GET IT RIGHT THE FIRST TIME: Innovation in Pavement Management

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RMACES

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Topics

Getting it Right the First Time

Planning

Pavement Design

Material Selection

Construction

Renewal

Options

Costs of Not Getting It Right the First Time

Shorter pavement life until repair is needed

- Increased costs for maintenance and rehab

Increased user costs

- Delay and congestion

Decreased safety

- Surface defects and traffic queues

Environmental effects

- Increased emissions

Getting It Right Means

Using the right treatment/design

Using it at the right time

Designing appropriately

- Anticipating changes
- Not over-designing

Using the right materials

Building what was designed

Monitoring performance to plan/revise

How to Get It Right -- Planning

Agency decisions

- Project scope, details and specifications
- Traffic considerations

Contractor's choices

- Mix design
- Paving equipment types and amount
- Number of trucks and dispatching
- Locations of joints

Planning is Key!

OLLEGE OF ARCHITECTURE AND *BAD* PLANNING?

How to Get It Right – Pavement Design Methodologies

Experience

Empirical

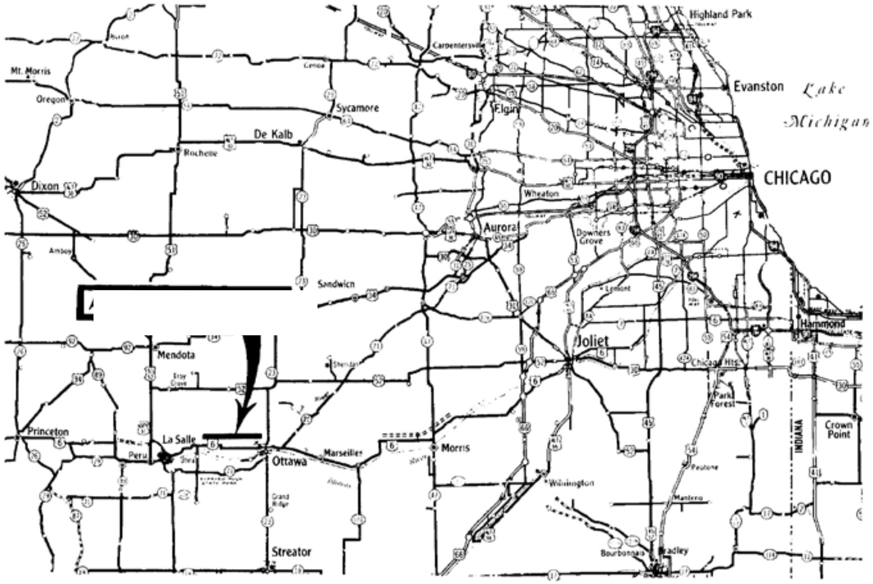
- Statistical models from road tests (AASHO)

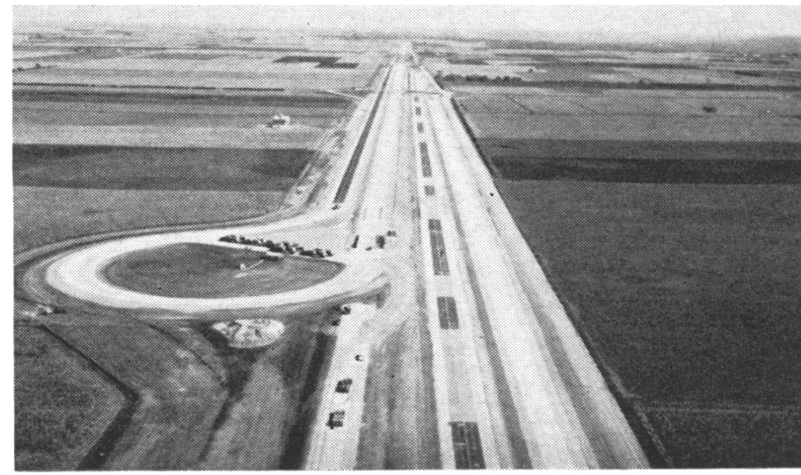
Mechanistic-empirical

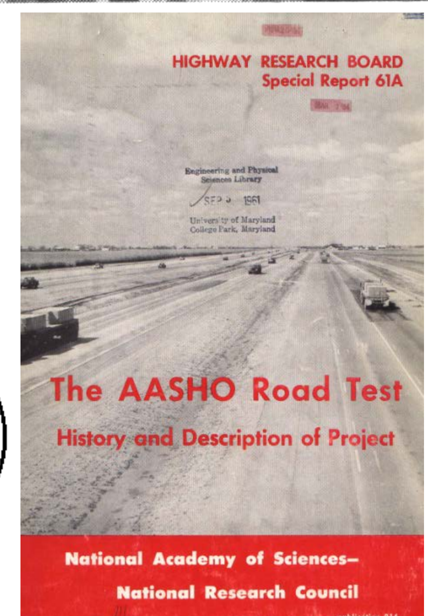
- Calculation of pavement responses, i.e., stresses, strains, deformations
- Empirical pavement performance models

