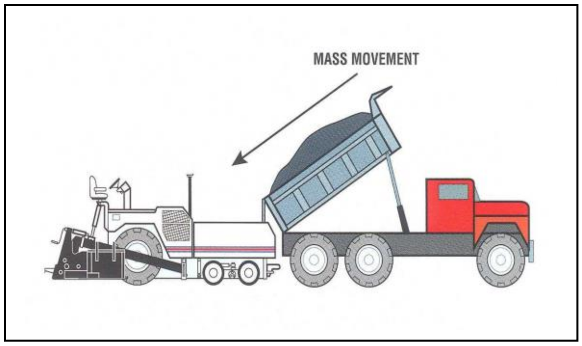
VII. Mix Delivery, Placement, and Compaction

Truck Unloading



Observe trucks unloading. The mix should look uniform. If segregation (non-uniform distribution of aggregate sizes in mix) is noticed, this is a good indication that there is a problem in the plant or in the way the trucks are being loaded. Also, look for other visual indicators of potential deficiencies in the mix, such as blue smoke (overheated mix), stiff appearance (cool mix), mix slumped in the truck (excess asphalt binder), or a lean, dull appearance (too little asphalt binder). Loads exhibiting such characteristics require close inspection and possible corrective action.

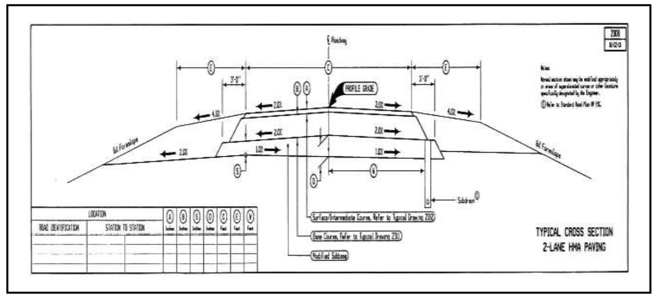
For bottom-dump trucks, the windrow of mix placed ahead of the pickup machine must be properly sized and located to meet the needs of the paver. The windrow size is normally controlled by the width of the gate opening under the truck and the speed of the truck. The amount of mix delivered is dependent on the width and thickness of the layer being placed by the paver. Ideally, the windrow should be sized so that the paver hopper is consistently 25 to 75 percent full during operation. The windrow should be centered in the lane being placed, and never extend more than two truckloads ahead of the paver. The actual distance the windrow is placed ahead of the paver depends on the speed of the paver, along with the mix temperature, weather, and other conditions that affect the rate of mix cooling.

With end-dump trucks, unloading becomes an art. For continuous paving operations, the paver operator will "pick up" trucks while the paver is moving forward. This technique will reduce the incidence of screed marks and roughness in the mat due to trucks backing into and bumping the paver. The truck is dumped into the paver hopper while the paver is on the move. To minimize segregation, flood the hopper as much as possible. When the hopper is fully loaded, the mix tends to be conveyed from under the load rather than streaming from the truck into the hopper.

Watch for excessive spillage that falls in the path of the paver. Wheels or tracks that run over this will lift up and distort the trailing mat. If this occurs, stop the paver until the spillage is cleaned up. Watch for mix remaining in the corners of the truck bed after the load is dumped. Any remaining material needs to be removed before the truck is loaded again. However, drivers should be discouraged from the practice of "banging the gate" ahead of the paver to expel remaining mix from end-dump trucks. Cool, crusted mix that has been loosened from the truck bed must be completely removed from the project, and not incorporated in the mat.

Any equipment, including trucks, leaking fluid must be removed immediately from the paving train to avoid contaminating the mat. Many types of equipment fluids act as solvents, which can break down the asphalt binder in the mix and lead to premature deterioration of HMA pavement.

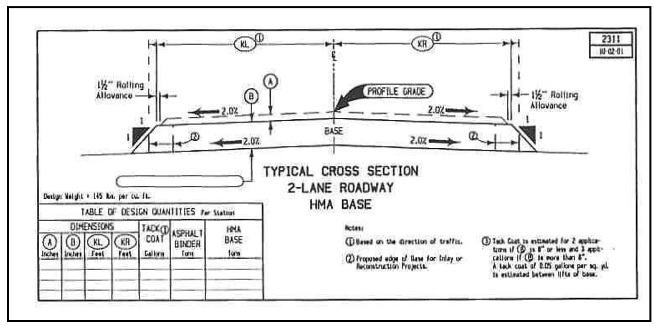
Do not allow the use of diesel fuel, kerosene or distillates for cleaning truck boxes or other equipment that comes into contact with the mix. If treated with distillates, trucks must drain for a minimum of 5 hours prior to being used to haul mix. Approved release agents are found in Materials *IM 491.15*.



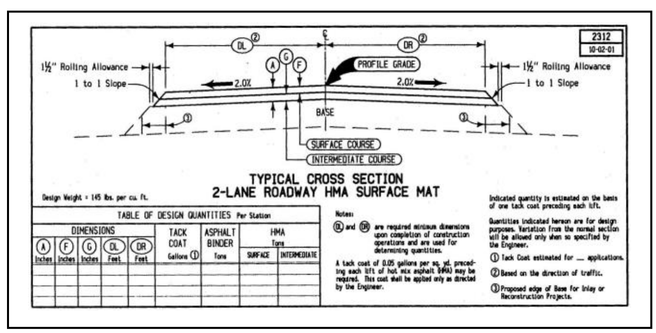
Dimensions

(Construction Manual sections 8.52 & 8.53)

Typical Sections are located in the plans that detail the design thickness, width, cross-slope, and other dimensions of the finished pavement. The inspector should review the plans to become familiar with these requirements and make frequent checks to insure they are being obtained.



