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Final Report

THERMAL SEGREGATION

Kim Gilbert

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COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH BRANCH

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16. Abstract

The purpose of this study was to detect thermal segregation and its resulting effect on pavement density. Thermal segregation can be caused by material cooling and not being thoroughly remixed or by segregation of the hot mix asphalt (HMA). If the HMA segregates, it is expected that the coarse aggregate will cool more quickly than will the fine aggregate. This study identified areas of thermal segregation, either by cooling or by material segregation. A thermal camera was used to quickly identify areas with a 25º F or greater temperature difference. An infrared temperature gun was also used in an attempt to locate temperature segregation with a less costly device.

Segregated areas were located for nuclear density testing following rolling of the HMA. The area that was 25º F or more cooler than the surrounding mat was tested for relative compaction. An adjacent area that was a minimum of 25º F warmer was also tested for relative compaction. Information was gathered about mix nominal maximum aggregate size, binder type, paver type, truck type, delivery system, etc. to determine if a change in some factors could aid in decreasing segregation.

The study showed that grading S mixes temperature segregate at three times the rate than do the finer gradation SX mixes. End dump trucks used without Material Transfer Devices are prone to temperature segregation. Also, windrow elevators appear to work as well as do Material Transfer Devices.

Implementation: This study should be used to develop a temperature segregation specification. The specification would be used for information only in 2006 and as a pilot specification in 2007. The specification would be a standard special in 2008.

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Executive Summary

Segregation is an asphalt pavement problem that has been tough to solve. Visible segregation is easy to identify so it can be dealt with in some manner. However, temperature segregation can not be seen with the naked eye and isn't normally evidenced until the pavement fails from the effects of water permeation and oxidation of the binder. Infrared thermal cameras or infrared temperature guns can be used during paving to identify cold areas that may become a problem during the life of the pavement.

In this study, an infrared thermal camera and a less expensive infrared temperature gun were used to locate areas of the asphalt mat that were at least 25° F "colder" than adjacent mat areas. These "cold" areas and the adjacent "hot" areas were further tested for percent relative compaction. Temperatures, paver types, roller types and other data were collected on projects in hopes of identifying factors that can negatively or positively impact the density of the asphalt mat. Twenty Colorado Department of Transportation (CDOT) projects were visited during the study.

The study showed that a great deal of Colorado's temperature segregation problems could be solved simply by using SX gradation mixes instead of S gradation mixes. This was important to discover, as CDOT is solely in control of specifying the type of gradation that will be used on CDOT non-warranty projects.

The study clearly shows that end dump trucks cause temperature segregation and should not be used without a material transfer vehicle (MTV) if temperature segregation is a concern. A surprise from the study is the data showing that windrow elevators that do not remix material placed by belly dump trucks appear to work as well as MTVs, that do remix material, in preventing temperature segregation.

The study can be used to guide CDOT and Industry in writing an end-result specification that will prevent temperature segregation. Contractors can look at the study to find that simple solutions exist to prevent temperature segregation. This should help alleviate Contractor fears about moving in a specification direction.

Areas that were included in the study were marked so they can be tracked by CDOT to see if non-temperature segregated areas hold up better than do the temperature segregated areas. This should be done over the life of the pavements.

Implementation Statement. It is recommended that a temperature segregation specification be written. It is also recommended that CDOT review its policy of using many S gradation mixes, as the S mixes segregate far more often than do the SX mixes. SX mixes should be used whenever possible.

CDOT should immediately work with Industry to write an end-result specification for the prevention of temperature segregation. If the specification can be agreed upon quickly, 2006 could be a "for information" year for specification use. The 2007 paving season could be a "pilot" year where a couple of projects in each Region use the specification with full monetary disincentives. Full implementation of the specification would then be in the 2008 paving season.

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I. Introduction

Elimination of segregation in hot mix asphalt (HMA) is a major challenge for the Colorado Department of Transportation (CDOT). Although sporadic, it has been a persistent issue and is a problem that decreases the service life of HMA. Segregation leads to lower densities and higher permeabilities. Zube (1) has shown that asphalt pavement becomes permeable to water when density gets down to approximately 92% relative compaction. Brown (2) determined that for every 1% decrease in relative compaction, the permeability of the mix doubles. When permeability increases, water gains easier entrance into the mat, shear strength is lowered, and oxidation of the binder is increased. Linden et al (3) also found that for every 1% decrease in density below 93%, the life of the road is reduced by 10 percent. For these reasons, it is important that CDOT limit the number of low density areas in HMA pavements.

Washington DOT did an extensive study titled "Construction-Related Asphalt Concrete Pavement Temperature Differentials and the Corresponding Density Differentials" (4) in which they determined that 25° F is the temperature differential at which compaction may become a problem. Using their experience, this segregation study objective was to determine if areas that were 25° F or "colder" than the surrounding mat would have lower densities following rolling of the HMA. In addition, other construction and material factors were recorded in an effort to gather insight into what practices or material factors can minimize HMA temperature segregation.

The following details were gathered:

Job mix formula information, such as, grading, binder and compaction gyrations;
paver type;
type of material transfer device;
roller types;
truck types and if their loads were covered;
mat depth;

weather conditions;
existing pavement surface temperature;
mix temperature out of the screed;
thermal camera temperatures of “hot” and “cold” areas on the HMA surface;
heat gun temperatures of “hot” and “cold” areas on the HMA surface;
location of the “colder” areas;
location of the “colder” areas relative to the paver;
the shape and approximate size of the “colder” areas;
densities of the “colder” areas; and
densities of the “hotter” areas.

“Cold” areas were defined as those areas that were 25° F or more cooler than surrounding areas of the hot mat. This is a relative term, as a “cold” area may still have a temperature of 280° F.

“Cold” areas were identified with both an infrared camera and with an infrared temperature gun in an effort to determine if the less costly ($350) infrared temperature gun would be equally able to identify “cold” areas as the expensive ($20,000) infrared camera. The $350 infrared temperature gun had a distance to spot size ratio (D:S) of 30:1. While less expensive guns may be used, their ability to identify smaller cold areas would be compromised by having D:S ratios of less than 30:1. Temperatures from both the gun and the camera were recorded when “cold” areas were found.

After identifying a “cold” area, an adjacent “hot” area was identified with both the gun and the camera and its temperature was recorded. For “cold” areas that were in strips running lengthwise behind the paver, the adjacent “hot” area was found by recording a temperature within a few feet of the “cold” streak and toward the middle of the mat. If the “cold” area was not a streak but was a “spot” that was round, oval, etc, the temperature of the “hot” area was found by recording a temperature within a few feet ahead of the “cold” area. This move forward was done because in data that was collected transversely during density profiles in Colorado during the 2004 paving season, CDOT learned that readings across the width of the mat often vary with location based on the paver and rolling pattern. See Figure 1 for a typical transverse density profile that was collected in 2004. Therefore, rather than locate adjacent "hot" areas transversely to the "cold" areas, the "hot" areas were located forward of the "cold" areas when the temperature segregation was not in strips.

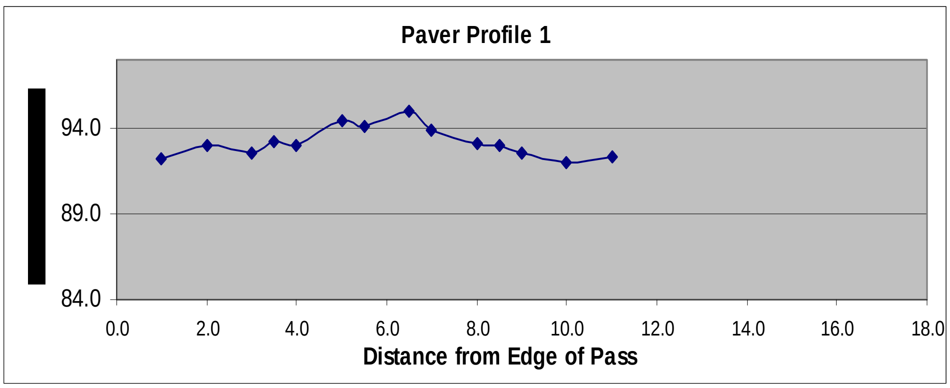

Figure 1. Transverse relative compaction profile. The outer 1 foot of each side of the mat was not measured for relative compaction.

While "Shuttlebuggies" and "pickup machines" both transfer material to the paver, this report will refer to material transfer vehicles (MTVs) as those, such as Shuttlebuggies, that pick up and remix the material. The "pickup machines," referred to in this report as windrow elevators, did not remix the material and will be looked at separately from the MTVs.

MTVs receive material from a truck, reblend the material, and provide extra surge volume for continuous inline paving. The different types of MTVs seen in the study were:

Roadtec SB2500 (Shuttlebuggy), and

Ingersoll-Rand MC-330.

Windrow elevators are listed separately from the MTVs because they simply pick up material that has been laid out ahead of the paver in windrows and transfer the material, without reblending, to the paver. The different types of windrow elevators seen in the study were:

Cat 851B,
Barber Greene 650,
Lincoln 66H, and
CR MS-2.

Various types of trucks were used to deliver HMA to the projects. The truck types seen in the study were:

Live bottoms,
end dumps with both square beds and round beds, and
belly dumps.

Several projects had a combination of live bottom and end dump trucks delivering mix.

II. Study Results and Discussion

Gradation Results. Table 1 shows, by mix type, how often "cold" areas were found. For instance, S75 mixes had "cold" areas once every 64 tons. It's clear from the table that S mixes can be expected to have three times the temperature segregation of SX mixes. Many designers specify S mix types out of a belief that larger aggregates are better at preventing rutting. Khedawi and Tons (5) demonstrated that smaller coarse aggregate provides more contact points, which provides more chances for interlocking to occur. This leads to a higher strength mix. Therefore, SX mixes can be stronger than S mixes and can be expected to segregate at one-third of the rate of S mixes.

Only one SMA project of 141 tons was in the study, so it's not clear that one "cold" spot per every 71 tons is the norm for SMA mixes.

Table 1. "Cold" areas by mix type.

	S			SX			SMA
	75	100	Total	75	100	Total	100
"Cold" Areas/Ton	1/64 (4)	1/70 (7)	**1/68 (11)**	1/107 (4)	0/644 (4)	**1/214 (8)**	1/**71** **(1)**

(Parentheses) indicate the number of projects contributing to the tonnage.

<u>Transfer Devices.</u> Table 2 shows, by transfer device, how often "cold" areas were found. As the totals show, with no transfer device of any type, temperature segregation was found once every 43 tons. In contrast, the MTVs and windrow elevators were temperature segregated once per every 182 and 197 tons, respectively.

Table 2. "Cold" areas by transfer device.

	MTV	**Windrow Elevator**	**No Device**
"Cold" Areas/Ton			
SX 75	0/94 (1)	1/197 (2)	1/17 1)
SX 100	0/404 (3)		0/240 (1)
SX Total	**0/498 (4)**	**1/197 (2)**	**1/77 (2)**
S 75	1/45 (1)	1/38 (2)	0/168 (1)
S 100		0/710 (4)	1/22 (3)
S Total	**1/45 (1)**	**1/180 (6)**	**1/33 (4)**
SMA	**1/71 (1)**		
Total	**1/182 (6)**	**1/197 (8)**	**1/43 (6)**

(Parentheses) indicate the number of projects contributing to the tonnage.

Table 2 data also demonstrates that less costly windrow elevators may work as well as MTVs in preventing temperature segregation. Because windrow elevators do not remix, it is likely that the lack of temperature segregation with windrow elevators is due to belly dump trucks causing much less temperature segregation than do end dump trucks.

Transfer Device and Truck Types. Table 3 breaks down "cold" areas by transfer device and truck type. The difference in the end dumps when there is no transfer device and when an MTV is used demonstrates the need for end dump trucks to have their material remixed. End dumps with no transfer device had "cold" areas 1/22 tons. When end dumps fed into MTVs, the frequency of "cold" spots decreased by ten fold to 1/247 tons. One may further contrast the use of end dumps vs. the use of live bottoms trucks in the row of "No Device." While there were only four projects to gather this data from, 1/22 tons for end dumps vs. 0/168 tons for live bottoms gives another clear indication that end dumps do increase the rate of temperature segregation.

Table 3. Transfer devices and truck types.

	End Dump			**Live Bottom**	**Mix of Trucks**	**Belly Dump**
	Square Bed	Round Bed	**Total**			
No Device	1/20 (2)	1/27 (1)	1/22 (3)	0/168 (1)	1/77 (2)	
MTV	1/247 (4)		1/247 (4)	1/117 (2)		
Elevator						1/197 (8)

(Parentheses) indicate the number of projects contributing to the tonnage.

Good Equipment and Best Practices. Some Contractors are more conscientious than others about using good equipment and industry best practices. Therefore, the number of "cold" areas was also examined by Contractor. In Table 4, Contractor A was on three of the twenty projects that were in the study. A windrow elevator was used all three times. One of the projects had five "cold" areas and two of the projects had no "cold" areas. This Contractor attributed the five "cold" areas to problems with the screed. The screed was subsequently replaced and the "cold" areas disappeared on the other two projects. Because two different windrow elevators were used by this Contractor before and after the screed was replaced, the improvement can't be tied solely to the replacement of the screed. Figure 2 below is from the project where the screed was old and worn. Figure 3 is from a project by the same Contractor after the screed was replaced.

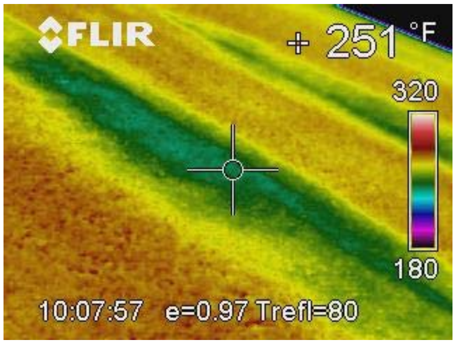

Figure 2. Contractor A with a windrow elevator and a worn screed.

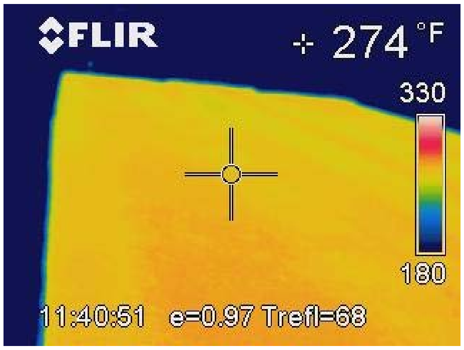

Figure 3. Contractor A with a new screed and a different windrow elevator.

Table 4. "Cold" areas by Contractor.

	MTV		Windrow Elevator	No Delivery System		
	End Dump	Live Bottom	Belly Dump	End Dump	Live Bottom	Mix
Contractor						
A			5,0,0			
B	2			5		
C		0				5
D					0	0
E		2				
F	0					
G			0			
H			0			
I			2,0			
J				5		
K	0,0					
L				5,0		

One number is listed for each separate project the Contractor was tested on.

Table 5 shows, by Contractor, the number of areas that actually had compactions, relative to the maximum specific gravity of the mix, below 92%. When compared to Table 4, one can see that "cold" areas may still be able to be compacted even though they were 25° F cooler than adjacent areas. Of the 31 "cold" areas, 19 of the areas were able to meet a minimum relative compaction of 92%. For example, Contractor A had five "cold" areas when paving with the worn screed. However, the mix was over 300° F and the rollers were close enough to the paver that minimum 92% relative compactions were obtained. By utilizing industry "best practices," the temperature segregation created by the worn screed was overcome.

Table 5. Low relative compaction areas by Contractor.

	MTV		Windrow Elevator	No Delivery System		
	End Dump	Live Bottom	Belly Dump	End Dump	Live Bottom	Mix
Contractor						
A			0,0,0			
B	1			2		
C		0				2
D					0	0
E		0				
F	0					
G			0			
H			0			
I			2,0			
J				4		
K	0,0					
L				1,0		

One number is listed for each separate project the Contractor was tested on.

While Contractors' segregation tendencies are affected by the type of equipment used in paving, the use or non-use of industry "best practices" also plays a large role in how much temperature segregation is produced. For instance, Contractor J had material arriving at the project at the rate of approximately one truck per hour. In addition, the mat was paved with end dump trucks and no MTV. All of these factors likely contributed to the temperature segregation seen in Figure 4.

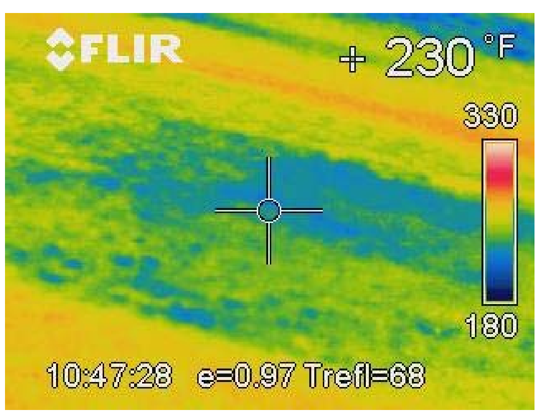

Figure 4. Temperature segregation across the mat width.

In contrast, Figure 5 is from a project that kept a constant flow of material going to the paver and used end dump trucks with an MTV.

Figure 5. No temperature segregation across the mat width.

Relative Compaction Readings. The bottom line of the relative compaction testing is the determination of whether or not the temperature segregated areas were able to achieve 92% relative compaction. Table 6 below is a compilation of all of the readings that were triggered by locating "cold" areas.

Table 6. Relative compaction readings.

Mix	Binder	Mix Temp out of screed	Relative Comp. Cold Area	Relative Comp. Hot Area
SX75	58-28	262	92.1	92.9
		262	90.8	93.3
		262	92.3	93.1
		290	91.6	92.9
SX75	58-34	290	89.9	93.4
		293	90.7	92.8
S75	64-22	300	94.3	96.4
		300	93.7	93.3
		305	94.5	93.8
		310	94.0	93.7
		310	93.3	92.7
S75	64-28	283	90.9	92.6
		283	92.0	93.6
S100	64-28	290	89.1	90.0
		290	90.2	92.0
		290	92.4	93.2
		290	91.0	92.0
		290	91.3	92.1
S100	64-28	272	94.4	95.8
		272	93.0	94.2
		272	93.0	95.8
		272	91.1	91.7
		272	94.0	93.9
S100	76-28	315	92.8	93.3
		330	92.3	93.5
		330	93.2	93.1
		342	91.6	92.3
		330	91.9	91.9
SMA	76-28	320	94.9	96.5

The highlighted pairs are readings that had “cold” relative compactions below 92%. In some of the pairs the relative compaction readings of the “hot” areas were also below 92%. Out of 29 “cold” areas that were tested for relative compaction, 17 (58.6%) were able to achieve a minimum relative compaction of 92%. If the pairs were dropped that were unable to achieve relative compaction in either the “hot” or “cold” areas, there were 26 “cold” areas to look at and 20 of those areas (76.9%) were able to achieve a minimum of 92% relative compaction.

In looking at Table 6, it can’t be said that simply having hot mix is enough to guarantee achievement of density. For instance, the S100 PG 76-28 mix came out of the screed at 330° F and 342° F. These were among the hottest of the temperatures seen during the study. The S100 PG 76-28 mix should have been easier to compact than the SMA material in the table; the SMA wasn’t as hot as the S100 and had more angular aggregates than did the S100. Yet the SMA was able to achieve a much higher relative compaction than was the S100 mix. Therefore, it’s difficult to attribute too much weight to any one factor when relative compaction isn’t achieved.

Infrared Camera and Infrared Gun. “Cold” temperature readings of the infrared temperature gun and infrared camera were compared to determine if the less costly gun could provide the same temperature readings that the very costly camera provided. An analysis of the paired data follows in Table 7.

Table 7. Paired data.

	Infrared Camera	Infrared Gun	Difference	Difference Squared
1	263	264	1	1
2	235	235	0	0
3	250	253	3	3
4	267	271	4	16
5	267	271	4	16
6	230	229	1	1
7	220	220	0	0
8	150	151	1	1
9	200	200	0	0
10	200	204	4	16
11	215	217	2	4
12	277	277	0	0
13	260	260	0	0
14	260	260	0	0
15	265	265	0	0
16	260	264	4	16
17	290	290	0	0
18	200	203	3	9
19	203	202	1	1
20	235	234	1	1
		Sum =	29	91

$$t_{\text{paired}} = \frac{\bar{d}}{S_D/\sqrt{n}}$$

$$\bar{d} = \frac{29}{20} = 1.45$$

$$S_D^2 = 91 - (29^2/20) = 48.95$$

$$S_D = \sqrt{48.95} = 6.996$$

$$\sqrt{n} = \sqrt{20} = 4.472$$

$$t_{paired} = \frac{1.45}{6.966 / 4.472} = .9269$$

$t_{.05,19} = 1.729$

$.9269 < 1.729$

$t_{paired} < t_{.05,19}$

This analysis of paired data shows that the two methods of obtaining temperature readings give equal results. Therefore, an inexpensive ($350) infrared temperature gun can provide temperature readings as accurately as an expensive ($20,000) infrared camera.

Appendix A contains all of the data that was collected in the study. It was hoped that all data would lead to conclusions; however, some data did not. For instance, one can't determine from the data if one type of paver is better than another type or if some rollers are much better than others. The data is provided in Appendix A for the reader to draw his/her own conjectures.

III. Conclusions

1. Segregation is three times more likely to occur if CDOT specifies an S mix rather than an SX mix.

2. Infrared temperature guns with a distance to spot size ratio of 30:1 can find "cold" areas as well as infrared cameras can.

3. End dumps have a much greater incidence of temperature segregation than do live bottom trucks or belly dump trucks.

4. Windrow elevators do as good a job or better of reducing temperature segregation than do MTVs.

5. Adherence to industry best practices can cut down on temperature segregation.

6. When thermal segregation is identified, it does not always relate to aggregate segregation. For the sites in this study, 77% of the locations with thermal segregation had adequate relative compaction of both the "cold" areas and of the "hot" areas. This indicates that these areas likely did not contain aggregate segregation.

IV. Recommendations

CDOT should consider using fewer S gradation mixes and increasing the use of SX gradation mixes. The incidence of thermal segregation would be greatly reduced if this change were implemented. There is evidence that the CDOT SX mixes have the same strength or even more strength than S mixes, so rutting concerns should not be a barrier to making this change. Preventing temperature segregation would help decrease permeability which, in turn, would increase shear strength and help prevent oxidation of the binder. Pavement life is increased by all of these factors.

An end-result specification should be written that encourages the asphalt industry to utilize industry best practices. While end dump trucks are a part of industry practice, their use without MTVs should be discouraged through stiff penalties for temperature segregation that results in relative compactions falling below 92%. The specification could be applied even if the lower cost infrared temperature guns were allowed to be used (as opposed to the expensive infrared cameras) to search for temperature segregation. The Washington DOT has a report (4) and specification that does not involve density profiles and can be used to guide specification development. The "cold" areas should be monitored over time to observe their performance.

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APPENDIX A

Temperature Segregation Data

Cont Code	Mix	Binder	Tons	Paver	Pick-up	Rollers Break	Rollers Int	Rollers Finish	Truck	Covered?	Depth	Weather	Surf Temp	Air Temp
A	S 75	64-22	121	Cat AP-1055B	Windrow Elevator Cat 851B	Cat B-634D	Dynapac Huge	Cat 634D	Belly Dump	Yes	3"	Sunny	94	80 85
A	S 100	64-22	182	Cat AP1055B	Barber Green Windrow Elevator	CB 634 D	Dynapac Huge		Belly Dump	No (Plant 5 mins away)	3.0"	Sunny	102	90
A	S 100	64-28	252	Cat AP-1055B	Barber Greene Windrow Elevator BG650				Belly Dump	Yes	2.0"	Cloudy	94	80
B	S 75	64-28	89	Blaw-Knox PF-5510	Roadtec SB 2500	Cat CB-534C	IR PT-125R	Cat CB-534C	End Dump	Yes	2.5"	Sunny	100	80
B	S 100	76-28	183	Blaw Know PF 5510	NA	Hypac C766C		IR DD-90HF	End Dump	Yes	2.0"	Sunny	114	90 90

Cont Code	Mix	Binder	Tons	Paver	Pick-up	Rollers Break	Rollers Int	Rollers Finish	Truck	Covered?	Depth	Weather	Surf Temp	Air Temp
C	SX75	58-28	69	Cat AP 1055-B	NA	Bomac BW 190 AD	Hypac 5-110	IR DD-130	Mostly Live Bottom some End Dumps	Yes	2.0"	Sunny	100	73
C	SX 75	58-34	94	Cat AP 1055-B	Roadtec Shuttle Buggy SB 2500	Bomac BW 190 AD			Live Bottom	Yes	2.0"	Sunny	61	54
D	S 75	64-28	168	Cedarapids Terex 562	NA				Live Bottom	Yes	2.5"	Sunny	98	80
D	SX 100	64-22	240	Cedarapids Terex 562		Cat CB 634D	Hyster C530A	Dynapac CA25? (Old)	7 Live and 1 End	Yes	2.5"	Sunny		
E	SMA	76-28	141	Blaw Knox AP 51	IR MC-330 Double Augers in Hopper	IR DD 138	Dynapac CC 522		Live Bottom	Yes	2.0"	Sunny	82	80

Cont Code	Mix	Binder	Tons	Paver	Pick-up	Rollers Break	Rollers Int	Rollers Finish	Truck	Covered?	Depth	Weather	Surf Temp	Air Temp
F	SX 100	76-28	80	Blaw Knox PF 5510	Roadtec Shuttle Buggy SB 2500	IR DD 130			End Dump	Yes	2.0"	Night, hot	85	78
G	S 100	64-28	155	Cat AP1055B	Lincoln 66H Windrow Elevator	Cat CB 634D			Belly Dump	Yes	2.0"	Sunny	118	90
H	SX 75	58-34	203	Cedarapids Terex 552	CR windrow Elevator	Hypac C784	Hypac C784	Hypac C778B	Belly Dump	Yes	2.75"	Cloudy	100	75
I	SX 75	58-34	276	Cedarapids CR 55	CR MS-2	Hypac C784		Hypac C778B	Belly Dump	Yes	3.5"	Sunny	120	83
I	S 75	64-22	70	Cedarapids CR 551	Cedarapids Windrow Elevator MS 2 Power	Bomag BW 205	Bomag BW 24R	Hypac	Belly Dump	Yes	2.0"	Sunny	122	90
J	S 100	64-28	16	Cat AP1055B		IR DD 90		IR DA 50	End Dump	Yes	2.0"	Cloudy	98	80

Cont Code	Mix	Binder	Tons	Paver	Pick-up	Break	Rollers Int	Finish	Truck	Covered?	Depth	Weather	Surf Temp	Air Temp
K	SX 100	76-28	129	Blaw Knox PF 5510	Roadtec Shuttle Buggy SB 2500	Hypac C766C			End Dump	Yes	2.0"	Sunny	102	82
K	SX 100	76-28	129	Blaw Knox PF 5510	Roadtec Shuttle Buggy SB 2500				End Dump	Yes	2.0"	Night/ Warm	77	70
L	S 100	64-28	135	Cedarapids Terex 552		Hypac C766C	Hypac C766C	Bomac BW 190AD	Rounded End Dump	Yes	2.0"	Cloudy	110	85
L	S 100	64-22	121	Cedarapids Terex 552	Barber Greene Windrow Elevator	Hypac C766C	Hypac C766C	Bomac BW 190AD	Belly Dump	Yes	2.0"	Cloudy Windy	72	60

Cont Code	Mix Temp	Seg Temp Camera	Seg Temp Gun	Locat of Seg Area	Relative to Paver	Shape	Temp of Adj Area Camera	Temp of Adj Area Gun	Location of Adj Area	Relative Compaction Cold Area	Relative Compaction Adj Area
A	300	263	264	60" ROCL	33" L of screw	Strip, ≈ 5" long	295	295	1' L of strip	94.3	96.4
	300	235	235	125"	32" R of screw	Oval, ≈ 1' x 2'	300	306	3' South	93.7	93.3
	305	250	253	120"	27" R of screw	Strip, ≈ 3" long	295	295	1' L of strip	94.5	93.8
	310	267	271	60"	33" L of screw	Round, ≈1' Diam	299	295	3' South	94.0	93.7
	310	267	271	118"	25" R of screw	Oval, ≈ 1' x 2'	299	296	3' South	93.3	92.7
A	253	There were no temperature segregated areas. The greatest temperature difference was 10 degrees.									
A	305	There were no temperature segregated areas. The greatest temperature difference was 15 degrees. Some streaking with a 10 degree difference on either side of the screw.									
B	283	230	229	48" LORE	Ran over mix.	Round, ≈1' Diam	280	276	3' East	90.9	92.6
	283	220	220	84" LORE	18" R of screw	Amoeba, ≈ 1' Diam	280	281	3' East	92.0	93.6