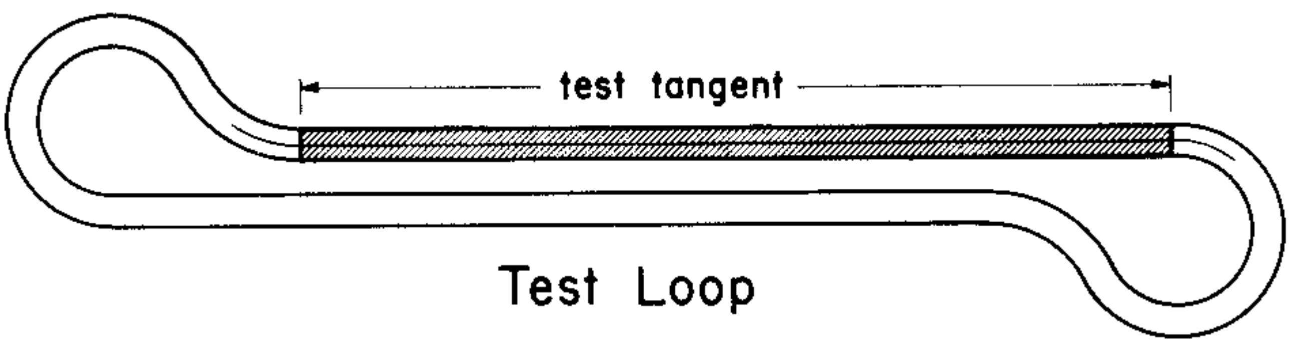
Mechanistic

AASHO Road Test

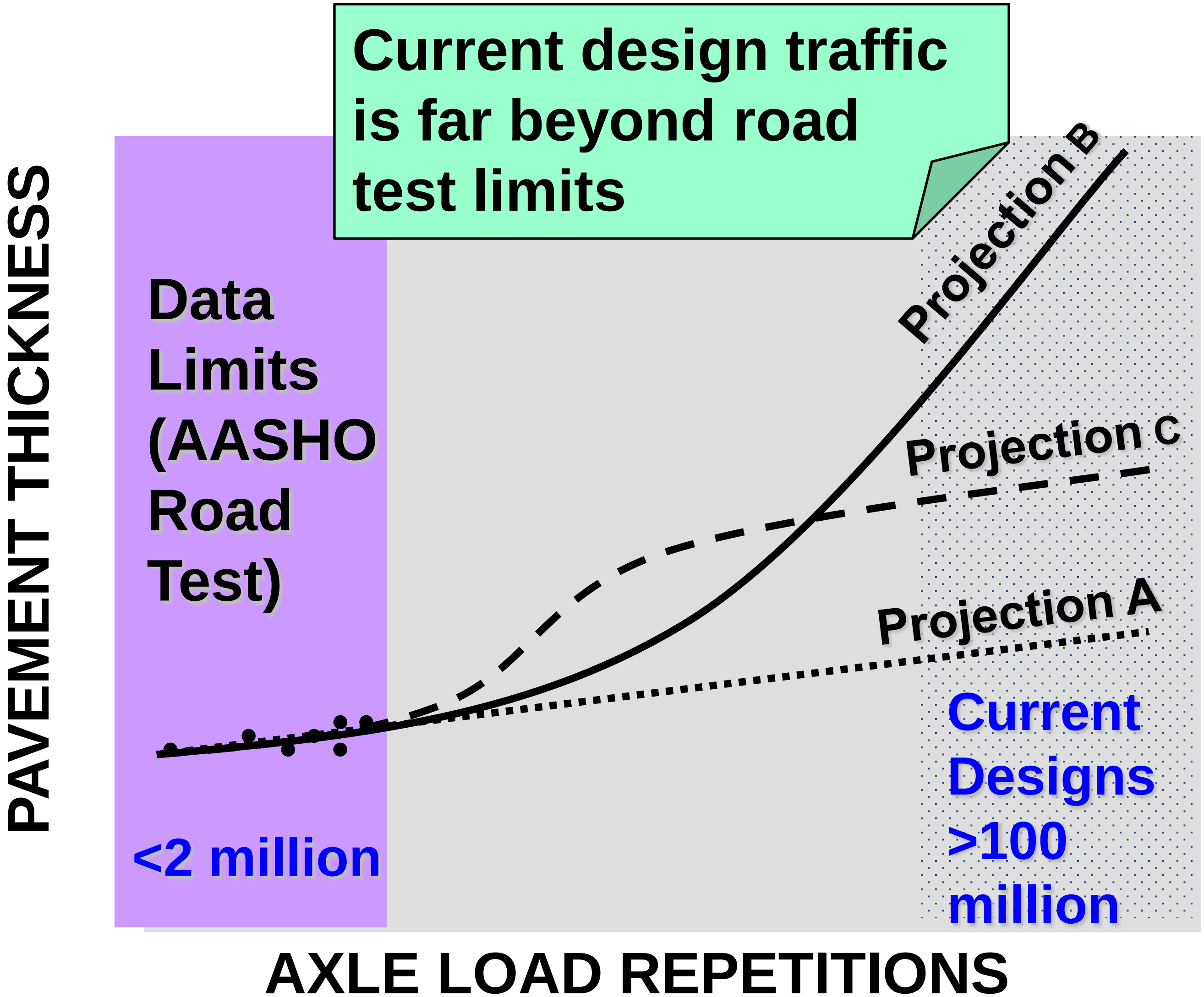




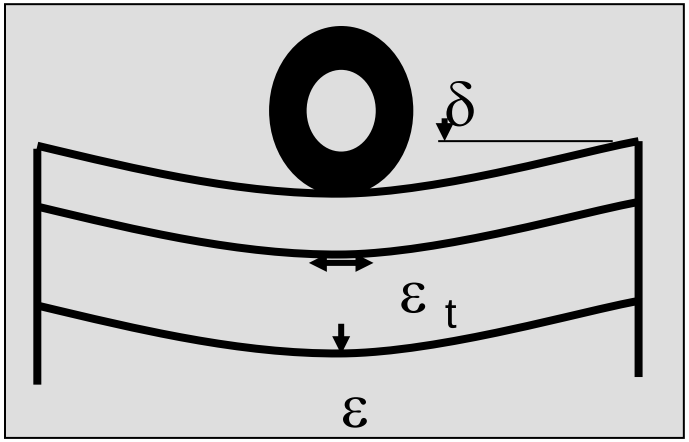




What Is Wrong with Empirical AASHTO Design?



M-E Design



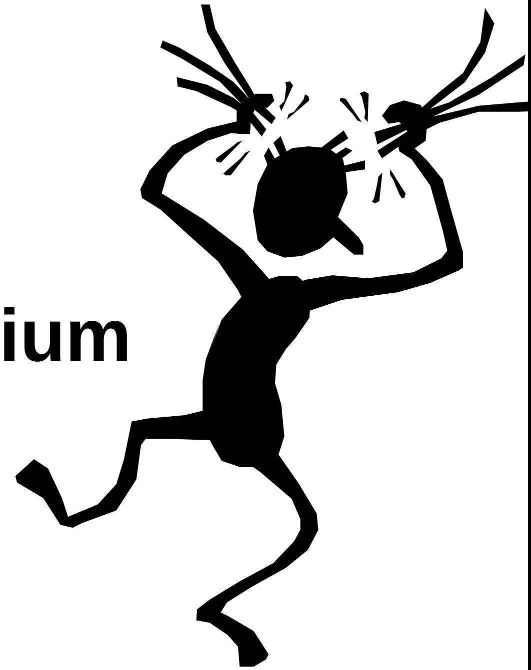
- Considers applied stresses and resulting strains
- Uses fundamental engineering properties that can be measured
- Computes reactions to stresses and strains and predicts distresses
- Feasible with improved computing capabilities

Mechanistic – Empirical Design Sounds Complicated

MEPDG (DARWin ME) expensive ($5 to 40k) and fairly complex, requires lots of inputs and time.

Options:

- **PerRoad 3.5**
- **PerRoad Express for low to medium volume roadways**
- **Free to download from APA**



Perpetual Pavement

Asphalt pavement designed to last over 50 years without requiring major structural rehabilitation and needing only periodic surface renewal.

- *Full-depth pavement* – constructed on subgrade
- *Deep-strength pavement* – constructed on thin granular base course
- AKA *extended-life pavement* or *long-life pavement*

Concept

- **Asphalt pavements with high enough strength will not exhibit structural failures even under heavy traffic.**
- **Distresses will initiate at the surface, typically in the form of rutting or cracking.**
- **Surface distresses can be removed/ repaired relatively easily,**
  - Before causing structural damage,
  - Leaving most of pavement in place, performing well.

Perpetual Pavement Features

Three layer system

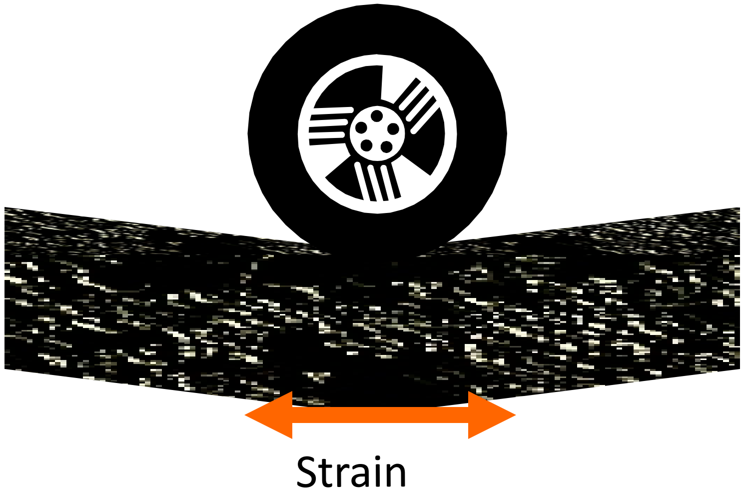
Each layer designed to resist specific distresses

