
9 Thickness and Tonnage Control

Mixture Adjustment Factor

Checking Mat Thickness

Determining Mat Thickness

Depth Checks

Actual Rate of Spread

Stationing

Weigh Tickets

Computing Rates of Spread

CHAPTER SEVEN:

THICKNESS AND TONNAGE CONTROL

The lay rates (thickness) and width of the paving operation are shown on the typical sections in the contract plans or the Contract Information Book. Lay rates are used to define the thickness of the layers of the pavement. The actual compacted thickness of the mat is required to conform to the planned design. The design thickness is determined so the pavement is strong enough to carry the anticipated traffic. If the mat is too thin, the pavement will likely fail prematurely. If the mat is too thick, the pay quantities will overrun and increase the cost of the contract unnecessarily.

The thickness of the mat is checked by verifying the uncompacted thickness behind the paver and by verifying the actual lay rate (sometimes call yield).

The plans specify the rate in pounds per square yard that the HMA is to be placed. This is known as the "Planned Lay Rate". The planned quantity is used in the rate of spread and verifying the design thickness.

MIXTURE ADJUSTMENT FACTOR

A Mixture Adjustment Factor (MAF) is used to adjust the mixture planned quantity and lay rate prior to paving operations, and the pay quantity upon completion of production of the mixture. The MAF is a means of adjusting lay rates to the design thickness due to materials with different densities. The MAF is calculated by dividing the maximum specific gravity (G_{mm}) from the mixture design by the following values:

Mixture	Maximum Specific Gravity
9.5 mm	2.465
12.5 mm	2.500
19.0 mm	2.500
25.0 mm	2.500

If the calculated MAF is equal to or greater than 0.980 and equal to or less than 1.020, the MAF value is considered to be 1.000. If the calculated MAF is less than 0.980, then 0.020 is added to the value. If the calculated MAF is greater than 1.020, 0.020 is subtracted from the value. The planned quantity and lay rate are adjusted by multiplying by the MAF. The accepted quantity for payment is adjusted by dividing by the MAF.

Example:

Mixture	=	9.5 mm Surface
Planned Quantity	=	9750.00 tons
Placed Quantity	=	9500.00 tons
Mix Design G_{mm}	=	2.360
Lay Rate	=	165 lb/yd ²

$$MAF = \frac{2.360}{2.465} = 0.957$$

$$MAF = 0.957 + 0.020 = 0.977$$

$$\text{Adjusted Planned Quantity} = 0.977 \times 9750.00 = 9525.75 \text{ tons}$$

$$\text{Adjusted Lay Rate} = 0.977 \times 165 \text{ lb/yd}^2 = 161 \text{ lb/yd}^2$$

$$\text{Adjusted Pay Quantity} = \frac{9500.00}{0.977} = 9723.64 \text{ tons}$$

The MAF does not apply to open graded mixtures, temporary HMA, HMA patching and widening with HMA.

CHECKING MAT THICKNESS***DETERMINING MAT THICKNESS***

Before conducting any depth checks, the required thickness is obtained. Through experience, HMA mixes have indicated that 110 lb/yd² is equivalent to approximately 1 in. of compacted depth when the MAF is approximately equal to 1.0. Mixes made with some aggregates such as slag, weigh somewhat less or more depending on the type of aggregate used.

The formula for determining the compacted mat thickness is:

$$\frac{\text{Planned Lay Rate (lb/yd}^2\text{)}}{110 \text{ lb/yd}^2} = \text{Desired mat thickness in inches}$$

or

$$\frac{\text{Adjusted Lay Rate}}{MAF \times 110 \text{ lb/yd}^2} = \text{Desired mat thickness in inches}$$

Example:

$$\text{Planned Lay Rate} = 165 \text{ lb/yd}^2$$

$$\frac{165}{110} = 1.5 \text{ inches}$$

The mat thickness for 165 lb/yd² would be approximately 1 1/2 inches.

or

$$\begin{aligned} \text{Adjusted Lay Rate} &= 161 \text{ lb/yd}^2 \\ \text{MAF} &= 0.977 \end{aligned}$$

$$\frac{161}{110 \times .977} = 1.5 \text{ inches}$$

The mat thickness for 161 lb/yd² would be approximately 1 1/2 inches.

DEPTH CHECKS

The approximate thickness of the uncompacted mat is checked immediately behind the paver screed and at various points across the lane. Uncompacted mat (loose mix) is placed approximately 1/4 inch additional thickness per inch of depth placed. For example, a compacted thickness of 3 inches will be placed 3 3/4 inches behind the paver uncompacted. Depth checks are made regularly and are useful in determining if particular areas on the grade or pavement differ greatly from the typical cross sections. An excessively thin or thick mat does not compact properly. A mat too thin drags the mix aggregate. A mat too thick is difficult to compact to the required density. Adjustments to the paver may be required for the depth of mix. If the problem is extensive, the slope of the pavement or the planned thickness may need to be changed.

ACTUAL RATE OF SPREAD

The determination of the actual rate of spread is a more accurate method of determining the mixture placed than individual depth checks because the rate of spread considers the average spread over a longer paving area.

Weigh tickets are collected as the mix is delivered to the paving site and a record is kept of the actual amount of mix placed. This record is used to determine the "Placed Quantity" and compare this quantity to the "Planned Quantity".

The actual rate of spread is computed and compared this to the planned rate. The planned rate is typically shown on the plans in pounds per square yard. The actual rate of spread may be computed in pounds per linear foot, tons per linear foot, or pounds per square yard. Both the planned and actual rates are required to be in the same units for valid comparisons.

The purpose of computing the actual rate of spread is to determine if the planned amount is being placed. If the actual rate exceeds the planned rate, too much mix is being placed and there is an overrun of material. If the actual rate is less than the planned rate, too little mix is being placed and there is an underrun. In either case, adjustments are required to be made to bring the actual quantity in line with the planned quantity.

STATIONING

Highway contracts are surveyed and staked in 100 ft increments called stations. Station 1 is written as 1+00, Station 25 as 25+00, and so on. Station 25+00 would equal 2500 ft from a fixed reference point.

The use of stations makes the determination of distance paved relatively easy. If the paving started at Station 25+00 and ended at Station 60+00, there would be 3500 ft (6000 minus 2500) of mix paved. To be more precise, the distance from the actual starting or ending point to a station is determined and added or subtracted from the station referenced. For example, if the paving started 75 ft past Station 25+00, the starting point would be 25+75, or 2575 ft from the fixed reference point. If the ending point was 40 ft beyond Station 60+00, or 60+40, the distance paved would be 6040 minus 2575 or 3465 ft.

WEIGH TICKETS

A weigh ticket which shows the net weight of the material is required to be furnished for every load of mix delivered to the paving site. The weigh ticket is issued to the truck driver at the weighing site. The weigh tickets also show the cumulative tonnage delivered each day. Weigh tickets are collected from the truck driver by INDOT for each load at the same time the material is unloaded at the paving site. Upon taking the ticket, the INDOT is required to:

- 1) Write on the ticket the starting station of the load and the lane (right, left, or center) where the material is placed. A preferred method of designating lanes is EBPL (eastbound passing lane), EBDL (eastbound driving lane), etc.
- 2) Keep a running total of the mix unloaded at the paving site on the back of the ticket

- 3) Sign the original ticket after checking the appearance of the mix

At any time during the day and at any point along the roadway, the number of tons of mix that has been dumped into the paver is required to be known.

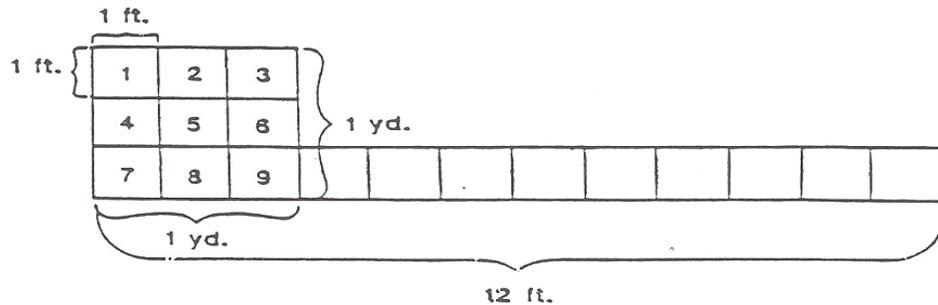
COMPUTING RATES OF SPREAD

As stated above, there are several methods of computing the actual rate of spread. The calculations differ primarily in the units in which the rates are expressed. The three methods are:

- 1) Method 1 – rate expressed in pounds per square yard
- 2) Method 2 – rate expressed in pounds per linear foot
- 3) Method 3 – rate expressed in tons per linear foot
- 4) Method 4 – quick method in linear feet per truck load

When the MAF is not equal to 1.000 then the adjusted lay rates and adjusted planned quantities should be used for the comparisons below.

Before starting the explanations of the rates of spread, the relationship between the areas of the three methods is required. As indicated in the diagram below, 9 ft² equals 1 yd². The number of square yards in a linear foot depends on the width being paved.



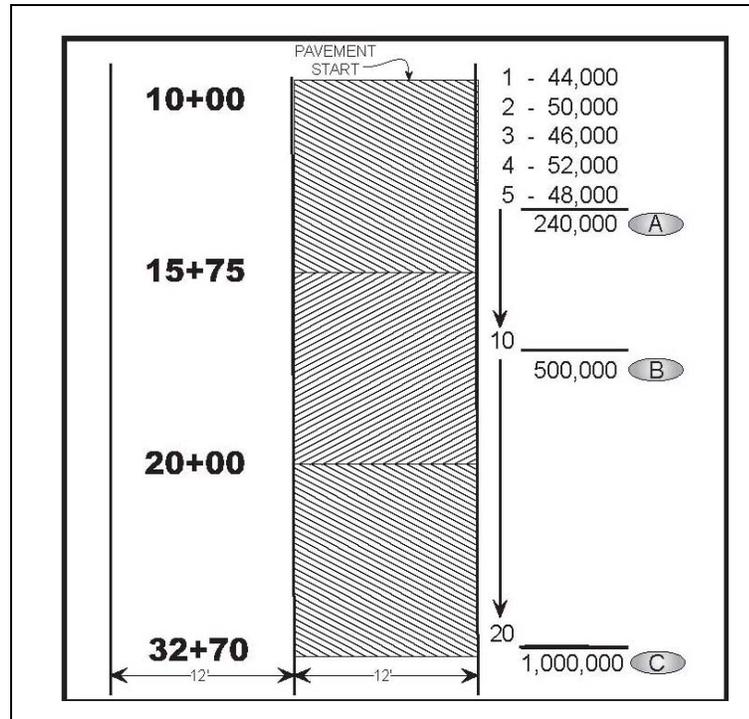
The formula for determining the relationship is:

$$\frac{1 \text{ foot} \times \text{pavement width (feet)}}{9 \text{ ft}^2/\text{yd}^2} = \frac{1 \times w}{9} = \text{yd}^2/\text{lft (linear foot)}$$

For a width of 12 ft as shown in the above diagram, the square yards per linear foot would be:

$$\frac{1 \times 12}{9} = 1.33 \text{ yd}^2/\text{lft}$$

Examples of the three methods of checking the actual rates with planned rates are as follows. The diagram below indicating the amount paved and quantities used applies to all three examples.



Method 1 – Pounds per Square Yard

The planned quantity is 330 lb/yd². The procedure for the first 5 loads is as follows:

- 1) Total the weights of the loads placed in pounds to the point where the check is made. The total of the first five loads equals 240,000 pounds.
- 2) Determine the total length paved in linear feet. Loads 1 through 5 began at Station 10+00 and end at Station 15+75

$$(15+75) - (10+00) = 575 \text{ ft}$$

- 3) Determine the area paved in square yards.

$$\frac{\text{Total length} \times \text{width paved}}{9} = \frac{575 \times 12}{9} = 767 \text{ yd}^2$$

- 4) Calculate the actual rate of spread in lb/yd²

$$\frac{\text{Total mix placed (lb)}}{\text{Area paved (yd}^2\text{)}} = \frac{240,000 \text{ lb}}{767 \text{ yd}^2} = 313 \text{ lb/yd}^2$$

- 5) Compare the placed quantity and planned quantity

If placed quantity = planned quantity: Mat is correct
If placed quantity > planned quantity: Overrun
If placed quantity < planned quantity: Underrun

The planned quantity equals 330 lb/yd². The placed quantity of 312.9 lb/yd² is less than the planned quantity indicating an underrun and a mat that is too thin. The Contractor is required to make the necessary adjustments.

After load 10, the paver is at Station 20+00 and 500,000 pounds have been placed.

$$\begin{aligned}\text{Total length} &= (20+00) - (10+00) = 1000 \text{ lft} \\ \text{Area} &= (1000 \times 12) / 9 = 1333 \text{ yd}^2 \\ \text{Placed Quantity} &= 500,000 / 1333 = 375 \text{ lb /yd}^2\end{aligned}$$

The placed quantity of 375 lb/yd² is greater than the planned quantity indicating an overrun.

After Load 20, the paver is at Station 32+70 and a total of 1,000,000 lb have been placed.

$$\begin{aligned}\text{Total length} &= (32+70) - (10+00) = 2270 \text{ lft} \\ \text{Area} &= (2270 \times 12) / 9 = 3027 \text{ yd}^2 \\ \text{Placed quantity} &= 1,000,000 / 3027 = 330.4 \text{ lb/yd}^2\end{aligned}$$

The placed quantity equals the planned quantity indicating the spread rate is correct.

Method 2 – Pounds per Linear Foot

The planned quantity is 330 lb/yd²

- 1) Convert the planned quantity from lb/yd² to lb/lft

$$\frac{\text{length of one foot x width paved}}{9 \text{ ft}^2/\text{yd}^2} = \frac{1 \times 12}{9} = 1.33 \text{ yd}^2/\text{lft}$$

$$\text{planned quantity} \times \text{yd}^2/\text{lft} = 330 \times 1.33 = 440 \text{ lb/lft}$$

- 2) Total the weights of the loads placed in pounds to the point where the check is made.

The total of the first five loads equals 240,000 pounds

- 3) Determine the total length paved in linear feet

Loads 1 through 5 began at Station 10+00 and end at Station 15+75

$$(15+75) - (10+00) = 575 \text{ lft}$$

- 4) Calculate the actual rate of spread in lb/lft

$$\frac{\text{total mix placed}}{\text{total length paved}} = \frac{240,000 \text{ lb}}{575 \text{ lft}} = 417.4 \text{ lb/lft}$$

- 5) Compare the placed quantity and the planned quantity

The placed quantity of 417.4 lb/lft is less than the planned quantity of 440 lb/lft indicating that an underrun and a mat that is too thin.

After Load 10, the paver is at Station 20+00 and 500,000 pounds have been placed.

$$\begin{aligned} \text{Total length} &= (20+00) - (10+00) = 1,000 \text{ lft} \\ \text{Placed quantity} &= 500,000 / 1,000 = 500 \text{ lb/lft} \end{aligned}$$

The placed quantity of 500 lb/lft is greater than the planned quantity of 440 lb/lft indicating an overrun and a mat that is too thick.

After Load 20, the paver is at Station 32+70 and 1,000,000 lb have been placed.

$$\begin{aligned} \text{Total length} &= (32+70) - (10+00) = 2270 \text{ lft} \\ \text{Placed quantity} &= 1,000,000 / 2270 = 440.5 \text{ lb/lft} \end{aligned}$$

The placed quantity equals the planned quantity indicating that the spread rate is correct.

Method 3 – Tons per Linear Foot

The planned quantity is 330 lb/yd²

- 1) Convert the planned quantity from lb/yd² to t/lft

$$\frac{\text{planned quantity (lb/yd}^2\text{)} \times \text{width of paving (ft)}}{9 \text{ (ft}^2\text{/yd}^2\text{)} \times 2000 \text{ (lb/t)}} = \frac{330 \times 12}{18,000} = 0.22 \text{ t/lft}$$

- 2) Total the weights of the loads placed in pounds to the point where the check is made and convert to tons.

The total of the first five loads equals 240,000 pounds.

Note: 2,000 pounds equals 1 ton.

$$\frac{\text{pounds placed}}{2000 \text{ lb}} = \frac{240,000}{2,000} = 120 \text{ tons}$$

- 3) Determine the total length paved in linear feet.

Loads 1 through 5 began at Station 10+00 and end at Station 15+75

$$(15+75) - (10+00) = 575 \text{ lft}$$

- 4) Calculate the theoretical quantity (tons) for the total length paved.

planned quantity (tons/lft) x total length paved (lft)

$$0.22 \text{ tons/lft} \times 575 \text{ lft} = 126.5 \text{ tons}$$

- 5) Compare the placed quantity and theoretical quantity

placed quantity – theoretical quantity = tons over/under

$$120 \text{ tons} - 126.5 \text{ tons} = -6.5 \text{ tons (Underrun)}$$

Note: If net tons is positive, there is an overrun

If net tons are negative, there is an underrun

- 6) Calculate % of underrun or overrun

$$\frac{\text{net over/under (tons)}}{\text{theoretical quantity (tons)}} \times 100 = \frac{-6.5}{126.5} \times 100 = 5.14\% \text{ underrun}$$

Method 4 – linear feet covered per truck load

A typical tri-axle truck contains a net weight of 20 tons of HMA.

- 1) Convert tons to pounds

$$(20 \text{ ton}) \times (2000 \text{ lb/ton}) = 40000 \text{ lb}$$

- 2) Divide the pounds of HMA by the adjusted lay rate to determine the square yards a truckload will cover

$$\frac{40,000 \text{ lb}}{330 \text{ lb/yd}^2} = 121 \text{ yd}^2$$

- 3) Convert the square yards to square feet

$$(121.2 \text{ yd}^2) \times (9 \text{ ft}^2/\text{yd}^2) = 1090.9 \text{ ft}^2$$

- 4) Divide by the width of paving to find the length covered in feet

$$\frac{1090.9 \text{ ft}^2}{12 \text{ ft}} = 90.9 \text{ ft}$$