Technical Paper T-135

HOT MIX ASPHALT TRUCKING

by J. Don Brock, PhD., P.E.

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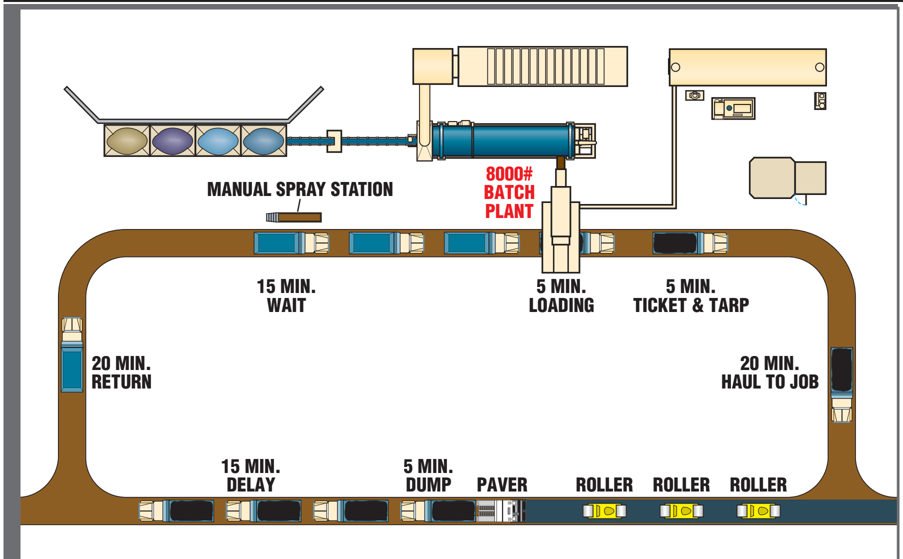


TRUCK CYCLE DIAGRAM F1

INTRODUCTION

The hot mix asphalt producer is faced with four separate cost categories in mixing, hauling, and placing hot mix on the road. These cost categories are as follows:

- *Material Cost*
- *Plant Processing Cost*
- *Trucking Cost*
- *Paving Cost*

Today, the highest of these costs is material cost. The second highest is trucking cost. Considerable attention has been paid to plant cost and paving crew costs over the past few years. These costs have been reduced substantially by increased production capacity of hot mix production facilities and increased yearly throughput at the facilities. However, less effort has gone into trucking cost reduction because trucks are often rented and their cost seems difficult to control. Often, rental rates are charged by the ton/mile and producers mistakenly assume that the cost is totally controlled by the trucker. In many companies, no attention is paid to trucking cost containment. Over the past few years, trucking costs, like many other costs, have escalated for the following reasons:

- *Increases in cost of equipment*
- *Substantial increases in fuel costs*
- *Shortages of drivers*
- *Increased driver labor rates*
- *Higher insurance costs*
- *Additional regulations related to drivers' hours, etc.*

In addition to these rising costs, another difficulty impacting United States hot mix producers is the severe shortage of qualified drivers and of trucks in many areas. These factors have led to a new emphasis on better management of trucking fleets in an effort to achieve better truck utilization and higher efficiency.

TRUCK CYCLES

A diagram of a typical batch plant operation of the 1970s/1980s era is shown in **Figure 1**. Usually, three trucks would be waiting in line at such a plant. Often, in the morning, as many as 20 trucks would be lined up, waiting for load-out. In the afternoon, when business slowed for the day, the facility would be stopped and started frequently, with restarts usually not taking place until at least 2-3 trucks were in line. Likewise, 2-4 full trucks would often be waiting in line at the paver, resulting in substantial delays in trucking at both the hot mix facility and the paver.

Perhaps the best way to understand a trucking operation is to ride in the truck or to drive the truck through the truck cycle and see the various places where the truck is required to stop. **Figure 2** lists the components of a typical truck cycle. The mission of the truck is to haul mix from point A to point B. Anytime the truck is not moving, inefficiencies occur in the operation. Note that six of the eight steps shown in Figure 2 are related to non-movement of the truck. Adding up the time required for each of the eight events results in the total time required to complete one truck cycle.

ITEMS	CALCULATIONS
• Delay at the plant	• Cost/cycles...
• Loading time	• Cost/ton...
• Ticket & Tarp	• No. of cycles/truck in __ hrs.
• Haul to job	• No. of cycles required
• Delay at job	• No. of trucks required
• Truck exchange	
• Dump	
• Return to plant	

TRUCK CYCLE ITEMS AND CALCULATIONS F2

Trucking costs today usually range from $40-$50 per hour. By calculating the truck cycle time in minutes and multiplying the minutes by the trucking cost per minute, the trucking cost per cycle can be calculated. Dividing this cost per cycle by the tons of mix the truck is hauling results in the trucking cost per ton of mix. **Figure 3** shows a truck cycle for the operation illustrated in Figure 1. As can be seen in Figure 3, a total time of 85 minutes is required to complete one truck cycle. At $45 per hour (or $0.75 per minute), the trucking cost for the cycle is $63.75. Assuming that the trucks carry 20 tons of mix, a trucking cost of $3.19 per ton results ($63.75 divided by 20). If the trucks operate 10 hours per day, the number of trips (cycles) each truck can make is found by dividing 85 minutes per cycle into 600 available minutes. Therefore, each truck can make 7 trips. If the plant is producing 2,400 tons of mix per day, and each truck hauls 20 tons, 120 trips will be required. Dividing the total trips required by the number of trips each truck can complete in ten hours shows that a total number of 17 trucks is required.

- **Production: 240 tons per hour = 2,400 tons per day**
- **20 tons per truck**
- **Truck Cost: $45 per hour = $0.75 per minute**

