Paving Principles & Control Methods

This chapter describes the components of pavers and the basics in paving principles, as well as control methods used for paving.

Paver Components

Modern pavers (Figure 2-1) consist of two major units: the Tractor and the Screed.

The primary function of the tractor is to propel the truck or paver feeding device, to convey and distribute the paving material and to tow the screed. The function of the screed is to strike off the material in preparation for further compaction. The screed is mounted to the tow arms at the screed pivot points and is attached to the paver at the tow points.

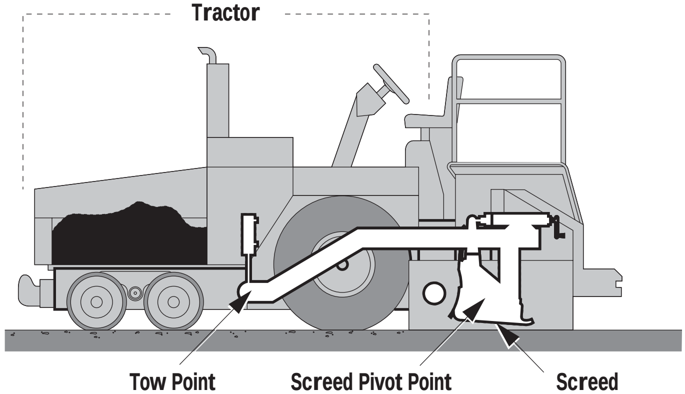

Figure 2-1. Paver Components

How a Screed Works

The screed on all modern pavers is of the “floating, self leveling” type. As the paver tows the screed unit forward, paving material flows under the screed. This causes the screed to float on the mat of material, thus establishing mat thickness. Since the screed is mounted to the paver only at the tow points, the screed is completely free to float up or down (Figure 2-2). The screed will always seek it's own “Planing Angle”, or angle of attack, dependent on the combination of forces acting upon the screed (Figure 2-2).

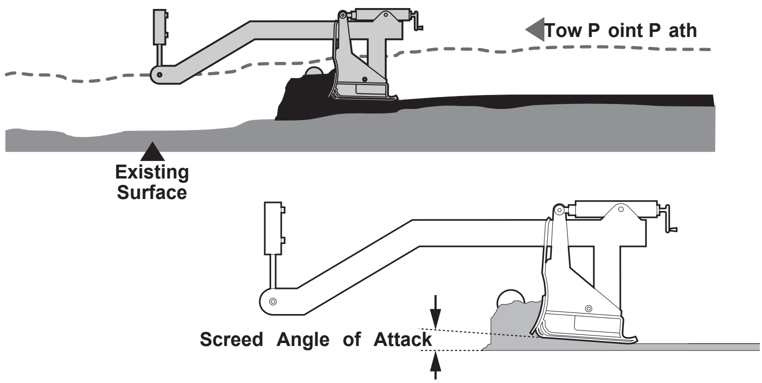

Figure 2-2. Tow Point Path and Planning Angle

- If the screed angle of attack is increased the screed rises, increasing the mat thickness (Figure 2-3).
- If the angle of attack is decreased, the screed will settle, providing a thinner mat surface (Figure 2-3).

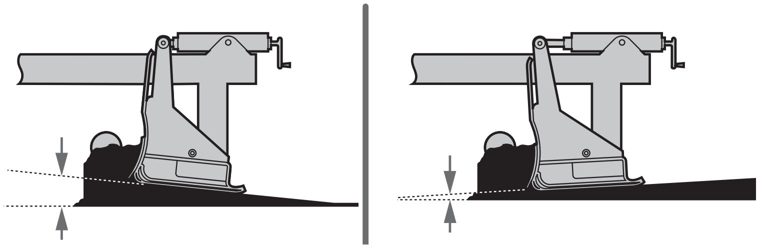

Figure 2-3. Screed Determines Mat Thickness

Because the screed floats, it will not immediately react to a change in the tow point. It needs a certain amount of time or distance to make a correction in the mat thickness (Figure 2-4).

- If the tow point is changed by a unit of one, the paver must move one tow arm length before the screed will correct 63% of the elevation.
- After 2 tow arm lengths 83% of the correction is made and 3 tow arm lengths would account for 95%.
- It takes 6 tow arm lengths to achieve 100% of the elevation change.

Considering that 95% of the change takes place after 3 tow arm lengths, this can be used in practical applications to qualify for full correction.

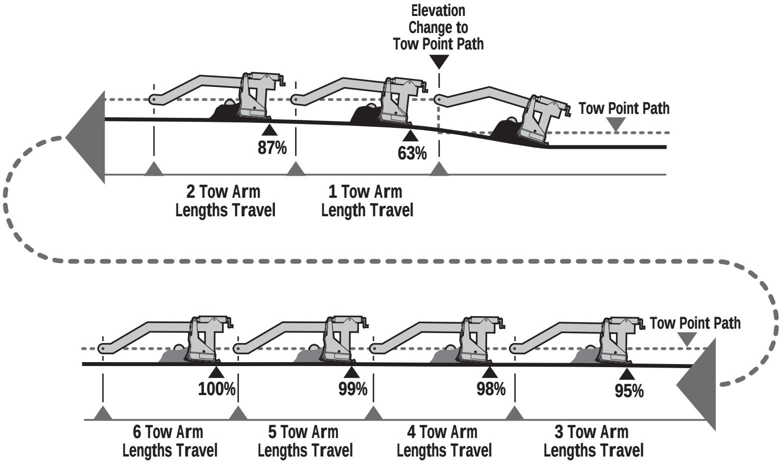

Figure 2-4. Tow Arm Travel

The same is true when making elevation changes with the manual thickness cranks (Figure 2-5).

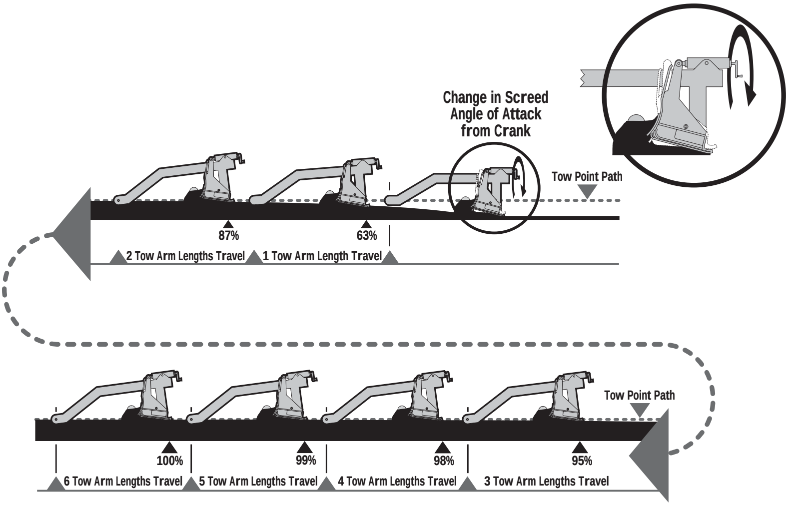

Figure 2-5. Manually Changing Mat Thickness

Always check mat depth in several locations before making any elevation corrections. The surface being paved may have wheel ruts, dips and ridges that will give an untrue indication of overall mat depth. Check several spots to get an average (Figure 2-6). If an elevation change is made, wait 3 tow arm lengths for full correction. Too much cranking and stabbing will cause raise and lower changes that will produce an uneven mat surface.

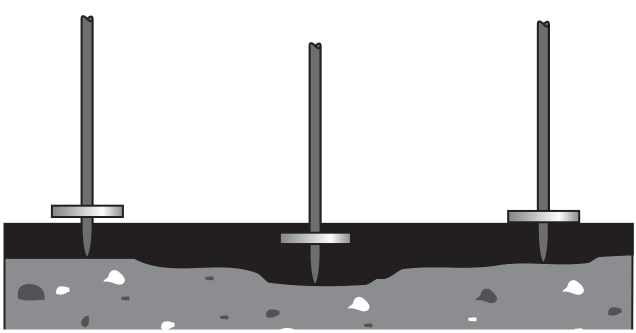

Figure 2-6. Checking Mat Thickness

The screed has four main forces acting on it at all times, whether paving in manual or with automatics (Figure 2-7). A change in any one of the forces will cause the screed to rise or fall, changing the mat depth. The key to smoother paving is to keep these forces as constant as possible. The following sections review these forces and the factors that will have an effect on the paving.

