Technical Paper T-129

STOCKPILES

by George H. Simmons, Jr.

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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INTRODUCTION

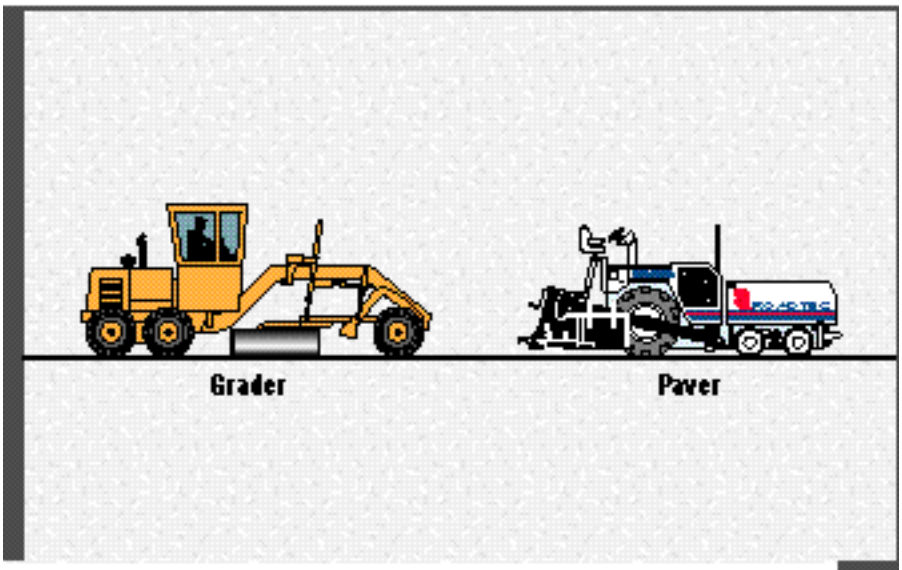
For years, American contractors and asphalt producers have searched for the least expensive way to dry aggregate. They looked at many things, such as bigger dryers, bigger burners, more complex burners, and better air handling systems. They searched from one manufacturer to another looking for “magic” dryer flights, hoping to get the edge over their competition. They studied flighting patterns, burner tuning, air flows, fuel-to-air ratios and anything else that might be helpful. Yes, all those things were helpful. And the contractors who did the best job with these tools were the most profitable.

But alas, it seems we always overlook the most obvious things. Most contractors already have the very equipment that could help them most to decrease drying costs and increase plant capacity: a grader and paver (See **Figure 1**.) And they manufacture the very product that would help most: hot mix asphalt. Yes, with those products they could easily create well-sloped, paved stockpile areas. Doing that would launch a whole chain of improvements. These improvements would increase production and lower drying costs better than anything he could try.

Sure, you’ve heard stories of how people sloped and paved their stockpiles areas and had less moisture to dry out of their aggregates. But you probably didn’t believe it. (See **Figure 2**.) Or you may have thought it cost too much. Perhaps you thought the payback would take too long. Well, did you ever think hot mix storage silos were a fad? Or do you remember when RAP (reclaimed asphalt pavement) was first used? Were you among the first to enjoy the profits from those innovations?

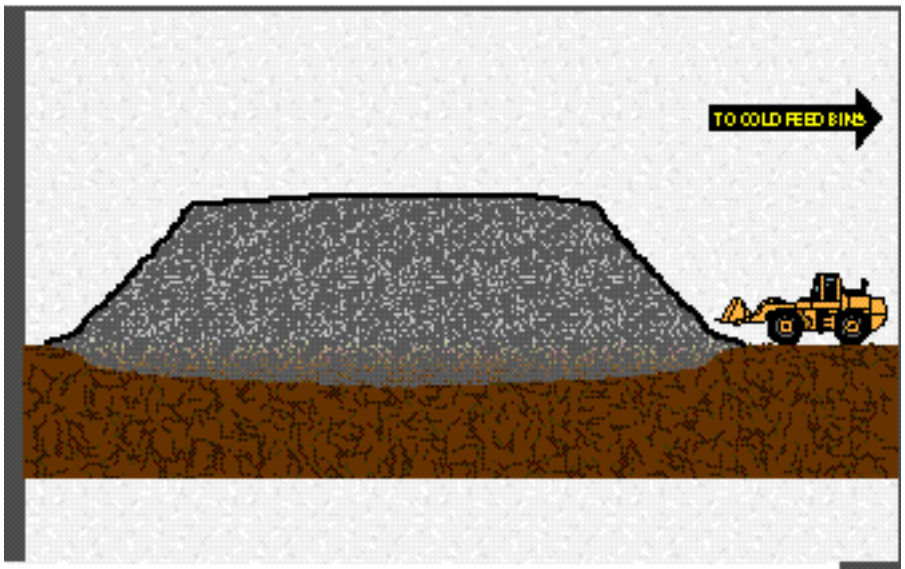
Are you now beginning to feel a little embarrassed about not paving under your stockpiles? Well, it’s not too late. But the longer you wait the more you lose. Stockpile paving and drainage is something none of us has paid enough attention to in the past. Yet, it is one of the easiest ways to save money and increase production capacity. Properly managing your stockpiles produces savings in at least seven specific ways. They are as follows:

1. Lowers drying costs.
2. Increases production capacity.
3. Lowers paving costs.
4. Decreases material loss.
5. Lowers equipment and electrical power costs.
6. Reduces penalties from segregation and gradation problems.
7. Lowers maintenance cost for loader.

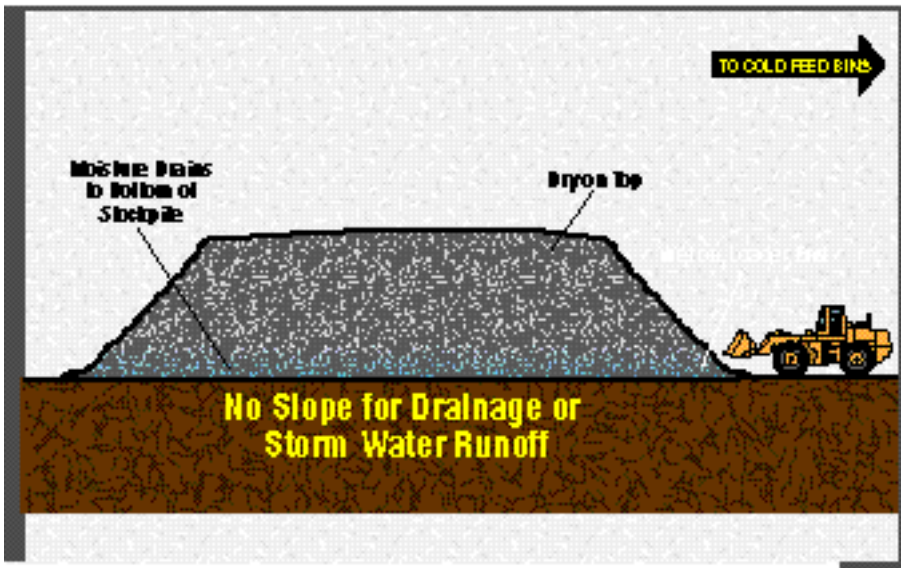


YOU MAY ALREADY HAVE THE EQUIPMENT YOU NEED F1

WATER DRAINS FROM SLOPED STOCK PILE F2



MATERIAL SINKS INTO THE GROUND UNDER UNPAVED STOCK PILES F3



UNSLOPED STOCK PILES HOLD WATER F4

It is easy to calculate some of these savings, such as lower drying costs. However, it is not easy to put a value on other savings, such as lower paving costs. Nevertheless, savings from lower paving costs could exceed those from other sources.

BACKGROUND

In the past, most stockpiles were put behind the cold feed bins without any concern for elevation, surface preparation or provisions for water drainage. They were simply piled on ground that was unprepared and unconditioned. The piles sank into the ground. (See **Figure 3**.)

An unconditioned earth surface is unstable, causing much of the aggregate to get buried. Buried aggregate is lost aggregate. It costs money. Moreover, such a pile of aggregate usually has no way to rid itself of water. If the material was hauled in wet or was rained on before use, it simply held the water. There was no way for the water to drain away. (See **Figure 4**.)

Stockpiles on unprepared surfaces also create other problems. In time, the pile gets shifted out of its original spot. Some of the material previously buried may get mixed with new material added to the pile. The loader operator usually spots this potential for contaminating material. He then tries to keep a layer of fresh material on top of the surface to avoid mix gradation failure. This practice is common. And it is the main reason that stockpile grade elevations grow higher and higher. (See **Figure 5**.)

When a hard-surfaced stockpile storage area is used, the loader operator will *not* experience these problems. Material buildup and poor drainage conditions will *not* occur. Moreover, the loader operator will undoubtedly do a better job when operating in ideal conditions.

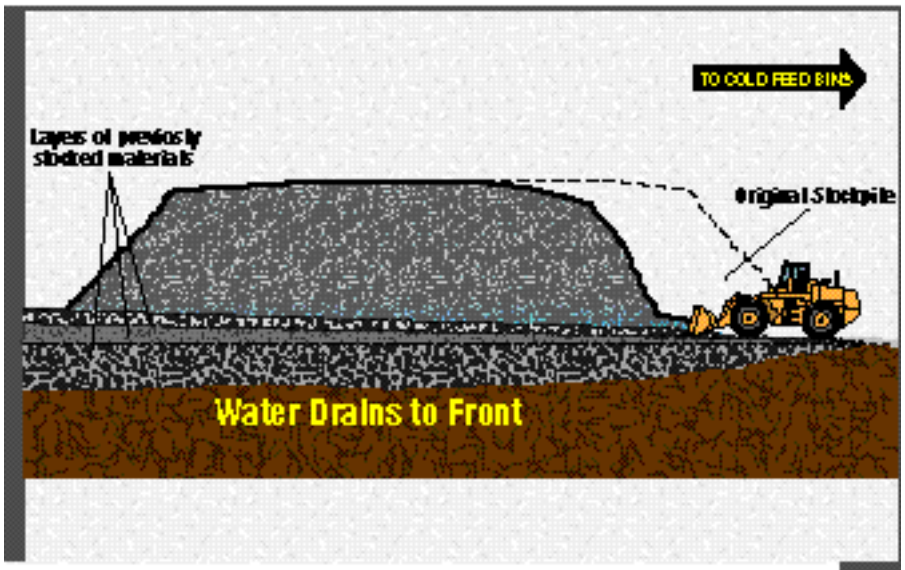
Of course, there have been sloped and hard-surfaced stockpile areas as long as there have been asphalt plants. Unfortunately, only a few of the more successful hot mix producers are utilizing them today.

So let's look at how sloping and paving stockpile areas can actually make more money for you and make you more competitive.

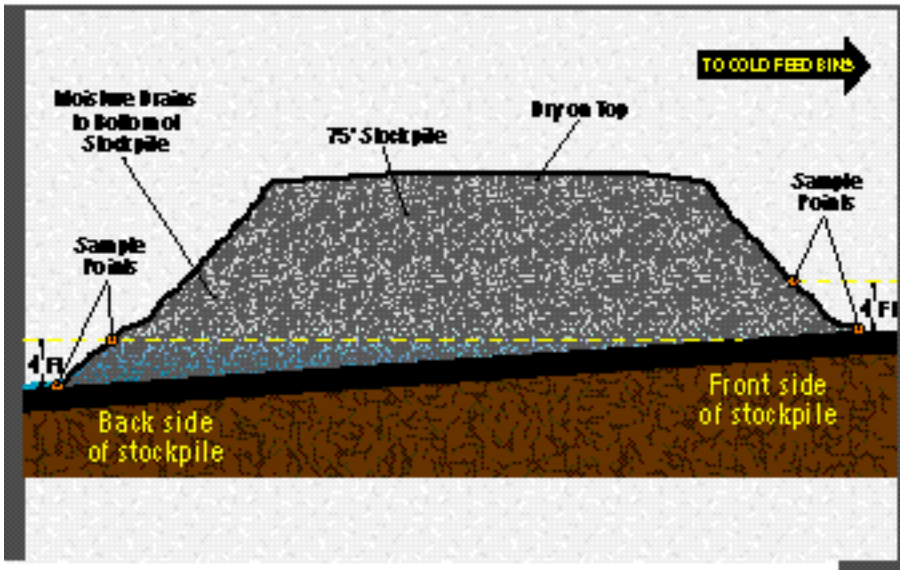
LOWER FUEL COSTS

No matter how efficient your plant equipment is or how well it is working, you can reduce drying costs by *starting* with drier aggregate. Thus, you need to reduce its moisture content *before* introducing it into the dryer or drum mixer.

Figure 6 represents stockpiles on paved areas at a HMA plant in the central part of North Carolina. Moisture measurements were made on samples taken from five of its freshly stocked stockpiles. Samples were taken at ground level at the front and back of each stockpile. **Figure 7** shows measurement results.



ELEVATION OF STOCKPILES ON UNPAVED SURFACE TENDS TO GROW F5



STOCKPILES WITH IDEAL 4 PERCENT SLOPE F6

Material type	Front side ground level	Front side 4' level	Back side ground level	Back side 4' level	Avg. moisture use level
Sand	5.6%	5.2%	23.3%	5.8%	5.4%
Screenings	7.0%	6.0%	14.0%	7.2%	6.5%
No. 78	1.4%	—	4.4%	—	1.4%
No. 67	0.5%	—	1.5%	—	0.8%
No. 5 (-1-1/2')	—	—	—	—	—
RAP (-1/2')	5.7%	5.6%	9.6%	5.7%	5.7%

MOISTURE IN STOCKPILES FROM HMA PLANT IN NORTH CAROLINA F7

Material type	ground level	4" level	Avg. use level
Sand	15.6%	5.6%	10.6%
Screenings	10.0%	6.0%	8.3%
No. 78	2.9%	1.4%	2.2%
No. 67	1.0%	0.8%	0.9%
RAP (-1,2")	7.7%	5.7%	6.7%

AVERAGE MOISTURE CONTENT STOCKPILES ON UNSLOPED, UNPAVED SURFACES F8

Material type	Sloped and Paved	Unsloped and Unpaved	Difference
Sand	5.4%	10.6%	5.2%
Screenings	6.5%	8.3%	1.8%
No. 78	1.4%	2.2%	0.8%
No. 67	0.8%	0.9%	0.1%
RAP (-1,2")	5.7%	6.7%	1.0%

COMPARISON OF STOCK PILE MOISTURES (AT USE LEVEL) F9

Samples were also taken four feet up at stockpile fronts and backs. (**Figure 6**.) The stockpiles were about seventy-five feet in diameter and the pavement dropped about four feet in elevation from front to back. Their drainage can only be described as astounding. They verify the tremendous drainage potential of sloping and paving.

How steep should the slope be? Obviously, the steeper the slope the better the drainage. But you must consider existing yard elevations when determining how steep you can reasonably make the slopes.

Note that the larger materials (No. 67s and No. 5s) are normally fairly dry and drain quickly. No. 5s were not measured for this study because they had very low moisture content. Consider these factors regarding materials:

Larger materials are more susceptible to segregation than fine materials.

The finer a material is, the more surface area it has.

Finer materials hold more moisture than coarse materials because they have more surface area.

Fine materials do not drain as well as coarse materials.

Fine materials deserve more watchful care than coarse materials.

Seventy-five to 80 percent of all mixes produced each year are surface mixes that include fine materials.

Figure 8 shows the average moisture content of the similar stockpiles on unsloped, unpaved surfaces. Paving under these stockpiles would not increase drainage unless the surfaces were sloped.

Figure 9 compares the average moisture level of stockpiles on sloped and paved surfaces with those on unsloped and unpaved surfaces.

Figure 10 compares the moisture of aggregates that make up a state approved surface mix. Aggregate moistures of the stockpiles described in Figure 9 were used to calculate the moisture in the mix. The results show that materials from sloped and paved stockpiles are 2.26 percent drier.

Figure 11 shows production rates and fuel usage. They are based on industry standard conditions, i.e. sea level altitude, standard barometric pressure, 70°F ambient temperature, and 300°F mix temperature. The moisture shown is the amount that must be removed from the aggregate.

Figure 12 shows the increased production and decreased fuel usage from having stockpiles on a sloped and paved surface. The rate increase for the Double Barrel is 83 tph or 664 tons per day. The rate increase for the counterflow dryer is 80 tph or 640 tons per day. Just lowering the moisture 2.26 percent gives a very significant 42 percent increase in plant production and six tenths of a gallon per ton of mix in fuel savings. Is this really possible? Yes! No other technique can make a plant this much more productive.

Aggregates from stockpiles on sloped and paved surfaces	Aggregates from stockpiles on unsloped and unpaved surfaces	Difference
4.84%	7.10%	2.26%

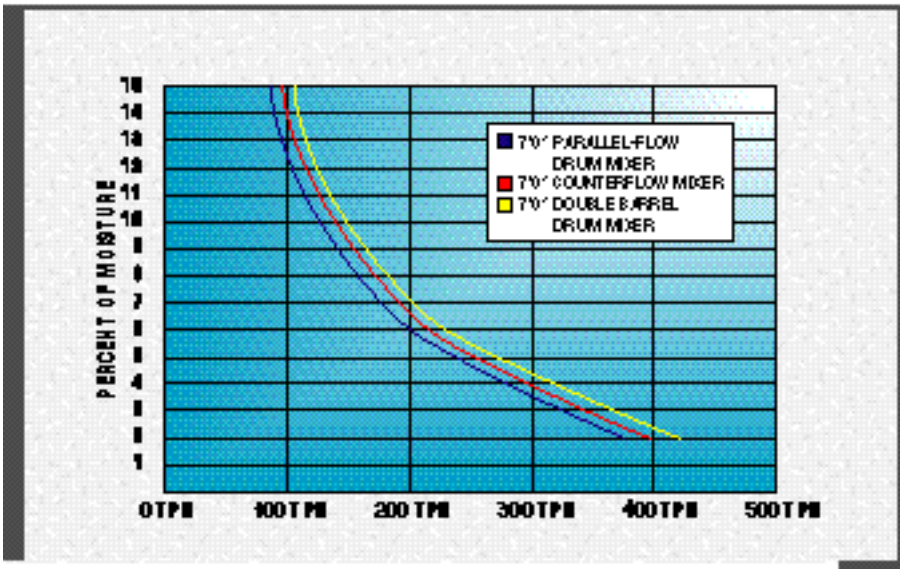
COMPARISON OF MOISTURES IN AGGREGATES FOR A SPECIFIED SURFACE MIX F10

	DOUBLE BARREL				COUNTERFLOW DRYER			
	moisture removed	gal/ton	cu ft gas/ton	tph	moisture removed	gal/ton	cu ft gas/ton	tph
Sloped and Paved	4.84%	1.68	235	279	4.84%	1.75	254	272
Unsloped and Unpaved	7.10%	2.26	316	196	7.10%	2.35	329	192

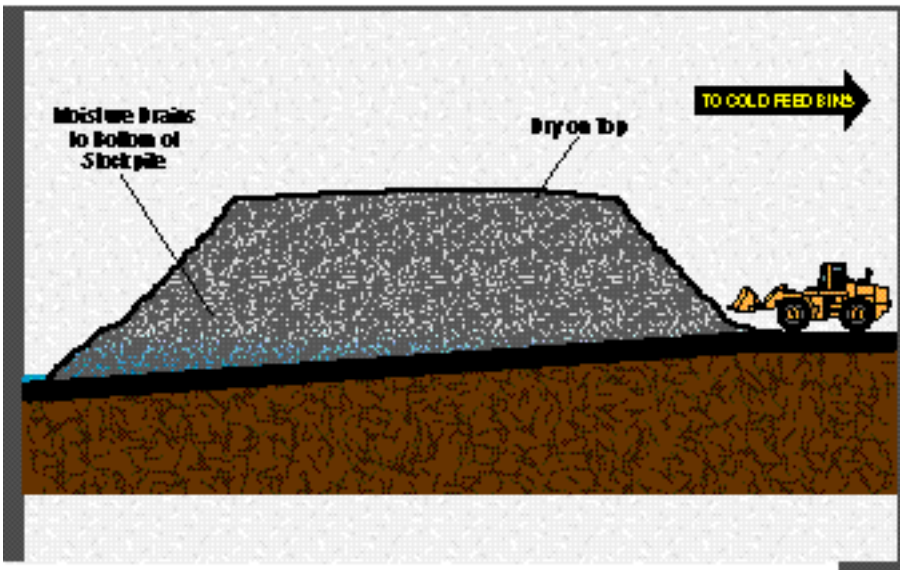
PRODUCTION RATES AND FUEL USAGE (BASED ON 38,500 ACFM) F11

	DOUBLE BARREL	COUNTERFLOW DRYER
Increase in tph	83	80
Increase in tons per day	664	640
Decreased usage of No. 2 fuel per mix ton	0.58 gal	0.60 gal
Decreased usage of natural gas per mix ton	81 cu ft	85 cu ft

BENEFITS FROM SLOPED AND PAVED AREAS F12



PRODUCTION RATES (TPH) OF DRUM MIXERS F13



STOCKPILES WITH IDEAL 4 PERCENT SLOPE F14

Percent of Moisture Removed and Gallons of Fuel per Ton

DRUM DIAMETER	PRODUCTION RATES THRU DRUM	3% / 1.39	4% / 1.63	5% / 1.78	6% / 1.99	7% / 2.19	8% / 2.42	9% / 2.63	10% / 2.87	11% / 3.02	12% / 3.32	TOTAL OUTPUT THRU SYSTEM
6'	28,000	274	270	197	171	152	135	122	111	102	94	32,200
7'	38,500	379	316	270	236	208	186	168	153	140	129	44,275
8'	50,000	491	411	351	306	271	242	218	198	182	167	57,500
9'	63,500	624	521	446	389	344	307	277	252	231	212	73,025
10'	78,500	772	644	551	481	425	380	343	312	285	262	90,275

(240°F Stock / 300°F Mix)

- 50% EXCESS COMBUSTION AIR IN DRUM
- 15% LEAKAGE THROUGH RAP INLET AND DISCHARGE CHUTE AND SEALS
- MATERIAL TO WEIGH 110 #/FT³

NOTE: MIXING CAPACITY IS LIMITED TO 4% MOISTURE DRYING RATE

PRODUCTION RATES OF COUNTER FLOW DRUM MIXERS (IMBEDDED BURNER) INCLUDING LIQUID ASPHALT F15

A quick review of **Figure 13** shows how the production level increases as the moisture content goes down.

Figure 14 shows an ideal stockpile grade, sloped away from the loader side and hard surfaced with asphalt pavement to achieve the best possible drainage conditions.

Obviously, different parts of the country have different weather conditions, materials, and average moisture contents. Even so, any plant with stockpiles on unsloped, unpaved surfaces, where moisture averages 5 percent or higher, can expect to reduce the moisture 25 to 30 percent by sloping and paving. Remember, finer materials have the higher moisture contents. So, the finer the mix gradation, the more moisture can be eliminated. **Figure 15** shows the production chart of a counterflow dryer. **Figure 16** shows the production chart of a Double Barrel drum mixer. Notice the effect of moisture content on fuel usage and production volume for units of various sizes. Observe the difference in results caused by a 2 percent difference in moisture.

LOWER PAVING COSTS

Obviously, the more hot mix we send to the paving site, the more money we can make. But sometimes we can't produce mix as fast as the paving crews can use it, especially if we experience a decrease in production of mix for some reason. Do you sometimes experience a decrease in production capability and don't know exactly why?

Perhaps your plant experiences a decrease in production capability for a period after a heavy rain. The decrease may last for days, or even weeks. The decrease may have been either small or large. Most likely, the decrease was caused by the extra water remaining in your stockpiles. If you could get it out quickly, you could resume higher tonnage rates. Paved and sloped stockpile areas can solve the problem. And it costs *nothing to operate*! Now *that* is cheap drying.

Consider this example. Suppose your paving plan calls for 300 tons per hour on a job—any job. But suppose it rained Saturday night. Then on Monday your plant could only produce 200 tons per hour. Ever happen to you? Well, think of the money you just lost because of the lower production rate. And remember, most of this loss could have been avoided by simply having paved and sloped stockpile areas. **Figure 17** shows how the rain just cost you 50 cents a ton of your paving profits!

LESS MATERIAL LOSS

Most contractors assume they will lose material throughout the year. Many expect to lose anywhere from 3 to 5 percent of their material, not counting the loss due to moisture. Where does the material go? Actually, most of it stays on the yard. The stockpile either sinks or pumps its aggregate into the ground, (**Figure 3**) or its base grows in elevation (**Figure 5**).

DRUM DIAMETER	PRODUCT GASES THRU DRUM (CFM)	Percent of Moisture Removed and Gallons of Fuel per Ton										TOTAL EXHAUST THRU SYSTEM (CFM)
		3% / 1.32	4% / 1.51	5% / 1.71	6% / 1.90	7% / 2.10	8% / 2.30	9% / 2.51	10% / 2.72	11% / 2.94	12% / 3.17	
6'	28,000	287	239	205	178	157	140	127	115	105	97	30,800
7'	38,500	394	329	281	245	216	193	174	158	145	133	42,350
8'	50,000	512	427	365	318	280	251	226	205	188	173	55,000
9'	63,500	651	542	463	403	356	318	287	261	239	219	69,850
10'	78,500	804	670	573	499	440	393	355	322	295	271	86,350

300°F Mix with 240° FS Inlet

- 50% EXCESS COMBUSTION AIR IN DRUM
- 10% LEAKAGE THROUGH RAP INLET AND DISCHARGE CHUTE AND SEALS
- MATERIAL TO WEIGH 110#/FT³
- 4% MOISTURE
- 5.5% LIQUID ASPHALT

PRODUCTION RATES (TPH) OF DOUBLE BARREL DRUM MIXERS F16

COST PER DAY OF 200 TPH VS 300 TPH

The fixed paving cost is $2,400.00 per day based on a paving crew and equipment cost of $300.00 per hour and an 8-hour day.

The paving crew can place a maximum of 3,000 tons of mix in an 8 hour day or 375 tons per hour. But the actual amount placed may be limited by the amount of mix delivered to the paving site.

The cost per ton for placing mix at 300 tph or 2,400 tons per day is:

$2,400.00 per day / 2,400 tons per day = $1.00 per ton

The cost per ton for placing mix at 200 tph or 1,600 tons per day is:

$2,400.00 per day / 1,600 tons per day = $1.50 per ton

COST PER DAY OF 200 TPH VS 300 TPH F17

Paving the stockpile area totally eliminates losses from both of those causes. Because the front-end loader can scoop up material cleanly from a paved surface, there will be no buildup of aggregate. And, if a pile needs to be moved, it can be completely relocated without leaving any material on the ground. Furthermore, this avoids contaminating any material that may be placed on the cleared spot in the future.

Paving the stockpile area may not eliminate all stockpile losses, but it will make those losses very predictable.

LOWER EQUIPMENT AND ELECTRICAL COSTS

Paving your stockpile area saves on equipment costs in several ways. Everyone knows that a front end loader runs easier on a hard surface. On a paved surface, the loader takes less horsepower and uses less fuel to drive the bucket into the pile because the bucket encounters less friction. Consequently, the loader does not have to work as hard. It requires less maintenance and its tire wear is reduced considerably. Maintenance supervisors believe that the savings may reach 10 percent. With average operational costs around 25 cents per ton, those savings can add up.

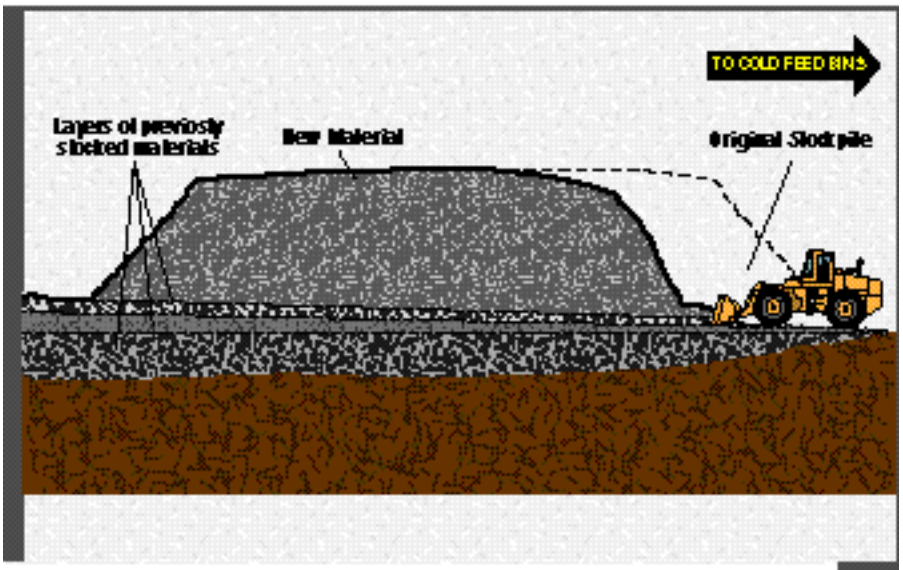
The asphalt plant works less, too. Reducing moisture reduces the amount of air that the draft system must move. It uses less horsepower and less electrical power. Reduced air flow causes less dust carryout, which reduces wear on equipment and filter bags. Resulting savings can be significant.

SEGREGATION AND CONTAMINATION

Paved stockpile areas allow use of *all* the material in a stockpile. Moreover, the loader operator doesn't have to be concerned about:

- How far down to lower the bucket when scooping.
- Digging too low and contaminating the mix with unknown material.
- Inadvertently picking up finer particles of material that may have accumulated on the bottom of the pile before because its bottom is undefined.

Such unknown and finer materials can cause segregation that could result in payment penalties equal or exceeding the cost of paving the stockpile areas. (**Figure 18**.)



PROBLEMS WITH STOCK PILES ON UNPAVED AREAS F18

ECONOMIC JUSTIFICATION—A SUMMARY

Almost all plant costs go down as a result of lowering the moisture content of the aggregates being processed. Here's why:

1. Hard surfaces under stockpiles eliminate most material losses.

2. The loader doesn't work as hard. Thus, it uses less fuel and incurs less wear, which lowers its operational and maintenance costs.

3. Penalties for contamination and segregation are less likely because unwanted mixing of materials in the stockpiles is eliminated.

4. Drier materials feed through the plant easier and cleaner. They require less cleanup and cause fewer plant shutdowns caused by plugging of chutes, buildup under belts, etc.

5. Drier materials produce less steam (gas) in the drying process. Moreover, using less fuel produces less combustion byproducts. There is less air flow through the air handling system. This requires less electrical power and causes less wear in the ductwork, in the baghouse and to the filtering bags.

6. Major fuel savings result. (Less moisture requires less fuel for drying.)

7. Increased production rates lower your per ton of mix fixed costs (labor, electrical, equipment depreciation, insurance, rents, etc.). Also, with the increased production potential, you may be able to do more jobs per day or furnish more mix for outside sales.

8. Paving costs decrease. With added production capacity for hot mix, you are better able to keep up with paving crews. Often, they can put down more mix than a plant can make. So, if you can make more mix and send it to the job, your paving cost per ton will go down significantly. Remember, the paving crew cost per hour is fixed. So when tonnage volume goes up, cost per ton goes down.

These are only the main savings and advantages. In the following return-on-investment study (**Figure 19**) only the fuel savings, material losses and equipment (loader) savings are used. Again, there are other savings and advantages that should be considered. But it is difficult to affix a dollar value to them. In some cases, added production capacity alone could quickly offset the expense of paving stockpile areas.

Basis

1. An average decrease of 2 percent moisture. (Our sample stockpile average decrease was 2.26 percent.)
2. Two percent less moisture requires approximately 1/2 gallon less fuel. (See Figure 11.)
3. No. 2 fuel cost at 60 cents per gallon.
4. Equivalent natural gas cost at $4.29 per therm (1,000 cu. ft.).
5. Stockpile area is 200 x 300 feet (6,667 square yards).
6. Contractor's paving cost at $5.50 per square yard.
7. Production volume at 150,000 tons per year.
8. Elimination of unaccounted for material loss of 3 percent per year.
9. Average aggregate cost at $8.50 per ton.
10. Loader maintenance and fuel cost at 25 cents per ton. (Does not include labor or depreciation).

Material Savings :

150,000 tons HMA x 0.95 (less 5% AC content) x 0.03 (unaccounted loss) = 4,275 tons
4,275 tons x $8.50 per ton cost =$36,337.50

Fuel Savings :

0.5 (1/2 gal per ton savings) x 60 cents x 150,000 tons =$45,000.00

Loader Savings :

25 cents per ton cost x 150,000 tons x 0.10 saving =$3,750.00

Total Savings per year :

=$85,087.50
(or 57 cents per ton)

Paving Cost :

6,667 square yards x $5.50 per yard cost =$36,670.00

Payback :

$$\text{Time Required for Payback} = \frac{36{,}670.00 \text{ (cost of paving)}}{85{,}087.50 \text{ (total savings per year)}} = 0.43 \text{ years or } 5.16 \text{ months}$$

$$\text{Tons Required for Payback} = \frac{36{,}670.00 \text{ (cost of paving)}}{.57 \text{ (savings /ton)}} = 64{,}333 \text{ tons of mix}$$

PARALLEL-FLOW DRUM MIX PLANTS

Significant advantages of reduced aggregate and reclaimed asphalt pavement (RAP) moisture are available for users of parallel-flow drum mix plants. Remember that each pound of water generates 33 cubic feet of steam when exposed to temperatures inside a dryer or drum mixer of any kind. In addition to the obvious depletion of available combustion air, the extra steam extracts light ends (oil) from the liquid asphalt as it is injected and distributed inside the drum mixer. Light ends escape the drum in the form of a vapor.

Steam is a critical catalyst in the refining process of crude oil and actually allows refineries to split the lighter oils from the heavier residue (asphalt) at a lower temperature. The same basic conditions occur inside the parallel-flow drum mixer. The asphalt is spread (or mixed) over an area of approximately 53,000 square feet (in a typical surface mix) and exposed to 300 to 400°F temperatures in the presence of steam. These are the same basic conditions that occur in the original refining process.

If you are using an AC which has been cut back or blended with a lighter oil to achieve a specific viscosity grading (which is the case for almost all asphalt grades used today) you may experience a *cracking* away of the light oil in the mixing process. It may reveal itself in the form of smoke (i.e. the gaseous particles released to the exhaust gas which recondense in the atmosphere in the form of oil droplets after being discharged from the stack).

Worse yet, it may show up as oil inside your baghouse or on the filtering bags. In this case the light ends have condensed and reformed as the original oil used to achieve desired viscosity of the asphalt at the refinery. This of course, may be disastrous. In many cases it has caused baghouse fires, which in all cases are expensive and dangerous and provide for even more unwanted risks and liability. At the very least it blinds the baghouse bags and restricts the air flow through your baghouse, thus restricting plant production significantly.

It seems obvious then that reasonable actions should be taken to limit the amount of moisture that is fed into the drum mixer. This applies to both virgin aggregate and RAP. Steam in a parallel-flow drum mixer creates a much more adverse situation compared to steam in other mixer designs because liquid asphalt is injected into a high steam area. Paving of stockpile areas will positively impact every plant's profits, however, for owners of parallel-flow plants, paved stockpile areas will not only provide additional economic benefit but also enhance safety and environmental conformance.

PAVED, SLOPED STOCK PILE AREAS SAVE MONEY F20

CONCLUSION

Costs and conditions vary around the country, so all variables used in this discussion may not apply to you. In this case, substitute tons, costs, moisture percentages, etc. that apply to your individual conditions when running through the calculations.

If you find that making money in the 90s is more difficult than in the past decade, you might want to look closely at these recommendations. Sloping and paving your stockpile area is bound to increase your productivity and profits. (**Figure 20**.) Now, break out those graders and paving machines and make some money. Pave under those stockpiles and save!

NOTES

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