CHAPTER 3
HMA PLACEMENT

Placing hot mix can best be described as a balancing act. Many forces and variables must be balanced together to produce a mat that is uniform, dense, and smooth. The screed’s operation is very simple in theory and, therefore, should be fairly simple in practice. However, a lack of understanding of the forces on the screed complicate the scene. Difficulties arise in trying to continually adjust a system that is continually trying to balance itself out. Proper operation of the paver involves more than just the mechanics of how the machine works. It also has to do with how the machine is used, dimensions of the final mat and the efficiency of the process. It is in the contractors and the agency’s best interests to pave as wide as possible (given the circumstances) for several reasons: wider paving means fewer pulls with the paver, fewer lane closures, and fewer longitudinal joints.

The operation of the paver requires careful attention to detail to ensure that the quality of the final mat meets or exceeds the specifications. There is a Standard Operating Procedure for starting up paving operations regardless of the type of paving being scheduled. In addition to a start up plan, there are specific practices that, if followed, will ensure the highest probability of success for the paving process. The objective is to place the highest quality pavement at the lowest cost per ton.

Tractor Unit

The purpose of the paver is to place the hot-mix asphalt to the desired width and thickness and to produce a satisfactory mat texture. The paver consists of two primary parts: the tractor unit and the screed unit. The tractor unit provides the motive power to the paver and transfer the asphalt mixture from the receiving hopper on the front of the machine to the spreading screws at the back of the paver.

The tractor unit fulfills all of the functions necessary to receive the asphalt mix from the haul trucks, carry the material back to the spreading screws, and distribute the mix across the width of the screed. It is composed of several major components including the track push rollers, mix-receiving hopper, material flow gates, twin slat conveyors, and a pair of screw conveyors or augers.

Drive System

The tractor unit is powered by its own engine and provides the required propulsion energy to move the machine forward, either on rubber tires or crawler tracks.
Rubber Tire

If the paver is moved regularly under its own power between paving locations, the rubber tire machine is normally used because its travel speed is much greater than that of the crawler track paver.

Track

The crawler tracks could be all steel, steel equipped with rubber pads, or flexible bands with steel shoes and rubber pads. If the paver is used on top of a yielding surface, the crawler track system will provide an increased area over which to spread and support the weight of the paver.

Screed Vibration Shaft with Weights

The applied amplitude is determined by the location of the eccentric weights on the shaft. The position of the weights can be altered to increase or decrease the amount of compactive effort applied to the mix by the screed (as shown in the figure at the left). Typically the amplitude setting selected is related to the thickness of the mat being placed - low amplitude for thinner lifts and higher amplitude for thicker lifts.
**Hopper**

The paver hopper is used to receive and temporarily hold the asphalt mix from the haul vehicle or the pickup machine.

**Shape, Capacity, Wings**

The hopper must be wide enough to allow the body of the haul truck to fit inside of it. In addition, particularly for smaller pavers, the hopper must be low enough to permit the truck bed to be raised without the bed placing excessive weight on the front of the hopper.

Some Contractors weld a diagonal wedge into the back corners of the hoppers to redirect the mix into the center of the hopper.

**Conveyor (slat conveyor)**

At the bottom of the paver hopper is a set of slat conveyors. Their purpose is to carry the asphalt mix from the hopper through the tunnel on the paver and back to the spreading screws. The slat conveyors are on either side of the paver, operating independently of each other. This allows the paver operator to control the amount of material fed to each side of the paver in order to pave ramps, mail box turnouts, or tapers.
Conveyor Flow Gates (hopper gates)

At the back of the paver hopper is a set of flow gates, one over each of the two slat conveyors. These are used to regulate the amount of mix that can be delivered by the conveyors to the augers. The gates move vertically, either by manual manipulation or mechanically. The flow gates should be adjusted to provide a uniform head of material (at a level of or just above the center of the auger shaft) in front of the screed.

Augers

Keep the amount of mix carried in the auger chamber as constant as possible. The proper depth of material on the augers should be at the center of the auger shaft. The level of material carried in front of the screed should not be so little as to expose the lower half of the screw conveyor flights. Further, the level of mix delivered to the screed should never be so great as to cover the upper portion of the auger, as shown in this same figure.

The mix that is carried to the back of the tractor unit by the slat conveyors is deposited in front of the screw conveyors or augers. Just as the two slat conveyors operate independently of each other, the augers on each side of the paver are run separately from one another.

The mix placed in the auger chamber from the slat conveyors is distributed across the width of the paver screed by the movement of the augers. At the junction of the two augers in the center of the paver, adjacent to the auger gear box, there typically is a different-shaped auger (reverse auger or paddle) to tuck mix under the gear box and assure that the mix placement at this location is the same as that across the rest of the width of the mix being laid. It is important that the augers carry a consistent amount of mix across the front of the screed so that the pressure (head of material) on the screed is kept as consistent as possible.
Material Feed System

If the feed system is set and operating properly, the slat conveyor and augers on each side of the paver will rarely shut off. This continuous action of the conveyors and augers is accomplished by setting the proper position for the hopper flow gates and determining the correct speed setting for the slat and screw conveyors.

The primary key to the placement of a smooth pavement layer is the use of the material feed system to keep the head (level) of material in front of the screed constant, primarily by keeping the slat conveyor and augers running as close to 100 percent of the time as possible.