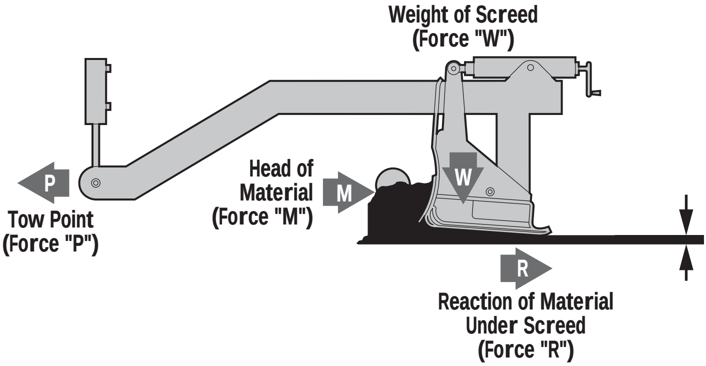

Figure 2-7. Forces Affecting the Screed

Tow Point Force (“P”)

The tow point force (P) is the resistance to forward travel (Figure 2-8).

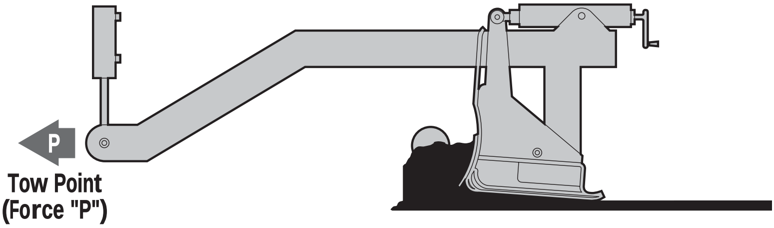

Figure 2-8. Tow Point Force (“P”)

The P force will remain constant if the paver is kept moving at a consistent speed at all times. If the paver is allowed to stop, the screed will settle in the fresh mat and leave a mark. The mark cannot be fully smoothed out by the roller and a bump will end up in the mat that will show up in the profilograph readings. Changing the speed of the paver will also cause the screed to rise and fall, affecting the mat thickness.

The optimum paving speed is determined by the depth and width being paved and the rate at which material can be delivered to the job. Calculate the tons/hour into feet per minute (Figure 2-9). Do not start and stop the paver.

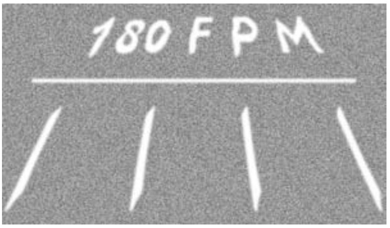

Figure 2-9. Travel Speed to Reduce Tow Point Force ("P")

Truck Exchange, Another Tow Point Force

It is very important that truck exchanges be carried out as smoothly as possible to avoid disturbing the smooth, uninterrupted forward motion of the paver. The following lists some steps to take to avoid disturbance of the paving operation by trucks.

1. Stop the mix delivery truck close, but not too short of the paver. Always allow the paver to pickup trucks on the run.
2. Never allow the truck to bump the paver. Allowing trucks to bump the paver when backing up, can drive the screed into the mat and produces bumps and ridges which may not roll out.
3. Trucks applying and holding their brakes excessively while dumping their load may cause the paver to slow, which in turn will cause the screed to rise. The truck driver should apply only light pressure on the brakes, sufficient to maintain contact with the paver.

4. Dumping of material in front of the paver as the truck pulls away after emptying its load into the hopper, can cause the paver to ride over the pile of material with subsequent adverse effects on mat quality. Avoid trucks pulling away prior to completely dumping all material. Use a dump person to monitor and regulate truck movements in front of the paver.

Head of Material (“M”)

One of the primary functions of the paver tractor is to convey and distribute paving material onto the ground in front of the entire width of the screed. This material, once deposited in front of the screed is the head of material over which the screed will pass.

One of the keys to smooth paving is to maintain this head of material as constant as is possible. The resistance to forward motion exerted by the head of material (M) is one of the major component of resistance to forward motion (Figure 2-10). Control of this force is a basic and necessary function of any paving operation.

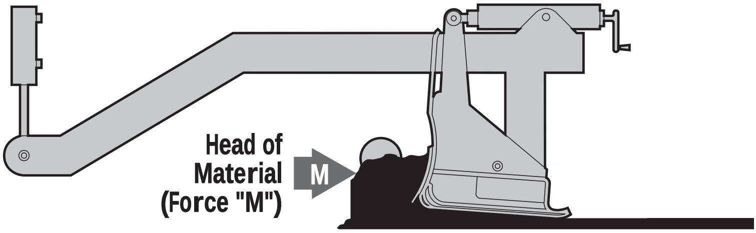

Figure 2-10. Head of Material Force (“M”)

The volume and consistency of the head of material determines how much paving material flows under the screed and influences mat thickness and surface texture.

The most common factor affecting force “M”, the head of material, is incorrectly adjusting the Automatic Feeder Controls.

These systems, whether of the “hanging paddle” type or the sonic sensor type, should be adjusted to operate the auger/conveyor assemblies 95% to 100% of the time. On/off operation of the auger system will cause fluctuation in the head of material.

The highest quality mat will generally result when a constant head of material is maintained across the entire width of the screed and the material almost covers the auger shaft. If the volume of paving material is too high, there is resistance to the travel of the screed. This causes the screed to rise and can result in ripples, auger shadows and long waves. It also results in increased auger wear (Figure 2-11).

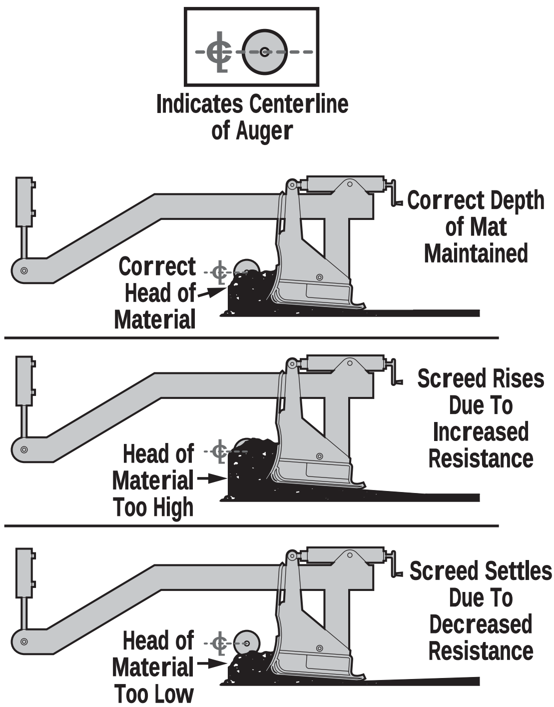

Figure 2-11. Head of Material Affects Mat

Reaction of Material Under Screed ("R")

Ideally, every truck load of material delivered to the paver would be exactly like every other load, with no variation. However, as a practical matter, changes in mix characteristics such as mix temperature, density, gradation, A.C. Content, segregation, etc., will affect the internal stresses developed within the mix, which in turn affects the resistance of the mix to flow under the screed (reaction of material under screed, "R"). The key element to bear in mind is that the screed passing over the paving material will compact the material to a certain degree. Variables in the resistance of the material to compactive forces will cause changes in the screed's angle of attack, which in turn will affect mat thickness and therefore mat smoothness (Figure 2-12).

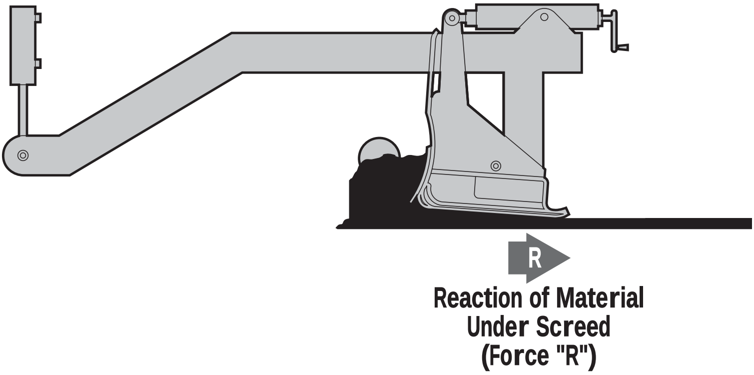

Figure 2-12. Reaction of Material Under Screed

Gradation Mix Characteristics

This aspect of the paving material will vary according to the intended use of the material as abase course, binder course or the final wearing surface. Normally, maximum aggregate size, ratio of aggregates, fines content and most importantly, asphaltic binder content, is specified by the contracting agency.

Adherence to mix design specifications is usually the responsibility of the material supplier.

Segregation is a material deficiency caused by a separation of the larger aggregate sizes from the bulk of the paving material.

