Technology Transfer

Inspectors' Guide

Mat Problems

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16. Abstract

Mat problems can be defined as defects that occur in the asphalt concrete mixture during, or soon after, the laydown and compaction operations. The problems are divided into two primary categories: (a) equipment-related problems; (b) mixture-related problems. Twelve types of mat deficiencies are discussed with an emphasis on the description of the problem, the cause of the problem (equipment or mix related), the cure, and the effect on pavement performance. The twelve problems discussed are: surface waves, mat tearing, nonuniform mat texture, screed marks, screed responsiveness, auger shadows, precompaction levels, joints, checking, shoving, fat spots and bleeding, and roller marks.

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MAT PROBLEMS: AN INSPECTOR'S GUIDE

Mat problems can be defined as defects that occur in the asphalt concrete mixture during, or soon after, the laydown and compaction operations. These problems can be divided into two primary categories: (a) equipment-related problems; and (b) mixture-related problems. Several different types of mat deficiences will be discussed below, with emphasis on the description of the problem, the cause of the problem (equipment or mix related), the cure, and the effect on pavement performance.

Figure 1 summarizes the various kinds of problems that can occur in an asphalt concrete layer during construction. Listed in the first column is a description of various mat defects. Marked in the remaining columns are several possible causes for each particular mat problem. The check marks indicate equipment-related causes and the X marks indicated mix-related causes.

SURFACE WAVES

A wavy asphalt concrete surface can be of two types: short waves or (ripples) and long waves. Short waves are generally 1 to 3 feet apart, with 1-1/2 to 2 feet being the most common distance. Long waves are considerably farther apart and may correspond to the distance between truckloads of mix.

The primary cause of ripples or short waves is a fluctuating head of material in front of the paver screed. This variation in the amount of mix being carried back to the augers by the slat conveyors and deposited in front of the screed causes the screed to rise and fall as the pressure against it changes. To much (the mix at the top of the augers) and then too little (the mix at the bottom of the augers) asphalt concrete material being carried in the auger chamber in front of the screed causes the wavy surface as the screed reacts to the variable forces on it.

A secondary cause of ripples can be a screed that is in poor mechanical condition—one which has loose screed plates or has excessive play in the screed control connections. Ripples can also be formed in the mat by improper mounting or setting of the automatic grade control on the paver or by use of an inadequate grade reference device. In the latter case, the problem might be related to a mobile reference (floating beam) that is bouncing for some reason.

Short waves can also be a function of the mix design, particularly in regard to a tender mix or one that varies in stiffness caused by changes in mix temperature or in mix composition. As the stiffness of the mix varies, the forces of the mix pushing on the screed also vary, causing the screed to rise and fall and place a mat with ripples in it. Finally, ripples can be formed in the asphalt concrete mat by compaction equipment, especially with a tender mix. If the mix design is improper—either in aggregate gradation, asphalt content, moisture content, or mix temperature—the rollers may shove and displace the mix during the compaction process. Normally, however, the ripples are placed in the mat by the paver, either because of its operation or because of changes in mix stiffness, rather than by the compaction equipment.

Long waves are caused by many of the same variables that cause short waves. A fluctuation in the amount of material in front of the screed and mix stiffness variation causes the screed to react to the change in the pressure on it. If the distance between the wave peaks, however, corresponds to the length of pavement between truckloads of mix, then the waves may have been caused by incorrectly set hopper flow gates on the paver or by emptying the paver hopper and slat conveyor between loads of mix. Mechanical condition and improper operation of the screed—continually changing the manual