The plans will show the total thickness of each course (base, intermediate, and surface) required for the project. The contractor must divulge the lift thickness(es) he intends to place in order to obtain the finished plan dimensions. Each placement thickness must be within the allowable range of lift thickness for the mix size specified. In general, lift thickness must be at least three times the nominal maximum aggregate size for effective compaction.



Since a typical HMA pavement will broaden in width during rolling, the contractor must adjust the spreading width so that the final dimension (as constructed) conforms to the design width specified in the contract documents.

Spread rates for hot mix asphalt are normally found by using the contract quantity of mix as a basis. If the contract quantity is not sufficient to construct the required thickness, notify your supervisor as soon as possible. If necessary, the Construction Residency can contact the District Office to obtain spread rate adjustments required to obtain the design thickness.

String Line

(Specification 2303.03, C, 4; Construction Manual section 8.43)

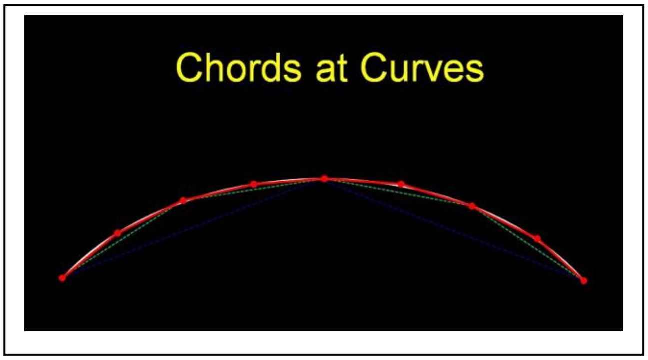
A wire / string guideline is used to guide the finishing machine and to maintain alignment. The inspector should make frequent checks to ensure the guideline string has been correctly set and maintained. Nails used to secure guideline string must be located at intervals close enough to provide a smooth transition and eliminate “chords” through curves.

The finishing machine operator shall follow the guideline string exactly. If machine goes offline for any reason, it shall be adjusted back onto the line immediately. It is incorrect to smooth out the edge alignment by coming back onto the line gradually. This produces long stretches where incorrect lap at the centerline joint will occur. A lack of material at the joint results in insufficient mix compaction, leading to water infiltration and premature deterioration of the pavement.

Edge Alignment

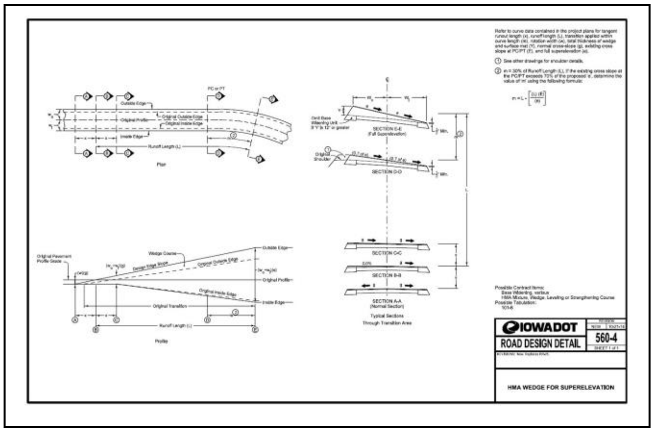
(Construction Manual section 8.43)

The use of a string/guideline is very important for good edge alignment. Establish the center of the pavement early in the project and work from this line throughout the project. Check the contractor's methods and measurements to verify that the contractor is maintaining the line and making the appropriate adjustments.



When placing string/guideline through curve sections, make sure that the contractor is locating it with enough intermediate points to form a smooth radius, avoiding the appearance of placing a series of longer chords around the curve.

If a jog in the alignment occurs, have the contractor stop and correct both the centerline and edge line immediately. If cracking is noticed on the outside edge of the mat, check to see if the edge of the overlaying mat is being placed incorrectly by overhanging the underlying roadway surface.



Wedge, Leveling, and Strengthening Courses

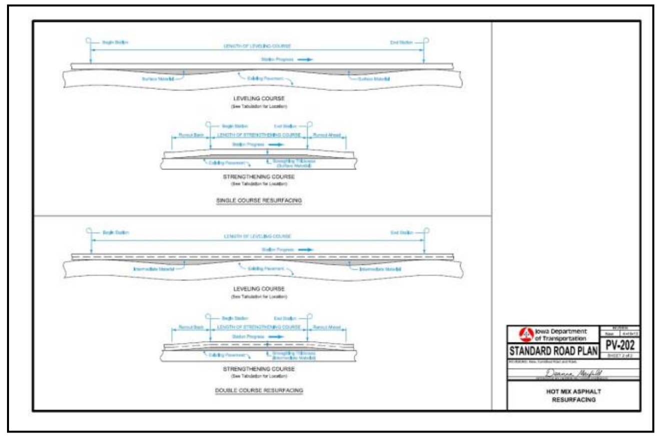
(Specification 2303.03, C, 7;
Construction Manual section 8.51;
Standard Road Plan PV-202;
Detail Sheet 560-4)

Wedge Courses

Wedge courses are placed on resurfacing projects to correct (usually increase) the superelevation of existing roadway curves. Project plans will identify required rate of superelevation and transition lengths.