This condition is encountered especially in mixes with relatively large maximum size aggregate (example: 1" and larger, the so called "large-particle" mixes). When paving material is deposited in piles, as in an asphalt plant silo, a haul truck, a paver hopper, on the ground in front of the paver in a windrow, or on the ground in the auger chamber, segregation can and does frequently occur.

NOTICE *NOTICE*

The areas listed above where segregation can occur are all areas that the material may encounter before being laid down as a mat. Therefore, these areas of segregation must be addressed prior to any paving. The screed cannot rectify segregation during the paving process.

Segregation can also be the result of improper hopper dumping.

During normal operation, the vibration of the pavers hopper will cause segregation. Therefore, dumping the hopper after each truck should be avoided because material that has rolled to the outside of the hopper (the large aggregate) will fill the conveyors and auger chamber and result in a segregated area behind the paver with a noticeable difference in surface texture.

<u>If It Doesn't Look Right, It Isn't Right:</u> Surface and texture irregularities indicate that the homogeneous characteristics

of the material in the mat have been interrupted, which usually results in bumpiness and premature failure of the pavement in those areas.

Segregation can also be the result of excessively worn augers: “Center Streak” segregation can be caused by worn “Kicker Paddles” at the center chain cause or near the outside auger bearings. In fact center streak segregation is frequently caused by incorrect arrangement of the auger segments adjacent to the auger chain case. (Consult the Manufacturers Manual).

“Center Streak” segregation is also caused by feeder gates being set to tow. Adjust as necessary to provide sufficient uniform material at the center of the paver.

NOTICE *NOTICE*

“Center Streak” segregation can be limited and even eliminated by slowing paving speed.

Mix Temperature Characteristics

A common paving problem is inconsistent temperatures in the asphalt mix. As the material cools it loses its viscosity making it more difficult to compact. If the resistance to compaction increases, the screed will naturally increase its angle of attack and begin to float up. This will change the mat depth, resulting in bumps in the surface. If the mix and or screed temperature are too low, the screed may no longer slide smoothly over the material and a tearing of the mat will occur.

<u>Simple steps to take to control temperature variations:</u>

1. Ensure that haul trucks take the shortest, most practical route to the paver. Make certain that all trucks take the same route to the paver.

2. Make sure that the trucks arrive at the same order in which they were loaded at the asphalt plant.
3. Ensure that no bunching of trucks occurs at the paver, with several trucks waiting to dump their loads.
4. Match lay-down rate to material delivery rate.

NOTICE

NOTICE

Temperature problems may occur will before the time the material is loaded into the trucks, or during the trip to the paver. They can be the result of temperature variations at the plant. If this is not addressed prior to delivery of material to the paver, waviness in the he mat will be the result.

Weight of Screed ("W")

For the weight of screed force "W" to remain constant, the weight of the screed or the downward pressure exerted by the screed on the paving material should not change (Figure 2-13). The weight of the screed is measured in pounds per square inch.

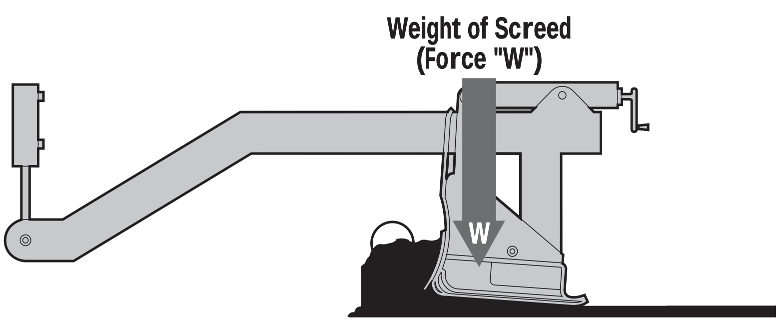

Figure 2-13. Weight of Screed

Members of the paving crew climbing on and off the screed will also have some affect on the weight of screed force.

The primary factor affecting this force is changing the width of the screed (Figure 2-14). Extendible screeds weigh the same whether they are fully retracted or fully extended. The difference is the wider the extension of the screed the greater the surface area of paving material to support. An extended screed has fewer psi, which means less compaction, causing the screed to raise.

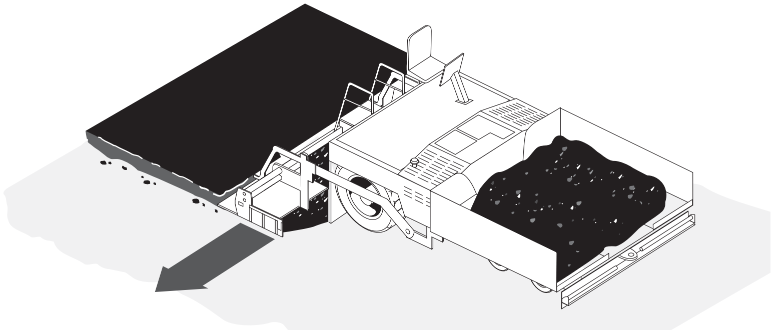

Figure 2-14. Width of Screed Affects Weight of Screed

Quality of Base Being Paved

There are factors other than the four main forces that can have an effect on the quality of the mat. An important one is the quality of the base to be paved. It makes more sense to build smoothness from the base up, than to try to smooth a road in the last lift of paving. However, on overlay paving jobs we have to work with what we have.

Remember that a mat which appears smooth immediately behind the paver, may actually contain areas of considerably varying thickness of material as a result of undulations in the base being paved. Due to the principle of "Differential Compaction" high spots will not compact as much as the low, therefore allowing some of the irregularities to be rolled back onto the mat (Figure 2-15 on page 2-14). To minimize this problem, lay a leveling course in the low spots or pave multiple lifts to average out the irregularities.

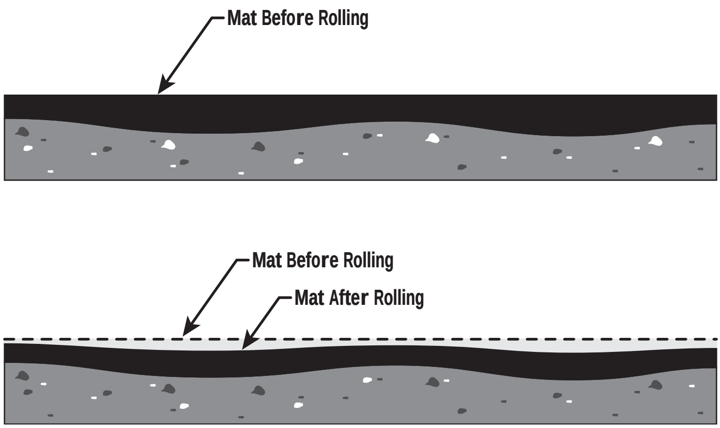

Figure 2-15. Differential Compaction

Rolling Techniques

A well laid mat can end up with a poor ride quality if proper rolling methods are not followed. Consult your compaction equipment manufacture's manuals and handbooks on compaction techniques.

Controlling Mat Quality

The primary purpose of the asphalt paver is to place a smooth mat of material. The primary function of System Five is to control the vertical position of the screed in relation to the surface being paved. Automatic grade and slope control systems can help tremendously in controlling mat smoothness but mat quality is also dependent on the following factors:

- Non-stop, continuous operation of paver
- Constant speed of paver
- Truck exchange
- Head of material

- Mix characteristics
  - Gradation
  - Segregation
  - Mix Temperature
- Screed Compaction
- Quality of Base Being Paved
- Rolling Techniques

NOTICE *NOTICE*

Changes in any of these factors will cause a change in mat thickness, density, surface appearance and mat quality. If changes must be made, make them as gradually as possible. Abrupt changes in any of the above factors will produce rapid changes in mat thickness, adversely affecting mat quality.

Control Methods

The following sections describe the three types of control possible with the Pave System Five: sonic, laser, and slope.

Sonic Control

The Sonic Tracker II™ measures and controls the elevation of the screed, controlling grade from a physical grade reference, such as a curb, stringline, or existing road surface.

A transducer, located in the bottom of the Tracker, generates 39 sound pulses per second and listens for returned echoes like a microphone. As soon as the Tracker sends out a sound wave, it starts a stop watch. The sound waves go down, bounce off of a physical reference, and reflect back to the Tracker. The Tracker measures the time it takes for the sound wave to return to the

Tracker. Knowing the speed of sound, the Tracker accurately calculates the exact distance to the grade reference (Figure 2-16).

