Coring

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 sublot for sampling in accordance with the **ITM 802.** Samples from the pavement are obtained from each sublot in accordance with **ITM 580**.

Some QC/QA mixtures are not accepted by tests conducted by INDOT and are instead acceptaed by Type D certifications in accordance with **916**. A type D certification is prepared by the Contractor, refers to the applicable specification, and certifies that the materials furnished are in accordance with the specifications. In general, these mixtures have low quantities, are placed in locations that plate samples are difficult to obtain, and the random sampling procedures are not applicable.

An example of the type D certification form is shown in Figure 3-11. This form is submitted by the Producer to the Project Engineer on a contract 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. QC/QA mixtures that are accepted by a type D certification include:

1. Mixtures with original contract pay item quantities less than 300 t
2. Dense graded 4.75 mm mixtures

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

All acceptance test results for each sublot are available after the sublot and the testing are complete.

HMA

Acceptance of HMA mixtures in accordance with **402** is done on the basis of a Type D certification. Mixtures in **402** include miscellaneous HMA mixtures such as patching, widening, rumble strips, wedge and leveling, approaches, temporary mixtures, etc. that are difficult to sample with a plate.

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.**

INDIANA DEPARTMENT OF TRANSPORTATION
HOT MIX ASPHALT (HMA) CERTIFICATION

CONTRACT NUMBER ____RS-38000_________ DATE__5/3/16______

CERTIFIED HMA PRODUCER ______R. Walker Construction____________________________

CERTIFIED HMA PLANT NUMBER ____3550___ DMF/JMF NUMBER ___161999___

PG BINDER SOURCE _____7199_____ PG BINDER GRADE ____PG 64-22_____________

MIXTURE TYPE AND SIZE ______HMA Surface, 9.5 mm, Type B_______________________

DESIGN ESAL _____3,000,000_______

Air Voids __4.0__ (DMF/JMF) Binder Content ___5.5__ (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_ (± 1.5 % from DMF/JMF value for all mixtures except open graded mixtures which shall be ± 3.5% from DMF/JMF value)

Binder Content __5.7_ (± 0.7 % from DMF/JMF value)

* [ ] 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/PS USE ONLY

PAY ITEM(S) ______________________________ BASIS FOR USE NO. C999998

SPECIFICATION REFERENCE

__ 304.04 - Patching	__ 402.07(c) - Temporary HMA	__ 610.02 - Approaches
__ 304.05 - Widening	__ 503.03(e) - Terminal Joints	__ 611.02 - Crossovers
__ 402.04 - HMA Pavements	__ 507.05(b) - Partial Depth Patching	__ 718.04 - Underdrains
__ 402.07(a) - Rumble Strips	__ 604.07(c) – Sidewalk	__ 801.11- Temp. Cross
__ 402.07(b) - Wedge & Leveling	__ 605.07(c) – Curbing	

Figure 3-11. HMA Certification

PAY FACTORS – QC/QA HMA (Dense Graded ≥ 1 Lot)

Pay factors for dense graded QC/QA HMA mixtures with original pay item quantities greater than or equal to one lot are determined in accordance with the procedures for Percent Within Limits (PWL) designated in **ITM 588**. The PWL method uses the average and standard deviation of the lot tests to estimate the percentage of the lot that is within the specification limits. The procedure for determining the PWL of the lot is as follows:

PWL - Mixture

1. Determine the average of the lot mixture properties for air voids at N_{des} and VMA at N_{des} as follows:

$$\bar{x} = \sum_{i=1}^{n} \frac{x_i}{n}$$

where:

$\bar{x}$ = average of the lot mixture property values
x_i = sublot mixture property value
n = number of mixture sublot samples in the lot

The air voids and VMA lot average values are reported to the nearest 0.01 %.

2. Determine the standard deviation of the lot mixture property as follows:

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

where:

s = standard deviation of the lot mixture property
x_i = sublot mixture property value
$\bar{x}$ = average of the lot mixture property values
n = number of mixture sublot samples in the lot

The standard deviation values for air voids and VMA are reported to the nearest 0.01.

3. Calculate the Upper Quality Index for each mixture property by subtracting the lot average of each mixture property from the Upper Specification Limit (Figure 3-12) and dividing the result by the standard deviation of the lot mixture property as follows:

$$Q_U = \frac{USL - \bar{x}}{s}$$

where:

Q_u = Upper Quality Index
USL = Upper Specification Limit
$\bar{x}$ = average of the lot mixture property values
s = standard deviation of the lot mixture property

The air voids and VMA Upper Quality Index values are reported to the nearest 0.01.

SPECIFICATION LIMITS		
Mixture		
	LSL*	USL**
Air Voids(Va) at N_{des}, %	2.60	5.40
VMA at N_{des}, %	Spec	Spec+2.50
Density		
	LSL	USL
Roadway Core Density (%Gmm), %	91.00	Not Applicable
* LSL, Lower Specification Limit ** USL, Upper Specification Limit		

Figure 3-12. Specification Limits

4. Calculate the Lower Quality Index for each mixture property by subtracting the Lower Specification Limit (Figure 3-12) from the lot average of each mixture property and dividing the result by the standard deviation of the lot mixture property as follows:

$$Q_L = \frac{\bar{x} - LSL}{s}$$

where:

Q_L = Lower Quality Index
LSL = Lower Specification Limit
$\bar{x}$ = average of the lot mixture property values
s = standard deviation of the lot mixture property

The air voids and VMA Lower Quality Index values are reported to the nearest 0.01.

5. Determine the percentage of material that will fall within the Upper and Lower Specification Limits (Figure 3-12) by entering the table of Quality Index Values (Figure 3-13) with Q_U or Q_L using the column appropriate to the total number of measurements, n.

6. Determine the percent of material that will fall within the limits for each mixture property by adding the percent within the Upper Specification Limit (PWL_U) to the percent within the Lower Specification Limit (PWL_L), and subtracting 100 from the total as follows:

$$\text{Total PWL} = (PWL_U + PWL_L) - 100$$

PWL - Density

1. Determine the average of the lot density values as follows:

$$\bar{x} = \sum_{i=1}^{n} \frac{x_i}{n}$$

where:

$\bar{x}$ = average of the lot density values
x_i = core density value
n = number of cores in the lot

The density (% Gmm) lot average value is reported to the nearest 0.01 %.

2. Determine the standard deviation of the lot density as follows:

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

where:

s = standard deviation of the density of the lot
$\bar{x}$ = average of the lot density values
x_i = core density value
n = number of cores in the lot

The standard deviation value is reported to the nearest 0.01.

3. Calculate the Lower Quality Index for in-place density (% G_{mm}) by subtracting the Lower Specification Limit (Figure 3-12) from the average of the density of the lot and dividing the result by the standard deviation of the density of the lot as follows:

$$Q_L = \frac{\bar{x} - LSL}{s}$$

where:

Q_L = Lower Quality Index
LSL = Lower Specification Limit
$\bar{x}$ = average of the lot density values
s = standard deviation of the density of the lot

The density Lower Quality Index value is reported to the nearest 0.01.

4. Determine the PWL for density by entering the table of Quality Index Values (Figure 3-13) using the column appropriate to the total number of measurements, n.

5. Determine the percent within the lower specification limit (PWL_L) for density as follows:

$$\text{Total PWL} = PWL_L$$

Quality Index (QI) Values PWL for a given sample size (n)												
QI	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=9**	**n=10**	**n=11**	**n=12**	**n=13**	**n=14**
2.30	100	100	100	100	100	100	100	100	100	100	100	100
2.29	100	100	100	100	100	100	100	100	100	100	100	99
2.28	100	100	100	100	100	100	100	100	100	100	100	99
2.27	100	100	100	100	100	100	100	100	100	100	99	99
2.26	100	100	100	100	100	100	100	100	100	100	99	99
2.25	100	100	100	100	100	100	100	100	100	100	99	99
2.24	100	100	100	100	100	100	100	100	100	99	99	99
2.23	100	100	100	100	100	100	100	100	100	99	99	99
2.22	100	100	100	100	100	100	100	100	100	99	99	99
2.21	100	100	100	100	100	100	100	100	99	99	99	99
2.20	100	100	100	100	100	100	100	100	99	99	99	99
2.19	100	100	100	100	100	100	100	100	99	99	99	99
2.18	100	100	100	100	100	100	100	100	99	99	99	99
2.17	100	100	100	100	100	100	100	99	99	99	99	99
2.16	100	100	100	100	100	100	100	99	99	99	99	99
2.15	100	100	100	100	100	100	100	99	99	99	99	99
2.14	100	100	100	100	100	100	100	99	99	99	99	99
2.13	100	100	100	100	100	100	100	99	99	99	99	99
2.12	100	100	100	100	100	100	99	99	99	99	99	99
2.11	100	100	100	100	100	100	99	99	99	99	99	99
2.10	100	100	100	100	100	100	99	99	99	99	99	99
2.09	100	100	100	100	100	100	99	99	99	99	99	99
2.08	100	100	100	100	100	100	99	99	99	99	99	99
2.07	100	100	100	100	100	100	99	99	99	99	99	99
2.06	100	100	100	100	100	99	99	99	99	99	99	99
2.05	100	100	100	100	100	99	99	99	99	99	99	99
2.04	100	100	100	100	100	99	99	99	99	99	99	99
2.03	100	100	100	100	100	99	99	99	99	99	99	99
2.02	100	100	100	100	100	99	99	99	99	99	99	99
2.01	100	100	100	100	100	99	99	99	99	99	99	98
2.00	100	100	100	100	100	99	99	99	99	99	99	98
1.99	100	100	100	100	100	99	99	99	99	99	98	98
1.98	100	100	100	100	99	99	99	99	99	98	98	98
1.97	100	100	100	100	99	99	99	99	99	98	98	98
1.96	100	100	100	100	99	99	99	99	98	98	98	98
1.95	100	100	100	100	99	99	99	99	98	98	98	98
1.94	100	100	100	100	99	99	99	99	98	98	98	98
1.93	100	100	100	100	99	99	99	98	98	98	98	98

Figure 3-13. Quality Index (QI) Values

Quality Index (QI) Values PWL for a given sample size (n)												
1.92	100	100	100	100	99	99	99	98	98	98	98	98
1.91	100	100	100	100	99	99	99	98	98	98	98	98
1.90	100	100	100	100	99	99	98	98	98	98	98	98
1.89	100	100	100	100	99	99	98	98	98	98	98	98
1.88	100	100	100	100	99	99	98	98	98	98	98	98
1.87	100	100	100	99	99	98	98	98	98	98	98	98
1.86	100	100	100	99	99	98	98	98	98	98	98	98
1.85	100	100	100	99	99	98	98	98	98	98	98	98
1.84	100	100	100	99	99	98	98	98	98	98	97	97
1.83	100	100	100	99	99	98	98	98	98	98	97	97
1.82	100	100	100	99	99	98	98	98	98	97	97	97
1.81	100	100	100	99	98	98	98	98	97	97	97	97
1.80	100	100	100	99	98	98	98	98	97	97	97	97
1.79	100	100	100	99	98	98	98	97	97	97	97	97
1.78	100	100	100	99	98	98	98	97	97	97	97	97
1.77	100	100	100	99	98	98	97	97	97	97	97	97
1.76	100	100	100	99	98	98	97	97	97	97	97	97
1.75	100	100	100	99	98	98	97	97	97	97	97	97
1.74	100	100	100	98	98	97	97	97	97	97	97	97
1.73	100	100	100	98	98	97	97	97	97	97	97	97
1.72	100	100	100	98	98	97	97	97	97	97	96	96
1.71	100	100	99	98	97	97	97	97	97	96	96	96
1.70	100	100	99	98	97	97	97	97	96	96	96	96
1.69	100	100	99	98	97	97	97	96	96	96	96	96
1.68	100	100	99	98	97	97	97	96	96	96	96	96
1.67	100	100	99	98	97	97	96	96	96	96	96	96
1.66	100	100	99	98	97	97	96	96	96	96	96	96
1.65	100	100	99	97	97	96	96	96	96	96	96	96
1.64	100	100	99	97	97	96	96	96	96	96	96	96
1.63	100	100	98	97	97	96	96	96	96	96	96	95
1.62	100	100	98	97	96	96	96	96	96	95	95	95
1.61	100	100	98	97	96	96	96	96	95	95	95	95
1.60	100	100	98	97	96	96	96	95	95	95	95	95
1.59	100	100	98	97	96	96	95	95	95	95	95	95
1.58	100	100	98	96	96	96	95	95	95	95	95	95
1.57	100	100	97	96	96	95	95	95	95	95	95	95
1.56	100	100	97	96	96	95	95	95	95	95	95	95
1.55	100	100	97	96	95	95	95	95	95	95	95	95

Quality Index Values (continued)

Quality Index (QI) Values PWL for a given sample size (n)												
QI	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	n=13	n=14
1.54	100	100	97	96	95	95	95	95	95	94	94	94
1.53	100	100	97	96	95	95	95	95	94	94	94	94
1.52	100	100	97	96	95	95	95	94	94	94	94	94
1.51	100	100	96	95	95	95	94	94	94	94	94	94
1.50	100	100	96	95	95	94	94	94	94	94	94	94
1.49	100	100	96	95	95	94	94	94	94	94	94	94
1.48	100	99	96	95	94	94	94	94	94	94	94	94
1.47	100	99	96	95	94	94	94	94	94	94	93	93
1.46	100	99	95	94	94	94	94	94	93	93	93	93
1.45	100	98	95	94	94	94	93	93	93	93	93	93
1.44	100	98	95	94	94	93	93	93	93	93	93	93
1.43	100	98	95	94	94	93	93	93	93	93	93	93
1.42	100	97	95	94	93	93	93	93	93	93	93	93
1.41	100	97	94	94	93	93	93	93	93	93	93	93
1.40	100	97	94	93	93	93	93	93	92	92	92	92
1.39	100	96	94	93	93	93	92	92	92	92	92	92
1.38	100	96	94	93	93	92	92	92	92	92	92	92
1.37	100	96	93	93	92	92	92	92	92	92	92	92
1.36	100	95	93	93	92	92	92	92	92	92	92	92
1.35	100	95	93	92	92	92	92	92	92	92	92	92
1.34	100	95	93	92	92	92	92	92	91	91	91	91
1.33	100	94	93	92	92	92	91	91	91	91	91	91
1.32	100	94	92	92	91	91	91	91	91	91	91	91
1.31	100	94	92	92	91	91	91	91	91	91	91	91
1.30	100	93	92	91	91	91	91	91	91	91	91	91
1.29	100	93	92	91	91	91	91	91	91	90	90	90
1.28	100	93	91	91	91	91	90	90	90	90	90	90
1.27	100	92	91	91	90	90	90	90	90	90	90	90
1.26	100	92	91	90	90	90	90	90	90	90	90	90
1.25	100	92	91	90	90	90	90	90	90	90	90	90
1.24	100	91	90	90	90	90	90	90	90	90	90	89
1.23	100	91	90	90	90	89	89	89	89	89	89	89
1.22	100	91	90	89	89	89	89	89	89	89	89	89
1.21	100	90	90	89	89	89	89	89	89	89	89	89
1.20	100	90	89	89	89	89	89	89	89	89	89	89
1.19	100	90	89	89	89	89	89	89	89	88	88	88
1.18	100	89	89	89	88	88	88	88	88	88	88	88
1.17	100	89	88	88	88	88	88	88	88	88	88	88

Quality Index Values (continued)