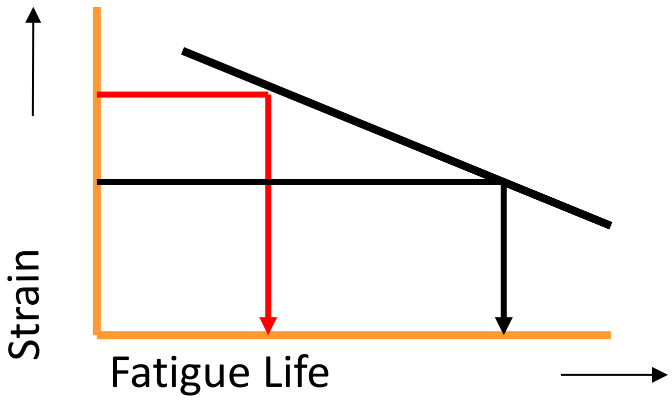
- Base – designed to resist fatigue and moisture damage, to be durable
- Intermediate/binder – designed for durability and stability (rut resistance)
- Surface – designed to resist surface initiated distresses (top-down cracking, rutting, other)

Classic Fatigue Theory

High Strain = Short Life

Low Strain = Long Life





Extrapolations of loads from AASHO Road Test

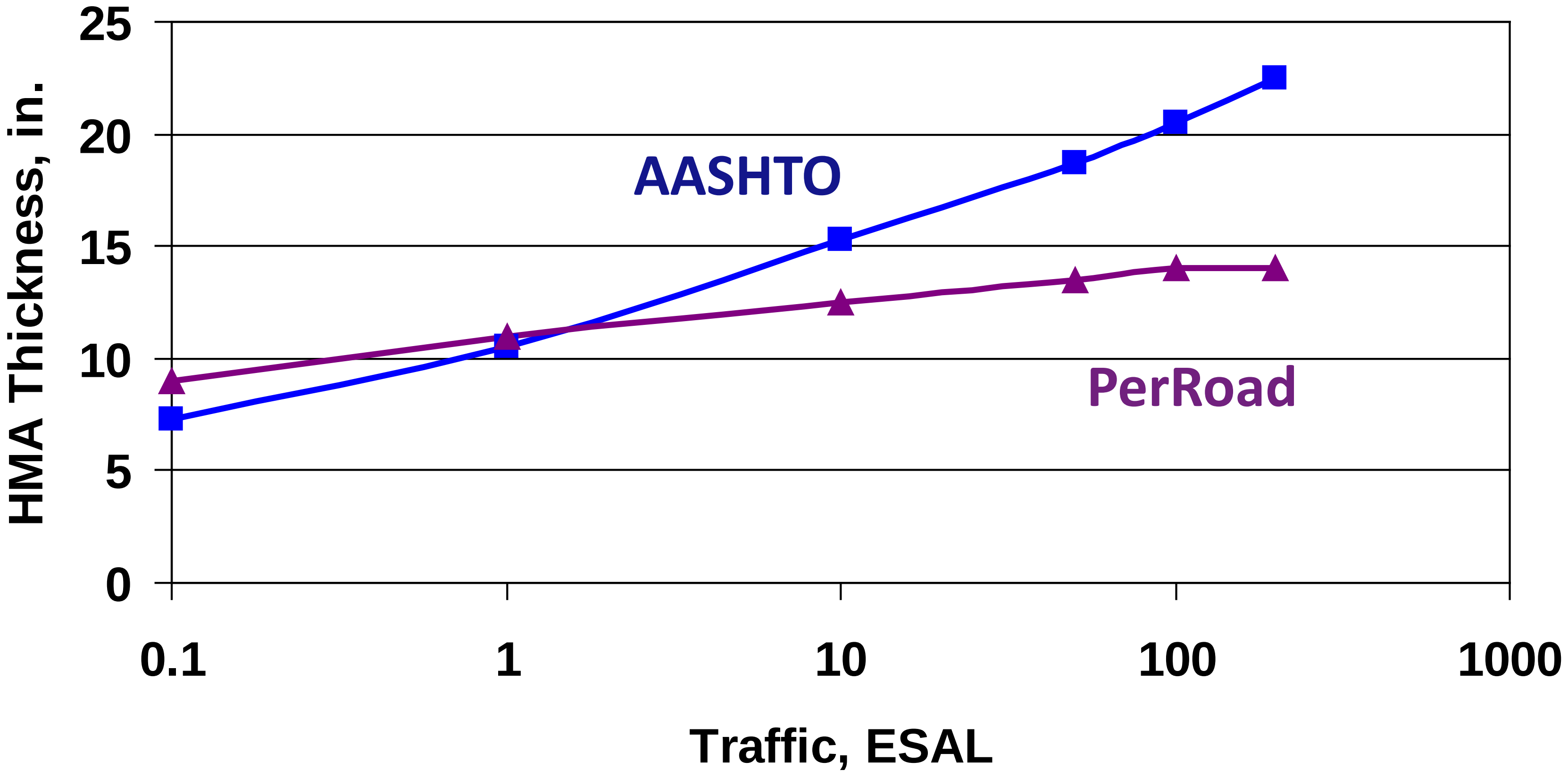
Extrapolation of Fatigue

Higher traffic leads to thicker pavements

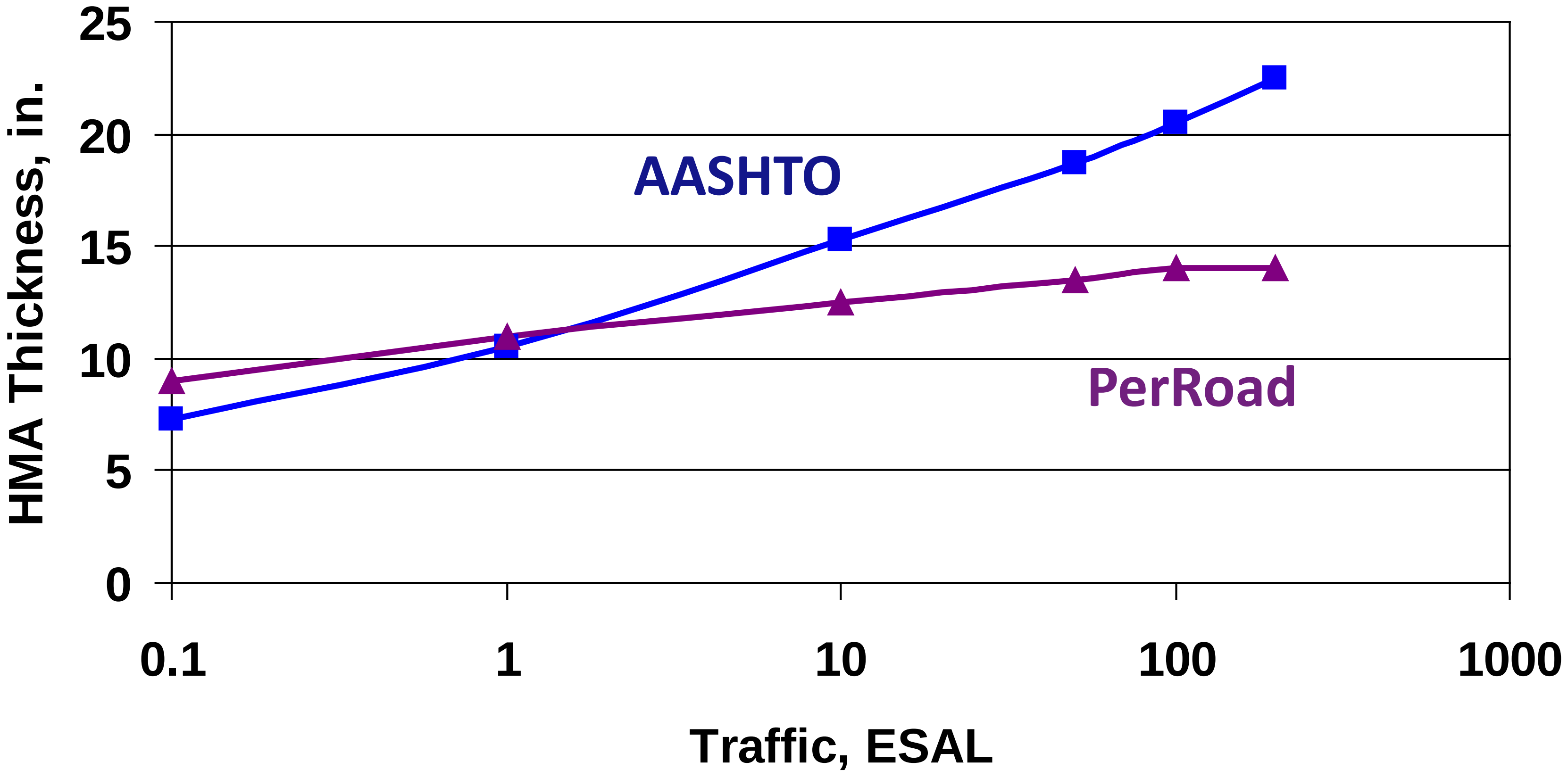
Pavements may be over-designed

- Over-conservative
- Unnecessary expense
- Not sustainable
- Example - Indiana pavements over-designed by 1.5 to 4.5 inches using 1993 AASHTO Guide (Huber et al., 2009)

Perpetual Pavement vs. Conventional Design



Perpetual Pavement vs. Conventional Design

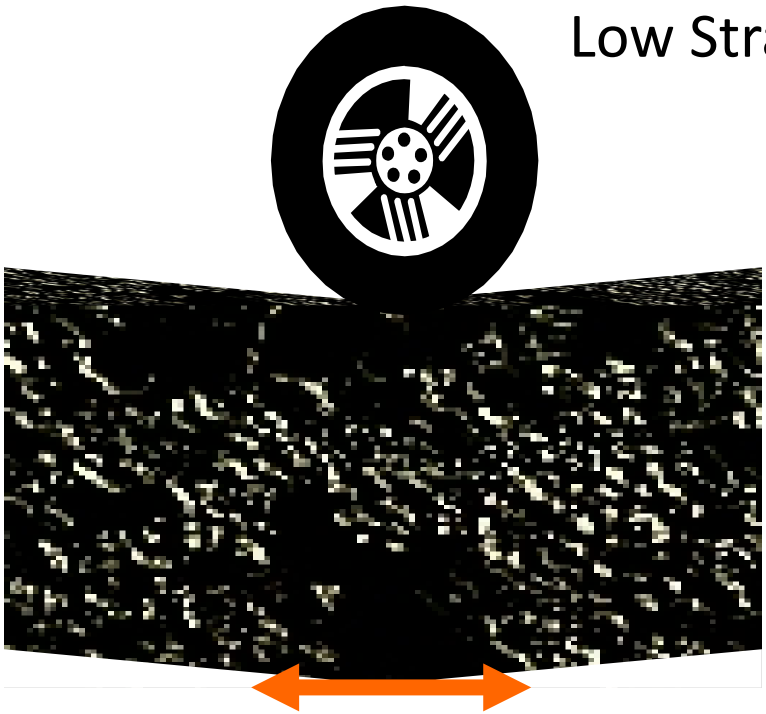


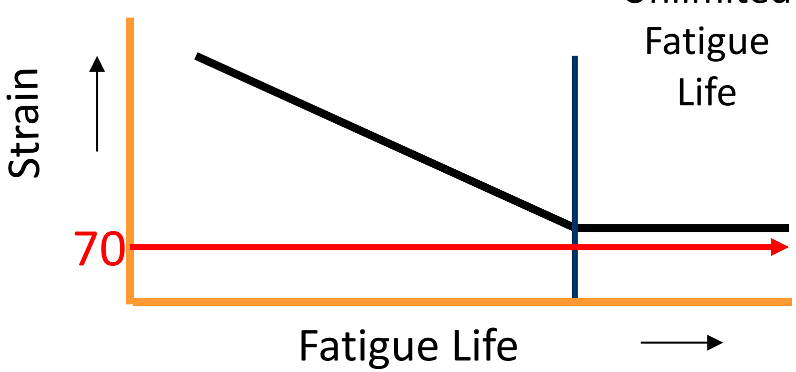
Mechanistic design can be thinner and less expensive!

Fatigue Theory for Thick Pavements

High Strain = Short Life

Low Strain = Unlimited Life