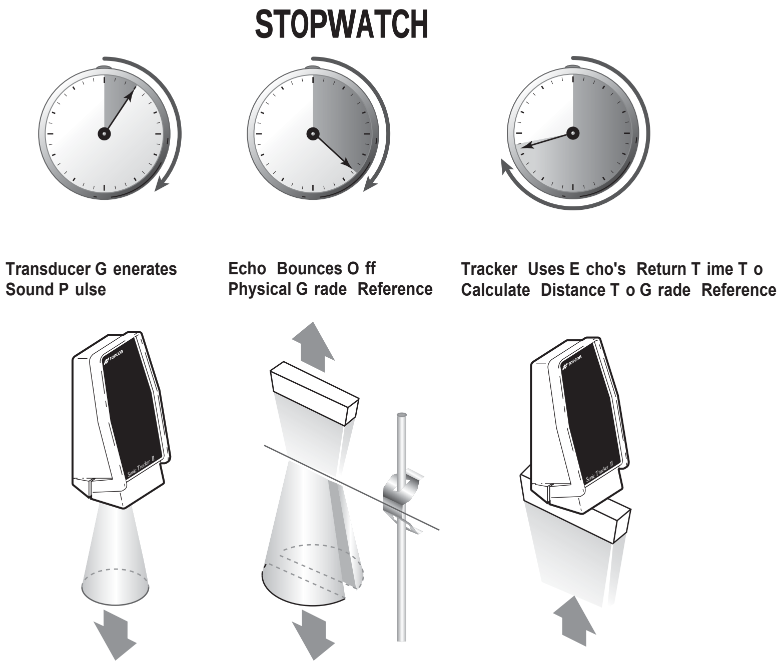

Figure 2-16. Timed Sound Pulses Determine Distance

Working Window and Sonic "Footprint"

Built into the Tracker is an operational zone, or Working Window, 2.4 inches above and below the grade reference (Figure 2-17 on page 2-17). The grade lights on the Sonic Tracker and Control Box continuously display this grade information to the operator.

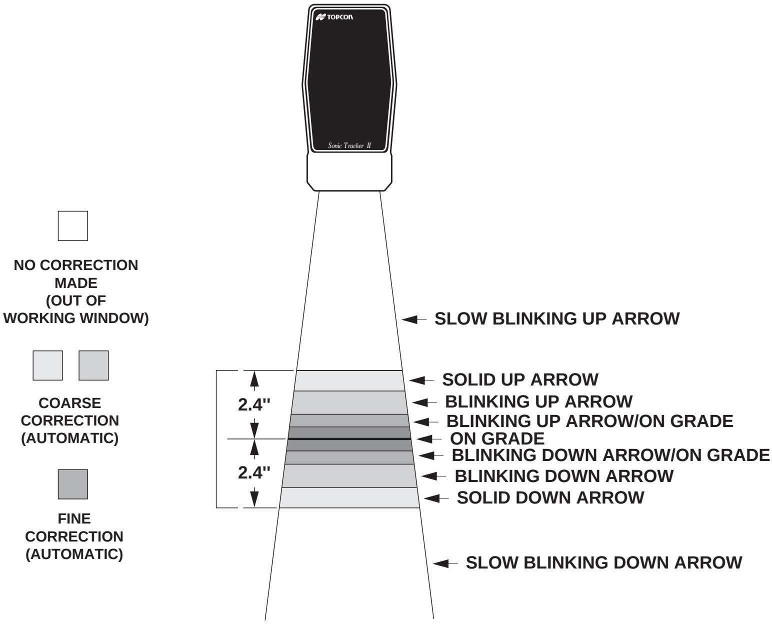

Figure 2-17. Sonic Tracker Working Window

When setting up the Tracker over a grade reference, the size of the Sonic Cone or the “footprint” needs to be considered (Figure 2-18 on page 2-18). As an example, at about 2 feet from the tracker, you will have a footprint or cone of about 6 inches.

As the Tracker is positioned closer to the grade reference the working footprint decreases in size. As the Tracker is moving farther away from the grade reference the sonic footprint or cone will increase in size.

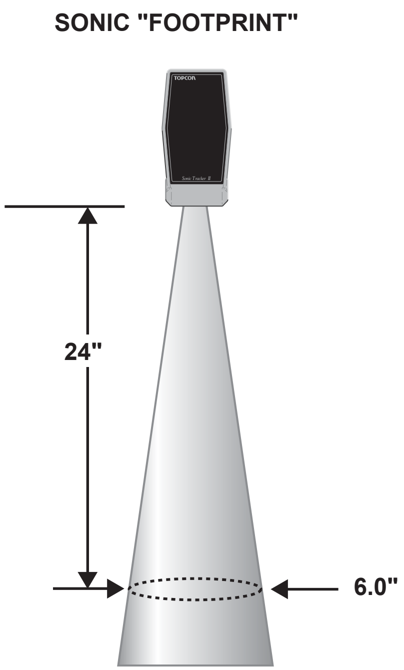

Figure 2-18. Sonic Tracker “Footprint”

Sonic Tracker Operation and its Position

On the paver, the Sonic Tracker II will be positioned above the grade reference to maintain an exact distance from the tracker to the reference (Figure 2-19 on page 2-19). If the Tracker is on-grade, the mat being laid will be at the desired depth.

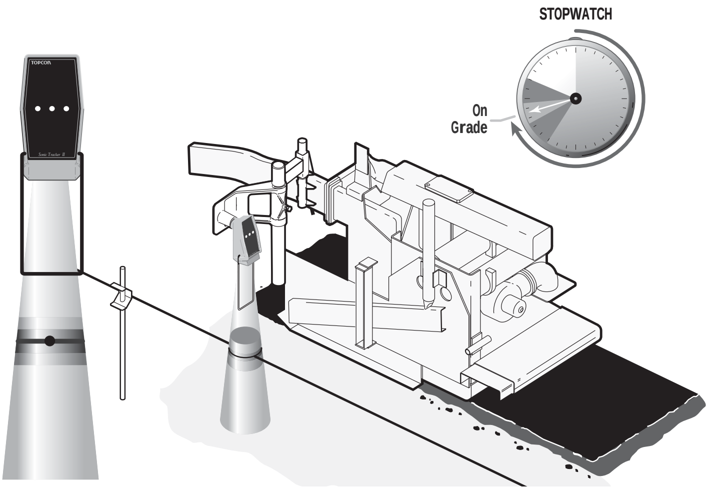

Figure 2-19. Sonic Tracker On-Grade

If the screed and the Sonic Tracker II start to raise, the watch stops at a longer time (Figure 2-20). The Tracker and Control Box will indicate a down correction arrow, and lower hydraulic valve corrections are applied to bring the Tracker back to on-grade.

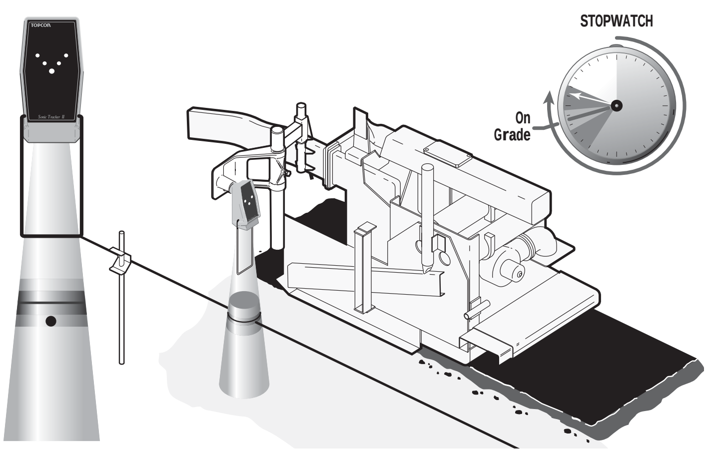

Figure 2-20. Sonic Tracker above Grade

If the screed and Sonic Tracker II are lowered, the watch stops at a shorter time (Figure 2-21). The Tracker and Control Box indicate a raise correction arrow, and raise hydraulic valve corrections are applied to bring the Tracker back to on-grade.

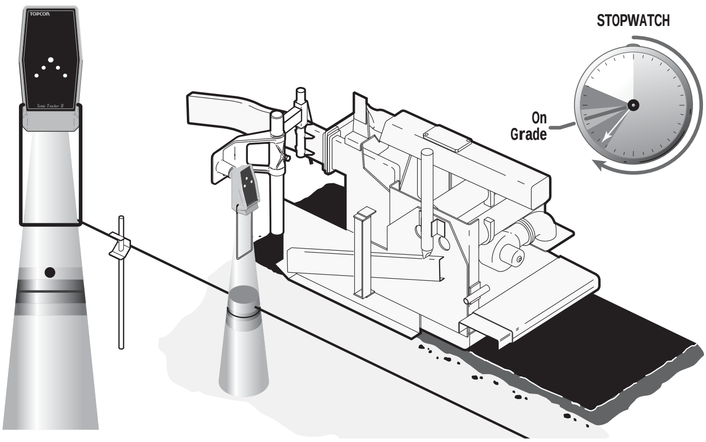

Figure 2-21. Sonic Tracker Below Grade

If the Sonic Tracker II is side shifted off a stringline, the sound waves reflect off the ground and the Tracker's stopwatch indicate a longer time (Figure 2-22 on page 2-21). The Tracker is out of the Working Window, and no on-grade corrections are applied.