Quality Index (QI) Values PWL for a given sample size (n)												
QI	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=9**	**n=10**	**n=11**	**n=12**	**n=13**	**n=14**
1.16	100	89	88	88	88	88	88	88	88	88	88	88
1.15	97	88	88	88	88	88	88	88	88	88	88	88
1.14	95	88	88	88	87	87	87	87	87	87	87	87
1.13	93	88	87	87	87	87	87	87	87	87	87	87
1.12	92	87	87	87	87	87	87	87	87	87	87	87
1.11	91	87	87	87	87	87	87	87	87	87	87	87
1.10	90	87	87	87	87	87	87	87	87	87	86	86
1.09	89	86	86	86	86	86	86	86	86	86	86	86
1.08	88	86	86	86	86	86	86	86	86	86	86	86
1.07	88	86	86	86	86	86	86	86	86	86	86	86
1.06	87	85	85	85	85	86	86	86	86	86	86	86
1.05	86	85	85	85	85	85	85	85	85	85	85	85
1.04	86	85	85	85	85	85	85	85	85	85	85	85
1.03	85	84	85	85	85	85	85	85	85	85	85	85
1.02	84	84	84	84	84	84	85	85	85	85	85	85
1.01	84	84	84	84	84	84	84	84	84	84	84	84
1.00	83	83	84	84	84	84	84	84	84	84	84	84
0.99	83	83	83	84	84	84	84	84	84	84	84	84
0.98	82	83	83	83	83	83	83	84	84	84	84	84
0.97	82	82	83	83	83	83	83	83	83	83	83	83
0.96	81	82	82	83	83	83	83	83	83	83	83	83
0.95	81	82	82	82	83	83	83	83	83	83	83	83
0.94	80	81	82	82	82	82	82	82	82	82	83	83
0.93	80	81	82	82	82	82	82	82	82	82	82	82
0.92	79	81	81	82	82	82	82	82	82	82	82	82
0.91	79	80	81	81	81	81	82	82	82	82	82	82
0.90	78	80	81	81	81	81	81	81	81	81	81	81
0.89	78	80	80	81	81	81	81	81	81	81	81	81
0.88	78	79	80	80	81	81	81	81	81	81	81	81
0.87	77	79	80	80	80	80	80	80	81	81	81	81
0.86	77	79	79	80	80	80	80	80	80	80	80	80
0.85	76	78	79	79	80	80	80	80	80	80	80	80
0.84	76	78	79	79	79	79	80	80	80	80	80	80
0.83	76	78	78	79	79	79	79	79	79	79	79	79
0.82	75	77	78	79	79	79	79	79	79	79	79	79
0.81	75	77	78	78	78	79	79	79	79	79	79	79
0.80	74	77	77	78	78	78	78	78	78	79	79	79
0.79	74	76	77	78	78	78	78	78	78	78	78	78
0.78	74	76	77	77	77	78	78	78	78	78	78	78
0.77	73	76	77	77	77	77	77	78	78	78	78	78
0.76	73	75	76	77	77	77	77	77	77	77	77	77

Quality Index Values (continued)

Quality Index (QI) Values PWL for a given sample size (n)												
QI	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	n=13	n=14
0.75	73	75	76	76	77	77	77	77	77	77	77	77
0.74	72	75	76	76	76	76	77	77	77	77	77	77
0.73	72	74	75	76	76	76	76	76	76	76	76	76
0.72	71	74	75	75	76	76	76	76	76	76	76	76
0.71	71	74	75	75	75	75	76	76	76	76	76	76
0.70	71	73	74	75	75	75	75	75	75	75	75	76
0.69	70	73	74	74	75	75	75	75	75	75	75	75
0.68	70	73	74	74	74	74	75	75	75	75	75	75
0.67	70	72	73	74	74	74	74	74	74	74	75	75
0.66	69	72	73	73	74	74	74	74	74	74	74	74
0.65	69	72	73	73	73	74	74	74	74	74	74	74
0.64	69	71	72	73	73	73	73	73	73	74	74	74
0.63	68	71	72	72	73	73	73	73	73	73	73	73
0.62	68	71	72	72	72	73	73	73	73	73	73	73
0.61	68	70	71	72	72	72	72	72	72	73	73	73
0.60	67	70	71	71	72	72	72	72	72	72	72	72
0.59	67	70	71	71	71	72	72	72	72	72	72	72
0.58	67	69	70	71	71	71	71	71	71	72	72	72
0.57	66	69	70	70	71	71	71	71	71	71	71	71
0.56	66	69	70	70	70	71	71	71	71	71	71	71
0.55	66	68	69	70	70	70	70	70	70	70	71	71
0.54	65	68	69	69	70	70	70	70	70	70	70	70
0.53	65	68	69	69	69	69	70	70	70	70	70	70
0.52	65	67	68	69	69	69	69	69	69	69	69	70
0.51	65	67	68	68	69	69	69	69	69	69	69	69
0.50	64	67	68	68	68	68	69	69	69	69	69	69
0.49	64	66	67	68	68	68	68	68	68	68	68	68
0.48	64	66	67	67	68	68	68	68	68	68	68	68
0.47	63	66	67	67	67	67	67	68	68	68	68	68
0.46	63	65	66	67	67	67	67	67	67	67	67	67
0.45	63	65	66	66	67	67	67	67	67	67	67	67
0.44	62	65	65	66	66	66	66	67	67	67	67	67
0.43	62	64	65	66	66	66	66	66	66	66	66	66
0.42	62	64	65	65	65	66	66	66	66	66	66	66
0.41	62	64	64	65	65	65	65	65	65	66	66	66
0.40	61	63	64	65	65	65	65	65	65	65	65	65
0.39	61	63	64	64	64	65	65	65	65	65	65	65
0.38	61	63	63	64	64	64	64	64	64	64	64	65

Quality Index Values (continued)

Quality Index (QI) Values PWL for a given sample size (n)												
QI	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=9**	**n=10**	**n=11**	**n=12**	**n=13**	**n=14**
0.37	60	62	63	63	64	64	64	64	64	64	64	64
0.36	60	62	63	63	63	63	64	64	64	64	64	64
0.35	60	62	62	63	63	63	63	63	63	63	63	63
0.34	60	61	62	62	63	63	63	63	63	63	63	63
0.33	59	61	62	62	62	62	62	63	63	63	63	63
0.32	59	61	61	62	62	62	62	62	62	62	62	62
0.31	59	60	61	61	61	62	62	62	62	62	62	62
0.30	58	60	61	61	61	61	61	61	61	61	62	62
0.29	58	60	60	61	61	61	61	61	61	61	61	61
0.28	58	59	60	60	60	61	61	61	61	61	61	61
0.27	58	59	60	60	60	60	60	60	60	60	60	60
0.26	57	59	59	60	60	60	60	60	60	60	60	60
0.25	57	58	59	59	59	59	59	60	60	60	60	60
0.16	54	55	56	56	56	56	56	56	56	56	56	56
0.15	54	55	55	56	56	56	56	56	56	56	56	56
0.14	54	55	55	55	55	55	55	55	55	55	55	55
0.13	54	54	55	55	55	55	55	55	55	55	55	55
0.12	53	54	54	54	54	55	55	55	55	55	55	55
0.11	53	54	54	54	54	54	54	54	54	54	54	54
0.10	53	53	54	54	54	54	54	54	54	54	54	54
0.09	52	53	53	53	53	53	53	53	53	53	53	54
0.08	52	53	53	53	53	53	53	53	53	53	53	53
0.07	52	52	52	53	53	53	53	53	53	53	53	53
0.06	52	52	52	52	52	52	52	52	52	52	52	52
0.05	51	52	52	52	52	52	52	52	52	52	52	52
0.04	51	51	51	51	51	52	52	52	52	52	52	52
0.03	51	51	51	51	51	51	51	51	51	51	51	51
0.02	51	51	51	51	51	51	51	51	51	51	51	51
0.01	50	50	50	50	50	50	50	50	50	50	50	50
0.00	50	50	50	50	50	50	50	50	50	50	50	50
-0.01	50	50	50	50	50	50	50	50	50	50	50	50
-0.02	49	49	49	49	49	49	49	49	49	49	49	49
-0.03	49	49	49	49	49	49	49	49	49	49	49	49
-0.04	49	49	49	49	49	48	48	48	48	48	48	48
-0.05	49	48	48	48	48	48	48	48	48	48	48	48
-0.06	48	48	48	48	48	48	48	48	48	48	48	48
-0.07	48	48	48	47	47	47	47	47	47	47	47	47
-0.08	48	47	47	47	47	47	47	47	47	47	47	47
-0.09	48	47	47	47	47	47	47	47	47	47	47	46
-0.10	47	47	46	46	46	46	46	46	46	46	46	46

Quality Index Values (continued)

Quality Index (QI) Values PWL for a given sample size (n)												
QI	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=9**	**n=10**	**n=11**	**n=12**	**n=13**	**n=14**
-0.11	47	46	46	46	46	46	46	46	46	46	46	46
-0.12	47	46	46	46	46	45	45	45	45	45	45	45
-0.13	46	46	45	45	45	45	45	45	45	45	45	45
-0.14	46	45	45	45	45	45	45	45	45	45	45	45
-0.15	46	45	45	44	44	44	44	44	44	44	44	44
-0.16	46	45	44	44	44	44	44	44	44	44	44	44
-0.17	45	44	44	44	44	44	44	43	43	43	43	43
-0.18	45	44	44	43	43	43	43	43	43	43	43	43
-0.19	45	44	43	43	43	43	43	43	43	43	43	43
-0.20	44	43	43	43	43	42	42	42	42	42	42	42
-0.21	44	43	43	42	42	42	42	42	42	42	42	42
-0.22	44	43	42	42	42	42	42	42	42	42	42	
-0.23	44	42	42	42								
-0.24	43	42										
-0.25	43	42										
-0.26	43											
-0.27	42											
-0.28	42											
-0.29	42											
-0.30	42											

Quality Index Values (continued)

Pay Factors

Pay factors (PF) are calculated for the binder content, air voids at N_{des}, VMA at N_{des}, and in-place density (% Gmm). The appropriate pay factor for each property is calculated as follows:

<u>Estimated PWL > 90</u>

Pay Factor = PF = (0.50 x PWL) + 55.00

<u>Estimated PWL ≥ 50 and ≤ 90</u>

Pay Factor = PF = (0.625 x PWL) + 43.75

Air voids VMA, and in-place density PF values are reported to the nearest 0.01.

If the Lot PWL for any one of the properties is less than 50 or a sublot has an air void content less than 1.0 %, the lot is referred to the Office of Materials Management as a failed material.

A composite pay factor for each lot based on the mixture properties and density is determined by a weighted formula as follows:

$$\text{Lot Pay Factor} = 0.30\,(PF_{VOIDS}) + 0.35\,(PF_{VMA}) + 0.35\,(PF_{DENSITY})$$

where:

Lot PF = Lot Composite Pay Factor for Mixture and Density
PF_{VOIDS} = Lot Pay Factor for Air Vois at N_{des}
PF_{VMA} = Lot Pay Factor for VMA at N_{des}
$PF_{DENSITY}$ = Lot Pay Factor for In-Place Density (%Gmm)

QUALITY ASSURANCE ADJUSTMENT -- QC/QA HMA ≥ 1 Lot

The pay factors are used to calculate a quality assurance adjustment quantity (q) for the lot. The adjustment for mixture properties and density is calculated as follows:

$$q = L \times U \times (\text{Lot PF} - 1.00)/MAF$$

where:

q = quality assurance adjustment for mixture properties and density of the lot
L = Lot quantity
U = Unit price for the material, \$/Ton
Lot PF = Lot Pay Factor

The following example indicates how the Pay Factors and the Quality Assurance Adjustment for PWL are determined for QC/QA mixtures ≥ 1 Lot:

Example:

19.0 mm Intermediate

Sublot 1 = 1000 tons
Sublot 2 = 1000 tons
Sublot 3 = 1000 tons
Sublot 4 = 1000 tons
Sublot 5 = 1000 tons

Unit Price = $60.00/ton

MAF = 1.000

Air Voids = 4.0 %
VMA = 13.5 %

	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5
% Binder	4.80	4.90	5.20	5.20	5.30
Air Voids	3.80	3.50	3.20	4.70	4.60
VMA	13.80	13.90	12.60	12.80	13.70
Density (%MSG)	91.10	91.70	92.30	92.90	92.50

Air Voids

$$\bar{x} = \frac{3.80 + 3.50 + 3.20 + 4.70 + 4.60}{5} = 3.96$$

s = 0.67

USL = 5.40

$$Q_U = \frac{USL - \bar{x}}{s} = \frac{5.40 - 3.96}{0.67} = 2.15$$

From Figure 5-8 for n = 5 the PWL_U is 100

LSL = 2.60

$$Q_L = \frac{\bar{x} - LSL}{s} = \frac{3.96 - 2.60}{0.67} = 2.03$$

From Figure 5-8 for n = 5 the PWL_L is 100

Total PWL = (PWL_U + PWL_L) – 100 = (100 + 100) – 100 = 100

Pay Factor (Estimated PWL > 90) = (0.50 x PWL) + 55.00

= (0.50 x 100.00) + 55.00

= (0.50 x 100.00) + 55.00 = 1.05

Pay Factors for the VMA, and Density are indicated in Figure 5-9 and are as follows:

Pay Factor (VMA) = 0.88

Paty Factor (Density) = 1.04

Lot Pay Factor = + 0.30 (PF_{VOIDS}) + 0.35 (PF_{VMA}) + 0.35 ($PF_{DENSITY}$)

= + 0.30 (1.05) + 0.35 (0.88) + 0.35 (1.04)

= + 0.315 + 0..308 + 0.364 = 0.987 = 0.99

The Quality Assurance Adjustment for the Lot is calculated as follows:

Quality Assurance Adjustment ($) = L x U x (Lot PF – 1.00)/MAF

L = Lot quantity
U = Unit Price for Material, $/Ton
Lot PF = Lot Pay Factor

Quality Assurance Adjustment = 5000 x $60.00 x (0.99 – 1.00)/1.000

= - $3000.00

INDIANA DEPARTMENT OF TRANSPORTATION

HOT MIX ASPHALT ANALYSIS FOR QUALITY ASSURANCE

CONTRACT NO. _____________ PLANT NO. ___________ LOT NO. _______ DATE ____________

MIXTURE ___________________________________ DMF NO. ____________________________

Mixture & Density	$\bar{x}$	s	Qu			Q_L			Total PWL
			USL	$Q_U = \frac{USL - \bar{x}}{s}$	PWL_U	LSL	$Q_L = \frac{\bar{x} - LSL}{s}$	PWL_L	
Air Voids	3.96	0.67	5.40	2.15	100	2.60	2.03	100	100
VMA	13.36	0.61	15.00	2.69	100	13.00	0.59	71	71
Density (% MSG)	92.10	0.71				91.00	1.55	97	97

* Requires submittal to the Office of Materials Management for Failed Material Investigation

Air Voids		VMA		Density		Lot Pay Factor	Quality Assurance Adjustment
Pay Factor	0.30xPF	Pay Factor	0.35xPF	Pay Factor	0.35xPF		
1.05	0.315	0.88	0.308	1.04	0.364	0.99	- $8000

<u>Estimated PWL > 90</u>

Pay Factor = (0.50 x PWL) + 55.00

<u>Estimated PWL ≥ 50 and ≤ 90</u>

Pay Factor = (0.625 x PWL) + 43.75

Lot Pay Factor = 0.30 (PF_{VOIDS}) + 0.35 (PF_{VMA}) + 0.35 ($PF_{DENSITY}$)

Quality Assurance Adjustment ($) = L x U x (Lot PF – 1.00)/MAF

L = Lot quantity
U = Unit Price for Material, $/Ton
Lot PF = Lot Pay Factor

Figure 3-14. Quality Assurance Adjustment

PAY FACTORS -- QC/QA HMA (Dense Graded Mixture < 1 Lot and Open Graded Mixtures)

After the tests are conducted, the test data is evaluated for compliance with the Specifications. CAA and temperature tests are taken in accordance with standard procedures and recorded. For open graded mixtures, lot numbers begin with number 1 for each type of mixture and are continuous for the entire contract regardless of the number of adjustment periods for that type of mixture. Mixtures with original pay item quantites less than 300 tons will be accepted by Type D Certification.

