Use of DPS to Support In-Place Density Optimization Project

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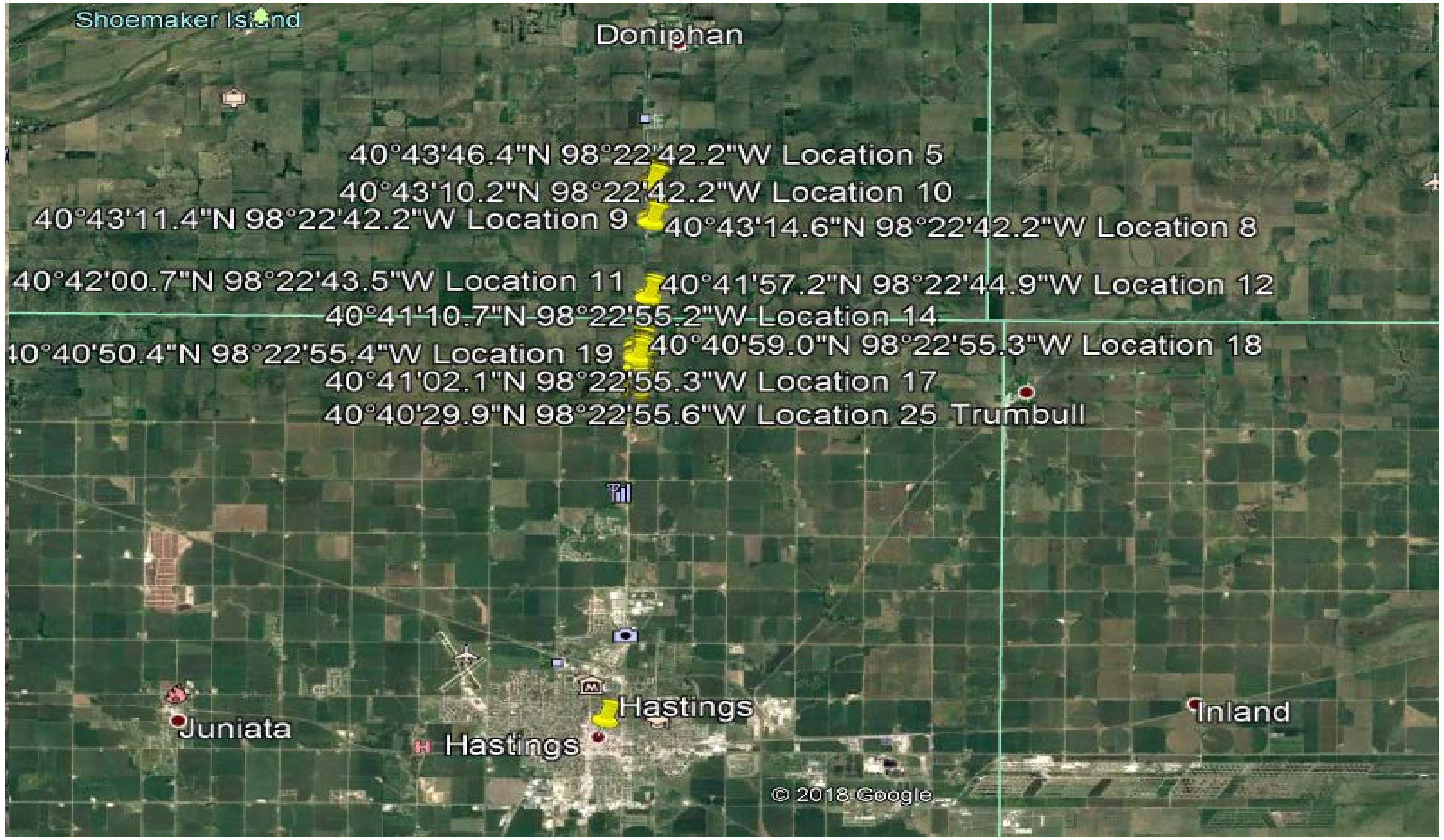
Agenda

- Introduction and Background
- Problem Statement/Objectives
- Methodology/Materials
- Results and Discussions
- Conclusions

Introduction and Background

- ➢Project location
- ➢US Highway 34/US Highway 281



Introduction and Background

- Asphaltic concrete (AC): **85%** of paved roads and highways in Nebraska.
- Increasing the durability to prevent major damage and minimize the large cost of rehabilitation and maintenance.