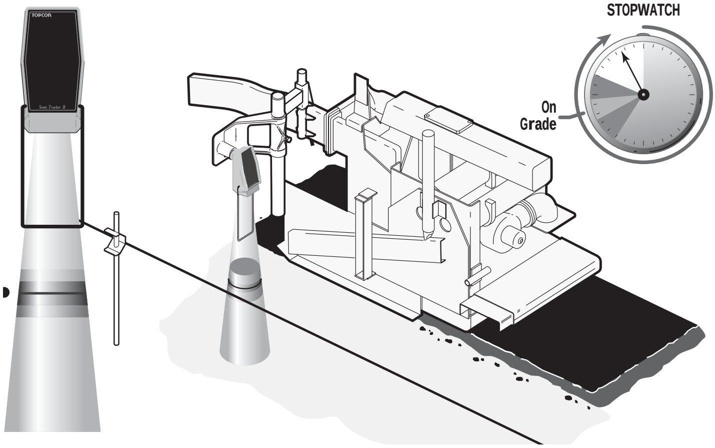

Figure 2-22. Sonic Tracker Scanning Outside of Stringline

If the Tracker sees an obstruction closer than the reference signal, such as a grade pin, the watch stops at an even shorter time (Figure 2-23). The Tracker is out of the Working Window, and no on-grade correction signals are applied.

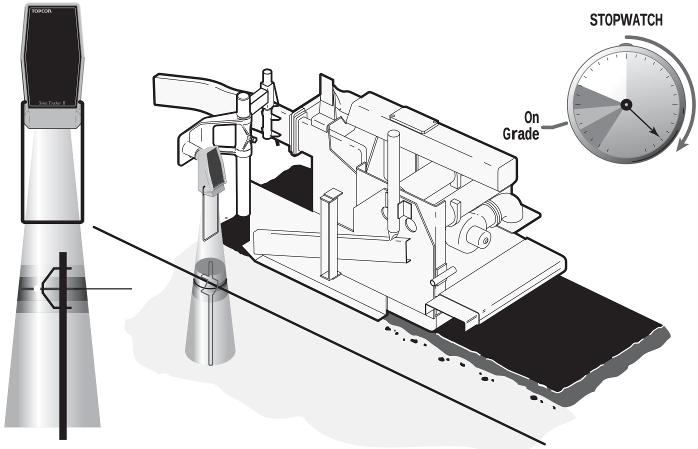

Figure 2-23. Obstructions within the Sonic Tracker's Working Window

Sonic Tracker and Temperature Changes

Since temperature affects the speed of sound, the tracker has a built in temperature sensor for applications with gradual temperature changes such as on graders or dozers. In paving applications you can get a more dramatic and rapid change in air temperature. To compensate for these variations a temperature bail is positioned below the tracker.

When the Sonic Tracker's transducer emits a sound wave, the tracker records the time to the bail and continues to listen for the grade reference. If a temperature variation occurs, such as heat off a freshly paved mat, a difference in time to the temperature bail is recorded. The correction for the speed of sound is then applied to the grade reference signal, preventing a change in mat depth. The tracker corrects for temperature variations with every sound wave, 39 times per second. Figure 2-24 illustrates this concept.

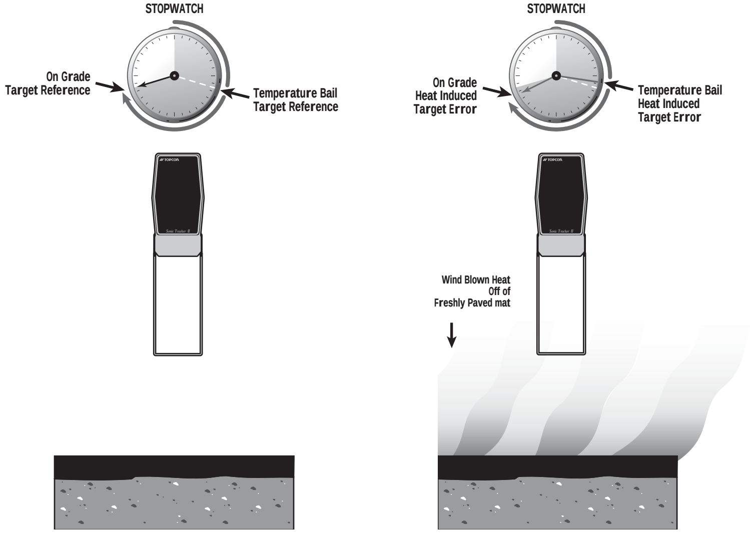

Figure 2-24. Working with Sonic Trackers and Temperature Changes

In the upper right hand corner of the Sonic Tracker II faceplate is a small symbol used to represent the use of the temperature bail. The LED symbol automatically illuminate when the bail is connected to the tracker. The tracker is cast with holes on each side for the bail to snap and lock into place (Figure 2-25).

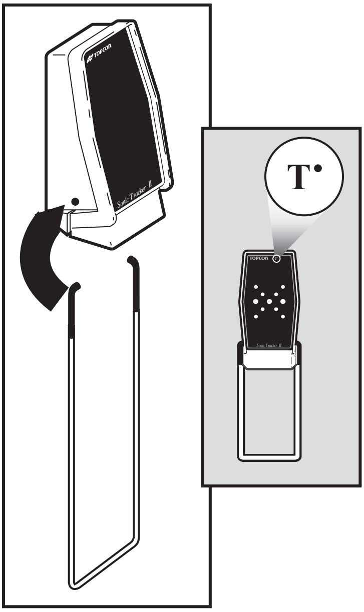

Figure 2-25. Sonic Tracker and Components

Laser Control

For Laser Control a laser transmitter is used to produce a plane of light which becomes the grade control reference for the job site. The laser receiver will control the screed to lay a mat parallel to the laser beam reference.

When the laser beam is in the center of the receiver, it indicates an on-grade signal (Figure 2-26).

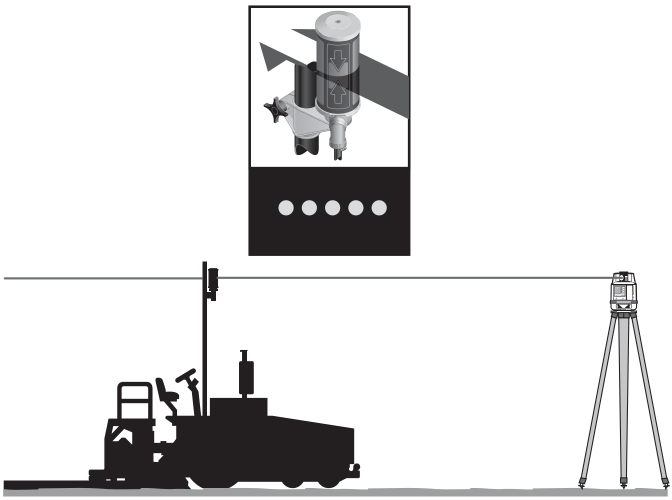

Figure 2-26. Laser Control – On-Grade

As the screed is raised, the beam of light hits the laser receiver below the center and a lower signal is indicated (Figure 2-27 on page 2-25).

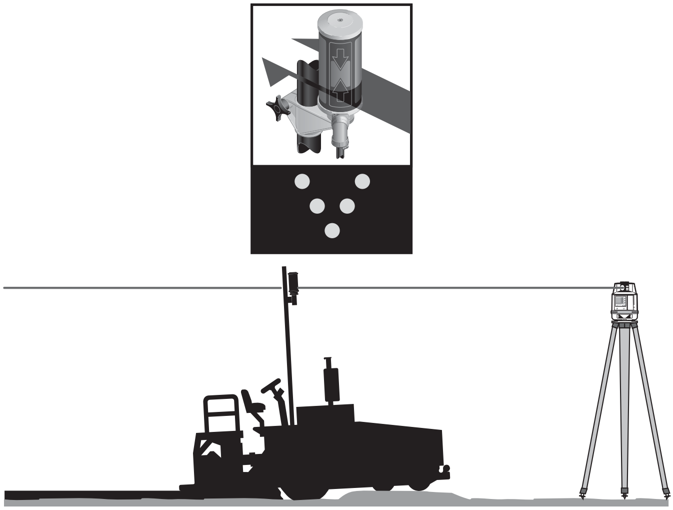

Figure 2-27. Laser Control – Above Grade

As screed is lowered the beam of light hits the Laser Receiver above the center a raise signal is indicated (Figure 2-28).

