ASPHALT CONTRACTOR

How-to-Guide for Asphalt Pavement Compaction

A detailed guide for the success (or failure) of asphalt pavement compaction — temperature of the mat, pattern of rollers, impact mat density and more recommendations!

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Given that the best time to achieve the greatest density is when the mat is hottest, it makes sense to get as much compaction at the higher temperatures as possible. Scherocman says the best way to do that is to operate two rollers in echelon – side by side – down the mat. This enables the full width of the mat to be compacted while that mat is hottest.

While the industry has shifted focus to how different mix designs can improve the life of a pavement, one thing remains constant: the level of compaction any asphalt mix receives directly impacts the quality and lifetime of that pavement.

“The single most important thing you can do to a pavement is compact it,” says Jim Scherocman, P.E. “A pavement that has the world’s best mix design compacted to 9-10% air voids is not going to perform well. Conversely, a pavement that has only a marginal mix design compacted to 7% air voids or less, will perform very well under traffic.”

Accepted knowledge says that for every 1% increase in air voids, about 10% of the pavement life may be lost. That’s because the more air voids a pavement has, the more that pavement is compromised in terms of pavement strength, fatigue life, durability, raveling, rutting and susceptibility to moisture damage.

So the paving industry relies on compaction to increase pavement density to extend pavement life. As a result of the compaction process, the asphalt-coated aggregate particles in the mix are forced closer together, which increases the amount of aggregate interlock and interparticle friction and also reduces the air void content of the mix.

“A consistent density level or air void content is what is really important,” Scherocman says. “The correct rolling pattern obtains uniform density, which achieves performance. The level of air voids obtained during rolling needs to be the same both longitudinally and transversely.”

Therefore, the work done by roller operators needs to be done correctly and consistently in order to ensure the success of the pavement life.”

If the operator isn’t running it at the right settings, the right speed, etc., it can affect the quality of the mat, and that quality is important to the life of the road. The better the operator, the better the machine, the better the performance and the longer the life of the road.

Five Factors Affecting Density

There are five factors that affect finished density of the asphalt mat: temperature of the mix itself, mat thickness, base temperature, environmental conditions (air temperature) and wind.

“The two most important factors are the temperature of the mix as it passes out from under the screed of the paver and the thickness of the layer. The ambient air temperature and the temperature of the surface on which the mix is placed are of secondary importance. Wind velocity, however, can have a significant effect of the rate of cooling as well,” Scherocman says.

Asphalt concrete mixtures cool quickly so it’s important to compact while the mix is hot. Typically, asphalt comes out of the plant at about 300° F. At that temperature, it is relatively soft and is readily compacted. As it cools, it firms up and compaction becomes increasingly difficult.

“The three most important factors when it comes to compaction are temperature, temperature, temperature. You need to compact the mix while it’s hot,” Scherocman says. “Be sure to keep the rollers right behind the pavers, no more than 300 ft. back. This will help operators take advantage of the temperature.

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How to Use a Rolling Train

The most-common approach to compaction, but not the best, is a rolling train, which involves a series of rollers operating one after the other close behind the paver. The train starts with a double drum vibratory roller operating close behind the paver to obtain the initial compactive effort while the mix is still hot.

A rule of thumb is this "breakdown" rolling should be completed before the surface temperature of the mix falls below 240º F. The breakdown roller should be operated at the highest possible frequency level available for the particular make and model of roller and at an amplitude setting that is dependent on the thickness of the asphalt concrete mat being placed (see sidebar).

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"Vibrate every chance you can," Scherocman says. "The harder and more often you hit the pavement, the more density you get."

The next part of the train, intermediate rolling, is usually done with a vibratory roller as well and must be accomplished immediately after the initial rolling is completed. When a pneumatic tire roller is used as an intermediate roller, it is necessary to keep the tires at the same temperature as the mat being compacted — otherwise the rubber tires will pick up some of the mix from the mat. So when using a pneumatic roller, don't allow the roller to sit and wait for long periods of time as the tires will cool.

The final roller in the train is a static steel wheel roller for finish rolling. The primary purpose of finish rolling is to obtain the "last little bit" of density and to remove the marks, if any, left by the first and second rollers. When needed finish rolling should be accomplished at a mix surface temperature above 175° F. "Only the finish rolling, the last rolling done, should be done in a static mode," Scherocman says.

The Impact of Roller Speed

The speed at which the operator drives the vibratory roller also has one of the greatest influences on mat quality. Driving too fast can leave gaps and ripples in compaction and compromise crew safety if the operator gets too close to the paver. Using the correct speed will also help to maintain the appropriate impact spacing to prevent washboarding.

