Research and Implementation of Pavement Preservation Strategies:

Thin Lift Overlay (TLO) Advances- City of Sioux Falls

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NORTH DAKOTA
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March 2–3, 2022 ▪ Baymont Inn and Suites Mandan

City of Sioux Falls

Pavement Preservation Implementation: Strategies and Options

Pavement Preservation Implementation Strategies and Options

City of Sioux Falls

One of the keys to successful preservation is the continued development of innovative and proven strategies and documenting their performance characteristics. Ideally, performance testing of these materials provides valuable insight into their value providing a base line for the longer-term process of developing performance curves over many years. In essence, ***deepening the toolbox in real time****.*

Thin-Lift Asphalt Overlay
Introduction

Transportation System in Sioux Falls

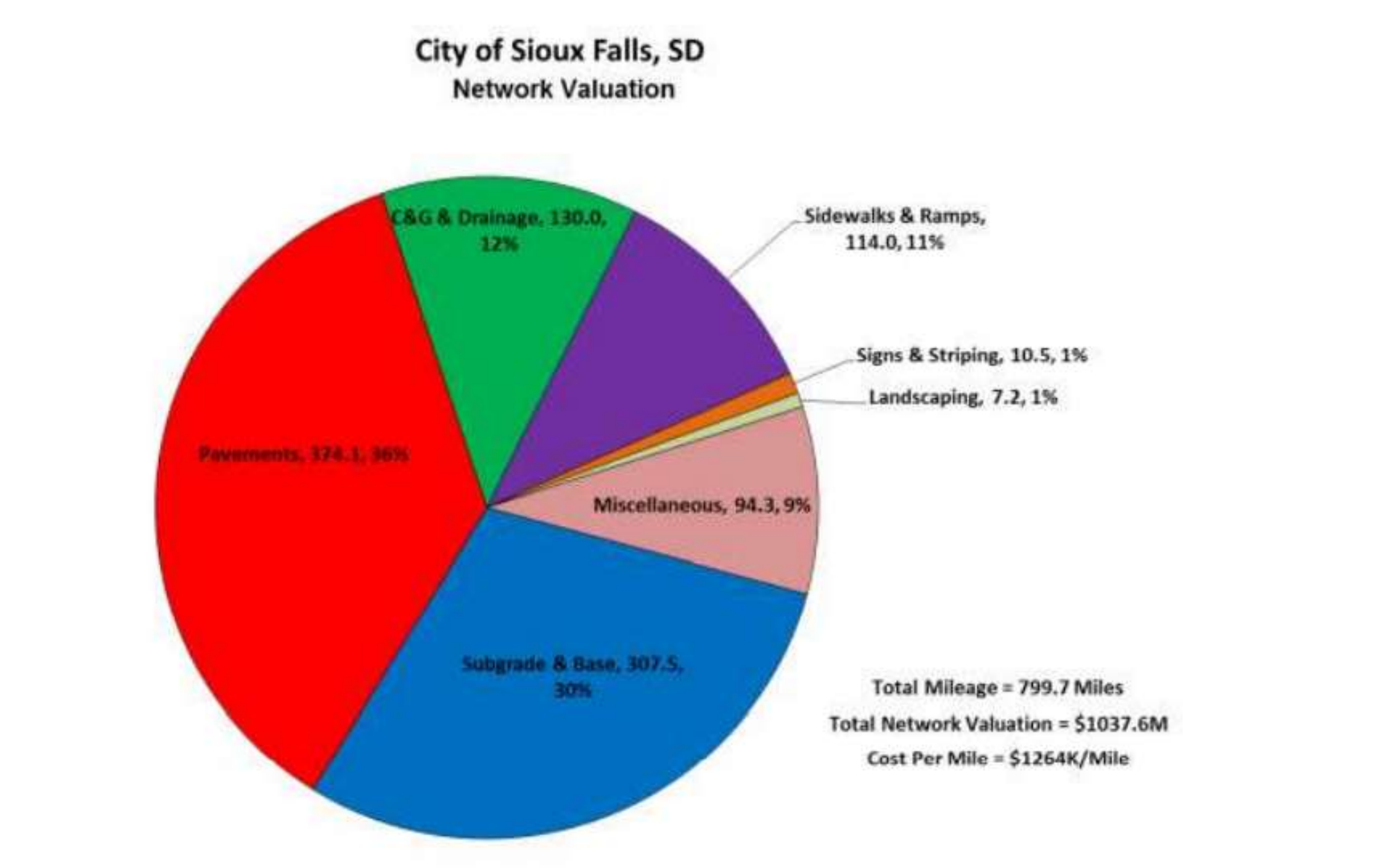
Existing Pavement Inventory

- The CSF maintains almost 900 miles of pavements
- Replacement value of the CSF transportation roadway network **> $1 Billion**