Automatic Control

Sensor Types and Location

For the automatic feed control system to function properly, the feed sensor control arm should be located as close to the outside end of the augers as possible. If rigid paver screed extensions are used, as discussed later, the control arm should be mounted beyond the end of the augers, just inside the end gate on the paver screed.

Material Feed Sensor

For this system, a feed control sensor (a type of limit switch) is used to determine the amount of mix in the auger chamber. If the volume of mix available in front of the screed falls below the desired amount, the feed control sensor will move enough to engage the slat conveyor and auger system, pulling more mix back to the screed area. As the material is distributed in front of the screed, the feed control sensor will rise and disengage the feed system.

This action will maintain the pre-selected head of material in front of the screed. This sequence repeats itself, continuously maintaining consistent head of mix as long as material is available in the hopper. On some pavers, a variable-speed (potentiometer-type) feed system is used to control the amount of material in front of the screed. Instead of an on-off system, the speed of the delivery system is increased when more mix is needed and the speed of the slat conveyor and auger system (on each side of the paver) is decreased when the head of material in front of the screed is too great.
In addition to these limit switch-type and variable-speed systems, both ultrasound and infrared sensing devices can be used to determine the amount of mix in the auger chamber. These two types of systems operate on the same basis as the limit switch system; measuring the amount of mix in front of the screed and controlling the slat conveyor and auger feed system to maintain a constant head of mix at the screed.

**Tow Points**

The screed unit is attached to the tractor at only one point on each side of the paver. This point is called the tow point or the pull point by the different paver manufacturers. The tow point is really a pin-type connection that allows the leveling arms (also called side arms or pull arms) of the screed to rotate or pivot around the point. This pin connection reduces the transmission of movement between the tractor unit and the screed unit.

**Screed Unit (Review of Equipment and Function)**

**Paver Screed**

The second unit consists of the paver screed. This leveling device is attached to the tractor unit at only one point on each side of the paver and is able to “float” on the asphalt mix and provide initial texture and compaction to that material as it passes out from under the screed.
The screed unit, which is towed by the tractor unit, establishes the thickness of the asphalt layer and provides the initial texture to the new surface. In addition, the screed imparts some level of density to the material being placed through the vibratory or combination tamping and vibratory action of the screed. The principle of the free-floating paver screed was developed in the early 1930’s. That concept allows the paver screed which is attached to the tractor unit at only one point on each side of the machine (the tow or pull point), to average out changes in grade that are experienced by the wheelbase (rubber tires or crawler tracks) of the tractor unit. The floating-screed principle is employed on all of the modern asphalt pavers in use today.

**Screed Plate**

The screed plate is a formed piece of steel that bolts to the bottom of the screed. The screed plate is the only portion of the screed that develops the initial texture of the mat and can be adjusted. The center of the leading edge of a rigid screed has grooves cut into it to allow the screed to be flexed or warped.
Strike-Off (Pre-Strike Off)

The screed may be equipped with a device on its front edge that is called a strike-off by some manufacturers and a prestrike-off by others. The purpose of this device is to control the feet of the asphalt mix under the paver screed, thereby regulating the amount of mix that reaches the nose of the screed plate. Further, the strike-off or prestrike-off is used to reduce the wear on the leading edge of the screed. When the strike-off is attached to the front of the screed, its position becomes important relative to the ability of the screed to handle the asphalt mix properly. If the strike-off is set too high, extra material will be fed under the screed. This action will cause the screed to rise. The resulting increase in the mat thickness will be overcome by manually reducing the angle of attack of the screed, using the thickness-control cranks. This, in turn, will cause the screed to pivot around its hinge point and ride on its nose. Rapid wear of the nose plate will result. In addition, the screed will settle when the paver is stopped between truckloads of mix because the weight of the screed is carried only on the front part of the screed.

When the strike-off is set too low, the thickness of the lift will be reduced because of the lack of mix being fed under the screed. In order to maintain the proper thickness, the angle of attack of the screed must be altered, causing the screed to ride on its tail. This increases the wear on the back of the screed and also causes the screed to settle whenever the paver is stopped because of the concentration of weight of the screed on a smaller surface area.

Crown Control

The screed on the paver can be angled at its center to provide for positive or negative crown. The amount of crown that can be introduced into the screed varies. The adjustment of the crown is typically done using a turnbuckle device to flex the bottom of the screed and impart the desired degree of crown. Normally the lead crown setting is 1/32 to 3/16 inch greater than the tail crown position, with 1/8 inch being the average difference in the crown settings.
Screed Extensions and End Plates

Hydraulically Extendible

Most paver manufacturers have developed hydraulically extendable paver screeds that trail the primary or basic screed on the paver. One make of pavers, however, is equipped with a power extendable screed that places the extendable portion of the screed in front of the main screed. For all hydraulically extendable screeds, it is very important that the angle of attack for the extendable screeds is the same as the basic screed. If the extensions on the extendable portion of the screed are not properly aligned with the main screed, a longitudinal mark or ridge will occur in the surface of the mix at the junction between the two screeds. In addition to the longitudinal mark, a mismatch in the elevation between the two screeds can also result in a possible difference in surface texture in the mix. Finally, the lack of proper alignment between the two screeds can cause a difference in the degree of compaction that is obtained in the mix under the extendable screed. In addition, proper placement of the material feed sensor is important to avoid segregation problems.

Rigid Screed Extension

When the basic width of the paver screed (8 feet for small pavers and 10 feet for the larger machines) needs to be changed to accommodate increased paving widths, rigid screed extensions can be employed. These extensions come in several widths, usually 6 in., 1 ft., 2 ft., 3 ft. and 5 ft. sections. Further, it is very important that the extension be set at the same elevation and angle as the basic screed to prevent the presence of a transition line or ridge at the intersection of the main screed and the extension or between different sections of extension. Whenever a rigid screed extension is employed on the basic paver screed, auger extensions and the accompanying auger tunnel extensions should also be added. The length of all the auger and tunnel extensions should, in general, be the same length as the added screed extensions to allow room between the end of the auger and the end plate of the screed. Typically the distance between the end of the auger extension and the end plate should be about 18 inches.
**Hydraulic Strike-Off**

The hydraulic strike off is an option for most screeds and allows the screed to be extended for brief periods to form turnouts, ramps, etc. Either a strike off or mini screed approximately 6 inches is available to impart initial texture and compaction to the mix that passes under it. However, this texture and compactive effort are normally different from that which develops under the screed. In addition, the mix will need to be left higher than the screed placed mix.

The use of hydraulic strike-offs to place mainline paving instead of adding rigid extensions is not considered best practice.

**End Plate (end gate)**

An end plate (or end gate or edger plate) is attached to the end of the screed to restrict the outward movement of the mix around the end of the screed. In typical operating mode, however, the end plate is positioned tight to the surface being paved to retain the mix and control the width of material being placed.

**Cut-Off Shoes**

Cut-off shoes can be used, if necessary, to reduce the width of mix placed to a width that is less than the basic main screed width. Typically the cutoff shoes come in widths of 1 - 2 feet, and are adjustable in increments of 1½ - 3 inches, depending on the manufacturer.
**Thickness Control Screws**

The thickness-control mechanism, usually either a crank or a handle, allows the screed to be moved or rotated around the pivot point. As the mix passes under the screed plate, the screed floats on the mix, determining the mat thickness and the texture of the material as well as providing the initial compaction of the asphalt mix. For a constant position of the tow point (the tractor unit running on a level surface and without automatic screed controls), altering the setting of the thickness-control devices changes the attitude (angle of attack) of the screed and changes the forces acting on the screed. This, in turn, causes the screed to move up to, or down to, a new elevation as the paver moves forward, and thus alters the thickness of the mat being placed. The reaction of the screed to changes in position of the thickness-control settings, however, is not instantaneous.

**Screed Arm (tow arm)**

The screed is attached to the leveling or tow arms on each side of the paver through a hinge or pivot point.

The pivot point is located at the center of the wheelbase of the tractor. This allows the screed to use the tractor as a leveling device, much like a ski.
Pre-Compaction Systems

Early pavers were equipped with tamper bars that were located on the leading edge of the paver screed. These tamper bars were used to tuck the asphalt mix under the screed and to provide some degree of initial compaction to the mix as it passed under the screed. The tamper bar system was replaced by the more efficient vibratory screed system.

Two factors within the screed itself also contribute to the degree of compaction. The first is the frequency of vibration and the second is the amplitude of the compactive effort. The frequency of vibration is controlled by the rotary speed of the vibrator shaft. Increasing the revolutions per minute of the shaft will increase the frequency of the vibration. The applied amplitude is determined by the location of the eccentric weights that are located on the shaft. The position of the eccentric weights can be altered to increase or decrease the amount of compactive effort applied to the mix by the screed. In general, the vibrators should be used near the maximum possible frequency. On screeds where it is possible to change the amplitude of the applied vibrational force, the amplitude setting selected is related to the thickness of the mat being placed; lower amplitude for thinner lifts and higher amplitude for thicker lifts.

The amount of density obtained by the paver screed is also a function of the speed of the paver. The faster the paver moves, the less time the screed sits over any particular point in the new mat, and, thus, the amount of compactive effort applied by the screed decreases. For asphalt concrete mixes, it can be expected that approximately 70 to 80 percent of the theoretical maximum density of the mix will be realized in the mix when it passes out from under the paver screed. A few of the most recent pavers (and many pavers used in other countries) are equipped with combination screeds--both tamper bars and a vibratory screed.

Heating Systems

The screed is equipped with heaters or burners, the primary purpose of which is to increase the temperature of a cold bottom screed plate to approximately 300°F. It is necessary for the screed to be at the same temperature as the asphalt material passing under it in order to assure that the mix does not stick to the screed plate and tear, providing a rough texture to the mat. A properly heated screed, particularly at the start of the day's paving operations or after any extended shutdown of the laydown process, provides for a more uniform mat surface texture.

The screed heaters cannot be used to increase the temperature of the mix being placed because the amount of time that the mix is actually under the screed is much too short to accomplish any temperature rise in the mix.
Operational Principles of the Screed

Self-Leveling Concepts

As a roadway is being paved without the use of automatic grade and slope controls, the tractor unit moves upward and downward in response to the grade of the underlying material. The fact that it takes five times the length of the leveling arm before the screed completely reacts to a change in the location of the tow point allows the screed to reduce the thickness of the asphalt mix being placed over the high places in the existing surface and to place more mix in the low spots on the present roadway. It is this averaging or leveling action that forms the basis for the floating screed principle of the asphalt paver.

The use of automatic paver controls allows the paver to construct a smoother pavement by keeping the location of the screed pull or tow point constant relative to a predetermined reference as the tractor unit moves up and down vertically in response to small changes in the grade of the underlying pavement surface. This allows the screed to carry out the leveling action needed over a longer reference length in order to reduce the roughness of the existing surface through the application of the new asphalt layer.

Screed Response Versus Distance Traveled

After the tow or pull point has been raised it takes approximately five times the length of the leveling or tow arms on the paver screed for the screed to complete 99% change, up or down, to the desired new elevation. This means that if the length of the leveling arm is 9 ft., the paver would have to move forward for a distance of at least 45 ft. before the required input to the thickness-control device was completely carried out by the paver screed.

As an example, assume that it is desired to increase the thickness of the mat being placed from 1 in. to 1½ in. Approximately 63 percent of the thickness change is accomplished after the paver has moved forward a distance equal to one leveling arm length, or 9 ft. in this example. As the paver moves forward another 9 ft., about 95 percent of the elevation change is done by the time a distance of 27 ft. has been traveled (three leveling arm lengths of 9 ft. each). It is not until the paver has moved down the roadway a distance equal to at least five leveling arm lengths, however, that some 99+ percent of the thickness change has been completed. The same exercise holds for a reduction in the thickness-control settings at the screed.
The same principle applies to a change in the location of the tow point or pull point of the screed leveling arm where it is attached to the tractor unit. If the tow point is displaced, the change in elevation of the tow point is translated to a change in the angle of attack of the paver screed. The paver must still move forward for a distance of approximately five times the length of the leveling arm on the machine for the screed to react to the change in the location of the tow point and move up to or down to the new elevation.

**Forces Acting on Screed**

![Diagram of forces acting on the paver screed]

**Speed of Paver**

The first force acting on the screed is the towing force of the tractor. This force varies as the speed of the tractor unit increases and decreases. Because the speed of the paver has a major effect on the angle of attack of the paver screed, it is good paving practice to keep the speed of the paver as consistent as possible during laydown operations. Under manual material flow control and screed control, if forces on the screed remain constant except for the change in paver speed, an increase in the speed of the paver will cause the thickness of the asphalt layer being placed to decrease. Similarly, a decrease in the speed of the tractor unit will cause an increase of the thickness of the mat being laid. This will only occur, however, as long as no other changes are made in the system; the location of the pull points (tow points) of the screed remain at a constant level and the rate of feed of mix to the augers remains constant. As paver speed increases, if no additional mix is delivered by the slat conveyors to the augers, less mix is available to pass under the screed and the thickness of the layer would be reduced.

Under automatic material flow control, however, the volume of mix delivered to the augers would increase as the paver speed increased, maintaining a constant head of mix in front of the screed. In this latter case, the forces against the screed would remain balanced at the new speed and the thickness of the layer would be unchanged even as the paver speed was increased. Thus, through the use of automatic material-control devices on the paver, the head of material can be maintained at a constant level regardless of paver speed, and the layer thickness placed will remain constant.
**Head of Material**

The second force on the screed is the head of material pushing against the screed. As the amount of asphalt material in the auger chamber that pushes against the screed changes, the net force acting on the screed also changes.

The head of material is the most important force acting on the screed. Some paving experts maintain that 90-95 percent of paver-related problems can be solved by maintaining a uniform head of material during paving operations.

**Angle of Attack**

If the volume of mix in the auger chamber is increased, the force on the screed will also increase, causing the screed to rise. This action will then cause the angle of attack of the screed to decrease until a new equilibrium position is reached. If the amount of material being carried on the augers is decreased, the thickness of the mat will be reduced, all other factors being equal, as the screed falls. This results in an increase in the angle of attack of the screed until the forces on the screed are once again in equilibrium.

There is a potential for the head of material to be affected each time the slat conveyors and augers are turned off and on. This is true particularly if the head of material is not properly set initially. For this reason, the use of a proportional automatic feed-control system is very important, because this device keeps the slat conveyors and augers running as much of the time as possible, provided the floodgates are properly set. This, in turn, keeps the head of material relatively constant and allows the screed to place a mat of consistent thickness. A constant head of material against the paver screed reduces the occurrence of ripples and auger shadows.

**Pre-Compaction Force**

Most screeds in the U. S. use a vibratory system to impart initial compaction into the mix. The force will vary with the settings of amplitude and frequency along with the speed of the paver. Another drawback in speeding up the paver is that the pre-compactive force from the screed will decrease. This will require additional compactive effort from the rollers to achieve the specified density.
**Screed Weight**

Hydraulically extendable screeds weigh more than rigid screeds. On average a rigid, ‘wedge lock’ screed weighs about 3000 pounds and a hydraulically extendable screed weighs about 5000 pounds. As the extensions are extended the weight is transmitted over a larger area and the contact pressure approaches the same as a rigid screed. A heavier screed may aid in pre-compaction force, but may require a different initial settings than a rigid screed to place the same mat.

In summary, the three main forces acting on the screed are speed of the paver, head of material, and angle of attack. The head of material is the most important force. It is the result of balancing material feed systems, truck exchanges, and speed of the paver and will significantly affect the smoothness of the mat. Therefore, **KEEP THE HEAD OF MATERIAL UNIFORM!**

**Screed Control Systems**

If the paver always moved over a level grade, the forces on the screed would be constant as long as the paver was moving at a constant speed. The towing force on the screed would be stable and the head of material in front of the screed would be consistent as long as the feed control system was set to operate as much of the time (close to 100 percent) as possible. Under these conditions, a very smooth asphalt mat could be obtained from behind the paver without a screed operator ever changing the setting of the thickness-control cranks on the back of the screed. Indeed, once the angle of attack of the screed is set when the paver starts up in the morning, no changes would ever need to be made to the setting of the thickness-control handles.

In the real world, however, the tractor unit operates on a grade that is variable. As the elevation of the existing surface moves up and down, the wheelbase of the tractor unit (either crawler or rubber tire) follows that grade. This vertical movement of the tractor as it moves forward causes the elevation of the tow or pull point on the tractor to change in direct relation to the movement of the tractor unit. As the location of the tow point is altered by the movement of the tractor, the angle of attack of the screed is changed.

**Sticking the Mat**

On many projects, particularly those involving the resurfacing of an existing pavement, the screed operator is forced by the job specifications to maintain a certain yield of asphalt mix per square yard or station.

It is not uncommon to watch a screed operator continually check the thickness of the mat being placed by the paver and then adjust the setting of the thickness-control cranks to increase or decrease the amount of mix being placed. This change in setting of the thickness-control system is done without regard to the changes being made at the same time to the screed as the elevation of the tow point changes while the tractor unit moves forward over the variable grade.
Two inputs, then, are being introduced into the self-leveling system at the same time. The first input is the vertical movement of the tow point of the screed, which reacts to changes in the movement of the wheelbase of the paver. The second input is the manual changing of the thickness-control cranks by the screed operator. The input from the movement of the tow point and the input from the change in setting of the thickness-control device may be in the same direction as one another or they may be opposite to one another, even canceling each other out.

Sticking the mat is useful for training to understand screed response versus distance traveled, and occasionally to verify mat thickness. It is best practice to refrain from continually sticking of the mat during normal paving operations.

Note: Always allow adequate screed response time after changing thickness control screws or tow point position before making additional changes. (It takes five tow lengths of the paver before an adjustment is completed.)

**Automatic Controls**

The primary purpose of automatic screed controls is to produce a smoother asphalt layer; smoother than the paver can accomplish by itself and smoother than a screed operator can accomplish by continually changing the setting of the thickness-control cranks. The automatic screed control functions by maintaining the elevation of the screed tow points in relation to a reference other than that of the wheelbase of the paver itself.

The elevation of the tow point is kept at a constant elevation in relation to a given grade reference. The automatic system does not permit the relative position of the tow or pull point to change even though the tractor unit is moving up and down vertically in response to the roughness of the surface over which it is traveling. Thus, by maintaining the tow point at a constant elevation, the angle of attack of the screed is also maintained at a constant setting. This allows the screed to ride at a consistent angle, permitting the screed to do an even better job of reducing the quantity of mix placed over the high spots in the existing pavement surface and increasing the amount of mix laid in the low spots.
Automatic screed controls are employed to keep the elevation of the tow points on the paver at a more constant elevation relative to the reference being used. Deviations in the pavement surface are averaged out over the length of the reference (either a preset stringline or a long mobile ski). As the tractor unit moves up and down over the existing grade, the elevation of the tow point moves over a smaller range of elevations than if the relatively short wheelbase of the tractor provided the reference. Keeping the elevation of the tow points constant permits the screed to maintain a more consistent angle of attack. This provides for a smoother mat behind the screed.

**Grade Control**

**Types of Grade Reference**

Grade sensors are used to monitor the elevation of the existing pavement surface in a longitudinal direction. There are three basic types of grade references that can be employed to maintain the elevation of the screed tow point: (a) the erected stringline, (b) the mobile reference, and (c) the joint matching shoe.

Each type of grade control can be used alone on either side of the paver. Grade sensors can also be employed on both sides of the paver at the same time. This use of the references will average out the variations in the grade of the existing pavement surface on both sides of the lane being paved. The same type of grade reference can be used on both sides of the machine or a different type of grade reference can be mounted on each side of the paver; a preset stringline on one side and a mobile reference on the other side, for example.

Use of double grade references generally will not produce a uniform cross-slope for the new asphalt layer except if a preset stringline is used on both sides of the laydown machine. When a grade reference is used in conjunction with a slope-control device, the grade is typically positioned on the centerline side of the paver, with the slope controller determining the depth of the mat on the outside edge of the pavement.

**Stringline**

Theoretically, the use of an erected stringline should allow for the smoothest possible asphalt mat behind the paver screed. This method of supplying an elevation input provides the most consistent reference for the paver tow point. Thus, its principle advantage is that a predetermined grade can be matched very accurately if the controls are used properly. Practically, however, the use of the erected stringline has a number of drawbacks that may offset the theoretical increase in smoothness obtained by its use.
The elevation of the erected stringline must be set by a surveying crew. On horizontal curves, it is very difficult to use an erected stringline to control the grade of the new pavement layer. The string cannot be set in a curve, and therefore a series of cords must be used around the radius of the curve. If the string is not stretched tightly, the sensor wand on the paver, which can run either on the top or below the stringline, will react to the sags in the line and duplicate those sags in the new pavement surface.

Another disadvantage of the erected stringline is the fact that the haul trucks and all paving personnel must keep away from the line and not disturb it in any way. With a properly set and maintained stringline, the mat placed by a paver equipped with automatic screed controls can be very smooth and at the correct elevation. Unless smoothness, or compliance with a predetermined grade reference, is extremely important criterion on a paving project. However, it is questionable that the added price of erecting and maintaining the stringline is cost-effective for the typical hot-mix asphalt highway-paving job. Thus, for the vast majority of the highway-paving projects, an erected stringline is not used.