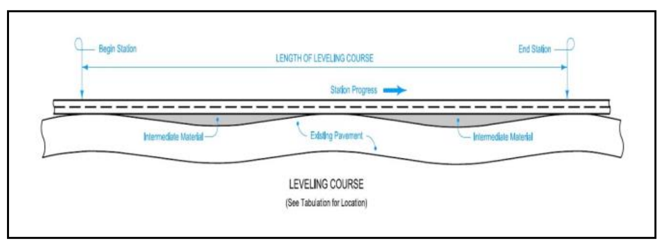
Detail Sheet 560-4 provides additional detailed geometric design information used for superelevation wedge layout at various speeds and degrees of curvature.

In placing a wedge course, the maximum thickness of individual layers, when compacted, shall not exceed three inches. When rolling, care shall be used to avoid crushing the coarse aggregate in the thinner portion of the wedge. Wedge courses shall be placed to the full width of pavement before any other course is placed thereon. *Construction Manual section 8.51* provides procedures to use in determining layout and placement of successive passes of wedge courses and placement sequence of required lifts. The inspector should constantly check the slope using 4-foot level and ruler. If the desired slope is not obtained on a given pass, then adjust slope and thickness of the next pass. The final pass should always be at the final superelevation rate.

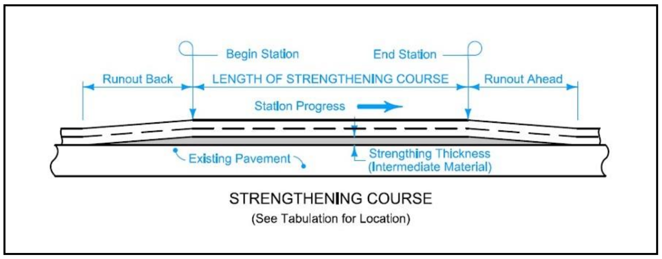


Leveling Courses

Leveling courses are used to correct existing pavement surface distortions, such as depressions or low areas typically more than one inch deep. The contract documents will show the thickness of the courses to be placed. A scratch course is a type of leveling course sometimes used to make minor corrections to the existing surface. The term “scratch” relates to the screed scratching on the aggregate, as the lift thickness is set at or just above the largest aggregate size in the mix. For scratch courses, the lift thickness does not adhere to the normal 3:1 (lift thickness: nominal maximum aggregate size) requirement.



Leveling courses are compacted using pneumatic rollers to ensure uniform compaction versus "bridging" of mix over existing depressions.



Strengthening Courses
Strengthening courses are placed over weak areas in the existing pavement. The contract documents will show the thickness of the courses to be placed.

Standard Road Plan PV-202 shows typical details for leveling and strengthening courses in conjunction with double course and single course resurfacing, respectively. When the depth of leveling & strengthening course is more than three inches, the desired depth shall be placed in approximately equal layers not exceeding three inches thickness.

Areas of wedge, leveling and strengthening courses will be identified on the plans. Always check to make sure the plan locations match the actual field conditions.

Paver Speeds and Plant Production

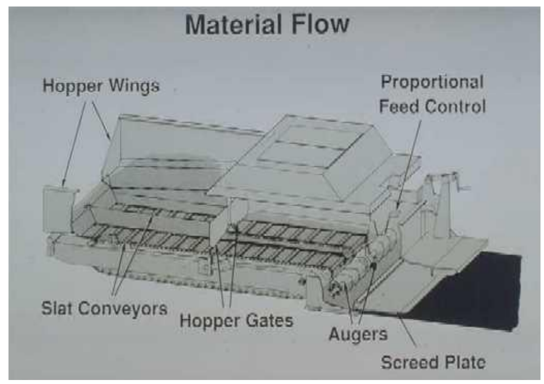
(Specification 2303.03, C, 3; Construction Manual section 8.13)

Uniformity and consistency of operations is essential in hot mix asphalt paving. Uniform, continuous operation of the paver produces the highest quality pavement.

It is important to adjust paver speed to match plant output in order to minimize paver stoppages. Frequent stops of the paver may allow the screed to settle, creating bumps in the roadway surface.

Trying to continue laying mat with long waits between truckloads will decrease the head of mix in front of the screed, allowing it to settle and create a dip. Ideally, paver speed should be adjusted to delivery rate so that the paver does have to stop and is not starved for mix as it is moving forward between loads.

Work with the contractor to make the appropriate adjustments so that the paver and plant are similar in their output. Adjustments to achieve proper paver speed must take the following into account: plant production, haul distance, number of haul trucks available, and lag time between loads due to traffic control or other delays.



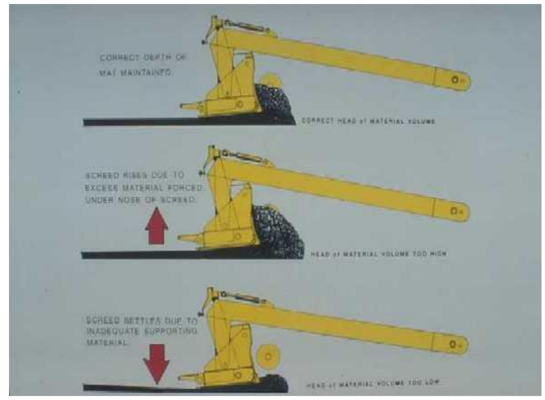
Paver Operations

(Specifications 2001.19 & 2303.03, C, 3 & 4)

While the proper operation and adjustment of the paver is the responsibility of the contractor, there are a number of things the inspector can check to ensure that a high quality pavement is produced:

- Keep the paver hopper sufficiently full at all times. The hopper level should consistently run between 25 and 75 percent full.
- If load interval segregation is present, make sure the contractor is not lifting the wings with each load.
- Make sure that the augers are running as much of the time as possible. To control this, the speed of the conveyor and the control gates can be adjusted to maximize the use of the augers.