Introduction and Background

- Most DOTs specify asphalt pavement to be constructed at a minimum in-place density at 91 to 92.5% of its theoretical maximum density.
- Research studies have found that for every 1% increase in density, the roadway service life will increase an estimated 5%, up to as much as 15%.

Problem Statement

Many studies have evaluated the effects of different factors on density of asphaltic pavement. Through advances in testing and measurement technology, there is an opportunity for major advancements for real-time measurement methods to measure in-place density in a more rigorous manner, improve upon functional-structural performance expectations, and improve pavement construction quality, especially in cold weather conditions.

Objectives

1) To evaluate and compare the effectiveness of different delivery, compaction, and mix design to ensure the optimization of in-place asphalt pavement density.

2) To study different in-place density measuring techniques.

Methodology/Materials

- ☐ ***Mixture:***
  - ❖ NDOT SLX mixture with NMAS of 0.375 inch (9.5 mm), 50 gyration @(N_{des}) PG 58V-34 Binder
  - ❖ Different binders PG 40-40, and PG 52-40
  - ❖ Less coarse ledge rock
  - ❖ Increase binder content (0.5%)

- ☐ *Measuring Techniques*:
  1) Conventional/traditional cut roadway cores
  2) Infrared Continuous Thermal Scanning (**ICTS**)
  3) Pavement Quality Indicator (**PQI**)
  4) Rolling Density Meter (**RDM**) utilizing Ground Penetrating Radar (**GPR**)

- ☐ ***Laydown methods:***

Standard Pick-up Machine (SPM)

Material Transfer Vehicle (MTV)

