ASPHALT PAVING

IMPROVING RIDE QUALITY

Everybody benefits from smooth roads and streets. In addition to the pleasure of operating vehicles on a smooth surface, other reasons are prompting public works departments to focus on specifications that require high levels of smoothness. First, research has proven that smooth roads last longer than rough roads—all other factors being equal. So, life cycle costs decrease; tax dollars have a bigger return on investment; and there is less disruption to traffic flow when repairs or maintenance steps are not as frequent. Second, smooth roads contribute to better fuel economy due to decreased rolling resistance. Less fuel consumed means fewer emissions.

Creating smooth bituminous layers involves managing the four factors that contribute to quality paving. Executing the fundamentals correctly and avoiding big mistakes are important for smoothness. However, the other two factors, paving efficiently and proper use of grade and slope control are even more important.

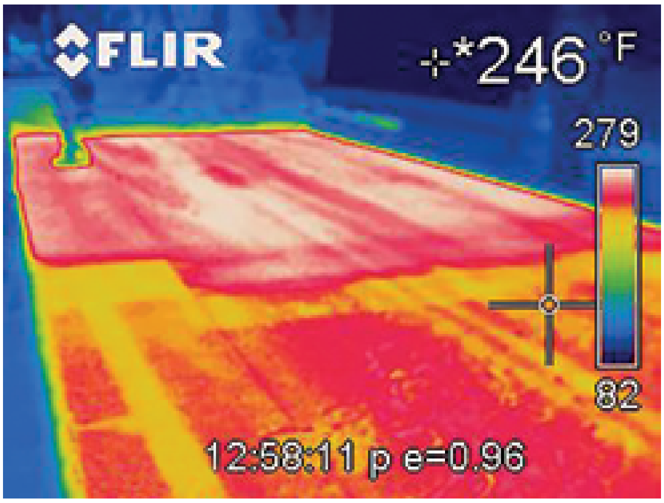
Most projects that have smoothness specifications lend themselves to efficient paving. Prior to paving, the superintendent or crew supervisor should calculate the paving speed that will minimize paver stops. There are formulas for calculating speed based on hourly tonnage, weight of material, paving depth and paving width. Software such as the Paving Production Calculator simplify the process of calculating paving speeds. (See Unit 2 for details on pre-project planning.)

PAVER SPEED CALCULATOR

Menu		Imperial Units	Metric Units
Trucking	**General Inputs**		
Paver Speed	Paving Thickness:	[2.56] *in*	[65] *mm*
Compaction	Paving Width:	[16.00] *feet*	[4.877] *meter*
Windrow	Material Density Uncompacted:	[140] *lbs/ft³*	[2243] *kg/m³*
Yield	**Paver Speed @ Given Production Rate**		
Slope	Production Rate of Hot Plant:	[220] *tons/hr*	[200] *tonnes/hr*
Thickness	Calculated Paving Speed - 100% Efficiency:	[15.3] *ft/min*	[4.67] *m/min*
Job Summary	Calculated Paving Speed - 95% Efficiency:	[16.1] *ft/min*	[4.90] *m/min*
Legal	Calculated Paving Speed - 90% Efficiency:	[16.8] *ft/min*	[5.14] *m/min*
	Calculated Paving Speed - 85% Efficiency:	[17.6] *ft/min*	[5.37] *m/min*
	Calculated Paving Speed - 80% Efficiency:	[18.4] *ft/min*	[5.60] *m/min*
	Calculated Paving Speed - 75% Efficiency:	[19.1] *ft/min*	[5.84] *m/min*
Exit	**Effective Paving Speed**:	[15.3] *ft/min*	[4.67] *m/min*

Paving speeds vary according to the efficiency factor.

On any project that has long passes, the minimum efficiency factor should be 75 percent. In other words, the paver should be placing material at least 45 minutes out of every hour. Ride quality improves as the efficiency rate goes up. Short interruptions to the paving process, typically during truck exchanges, are often unavoidable and do not necessarily mean that substantial roughness will result. But, the best ride quality occurs when paving is continuous—all other factors being equal. In the previous example, the best ride quality results if the paving speed can be maintained at 4.7 m / minute (15' / minute) for 100 percent efficiency. Ride quality will begin to deteriorate as the efficiency rate goes down. The crew can still place the hourly production rate by adjusting the working speed upward a little, but stops tend to create some roughness.



Temperature differential created by stopping the paver.

Paver stops can create roughness in two ways. One is by creating a temperature differential between the portion of the bituminous layer confined by the screed and the portion of the layer that is directly behind the screed in the area where the initial phase compactor cannot reach. Depending on the ambient temperature and the thickness of the layer, the material may lose heat rather quickly. When the temperature differential exceeds 15° C (59° F), there is likely to be a compaction differential. In other words, the hotter material confined by the screed will compact at a different rate than the colder material exposed to the ambient conditions behind the screed.

User Tip: *To determine how long it will take for a given layer thickness to lose 15° C (30° F) under specific ambient conditions), use PaveCool software. PaveCool is available as a download from the Minnesota Department of Transportation.*

Screed imprint in the bituminous layer created by stopping the paver.

The other way that paver stops may contribute to roughness is by creating a screed settlement mark in the surface of the bituminous layer. The depth of settlement marks is affected by several factors.

Mix Parameters

- Temperature (hotter mixes deform easier)
- Grain size (finer mixes deform easier)
- Gradation curve (well graded mixes deform easier)
- Stiffness (stiff mixes deform less)

Paving Parameters

- Layer thickness (thicker the mat, the deeper the dent)
- Paving width (the more extension, the deeper the dent)
- Ambient temperature (hotter the day, deeper the dent)
- Head of material (lower the head of material, deeper the dent)
- Length of stop (longer the stop, deeper the dent)

Paver Parameters

- Paving speed (higher the speed, greater the settlement)
- Tamper amplitude (higher the amplitude, lower the settlement)
- Tamper speed (higher the speed, lower the settlement)
- Screed set-up (higher the angle of attack, greater the settlement)

The initial phase roller may erase the settlement mark, but roughness is still a concern. For example, the grade and slope control system may react to the screed settlement when the paver resumes operation. Watch the tow-point. If the tow-point makes a significant move (more than 12 mm / 0.5") when the paver resumes operation, there will be enough of a layer deviation to be felt by a vehicle.

Cat pavers are equipped with a screed counterbalance system that reduces the amount of screed settlement during stops. Some Cat pavers also feature a screed lower lock system. Consult the Operation and Maintenance Manual for instructions about the operation of the screed counterbalance and screed lower lock systems.

Material transfer devices, this one equipped with a windrow elevating head, enable the paver to operate continuously at the same speed.

The use of material transfer devices makes high efficiency rates possible. With proper planning, it is possible to pave for hours without stopping or changing the paving speed.

Material transfer devices include machines such as windrow elevators that attach to the front of the paver and are pushed by the paver. Self-propelled material transfer vehicles that operate independently of the paver are also available. Some material transfer vehicles have as much as 23 tonnes (25 tons) of surge capacity. Inserts are often installed in the paver's hopper to increase the amount of material that is available while a new truck is being positioned to supply the transfer device.

It is common to have as much as 36 tonnes (40 tons) of total material available for production between trucks. Do not consume all of the material that is stored in the transfer vehicle or hopper insert when continuing to pave. Using all the material, especially if it is a large-aggregate base material, can cause segregation in the bituminous layer.

Assume that 27 tonnes (30 tons) is available for paving between trucks and a layer that is 65 mm (2.50") thick and 3.66 m (12') wide will be placed. The planned production rate is 200 tonnes per hour (220 tons per hour). The calculated paving speed at 100 percent efficiency under those conditions is 6.25 m / minute (20.5' / minute).

YIELD CALCULATOR

- Trucking
- Paver Speed
- Compaction
- Windrow
- **Yield**
- Slope
- Thickness
- Job Summary
- Legal
- Exit

General Inputs	*Imperial Units*		*Metric Units*	
Paving Thickness:	[2.56]	*in*	[65.0]	*mm*
Paving Width:	[12.00]	*feet*	[3.658]	*meter*
Material Density Uncompacted:	[140]	*lbs/ft³*	[2243]	*kg/m³*
Truck Capacity or Total Tonnage:	[30.0]	*ton*	[27.2]	*tonnes*
Length of Mat at 100% Yield:	[167.41]	*feet*	[51]	*meter*
Actual Length of Mat produced:	[0.00]	*feet*	[0.00]	*meter*
% Yield for given truck load or tonnage:			[0]	

Thickness:	[2.56]	*in*	[65.0]	*mm*
Length of Mat produced:	[0.00]	*feet*	[0.00]	*meters*
Width:	[12]	*feet*	[3.658]	*meters*

The yield calculator provides length of paving for a given weight of material.

Use the Yield Calculator function of the Paving Production Calculator. If 27 tonnes (30 tons) are available in the transfer vehicle and insert, a length of 51 m (167') can be paved. At a paving speed of 6.25 m / minute (20.5' / minute), there will be just over eight minutes of paving production. If it is taking more than eight minutes to complete a truck exchange, something is wrong with the procedure. A truck exchange should take no longer than three minutes unless severe traffic congestion is encountered.

Caterpillar recommends the use of material transfer devices on projects that have a ride quality specification or anytime there is a need to significantly improve smoothness. Non-stop paving at a continuous speed will produce a 10-15 percent smoother ride compared to stop-and-go paving—all other factors being equal.

In addition to continuous paving at a constant speed, installation of averaging skis is another proven way to create better ride quality.

Mechanical averaging skis are suitable for applications where there are long passes and few obstacles such as drain inlets and utility boxes. Mechanical skis like the Cat 9-meter (30') Outboard Leveler should be installed when there is a suitable grade reference outside the paving width. Mechanical skis like the Cat Fore ‘N Aft Leveler should be installed when the only suitable grade reference is inside the paving width. Caterpillar recommends using mechanical averaging skis on both sides of the paver when there is moderate to severe roughness in the surface to be paved.

Dual, mechanical averaging skis can produce up to a 60-70 percent improvement in one-pass smoothness.

Granular bases often have a high degree of roughness. Some milled surfaces have moderate roughness as well. Using the International Roughness Index as a reference, moderate roughness can be classified as total deviations between 1.9 m / kilometer and 2.8 m / kilometer (120" / mile and 180" / mile). Extreme roughness as measured by the International Roughness Index would be deviations in excess of 2.8 m / kilometer (180" / mile).

Caterpillar research indicates that a paver equipped with mechanical averaging skis on both sides and paving at a continuous speed can reduce roughness by 60 – 70 percent in one pass when moderate to severe roughness exists. For example if the grade deviations total 2.3 m / kilometer (150" / mile) prior to paving, the predicted deviations will be lowered to around 80 cm / kilometer (53" / mile) in one pass when dual mechanical averaging skis are installed on the paver.

During installation of another bituminous layer using a paver equipped with two mechanical averaging skis, another 20-40 percent smoothness improvement can be realized. Using the previous example, expected deviations can be lowered to around 56 cm / kilometer (37" / mile). The percentage of smoothness improvement will be even less if a third layer of bituminous material is added.

Non-contact skis are more versatile and more convenient than mechanical skis. Non-contact skis can be installed to reference grade inside the paving width or outside the paving width. Non-contact skis use electronic averaging to reduce roughness. The roughness reduction factor of non-contact skis is not quite as high as the roughness reduction factor of mechanical averaging skis. Non-contact averaging skis are most suitable on projects where there is light to moderate roughness in the surface to be paved. Excellent smoothness results have been obtained with non-contact skis on projects where the milled surface has the correct transverse profile and a reasonably smooth longitudinal profile.

Non-contact skis do not have to be removed in order to move the paver around the worksite. Therefore, Caterpillar recommends installing non-contact skis on projects with time constraints, like night shifts. Non-contact skis are not affected by obstacles like drain inlets and are preferred for their convenience by many crews.

Non-contact skis offer convenience and adequate averaging for surfaces with light to moderate roughness.

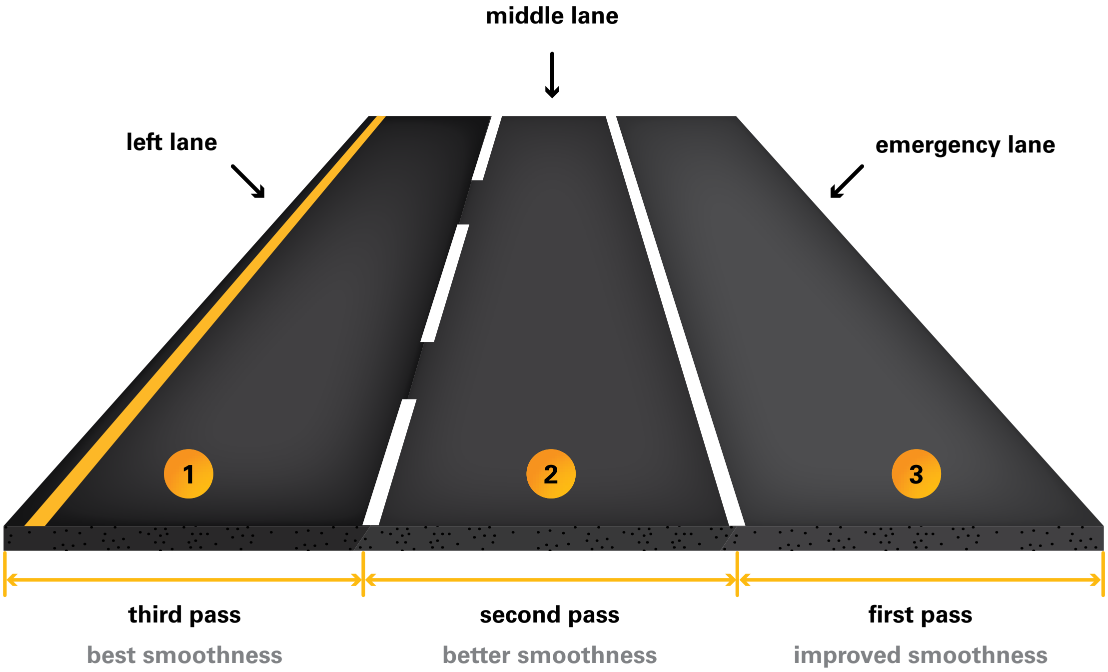
Another technique that can help improve smoothness in driving lanes is to pave the emergency lane (shoulder) first. When the emergency lane is paved first, it becomes an improved grade reference for the averaging ski when the paver works on the adjacent driving lane. Plans don't always specify paving the emergency lane first, but it is a good idea to ask for permission.

Paving emergency lanes first improves the smoothness of adjacent driving lanes.

The emergency lane that has been paved first should be a better grade reference than a milled surface, or granular base or even an existing bituminous surface. Plus, the emergency lane provides a place for the compactors to stop and reverse without leaving marks in the new layer of the driving lane. Remember, the emergency lane is not measured for smoothness. Only driving lanes are measured.

Smoothness will continue to improve as the paver completes adjacent driving lanes because the smoothness of the grade reference is constantly being improved.

Averaging ski using emergency lane as a grade reference.



Smoothness of the emergency lane should be improved when compared to a milled surface, for example. Then, the smoothness of the driving lane adjacent to the emergency lane will be better than the score of the emergency lane. Finally, the far left driving lane will have the best smoothness.

In summary, to maximize the smoothness of a bituminous layer, plan for continuous paving at a constant speed. Pave with averaging skis installed on both sides of the paver whenever possible. Choose the type of averaging ski that is appropriate for the application. Avoid the use of slope control unless it is a requirement of the specification or if the transverse profile needs correction. Whenever possible, pave the emergency lane first to provide an improved grade reference for the driving lanes.