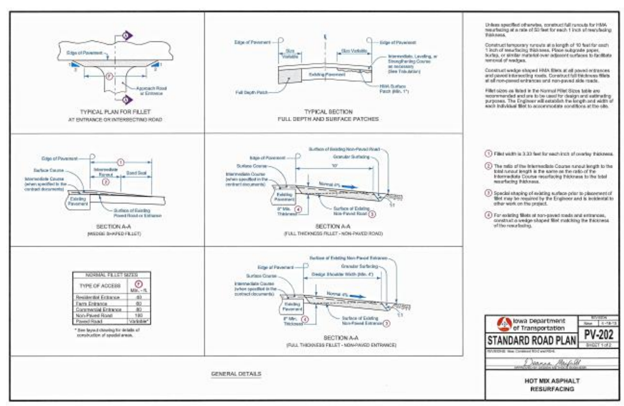
- Try to keep a consistent level of HMA ahead of the screed.
- Screed vibrators shall be in operation at all times mix is being laid. They should be run per manufacturer's recommendations.
- Check the automatic grade and slope controls. When approaching a curve, the automatic slope control can be shut off and controlled manually.
- The paver shall have automatic screed controls, except for the following instances:
  - Wedge courses.
  - Curb-fill resurfacing.
  - Urban type sections where fixtures or the other permanent grade control features take precedence.
  - Surfacing layers 1-inch or less in thickness.
  - Scratch courses.



Runouts

(Standard Road Plans PR-201, PR-202, and PV-202)

Runouts, sometimes called wedge shaped fillets, are used to provide a vertical transition from resurfacing course(s) to an existing pavement surface. The length of the runout is based on the thickness of the HMA resurfacing. Runout locations and lengths are found on Tabulation 100-25 and/or Tabulation 102-16 in the plans. Other runout information is found on the Standard Road Plans referenced above or may be included in plans by special notations or typical sections.



There are many different runout typical details available to fit many different situations (single vs. multiple lifts, notched vs. full runouts, etc.).

Use the information provided in the plans to layout and mark the runout location in the field. Make sure runouts fit field conditions properly, in order to prevent bumps.

The surface of the permanent runout is typically sand sealed after placement, to prevent water infiltration and premature deterioration of the thin HMA wedge.

Transverse Joints & Runouts

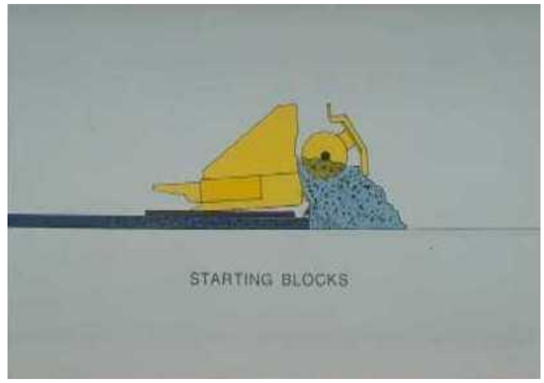
(Specifications 2001.19 & 2303.03, C, 6; Standard Road Plans PR-201 & PR-202)

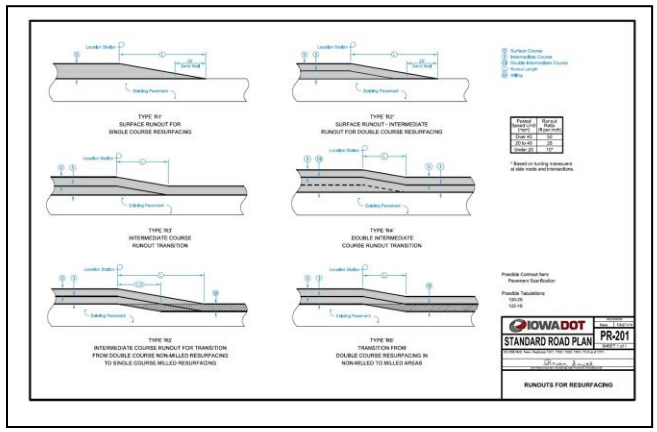
Temporary Runouts

- Slow paver and runout remaining material in the hopper.
- In order to maintain the proper mat thickness, the screed should be raised when the level of mix reaches the center of the auger shaft.
- Move paver; remove excess material to form a straight vertical edge along the joint.
- Place joint paper or burlap to separate the permanent pavement from the temporary runout material.
- Construct a temporary runout, tapering to the existing surface at the rate of no less than 10 feet of length for each 1 inch of compacted mat thickness being laid.