Cont Code	Mix Temp	Seg Temp Camera	Seg Temp Gun	Locat of Seg Area	Relative to Paver	Shape	Temp of Adj Area Camera	Temp of Adj Area Gun	Location of Adj Area	Relative Compaction Cold Area	Relative Compaction Adj Area
B	315	260	260	9' RofCL	1' L of screw	Amoeba, ≈ 3' x 1'	315	315	2' East	92.8	93.3
	330	260	260	93.5" RofCL	2.2' L of screw	Oval, 3' x 1'	300	300	2' East	92.3	93.5
	330	265	265	99" Rof CL	1.75' L of screw	Amoeba, ≈ 5' x 5'	300	300	2' East	93.2	93.1
	342	260	264	86" R of CL	2.8' L of screw	Amoeba, ≈ 5' x 6'	300	300	5' North	91.6	92.3
	330	290	290	93" R of CL	2.25' L of screw	Round, 1' x 1'	315	315	2' East	91.9	91.9
C	262	150	151	53" LORE	19" R of screw	Oval, ≈ 1' x 2'	260	258	3' West	92.1	92.9
	262	200	200	55" LORE	17" R of screw	Strip, ≈ 1' x 4'	250	254	4' East	90.8	93.3
	262	200	204	58" LORE	14" R of screw	Strip, ≈ 1' x 7'	260	258	2' L of strip	92.3	93.1
	290	215	217	53" LORE	19" R of screw	Strip, ≈ 1' x 6'	275	279	2' L of strip	91.6	92.9
C	284	There were no temperature segregated areas. The greatest temperature difference was 15 degrees. The Bomac was the only roller used.									
D	270	There were no temperature segregated areas. It's a miracle! Looked at 168 tons--far more than on other jobs.									
D		There were no temperature segregated areas. The greatest temperature difference was 20 degrees.									

Cont Code	Mix Temp	Seg Temp Camera	Seg Temp Gun	Locat of Seg Area	Relative to Paver	Shape	Temp of Adj Area Camera	Temp of Adj Area Gun	Location of Adj Area	Relative Compaction Cold Area	Relative Compaction Adj Area
E	320	Small seg area from a truck spill on mat. Roller hit it before I could locate it.									
	320	277	277	51" EOP	12" L of screw	Strip, ≈ 1" x 15'	305	305	1' East	94.9	96.5
F	300	There were no temperature segregated areas. Went 80 tons without even a 20 degree difference.									
G	300										
H	305	There were no temperature segregated areas. The greatest temperature difference was 10 degrees.									
I	290	200	203	81" R of CL	29" R of screw	Round, 1' x 1'	257	259	3' East	89.9	93.4
	293	203	202	80" R of CL	30" R of screw	Round, 1' x 1'	262	261	3' East	90.7	92.8
I	305	There were no temperature segregated areas. The greatest temperature difference was 20 degrees.									

Cont Code	Mix Temp	Seg Temp Camera	Seg Temp Gun	Locat of Seg Area	Relative to Paver	Shape	Temp of Adj Area Camera	Temp of Adj Area Gun	Location of Adj Area	Relative Compaction Cold Area	Relative Compaction Adj Area
J	290	225		103" RofCL	32" L of screw	Round, 2' x 2'	290		3' South	89.1	90.0
		235		103" RofCL	32" L of screw	Round, 2' x 2'	287		3' South	90.2	92.0
		237		168" RofCL	33" R of screw	Strip, 1.5' x 8'	267		3' East	92.4	93.2
		203		97" RofCL	38" L of screw	Amoeba, ≈ 3' x3'	270		3' South	91.0	92.0
		222		103" RofCL	32" L of screw	Amoeba, ≈ 2' x 4'	250		3' South	91.3	92.1
K	284	There were no temperature segregated areas. The greatest temperature difference was 10 degrees.									
K	295	There were no temperature segregated areas. The greatest temperature difference was 15 degrees.									
L	272	235	234	94" LofEOP	Right side edge	Strip, .5' x 10'	265	265	1.5' Left	94.4	95.8
				92" LofEOP	of auger exts.	Strip, .5' x 10'	261	263	1.5' Left	93.0	94.2
				94" LofEOP	" "	Strip, .5' x 10'	265	264	1.5' Left	93.0	95.8
				87" LofEOP	Outside of	Oval, 2' x 2'	310	309	2' South	91.1	91.7
				64" LofEOP	auger exts.	Strip, .5' x 8'	260	258	1.5' Left	94.0	93.9
L	248	There were no temperature segregated areas. The greatest temperature difference was 15 degrees.									