- Approx. 10 – 15 miles added annually (mostly NW, NE, and SW)
- 84% HMA and 14% PCC
- Most Strategic Corridors
  - Core areas of the City
  - Most of the major and minor urban arterials
  - Major collectors

Pavement Preservation Implementation Strategies and Options

City of Sioux Falls

The replacement value of the City of Sioux Falls transportation network represented by roadways exceeds **$1 Billion Dollars.** Maintenance and new construction required for 2020-2040 identified growth areas will encumber an increasing amount of funds dedicated to the transportation network.[1]



[1]IMS Infrastructure Management Services, May 2020, City of Sioux Falls Pavement Management Analysis Report

Thin-Lift Asphalt Overlay

Needs and Challenges

Transportation System in Sioux Falls

Needs

- Economical Feasibility
- Reliability
- Sustainability
- Constructability (reduced construction times and business and user impacts)

Challenges

- Shrinking Budgets
- Expanding Demand
- Capacity Limitations
- Evolving Environmental Standards
- Resource Constraints

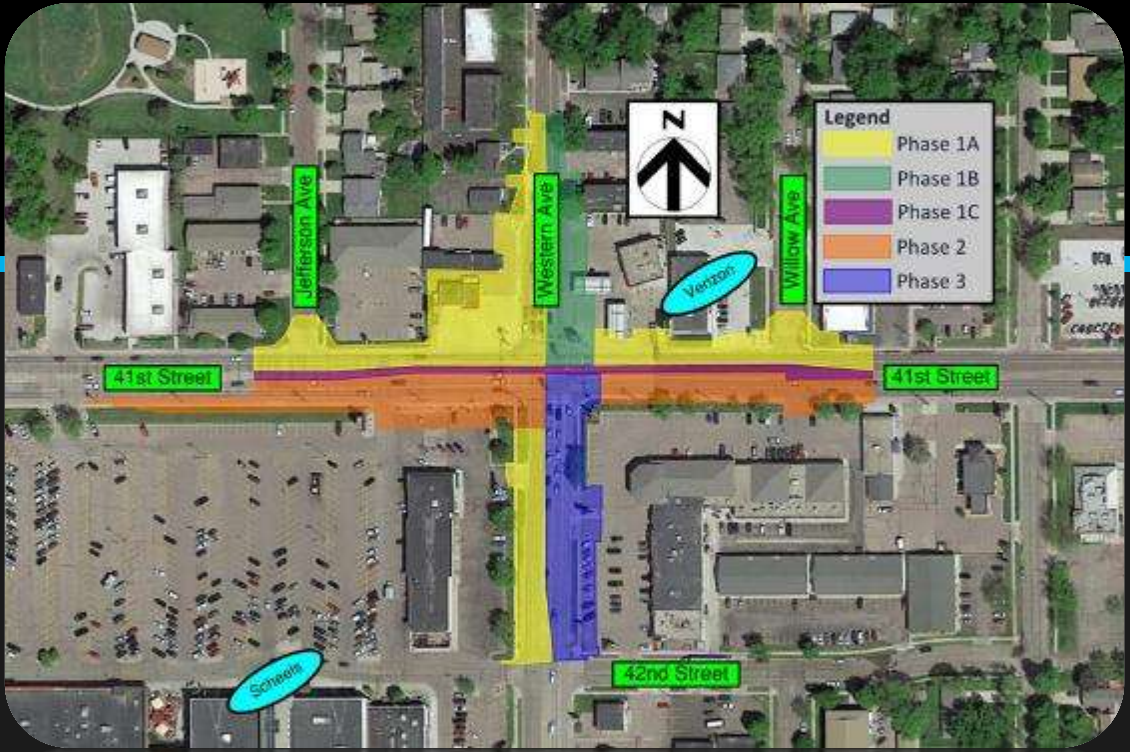
Solution

- Improved Pavement Preservation Techniques
- Optimization of Engineering Parameters