**Mobile Reference**

Different paver manufacturers use different types of mobile reference devices to extend the relative wheelbase for the automatic screed-control system. The operation of these reference systems, however, is essentially the same. One paver manufacturer offers a semi-grid tubular grade reference (pipe) that is 20, 30 or 40 ft. in length. For one version, the pipe or tube rides directly on the existing pavement surface. A spring loaded wire is stretched between the quarter points of the ski on top of the pipe.

The grade sensor that inputs the electrical signal to the paver tow point rides on top of the wire. The second variation employs the same semi-rigid tubular grade reference pipe with the spring-loaded wire, but it is equipped with numerous spring-loaded wheel assemblies attached to the pipe at 2½ ft. intervals. This version is similar to a floating beam.
**Joint Shoe**

The third type of reference is the joint matching shoe. This device consists of a short (approximately 1 ft.) shoe or ski that is used to reference the grade of an adjacent piece of pavement or curb. Because of its short length, the joint matching shoe will not remove any major variations that occur in the pavement surface. Indeed, the purpose of the shoe is to duplicate the grade of the adjacent surface.

When placing the second lane of a base course or a binder course layer, it may be better to use a longer mobile reference (a 30 ft. ski) instead of the joint matching shoe. The mobile reference will provide the input needed to construct a smoother pavement surface than will the joint matching shoe. For the surface course layer, however, the joint matching shoe may be used to assure that the elevation of the mix on both sides of the longitudinal joint is the same, although the use of a longer mobile reference is still better paving practice.

**Slope Control**

In most cases, paving that is done with automatic screed controls is accomplished with a combination of grade control on one side of the paver and slope control to determine the grade on the other side of the machine. The slope control operates through a slope sensor that is located on a cross-beam between the two side arms of the screed. One side of the paver screed is controlled by the grade sensor. The other side of the screed is controlled by the slope controller.

When slope control is used, the thickness of mat on the side of the machine (usually the outside edge of the roadway) that is controlled by the slope sensor could be variable in depth, depending on the condition of the existing pavement surface. The desired degree of cross-slope is dialed into the slope controller. Without regard to the grade of the existing pavement, the slope controller maintains a constant cross-slope regardless of the resulting thickness of the asphalt layer placed. If there is a high point in the present pavement surface, the slope controller will place less material over that location. If there is a low point in the existing pavement, the slope controller will allow the screed to deposit more mix in that location.
Types of Paving

Planning Layout of Pulls (optimal joint placement)

Planning is an important part of paving and should be done well before work is ready to begin. The paving plan should be reviewed in the pre-paving meeting and should focus on paving as wide as practical and keeping longitudinal joints out of the wheel paths in which the traffic will eventually travel.

Optimal joint spacing will place the final surface course joint in the center of the 4 in. lane stripe or slightly to the side. Temporary striping should also be placed as close to the final stripe location as possible.

Main Line Paving

Main line paving is typically 12 ft. wide, although wider widths are used to minimize joints. Typically, traffic is diverted to the adjoining lane, after one lane pass is completed traffic is rerouted over to the new mat and the adjoining lane is paved.

Use of Hydraulic Strike-Off

It is not best practice to use a hydraulic strike off to place main line paving, unless the texture and density are acceptable to the agency representative.
**Combined Mainline and Shoulder**

It is more common to see a paving mainline and shoulder combined, especially with the adjustable hydraulically extendable screeds. One screed extension can be used to place the shoulder and be set at a different cross slope than the main screed and the other extensions. When possible, this is good practice. It also eliminates another paver pass to pull the shoulder at a later date.

Caution: If a combination mainline shoulder pull is used, careful attention must be given to the layout of the temporary and permanent striping.

**Echelon Paving**

If echelon paving (two pavers running next to each other) is used, the construction of the longitudinal joint is similar to the building of a joint against a cold compacted pavement layer. No raking of the joint is needed. Properly lapped and properly compacted, it is usually difficult to see the longitudinal joint produced by the echelon paving process. In addition, use of this technique will normally result in the density of the longitudinal joint being equal to the density of the adjacent mat.

**Night Paving**

Night paving is commonplace in many urban areas. Additional attention to details is required at night for a number of reasons. Limited visibility, cooler weather, different crews and trucking personnel may be involved, and a host of other problems. A new mat looks different at night than during the day and may cause undo concern for inexperienced personnel. Safety is a big issue and all personnel must wear required safety vests. Construction equipment must be equipped with adequate supplemental lighting, especially the paver and rollers. Testing personnel need to be extra careful at night.
**Determining Paver Speed**

The first order in running a balanced process is determining the speed and capacities of the paver. Calculating paver production rate and speed is important. Making sure all the operators know at what speeds they are to operate at is even more important. The key is balance.

**Warming Up Paver and Screed**

The tractor must be warmed up and the screed must be heated prior to paving. This is a good time to give everything a last once-over to make sure you are ready.

**Positioning on Joint**

After the temporary joint is removed, cleaned, and tacked, the screed can be positioned. It is best practice to straighedge a cold joint in the longitudinal direction to ensure the new joint will be level with the previous mat.

**Overlap on Cold Joint**

As the screed is positioned on the joint, it should be placed far enough back so that the strike off is on the cold longitudinal joint.
**Aligning the Machine**

It is very important that the paver be aligned prior to the start of paving. Both transverse and longitudinal directions should be checked. Keeping the paver aligned during paving will also improve the joints (longitudinal and transverse).