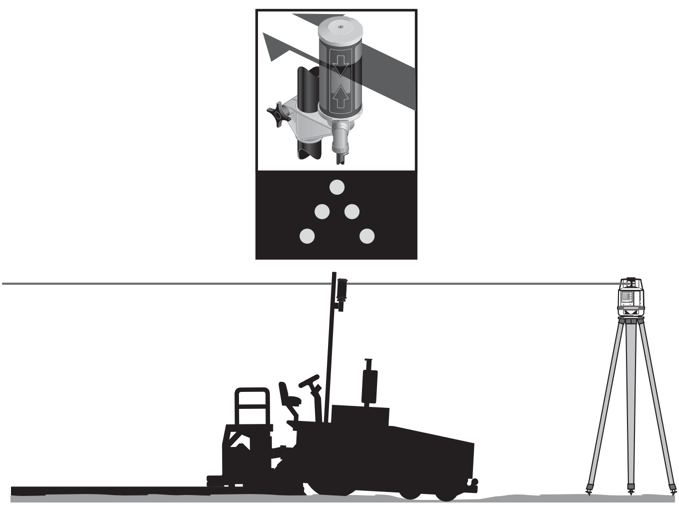

Figure 2-28. Laser Control – Below Grade

Slope Control

System Five uses a slope sensor mounted to the transducer beam on the paver to measure and control the slope of the mat being laid (Figure 2-29). The sensor contains an electronic level vial, that acts as a “precision carpenter's level”. Slope control with this electric level vial is very accurate and repeatable.

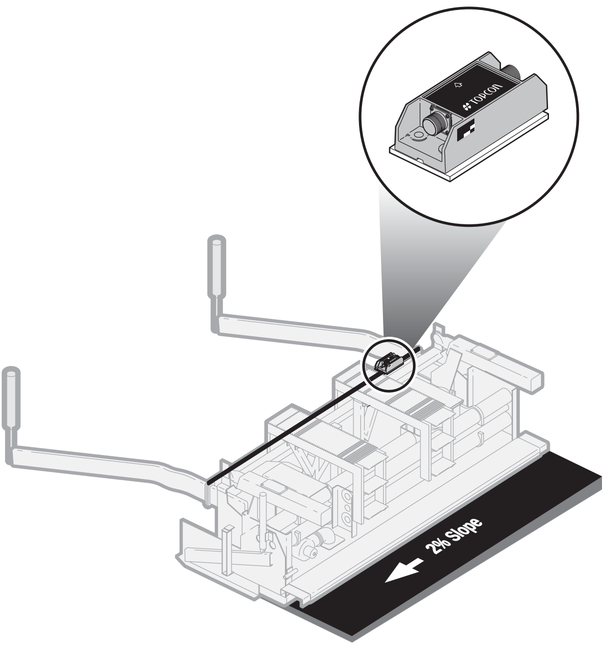

Figure 2-29. Position of Slope Control on Paving System

If the required slope changes, the screed operator dials the new slope into the System Five Control Box (Figure 2-30). The tow point cylinder on the slope side will raise or lower until the slope sensor measures the new slope.

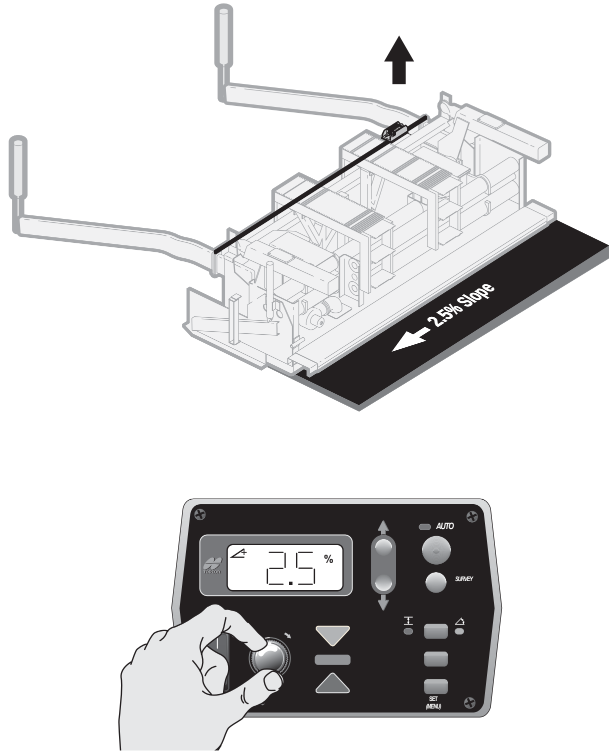

Figure 2-30. System Five Box directing the Slope Sensor position

Notes:

Stringline Setup

Sonic Stringline provides an inexpensive, easy to set up, continuous reference that takes the best advantage of the non-contacting feature of the Sonic Tracker II™. Stringline takes a few minutes to setup, and becomes a constant grade reference. The stringline also becomes a visual reference for the job, allowing any mistakes in a hub elevation to be quickly spotted by sighting down the string.

Sonic stringline is both a reference and an averaging solution.

- As a reference, surface and elevated stringline provides consistent results for level and sloped surfaces.
- As an averaging solution, surface stringline takes the place of averaging skis.

The sonic stringline setup consists of readily available materials and up to 500 feet of nylon stringline. Topcon's Sonic Tracker II works with many sizes and types of stringline, for best results use an 1/8 inch diameter nylon stringline.

NOTICE *NOTICE*

Using steel wire or a plastic coated stringline with a smooth surface can provide erroneous results.

For a review of how the Sonic Tracker II works, see "Sonic Control" on page 2-1. If the Sonic Tracker tracks the ground but not a 1/8 inch diameter stringline, clean or replace the transducer. See Chapter 7 for this procedure.

Setting Surface Stringline

Surface stringline provides a low-impact reference and averaging solution for steering and grade control. Because it rests close to the surface, trucks and other traffic can drive over the stringline without causing control problems and reference damage.

As a grade reference, Pavers use the Sonic Tracker II to track the stringline, producing a consistent and constant cut. When sighting down the stringline, problem areas can be spotted, and marked or fixed, before paving begins.

Surface stringline replaces a contacting averaging ski when a reference is unavailable or impractical. Averaging skis average out the irregularities of the surface being cut, but can be impractical, bulky, complex, and fragile. Surface stringline is simple, more practical, and easier to maintain than an averaging ski. When stretched over the ground, surface stringline levels the high places and bridges the low (Figure 3-1), creating a natural average over a distance as long as 500 feet.

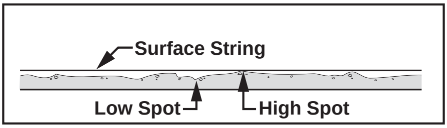

Figure 3-1. Surface String Averaging

Surface stringline is a verifiable reference for any job, replacing cumbersome averaging skis. In coordination with the Sonic Tracker II, stringline acts as 5 to 500 foot long, virtual, and more accurate, averaging ski.

Sometimes, the surface to be milled contains pot holes or surfaces too broken to use as a joint match reference Setting elevated stringline would be too time consuming, especially for small, divided projects. In these applications, surface stringline provides a simple, easy alternative.

Position the tracker 14 to 18 inches above the stringline (Figure 3-2).

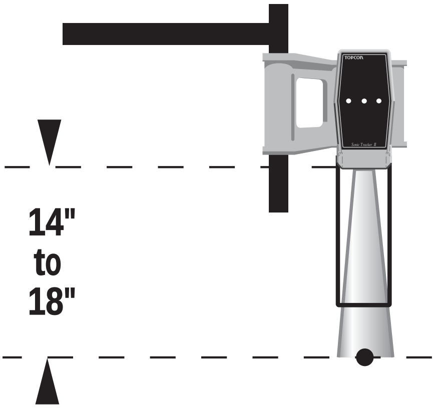

Figure 3-2. Position of Tracker in Correlation to Stringline

NOTICE

It is important to use a stringline with a diameter at least 1/8” thick. The sonic tracker can detect a smaller diameter stringline, but when stretched on the surface to be paved the surface below the stringline will be within the working window so you want to make sure you have a strong return signal.