Fatigue Endurance Limit

Strain level below which fatigue damage does not occur

- 500 million loads over 40 years, Prowell et al., 2010

Varying levels have been reported

- 70 µЄ – Monismith and McClean, 1972
- 150-200 µЄ – Mishizawa et al., 1996
- 70-100 µЄ conservative – Willis, 2009
- 75-200 µЄ – Prowell, et al., 2010
- 100-250 µЄ – MEPDG

Validating an Endurance Limit, NCHRP 9-44

Design Options

Stage construction

- Plan for added thickness

Make existing pavements perpetual with overlays

- With adequate structure

Low to medium volume roadways

- Not necessarily thicker and more expensive than conventional; lower life cycle costs

Rubblized concrete pavement foundation

Components of HMA Pavements

Aggregates (~95% by weight or ~85% by volume)

Asphalt Cement (~5% by weight or ~15% by volume)

Can include recycled asphalt pavement (RAP).

Surface/Wearing Course

High quality HMA, SMA or OGFC (38-75 mm)

Rut resistant

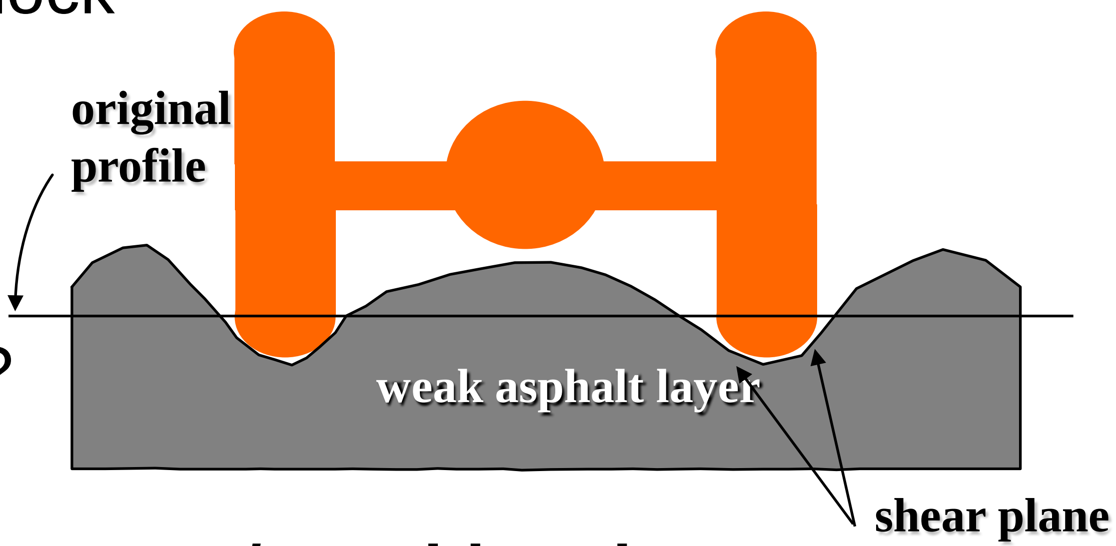
- Aggregate interlock
- PG grade

Crack resistant

- PG grade
- Polymer, fibers?

High friction

Other local requirements/considerations



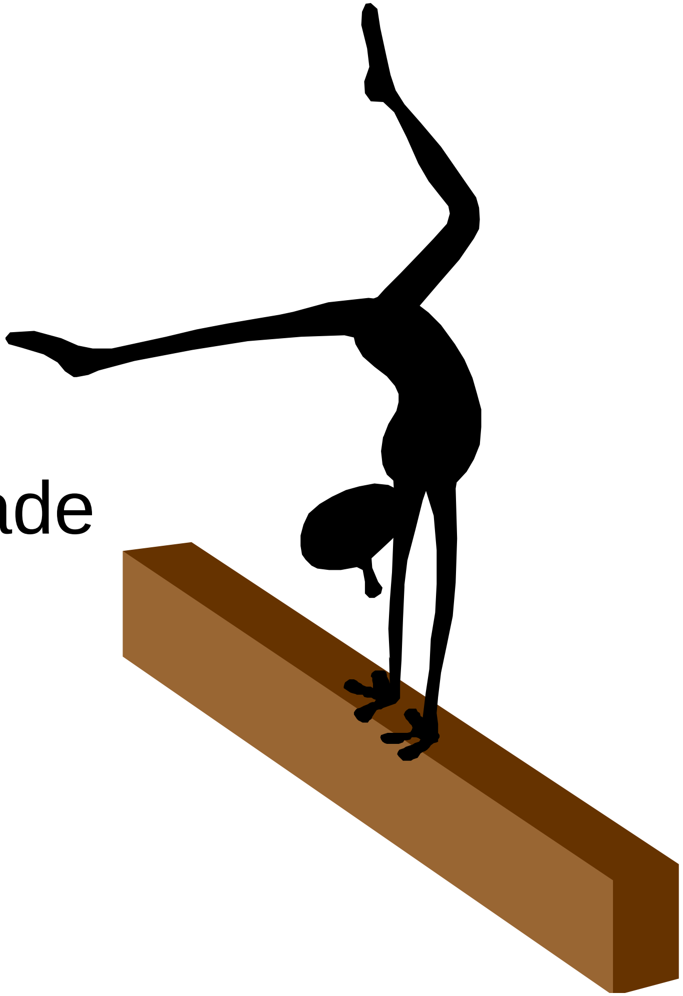
Intermediate/Binder Course

Stability

- Stone-on stone contact
- Angular aggregate
- High temperature PG grade

Durability

- Proper air void content
- Moisture resistant



Base Course

Resistant to fatigue cracking

- Higher binder content → lower voids, higher density → durability and fatigue resistance
    - Rich bottom bases – designed at 2-3% air voids
- Binder grade
- Fine gradation
- Moisture resistant

Base Course

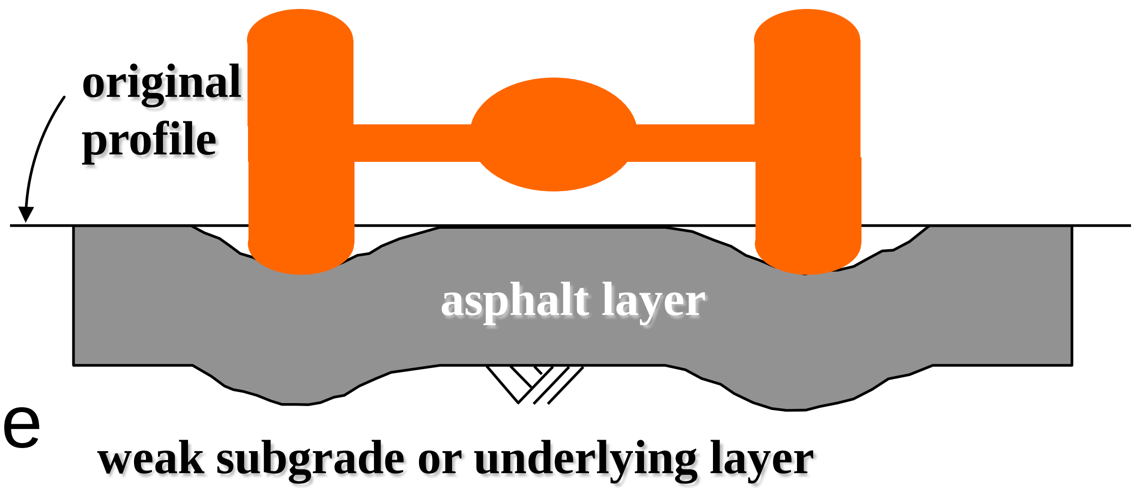
Alternate – stiff base of adequate thickness to reduce strain

- Hard binders
- High modulus mixes – hard binder and high binder content
  - Stiffness reduces strains in subgrade (at equal thickness)
  - High binder content improves compaction, reduces fatigue

Foundation

Working platform during construction and support over service life

- CBR ≥ 5%
- Mr ≥ 7000 psi
- Proof rolling
- Stabilization
- Positive drainage
- Frost penetration?
- *Intelligent compaction?*



Construction

Conventional equipment and procedures

Attention to detail/quality

Compaction critical

- Starting with foundation and including all layers
- Density and air voids

Avoid segregation

Ensure good bonding between layers

Intelligent Compaction

Inadequate compaction is major cause of distress. Intelligent Compaction allows:

- Mapping underlying layers to identify weak areas
- Monitoring coverage during rolling to improve rolling patterns
- Monitoring strength gain or increased density

IMPORTANCE OF COMPACTION

Each 1% increase in air voids (over 7%) reduces pavement life by about 1 year!

Intelligent Compaction can help us ensure good compaction.