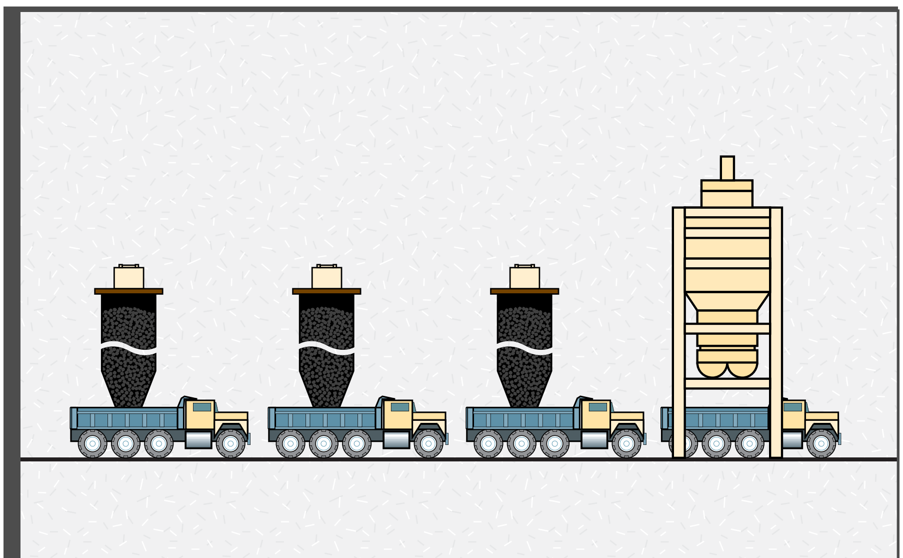
Delay at plant	15 min.	Cost/cycle	$63.75
Loading time	5 min.	Cost/ton	$3.19
Ticket, Tarp & Sampling	5 min.		
Haul to job (10 miles)	20 min.		
Delay at job	15 min.	Cycles/truck	7
Truck exchange	2 min.	Cycles required	120
Dump	3 min.	Trucks required	17
Return to plant	20 min.		
Total	85 min.	Efficiency %	47

TRUCK CYCLE - DIRECT BATCH PLANT LOADING F3

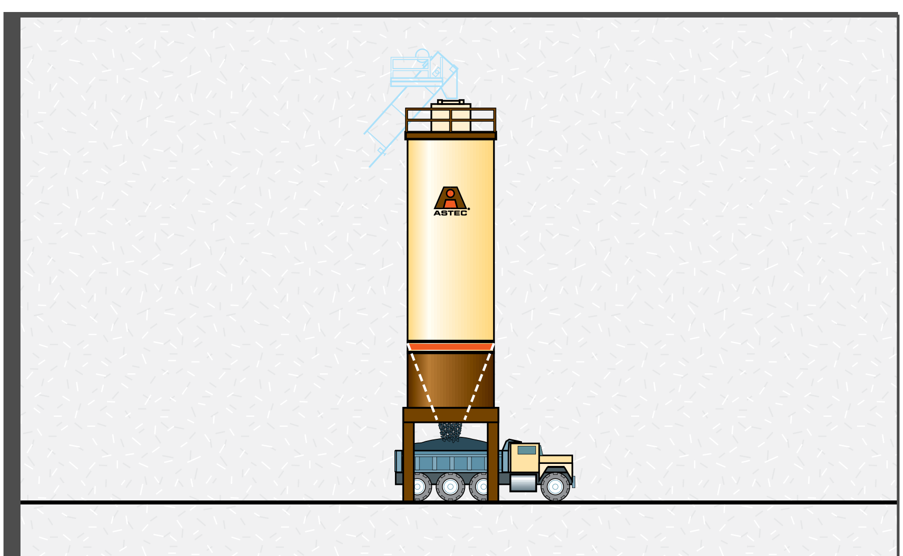
At an hourly rate of $45, each truck costs $0.75 per minute, regardless of whether or not the truck is moving. In the example of Figure 3, it takes 40 minutes to haul to the job and return to the plant. Dividing 40 minutes by the total cycle time of 85 minutes results in a truck cycle efficiency of only 47%. This example shows that in order to increase the efficiency of the trucking operation and reduce the cost, each of the non-moving portions of the truck cycle should be addressed and eliminated if at all possible. The following paragraphs discuss the various ways of reducing or eliminating these delays.

Mfg. by Cal Technologies - Palmer, MA

RELEASE AGENT APPLICATION SYSTEM **F4**



BATCH PLANT - USING TRUCKS AS SURGE **F5**



FAST LOADING FROM SURGE BIN **F6**

DELAY AT THE PLANT

Plant delays consist of the time to oil or spray a truck bed with release agent (often as long as five minutes) and the waiting time to be loaded. In the past, when hauling hot mix, fuel oil was used as a release agent to spray down in the truck bed. Today, ultra high-molecular weight bed liners are available, which eliminate the use of release agents. These liners generally cost $4,000-$5,000 per truck bed but can save the substantial amount of time previously required to spray the release agent in the truck bed.

To apply release agents, a system such as that shown in **Figure 4** can be used. This system utilizes a sensor on the truck bed that automatically turns on a spray as the truck passes underneath a series of nozzles. Not only is spray time reduced to approximately 15 seconds per truck bed, but the release agent is applied efficiently and with less waste.

When higher temperature mixes are hauled and the use of release agents is inappropriate, a fine sand material in the one to two millimeter size range keeps the mix from adhering to the truck bed. Cascading approximately one pint of this material into the truck bed has successfully prevented the mix from sticking.

When the producer owns his trucks, it is recommended to install bed liners to totally eliminate release agent delay.

LOADING TIME

In the past, extra trucks were sometimes backed up at the plant and used as surge bins to allow the plant to operate continuously **(Figure 5)**. When trucks were inexpensive, labor rates were low, and fuel was cheap, this type of surge may have been acceptable. However, with today's costs, a surge bin or some device that will allow quick truck loading (as shown in **Figures 6 and 7**) is much more cost effective than paying for a number of trucks and their drivers. Surge bins offer the following advantages:

- *The ability to operate the facility continuously.*
- *The ability to stabilize the mix temperature while storing in the surge bin.*
- *The ability for batch plants to run full batches at peak efficiencies at all times. Without surge capacity, partial batches are often produced when trucks are loaded to the maximum weight limit. This results in reduced total daily production of the batch plant.*
- *The ability to gross-load trucks to the maximum legal gross payload with the use of a truck scale underneath the surge bin. Trucks can be weighed on each round and loaded to their legal limit.*
- *The ability to reduce maintenance cost by eliminating stop/start operations.*

SURGE BIN F7

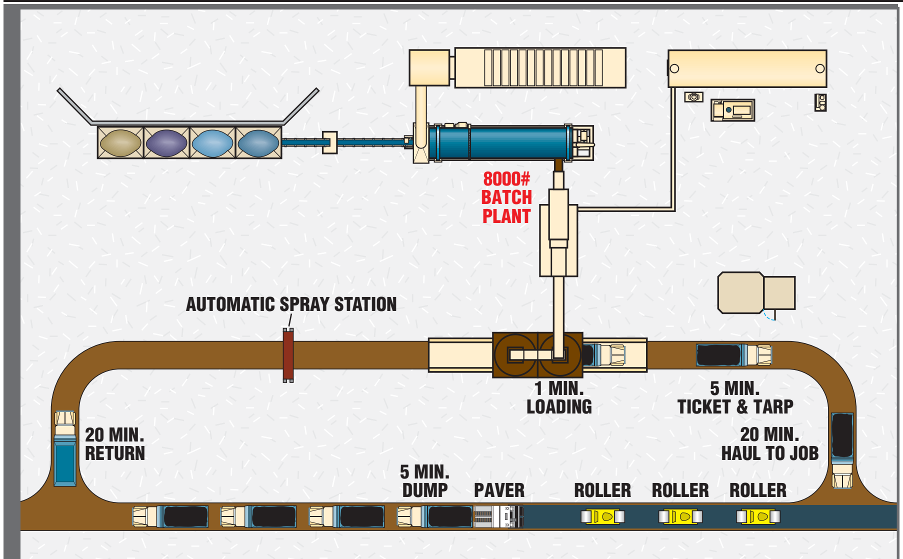
- **Production: 240 tons per hour = 2,400 tons per day**
- **20 tons per truck**
- **Truck Cost: $45 per hour = $0.75 per minute**