To setup surface string in two simple steps:

1. Drive a concrete nail into the existing surface to be cut (Figure 3-3) and tie the stringline to the concrete nail.

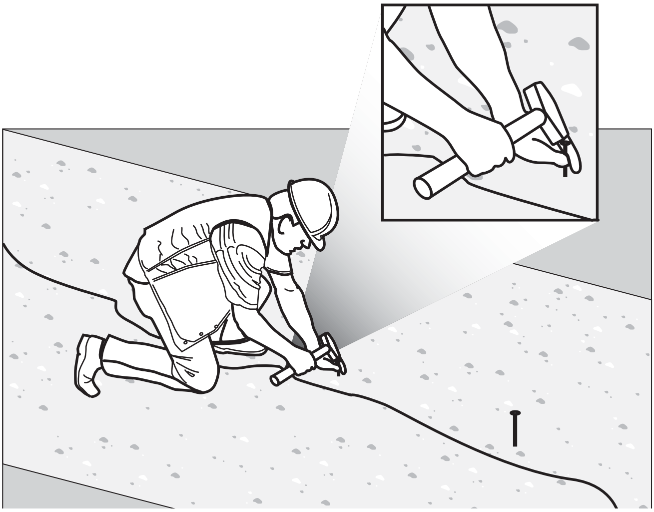

Figure 3-3. Setup Concrete Nails

2. Roll out the stringline to the desired length. Pull tight and secure to another nail at the opposite end. The tightened stringline rests on top of the existing surface (Figure 3-4).

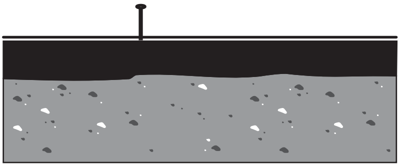

Figure 3-4. Stringline Reference

- When the sonic tracker sends out a sound wave, the first thing the tracker sees will be the reference stringline.

- Since the stringline is pulled tight, any small irregularities in the existing surface will be spanned (Figure 3-5).

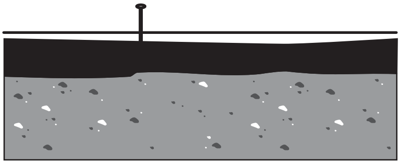

Figure 3-5. Stringline Spans Surface Irregularities

As a verifiable grade reference, potential problems can be pointed out to the inspector before paving.

Setting Elevated Stringline

On some projects the asphalt must be laid to a specified elevation. For this application an elevated stringline must be set. Elevated stringline is positioned 1–2 feet above the finished grade using referencing hubs or lath placed by the surveyor (Figure 3-6).

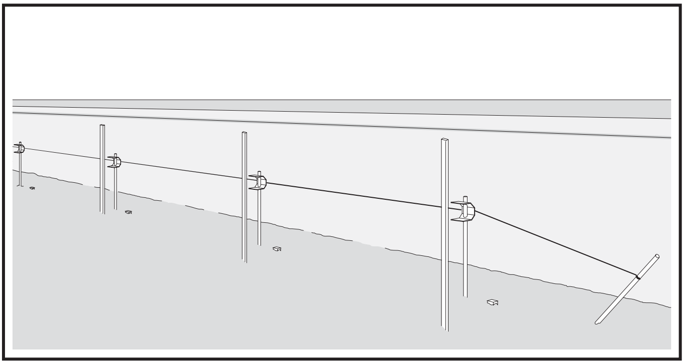

Figure 3-6. Elevated Stringline

Once positioned, the Sonic Tracker II tracks the stringline, providing a verifiable slope and cut reference.

NOTICE

NOTICE

Do Not disturb the hubs.

Your local Topcon dealer carries the following supplies for setting elevated stringline:

- Sonic Stringline, 1000’ roll (p/n 7020-0101)
- Sonic Grade Clips, box of 100 (p/n 7020-0121)
- Cut/fill Offset Tap, feet/tenths (p/n 7000-1026)
- Cut/fill Offset Tap, metric (p/n 7000-1027)

Although Topcon’s Sonic Tracker will work with many sizes and types of stringline, for best results use an 1/8 inch diameter nylon stringline. Using steel wire or a plastic coated stringline with a smooth surface can cause erroneous results.

1. Place the Sonic Grade Clips on stakes and drive the stakes approximately 6 to 8 inches away from, but in line with, the hubs—Do Not disturb the hubs (Figure 3-7).

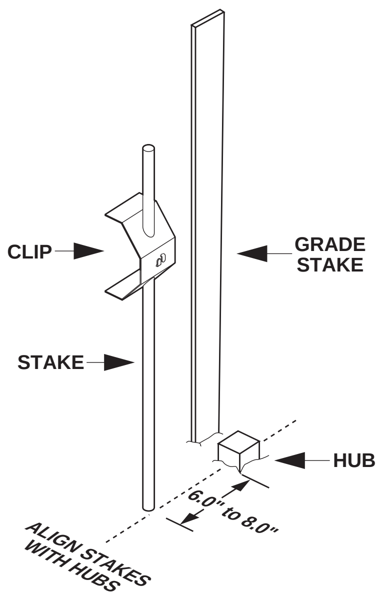

Figure 3-7. Place Clips and Position Stakes

2. Using an anchor pin at each end, roll out the Sonic Stringline the length of the working area and pull the stringline tight.

3. After the stringline has been pulled tight, place it into the "fingers" of each Sonic Grade Clip (Figure 3-8).

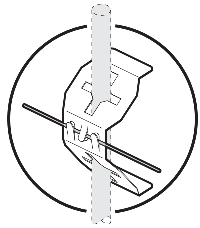

Figure 3-8. Place Stringline in Clip

4. Decide what the Sonic Stringline hike-up (the distance from Finished Grade to the Sonic Stringline) should be; in this example, two feet.

Making a Cut/Fill Lath

Once you have the stringline setup, fine-tune the height of the stringline above the grade. To do this, make a cut/fill lath using a lath and a Topcon Cut/Fill Decal.

1. Assemble the required number of laths for the job.
2. Measure from the bottom of the lath to the desired height above grade, and make a mark at that point. Place the Cut/Fill Decal on the lath with "0" at the marked point (Figure 3-9).

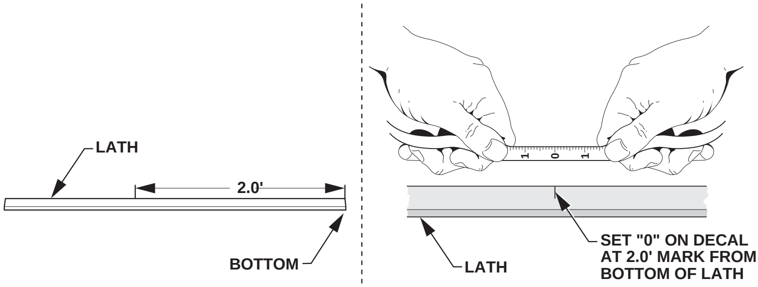

Figure 3-9. Measure Height Above Grade and Place Cut/Fill Decal

3. Set the cut/fill lath on the hub and read the cut or fill from the grade stake next to the hub. Adjust the clip up or down until the stringline crosses the cut/fill lath at that point (Figure 3-10).

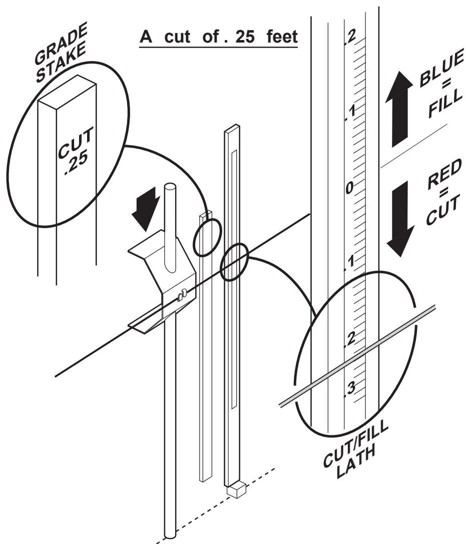

Figure 3-10. Adjust Clip and Stringline to Desired Cut/Fill

The stringline is now set to 2 feet above finished grade.

4. Repeat step 3 on page 3-8 at each station before starting to cut (Figure 3-11).

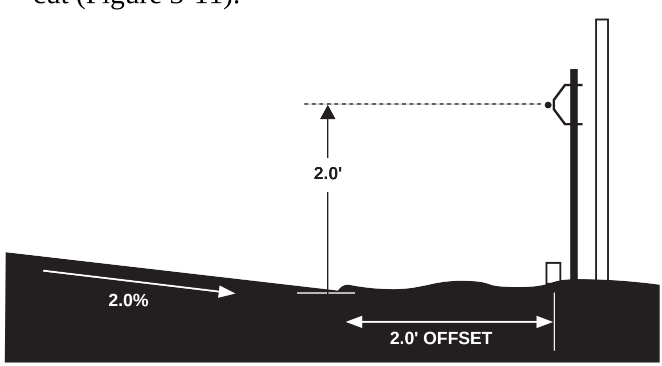

Figure 3-11. Stringline Set at Desired Elevation

Attaching Stringline to the Grade Stake

Some jobs may require the stringline to be secured directly to the grade stake rather than attached to the clip.