**Steering Guide**

Pavers come with steering guides which help keep the paver in a straight line. Often, they are painted with orange paint to increase visibility. The guide should be positioned so the paver operator can clearly see the guide, the reference on the pavement, and a distance down the mat.

**Stringline**

The layout of the first pass of the paver will determine the layout of all subsequent passes. It is good practice to use a stringline, paint mark, or some type of reference to use as a reference for the steering guide. This is one case where a little effort up front will save a lot of headaches down the road. On subsequent passes, the reference may be the edge of the previously placed mat or a curb line.

**Screed Width Versus Mat Width**

The width of the screed must equal the width of the mat. For wider paving, this is easier for hydraulically extendable screeds, but may require extensions on a rigid type screed. On both screeds, however, the extensions must correspond to the main screed settings or else the mat will show line or texture problem.

**Nulling the Screed**

The screed is nulled as per the manufacturers instructions. It usually is accomplished by rotating the thickness control screw both directions until the screw exhibits some free play. This must be done on both screws, then each re-checked, as freeing up one side may induce some force in the other side.
Initial Screed Settings

**Angle of Attack**

The initial angle of attack is induced in the screed by turning the thickness control screws to increase the depth approximately one turn. This must be accomplished on both sides of the screed. Extensions will also need to be adjusted.

**Screed Strike-Off**

In general, the strike-off is located in the range of 3/16 in. to 1/2 in. above the bottom plane of the main screed plate. No compaction of the mix occurs under the strike-off.

Location is determined by screed type, mix type, and experience. When in doubt, use the manufacturer’s recommendations.

**Lead & Tail Crown**

When rigid extensions are used in conjunction with the main or basic screed, the crown being placed in the pavement by the paver can usually also be altered at any of the points where the extensions are joined. If a hydraulically extendable screed is being used with the paver, the crown can be introduced not only in the center of the main screed but also at the points between the basic screed and the hydraulic extensions.

Normally the lead crown setting is 1/32 to 3/16 in. greater than the tail crown position, with 1/8 in. being the average difference in the crown settings.

**Material Feed Sensor Location/Adjustment**

For the automatic feed control system to function properly, the feed sensor control arm should be located as close to the outside end of the augers as possible. If rigid paver screed extensions are used, as discussed later, the control arm should be mounted beyond the end of the augers, just inside the end gate on the paver screed.
The primary key to the placement of a smooth pavement layer is the use of the material feed system to keep the head (level) of material in front of the screed constant, primarily by keeping the slat conveyor and augers running as close to 100 percent of the time as possible.

**Grade and Slope Control and Settings**

The grade controller and reference system, usually a ski, are attached to the paver. As mentioned earlier, the location of the sensor will vary but is normally one-third to two-thirds of the distance of the leveling arm forward of the screed. When paving wide, the sensor is often mounted on the screed, forward of the leading edge, to minimize vibration to the sensor. After the screed is charged, the sensors are switched from standby to on, the two-point cylinder valves are opened, and screed lift cylinders are not engaged.

**Position of Tow Arm**

The tow points are adjusted to the starting position, usually in the middle of the stroke of the cylinder, or as needed for the project. If the project calls for the mat to start thin and taper to a thick section, the tow point should be positioned lower. If running manually, the tow points are pinned in place, and mat thickness adjustments are made with the thickness control screws.

**Charging the Hopper, Tunnels, and Screed**

Once all initial settings have been made, the paving is almost ready to begin. The first truck should be backed into place and dumped into the paver. Some use the second or third load of mix first because it may be hotter. The hopper should be flooded and the slat conveyors started to pull the mix to the augers. Enough mix should be run back to provide a uniform head of material across the width of the screed and just up to the auger shafts. Using too much or too little mix to form the head of material will cause problems later. If extensions are used, some shoveling may be needed to move mix into the extreme corners of the end plates. Remember, the key is to create a uniform head of material and keep it constant.

**Pulling Off Joint**

After the screed is charged, the sensors are switched from standby to on, tow point cylinder valves are opened, and screed lift cylinders are checked. Pull off the joint once the screed is charged and all settings are in place. This should start fairly rapidly and then move quickly to paving speeds. Some time will be needed to properly construct and compact the transverse joint. The procedure that builds the best joint, with minimal disruption to the team should be used.
Re-checking Settings

Once the paver has moved away from the joint and the screed is balanced, the settings must be checked. If settings need to be changed, they should be made while the paver is moving.

**Grade and Slope of Mat -**
- Is the thickness adequate? Is the cross slope right?

Remember, don’t stick and turn, stick and turn. Adjustments take time to be fully realized in the mat.

**Screed Lead and Tail Crown Adjustment -**
How is the mat texture?
- Does the lead or tail crown need to be adjusted?

**Screed Extension Adjustment –**
- Is there a mark or a texture difference between screed extensions?

**Truck Exchanges**

When changing trucks, whenever possible the transfer could be done without slowing down or stopping the paver. At slower paving speeds, it may be possible to make the truck exchange while keeping the head of material in front of the screed constant. This requires that the level of mix in the hopper be kept at a level, even with the bottom of the flow gates at all times. Using a windrow elevator or a material transfer device eliminates this problem.