Taking off from a Cold Joint

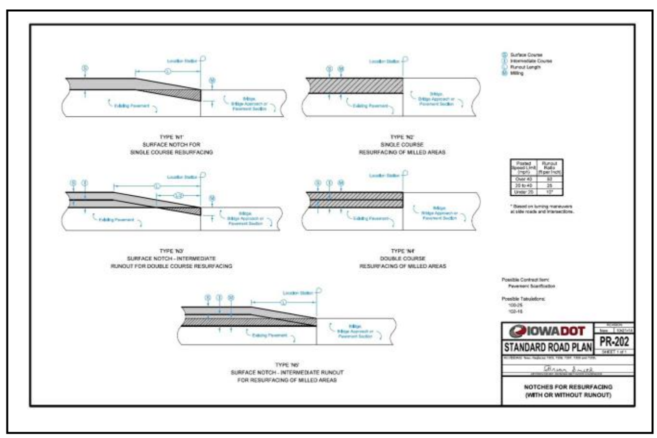
- Remove the joint paper (or burlap) and temporary runout material. The header shall be sawed to a straight line at right angles to the centerline, so that a full thickness vertical edge is provided.
- Make sure the screed is hot, but do not allow the screed to be placed directly on the existing mat.
- The contractor should use blocking material placed on the cold mat side of the joint in order to shim up the screed to obtain the desired lift thickness. The thickness of the shims is typically 20-25% of the compacted lift thickness (based on expected roll-down of the mix).
- After paving approximately 30 to 50 feet, check the surface with a 10-foot straight edge or string line.
- Continue paving if acceptable.
- If substantial bumps or dips are evident, scoop out the wheel tracks, back the paver up to the joint, and repave.





Permanent Runout

- Taper at a rate of 50 feet to 1 inch of mat thickness being laid, or as specified on the plans.
- String line the existing slab in the area of the runout ahead of laying mix to see how the runout will tie into the existing profile. The length of the runout may have to be adjusted in order to achieve a smooth transition.
- Use a sand seal on the surface course runout as per plan and specification.



Longitudinal Joints

(Specification 2303.03, C, 6;
Construction Manual section 8.44)

Longitudinal joints occur wherever adjacent lanes are placed. Hot joints are formed when two pavers are operated in echelon. Cold joints occur when one lane is placed and compacted. At a later time, after the first lane has cooled, the companion lane is placed against it. Cold joints will be emphasized in this section, as they are the predominate type of longitudinal joint used.

There are several procedures that must be followed to ensure a high quality HMA longitudinal joint:

First Lane Placement

- Use a string line to maintain true edge alignment at longitudinal joint locations. The string line should be secured with extra nails in curves to minimize the "chord" effect, thereby facilitating a better joint match by the second lane.
- Provide enough mix at the end of the screed by maintaining a consistent head of mix along the length of the paver augers. Mix confinement by the end gate will result in a more uniform edge to match.
- The vertical face of the exposed longitudinal joint (cold mat) must be tack coated, as a separate operation, before placing the adjacent lane. This insures a good seal at the joint. Do not allow tack to be over-sprayed on the surface of the lane being matched.

Second Lane Placement

- Allow 1/2 to 1-1/2 inches of overlap at the joint, with 1-inch being preferred. Too much lap at centerline will result in a wide scab of mixture at the surface or the appearance of a white streak at the joint, caused by the roller crushing aggregate in the mix against the surface of the cold mat.
- Allow enough loose lift thickness to compensate for roll down so that no bump or dip is produced at the joint (20 to 25 percent reduction in thickness is typical). If the loose lift thickness is insufficient prior to rolling, the joint will appear smooth but lack density.

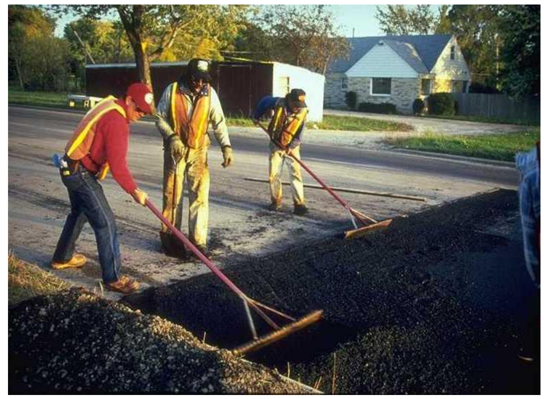
- Keep the end plate of the paver tight against the screed and tight against the surface of the cold mat. Do not allow mix to run out between the edge of screed and end plate, or in front of the end plate.
- Minimize the amount of handwork used in constructing longitudinal joints. This includes raking, luting, and "bumping" the joint. If excess mix is placed at the joint location, the extra material should be pulled back and removed, rather than "broadcast" across the mat's surface. Once adjusted, the paver will do a better job of uniformly placing the mix than can be achieved by using hand tools.

- Compact the joint from the hot side of the joint, <u>not</u> the cold side. This allows thru traffic to use the adjacent lane, and also prevents damage to the cold mat by vibratory (breakdown) rollers. Never have the vibrators turned on when the majority of the breakdown roller is being supported by the cold side of the joint.

Hand Spreading

(Specification 2303.03, C, 4)

Whenever practical, mix should be spread by the paver with no handwork necessary. “Bumping” of mix at centerline joint should not be necessary if the paver is being properly operated. Stop the lay down operation if there is excessive handwork required and correct the cause of the problem.

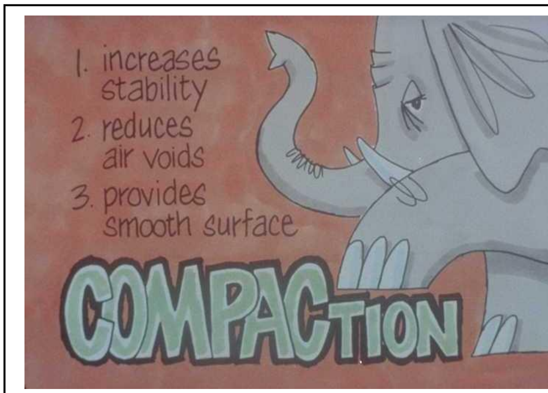


In small or irregular areas, however, spreading by hand may be unavoidable, as paver use is often either impossible or impractical. Placing and spreading by hand should be done carefully and the material distributed evenly to avoid segregating the mix. Workers shall not stand on the loose mixture while spreading.