- ☐ ***Compaction equipment:***

Double drum steel

Pneumatic

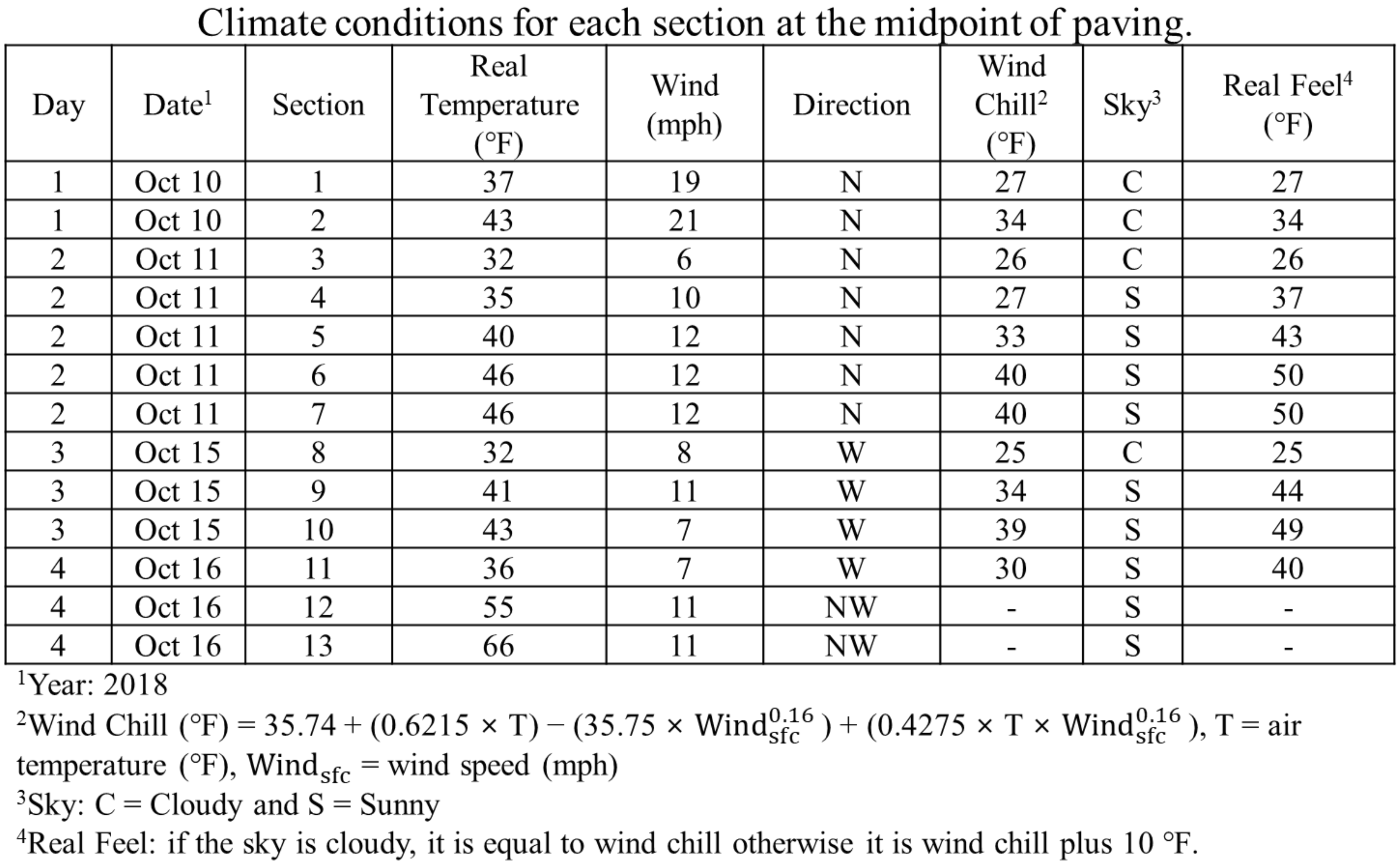
Combination roller

Test Sections

Construction information and measuring devices used for each section.

Day	Date	Section	Delivery Method	Mixture	Compaction Procedure	Measuring Techniques
***Day 1 Main Focus:** Effect of Different Delivery Methods*						
1	Oct 10	1	PSM	SLX_S	Method 1	ICTS, PQI, RDM-GPR, Coring
1	Oct 10	2	MTV	SLX_S	Method 1	ICTS, PQI, RDM-GPR, Coring
***Day 2 Main Focus:** Effect of Different Compaction Methods*						
2	Oct 11	3	MTV	SLX_S	Method 1	ICTS, PQI, RDM-GPR, Coring
2	Oct 11	4	MTV	SLX_S	Method 2	ICTS, PQI, RDM-GPR, Coring
2	Oct 11	5	MTV	SLX_S	Method 3	ICTS, PQI, RDM-GPR, Coring
2	Oct 11	6	MTV	SLX_S	Method 4	ICTS, PQI, RDM-GPR, Coring
2	Oct 11	7	MTV	SLX_S	Method 5	ICTS, PQI, RDM-GPR, Coring
***Day 3 Main Focus:** Effect of Different Asphalt Mixtures*						
3	Oct 15	8	MTV	SLX_M_40-40_R50%	Method 1	PQI, RDM-GPR, Coring
3	Oct 15	9	MTV	SLX_S_58V-34_0.5	Method 1	PQI, RDM-GPR, Coring
3	Oct 15	10	MTV	SLX_S	Method 1	PQI, RDM-GPR, Coring
***Day 4 Main Focus:** Effect of Different Asphalt Mixtures*						
4	Oct 16	11	MTV	SLX_M_52-40_R50%	Method 1	PQI, RDM-GPR, Coring
4	Oct 16	12	MTV	SLX_M_58V-34_LCR10%	Method 1	PQI, RDM-GPR, Coring
4	Oct 16	13	MTV	SLX_S	Method 1	PQI, RDM-GPR, Coring

Climate Conditions



Climate conditions for each section at the midpoint of paving.