When the required tests for one sublot are completed, the difference between the test values and the required value is determined and pay factors calculated. A composite pay factor for each sublot is determined for the air voids @ N_{des}, VMA @ N_{des}, and density of the mixture as follows:

$$SCPF = 0.30(PF_{VOIDS}) + 0.35(PF_{VMA}) + 0.35(PF_{DENSITY})$$

where:

SCPF	=	Sublot Composite Pay Factor for Mixture and Density
PF_{VOIDS}	=	Sublot Pay Factor for Air Voids at N_{des}
PF_{VMA}	=	Sublot Pay Factor for VMA at N_{des}
$PF_{DENSITY}$	=	Sublot Pay Factor for Density

If the SCPF for a sublot is less than 0.85, the pavement is evaluated by INDOT. If the Contractor is not required to remove the mixture, quality assurance adjustments of the sublot are assessed or other corrective actions taken as determined by INDOT.

MIXTURE

Sublot test results for mixture properties are assigned pay factors in accordance with the following:

BINDER CONTENT	
OPEN GRADED Deviation from DMF (±%)	**PAY FACTOR**
≤ 0.2	1.05
0.3	1.04
0.4	1.02
0.5	1.00
0.6	0.90
0.7	0.80
0.8	0.60
0.9	0.30
1.0	0.00
> 1.0	Submit to the Office of Materials Management*

* Test results are considered and adjudicated as a failed material in accordance with normal INDOT practice as listed in 105.03.

AIR VOIDS		
DENSE GRADED Deviation from DMF (±%)	**OPEN GRADED Deviation from DMF (±%)**	**PAY FACTOR**
≤ 0.5	≤ 1.0	1.05
> 0.5 and ≤ 1.0	> 1.0 and ≤ 3.0	1.00
1.1	3.1	0.98
1.2	3.2	0.96
1.3	3.3	0.94
1.4	3.4	0.92
1.5	3.5	0.90
1.6	3.6	0.84
1.7	3.7	0.78
1.8	3.8	0.72
1.9	3.9	0.66
2.0	4.0	0.60
> 2.0	> 4.0	Submit to the Office of Materials Management*

* Test results are considered and adjudicated as a failed material in accordance with normal INDOT practice as listed in 105.03.

VMA		
Dense Graded Deviation from Spec Minimum	Open Graded Deviation from Spec Minimum	Pay Factor
> + 3.0		Submitted to the Office of Materials Management*
> + 2.5 and ≤ + 3.0		1.00 minus 0.05 for each 0.1% over +2.5%
> + 2.0 and ≤ + 2.5		1.05 minus 0.01 for each 0.1% over +2.0%
> + 0.5 and ≤ + 2.0	All	1.05
≥ 0.0 and ≤ + 0.5		1.05 minus 0.01 for each 0.1% under 0.5%
≥ -2.0 and < 0.0		1.05 minus 0.05 for each 0.1% under 0.0%
< - 2.0		Submitted to the Office of Materials Management*
* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.		

DENSITY

Sublot test results for density are assigned pay factors in accordance with the following:

DENSITY		
Percentages based on % MSG	**Pay Factors – Percent**	
Dense Graded	Open Graded	
≥ 97.0		Submitted to the Office of Materials Management*
95.6 - 96.9		1.05 - 0.01 for each 0.1% above 95.5
94.0 - 95.5		1.05
93.1 - 93.9		1.00 + 0.005 for each 0.1% above 93.0
92.0 - 93.0	84.0	1.00
91.0 - 91.9		1.00 - 0.005 for each 0.1% below 92.0
90.0 - 90.9		0.95 - 0.010 for each 0.1% below 91.0
89.0 - 89.9		0.85 - 0.030 for each 0.1% below 90.0
≤ 88.9		Submitted to the Office of Materials Management*

* Test results are considered and adjudicated as a failed material in accordance with normal INDOT practice as listed in 105.03.

DENSITY -- DENSE GRADED							
% MSG	**Pay Factor**	**% MSG**	**Pay Factor**	**% MSG**	**Pay Factor**	**% MSG**	**Pay Factor**
≥97.0	*	94.9	1.05	92.8	1.00	90.7	0.92
96.9	0.91	94.8	1.05	92.7	1.00	90.6	0.91
96.8	0.92	94.7	1.05	92.6	1.00	90.5	0.90
96.7	0.93	94.6	1.05	92.5	1.00	90.4	0.89
96.6	0.94	94.5	1.05	92.4	1.00	90.3	0.88
96.5	0.95	94.4	1.05	92.3	1.00	90.2	0.87
96.4	0.96	94.3	1.05	92.2	1.00	90.1	0.86
96.3	0.97	94.2	1.05	92.1	1.00	90.0	0.85
96.2	0.98	94.1	1.05	92.0	1.00	89.9	0.82
96.1	0.99	94.0	1.05	91.9	1.00	89.8	0.79
96.0	1.00	93.9	1.05	91.8	0.99	89.7	0.76
95.9	1.01	93.8	1.04	91.7	0.99	89.6	0.73
95.8	1.02	93.7	1.04	91.6	0.98	89.5	0.70
95.7	1.03	93.6	1.03	91.5	0.98	89.4	0.67
95.6	1.04	93.5	1.03	91.4	0.97	89.3	0.64
95.5	1.05	93.4	1.02	91.3	0.97	89.2	0.61
95.4	1.05	93.3	1.02	91.2	0.96	89.1	0.58
95.3	1.05	93.2	1.01	91.1	0.96	89.0	0.55
95.2	1.05	93.1	1.01	91.0	0.95	88.9	*
95.1	1.05	93.0	1.00	90.9	0.94		
95.0	1.05	92.9	1.00	90.8	0.93		
DENSITY -- OPEN GRADED							
84.0 -- 1.00							

* Requires submittal to Office of Materials Management for Failed Material Investigation

Figure 3-15. Density Pay Factors

ADJUSTMENT QUANTITY -- QC/QA HMA < 1 Lot and Open Graded Mixtures

The pay factors are used to calculate a quality assurance adjustment quantity (q) for the sublot. The adjustment for mixture properties and density is calculated as follows:

q = L x U x (SCPF - 1.00)/MAF

where:

q	= quality assurance adjustment for the sublot
L	= Sublot quantity
U	= Unit price for the material, \$/Ton
SCPF	= Sublot composite pay factor

The following example indicates how Quality Assurance Adjustments are determined for QC/QA mixtures < 1 Lot and Open Graded mixtures:

Example:

25.0 mm Base

Sublot 1 = 1000 tons
Sublot 2 = 1000 tons
Sublot 3 = 1000 tons
Sublot 4 = 855 tons

Unit Price = $58.00/ton

MAF = 1.000

	Sublot 1	Sublot 2	Sublot 3	Sublot 4
Air Voids	3.8	3.7	3.2	4.7
VMA	12.2	12.1	11.6	13.4
Density (%MSG)	91.1	90.7	89.9	92.9

Deviations for Air Voids and VMA:

	Sublot 1	Sublot 2	Sublot 3	Sublot 4
Air Voids	0.2	0.3	0.8	0.7
VMA	+0.2	+0.1	-0.4	+1.4

Using the pay factor charts, the following values are obtained:

	Sublot 1	Sublot 2	Sublot 3	Sublot 4
Air Voids	1.05	1.05	1.00	1.00
VMA	1.02	1.01	0.80	1.05
Density (%MSG)	0.96	0.92	0.82	1.00

Calculations to determine the Quality Assurance Adjustment are indicated in Figure 3-16.

INDIANA DEPARTMENT OF TRANSPORTATION

HOT MIX ASPHALT ANALYSIS FOR QUALITY ASSURANCE

CONTRACT NO. _______________ PLANT NO. _________ LOT NO. __________ DATE ____________

MIXTURE ____ DMF NO. ____________________

Mixture & Density	SUBLOT 1			SUBLOT 2			SUBLOT 3			SUBLOT 4		
	Pay Factor	Mult		Pay Factor	Mult		Pay Factor	Mult.		Pay Factor	Mult.	
Air Voids	1.05	0.30	0.315	1.05	0.30	0.315	1.00	0.30	0.3000	1.00	0.30	0.3000
VMA	1.02	0.35	0.357	1.01	0.35	0.3535	0.80	0.35	0.2800	1.05	0.35	0.3675
Density	0.96	0.35	0.3360	0.92	0.35	0.3220	0.82	0.35	0.2870	1.00	0.35	0.3500
SCPF			1.01			0.99			0.87			1.02

* Requires submittal to the Materials and Tests Division for Failed Material Investigation

QUALITY ASSURANCE ADJUSTMENTS							
Sublot 1 Quantity L (tons)	Sublot 1 Adjustment ($)	Sublot 2 Quantity L (tons)	Sublot 2 Adjustment ($)	Sublot 3 Quantity L (tons)	Sublot 3 Adjustment ($)	Sublot 4 Quantity L (tons)	Sublot 4 Adjustment ($)
1000	+580	1000	-580	1000	-7540	1000	+992

U = Unit Price for Material, $/Ton

Quality Assurance Adjustment = L x U x (SCPF – 1.00) / MAF

Figure 3-16. Quality Assurance Adjustment

MIX APPEAL -- QC/QA HMA

If the Producer's QC test results do not agree with the Department's acceptance test results, a request may be submitted in writing that additional samples be tested. The written request is required to include a comparison of the QC and acceptance test results and be made within seven calendar days of receipt of the written results of the asphalt mixture tests for that lot.

The Contractor may appeal an individual sublot for the binder content, the MSG, the BSG of the gyratory specimens or the BSG of the density cores when the QC results are greater than one standard deviation from the acceptance test results as follows: 0.25 for binder content, 0.010 for the MSG and 0.010 for both the BSG of the gyratory specimens and the density cores 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.

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

A $500.00 credit adjustment will be included in a quality adjustment pay item for each appealed sublot that did not result in an improvement to the SCPF or LCPF.

SMOOTHNESS

Smoothness of HMA pavements is measured using a profilograph (Figure 3-17), and a profile index for a section of pavement is obtained from a profilogram recorded by the profilograph.

Figure 3-17. Profilograph

PROCEDURES

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

1) The profilograph is operated by a Contractor Qualified 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 kph).

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 ± 0.5 ft (0.9144 ± 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 ± 0.5 ft (0.9144 ± 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 ± 0.5 ft (0.9144 ± 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 ± 0.5 ft (0.9144 ± 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 the adjustment is applied to all QC/QA HMA pay items within the pavement section. The adjustment for each section is calculated as follows:

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

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, Qs, for the contract is the total of the quality assurance adjustnments, q_s, on each section calculated by the following formula:

$$Qs = \sum q_s$$

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.

PAY FACTORS FOR SMOOTHNESS **($PI_{0.0}$) ZERO BLANKING BAND**	
Design Speed Graeter than 45 mph (70 km/h)	
Profile Index in. / 0.1 mi. (mm per 0.16 km)	Pay Factor, PF_s
Over 0.00 to 1.20 in. (Over 0 to 30 mm)	1.06
Over 1.20 to 1.40 in. (Over 30 to 35 mm)	1.05
Over 1.40 to 1.60 in. (Over 35 to 40 mm)	1.04
Over 1.60 to 1.80 in. (Over 40 to 45 mm)	1.03
Over 1.80 to 2.00 in. (Over 45 to 50 mm)	1.02
Over 2.00 to 2.40 in. (Over 50 to 60 mm)	1.01
Over 2.40 to 3.20 in. (Over 60 to 80 mm)	1.00
Over 3.20 to 3.40 in. (Over 80 to 85 mm)	0.96
All pavement with a profile index ($PI_{0.0}$) greater than 3.40 in. (85 mm) shall be corrected to a profile index less than or equal to 3.40 in. (85 mm).	

4 Quality Control Procedures

Contractor Personnel

QCP Manager
QCP Site 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 FOUR: QUALITY CONTROL PROCEDURES

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.

CONTRACTOR PERSONNEL

The Contractor personnel required to provide quality control on a QC/QA Hot Mix Asphalt contract includes a QCP Manager, QCP Site 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/PS. 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.

TESTING

The procedure for measuring the macrotexture of the milled surface in accordance with **ITM 812** is required (Figure 4-1). The purpose of this test is to measure the condition of the surface after milling in preparation for resurfacing with HMA.

Figure 4-1. Macrotexture Test

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

	Macrotexture
Asphalt Scarification & Profile Preparation	≥ 2.2 for single course overlays ≥ 1.8 for multiple course overlays
Asphalt Milling	≥ 2.2 for single course overlays ≥ 1.8 for multiple course overlays
PCCP milling	≥ 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 4-2 to 4-4). The following example explains the procedures required to balance the HMA operations.

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
Truck Cycle (minutes)	
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 #/ft^3
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

MIX DELIVERY 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 deliverd to jobsite (H-RATE):						
= MIX / TIME =	**3,000**	/	**10**	=	**300**	tph
Rate of mix available from HMA facility (F-RATE):				=	**350**	tph
STOP: Is the H-RATE slightly greater than or equal to the F-RATE?						
Average Truck Capacity (SIZE):		=	**20**	net tons		
Total Truck Trips Needed (TRIPS):						
= MIX / SIZE =	**3,000**	/	**20**	=	**150**	TRIPS
TRUCK CYCLE (in minutes):						
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**					
Total cycle in minutes	**45**	/ 60 min / h				
= Truck Cycle (CYCLE)			**0.75**	h / trip		
Number of Trips per Truck (LOADS):						
= TIME /CYCLE =	**10**	h /	**0.75**	h/trip =	**13**	trips/truck
					(round down)	
Number of Trucks Needed (TRUCKS):						
= TRIPS / LOADS =	**150**	/	**13**	=	**12**	TRUCKS
					(round up)	
ARE TRUCKS x LOADS ≥ TRIPS?						
	12	x	**13**			
=	**156**	≥	**150**			

Figure 4-2. 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 deliverd to jobsite (H-RATE):

= MIX / TIME = **3,000** / **10** = **300** 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

= **143** pcf x **0.94** = **134.4** pcf

33.33 = Conversion factor (tons to pounds & hours to minutes)

Actual Paver Production Rate (P-RATE)

= MIX RATE x 33.33 / WIDTH / THICK / DENSITY

= **300** x 33.33 / **12.00** / **0.17** / **134.4**

P-RATE = **36** fpm

Paving Efficiency Factor (EFF1): **0.80** (recommended: 0.75 - 0.85)

Actual Paver Speed (PAVER):

PAVER = P-RATE x EFF1 =

36 x **0.80** = **29** fpm

Figure 4-3. 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[A]

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 **2,700**) / (**10**)impacts/ft **270** fpm/88 = **3.1** mph

EFF-SPEED = Actual - 10% = **270**) - 10% (**270**)impacts/ft ***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 4-4. 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 are 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^2. 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.