GPS Set Up

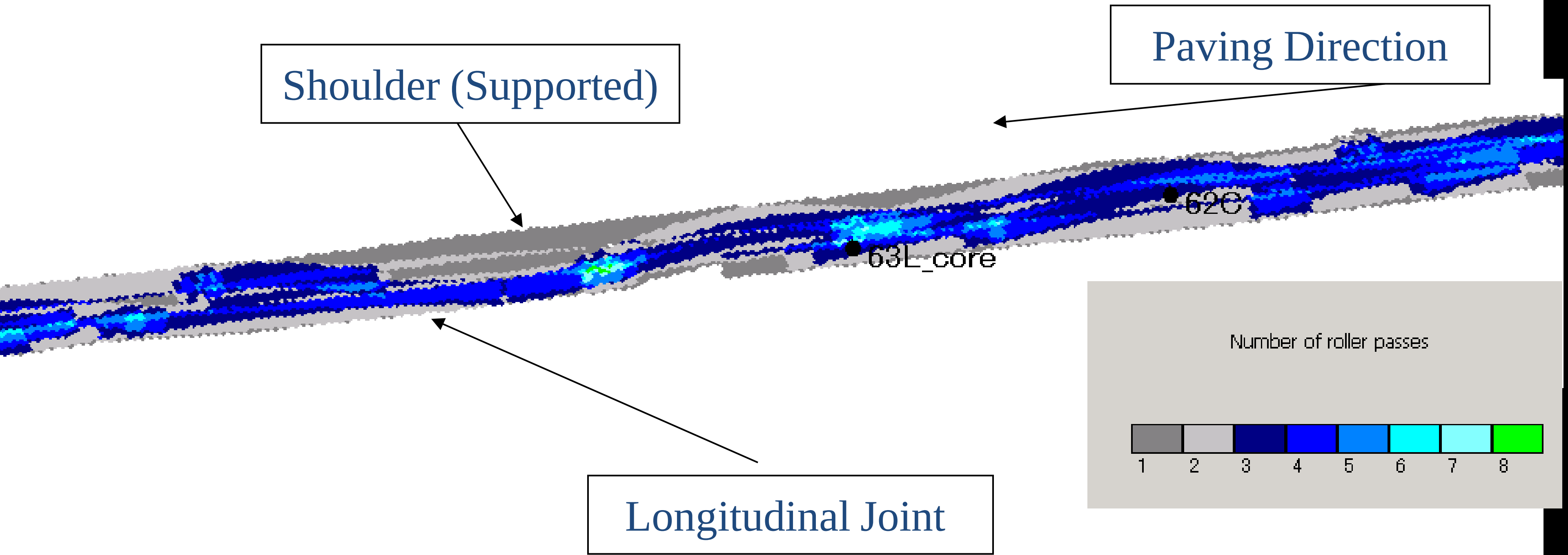
GPS Base Station

GPS Radio & Receiver

GPS Rover

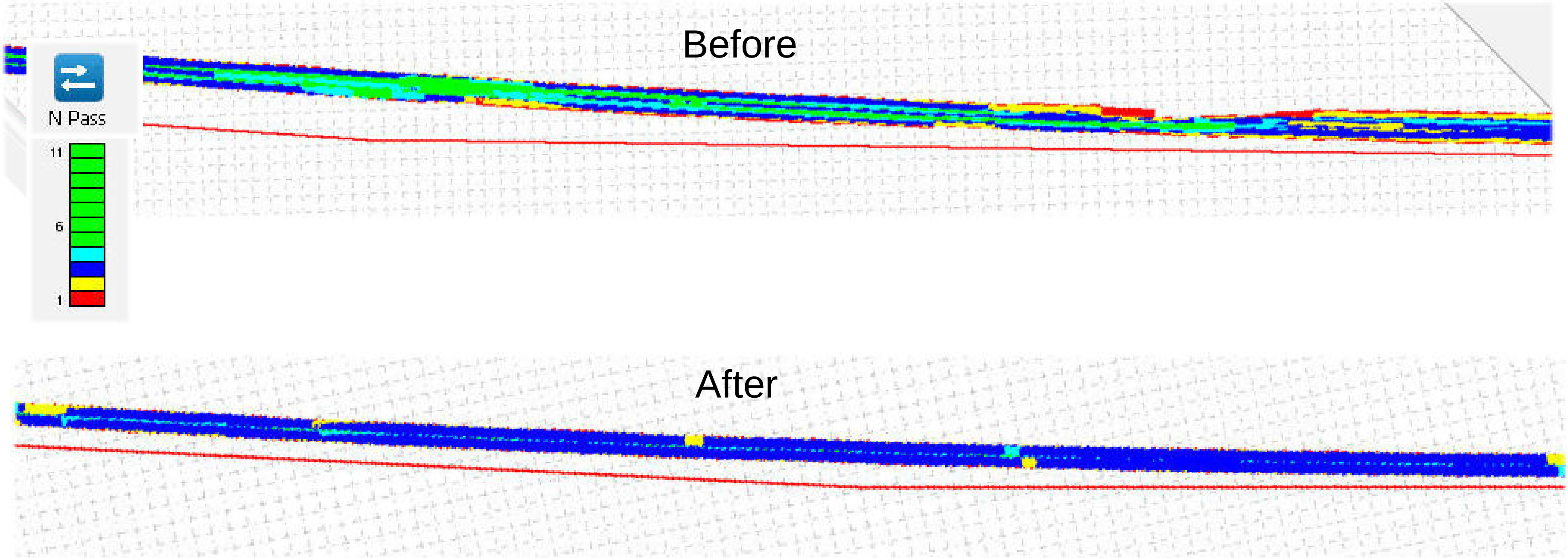
Real Time Kinematic (RTK) GPS Precision

Mapping of Roller Passes



Courtesy Sakai America

Improved Rolling Pattern



Improved Night Paving

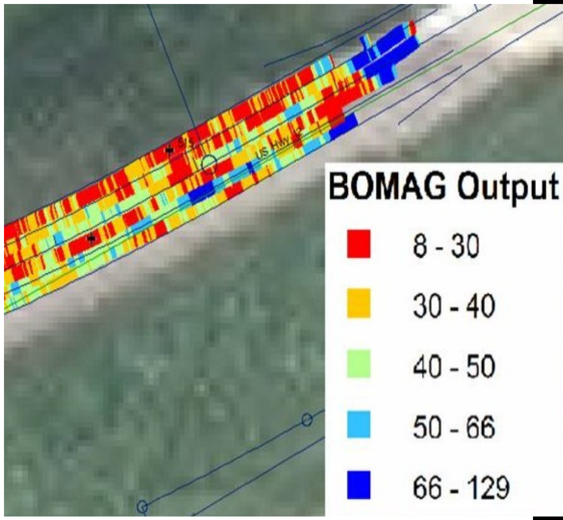
INFRA-RED THERMAL SENSOR

Benefits of IC for HMA

Improved density….better performance

Improved efficiency….cost savings

Increased information…better QC/QA, forensics



INTELLIGENT COMPACTION AND PAVE-IR IN MINNESOTA

2012 NCAUPG TECHNICAL CONFERENCE

FEBRUARY 16, 2012

GREG JOHNSON

MN/DOT – ASST. BITUMINOUS ENGR.

Pave-IR Purpose

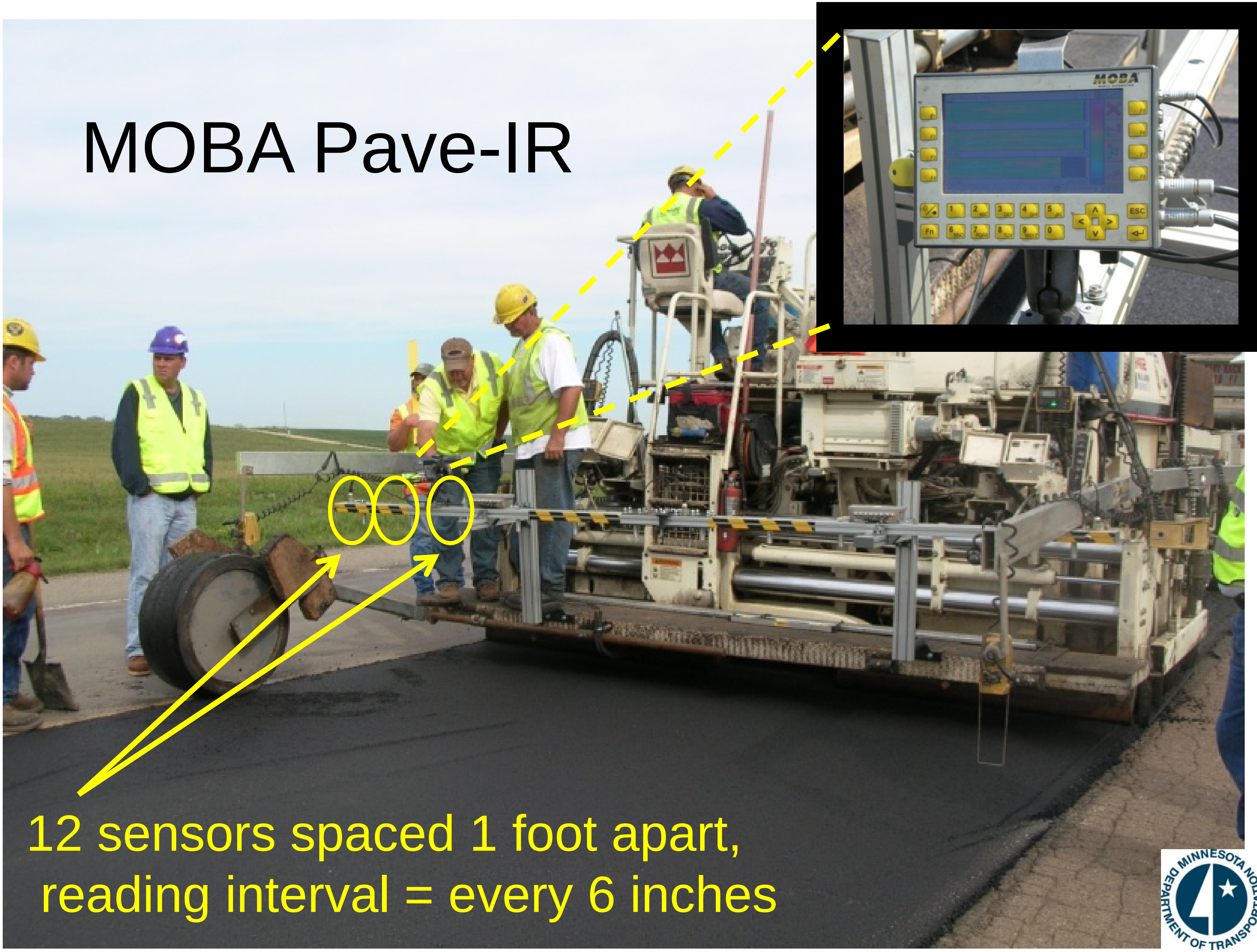
Promote more uniform, higher quality pavements