Day	Date[1]	Section	Real Temperature (°F)	Wind (mph)	Direction	Wind Chill[2] (°F)	Sky[3]	Real Feel[4] (°F)
1	Oct 10	1	37	19	N	27	C	27
1	Oct 10	2	43	21	N	34	C	34
2	Oct 11	3	32	6	N	26	C	26
2	Oct 11	4	35	10	N	27	S	37
2	Oct 11	5	40	12	N	33	S	43
2	Oct 11	6	46	12	N	40	S	50
2	Oct 11	7	46	12	N	40	S	50
3	Oct 15	8	32	8	W	25	C	25
3	Oct 15	9	41	11	W	34	S	44
3	Oct 15	10	43	7	W	39	S	49
4	Oct 16	11	36	7	W	30	S	40
4	Oct 16	12	55	11	NW	-	S	-
4	Oct 16	13	66	11	NW	-	S	-

[1] Year: 2018

[2] Wind Chill (°F) = $35.74 + (0.6215 \times T) - (35.75 \times \mathrm{Wind}_{\mathrm{sfc}}^{0.16}) + (0.4275 \times T \times \mathrm{Wind}_{\mathrm{sfc}}^{0.16})$, T = air temperature (°F), $\mathrm{Wind}_{\mathrm{sfc}}$ = wind speed (mph)

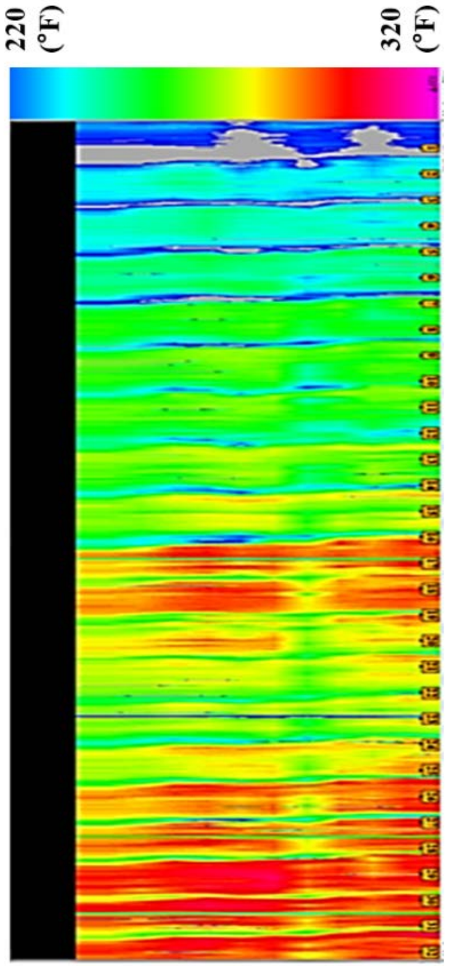
[3] Sky: C = Cloudy and S = Sunny

[4] Real Feel: if the sky is cloudy, it is equal to wind chill otherwise it is wind chill plus 10 °F.