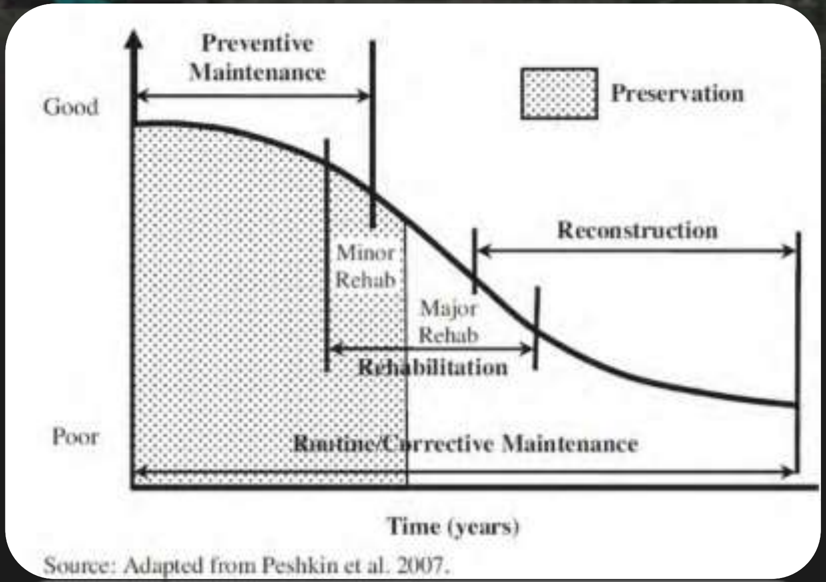
Developing a *toolbox* of
- **Pavement Designs**
- **Materials**
- **Engineered Solutions**

Thin-Lift Asphalt Overlay

Benefits



- Multifaceted ***toolbox*** approach to pavement maintenance, preservation, engineering standards, and holistic pavement selection criteria for new and reconstructed facilities.
- Core of an older infrastructure in the central areas
- Ever-expanding city and need for resilient infrastructure development on its periphery multiply the benefits of a ***toolbox*** approach to pavement maintenance, preservation, engineering standards, and holistic pavement selection criteria for new and reconstructed facilities.



Thin-Lift Asphalt Overlay

Introduction

- 50% of all infrastructure funds are invested in pavements

- More than half of that investment is in overlays

High Impact

Source: https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/docs/tops_factsheet_edc6.pdf

Thin-Lift Asphalt Overlay
Introduction

Enhancing overlay performance results in longer-lasting roadways and maximizing (and optimizing) State and local Highway Agency investment

Source: https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/docs/tops_factsheet_edc6.pdf

Thin-Lift Asphalt Overlay

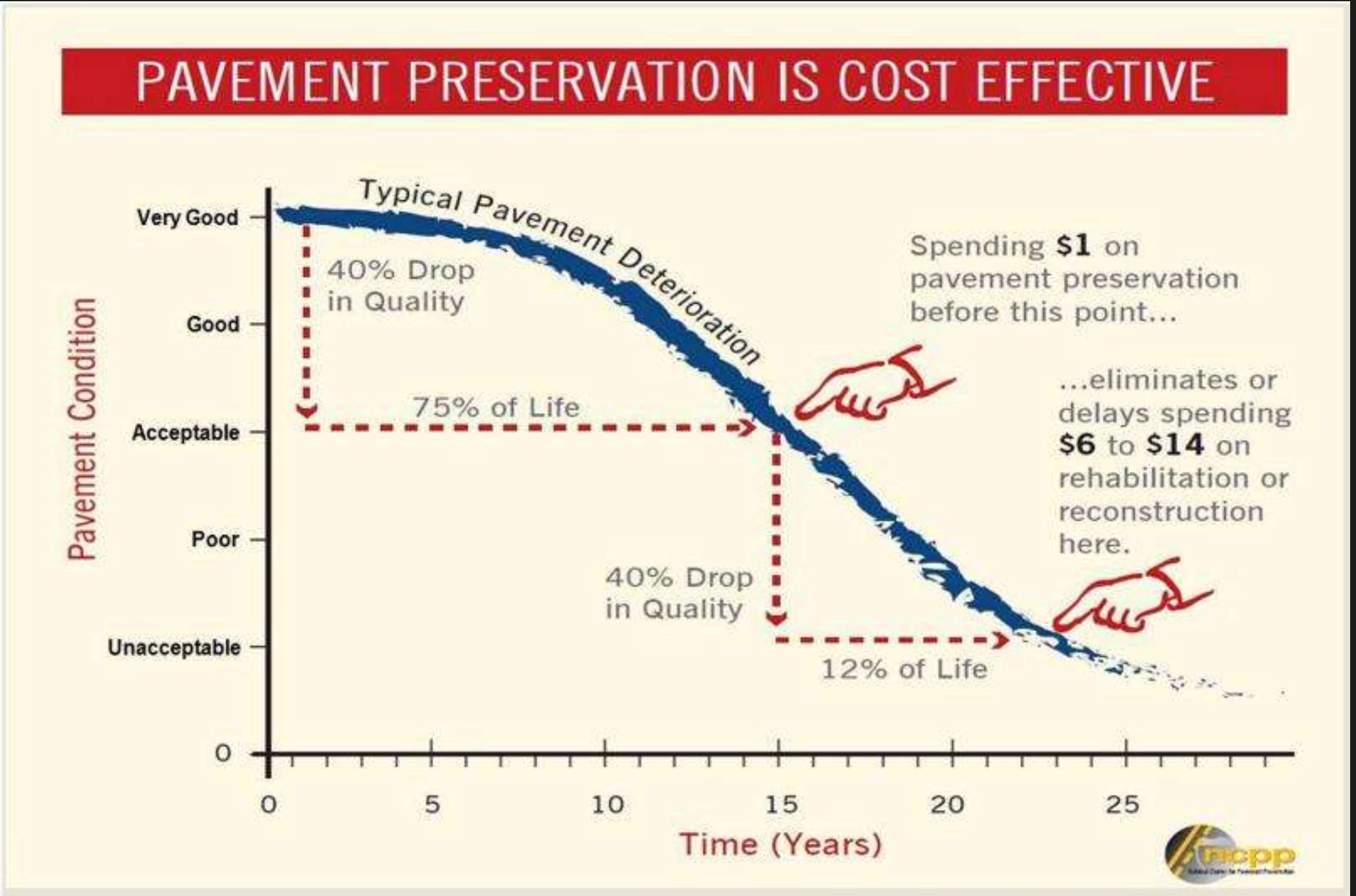
Needs and Challenges

"….the streets that are repaired while in good conditions will cost less overall than those left to deteriorate to a poor condition[1]".

"The key to a successful pavement management program is to develop a reasonably

- *Accurate performance model of the roadway*
- *Identify the optimal timing*
- *Identify rehabilitation strategy.*

Result: long-term cost savings and increase in pavement quality over time[1]".

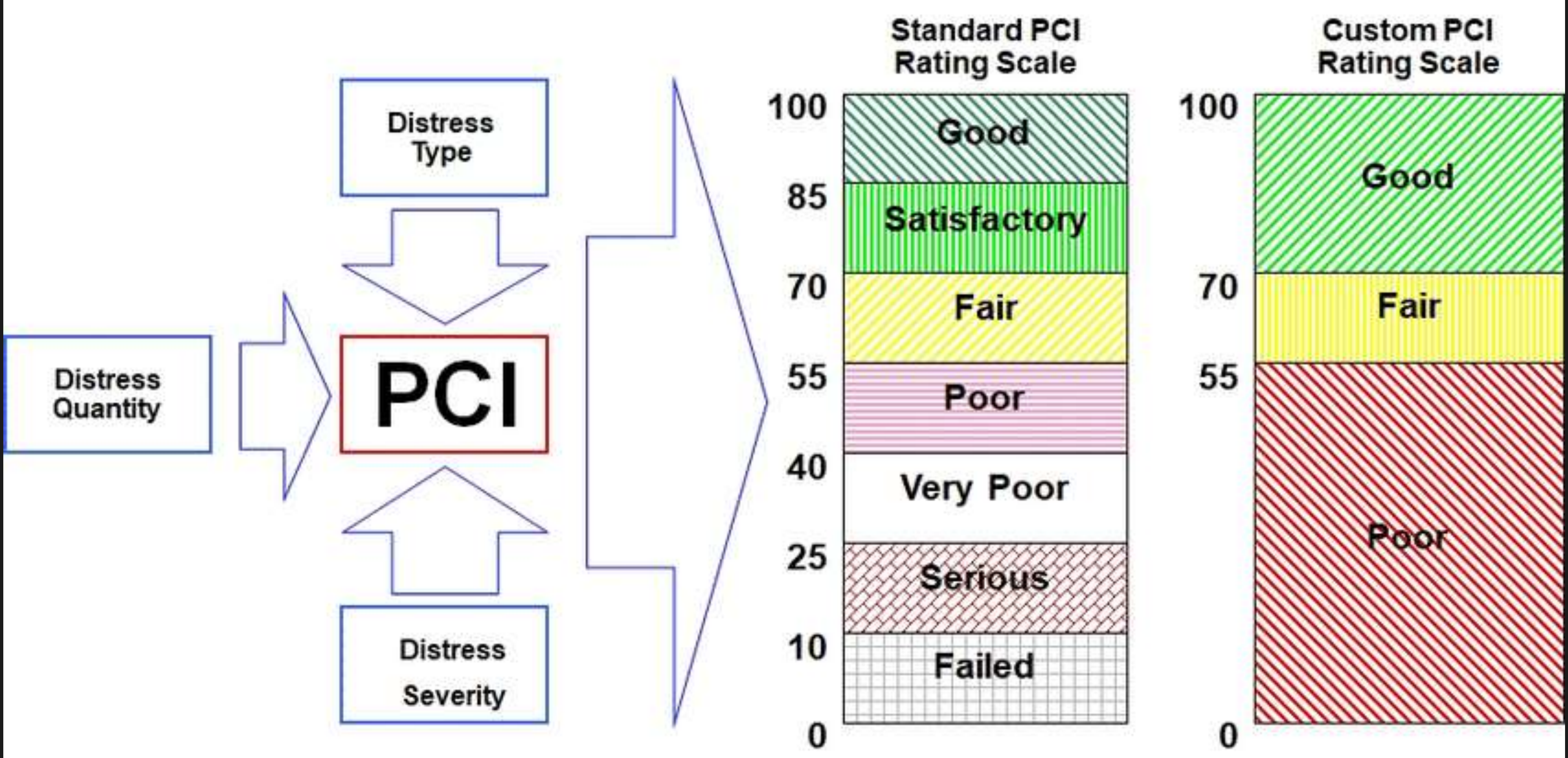


Source: National Center for Pavement Preservation.