MAT PROBLEM TROUBLE-SHOOTING GUIDE

CAUSES

PROBLEM	Fluctuating Head of Material	Feeder Screws Overloaded	Finisher Speed Too Fast	Too Much Lead Crown in Screed	Too Little Lead Crown in Screed	Overcorrecting Thickness Control Screws	Excessive Play in Screed Mechanical Connection	Screed Riding on Lift Cylinders	Screed Plates Worn Out or Warped	Screed Plates Not Tight	Cold Screed	Moldboard on Strikeoff Too Low	Running Hopper Empty Between Loads	Feeder Gates Set Incorrectly	Kicker Screws Worn Out or Mounted Incorrectly	Incorrect Nulling of Screed	Screed Starting Blocks Too Short	Screed Extensions Installed Incorrectly	Vibrators Running Too Slow	Grade Control Mounted Incorrectly	Grade Control Hunting (Sensitivity Too High)	Grade Control Wand Bouncing on Reference	Grade Reference Inadequate	Sitting Long Period Between Loads	Improper Joint Overlap	Improper Mat Thickness for Max. Agg. Size	Trucks Bumping Finisher	Truck Holding Brakes	Improper Base Preparation	Improper Rolling Operation	Reversing or Turning Too Fast of Rollers	Parking Roller on Hot Mat	Improper Mix Design (Aggregate)	Improper Mix Design (Asphalt)	Mix Segregation	Moisture in Mix	Variation of Mix Temperature	Cold Mix Temperature
Wavy Surface — Short Waves (Ripples)	✓	✓	✓				✓	✓		✓										✓	✓	✓	✓						X	X			X	X	X		X	
Wavy Surface — Long Waves	✓	✓				✓	✓	✓					✓	✓						✓			✓	✓			X	X	X		X	X			X		X	
Tearing of Mat — Full Width			✓						✓		✓															X							X	X	X	X	X	X
Tearing of Mat — Center Streak					✓				✓		✓			✓	✓																							X
Tearing of Mat — Outside Streaks				✓					✓		✓	✓		✓				✓																				X
Mat Texture — Nonuniform	✓	✓	✓					✓	✓	✓	✓		✓					✓	✓					✓		X			X				X	X	X		X	X
Screed Marks							✓																				X	X										
Screed Not Responding to Correction			✓				✓	✓		✓										✓						X											X	X
Auger Shadows		✓																															X	X	X			
Poor Precompaction			✓					✓											✓							X			X									X
Poor Longitudinal Joint	✓	✓				✓		✓												✓	✓	✓			✓					X								X
Poor Transverse Joint		✓					✓	✓		✓						✓	✓													X								X
Transverse Cracking (Checking)																													X	X			X	X		X	X	
Mat Shoving Under Roller																													X	X	X		X	X		X	X	
Bleeding or Fat Spots in Mat																																	X	X		X	X	
Roller Marks																													X	X	X	X					X	
Poor Mix Compaction																													X	X	X	X	X	X		X	X	X

1. Find problem above.
2. Checks indicate causes related to the paver. X's indicate other problems to be investigated.

NOTE: Many times a problem can be caused by more than one item, therefore, it is important that each cause listed is elliminated to assure solving the problem.

thickness control cranks, for example—as well as incorrectly mounted automatic grade controls can cause a long wave type of surface problem in the mat. If a stringline is being used as a grade reference, a sag in that line between support posts can easily be a cause of long waves. Delivery of the mix to the paver can also be a factor in long wave roughness, particularly if the haul truck bumps into the paver or if the truck driver rides his brakes while the truck is being pushed by the paver.

In terms of mix design, long waves can be caused by segregation of the mix and by changes in mix temperature. Both of these deficiences cause the forces on the screed to vary, causing, in turn, a wavy surface. Compaction equipment can also create a wavy mat if the roller operator turns or reverses the machine too abruptly or parks the roller on the hot mat while waiting for additional mix to be placed.

Ripples can be cured only by preventing their formation. The most important factor for short waves is to keep the amount of mix (head of material) in front of the screed as consistent as possible. In addition, the stiffness of the mix, which is related to both its temperature and its composition, should be maintained as constant as feasible. The amount of mix is controlled by the proper setting of the hopper flow gates and by keeping the slat conveyors and augers operating as much of the time (close to 100 percent) as possible while the machine is moving forward. Mix stiffness is controlled at the asphalt concrete batch or drum mix plant by keeping the mix temperature, aggregate gradation, and fluids content (asphalt content plus moisture content) within normal specification limits. Any factors that cause either the volume or the stiffness of the mix at the screed to change will cause ripples in the asphalt concrete mat.

Surface waves caused by automatic grade control problems can be detected by shutting off the grade controls and measuring whether or not the long or short waves continue to be formed. If the controls are at fault, the operation and maintenance manual supplied with the controls should be consulted to determine the proper corrective action to take. Sags in a stringline reference, if one is being used, can be found by sighting down the line. Short or long waves caused by the mechanical condition or operation of the paver screed can usually be detected by careful observation of the paver during mat laydown. The long waves formed by incorrect haul truck operation and/or incorrect compaction equipment operation also can be easily detected by spending a few minutes watching each of these processes.

Long term pavement performance is affected by surface waves (short and long) in two primary ways. First, the waves cause a decrease in the smoothness of the pavement. This in turn lowers the pavement condition rating or present severiceability index for a stretch or highway. Structural performance of the pavement may be changed, however, only if the waves are severe enough to increase the dynamic or impact loading of the pavement under heavy truck traffic. Second, ripples, or factors that cause the ripples, can affect pavement density levels. A tender mix generally cannot be compacted to the same density value as can a stable mix. The resulting decrease in density and the corresponding increase in air void content can cause a significant decrease in the fatigue life of the asphalt concrete mat.

TEARING OF THE MAT

There are three types of mat tearing, or pulling, of the asphalt concrete mix under the screed of the paver. Each of the types are described by the location of the tear marks in the mat: (a) full width; (b) center streak; and (c) outside streaks. Tearing of the mat is usually caused by improper paver condition or operation, or by a cold mix temperature.

The screed on a paver can be adjusted to provide the proper degree of crown to the mix being placed. The crown of the whole screed can be changed, but the problem is most likely with the relationship between the crown at the leading (front) edge and trailing (back) edge of the screed, which can be adjusted. A streak up the center of the mat is usually caused by a lack of lead crown in the paver screed. Conversely, streaks up both outside edges of the asphalt concrete mixture are normally caused by an excess of lead crown in the screed. For most mixers, the lead edge crown should be set slightly greater than the tail edge crown.

Center streaks can also be caused by a lack of asphalt concrete material being tucked under the auger gearbox area at the center of the auger chamber. This is caused by both improper flow gate settings and by worn or improperly set reverse augers or paddles on the augers. Edge streaks can be formed by improper flow gate settings or by incorrect installation of the screed extensions.

Full-width tearing of the mat can be attributed to a number of factors. If the paver is operated at too fast a forward speed for a particular mix, tearing can occur. Tearing can also take place, either full width, in the center, or along the edges of the mat, because of warped or worn-out screed plates. Cold mix temperatures, particularly combined with a cold paver screed, can significantly affect the amount of tearing that will occur. Mix design factors that create tender mixes can cause tearing of the mat and so can the use of oversized aggregate (compared to the thickenss of the layer being placed) in the mixture.

Center or outside edge mat tearing can usually be eliminated by adjusting the relationship between the lead and tail crown on the paver screed. If this change does not solve the problem, the setting of the paver flow gates should be modified. Full-width tearing is normally caused by a cold screed, cold mix temperature, or by worn screed plates and can be cured by correcting the three primary causes of the problem.

Tearing of the mat affects the long term pavement performance by causing changes in mixture density in areas where the tearing has occurred. Torn areas may appear segregated and are usually deficient in mix quality resulting from pulling the mix under the screed. Thus, pavement performance will be reduced somewhat, depending on the severity of the tearing, in relation to the degree to which the tearing affects the density and air void content of the mat. In addition, torn areas may be susceptible to raveling caused by the rough texture of the mat in the area adjacent ot the tear.

NONUNIFORM MAT TEXTURE

Nonuniform mat texture can be described as differences in the appearance of the asphalt concrete mixture, both transversely and longitudinally, as the mix is placed and compacted. Normally, minor differences in surface texture will be apparent because of differences in the alignment of the large coarse aggregates particles as the mix passes out from beneath the paver screed. Additionally, a mix with a higher fine aggregate (sand) content will have a more uniform surface texture than a mix containing a larger percentage of coarse aggregate.