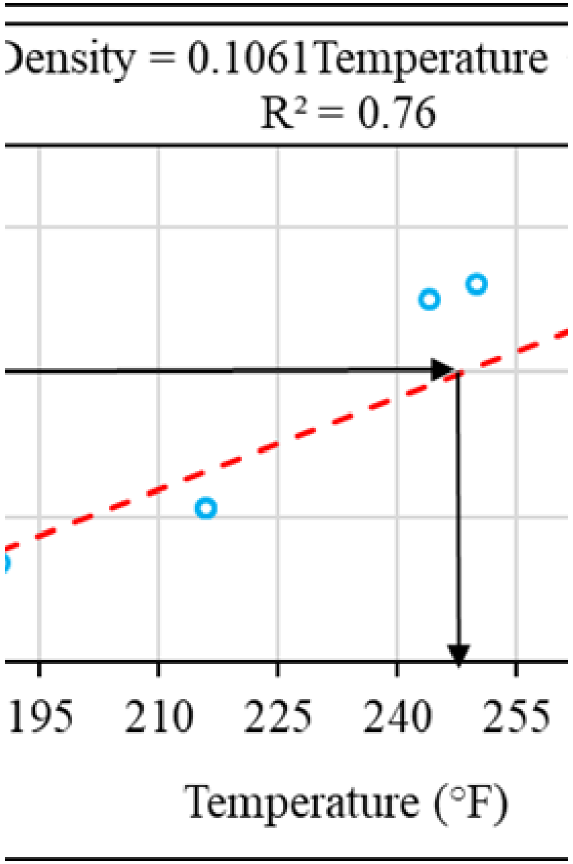
Results and Discussion

Day 1: Standard Pick-Up Machine vs Material Transfer Vehicle

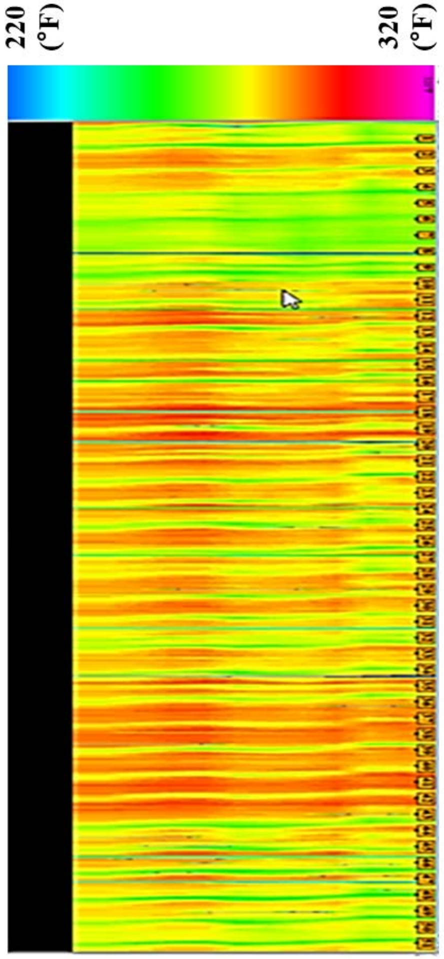
Dif



SPM ICTS profile



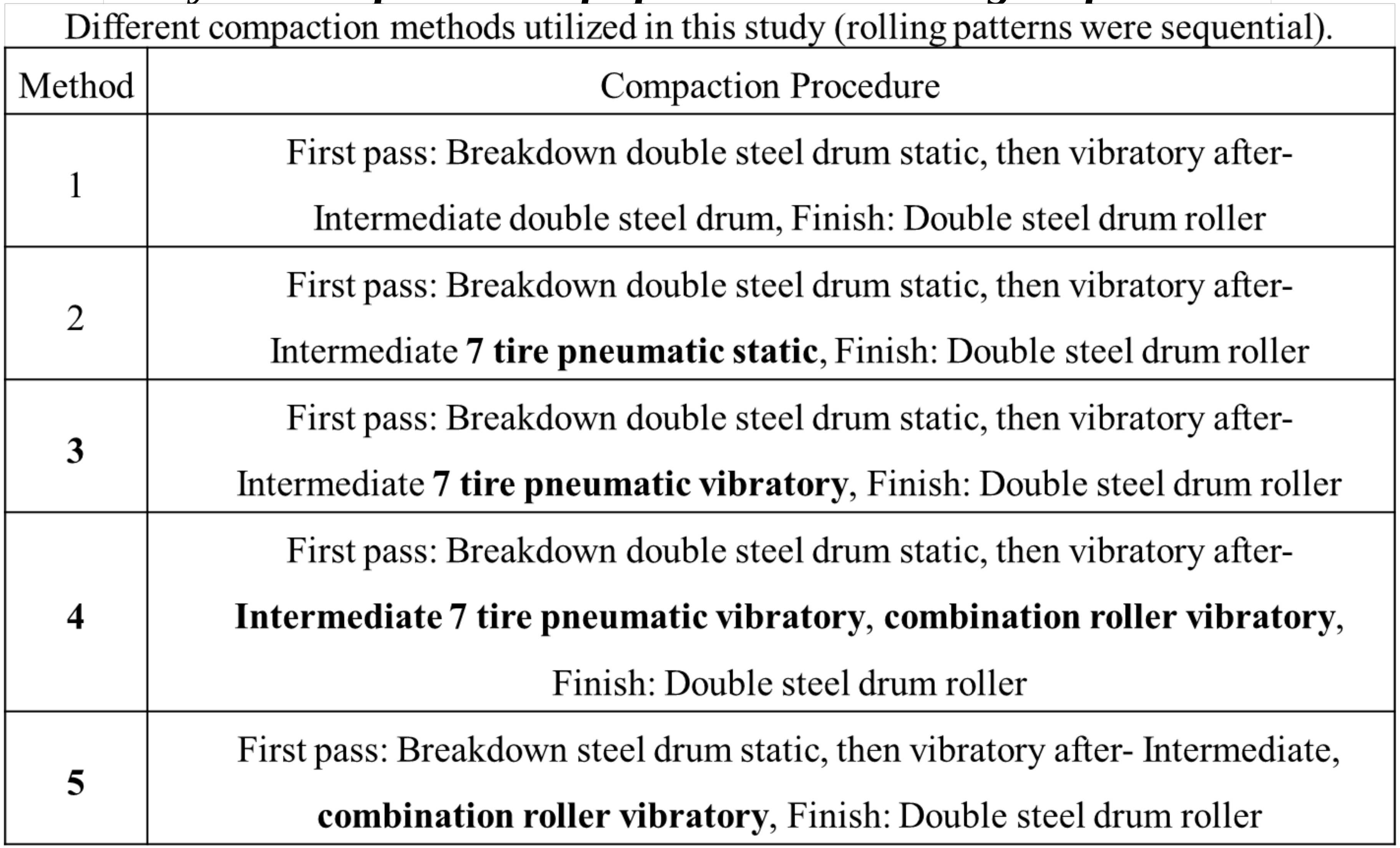
parison between MTV and SP
emperature and in-place dens
ed on thermal differential rate.