1. Mark the lath with the desired “hike-up” above grade (Figure 3-12).

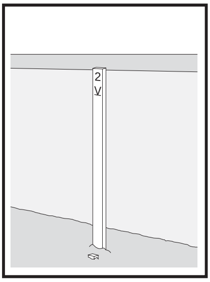

Figure 3-12. Mark Lath with Hike-up Height

2. Secure an anchor pin at each end of the stringline and pull the stringline tight.
3. At each station, staple or Ty-Wrap the stringline directly to the witness lath at the desired “hike-up” (Figure 3-13).

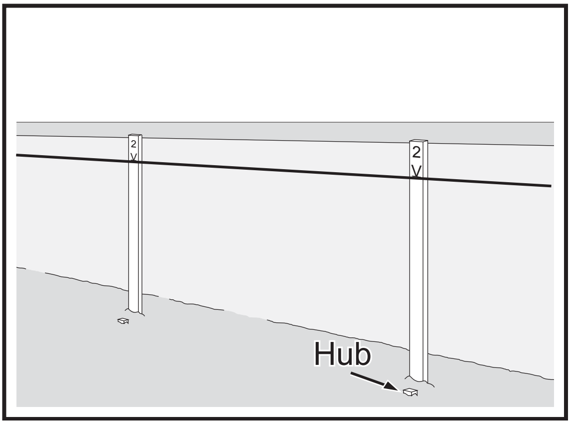

Figure 3-13. Stringline Attached to Lath

4. Due to the height of some stakes, raise the Tracker or cut off the tops of the stakes.

Setting Projected Slope Stringline

Jobs with slope transitions or super-elevations will have the stringline set to the "projected slope." As the profiler cuts, the Sonic Tracker and mill follow the slope of the job, preventing elevation errors at the edge of the road as the slope changes.

To set the stringline to the projected slope,

1. Set up the string at the desired elevation as shown in "Setting Elevated Stringline" on page 3-5.
2. Raise or lower the stringline to compensate for the percentage of slope and the distance from the edge of the road to the stringline:

$$Rise = Run \times SlopePercentage$$

- If the road rises away from the stringline, the stringline will need to be lowered (Figure 3-14).

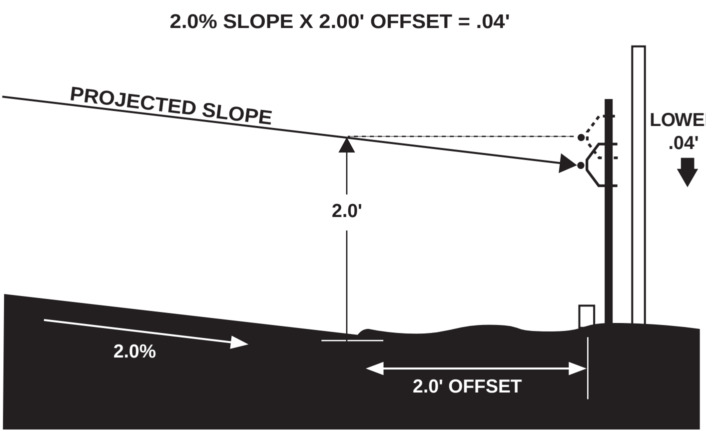

Figure 3-14. Lower Stringline: 2% Cross Slope with 2 Foot Offset

- If the road slopes down from the stringline, the stringline will need to be raised (Figure 3-15).

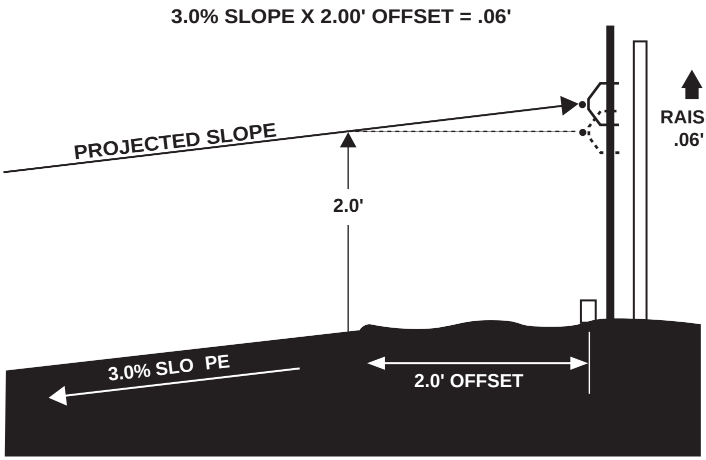

Figure 3-15. Raise Stringline: 3% Cross Slope with 2 Foot Offset

3. Repeat step 2 for each station.

Verifying Grade

Verifying grade requires measuring the distance from the cut ground to the Sonic Stringline. To check grade, use a Grade Checking Lath to check the levelness and depth of cut with the Sonic Stringline.

The following figures show an example of a hub offset of 1.5 feet from the edge of the road, and a hike-up of 2.0 feet.

1. Construct a Grade Checking Lath using a lath, a level bubble, nails, and standard hand tools as shown in Figure 3-16.

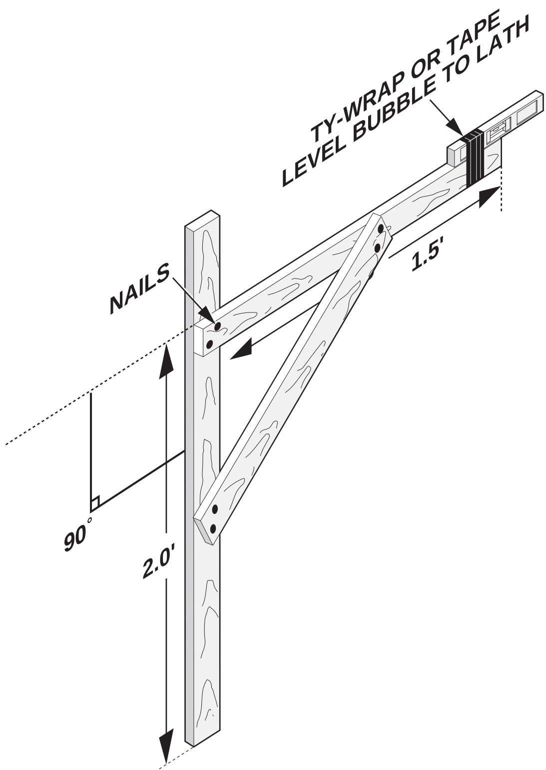

Figure 3-16. Grade Checking Lath

2. Set the Grade Checking Lath on the edge of the newly cut ground so the level bubble extends over the Sonic Stringline (Figure 3-17).

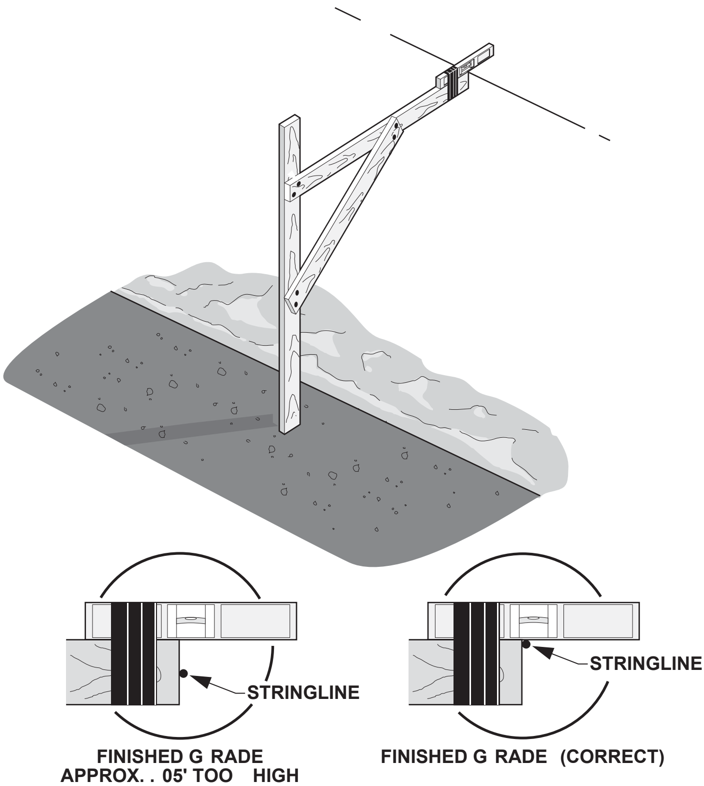

Figure 3-17. Check Finished Grade

3. Tilt the Grade Checking Lath to center the level bubble. Finished grade is correct if the level just touches the Sonic Stringline (Figure 3-17).

Notes: