Illinois Center for Transportation
University of Illinois at Urbana-Champaign

ILLINOIS

Local Aggregate Utilization in Stone-Matrix Asphalt (SMA)

Javier J. García Mainieri
Imad L. Al-Qadi

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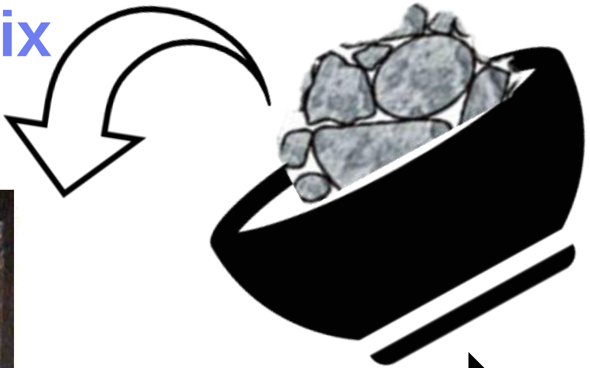
IAPA Conference

Stone-Matrix (Mastic) Asphalt (SMA)

- **Special asphalt mix**
- **Developed in Germany (60's) as a wearing course**
  - Used also as a binder course
- **Introduced in the U.S. in 1990**
- **Resilient**
  - Durable
  - Rut-resistant

Stone-to-Stone Contact Is Key to SMA Performance

Coarse-aggregates float on fine aggregate matrix and mastic



Dense-graded mix

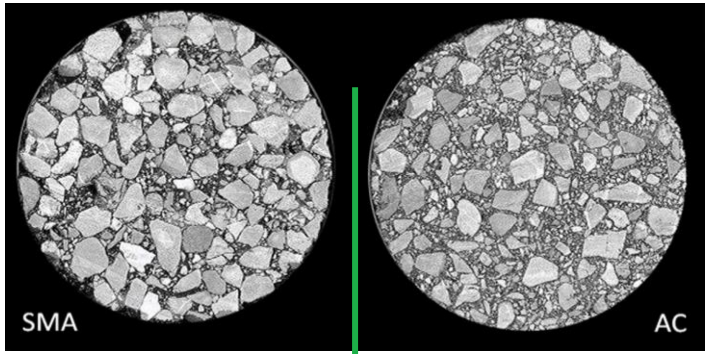
Coarse-aggregates are packed and in contact!

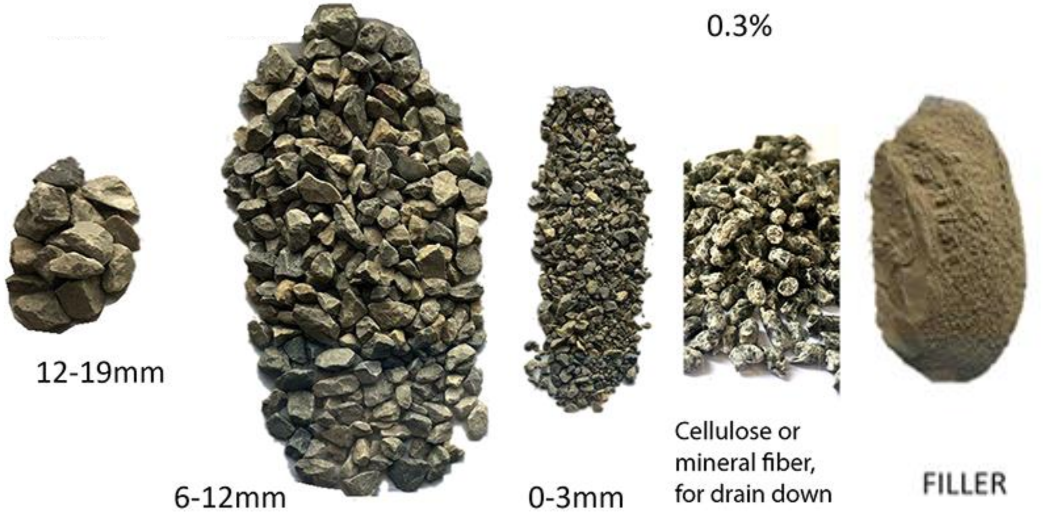
SMA

SMA Characteristics

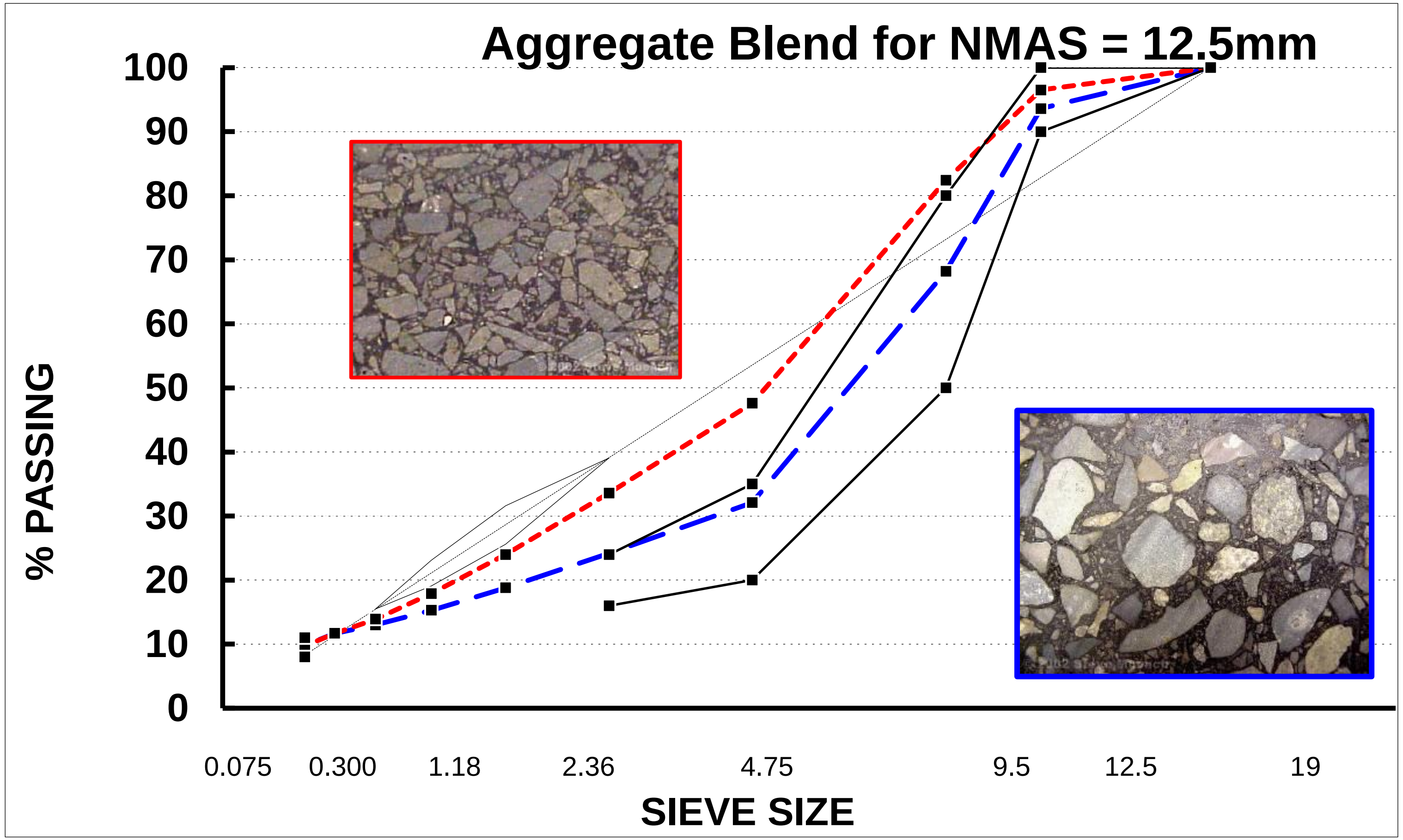
- **Relatively high optimum asphalt binder content**
  - Asphalt modifiers (polymers) improves mix quality and stability
  - Cellulose or mineral fibers control drain down
- **Aggregate quality (LA Abrasion < 30)**
  - All aggregate sides are crushed (cubical) w/ rough texture
  - Usually, double crushed
  - Relatively high fine content
- **Higher VMA (~> 17%) than traditional mixes**
- **Required mix time slows down production**
- **Less compaction passes are required in the field**

Aggregate Gradation





Typical Dense-Graded Mix vs SMA



SMA Challenges

- **Close-control preparation**
- **Lower abrasion aggregate**
  - Inferior quality crushed stone and “manufactured” fine aggregate would undermine SMA performance
  - Transporting good quality aggregate may be cost- and environmentally prohibitive
- **Rapid compaction (sticky mix)**
  - Echelon formation preferred (side by side)
  - Pneumatic tire compactors should be used with care

Summary of SMA Benefits/ Challenges

Benefits

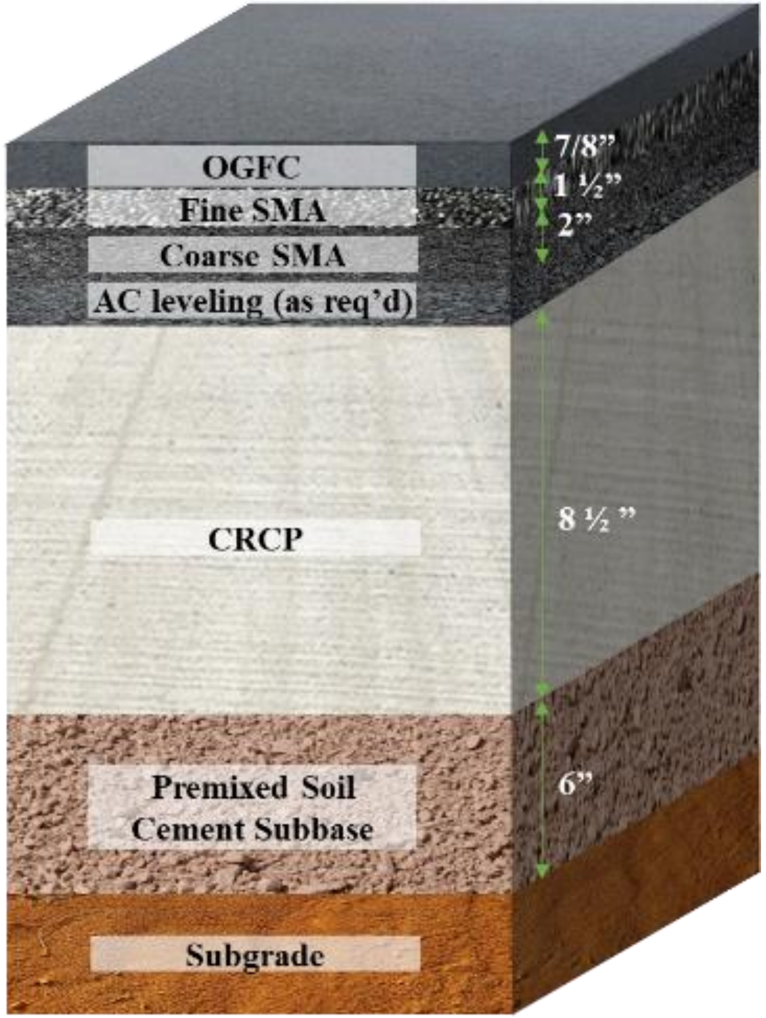
- Performance
- Stability and resiliency
- Higher Friction
- Reduced
  - water spray
  - traffic noise
  - temperature/aging cracking
  - compaction passes

Challenges

- Cost (20–30% higher than HMA)
- Special needs:
  - Additional cold feed bins
  - Needs fibers/polymers
  - Increased mixing time and temp.
  - Draindown
- Short hauling time
- Compaction has to be done quickly

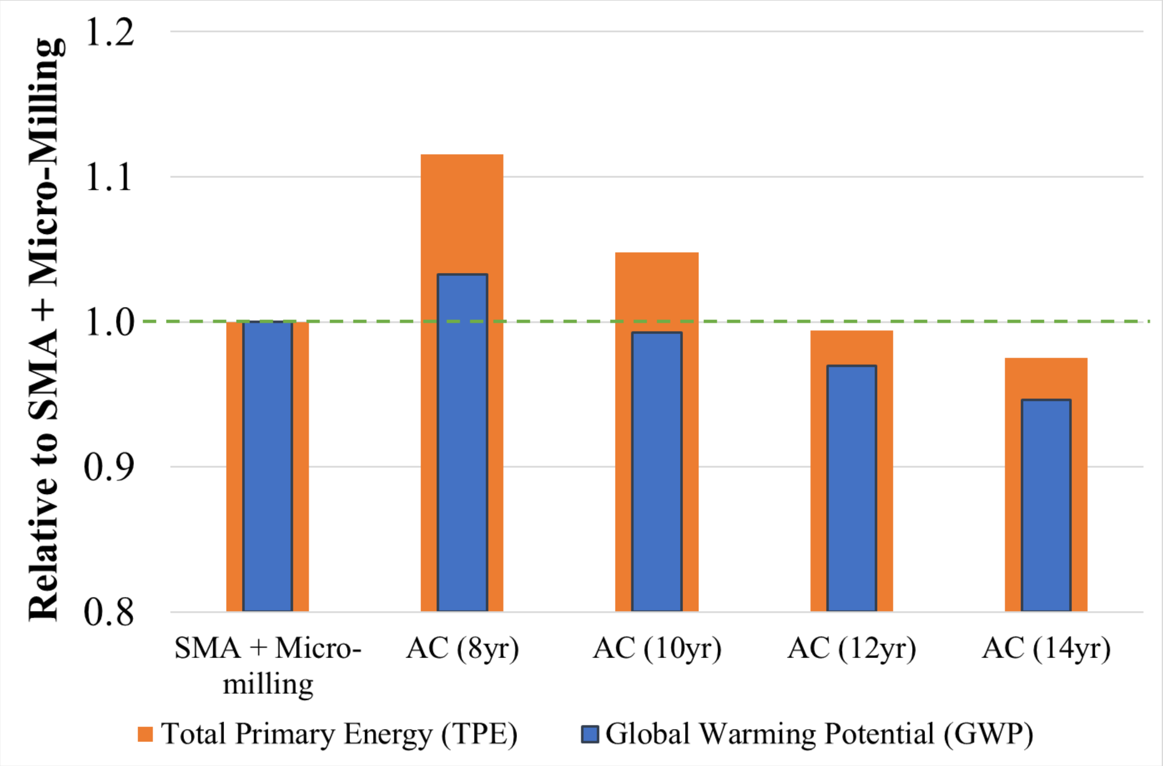
- **Bottom Line.** SMA has high capacity. Able to carry load through stone-to-stone contact and dissipate energy through a thick film of mastic
- Relatively higher cost is offset by increased durability, decreased maintenance costs, and increased service life

GDOT SMA Case Study



SMA+OGFC vs AC

Existing



M&C: Materials and Construction
M&R: Maintenance and Rehabilitation

Al-Qadi, I.L., Gamez, A., and Okte, E.
FHWA-HIF-19-084 www.fhwa.dot.gov/pavement/sustainability/case_studies/hif19084.pdf

SMA Use in Illinois

District	1	2	3	4	5	6	7	9	Total or Average
SMA use 2021 (Ktons)	240	10	28.5	92	16.4	34.8	35	36	492.7
SMA expected use 2022 (Ktons)	300	33	55.5	65	60	27.3	78		618.8
Expected Increase	20%	70%	49%	-42%	73%	-27%	55%		28%

- **NMAS: 12.5mm, 9.5mm, and 19.0mm (In the order of demand)**
- **Motivation for using SMA in IL:**
  - Stable mix that handles heavy traffic
  - Durable mix that provides a longer service life
  - Proper surface friction
  - Applicable with out vibratory compaction

Utilization of Local Aggregate in SMA

- Hypothetical project on I-55, just south of Springfield; **plant in Decatur**.

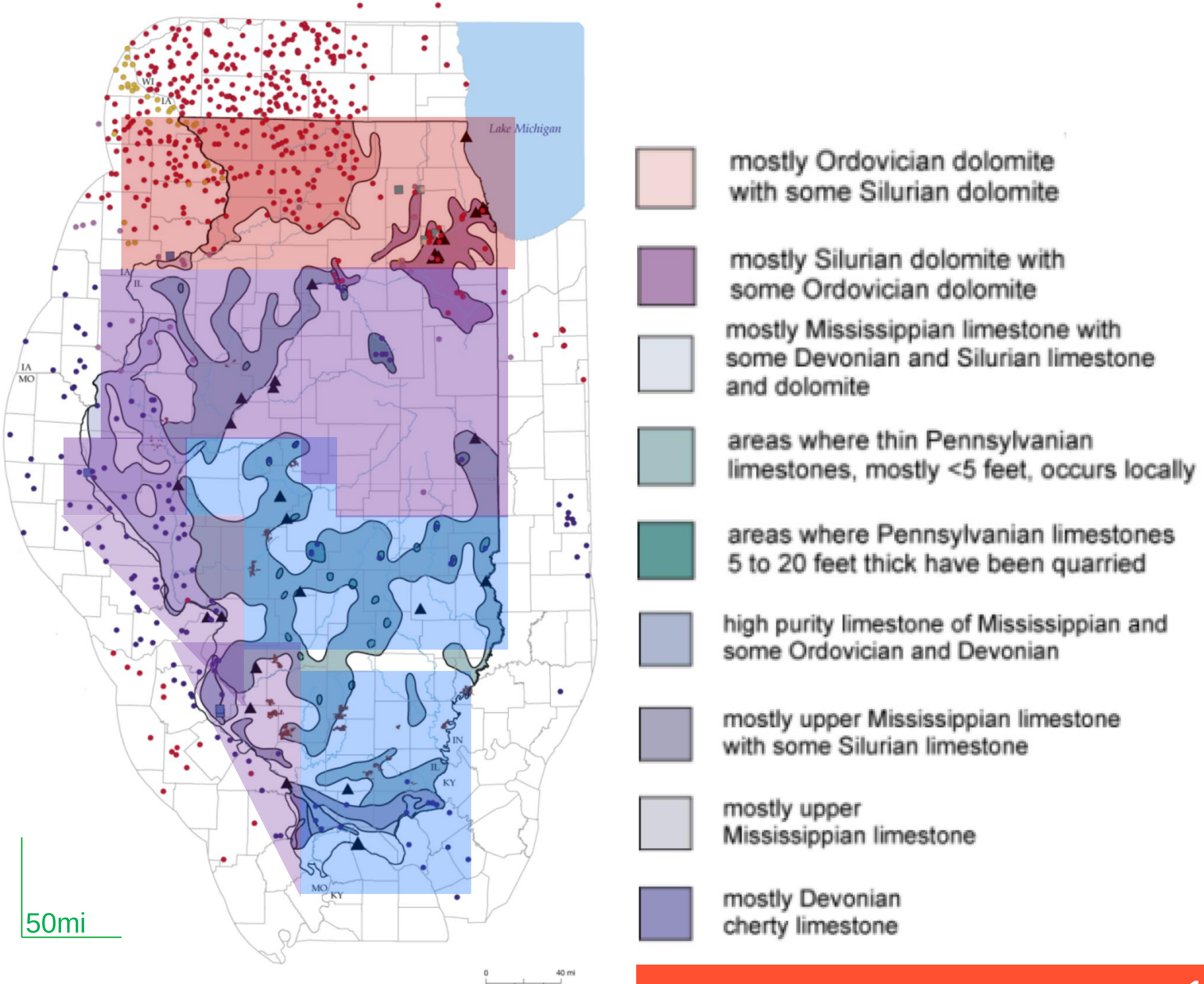
Aggregate Hauling (mi)	Material Hauling Emissions (kg eq CO_2)
202 (MS Trap Rock)	275,958
40.5 (Local Limestone Quarry)	68,997

Bhagwat, S. B. (2016). *Construction aggregates and silica sand in the economy of Illinois* (Special Report 5). Illinois State Geological Survey.

- **Reduction in CO_2 is four-fold!**
  - 206,962 kg of eq CO_2 reduction per lane-mi.

- **Price of crushed stone doubles if it travels 46mi**

Aggregate Families in Illinois



Z. Lasemi, 2020, ISGS

R27-216: Project Objective and Scope

LAB

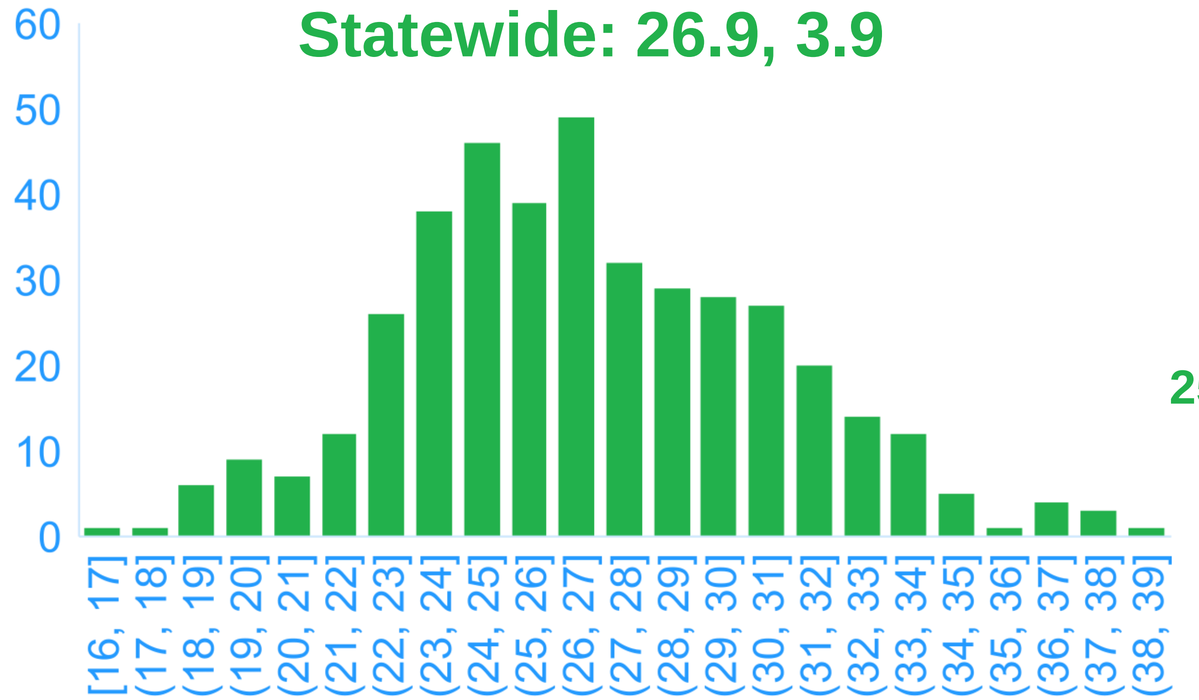
APT

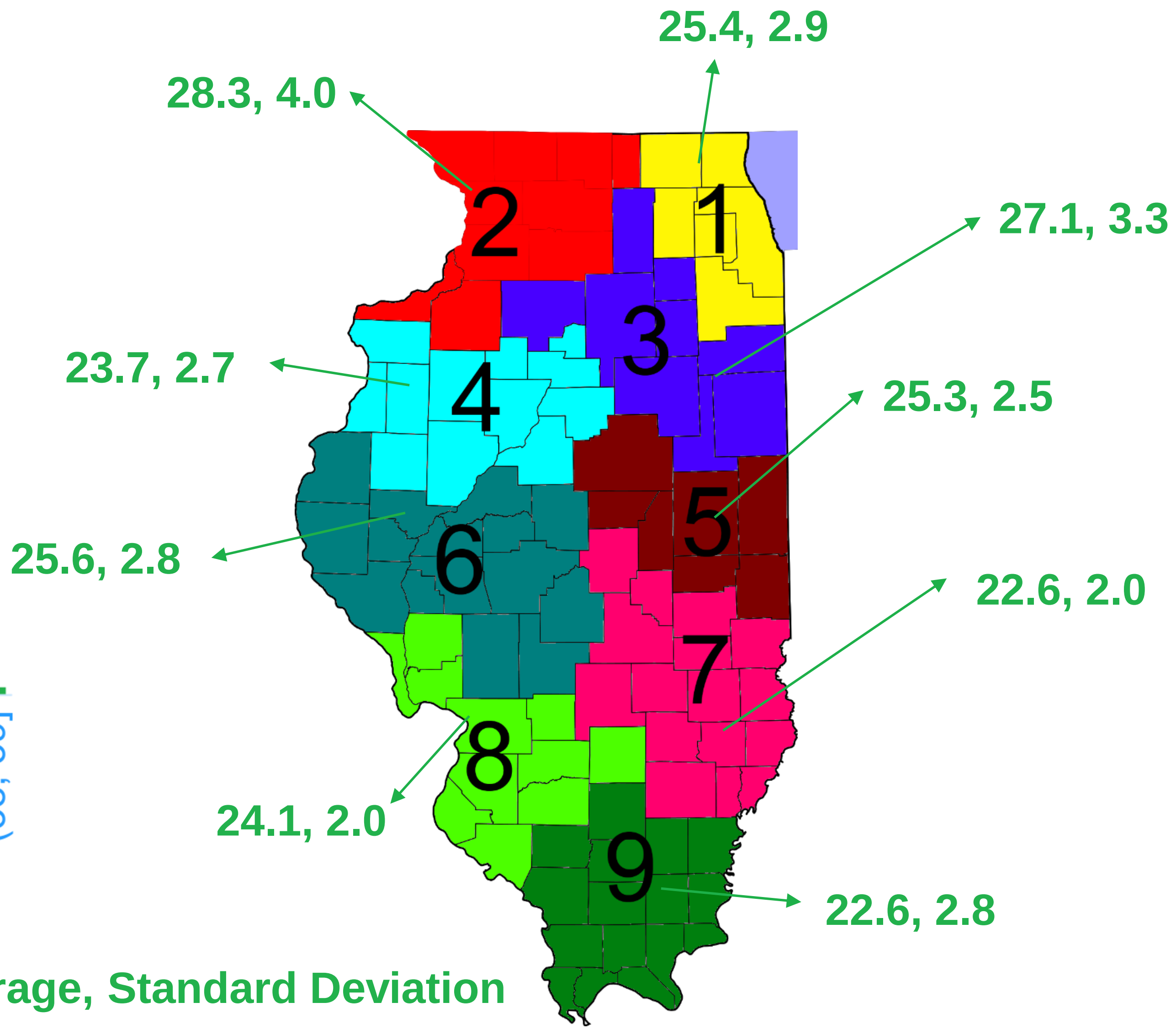
LCA & LCCA

Greg Heckel

FIELD

Aggregate LA Abrasion Data in Illinois





LA Abrasion Percentiles

All Sources		
75th Percentile	50th Percentile	25th Percentile
22.7	25.0	27.6

Dolomite Sources		
75th Percentile	50th Percentile	25th Percentile
23.5	26.2	29.3

Gravel Sources		
75th Percentile	50th Percentile	25th Percentile
22.5	24.4	26.8

Limestone Sources		
75th Percentile	50th Percentile	25th Percentile
22.1	24.2	26.4

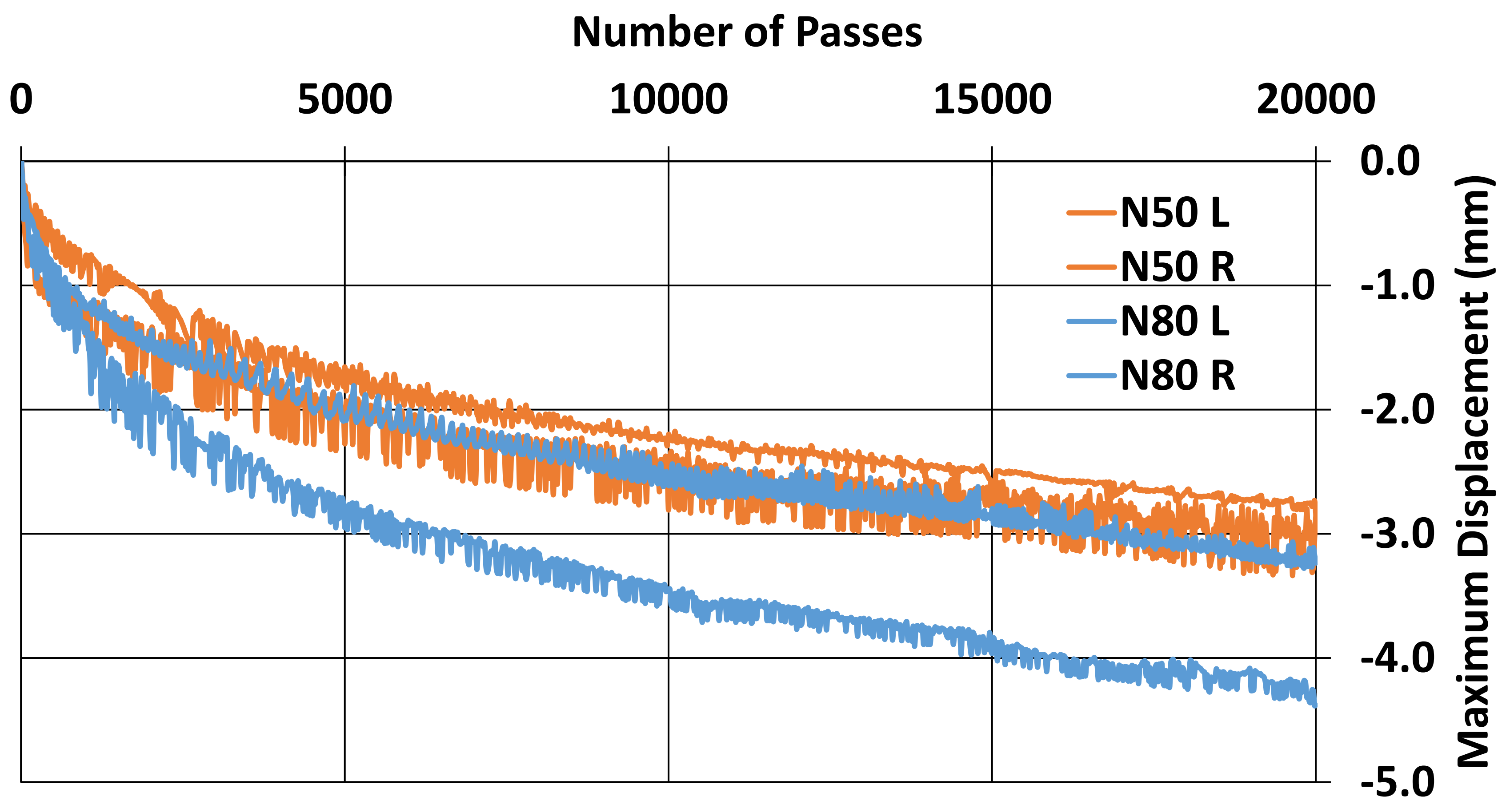
Quarry Stockpiles

SMA Experimental Matrix

Lithology of Coarse Aggregate	NMAS and N-Design				
	9.5mm		12.5mm		19mm
	80	50	80	50	50
Imported Trap Rock	CA-9.5	CB-9.5	CA and CC	CB and CD	
Local Limestone			LL75-80	LL25, LL50, LL75	LL25-19
Local Dolomite		LD25-9.5, and LD75-9.5		LD25, LD50, LD75	
Local Crushed Gravel				LCG	

- Note: 25, 50 and 75 are the LA abrasion percentiles

HWTT Results



Specimen	Max Rut (mm)
N50 L	3.34
N50 R	2.84
N80 L	4.38
N50 R	3.28

- Stability was maintained at reduced design gyration

I-FIT Results

N-Design	Aging Condition	Fracture Energy	Slope	Peak Load	FI
80	Unaged	2675.2	-0.6	37.1	50.1
	3D/95C	2327.4	-1.0	42.1	26.8
50	Unaged	3168.3	-0.7	43.3	50.5
	3D/95C	2502.7	-1.3	54.1	20.3

- Similar FI; N50: Higher peak load and FE
- Packing

TSR Results

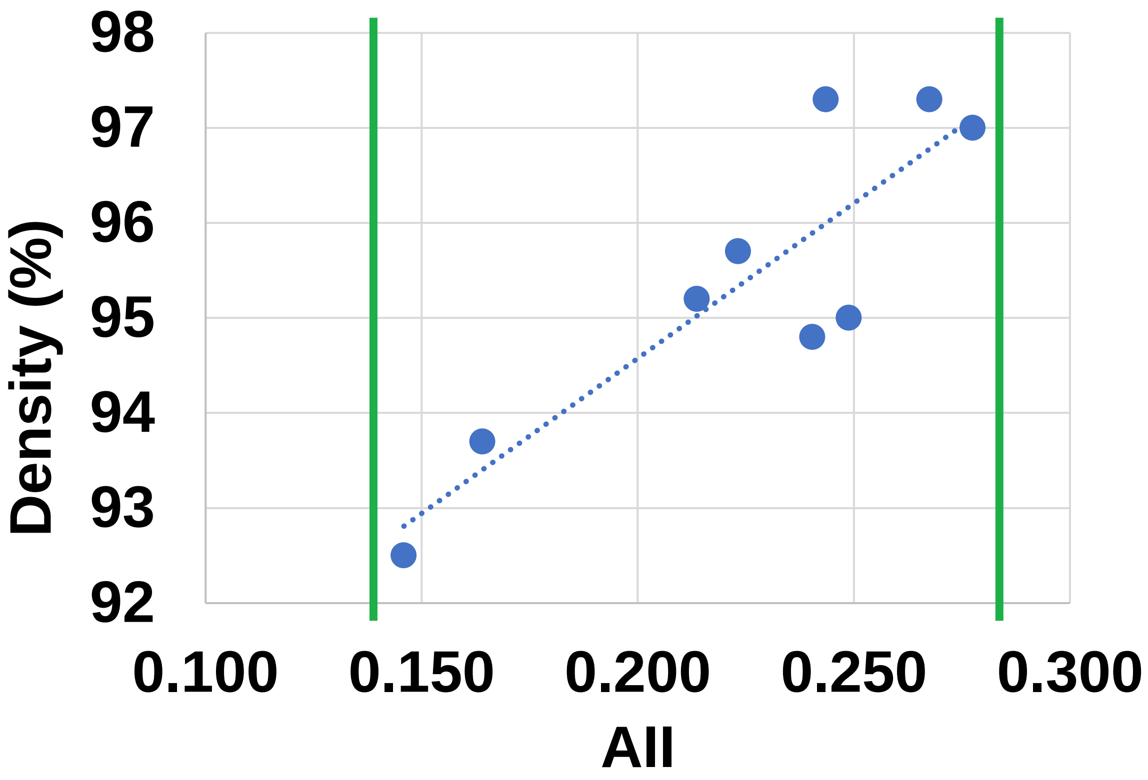
N-Design	Average Wet Strength (psi)	Average Dry Strength (psi)	TSR
50	96.7	99.9	0.97
80	92.2	101.6	0.91

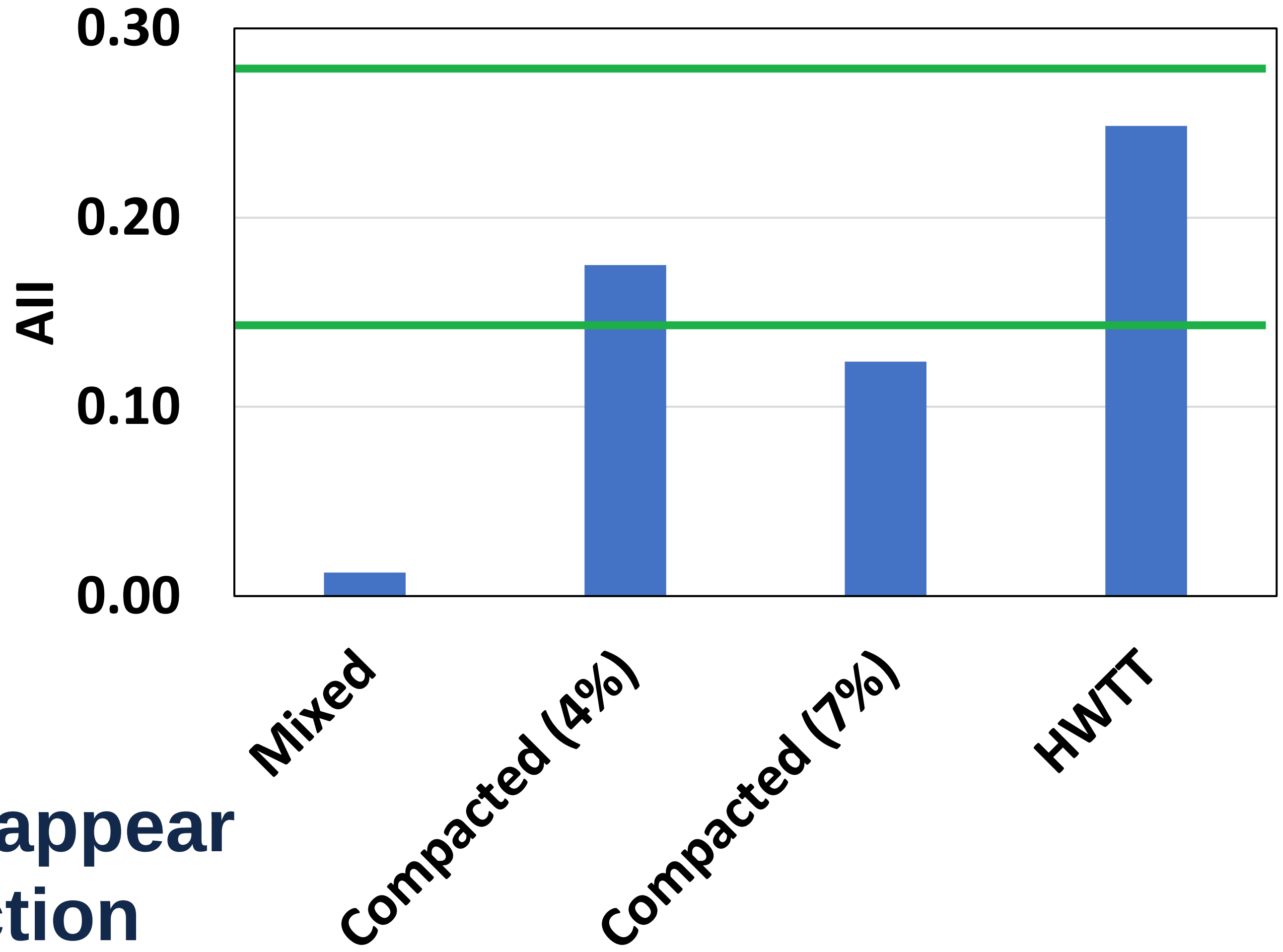
- N80 and N50 had similar TSR results

Aggregate Integrity Verification Testing

- Extraction
- Washed Gradation Sieve Analyses

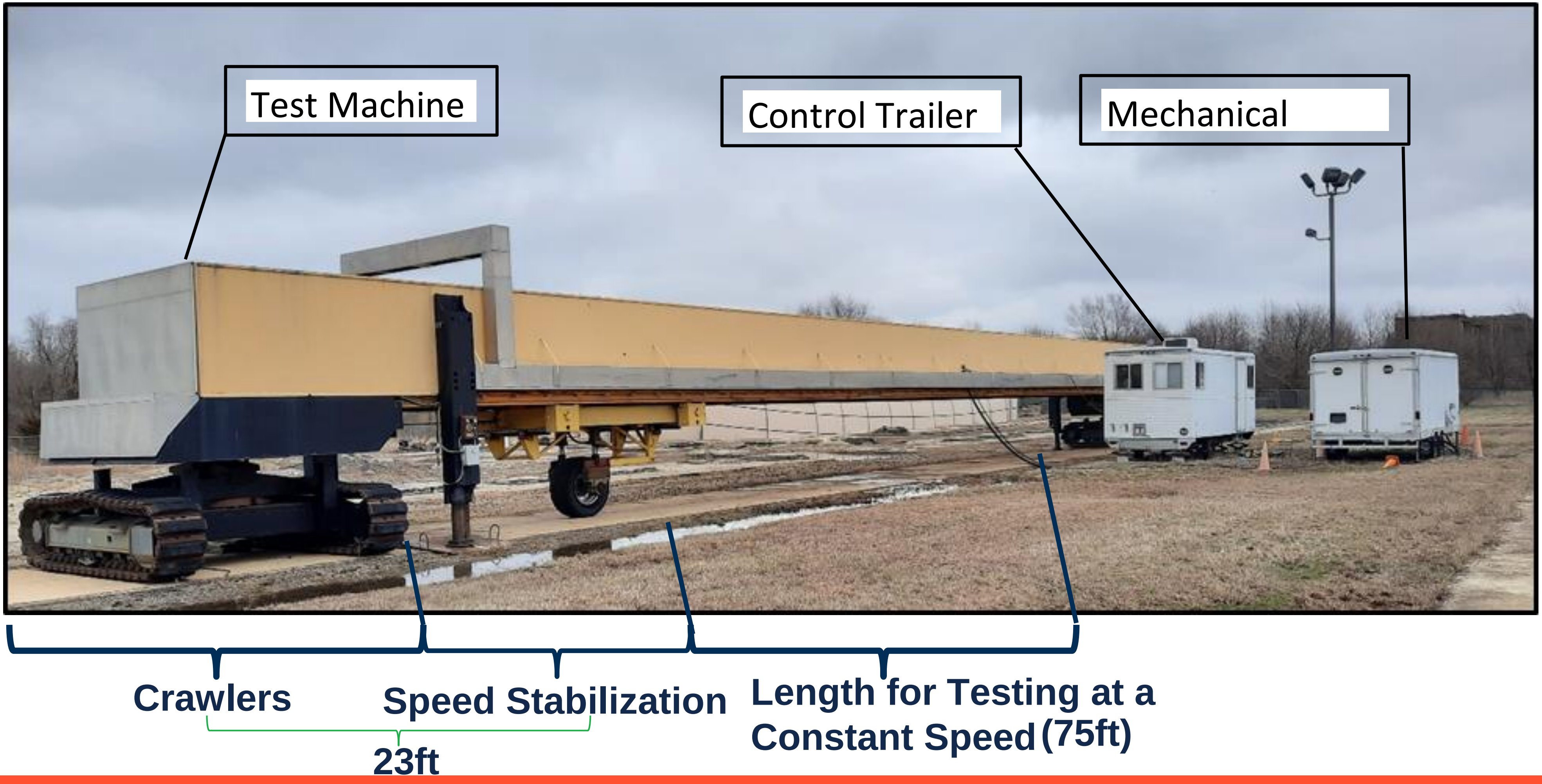
Aggregate Integrity Index Results

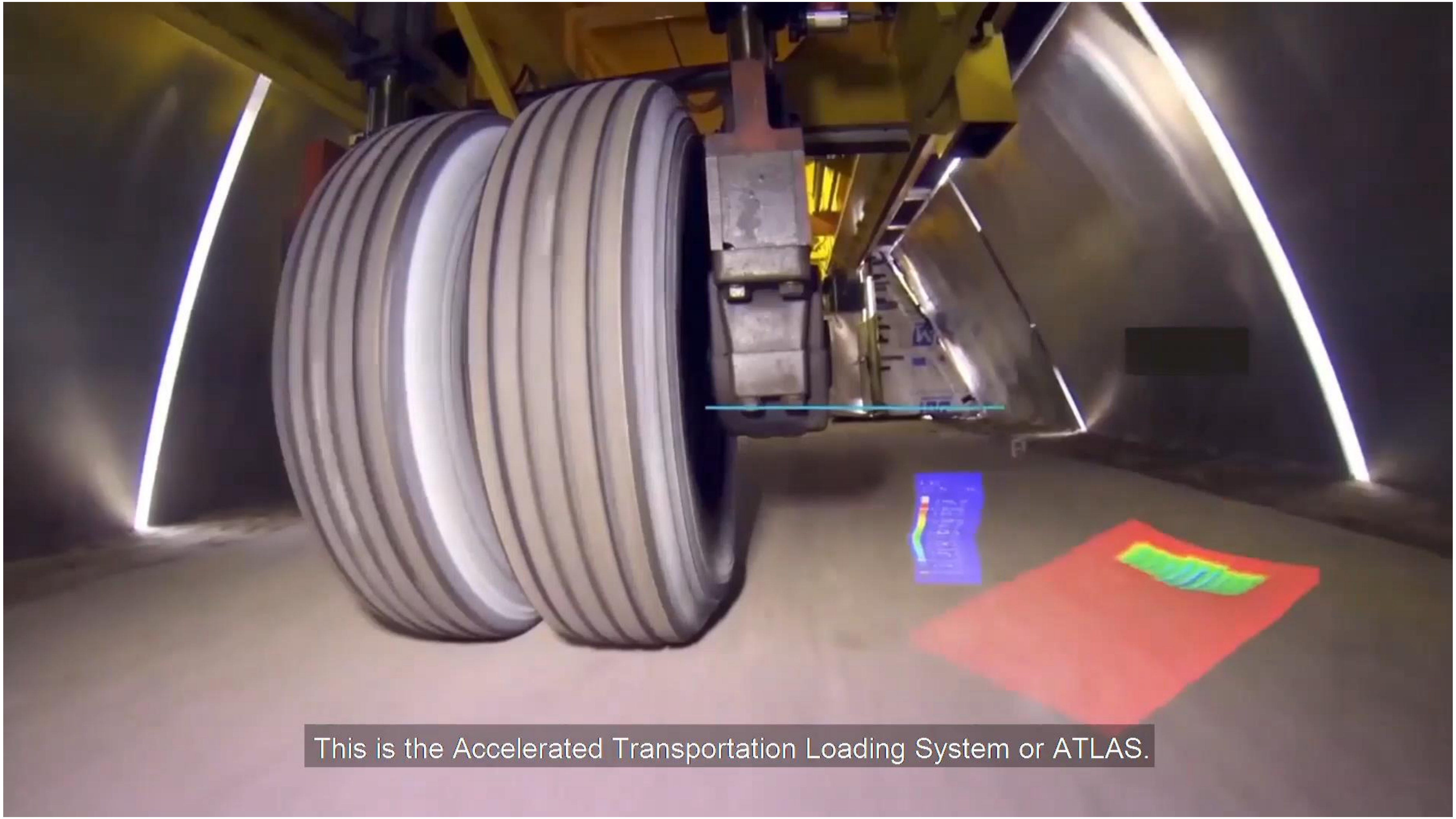




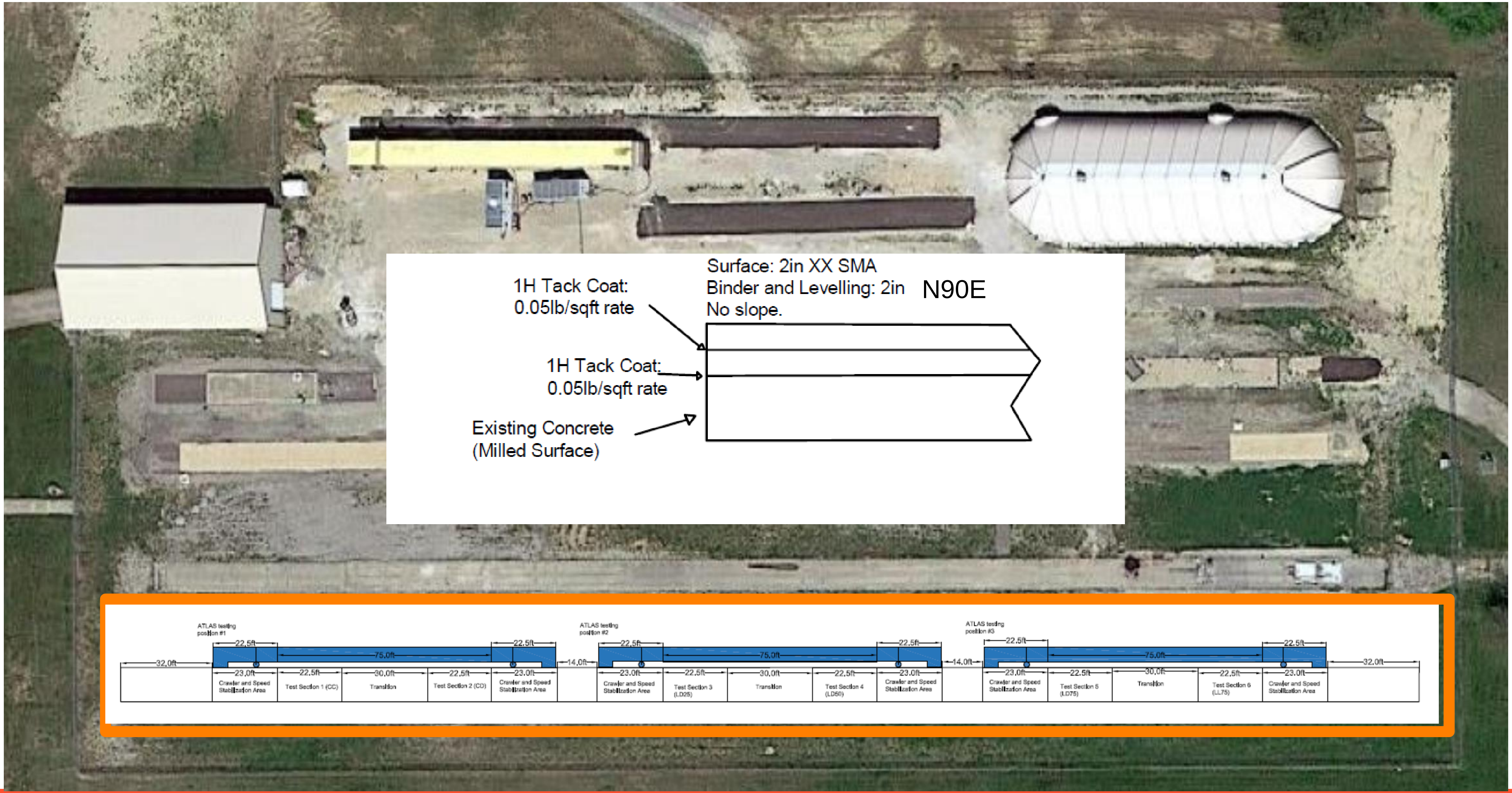
- N-Des compaction and HWTT appear representative of field compaction

Accelerated Transportation Loading System (ATLAS)

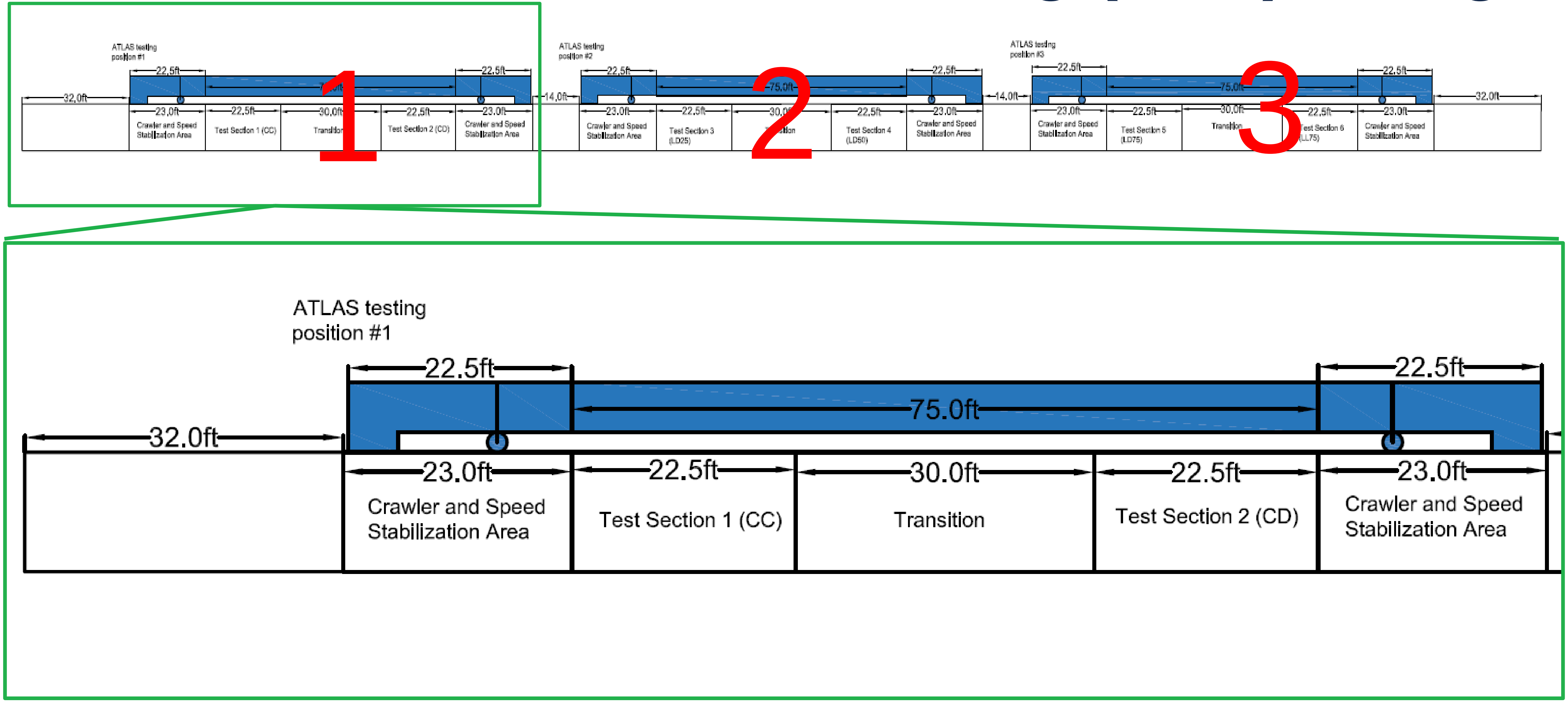



This is the Accelerated Transportation Loading System or ATLAS.

Testing Sections



Accelerated Pavement Testing (APT) Design



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THANK YOU

Any Question?

Illinois Center for Transportation (ICT)

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(217) 893 - 0200