Instead of a non-destructive testing device, an Intelligent Compaction (IC) roller meeting the Department requirements may be used to measure the stiffness and temperature of the mixture. A GPS radio and receiver unit shall be mounted on the IC roller to monitor the drum locations and track the number of passes of the roller. The IC roller shall include an integrated on-board documentation system that is capable of displaying real-time color-coded maps of IC measurement values including stiffness response values, location of roller passes, pavement surface temperatures, roller speeds, vibration frequencies, and amplitudes of the roller drums.

CORING

The plan for when cores are taken and the procedure for refilling the core holes is 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. Also, 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 Site 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/PS 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/PS. The PE/PS 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.

5 Traffic Control

Basic Setup

Continual Inspection

Temporary Pavement Markings

CHAPTER FIVE: TRAFFIC CONTROL

The need for standard traffic control is essential during roadway construction to guide traffic safely and efficiently through what would otherwise be hazardous areas.

Traffic control procedures are used at work sites to:

1) Warn motorists of the hazards involved and to advise them of the proper manner for traveling through the area

2) Inform the user of changes in regulations or additional regulations that apply to traffic traversing the area

3) Guide traffic through and around the work site

4) Delineate areas where traffic should not operate

BASIC SETUP

The required basic traffic control setup depends on several factors. Is the work being performed under traffic or is the road closed? Is the road closed to through traffic, but residences and businesses are located within the work area for which access is required to be maintained? Is the work zone at a fixed location or is the work zone moving down the road? Is the work being performed on a two lane road or a multi-lane facility? Is the work being performed on a travel lane or a shoulder? Is the work area on an interstate only affected by infrequent ramps or on a roadway with a number of driveways and at-grade intersections? The above factors, along with others, all affect the required traffic control setup.

On individual projects, the following contract documents apply:

1) Indiana Manual on Uniform Traffic Control Devices

2) Maintenance of Traffic Plan Sheets, if included in the plans

3) Standard Specifications Section **801**

4) Section **801** Standard Drawings

5) Special Provisions in the Contract Information Book

Section **801.03** of the Standard Specifications outlines the requirements for the Certified Worksite Traffic Supervisor (CWTS). The CWTS is not required to be on the contract site on a daily basis; however, the CWTS is responsible for the layout and maintenance of all traffic control devices on a contract. The CWTS should be involved in the initial layout of traffic control devices as well as the layout associated with all construction phase shifts that occur during the life of the contract.

For the purposes of this discussion, the primary emphasis will be related to resurface work or other moving operations conducted on a travel lane under traffic. Many of the principles discussed apply to other work situations. The appropriate contract documents for the actual traffic control setups required for other types of work should be reviewed on each contract.

Two typical traffic control situations are illustrated in Figures 5-1 and 5-2. The sign layouts noted in each figure are associated with the moving operation only. Additional ground mounted signs are required at the contract limits as noted in the Maintenance of Traffic Plans or Section **801** Standard Drawings.

A basic setup for a two-lane roadway with two-way traffic is shown in Figure 5-1. This situation requires a flagger with advance warning signs at both ends of the work area. All of the signs for this situation are to be located in relation to the roadway in accordance with the Standard Drawing. As the moving operation progresses down the road, relocation of the signs to maintain proximity to the work area is necessary. If the operation is allowed to progress too far in advance of the warning signs, a motorist may conclude that there is no work being conducted. This may result in a dangerous situation when the driver ultimately encounters the work area.

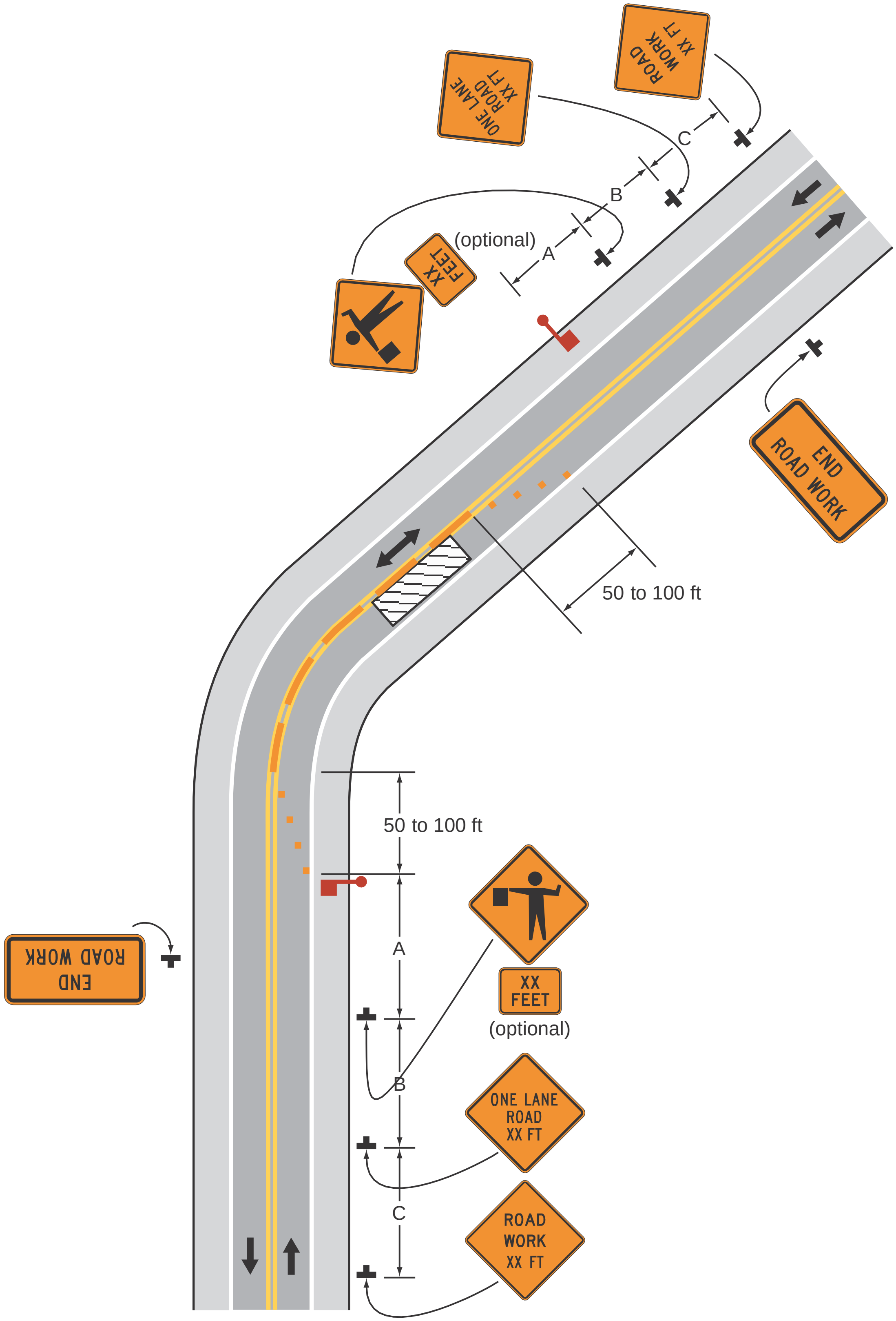


Figure 5-1. Lane Closure on a Two-Lane Roadway Using Flaggers

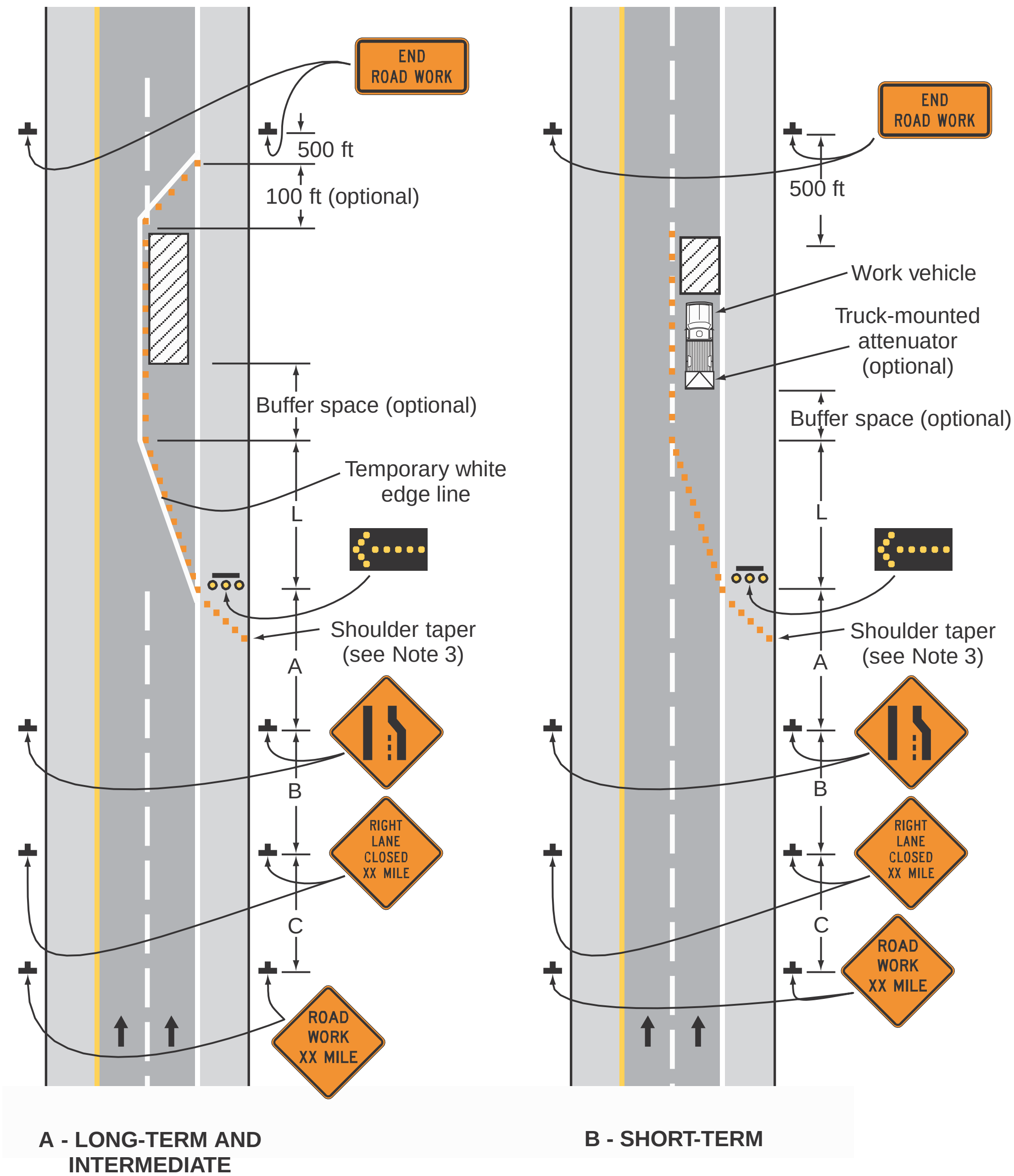


Figure 5-2. Stationary Lane Closure on a Divided Highway

Flaggers shall wear high-visibility safety apparel that meets the Performance Class 2 or 3 requirements of the ANSI/ISEA 107-2004 publication entitled “American National Standard for High-Visibility Apparel and Headwear”. Flaggers are required to be equipped with 24 in. diameter STOP/SLOW paddles. The use of these paddles should be limited to emergency situations. Flaggers should also be equipped with two way radios if they will not be able to see each other.

Basic flagging procedures are shown in Figure 5-3. All flaggers are required to remain alert while conducting flagging duties. Additional personnel available to provide breaks for the flaggers may be necessary. The following additional requirements for the flagger are necessary:

1. Stand either on the shoulder adjacent to the road user being controlled or in the closed lane prior to stopping road users

2. Stand only in the lane being used by moving road users after the road users have stopped

3. Be clearly visible to the first approaching road user at all times

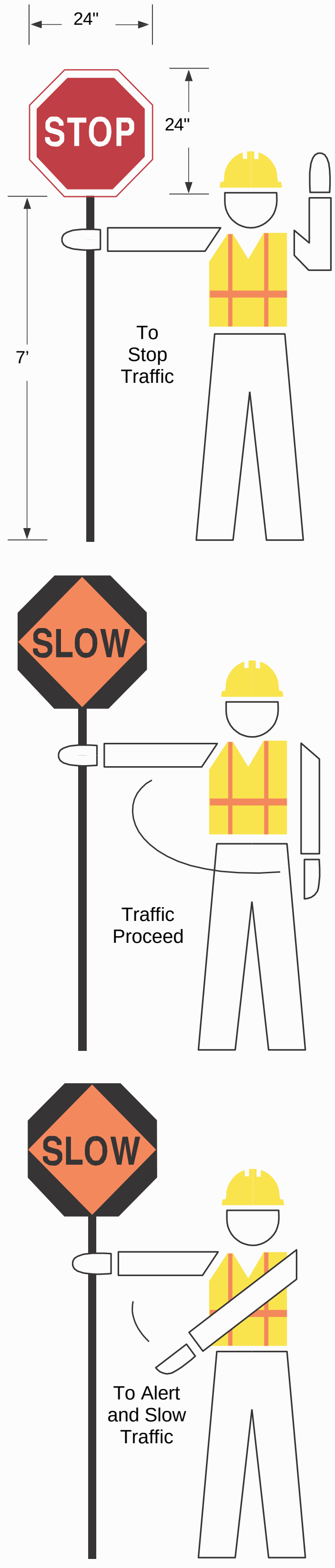
4. Be visible to other road users

5. Be stationed sufficiently in advance of the workers to warn them of approaching danger by out-of-control vehicles with an audible warning device such as a horn or whistle

6. Stand alone, away from other workers, work vehicles, or equipment

Flagger and other crew members should be alert for trucks associated with the work as they enter and leave the work area. Material delivery trucks entering or exiting the work zone are often moving slower than the through traffic and may cause traffic slowdowns. Also, motorists may follow these vehicles into the work area.

Other considerations when setting up flagging operations include intersections, driveways, and other site specific features within the work area. Flaggers should not stand in the center of an intersection. Additional flaggers may be necessary to prevent motorists from entering the available travel lane from an intersecting road or driveway.



Properly Trained Flaggers

- give clear messages to drivers as shown
- allow time and distance for drivers to react
- coordinate with other flaggers

Properly Equipped Flaggers

- approved sign paddles
- paddles are not to be used in a signalized intersection
- approved Personal Protective Garments (PPE)
- brightly colored hat for better visibility
- retroreflective night equipment

Proper Flagging Stations

- good approach sight distance
- highly visible to traffic
- never stand in moving traffic lane
- always have an escape route

Proper Advance Warning Signs

- always use warning signs
- allow reaction distance from signs
- remove signs if not flagging

Flags should only be used in emergency situations or when a paddle would present a conflicting message to the motorist. Flags shall be a minimum of 24in. x 24in., red in color, and mounted on a staff about 3ft long.

Figure 5-3. Flagging Procedures

The basic setup for a multi-lane roadway is shown in Figure 5-2. A flagger is not normally required in this situation since advance warning signs are sufficient to warn motorists. A set of signs is required to be located on both the outside and inside shoulders and installed in relation to the roadway in accordance with the Standard Drawing. The flashing arrow sign is placed on the pavement shoulder a calculated distance from the beginning of the work area. Channelizing devices are required to direct motorists from the lane to be closed to the adjacent open lane. For daylight operations, the use of cones or tubular markers for the channelizing devices is acceptable. For protection of nighttime work areas, drums or cones with a minimum height of 2 ft-4 in. are typically required.