"There is a relationship between speed and frequency," Scherocman says. "You want to hit the pavement with the vibratory roller drum at least 10 times in a linear foot. It's not just the speed per se, it's the combination of speed and frequency for the vibratory rollers."

Mat Thickness Affects Roller Amplitude

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Just like the mix properties will determine how you roll the pavement, the thickness of the lift will also determine how your roller operators should proceed.

Vibratory rollers introduce dynamic forces that helps to generate a high compaction effect with far less effort and cost. During vibration, the rotation of one shaft with weight delivers a centrifugal force that is sufficient to lift and drop the heavy steel drum as it moves through its cycle. The height at which the drum lifts is referred to as amplitude. Generally, amplitude settings are determined by the depth of the lift. Machines with variable amplitudes allow the operator to fine tune the setting to the mix.

"If the pavement is an inch or less in thickness, do not vibrate," Scherocman says. "The roller will simply bounce. Then all you're doing is beating the heck out of the pavement and the roller. If you're 1-1/4-in. to 2-1/4-in., use a lower amplitude setting. If you're over 2-1/2-in., you can put the roller in a higher amplitude setting.

"A lot of roller operators do think they can take a thin lift and kick it into high amplitude and they just tear their roller apart and create ripples in the mat," Scherocman says.

So a vibratory roller operated at a frequency of 3,000 vibrations per minute (vpm) can run at a speed of 3.5 mph to maintain an impact spacing of 10 impacts per foot. If that same roller is operated at a frequency of 4,000 vpm it can operate at a speed of approximately 4.7 mph and still maintain an impact spacing of 10 impacts per foot.

Operators should also avoid sharp turns or sudden speed changes. Sharp turns can tear the mat, and decelerating or accelerating quickly can rip or tear the mat or leave indentations.

Three Temperature Zones

Scherocman says contractors need to pay attention to, and take advantage of, the three temperature zones found in most asphalt concrete mixes.

In the first, or upper, temperature zone, the asphalt concrete mix is relatively stable during the compaction process. This stability extends from laydown temperature (300˚ F) down to roughly 240˚ F during which the mix remains stable and can support compaction – the mix won't shove or check under the roller.

Scherocman says that in some mixes there is a middle temperature -- or "tender" -- zone depending on the gradation and angularity of the aggregate in the mix. "Rounded materials don't interlock but angular materials do," Scherocman explains. He says if a mix does have a tender zone it extends from about 240˚ F down to 190˚ F depending on the mix properties.

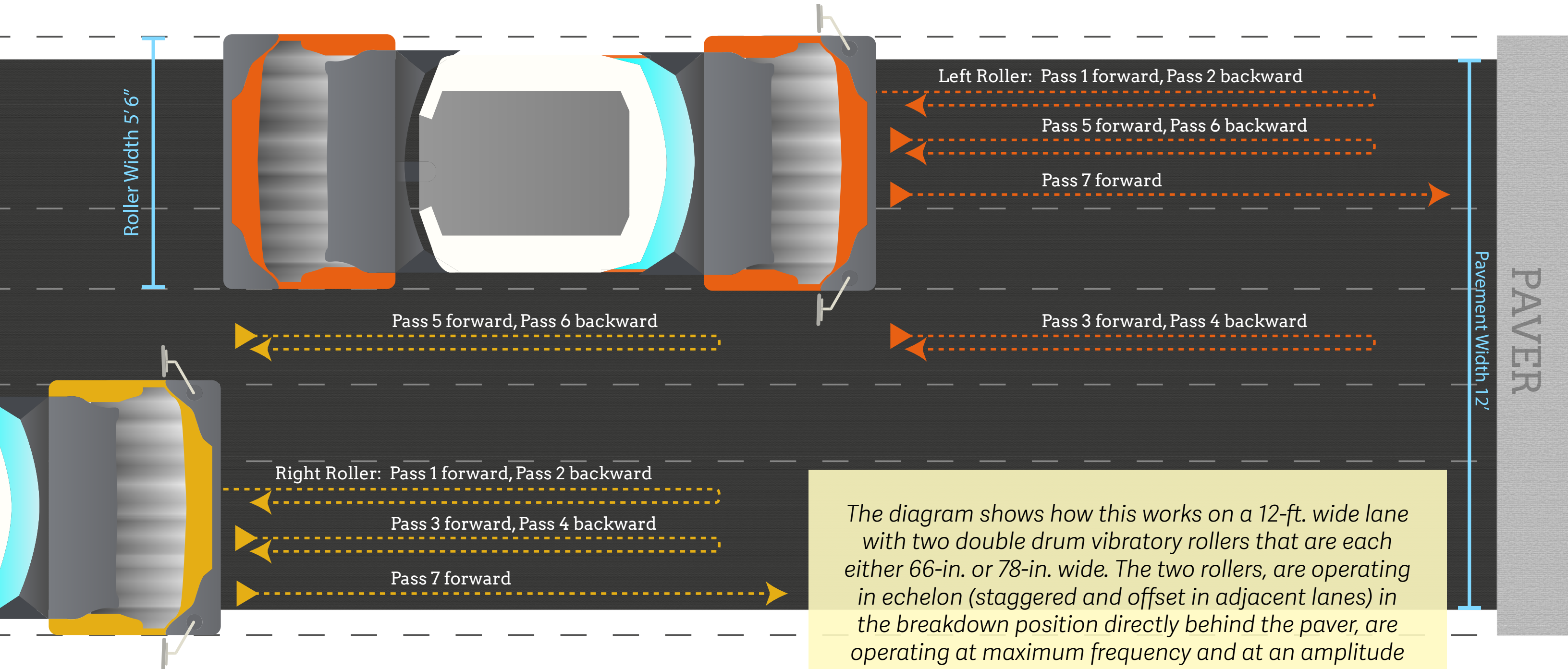
Within this temperature range the mix moves, shoves and checks when being compacted. In some cases a bow wave will form in front of the roller drums and the mix will crawl longitudinally. In addition the mix will also move laterally, widening the mat of the edge of the roller is not positioned properly (by about 6 in.) over the unsupported edge of the asphalt concrete. Scherocman says that in this middle temperature zone the HMA mix lacks the internal stability to support the weight of a steel wheel roller – but it will accept the use of a pneumatic roller.