Many variables concerning the operation of the asphalt paver affect the uniformity of the surface texture of the mix. A variable amount of mix against the screed, caused by overloaded augers or running the hopper empty between truckloads, can cause variations in the amount of mix tucked under the screed and thus can produce a nonuniform texture. Improper screed maintenance, including screed plates being worn or loose, the screed riding on the tow point cylinders, screed extensions incorrectly installed, and low screed vibratory frequency, can signifcantly alter the mat texture and cause nonuniformity. A low mix temperature, caused either by plant problems or by the paver sitting too long between truckloads of mix, can also be a factor in obtaining uneven mat texture, especially, if the paver screed is also cold.

A good rule of thumb for the relationship between maxiumum aggregate size used in the mix and the minimum course thickness is that the depth of the layer should be at least two times the largest coarse aggregate size. Thus a mix containing a 3/4 inch top size aggregate should be placed at least 1-1/2 inches thick. If this relationship is violated, the mat texture will be severely affected. When the layer placed is at least twice the coarse aggregate size, the mat texture should be uniform. When the layer thickness is less than two times the dimension of the largest aggregate particles, tearing of the mat and nonuniform surface texture result.

A soft or yielding base under the course being constructed will cause a variable surface texture for the new layer. Segregation of the mix, caused by poor mix design or improper handling of the mix during the mixing, loading, hauling, unloading, or placing operations, can obviously contribute to a nonuniform surface texture. The variability of the texture will also be increased by any factors that cause nonuniformity in the mix, such as deviations in aggregate gradation, asphalt content, or mix temperature.

The causes of nonuniform suface texture are many, and thus, the solutions to the problems are many. Paver operation, particularly in regard to the need for a constant head of material in front of the screed, should be closely monitored. The paver and screed should both be well maintained and in good operating condition. The thickness of the mat being placed should be set so that it is at least twice the value of the largest coarse aggregate piece used in the mix. Finally, a mix that is tender, variable in aggregate gradation or asphalt content, or easily segregated should be modified to improve its characteristics before it is delviered to the paver for laydown.

Nonuniform surface texture usually goes together with nonuniform density. Areas where the coarse aggregate has been dragged by the paver screed will normally have a high air void content. Areas where segregation of the mix has occurred, causing a variation in texture, will generally have a lower density with the same compactive effort by the rollers. As density decreases and air void content increases, the fatigue life and serviceability of the asphalt concrete mat decreases remarkably.

SCREED MARKS

Screed marks are transverse indentations in the asphalt concrete mat. They occur when the paver stops between truckloads of mix. Depending on the tenderness of the mixture being placed, some screed marks are barely noticeable, while some can be very deep.

There are two basic causes for screed marks. The first is caused by "slop" or excessive play in the mechanical connections on the screed. If this is the problem, the screed marks will be visible each time the paver stops. The second cause of screed marks is the haul truck bumping into the paver when preparing to discharge the mix, and/or the truck driver holding the brakes on the truck when the paver starts to push the truck. In this case, the screed marks will appear only when the truck-paver interchange is improper.

The solution to screed marks is simple. If they are a result of the mechanical condition of the paver and the screed, the screed should be repaired. If the screed marks are caused by the truck bumping into the paver, the laydown operation should be altered so that the paver picks up the haul truck instead of the truck backing into the paver. In addition, the truck drivers should be instructed not to ride their brakes when the paver establishes contact with the truck. Screed marks are not detrimental to the durability of the mat. They do, however, affect the ride, creating a bump whenever the marks are visible.

SCREED RESPONSIVENESS

The paver and screed must be in good operating condition. The sensor for the automatic grade controls, if used, must be located according to the manufacturer's instructions. If the mix texture is uniform (indicating a proper relationship between course thickness and maximum aggregate size), the screed should be able to respond to changes in the settings on the thickness controls.

As the thickness control cranks on the screed are changed, the angle of attack of the screed is increased or decreased. As the paver moves forward to place the mix, the screed moves up to or down to the new equilibrium point for the new mat thickness. If the screed fails to respond to changes in the thickness control cranks, the operator is manually unable to alter the depth of the mat being placed. The paver also loses its inherent ability, through the principle of the floating screed, to provide the self-leveling action needed to place a smooth asphalt concrete mat.