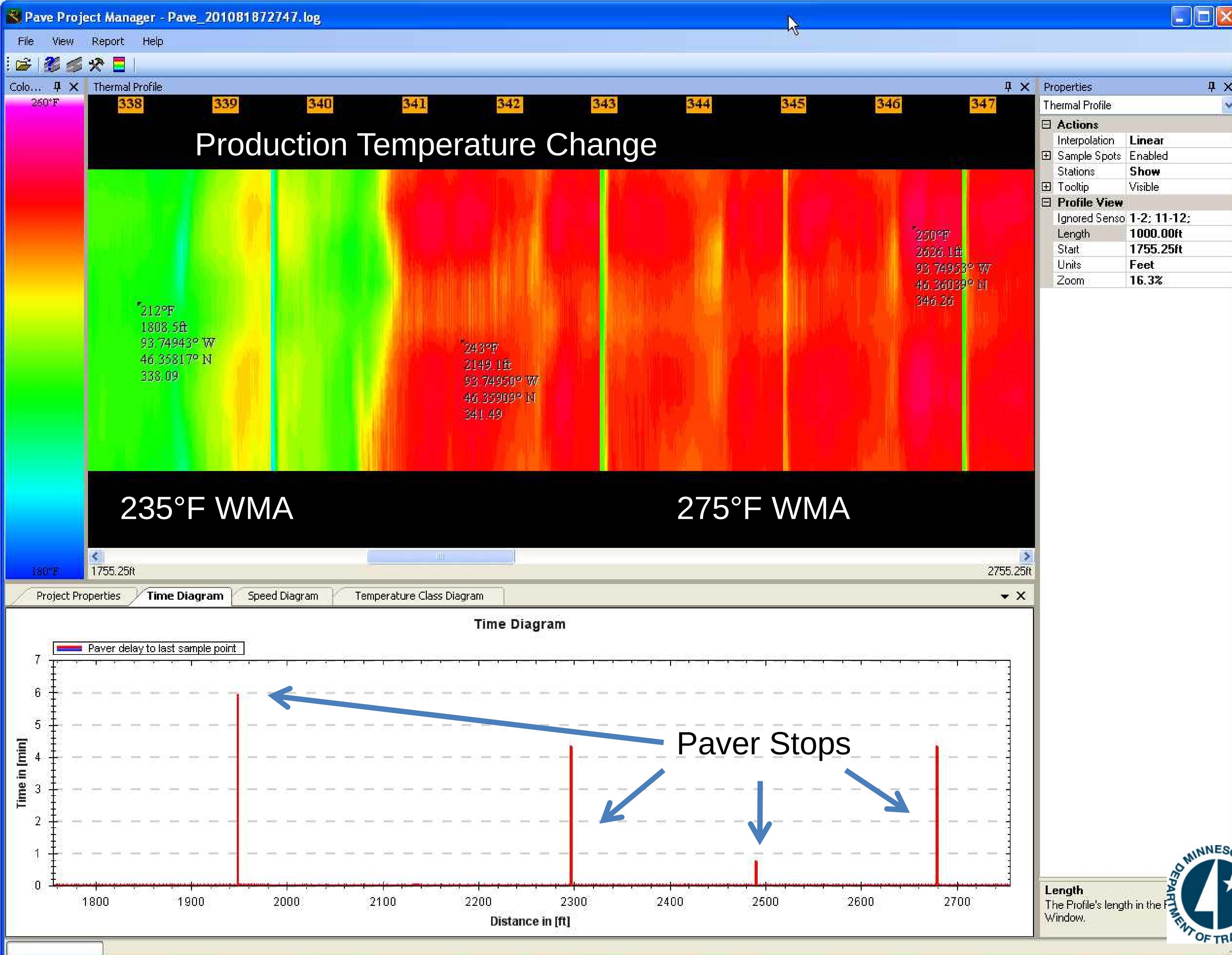
WSDOT, NCAT, and TTI found thermal uniformity useful for detecting segregation.

A segregated mat increases the contractor's chances of QC/QA core being in a poor/low density area.