CONTINUAL INSPECTION

All traffic control devices used at roadway work sites are required to be inspected daily to ensure the safety of the work force, the traveling public, pedestrians, as well as to protect the freshly placed mat. While the performance of these duties may be delegated to anyone, the CTWS is ultimately responsible for the inspection and maintenance of all traffic control devices on the contract. If an inspection determines that individual traffic control devices require reinstallation or replacement, the individual making that inspection is required to know how to contact the CTWS or designee to facilitate the repair or replacement of the defective devices.

TEMPORARY PAVEMENT MARKINGS

As the paving operation progresses down the road, any pavement markings that are covered by the newly placed mat are required to be replaced by temporary markings. The temporary pavement markings are required to be placed prior to reopening the work area to traffic. Section **801.12** of the Standard Specifications includes the requirements associated with temporary pavement markings. This information includes which markings are required and which marking materials are appropriate. There are also requirements associated with the length of time that the temporary markings will be in place and for situations where the traffic markings are used to indicate no passing zones.

6 Preparation of Surface

CHAPTER SIX:
PREPARATION OF SURFACE

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.

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 6-1).

Figure 6-1. 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 (Figure 6-2) 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.

Figure 6-2. Proofrolling

MILLING

Milling is part of a pavement rehabilitation process where a portion of the old HMA pavement or PCCP is removed or planed by a milling machine in preparation for an HMA overlay (Figure 6-3).

Figure 6-3. 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 6-4.

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.

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.

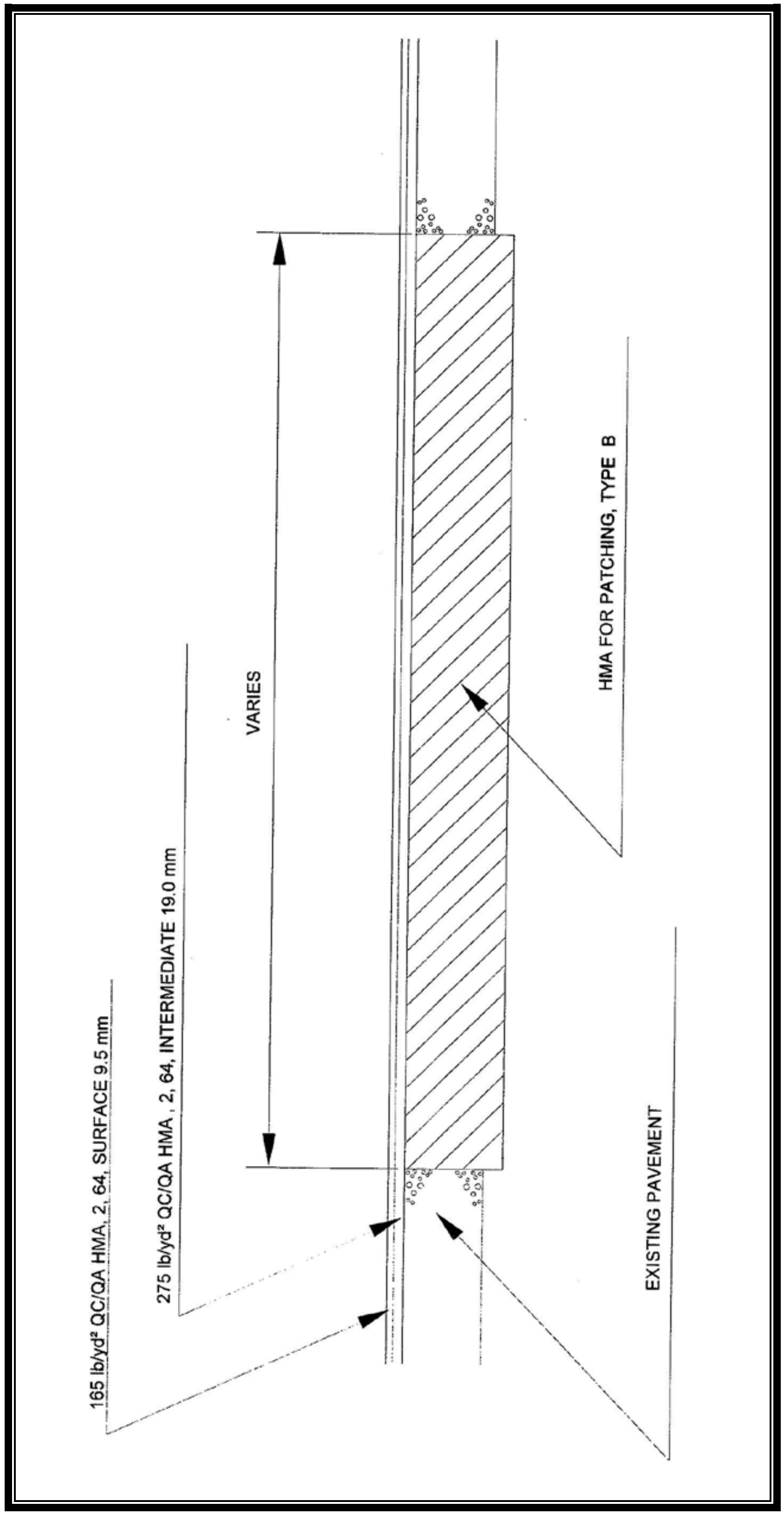


Figure 6-4. Typical Full Depth HMA Patch Section

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 6-5.

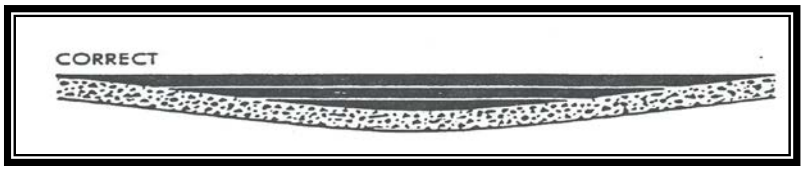


Figure 6-5. Correct Wedge and Level

Because of the difficulty of feathering the edges of HMA mixtures, placing the material in lifts parallel to the existing surface (Figure 6-6) usually results in rough patches that reflect to the finished surface.

Figure 6-6. 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 6-7).

Figure 6-7. Wedge and Level Lifts

Wedges are also used to re-establish the crown on a tangent roadway or superelevation on a curve (Figure 6-8). 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 6-8. 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 6-8. 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 6-9. 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 6-9. 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 6-10).

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 6-10. Power Broom

TACKING

A tack coat is the application of asphalt material to an existing paved surface (Figure 6-11). 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 6-11. 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 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 0.05 to 0.10 gallons per square yard. 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.

7 Mix Placement and Compaction

Weather Limitations

Asphalt Materials

Prime Coats
Tack Coats
Base Seals
Fog Seals
Joint Adhesive
Distributors

Mixture Transportation

Haul Trucks
Material Transfer Vehicles

Mix Temperature and Appearance

Placement of Mixture

Pavers
Paver Operation
Start-Up
Alignment
Grade and Slope Control
Transverse Joints
Longitudinal Joints
Widening Machines
Care and Cleaning of Pavers
Paving Crew Responsibilities

Compaction

Rollers

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

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.

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^2 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 as follows:

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

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** includes the requirements for base seals.

LIQUID ASPHALT SEALANT

Liquid asphalt sealant is 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 liquid asphalt sealant is applied to assist in sealing the material on each side of the joint. Section **401.15** includes the material and construction requirements for the liquid asphalt sealant.

JOINT ADHESIVE

Joint adhesives are used 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. **401.15** includes the material and construction requirements for a 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.

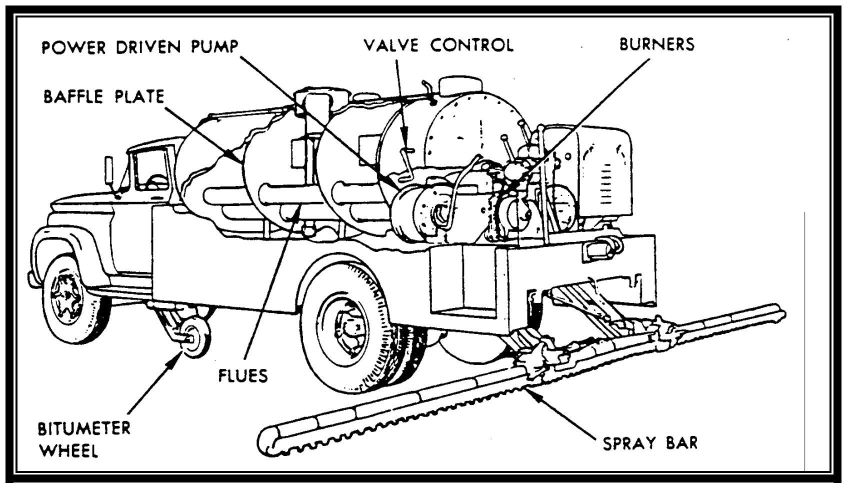


Figure 7-1. Distributor

MIXTURE TRANSPORTATION

HAUL TRUCKS

Haul trucks (Figure 7-2) used to transport the HMA to the paver should be continuously monitored. **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. Also, 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. Some daily checks of the trucks that should be made include:

1) Truck beds that are leaking mix because the gates are not tight

2) Foreign material in the mix that would indicate the beds were not clean when loaded. When tarps are used, they should overlap the bed of the trucks enough to prevent rain and foreign material from getting into the mix.

3) The appearance of the mix before the load is dumped

4) Evidence of the excess use of anti-adhesive agent

5) No hydraulic or fuel leaks

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.

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.

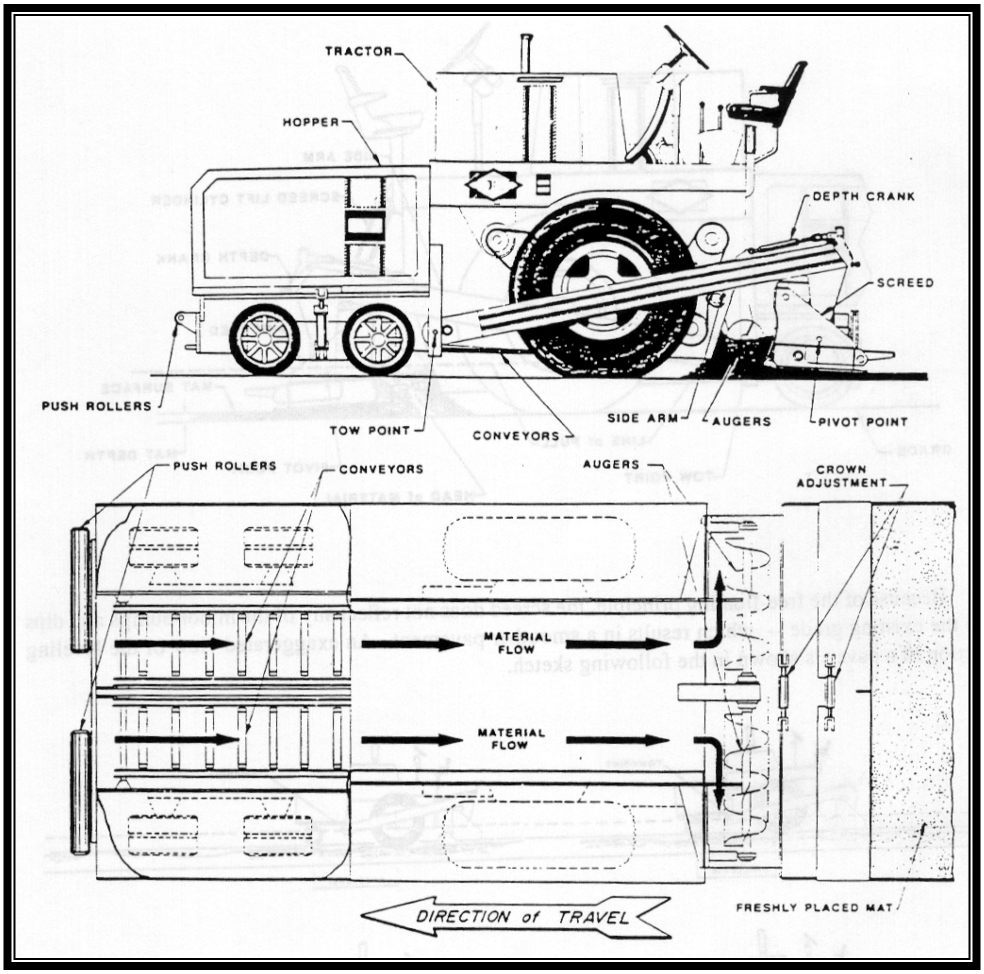


Figure 7-4. HMA Paver

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 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 7-5. 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.

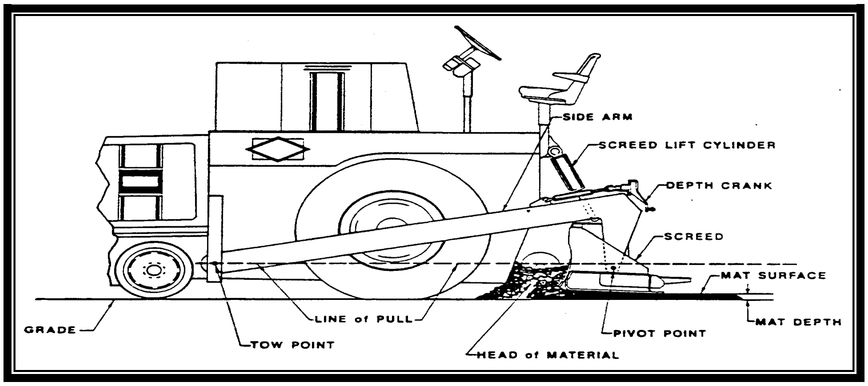


Figure 7-5. Paver Components

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. The leveling action of a paver is indicated in Figure 7-6.

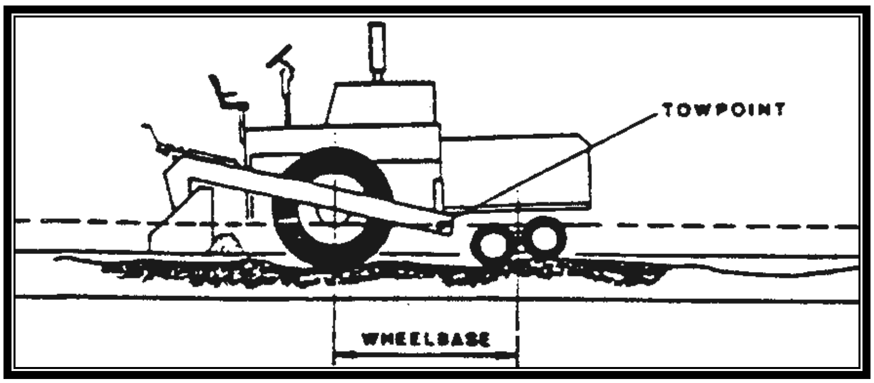


Figure 7-6. Free-Floating Screed

The relationship between the vertical movement of the screed tow point and the elevation of the screed is illustrated in Figure 7-7. There is commonly 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.

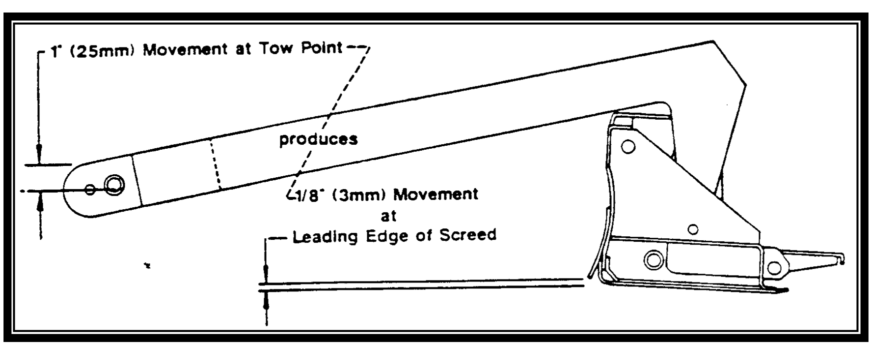


Figure 7-7. Screed Tow Point and Elevation

Section **409** requires that a paver (Figure 7-8):

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 wider. 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

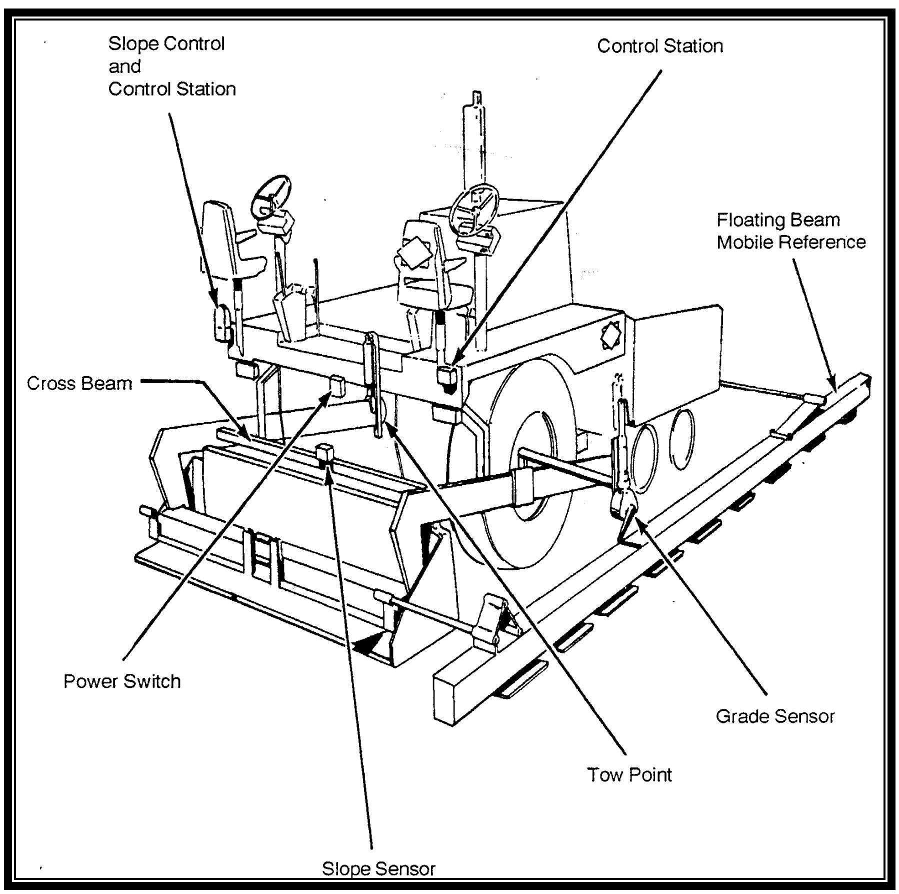


Figure 7-8. Paver Screed Controls

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 Sensors
2) Non-Contact Sensors
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 QCP.

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 7-9) are:

1) Factor F-1 -- Angle of Attack

2) Factor F-2 -- Head of Material

3) Factor F-3 -- Paving Speed

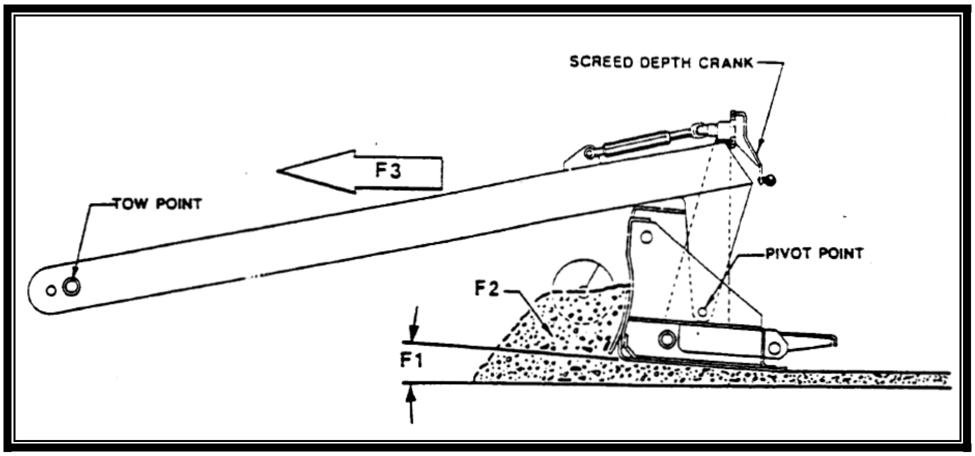


Figure 7-9. Free Floating Screed

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 7-10. The restoration action of the screed is referred to as self-leveling.

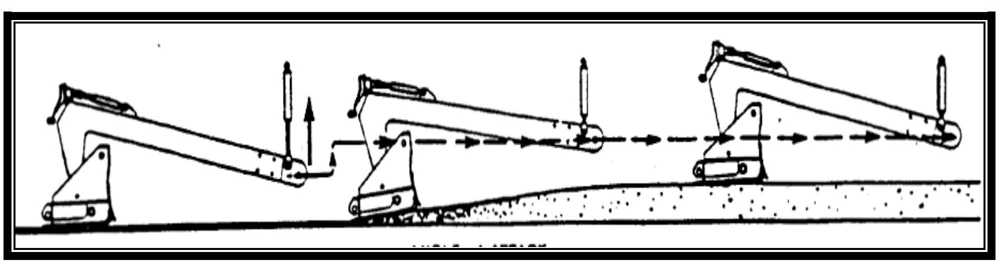


Figure 7-10. Angle of Attack

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 cranks 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 7-11). Modern pavers have automatic controls to maintain the correct level.

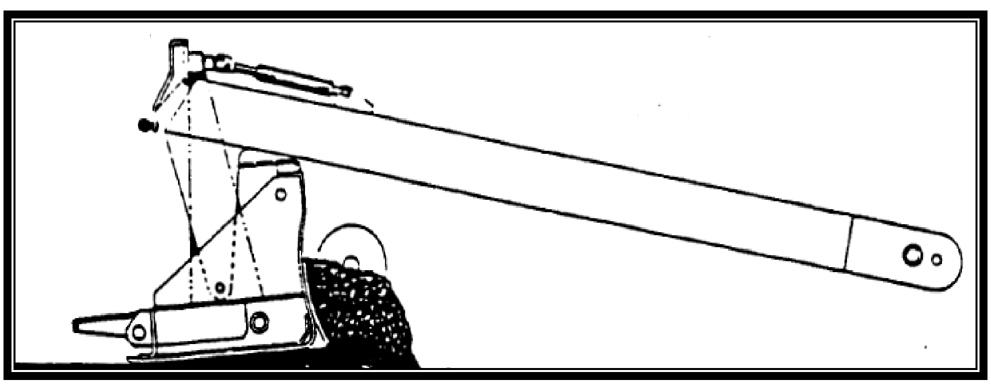


Figure 7-11. Correct Head of Material on Screed

If the head of material is too high (Figure 7-12), 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.

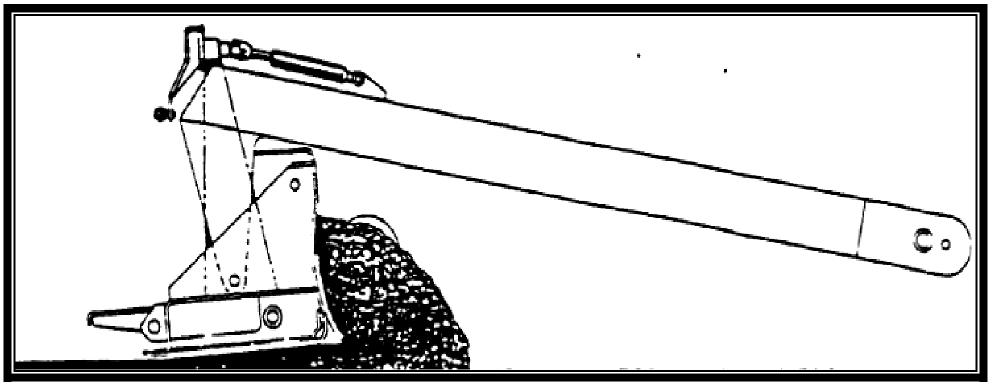


Figure 7-12. Head of Material Too High on Screed

If the head is too low (Figure 7-13), the resistance to forward travel is decreased and the screed gradually falls, resulting in a thin mat and possible voids in the mat.

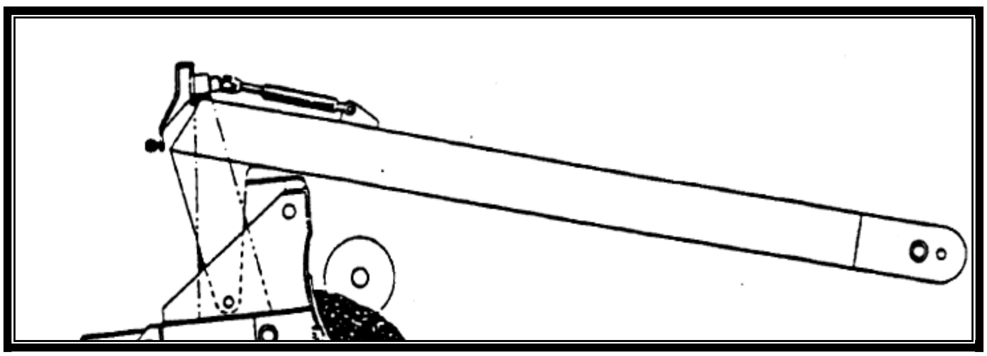


Figure 7-13. Head of Material Too Low on Screed

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 7-14. The front of the screed should never be placed beyond the joint.

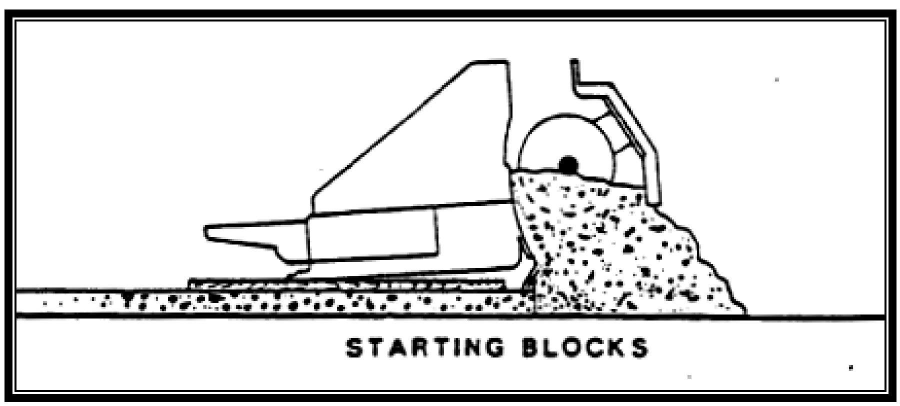


Figure 7-14. Continuing on Existing Lay

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 off-set 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 superelevation. 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 7-15; 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.

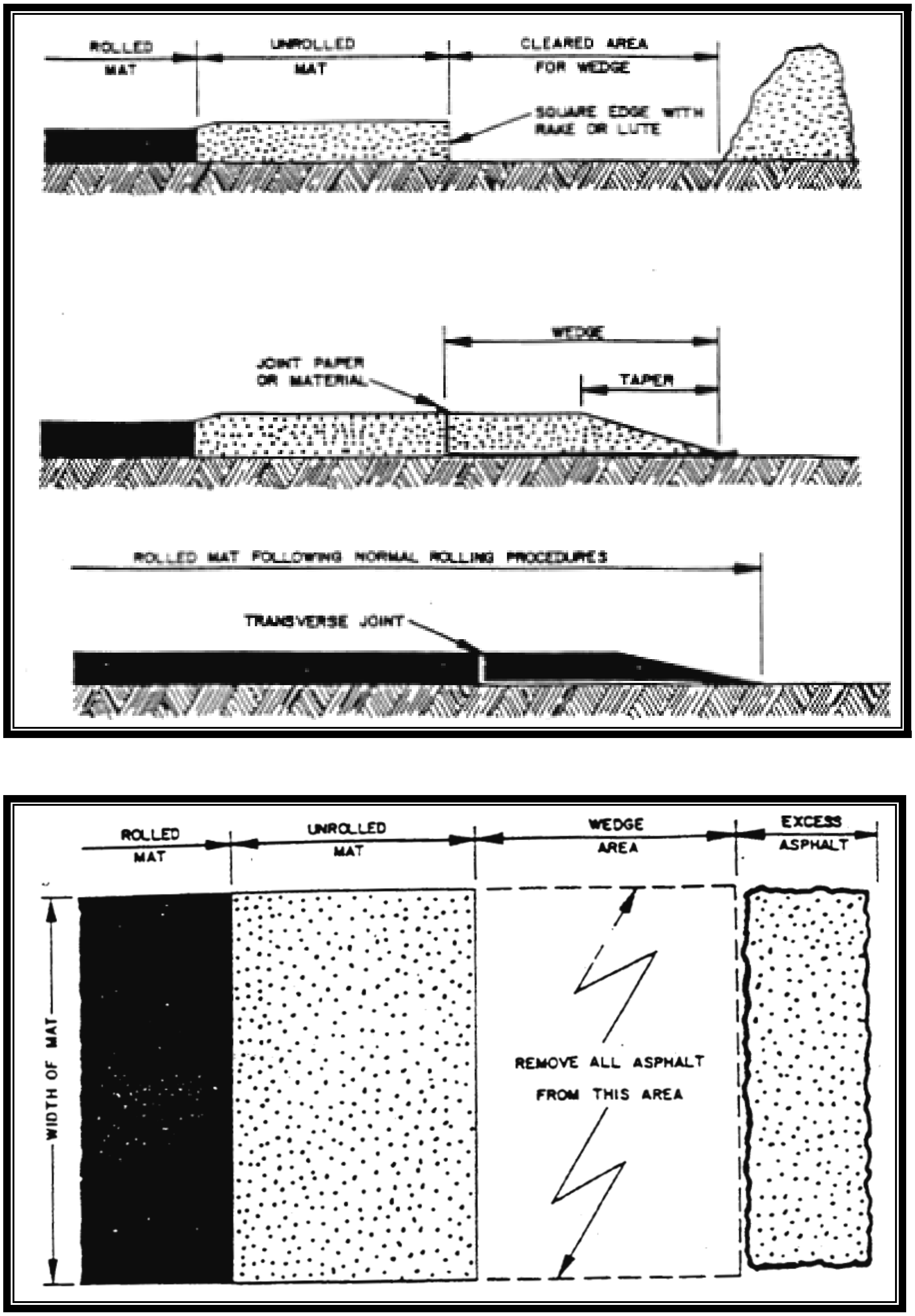


Figure 7-15. Construction of a Day Joint

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 7-16) would reduce the water penetration into the joint and improve the joint performance.

When joint adhesive materials are required by **401.15**, 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 7-16. Joint Adhesive

Safety Edge

A safety edge (Figure 7-17) 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. The devices approved for constructing the safety edge are listed in Section **409.03 (c)**.

Figure 7-17. Safety Edge

WIDENING MACHINES

Widening machines (Figure 7-18) 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. The use of widening pavers is not allowed on widths of 8 ft or more.

Figure 7-18. Widening Machine

Widening machines are equipped with hoppers for receiving the mix from the haul units, conveyors to carry the mix to either side of the machines, and adjustable strike-offs on each side of the machine to allow placing on either side. The strike-off may be adjusted vertically up to 12 in. below or above the grade, depending on the make and model, to allow placing material in lifts.

The strike-off blade does not have the compactive capability of the screed on a regular paver. Consequently, the surface texture is likely to be more open.

The proper adjustment of the strike-off blade is the key to obtaining a good pavement with a widening machine. 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 7-19), the plate rolls material up. Excessive backward tilt forces the strike-off to pull down into the material.

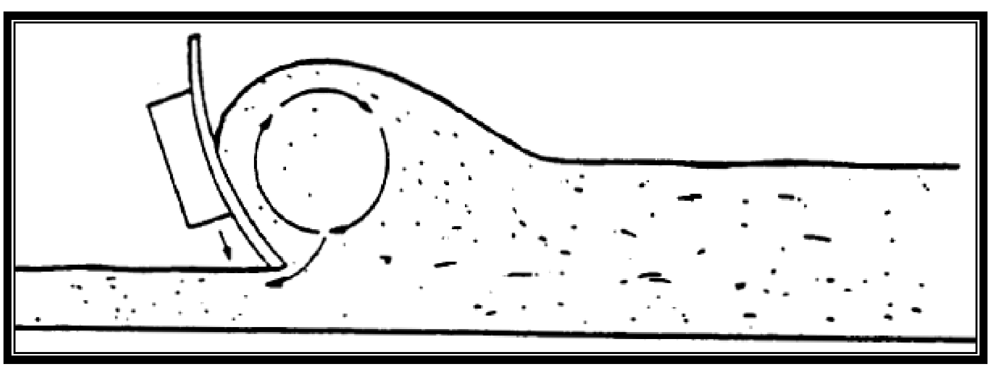


Figure 7-19. Strike-Off Plate Tilted Back

Tilting the top of the strike off plate forward (Figure 7-20) causes the strike-off to roll the material down. Excessive forward tilt forces the strike-off to ride up over the material.

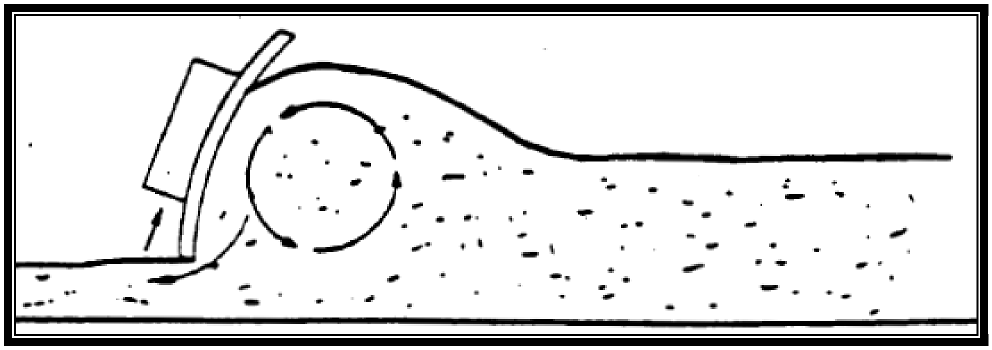


Figure 7-20. Strike-Off Plate Tilted Forward

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 7-21) 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 7-21. Luting Transverse Joint

COMPACTION

ROLLERS

Six types of rollers are used for compacting HMA: two-axle tandem, three-wheeled, pneumatic tire, vibratory, oscillatory, and trench rollers. 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. 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 **401** and SMA mixtures in accordance with **410** are compacted with rollers determined by the Contractor. HMA mixtures are required to be compacted by the rollers designated in **402.15**.

Tandem Roller

A tandem steel-wheel roller (Figure 7-22) is required by Section **409.03(d)1** to weigh at least 10 tons.

Figure 7-22. Tandem Roller

Three Wheel Roller

The three wheel roller (Figure 7-23) 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 7-23. Three Wheel Roller

Pneumatic Tire Roller

A pneumatic tire roller (Figure 7-24) 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 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 7-24. Pneumatic Tire Roller

The tires on a pneumatic tire 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 7-25.

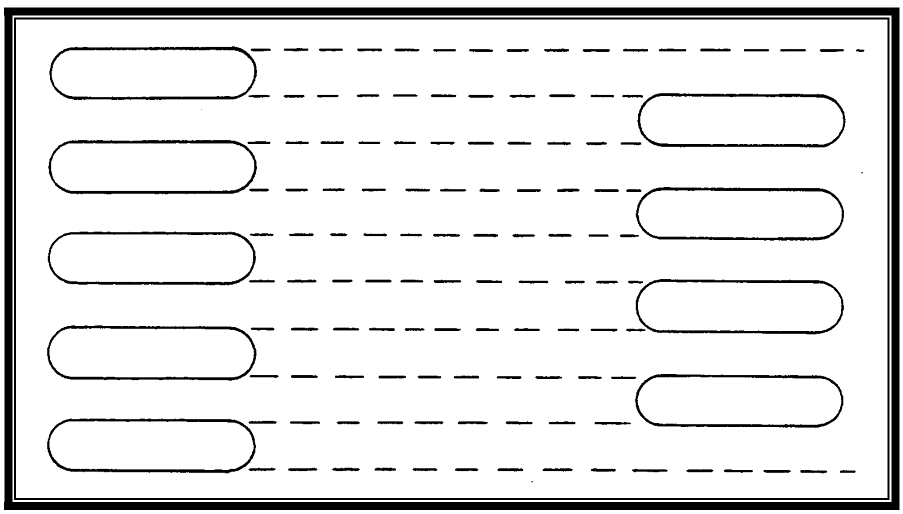


Figure 7-25. Pneumatic Tire Alignment

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 tire roller to be used.

Vibratory Roller

A vibratory roller (Figure 7-26) is a steel-wheeled roller that has the capability of vibrating one or both of the steel rollers. Eccentric weights within the drums rotate at high speeds causing the drum to vibrate and move vertically. This vibration results in vertical impact forces from the drum to the HMA.

Figure 7-26. Vibratory Roller

Only vibratory rollers specifically designed for the compaction of HMA may be used. Vibratory rollers are required by Section **409.03(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. Vibratory rollers are not allowed to be operated in the vibratory mode when compacting 4.75 mm mixtures.

Oscillatory Roller

An oscillatory roller (Figure 7-27) 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 sheer forces. Because the drum does not bounce like a vibratory roller, the oscillatory roller provides a smoother surface of the mixture.

An oscillatory roller may have both drums equipped for horizontal and vertical shear forces or one drum equipped for horizontal and vertical shear force and the other drum equipped for a vertical impact force. For 4.75 mm mixtures, the vertical impact force is not allowed.

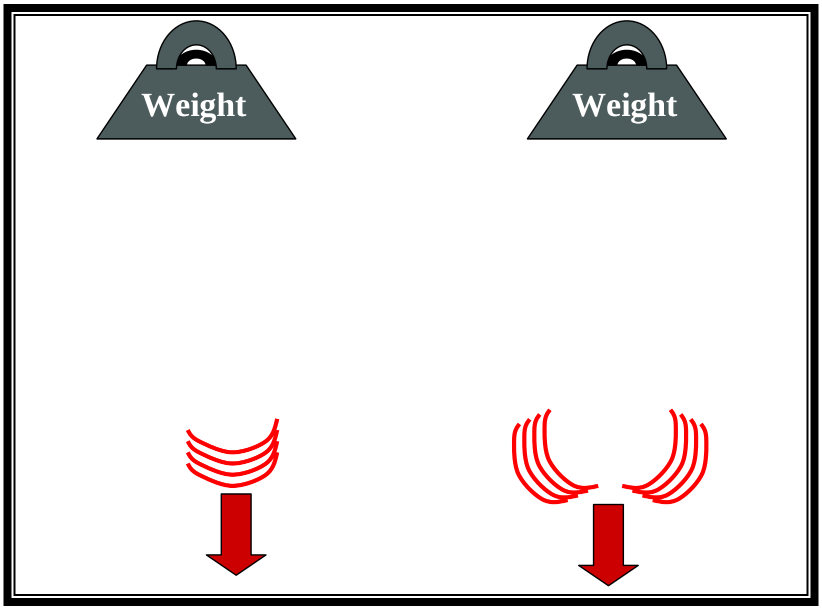


Figure 7-27. Oscillatory Roller

Trench Roller

When the width of a trench is too narrow to accommodate a standard roller, a trench roller (Figure 7-28) is used for compaction. The trench roller is required by Section **409.03(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. Counter-weights 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 7-28. Trench Roller

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

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 7-29.

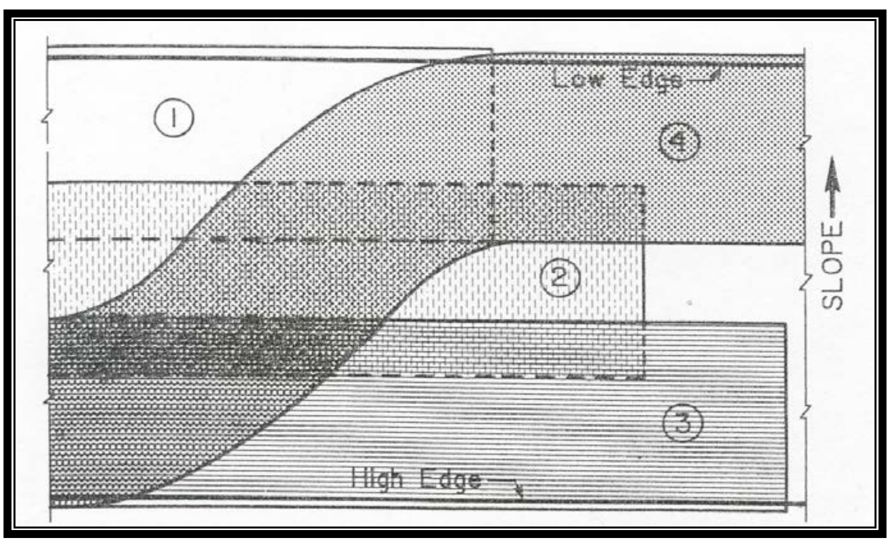


Figure 7-29. Breakdown Rolling Pattern

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 pass of the roller over the entire mat. The various options for rolling are included in the following table.

Number of Roller Applications							
Rollers	**Courses ≤ 440 lb/yd²**					**Courses > 440 lb/yd²**	
	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	--	--

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^2

2. The first lift of material placed at less than 385 lb/yd^2 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 laydown and rolling is continued. The joint is required to be checked with a straightedge. The roller usually smooths 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:

1) 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

2) 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 7-29 and explained as follows:

1) The uncompacted HMA abutting a cold mat is placed 1/4 in. per 110 lb/yd^2 higher than the cold mat. Any HMA placed on top of the cold mat is required to be removed from the cold mat prior to compaction.

2) The first pass of the breakdown roller to the paver and the return pass from the paver are required to overlap an unconfined edge or cold mat by 6 in.

3) The entire width of the mat is required to receive a uniform number of passes of the compaction equipment. If the 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.

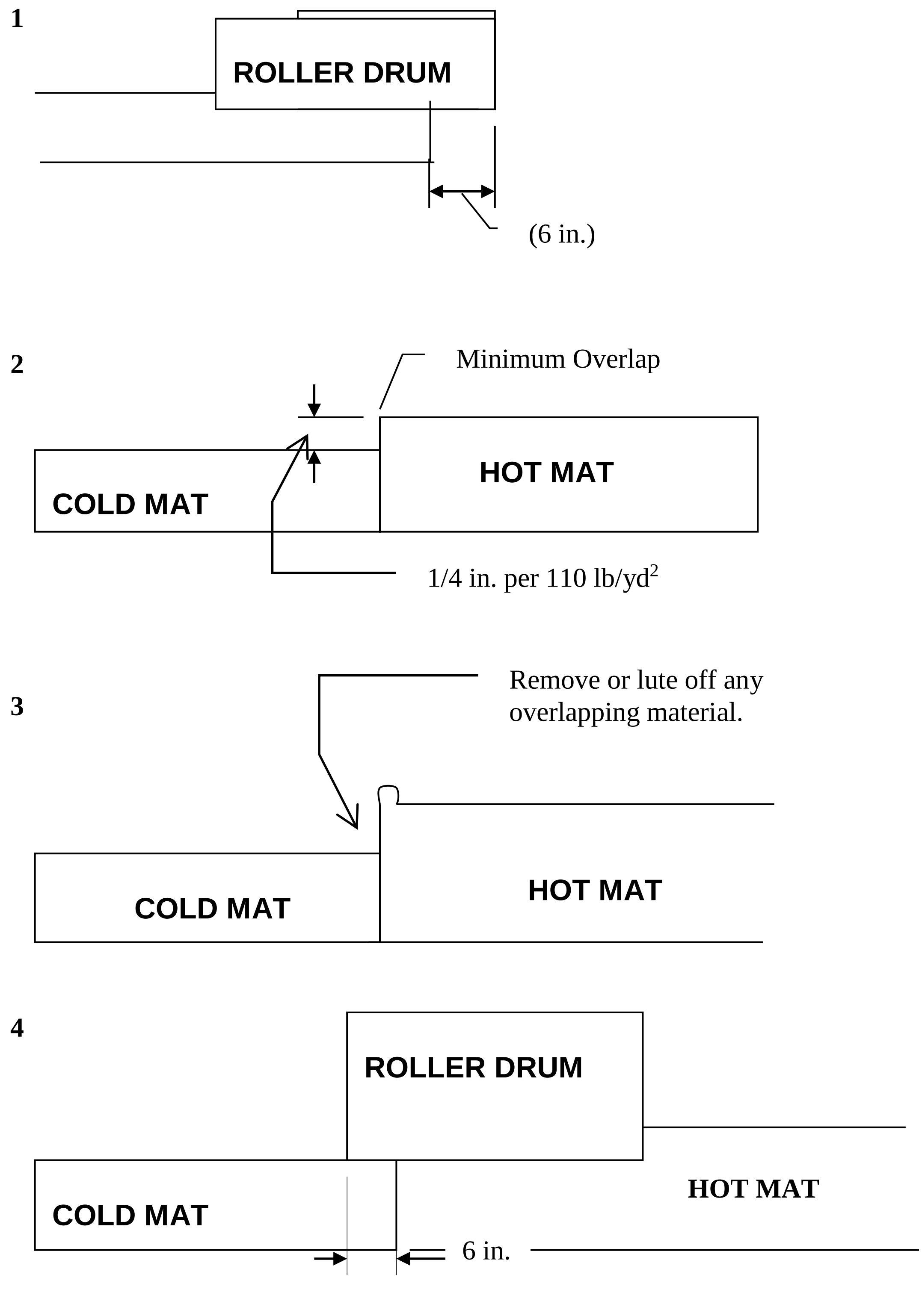


Figure 7-29. Longitudinal Joint Compaction

The notched wedge longitudinal construction joints (Figure 7-30) 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.

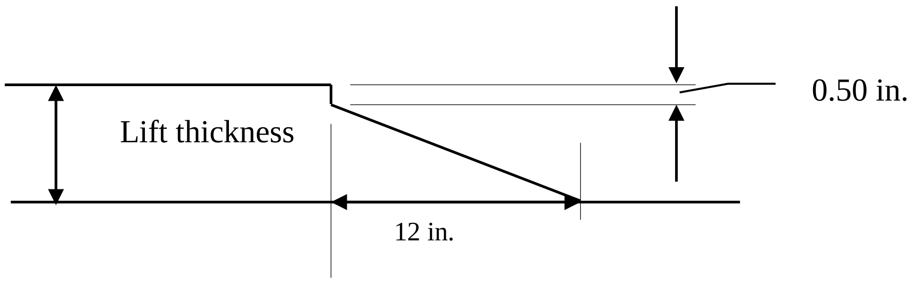


Figure 7-30. Notched Wedge Longitudinal Construction Joint

Joint adhesive materials are also being used for the purpose of sealing construction joints formed between adjacent HMA pavement courses (Figure 7-31). The joint adhesive 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 joints between the traveled way and an auxiliary lane, joints between the traveled way and a paved shoulder, and joints between an auxiliary lane and a paved shoulder.

Figure 7-31. Joint Adhesive Material

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

8 Paving Troubleshooting

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

CHAPTER EIGHT:
PAVING TROUBLESHOOTING

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 coasts, 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.

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 8-1)

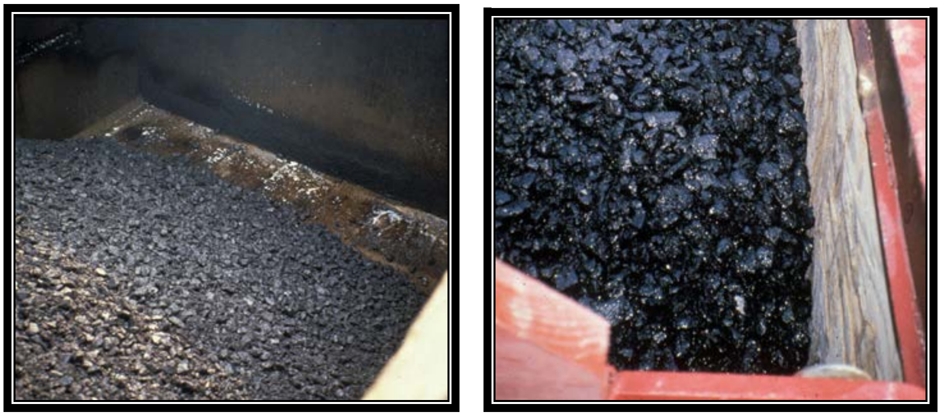


Figure 8-1. End of Truck Segregation

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 8-2)

Figure 8-2. Bleeding

Probable Cause-Possible Solution

1. Prime or tack coat too heavy (Figure 8-3)
    a. Use correct prime or tack coat application rates

Figure 8-3. 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 8-4)
    a. Minimize raking
    b. Trim and remove any excess from cold side of joint

Figure 8-4. 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 8-5)

Figure 8-5. 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 8-6)
    a. Allow paver to approach truck
    b. Make sure all rear wheels of truck are in contact with roller bar on paver

Figure 8-6. 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 8-7)

Figure 8-7. 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 8-8)

Figure 8-8. 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 8-9)
    a. Could be due to many factors including stockpiling procedures, mix gradation, operation and condition of storage bins, paver operations, etc.

Figure 8-9. 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

1. 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
2. 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
3. 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 8-10. Unstable HMA

4. 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
5. Hydraulic screed lift is not released
    a. Release hydraulics
    b. Check for improper or impaired operation of hydraulics

6. Yielding underlayer – granular bases (Figure 8-11)
    a. Improve or modify
    b. Check density
    c. Do not lay HMA over a saturated base
    d. Check drainage

Figure 8-11. Yielding Granular Base

7. Yielding underlayer – overlays
    a. Cut out and patch weak areas
    b. Maintain constant forward speed
    c. Match paver speed to plant output
8. Material on existing pavement (Figure 8-12)

Figure 8-12. 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 8-13. Auger Material Too Low

WAVY SURFACE – RIPPLES, SHORT WAVES (FIGURE 8-14)

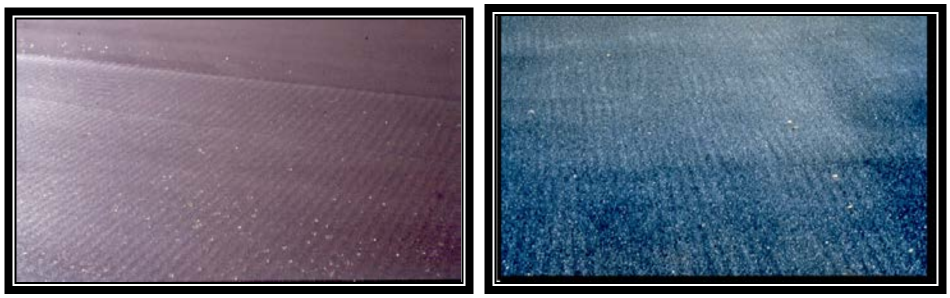


Figure 8-14. Wavy Surface – Short Waves

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. 8-15)

Figure 8-15. 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 8-16)

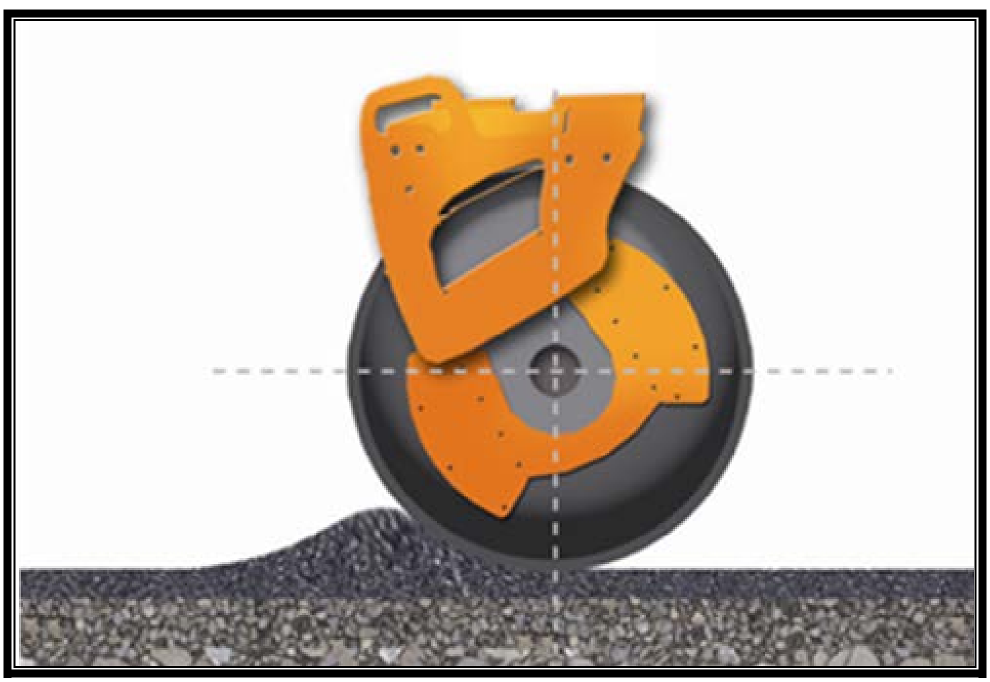


Figure 8-16. Mat Shoving Ahead of Roller

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 8-17)
    a. Use correct application rates
    b. Check sprayer calibration

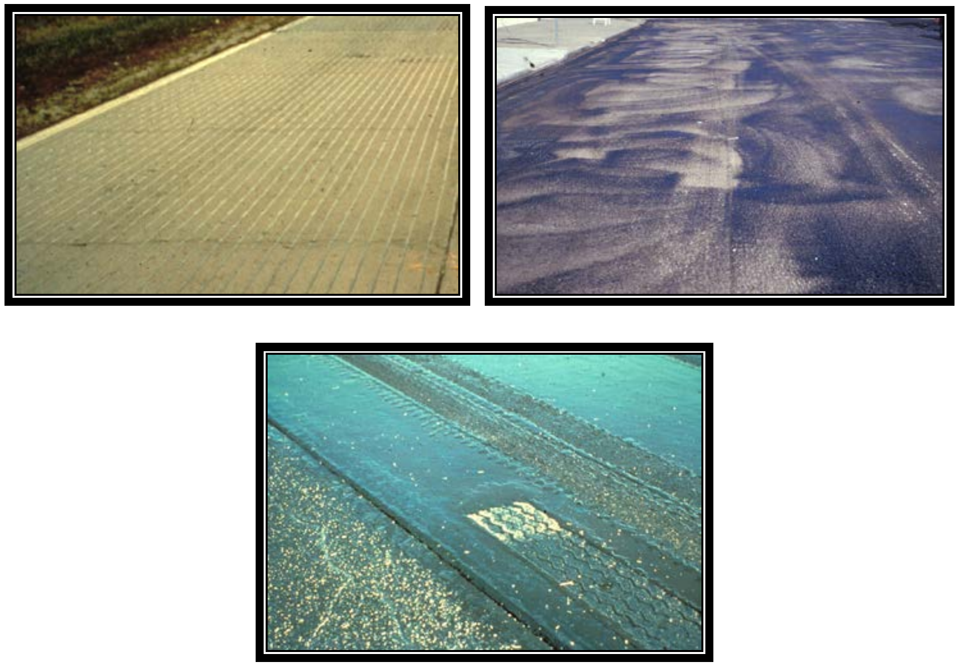


Figure 8-17. Incorrect Tack Coats

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 8-18)

Figure 8-18. 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 8-19)

Figure 8-19. End of Truck Segregation

11. Yielding underlayer – granular bases
    a. Check density
    b. Do not lay HMA over a saturated base
    c. Check drainage
12. Yielding underlayer – overlays
    a. Cut out and patch weak area
13. 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
14. Vibrator not operating
    a. Check for electric of hydraulic system malfunction
15. 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

9 Thickness and Tonnage Control

CHAPTER NINE:
THICKNESS AND TONNAGE CONTROL

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.

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:

Mixture	Maximum Specific Gravity
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^2

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

$$MAF = 0.957 + 0.020 = 0.977$$

Adjusted Planned Quantity = 0.977 x 9750.00 = 9525.75 tons

Adjusted Lay Rate = 0.977 x 165 lb/yd^2 = 161 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^2 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

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

Example:

Planned Lay Rate = 165 lb/yd²

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

The mat thickness for 165 lb/yd² would be approximately 1 1/2 inches.

or

Adjusted Lay Rate = 161 lb/yd²
MAF = 0.977

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

The mat thickness for 161 lb/yd² 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 ¼ inch additional thickness per inch of depth placed. For example, a compacted thickness of 3 inches will be placed 3 ¾ 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 changed.

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

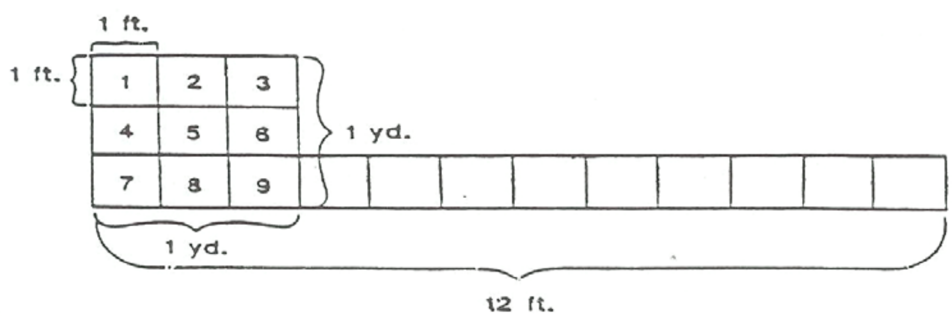
2) Method 2 – rate expressed in pounds per linear foot

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^2 equals 1 yd^2. The number of square yards in a linear foot depends on the width being paved.



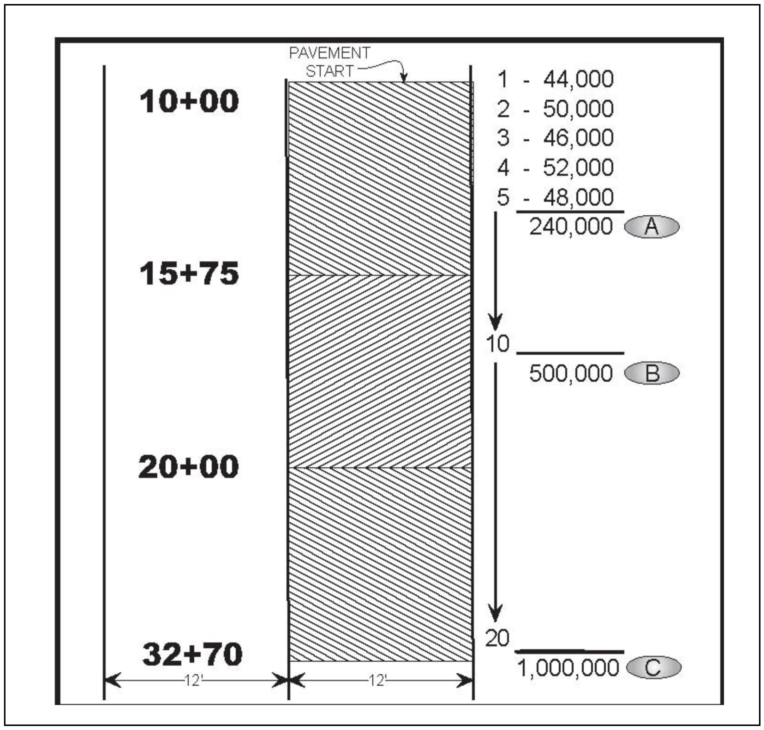
The formula for determining the relationship is:

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

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

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

Examples of the three 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.



Method 1 – Pounds per Square Yard

The planned quantity is 330 lb/yd². 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 lft

3) Determine the area paved in square yards.

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

4) Calculate the actual rate of spread in lb/yd²

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

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/yd². The placed quantity of 312.9 lb/yd² 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.

Total length = (20+00) – (10+00) = 1000 lft
Area = (1000 x 12) / 9 = 1333 yd²
Placed Quantity = 500,000 / 1333 = 375 lb /yd²

The placed quantity of 375 lb/yd² 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.

Total length = (32+70) – (10+00) = 2270 lft
Area = (2270 x 12) / 9 = 3027 yd²
Placed quantity = 1,000,000 / 3027 = 330.4 lb/yd²

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/yd²

1) Convert the planned quantity from lb/yd² to lb/lft

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

planned quantity x yd²/lft = 330 x 1.33 = 440 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 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.

Total length = (20+00) – (10+00) = 1,000 lft
Placed quantity = 500,000 / 1,000 = 500 lb/lft

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.

Total length = (32+70) – (10+00) = 2270 lft
Placed quantity = 1,000,000 / 2270 = 440.5 lb/lft

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^2

1) Convert the planned quantity from lb/yd^2 to t/lft

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

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 Station15+75

   (15+75) – (10+00) = 575 lft

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

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

   0.22 tons/lft x 575 lft = 126.5 tons

5) Compare the placed quantity and theoretical quantity

   placed quantity – theoretical quantity = tons over/under

   120 tons – 126.5 tons = -6.5 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 ton) x (2000 lb/ton) = 40000 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 yd^2) x (9 ft^2/yd^2) = 1090.9 ft^2

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

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