MTV ICTS profile

Results and Discussion

Day 2: Compaction Equipment and Rolling Sequences



Different compaction methods utilized in this study (rolling patterns were sequential).

Method	Compaction Procedure
1	First pass: Breakdown double steel drum static, then vibratory after- Intermediate double steel drum, Finish: Double steel drum roller
2	First pass: Breakdown double steel drum static, then vibratory after- Intermediate **7 tire pneumatic static**, Finish: Double steel drum roller
3	First pass: Breakdown double steel drum static, then vibratory after- Intermediate **7 tire pneumatic vibratory**, Finish: Double steel drum roller
4	First pass: Breakdown double steel drum static, then vibratory after- **Intermediate 7 tire pneumatic vibratory**, **combination roller vibratory**, Finish: Double steel drum roller
5	First pass: Breakdown steel drum static, then vibratory after- Intermediate, **combination roller vibratory**, Finish: Double steel drum roller

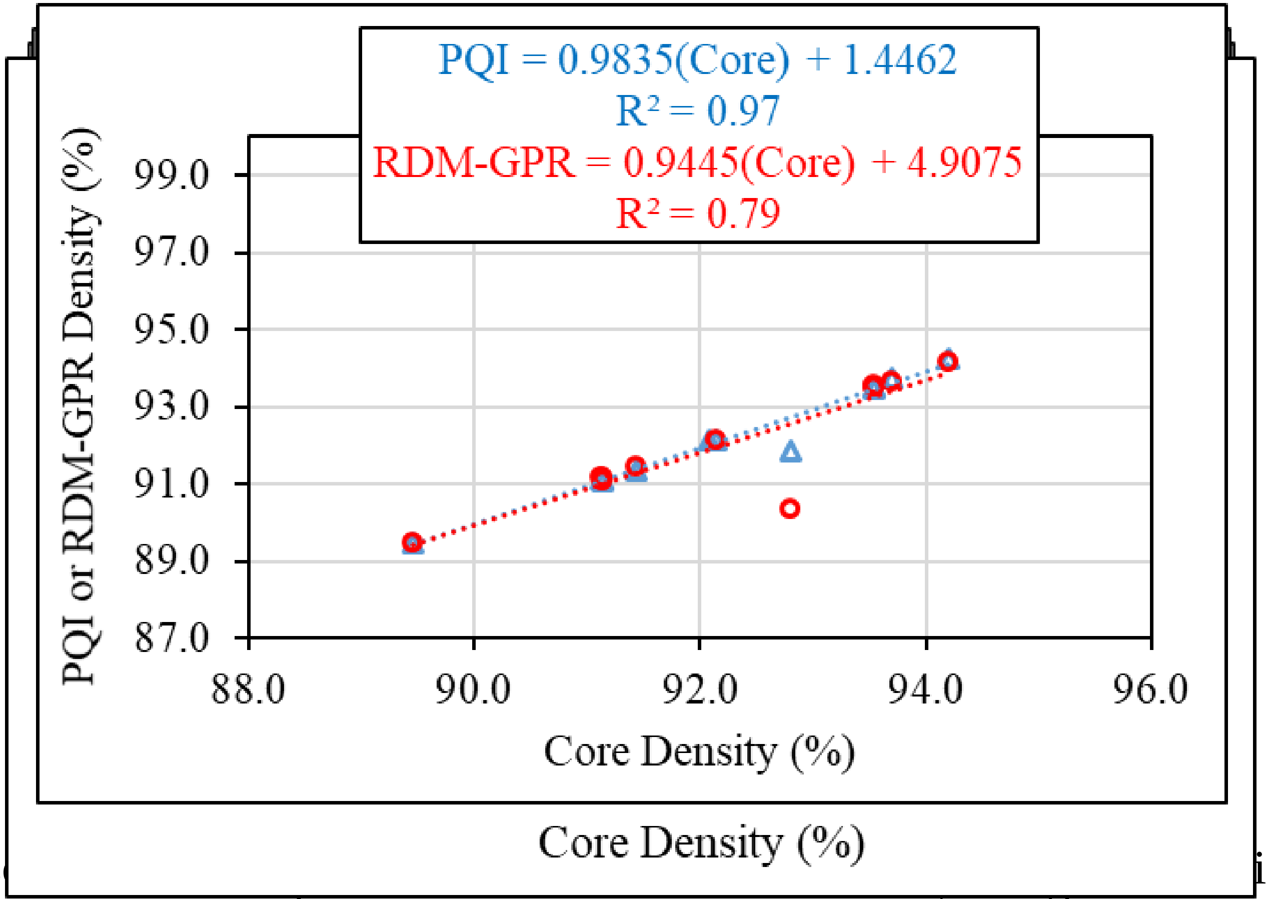
Results and Discussion

Day 3 and 4: Modified Mix Design, Modified Gradation, and Binders

- The SLX was modified by using a **PG 40-40 and 50% RAP**. However, after compaction, this section appeared visually similar to the control sections.
- The standard SLX mix with **0.5% increased binder** above the design target was used in the second section, this change did not provide significant changes to laydown or compaction.

- The SLX was modified by using a **PG 52-40 and 50% RAP**. There has been a slight reduction in density with the slightly stiffer 52-40 and 50% RAP.
- The SLX was modified by using **10% less rock**. The results were fairly similar to control mixture.

Correlations between Measuring Devices



Comparis iangular), and

RDM-GPR (red circle), density measured average of 5 density value.

Coring, PQI, and RDM-GPR.