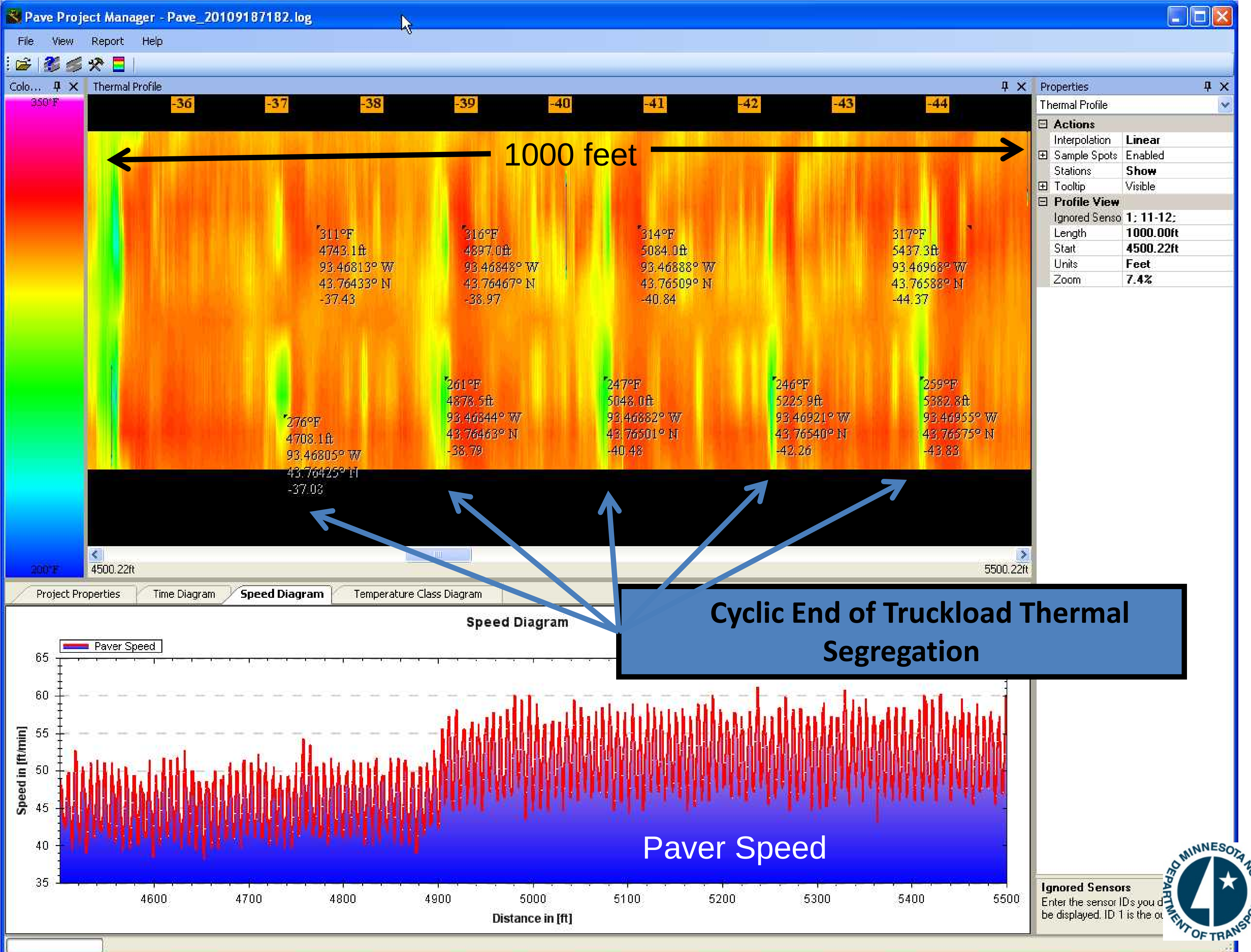
A segregated mat increases agency's risk of early distress.

MOBA Pave-IR


MOBA
12 sensors spaced 1 foot apart,
reading interval = every 6 inches
MINNESOTA DEPARTMENT OF TRANSPORTATION



Pave Project Manager - Pave_201081872747.log
File
View
Report
Help
Thermal Profile
Properties
338
339
340
341
342
343
344
345
346
347
Production Temperature Change
260°F
180°F
212°F
1808.5ft
93.74943° W
46.35817° N
338.09
243°F
2149.1ft
93.74950° W
46.35909° N
341.49
250°F
2626.1ft
93.74953° W
46.36039° N
346.26
235°F WMA
275°F WMA
1755.25ft
2755.25ft
Actions
Interpolation
Linear
Sample Spots
Enabled
Stations
Show
Tooltip
Visible
Profile View
Ignored Senso
1-2; 11-12;
Length
1000.00ft
Start
1755.25ft
Units
Feet
Zoom
16.3%
Project Properties
Time Diagram
Speed Diagram
Temperature Class Diagram
Time Diagram
Paver delay to last sample point
Time in [min]
Distance in [ft]
Paver Stops
Length
The Profile's length in the F
Window.



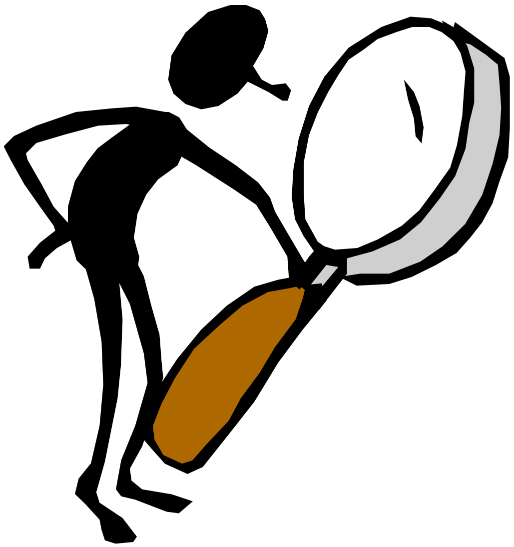
Pave Project Manager - Pave_20109187182.log
File View Report Help
Thermal Profile
350°F
200°F
-36 -37 -38 -39 -40 -41 -42 -43 -44
1000 feet
311°F 4743.1ft 93.46813° W 43.76433° N -37.43
316°F 4897.0ft 93.46848° W 43.76467° N -38.97
314°F 5084.0ft 93.46888° W 43.76509° N -40.84
317°F 5437.3ft 93.46968° W 43.76588° N -44.37
276°F 4708.1ft 93.46805° W 43.76425° N -37.03
261°F 4878.5ft 93.46844° W 43.76463° N -38.79
247°F 5048.0ft 93.46882° W 43.76501° N -40.48
246°F 5225.9ft 93.46921° W 43.76540° N -42.26
259°F 5382.8ft 93.46955° W 43.76575° N -43.83
4500.22ft
5500.22ft
Properties
Thermal Profile
Actions
Interpolation Linear
Sample Spots Enabled
Stations Show
Tooltip Visible
Profile View
Ignored Senso 1; 11-12;
Length 1000.00ft
Start 4500.22ft
Units Feet
Zoom 7.4%
Project Properties
Time Diagram
Speed Diagram
Temperature Class Diagram
Speed Diagram
Paver Speed
Speed in [ft/min]
65 60 55 50 45 40 35
4600 4700 4800 4900 5000 5100 5200 5300 5400 5500
Distance in [ft]
Paver Speed
Cyclic End of Truckload Thermal Segregation
Ignored Sensors
Enter the sensor IDs you d be displayed. ID 1 is the o
MINNESOTA DEPARTMENT OF TRANSPORTATION

Conclusion

IC and Pave-IR together can provide:

- Feedback and control of the paving process
- Increase uniformity of mix placement and compaction
- Increase the performance of our pavements
- Ability to decrease the amount of QC/QA testing needed
- Proof of quality placement and compaction
- Increased accountability

PERFORMANCE MONITORING



- **Monitor pavement distresses**
  - Thermal cracking
  - Minor surface rutting
  - Top-down fatigue
  - Raveling or functional problems
- **Repair surface distresses before they become structural**
  - Mill and fill
  - Thin overlay

Renewal Options

For Perpetual or Conventional Pavements

- **Mill and fill**
- **Mill and overlay**
- **Thin overlays** – 4.75 mm mixes
- **In-place recycling** – hot or cold
- **Full depth reclamation** – new construction

MILLING

- Removes old/distressed pavement
- Improves smoothness
- Eliminates costly shoulder work
- Maintains drainage features, curbs, overhead clearance
- Valuable rehabilitation option

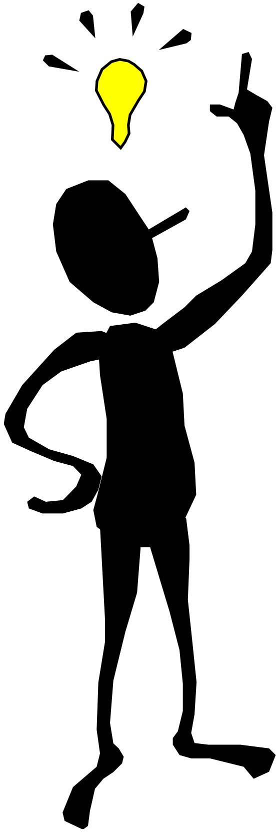
Customizable

Process can be simple or more involved

Ranges of options

Share the responsibility, risks, benefits

Quality is free as long as it is done right the first time.



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