An extremely fast paver speed will cause a lack of responsiveness of the screed. The mechanical condition of the screed affects the screed reaction. Loose screed plates, the screed riding on the tow point cylinders, or loose connections on the thickness control cranks will also cause the screed to be unresponsive. If automatic grade controls are used, an incorrect sensor location will cause the screed to be unable to react to input signals from the grade sensors. If the maximum aggregate size used in the mix is too great compared to the depth of mix being placed, the screed will ride on or drag the largest aggregate pieces. The screed, therefore, can not change angle and is thus unresponsive to changes in the thickness control settings. Variations in mix temperature also cause the screed to be unresponsive to angle of attack changes, since the mix stiffness variations themselves are causing the screed to continually seek new equilibrium points for the forces acting on it.

An unresponsive screed causes a rough asphalt concrete mat. The screed is unable to react to manual changes in the thickness settings. In addition, the screed loses its ability to level up an existing pavement surface by reducing the amount of mix placed over the high points in that surface and increasing the volume of material placed in the low areas. Thus, the rideability of the course being placed is significantly affected by the unresponsiveness of the paver screed, and the paver is unable to function as it should.

AUGER SHADOWS

Auger shadows are dark areas that appear in the surface of the mat behind the paver. They are rarely visible except in certain sunlight conditions. These shadows are caused primarily by overloading the augers on the paver. The intensity of the shadows will sometimes be increased when a tender mix is being laid.

The asphalt concrete mixture carried in the auger chamber should be maintained at a level near the center of the auger shaft. In no case should the bottom of the augers be visible or should the top of the augers be completely covered with mix. Similarly, keeping the augers from being over loaded prevents the development of auger shadows in the mix. Auger shadows are not necessarily detrimental to the mix except as they may affect rideability in a minor way.

PRECOMPACTION LEVELS

A modern asphalt paver is normally equipped with a vibratory screed. This type of screed, which has replaced the original tamper bar screed, allows the mix to be compacted as it passes beneath the screed. This precompaction, before the conventional compaction equipment rolls the asphalt concrete mixture, reduces the amount of compactive effort needed by the rollers before the proper density and air void content is reached. Some pavers are now equipped with combination screeds—screeds that have both tamper bars and vibratory mechanisms. At slow forward paver speeds, the degree of compaction achieved in the mix by the combination screed is typically greater than that obtained by the vibratory screed alone. At paver speeds greater than 25 feet per minute or so, however, the increased effectiveness of the tamper bar compactive effort is lost and the degree of compaction obtained is similar to that achieved with a normal vibratory screed.

The amount of precompaction obtained by the paver screed decreases as the paver speed increases. It increases, within limits, as the frequency of the screed vibration increases. This is to be expected since compaction should increase as the number of impacts applied on the mix surface increases (slow paver speed and greater frequency of impacts). Precompaction will decrease significantly, however, if the paver screed is riding on the lift (tow point) cylinders, thereby limiting the available compactive effort. The level of precompaction obtained will be further limited if the mat is too thin for the maxiumum aggregate size used in the mix, if the mix being placed is too cold, or if the base on which the new layer is being laid is soft and yielding.

Decreasing the paver speed and increasing the frequency of vibration of the paver screed should increase, within limits, the level of precompaction achieved during the laydown operation. Proper maintenance of the screed also helps obtain a uniform compactive effort from the screed. As long as the required density level is obtained using conventional rollers behind the paver, the absolute level of precompaction accomplished by the screed will not affect the long term performance of the asphalt concrete layer. It may be possible, however, to reduce the number of roller passes needed to make the density and air void content criteria if the amount of precompaction obtained by the screed is higher.

TRANSVERSE AND LONGITUDINAL JOINTS

Poor transverse joints are associated either with a bump at the joint or with a dip in the pavement surface several feet beyond the joint, or with both. Poor longitudinal joints between passes of the paver are usually characterized by a difference in elevation between the two lanes or by a raveling of the asphalt concrete at the joint, or by both. The area adjacent to the longitudinal joint seam is sometimes dished out. It is usually depressed below the level of the surrounding pavement surface.

The key to a good transverse joint is to start the paver with the screed sitting on blocks on the cold side of the joint. The thickness of the blocks in relation to the depth of the course being laid. The second factor is to do minimal, if any, raking of the joint. Finally, the joint should be compacted using normal compaction procedures. The key to a good longitudinal joint is the amount of overlap of the new mat over the adjacent cold material. If the overlap is only 1 to 1-1/2 inches, minimal, if any, raking is necessary and the compaction equipment will be able to densify the mix at the joint.

A poor transverse joint will not affect pavement performance to any significant degree if proper density levels are obtained by the compaction equipment. A poor ride will usually be the only negative result. An improperly constructed longitudinal joint, however, can seriously decrease the serviceability of the pavement structure. A poorly placed and compacted joint will ravel and cause one side of the joint to be lower than the other side. If the density level is too low, it is possible for the whole pavement layer thickness at the longitudinal joint to wear away under the action of traffic. A poor joint will also be porous, allowing water to enter the underlying pavement courses.

CHECKING

Checking can be defined as short transverse cracks, usually 1 to 4 inches in length and 1 to 3 inches apart, which occur in the asphalt concrete mat. These surface cracks, or checks, are not visible when the paver places the material. The cracks usually occur after the first or second pass of the compaction equipment over the mix. The checks do not extend completely through the course but normally are only 1/2 to 3/8 inch in depth.

Checking can be caused by two primary factors: (a) excessive deflection of the pavement structure under the compaction equipment and (b) a deficiency in the asphalt concrete mix design. In the former case, the pavement on which the new asphalt concrete layer is being placed is weak. The weight of the rollers causes the pavement layers to bend excessively, placing the new mix in tension. The check marks are then formed with the surface of the new mixture being pulled apart as the pavement deflects under the compaction equipment.

A more prevalent cause of checking is a deficiency in the asphalt concrete mixture. This is because of: (a) an excess of fluids in the mix—too much asphalt cement or too much moisture in the mix or both and (b) a nonuniform sand gradation—too much middle size sand (No. 10 and No. 40 sieve size material) and too little fine size sand (No. 80 and No. 200 sieve size material). The excess of fluids makes the mix tender and allows it to be easily displaced by the compaction equipment. The mix tends to be shoved by the roller instead of being tucked under the compaction rolls of tires. The hump in the fine aggregate gradation curve also causes the mix to be tender. This is characterized by a bow wave that occurs in front of the rolls on a steel wheel roller. The mix deficiency is compounded, and the amount of checking that occurs is increased, when the mix temperature is too high for the particular asphalt cement grade being used in the mix. As the mix temperature increases, the viscosity of flow of the asphalt cement decreases, causing an increase in the tenderness of the asphalt concrete mixture.

The wrong action to take for a checking problem is to back the breakdown roller off from the paver. By delaying compaction, the mix has a chance to cool and the viscosity of the asphalt cement in the mix increases. This, in turn, stiffens the mix and decreases the displacement by the rollers. If the mix is tender enough, because of excess fluids or a problem with the fine aggregate gradation, the mat temperature has to decrease to such a low point, before the rollers can get on the mix without checking it, that proper density is very difficult to obtain.

The proper solution to the checking problem, therefore, is to change the mix characteristics, not the rolling procedure. The mix changes may be simple—reducing the asphalt content, reducing the moisture content, reducing the mixture temperature at the plant, or all of these. The other changes, however, might be time consuming and expensive—changing the fine aggregate gradation to remove the hump from the grading curve in the area between the No. 10 and No. 200 sieves (usually between the No. 40 and No. 80 sieves). On a temporary basis, until the mix design can be altered, the mat can be compacted initially using a vibratory roller or pneumatic tire roller instead of a static steel wheel roller.

Because the cracks or checks extend only a short distance down from the surface, they are detrimental to long term performance only as the tender mix phenomenon affects the compaction operation. If the rollers are kept back from the paver to try to decrease the amount of checking and the level of density obtained by the compaction equipment is thus reduced, checking can decrease the ultimate pavement life significantly as the air void content of the asphalt concrete mat is increased.

SHOVING

Shoving of an asphalt concrete mat is the displacement of the mixture in a longitudinal direction. It can take place during the compaction operation or can occur under traffic. In many cases, shoving is accompanied by a large bow wave in front of the breakdown roller. Shoving may also occur together with mix checking. Finally, mat or mix shoving can happen at the reversal point of the rollers, especially at the location closest to the paver.

Shoving is caused by an unstable or tender mix. This instability can be due to the same variables that cause checking—an excess of fluids in the mix, a hump in the fine aggregate grading curve, or excessive mat temperature during rolling. A mix that has a high Marshall stability can still be a mix that will distort longitudinally under the compaction equipment or later under traffic. Shoving can be particularly prevalent when a sand mix is placed in a thick layer (over 1-1/2 inches thick) at a high temperature (over 280°F).

The cure for a mix that shoves under the compaction equipment is to increase the internal stability of the mixture. This can be accomplished by reducing the fluids content (either asphalt content or moisture content or both) of the mix. It can also be done by increasing the internal friction among the aggregate particles by changing the aggregate gradation or increasing the amount of angular (crushed) particles in the mix. Tender mixes should be placed at lower laydown temperatures consistent, however, with the ability to obtain sufficient density under the rollers. Sand mixes, because of their inherent tender nature, should be placed in several thick layers instead of one thick layer when used as base or binder courses.

Mats that tend to shove under the compaction equipment are basically unstable. These mixtures, under traffic, usually will continue to distort, both longitudinally and laterally. At stop intersections, this shoving is seen as waviness of the mat near the stop bar and sometimes even as forward movement of the mix under the painted stop line itself. Shoving of the asphalt concrete mixture during construction is a strong indication of the lack of adequate durability of the material under traffic.

FATS SPOTS AND BLEEDING

Fat spots in an asphalt concrete mixture are isolated areas where asphalt cement has come to the surface of the mix during the laydown and compaction operation. These spots can occur very erratically and irregularly, or they may be numerous and in a fairly regular pattern.

Fat spots are primarily caused by excessive moisture in the mix. The problem is more prevalent on mixtures that contain high percentages of fine aggregate (oversanded mixes) and on mixtures that contain aggregates that have a high porosity. If all the moisture in the coarse and fine aggregate is not removed during the drying and mixing operation at the asphalt batch or drum mix plant, the moisture will pull asphalt cement to the surface of the mix behind the paver as the moisture escapes from the mix and evaporates. Fat spots occur more frequently when the aggregate stockpiles are wet or when the moisture content varies in different parts of those stockpiles.

Bleeding of an asphalt concrete mixture occurs when the asphalt cement flows to the top of the mix surface under the action of traffic. Bleeding usually is characterized as two flushed longitudinal streaks in the wheelpaths of the roadway.

The cause of bleeding can normally be divided into two categories. The first cause is related to an excess of fluids in the asphalt concrete mixture, either aspahlt cement or moisture or both. Under traffic, the extra moisture and asphalt cement will be pulled to the surface by the suction of the vehicle tires. This bleeding phenomenon occurs usually on new mats and during hot weather when the viscosity of the asphalt cement is at its lowest level. Bleeding can also accompany pavement rutting. If, during construction, adequate density is not achieved in the mixture, traffic will cause densification and rutting of the mix with time. This traffic compaction process will decrease the air void content of the mix and may, in turn, squeeze asphalt cement out of the mix and to the surface of the roadway. The extra asphalt will appear as a longitudinal fat spot throughout the length of each wheelpath.

A wide fluctuation in the asphalt concrete mix temperature is an indication that the moisture content of that mix is also variable. This latter phenomenon can contribute to both the generation of fat spots in the mix during construction and bleeding of the mix later under traffic. It is important, therefore, that the aggregate used in the mix be dry and that the moisture content of the mix, upon discharge from the asphalt plant, be as low as possible (not more than 0.5%). Extra care in drying needs to be exercised when producing mixtures that incorporate highly absorptive aggregate. Bleeding problems caused by excess asphalt cement in the mix can most easily be solved by reducing the asphalt content of mix, consistent with other mixture properties such as air voids, voids in the mineral aggregate, and stability. Bleeding problems that occur in conjunction with pavement rutting may only be solved, however, by a redesign of the asphalt concrete mixture with emphasis on the air void content and the voids in mineral aggregate criteria.

Fat spots in the mix, if there are only a few of them, should not affect the ultimate durability of the mixture to a significant degree. A great number of fat spots or bleeding in the wheelpaths does affect pavement performance because of variable asphalt and air void contents in different parts of the mix. In addition, other mix problems, such as shoving and rutting, can occur in a mix that contains many fat areas or bleeding in the wheelpaths. The design of the asphalt concrete mixture, the operation of the asphalt batch or drum mix plant (more complete removal of the moisture), or both should be checked to assure adequate pavement performance under traffic.

COMPACTION AND ROLLER MARKS

Most asphalt pavers in use are equipped with a vibratory screed. Depending on such variables as forward paver speed, layer thickness, mix temperture, and ambient environmental conditions, the density of the asphalt concrete mixture measured behind the paver screed, before roller compaction, is usually in the range of 70 to 80% of the theoretical maximum density (a voidless mix). The purpose of the roller compaction process, then, is to increase the density of the asphalt concrete mat to at least 93% of maximum density (a 7% actual air void content). The type and number of rollers needed to achieve this level of compaction depend on the same variables as screed density as well as the operational characteristics of each particular piece of compaction equipment.

A discussion of the causes of poor compaction, or the lack of an adequate level of density, can be divided into two parts. The first concerns mix-design-related problems. Any of the mix deficiences that contribute to checking, shoving, or bleeding of the mix will also be a factor in the ability of the compaction equipment to reach the required density level. A mix that is unstable or tender because of excessive asphalt cement content, excessive moisture content, nonuniform aggregate gradation, rounded aggregate shape, or many other causes, will be a difficult mix to compact. A mix that has short waves or ripples in it will usually also have a variation in density level throughout the mat if the ripples are caused by mix related deficiences. For density to be obtained uniformily in the asphalt concrete layer, the mix design must be proper and the mix delivered to the paver at a consistent quality level with a minimum variation in mix characteristics and properties.

The roller operator will normally be unable to remove all the marks left by his compaction equipment if the mix is tender or unstable. A tender mix normally will not support the weight of the roller until the mix has cooled sufficiently for the asphalt cement viscosity to increase enough to stiffen the mix. By the time the mix has decreased in termperature to this point, however, the required level of density can no longer be achieved because the mix has lost its workability. For the same reason, the roller marks, or indentations, left during the breakdown roller passes usually cannot be rolled out during the finish rolling process. Roller marks left in the surface of an asphalt concrete mixture are an indication of tender mix problems and inadequate levels of density.

The second main cause of poor density is related to the operation of the compaction equipment. The variables that affect the ability of the roller to obtain density are the type of roller, the rolling pattern, the rolling zone (distance relationship of the breakdown roller to the paver), layer thickness, and environmental conditions. In addition, for vibratory rollers, the amplitude and frequency of the compactive effort affects the density level reached by that type of equipment.

The cures for inadequate compaction related to mix design deficiencies are all related to improvements in the design of the mix components and to the production of the mix at the asphalt plant. Asphalt cement quality and content, aggregate properties and characteristics, and mix temperatures all play a significant part in the workability and stability of the asphalt concrete material under the compaction equipment. The mix must, at the same time, be fluid enough to be workable and yet stiff enough support the weight of the compaction equipment without checking, shoving, or bleeding.

In terms of ultimate pavement durability, the air void content or density of the mix is probably the single most important characteristic that governs the performance of the asphalt concrete mixture under traffic. If the air void content of the mix is low (less than 7%), the pavement structure should perform well under vehicular loading, even with minor variations in mix design. If the level of density obtained during the compaction process is too low (too high an air void content), the mix will not be durable even with a perfect mix design and even without any other mat problems being present. If proper density can be and is obtained in the asphalt concrete material, the mixture will serve its intended purpose for many years.

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