"If the mix is tender, don't roll it with a vibratory roller; get off of it," Scherocman says. "These mixes occur all over the country due to the gradation and angularity of the aggregate and moisture present in the aggregate at the plant."

The lower temperature zone extends from the low end of the tender temperature zone (190˚ F) down. Once mix temperature reaches this point the mix can again support the weight of steel wheel compaction equipment, but it is very difficult to achieve much compaction in this lower "cold" temperature zone.

It should be noted that the upper and lower limits of each of these temperature zones will vary depending on the mix characteristics, how quickly the mat is cooling, the thickness of the HMA layer being compacted, environmental conditions and the type of roller (static or vibratory) used. The temperatures referenced are a rough guide.

Photo Credit: Stockr/AdobeStock



The diagram shows how this works on a 12-ft. wide lane with two double drum vibratory rollers that are each either 66-in. or 78-in. wide. The two rollers, are operating in echelon (staggered and offset in adjacent lanes) in the breakdown position directly behind the paver, are operating at maximum frequency and at an amplitude setting that is proper for the layer thickness being placed.

Echelon Rolling Takes Advantage of the Upper Zone

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1. The first roller (orange, close behind the paver) compacts the left side of the mat with two passes (numbers 1 and 2) up and back in exactly the same position, hanging over the left edge of the lane or joint by 6-in. (A pass is defined as one time over a point in the pavement surface).
2. At the same time, operating at an offset distance of 10-ft behind the orange roller in echelon, the second double drum vibratory roller (yellow) makes its first two passes (passes 1 and 2) on the right side of the pavement, hanging over the right edge of the lane or joint by 6-in.
3. The orange roller then moves toward the center of the mat and makes a pair of passes (numbers 3 and 4) -- up and back -- over the center of the lane.
4. The yellow roller, still staggered and offset about 10 ft. behind the orange roller, makes passes 3 and 4 up and back--over the right side of the mat, again hanging over the right edge of the lane or joint by 6-in.
5. The orange roller moves to the left edge and makes its passes 5 and 6 up the left side of the mat (over the first two passes made by that same roller and again hanging over the edge by 6 in.)
6. The yellow roller moves toward the center of the mat and makes its passes 5 and 6 directly on top of the orange roller's two passes (orange 3 and 4) on the center of the mat. This completes four passes over the center of the mat, two from each roller.
7. At the end of pass 7, the orange roller continues up to the back of the paver and then begins the pattern over again.
8. For yellow pass number 7 on the right, the yellow roller again moves back to the right side of the lane and makes its last pass over the top of its first passes (1, 2, 3, 4), again hanging over the edge or joint.
9. At the end of pass 7, the yellow roller continues up to the back of the paver and then begins its pattern over again, still staggered and offset behind the orange roller.

Scherocman says this rolling pattern will work for any mix, even a tender mix, as long as the pavement has not yet reached a temperature zone below 240° F. When the mix reaches those lower temperatures, there is no longer enough time to achieve the proper density with this pattern. "The key is get the compaction done before the mat temperature reaches 240° F," he says. ▼