Comparison between core density and measured density using PQI (blue triangular), and RDM-GPR (red circle).

Current Specifications

The current Nebraska acceptance standard for in-place density requires that one test per 1000 tons of mixture is randomly sampled and the pay factor is based on a five test average for a 5000 ton lot. The result of this research revealed that the current acceptance methods could be strengthened.

Comparison between densities measured for bias core and random core.

Core #	152.4 mm Core	Lot 6 Density	Sample #
1	85.3	91.3	6-2
2	93.0		
3	92.5		
4	83.4		
5	93.1		
Ave	**89.5**		

Findings

1) MTVs provide an effective method to minimize thermal segregation and therefore provide improved temperature and density consistency.

2) Pneumatic rollers provide an improved mode of compaction. More specifically the combination roller (CR) provided a consistent improvement compared to the ‘Standard’ three double drum steel roller compaction method.

3) Infrared continuous thermal scanning (ICTS) is an effective measuring technique that provides real-time information to the producer for improving temperature consistency that will result in more uniform densities.

Findings

4) RDM-GPR provides a continuous density measurement of the entire roadway. Further research and implementation studies with the R06C SHRP-2 research project that is currently underway at NDOT, will continue throughout 2019.

5) Heat loss is directly proportional to material mass, i.e., lift thickness. Therefore, lift thickness requirements need to be re-examined, especially for cold weather paving.

6) The use of non-destructive testing equipment could provide opportunities for a more rigorous acceptance procedure.

7) Consideration to the environmental conditions (temperature, wind, solar gain) can provide better pavement densities.

Challenges with RDM-GPR

1) Calibration
2) Sensors
3) Variability of results

Questions/Comments ?

Thank You!