If the normal paving speed is fast enough or the truck exchange is slow enough that the proper amount of mix cannot be maintained in the hopper (on the slat conveyor and on the augers) between loads, it would be better to stop the paver when the transfer of trucks occurs. As soon as one truck is emptied, it should pull away from the paver. The paver should be brought from paving speed to a stop as quickly and smoothly as possible without jerking the machine. The next truck should then be backed toward the paver, stopping short of the paver, 1 to 2 feet away. Without releasing the tailgate, the bed of a dump truck should be raised in the air, so that some mix can slide against the tailgate. The paver should be brought back to the pre-selected paving speed as quickly and smoothly as possible. The tailgate on the truck should be released as soon as the push roller on the paver makes contact with the vehicle tires, and the mix should be delivered to the paver hopper before the level of mix in the hopper drops below the level of the bottom of the flow gates. This procedure of stopping and restarting the paver quickly will minimize the change in the forces acting on the screed and will allow a near-constant mat thickness to be placed.

If dump-type haul trucks are used, quickly reducing the speed of the paver and then stopping the paver when a truckload of mix is depleted instead of keeping the paver creeping along until the next truck arrives at the hopper can construct a smoother-riding pavement.
**Speed of Paver**

Paver speed should be predetermined and set. A marker should be placed on the speed control to ensure the speed is maintained. The paver speed should be checked occasionally by marking, timing, and measuring on the pavement edge. Remember that the key to a good operation is balance and teamwork. Speeding up to empty a bunch of trucks does not help the situation. Remember, the roller operator may not be able to get density.

**Checking Yield**

An additional problem with a yield-type specification is the longitudinal distance used to determine the yield value. In some cases, yield is checked after every truckload of mix. This frequency of checking often leads to continual changes in the thickness-control cranks on the paver. Yield should only be checked periodically: the tons of mix placed over a distance of more than an hour’s duration of paving.

**Folding Hopper Wings**

The sides, or wings, of the hopper are moveable. Mix, if left to stand for a long period of time in the corners of the hopper, will cool and may appear as chunks of mix behind the paver. Thus, the mix is periodically moved from the sides of the hopper into the middle of the hopper by folding the wings (sides) and allowing the mix to be deposited into the area of the slat conveyors.

To minimize segregation, the paver operator should fold the wings as seldom as possible. The frequency at which the wings are dumped depends on the rate of delivery of the mix to the paver, the temperature of the mix, and the environmental conditions. The wings should be emptied before the mix that collects in the corners of the hopper cools so much that chunks are formed that cannot be broken up as that mix moves through the paver to the augers and under the screed. On colder days, the hopper wings will need to be dumped more frequently than on warmer days.

In all cases, the paver hopper should be at least partially full at the time that the wings are dumped into the center of the hopper; the amount of mix in the hopper should be approximately at the level of the bottom of the flow gates at the back of the hopper. The slat conveyors should not be visible at the time that the wings are raised. Keeping the hopper relatively full between truckloads of mix, keeps the head of asphalt mix in front of the paver screed constant and also reduces any segregation that might be present in the mix. In addition, the wings should not be “banged” repeatedly as they are emptied.
HMA Level in Hopper

The mix level in the hopper should always keep the tunnels buried above conveyor flow gate openings between truckloads. **Don’t run the tunnels empty!**

Auger Operation

Auger operation and conveyor operation should be adjusted to keep them running as close to 100 percent of the time as possible. If they need adjustments, check the location of the material feed sensor and/or the sensitivity setting.

Conveyor Flow Gate Position (Hopper Gate)

Adjustments may be needed to keep the augers and conveyors moving.

Raking/Luting

If the operation is set up properly, the transverse joints will need only minimal attention with rakes or lutes, and longitudinal joints will require at most only a slight bumping action. This will be discussed in more detail in the next chapter.

Some paving requires a great deal of handwork, i.e. many manhole covers, turnouts, etc. These take some time to do and the production schedules should account for this.
CHAPTER 3
HMA PLACEMENT
Study Questions

1. The paver consists of two primary parts: the tractor unit and the screed unit.
   A. True
   B. False

2. The rubber tired paver is typically used on jobs that involve regular movements of the machine to different locations.
   A. True
   B. False

3. The proper depth of material on the augers should be at the:
   A. fill mark on the auger shaft.
   B. top of the auger shaft.
   C. 2 inch mark of the auger shaft.
   D. center of the auger shaft.

4. The primary key to the placement of a smooth pavement layer is the use of the material feed system to keep a constant head (level) of material in front of the screed.
   A. True
   B. False

5. The screed unit is attached to the tractor at:
   A. two points on each side of the paver.
   B. three points on each side of the paver.
   C. one point on each side of the paver.

6. The screed on the paver can be angled at it’s center to provide for a positive crown.
   A. True
   B. False
CHAPTER 3
HMA PLACEMENT
Study Questions

7. The amount of density obtained by the paver screed is also a function of the speed of the paver.
   A. True
   B. False

8. The primary purpose of the heater or burner on the screed is to assist in reheating the asphalt mix to make up for heat loss during transit.
   A. True
   B. False

9. When changing the thickness control screws or tow point position, it takes __________ before an adjustment is completed.
   A. 15 minutes
   B. one tow length of the paver
   C. five tow lengths of the paver

10. When overlapping on a cold joint the screed should first be placed far enough back so that the strike-off is on the cold longitudinal joint.
    A. True
    B. False

11. When changing trucks during paving, it would be best if the transfer could be accomplished without slowing down or stopping the paver.
    A. True
    B. False

12. Auger operation and conveyor operation should be adjusted to keep them running as close to __________ percent of the time as possible.
    A. 90
    B. 80
    C. 95
    D. 100