All rakes, shovels, and other tools used for hand spreading shall be of a type designed for use on hot mix asphalt mixtures.

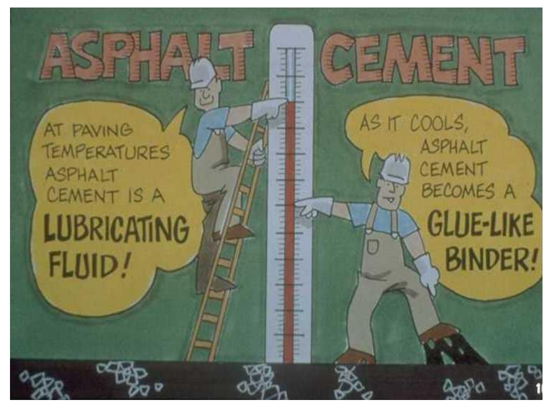
Compaction

(Specification 2303.03, C, 5)

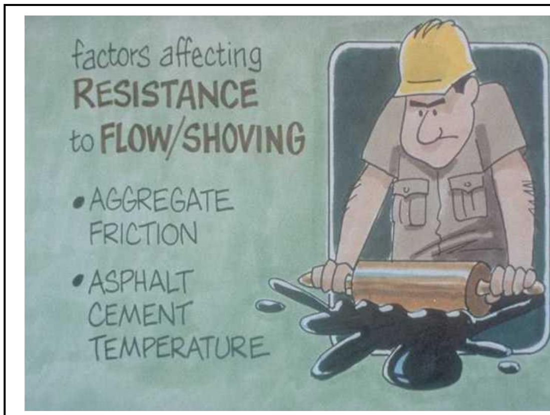


Compaction is the process through which the HMA mix is compressed and reduced in volume. Compaction permits the unit weight, or density, of the mix to be increased by placing more materials in a given volume of space. As a result of the compaction process, the asphalt binder-coated aggregates in the mix are forced closer together, which increases aggregate interlock and inter-particle friction, and also reduces the air void content in the mix to a desirable level.

Compaction is the single most important factor that affects the ultimate performance of a hot mix asphalt pavement. Adequate compaction of the mix increases the fatigue life, decreases permanent deformation (rutting), reduces oxidation or aging, decreases moisture damage, and increases strength and stability. An HMA mixture that has all the desirable mix design characteristics will perform poorly under traffic if that mix is not compacted to the proper density level.



The mechanics of compaction involve three main forces at work: the compressive force of the rollers, the resistive forces within the mixture, and the supporting forces exerted by the surface beneath the mat, be it subgrade, aggregate base, or pavement. If the underlying surface is not firm and stable, the hot mix asphalt will not be confined, and compaction will not be achieved. Similarly, if the hot mix asphalt is not stable enough to resist the compaction forces, it will tend to displace and not compact to the desired air void level. Finally, if the rollers do not exert enough force to overcome resistance within the mixture, the pavement will not be sufficiently compacted.

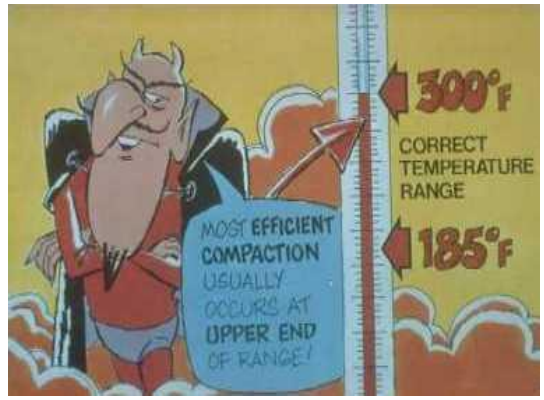


Internal resistance of the hot mix asphalt greatly affects compaction, and is dependent upon:

- Mixture properties and characteristics
- Environmental conditions
- Layer (lift) thickness
- Subgrade and bases

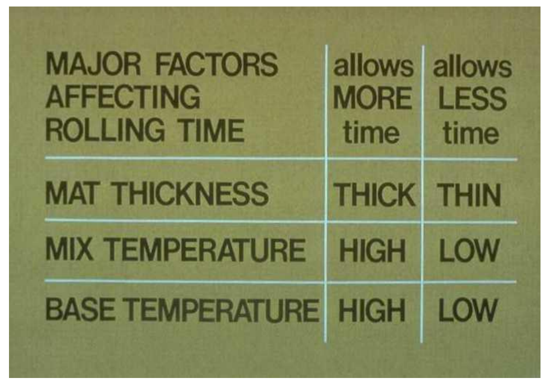
Mix Properties and Characteristics

It is important to remember that hot mix asphalt is a combination of aggregate and asphalt binder.



Interlocking aggregate acts as the structural skeleton of the pavement, and asphalt binder acts as the glue which holds the mixture together.

Aggregate gradation, surface texture and angularity are the primary characteristics that affect workability of a mixture. Mixtures with large amounts of coarse aggregate, along with higher levels of surface texture and angularity, require a greater amount of effort to compact.



MAJOR FACTORS AFFECTING ROLLING TIME	allows MORE time	allows LESS time
MAT THICKNESS	THICK	THIN
MIX TEMPERATURE	HIGH	LOW
BASE TEMPERATURE	HIGH	LOW

Asphalt binder is a thermoplastic, temperature susceptible material. At higher temperatures, it acts as a lubricant, coating aggregate particles and facilitating compaction of the mixture. As the asphalt binder cools, it becomes stiffer and binds the aggregates to produce a long lasting mixture. All compaction must take place before the in-place mix temperature falls below the prescribed minimum for the type of asphalt binder in the mix.

Environmental Conditions

Construction of quality pavements is highly dependent on the conditions under which they are placed. Ambient air temperature, wind, and the temperature of the surface on which the hot mix asphalt is placed can all affect the cooling rate of the mixture.

Placement and compaction of hot mix asphalt is often a race against time. Cool air temperatures, strong winds, and cool surfaces can shorten the time in which compaction must take place.

Increasing plant mix temperature, covering hauling units, minimizing haul length, and shortening windrows in front of pickup machines can all minimize the effects of the environment on HMA paving.

Layer Thickness
All HMA mixtures cool with time. The greater the surface area of the mixture, the faster the environment can cool the mixture. Thick layers, or lifts, have less material exposed to the air and subsurface in relation to their volume, and therefore cool slower.

Generally, it is easier to achieve required density in thicker lifts than in thinner ones. This is because the thicker the mat, the longer it retains heat, thus increasing the time during which compaction can take place. Thicker layers can permit mixtures to be placed at lower temperatures because of the reduced rate of cooling.

Subgrade and Bases
The subgrade or base must be firm and non-yielding under the haul trucks and other construction equipment. Subgrades or bases that show movement under equipment will require additional compaction or some type of remedial action to overcome the softness. Such remedial work may include PCC or lime stabilization, or removal and replacement with more suitable material. In some cases, the size and weight of the haul trucks or other construction equipment may be limited to prevent damage to the base.

Roller Operations

Breakdown

Breakdown rolling is the first interaction between the roller and the mat. Most contractors use steel drum vibratory rollers to breakdown the mix, increase the mat density, and establish the mat smoothness. However, some may use rubber-tired rollers for this operation.

The majority of density is obtained during breakdown rolling, so it is important to keep this roller moving as much of the time as possible. Rollers should always stop and start slowly on the uncompacted mix and angle the drum when stopping to reverse. When the roller does stop, it is important to park on a cold mat. Parking on a hot mat, particularly near the paver, will leave roller marks that are difficult to remove.

In most cases, the breakdown roller(s) should follow the paver as closely as possible. It is important to obtain as much compaction as possible before the mat has cooled significantly. This is especially true when working in cool and/or windy conditions, or when compacting tender mixes. *Tender mixes are discussed in more detail in Chapter 9 of this manual*.

Intermediate

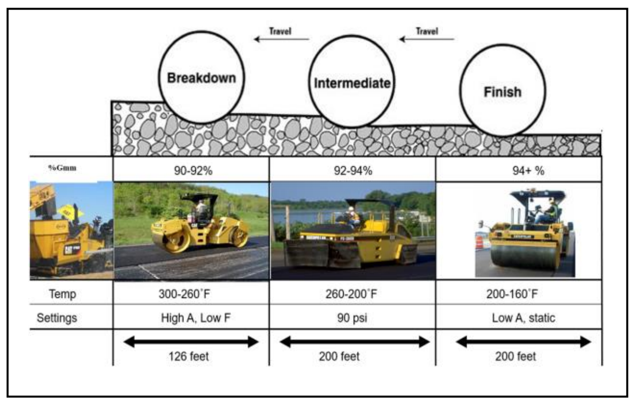
Intermediate rolling may or may not be required on a project. In most cases, a pneumatic (rubber-tired) roller is used. Intermediate rolling is usually required if adequate density cannot be achieved with the breakdown roller, or if the surface texture and kneading action of a rubber-tired roller is desired.

Intermediate rolling is commonly seen on interstate and higher volume primary paving projects, which typically use stiffer mixes and higher crushed aggregate contents.

Intermediate rollers generally operate at higher speeds than breakdown rollers, and often make more passes over a given section of mat than other roller types. As with breakdown rollers, intermediate rollers may operate independently or in tandem, depending on paver production rates, mat cooling rates, and other variables.

Finish

Finish rolling is the last step in the operation and is normally used to "iron" out any roller marks left by breakdown and intermediate rollers. Very little additional compaction is achieved during finishing rolling, as it is done after the mat has cooled significantly. This roller is typically a static steel wheel roller, or a steel vibratory roller operating in a static mode.



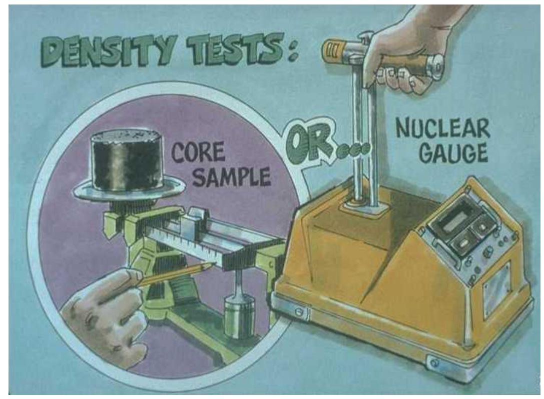
Classes of Compaction

(Specification 2303.03, C, 5)

The Iowa DOT specifies two classes of compaction, Class I and Class II. Class I compaction is intended for use on base, intermediate and surface courses for traffic lanes, ramps and loops on Interstate, Primary, and Secondary highways. Class II compaction is intended for paved shoulders, temporary crossovers, onsite detours, base widening in a non-travel lane and for other situations where Class I compaction is not specified.

Class I Compaction

<u>Class I</u> compaction specifications require a minimum of 91.5 percent of maximum specific gravity (Gmm) for all mainline paving. Payment is determined by Quality Index (Q.I.) and Percent Within Limits (PWL) calculations for the lot, based on 8.5 percent maximum and 3.5 percent minimum field voids limits.



Class II Compaction

<u>Class II</u> compaction requires a specified procedure and does not measure the density or the voids.

Procedures for Class II compaction are as follows:

1. Establish a rolling pattern to verify adequate density.
2. At Engineer's option, cores or gauge readings at the frequency designated in Materials IM 204, Appendix F for the first day of placement will be used. The Engineer may modify the sample size and frequency provided the compaction is thorough and effective.
3. The Engineer will accept the rolling pattern based on the average test results. When the average of field voids is less than or equal to 8.0%, the pattern is considered thorough and effective.
4. When the average of field voids exceeds 8.0%, modify the rolling pattern. The Engineer may require additional testing until thorough and effective compaction is achieved.
5. For areas inaccessible to rollers, use mechanical tampers or other approved compaction methods.

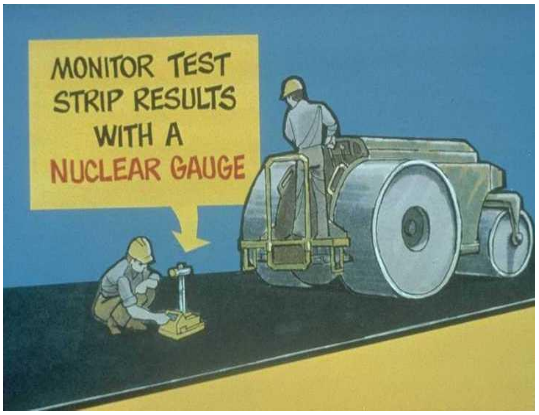
Test Strips

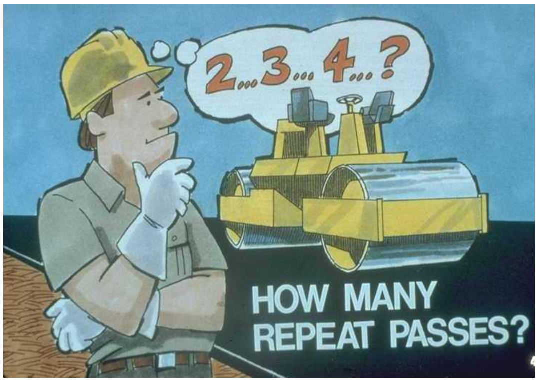
(Specification 2303.03, C, 5;
Construction Manual section 8.13)

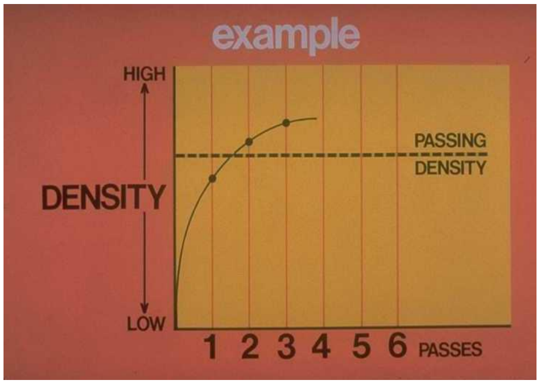
Test Strips may be required under Class I compaction only, for the purposes of evaluating properties of the HMA mixes and for evaluating an effective rolling pattern. The current specifications contain the following test strip requirements:

- Construct a test strip of the surface mixture prior to its placement on the surface course for Interstate highways, Primary highways, and ramps connecting Interstate and Primary highways.
- Construct a test strip of the intermediate mixture at the start of its placement on the intermediate course for Interstate highways and Interstate-to-Interstate ramps.
- Test strips for base mixtures may be constructed but are not typically required. An exception would be for a base mixture placed as a surface course.
- Only one test strip will be allowed for each mixture. The Engineer may require additional test strips if a complying HMA mixture or rolling pattern is not established.
- The quantity of HMA mixture subject to test strip construction is pre-established with the Engineer and limited to one-half day's production.

Procedures for proper construction and documentation of test strips are outlined in *Section 8.13* of the Construction Manual.







Checking Roller Coverage

For Class I compaction, the number of roller passes will be determined by test strip required in situations discussed in the previous section. When a test strip is not required, the contractor will have to determine the number of roller passes to achieve the compaction effort necessary for the desired density. In this situation, the contractor would base their rolling pattern on previous experience working with the mixtures and equipment involved in the paving operation.

Further adjustments may be necessary after stable production is established.

For Class II compaction, the number of roller passes is determined by the process used to establish rolling pattern providing adequate density, meeting specification requirements. As with Class I compaction, previous experience working with mixtures and equipment involved could prove to be valuable in this effort.

Pay particular attention to the area at the end of one rolling area and the beginning of the next, to see that this area is not being over-rolled or under-rolled.

Additional discussion of compaction procedures and roller operations are contained in Chapter 9 of this manual.