Delay at plant	0 min.	Cost/cycle	$49.50
Loading time	1 min.	Cost/ton	$2.47
Ticket, Tarp & Sampling	5 min.		
Haul to job (10 miles)	20 min.		
Delay at job	15 min.	Cycles/truck	9
Truck exchange	2 min.	Cycles required	120
Dump	3 min.	Trucks required	14
Return to plant	20 min.		
Total	66 min.	Efficiency %	61

TRUCK CYCLE - NO PLANT DELAYS F8

Figure 8 shows a truck cycle similar to the one shown in Figure 3, but reflects the use of a surge bin and trucks with bed liners (or an automatic spray system). This allows continuous plant operation and eliminates any plant delays of the trucks. Trucks can be loaded in less than one minute. As can be seen in Figure 8, the truck cycle is now reduced to 66 minutes from 85 minutes in the Figure 3 example. Using the same truck cost per hour ($45) as in the Figure 3 calculations, the cost per truck cycle is reduced to $49.50 and haul cost per ton is reduced to $2.47. With the reduced truck cycle time of 66 minutes, trucks can make 9 trips per day instead of 7, and the number of trucks can be reduced from 17 to 14. Notice the trucking efficiency has been increased to 61% because the trucks are moving 40 minutes out of the 66 minute cycle. **Figure 9** shows a diagram of the truck cycle and the facility when plant delays are eliminated.

Usually, a specific amount of mix, such as the 20 tons in the examples above, is loaded onto each truck. When scales are installed under a surge bin or if the



TYPICAL TRUCK CYCLE WITH SURGE BIN - NO PLANT DELAYS F9

- **Production: 240 tons per hour = 2,400 tons per day**
- **21 tons per truck**
- **Truck Cost: $45 per hour = $0.75 per minute**

Delay at plant	0 min.	Cost/cycle	$49.50
Loading time	1 min.	Cost/ton	$2.35
Ticket, Tarp & Sampling	5 min.		
Haul to job (10 miles)	20 min.		
Delay at job	15 min.	Cycles/truck	9
Truck exchange	2 min.	Cycles required	114
Dump	3 min.	Trucks required	13
Return to plant	20 min.		
Total	66 min.	Efficiency %	61

TRUCK CYCLE - NO PLANT DELAYS F10

- **Production: 240 tons per hour + 400 tons storage = 2,800 tons per day**
- **21 tons per truck**
- **Truck Cost: $45 per hour = $0.75 per minute**

Delay at plant	0 min.	Cost/cycle	$49.50
Loading time	1 min.	Cost/ton	$2.47
Ticket, Tarp & Sampling	5 min.		
Haul to job (10 miles)	20 min.		
Delay at job	15 min.	Cycles/truck	9
Truck exchange	2 min.	Cycles required	133
Dump	3 min.	Trucks required	15
Return to plant	20 min.		
Total	66 min.	Efficiency %	61

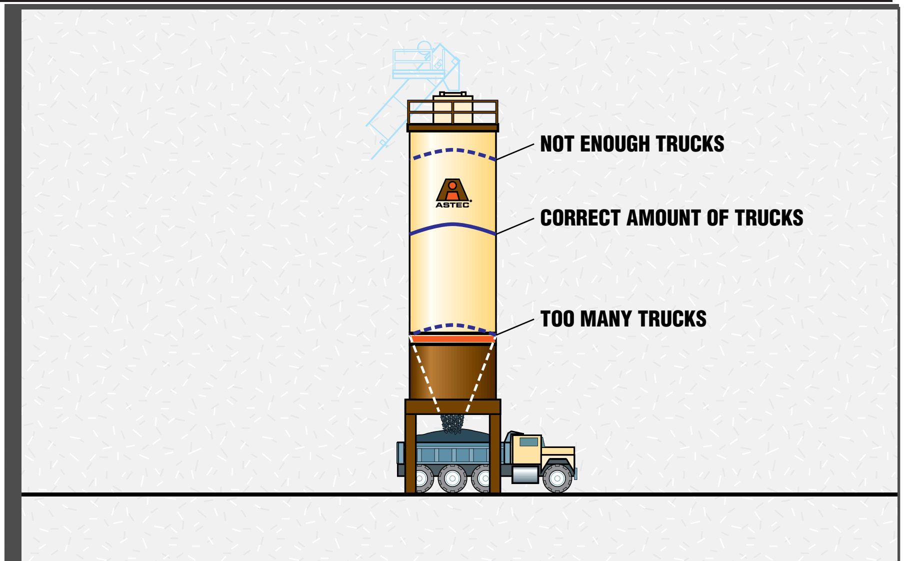
TRUCK CYCLE - NO PLANT DELAYS F11

exact tare weight of the truck is known when weigh batchers or back-way systems are used, a truck can be loaded safely to its legal limit each round. The truck cycle in **Figure 10** looks much like the one in Figure 8, but now trucks are loaded with 21 tons of mix instead of 20. The number of minutes in the cycle is exactly the same and the cycle efficiency is exactly the same. But, the trucking cost per ton is reduced from $2.47 to $2.35 because 21 tons are being hauled for the same cost as 20 tons. If the plant continues to produce 2,400 tons/day, only 114 trips are required and, therefore, 13 trucks can be used instead of 14. A slight increase in the payload of the trucks can reduce the number of trips and result in substantial savings.

There is heavy demand for trucks, resulting in frequent shortages. This makes some producers reluctant to release trucks once they have no use for them. It is therefore not uncommon to see a surge or storage bin installed at a hot mix facility without a corresponding reduction in the number of trucks in the truck cycle. As Figure 10 shows, adding a surge or storage bin to the plant operation and gross loading the trucks allows a reduction in the number of trucks from 17 to 13. If 17 trucks are left on the haul and are now cycling in 66 minutes instead of 85 minutes, the surge/silo will be empty before long and the trucks will be waiting 15 minutes under the silo, even with 200-400 tons of mix in storage at start-up in the morning.

The truck cycle for a facility that has increased production from 2,400 tons to 2,800 tons by beginning with the silos full in the morning is shown in **Figure 11**. The trucking cost per ton remains the same and the cycle time remains the same. The number of trips required increases from 114 to 133 and 15 trucks will be needed. If the operator continues to use 17 trucks, the silos will be empty in approximately four hours, and the trucks will again be waiting in line.

To help balance the number of trucks required, surge bins and silos can be used as truck indicators. **Figure 12** illustrates this point. If too many trucks are placed on the haul, the silo will soon be running empty. If too few trucks are on the haul, the silo will be full. By noting the mix level in the silo and increasing or decreasing the number of trucks as required, the proper number of trucks for the most efficient utilization can be determined.



BIN USED AS TRUCK INDICATOR F12

SURGE VERSUS STORAGE

Storage bins (silos) look and perform very similarly to surge bins. In portable operations, where the hot mix producer is producing, trucking, and placing all the mix, the plant operation can be controlled and managed very efficiently with a single surge bin. However, on stationary or permanent plants where multiple mixes are required each day and multiple paving crews along with FOB customers are supplied from the same facility, multiple silos are often required **(Figures 13 and 14)**. This allows the filling of silos with different mixes, making available two to five different mixes at any one time.

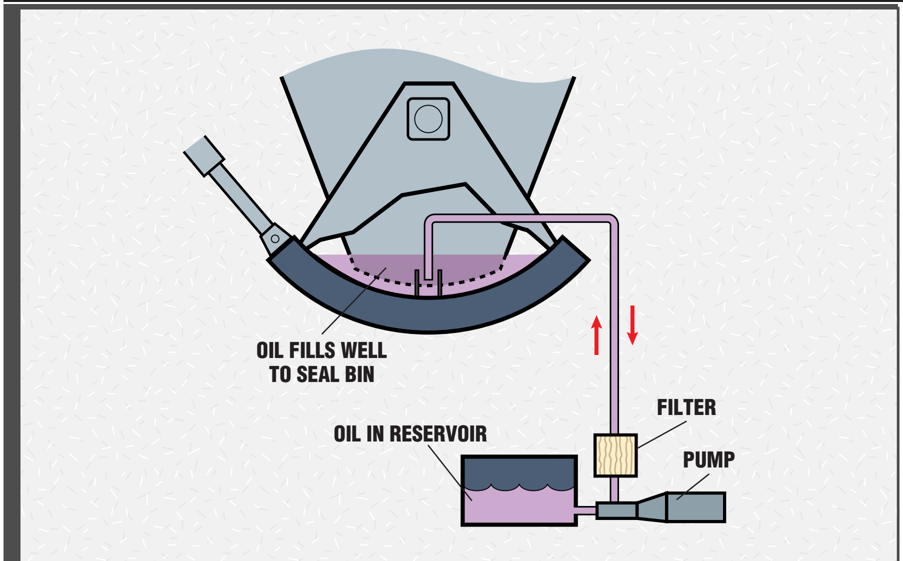
MULTIPLE SILO SYSTEM F13

The truck savings that can be achieved with a silo are exactly the same as those achievable with a surge bin (as described above). However, silos have the following additional advantages:

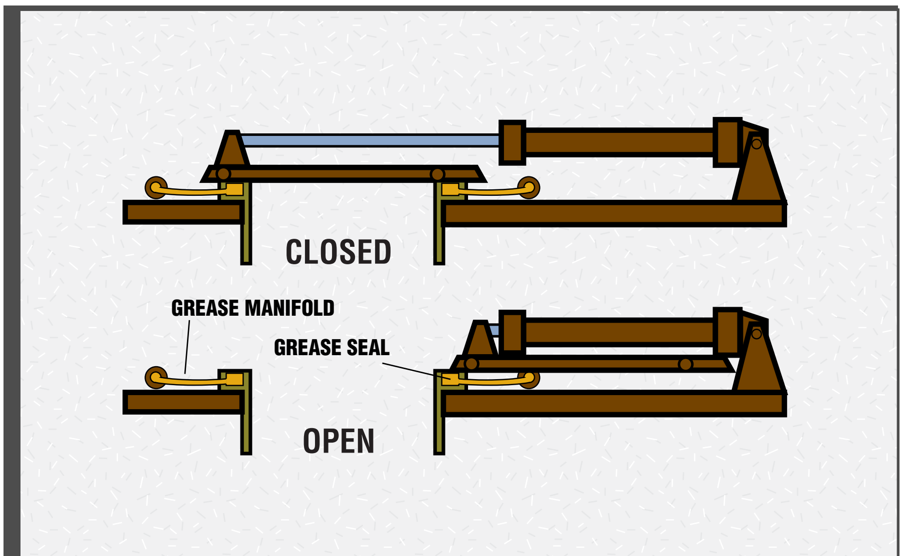
- *Performs the job of a surge bin plus also has storage capability (assures mix availability).*
- *Allows storage of multiple mixes for extended periods of time to be used as needed.*
- *Reduces plant crew time.*
- *Increases plant uptime.*
- *Allows the sale of more FOB mix because of better service and mix availability.*

MULTIPLE SILO SYSTEM F14

Most stationary hot mix plants are extremely busy in the morning and often unable to meet the demands of the plant owner's paving crews as



STORAGE BIN BOTTOM LIQUID SEAL F15



STORAGE BIN TOP GREASE SEAL F16

well as of FOB customers. However, in the afternoon, most asphalt plants assume a stop/start operation because there is not enough demand to run the facility continuously. Often, the plant crew is forced to stay as late as 6:00 to 7:00 o'clock in the evening, waiting for the paving crew to order the last load of mix. The use of storage bins can help with these problems.

Storage bins (silos) look like surge bins but on closer observation are more sophisticated and considerably different. They are designed to store mix for an extended period of time. To store mix for an extended period of time, it must not be exposed to oxygen. The higher the mix temperature, the faster the rate of oxidation. Starting at 200°F, for each 25°F rise in temperature, the rate of the reaction doubles. Mix stored at 350°F will oxidize four times as fast as mix stored at 300°F. The reaction doubles from 300°F to 325°F and again from 325°F to 350°F. Therefore, silos must be sealed airtight to prevent the mix from being exposed to oxygen in the air. A liquid seal, as shown in **Figure 15**, prevents oxygen from entering the storage bin around the gate area. The liquid/oil is pumped into the gate area each evening when the bin is filled with mix. The next morning the pump is reversed, sucking the liquid back out of the gate area and allowing the gate to then be opened. A top grease seal seals the top of the hot storage bin **(Figure 16)**. With a liquid seal at the bottom and the grease seal at the top, mix has been successfully stored in silos for up to a week without substantial changes in the mix. An inert gas system, which pressurizes the silo and forces the oxygen-free gas out of the silo and prevents air from coming in, is another type of silo seal. Mechanical seals have generally not been successful because contamination by hot mix prevents air tight sealing. The simplest and least expensive method of sealing a silo is to close it like a thermos bottle, and the liquid seal and grease seal have proven to be the most reliable over the long term. For more information on oxidation of mix, refer to Astec Technical Paper T-103 titled "Oxidation."

Operators often worry about temperature loss, but, with the generally well-insulated silos being built today, only hot oil or electric heat around the cone and gate is necessary if at least 6 inches of insulation is applied to the sidewall and top of the bin.

Storage is basically insurance. Knowing that the mix can be safely held for three days to a week gives the plant operator confidence to fill the storage bins every night. Usually, mix can be held in a surge bin without significant loss of mix quality if storage time is limited to 12 hours. However, because of the unpredictability of weather and various other factors that effect the paving operation, operators are generally reluctant to store overnight in a surge bin. This leads to the type of operation where the plant crew comes to the plant at 4:00 AM to 5:00 AM (at least two hours ahead of truck arrivals) in order to fill up the silos and have them full at 6:30 to 7:00 AM. To insure the silos are empty in the afternoon, batch plants are often operated without using the silos after lunch. As previously noted, this practice results in inefficiencies in the trucking operation and leads to substantial overtime for the plant crews. By ending the day with the silos full and having one person stay to load the last truck, the plant crew is required to work fewer hours, which not only reduces overtime cost but also personnel fatigue.

MULTIPLE SILO SYSTEM F17

EARLY MORNING LOADOUT F18

Multiple silos **(Figure 17)** allow storage of different mixes, making it possible to run high production through one silo while also serving customers out of the other silos.

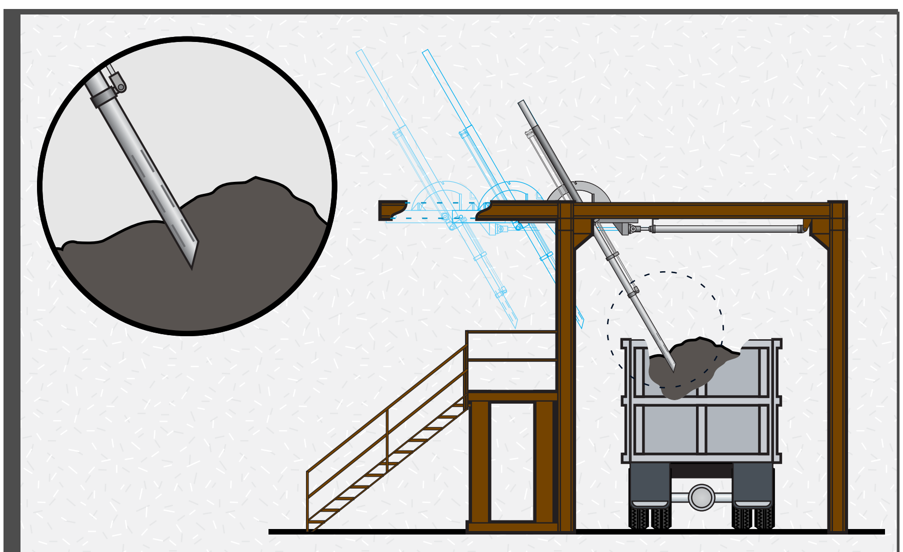
Filling the bins at night to be ready for load-out the next morning **(Figure 18)** substantially increases plant uptime. A recent survey showed that 95% of plant breakdowns occur first thing in the morning. When the plant is down first thing in the morning, and 15 trucks are forced to wait for two hours while the plant is being repaired, approximately $1,350 in excess trucking cost is incurred. In addition to this, approximately $600 in paving crew cost results from the two-hour breakdown. If silos are full, the plant operator can begin operation as normal, loading the trucks out of the filled silos. By the time the silos are emptied, hopefully the plant would be back in operation and neither the trucking nor the paving crew operations would have been adversely affected by the breakdown.

Having different kinds of mixes available in multiple silos (Figure 17) means better customer service and mix availability and can lead to increased FOB sales. Many operators have a relationship with their customers where the customers call in

AUTOMATIC LOAD-OUT SYSTEM CONTROLS F19

Photo: Truckjacket & Supply,Inc.

TRUCK WITH AUTOMATIC TARP F20



AUTOMATIC SAMPLING SYSTEM F21

and tell them the quantity and type of mix they want the next day. The operator can fill the silos during the slow time in the afternoon and have the mix available for those specific customers. The increased volume in sales not only directly increases profitability, but the additional tonnage also reduces plant cost.

TICKET, TARP, AND SAMPLE

Truck delay can be minimized with automatic loadout systems **(Figure 19)** that can load a truck (in less than one minute) and print a ticket. Silos and control houses should be arranged so that the truck driver is not required to leave the truck to get the ticket. Automatic tarps for trucks **(Figure 20)** are readily available and further reduce time delays at the plant. Automatic sampling systems **(Figure 21)** allow a hot mix sample to be quickly taken from the truck, without delaying the driver.

DELAY AT THE JOB

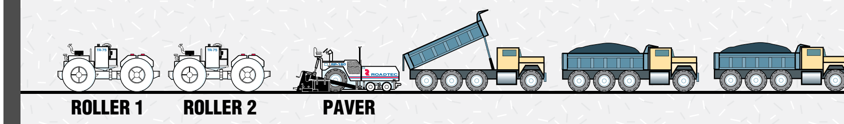
Figure 22 illustrates that three to four trucks are usually waiting to unload at the job site. Often, trucks are used as surge bins to allow the continuous operation of the paver. However, most pavers today are built to discharge trucks at a rate of 1500 tons/hour. The truck is unloaded very quickly. Then the paver stops as the truck is moved out and the next truck is moved in, the tailgate is unlocked, and the bed is raised. Surveys run over the past 30 years show an average truck delay of 12-15 minutes on most paving jobs. This delay increases trucking cost and also negatively affects mix quality. (Refer to Roadtec Technical Paper T-134 titled "Temperature Segregation" for more information.) **Figure 23** shows a Material Transfer Vehicle with a 25-

30 ton surge capacity. This machine can help decrease truck delays at the job site.

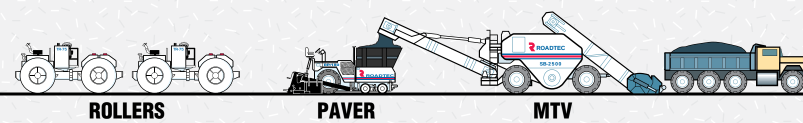
The Material Transfer Vehicle feeds the paver with a conveyor, as shown in Figure 23. As the paver approaches the Material Transfer Vehicle, it is refilled before the Material Transfer Vehicle moves forward to receive the next truck discharge. An insert can be installed in the paver, allowing storage of 15-20 tons of mix in the paver and providing a combined paver and Material Transfer Vehicle storage capacity of 45-50 tons. With storage capacity, the paver can operate continuously. When a Material Transfer Vehicle is used, trucks can be stopped 100-200 feet ahead of the paver and dump safely without moving. The truck can discharge at a location where there is no danger of the truck bed hitting power lines, tree limbs, etc.

Figure 24 shows the truck cycle that was illustrated in Figures 3 and 8 but takes into account the elimination of truck delay at the paving site. Remember that truck cycle time was reduced to 66 minutes with the use of a surge bin at the hot mix facility. By adding a Material Transfer Vehicle to perform as a surge bin on the road (as described above), the truck cycle time is further reduced to 48 minutes. Trucking cost falls to $36.00 per trip and to $1.80 per ton (when hauling 20 tons per truck). The trucks now make 12 trips instead of 7 in the original example. Only 10 trucks are required (versus 17) and the efficiency of the trucking operation climbs to 82%.

With a Material Transfer Vehicle, larger trailers of the type used for hauling aggregate can also be used for hauling asphalt because trucks can discharge without moving. Using larger trailers means using fewer



PAVING OPERATION USING TRUCKS AS SURGE BINS F22



PAVING OPERATIONS USING MTV AS SURGE BIN F23

- **Production: 240 tons per hour = 2,400 tons per day**
- **20 tons per truck; Material Transfer Vehicle used at paving site**
- **Truck Cost: $45 per hour = $0.75 per minute**

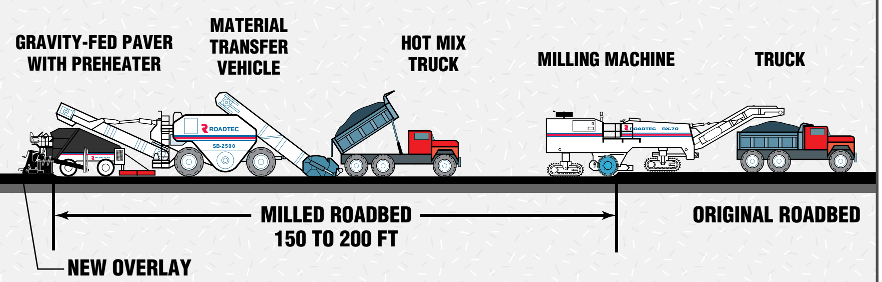
Delay at plant	0 min.	Cost/cycle	$36.00
Loading time	1 min.	Cost/ton	$1.80
Ticket, Tarp & Sampling	5 min.		
Haul to job (10 miles)	20 min.		
Delay at job	0 min.	Cycles/truck	12
Truck exchange	0 min.	Cycles required	120
Dump	2 min.	Trucks required	10
Return to plant	20 min.		
Total	48 min.	Efficiency %	82

TRUCK CYCLE - NO PLANT DELAYS F24

- **Production: 240 tons per hour = 2,400 tons per day**
- **26 tons per truck; Material Transfer Vehicle used at paving site**
- **Truck Cost: $50 per hour = $0.83 per minute**

Delay at plant	0 min.	Cost/cycle	$40.00
Loading time	1 min.	Cost/ton	$1.54
Ticket, Tarp & Sampling	5 min.		
Haul to job (10 miles)	20 min.		
Delay at job	0 min.	Cycles/truck	12
Truck exchange	0 min.	Cycles required	92
Dump	2 min.	Trucks required	8
Return to plant	20 min.		
Total	48 min.	Efficiency %	83

TRUCK CYCLE - NO PLANT DELAYS F25



CLOSE-COUPLE PAVING OPERATION F26

- **Production: 240 tons per hour = 2,400 tons per day**
- **20 tons per truck; Material Transfer Vehicle used at paving site**
- **Truck Cost: $45 per hour = $0.75 per minute; RAP backhaul**

Delay at plant	0 min.	Cost/cycle	$21.00
Loading time	1 min.	Cost/ton	$1.05
Ticket, Tarp & Sampling	5 min.		
Haul to job (10 miles)	20 min.		
Delay at job	0 min.	Cycles/truck	12
Truck exchange	0 min.	Cycles required	120
Dump	2 min.	Trucks required	10
Return to plant	0 min.		
Total	28 min.		

TRUCK CYCLE - NO PLANT OR PAVING SITE DELAYS F27

trucks and results in additional reduction in the cost of trucking operation **(Figure 25)**. Assuming a truck cost of $50 per hour for trailers that haul 26 tons, the cost of the haul per ton is reduced to $1.57. With the larger payload of 26 tons, only 92 trips are now required and the number of trucks is reduced from 10 to 8.

In order to satisfy public demands, highway officials are designing jobs to minimize user delays. In the close-couple operation shown in **Figure 26** a milling machine operates approximately 150 feet ahead of the paver. As the old material is milled out, the surface is automatically swept and new mix is placed immediately. Using high strength SMA mixes, traffic can be turned back to the lane almost directly behind the pavers. A combined milling-paving operation also lends itself to double-hauling: hauling mix out and hauling milled material back to the plant. When double-hauling, the trucking cost of the return load of milled material is generally charged to the milling operation, eliminating this cost from the paving operation trucking cost. This leads to a significant reduction in the mix haul cost, as shown in **Figure 27**. Assuming $45/hour trucking, the cycle time related to the mix haul is reduced to 28 minutes and the trucking cost per ton is reduced to $1.05 from $1.80 shown in Figure 24. Wherever milling and paving operations can be combined, a substantial savings in the trucking cost of both operations can be realized.

At this writing, Roadtec has manufactured over 300 Material Transfer Vehicles (Shuttle Buggy®, **Figure 28**). Essentially all of these machines were purchased to improve pavement smoothness or to eliminate segregation. Unfortunately, few of the Shuttle Buggy Material Transfer Vehicles have been used in a manner where they truly shuttle as described. To the surprise of many of the purchasers of these machines, maximum cost savings occur on intersection work where the Shuttle Buggy is truly used as a Material Transfer Vehicle **(Figure 29)**.

Truck cycles of typical intersection paving operations are shown in **Figures 30 and 31**. When no Material Transfer Vehicle is used on the intersection job, truck cycle time totals 83 minutes and efficiency is only 48 percent (Figure 30). With the use

SHUTTLE BUGGY® MATERIAL TRANSFER VEHICLE F28

THE SHUTTLE BUGGY® ALLOWS INCREASED PAVER MANEUVERABILITY F29 of a Material Transfer Vehicle, truck cycle times for the same intersection job fall to 48 minutes and efficiency increases to 83 percent. Using the Material Transfer Vehicle substantially reduces the paving cost because the truck can dump and eliminate the delays that occur in the very slow paving operation. One contractor reported that with the use of the Shuttle Buggy on intersection work, he was able to reduce the number of trucks from 7 to 3 while doubling the number of intersections completed in a workday. Contractors doing commercial work, such as parking lots, cul-de-sacs, etc., tell of similar savings achieved with the use of the Shuttle Buggy. While the machines have been purchased for other applications, the maximum savings they provide are due to the fact that the paver can separate from the truck, allowing higher paver maneuverability. A substantial amount of the handwork often required on commercial jobs, can then be eliminated because the mobile paver can perform more of the laydown operations mechanically.

In addition to reducing trucking cost, the Material Transfer Vehicle leads to great improvements in smoothness on most paving jobs, reducing ride numbers from 30" per mile to below 10" per mile when using the Mays meter and similar reductions when

- **Production: 96 tons per hour = 960 tons per day**
- **20 tons per truck**
- **Truck Cost: $45 per hour = $0.75 per minute**

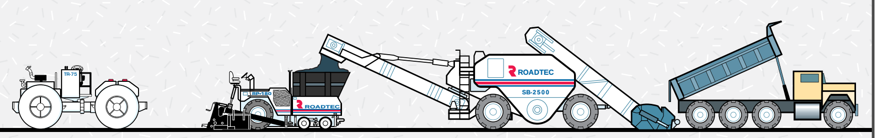
Delay at plant	0 min.	Cost/cycle	$62.25
Loading time	1 min.	Cost/ton	$3.11
Ticket, Tarp & Sampling	5 min.		
Haul to job (10 miles)	20 min.		
Delay at job	30 min.	Cycles/truck	7
Truck exchange	2 min.	Cycles required	48
Dump	5 min.	Trucks required	7
Return to plant	20 min.		
Total	83 min.	Efficiency %	48

TRUCK CYCLE FOR INTERSECTION WORK- NO PLANT DELAYS **F30**

- **Production: 96 tons per hour = 960 tons per day**
- **20 tons per truck; Material Transfer Vehicle used at paving site**
- **Truck Cost: $45 per hour = $0.75 per minute**

Delay at plant	0 min.	Cost/cycle	$36.00
Loading time	1 min.	Cost/ton	$1.80
Ticket, Tarp & Sampling	5 min.		
Haul to job (10 miles)	20 min.		
Delay at job	0 min.	Cycles/truck	12
Truck exchange	0 min.	Cycles required	48
Dump	2 min.	Trucks required	4
Return to plant	20 min.		
Total	48 min.	Efficiency %	83

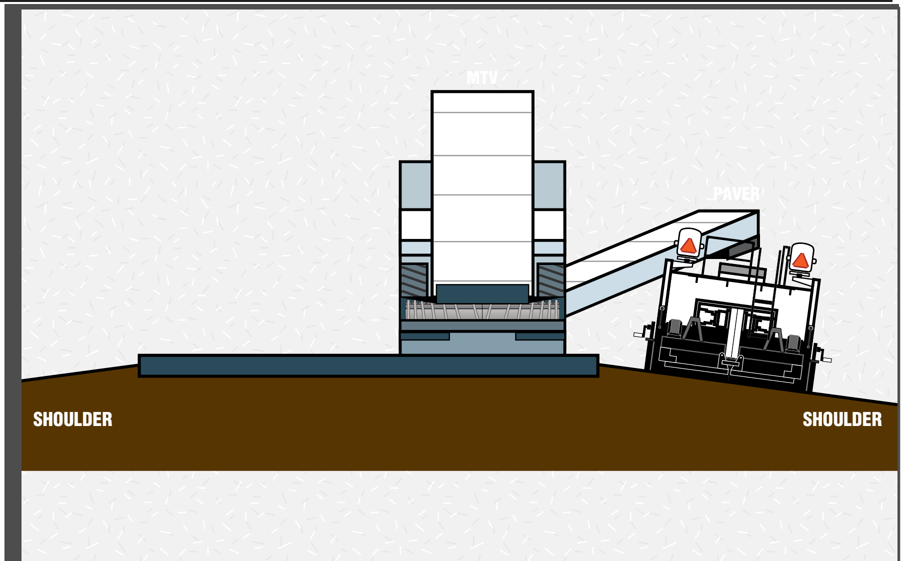
TRUCK CYCLE FOR INTERSECTION WORK - NO PLANT DELAYS **F31**



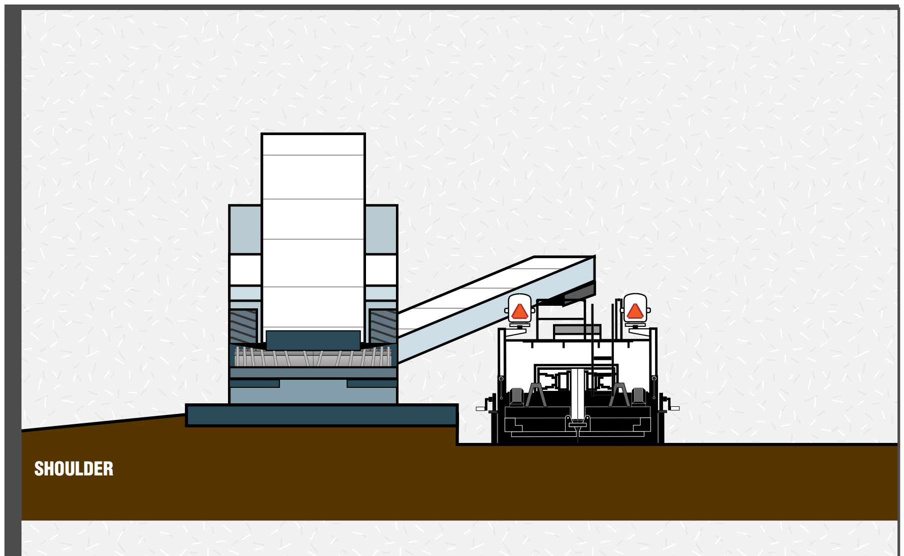
CONTINUOUS PAVING PRODUCES SMOOTHER ROADS **F32**

using different types of profilographs **(Figure 32)**. The Material Transfer Vehicle also allows offset paving when shoulders or additional lanes are added **(Figure 33)**. This results in significant truck savings since trucks are not required to drop down into the new lane and then pull back out into traffic **(Figure 34)**. On paving projects requiring string lines on both sides of the paver, such as airports, use of a Material Transfer Vehicle can also generate considerable savings. One contractor reported that he increased his laydown operation from 1,000 tons per day without a Material Transfer Vehicle to 2,000 tons with the same number of trucks and a Shuttle Buggy. String lines do not have to be broken and trucks do not have to back through tack because the trucks can discharge in the adjacent lane with the Material Transfer Vehicle's ability to transfer material over the string lines **(Figure 35)**. When paving high-banked race tracks, the Shuttle Buggy can be used as shown in **Figure 36**, making the job considerably easier to complete.

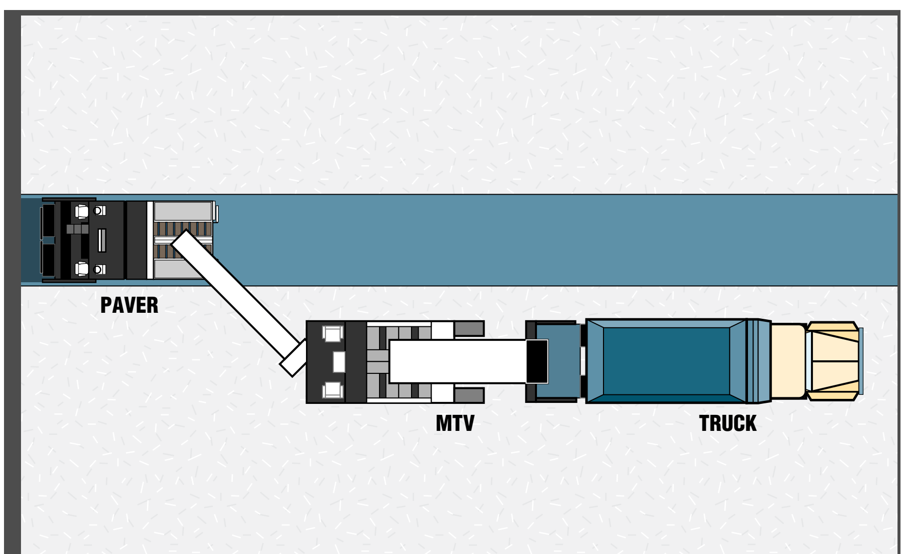
Figure 37 shows a bottom dump trailer. Using this type of trailer, mix can be dumped in windrows. The windrow acts as a large surge bin on the road. While various problems can occur due to uneven cooling, etc.,



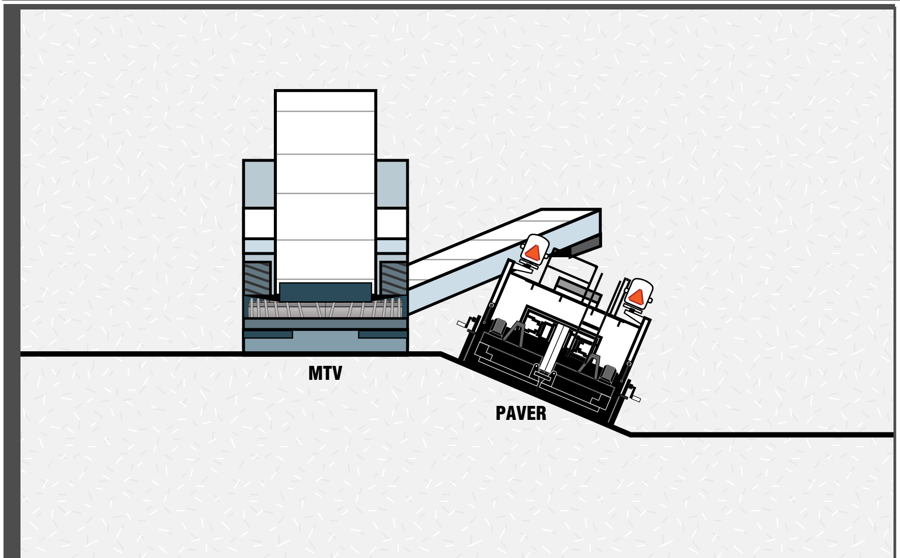
MTV ALLOWS PAVERS ON SHOULDER AREA F33



MTV KEEPS TRUCKS OUT OF NEW LANE F34



MTV FEEDS PAVER OVER STRING LINES F35



PAVING HIGH BANKED RACE TRACK WITH MTV F36

BOTTOM DUMP TRAILER DISCHARGING WINDROW F37

this method has been used quite successfully in the western part of the United States. Pickup machines **(Figure 38)** pick the windrow material up and feed it into the paver. A new version of the Material Transfer Vehicle has been developed to include an auger and screed on the rear and a windrow pickup head on the front. This new machine can pick up the windrow material, store it, remix it, and place it directly on the pavement **(Figure 39)**. This solves the temperature-differential problem often encountered in windrow paving.

CONCLUSION

Managing trucks is perhaps the most difficult part of the paving operation. Surge bins, storage bins and Material Transfer Vehicles allow quick loading and quick discharging of the trucks and reduce delays at the plant and the paving operation, thereby improving the efficiency of the truck cycle. These devices, along with others mentioned above, reduce the cycle time and allow trucks to make more trips in one day. While surge bins, storage bins, and Material Transfer Vehicles add equipment cost to the entire operation, the offset in the truck savings will more than pay for these devices. Also, demand for truck drivers, which are currently in very short supply, will be reduced. The number of trucks required will be reduced, as will insurance costs, and other operating costs related to trucking.

In conclusion, to minimize the trucking cost and manage the trucks properly, the following should be practiced:

- *Use the maximum size truck available.*
- *Eliminate all possible delays at plant*

and job site.

• Double-haul whenever possible.

• Do not over-truck (at $45/hr, one truck too many costs $450/day). Calculate the truck cycle and set the proper amount of trucks for the particular haul.

• Haul distances often vary from day to day as the job progresses. Try to find an alternate use for trucks when they are not needed on the short end of the job.

• Set an achievable production rate. Determine whether limitations are in plant production, laydown production, or availability of trucks. Know the limitations in production and determine the exact number of trucks required for the haul and do not over-truck.

Managing trucks to maximize the operation as outlined above is one of the most challenging tasks in running a hot mix operation. It is hoped that the preceding thoughts and ideas will assist in managing the problems related to trucking.

WINDROW PICK-UP MACHINE ON PAVER F38

SHUTTLE BUGGY PAVER™ F39

ASTEC encourages its engineers and executives to author articles that will be of value to members of the hot mix asphalt (HMA) industry. The company also sponsors independent research when appropriate and has coordinated joint authorship between industry competitors. Information is disbursed to any interested party in the form of technical papers. The purpose of the technical papers is to make information available within the HMA industry in order to contribute to the continued improvement process that will benefit the industry.

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