1 IMS Infrastructure Management Services, May 2020, City of Sioux Falls Pavement Management Analysis Report

Thin-Lift Asphalt Overlay

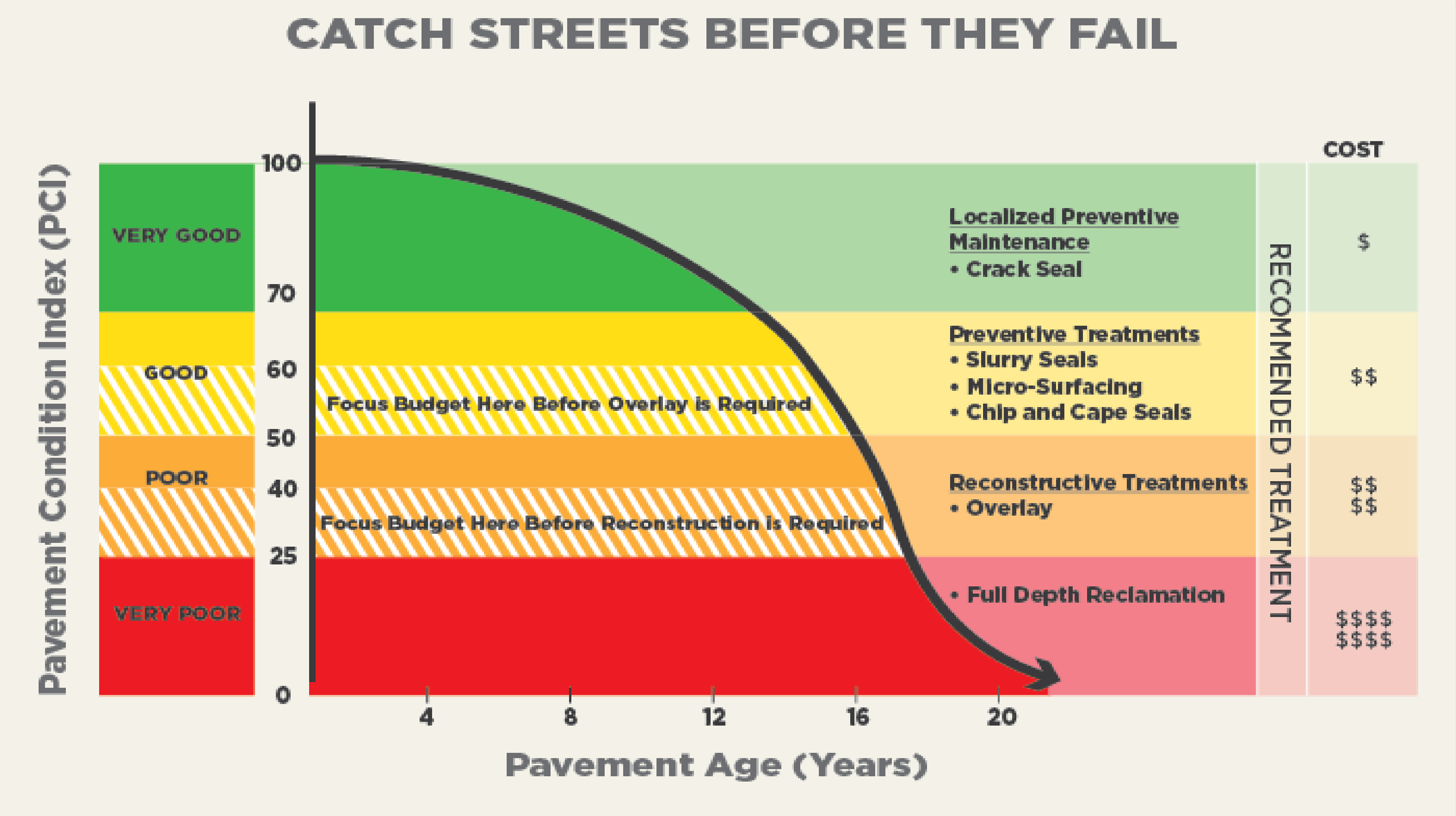
Pavement Condition



Wesołowski, M. and Iwanowski, P., 2020. APCI Evaluation Method for Cement Concrete Airport Pavements in the Scope of Air Operation Safety and Air Transport Participants Life. *International Journal of Environmental Research and Public Health*, *17*(5), p.1663.

Thin-Lift Asphalt Overlay

Pavement Condition



https://streetsaver.com/about/blog/streetsaver-blog/2017/10/02/case-study-city-of-elk-grove

Pavement Preservation Implementation Strategies and Options

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The "Paradigm Shift" in Pavement Preservation: Engineered TLO's Triggered Further Up the Performance Curve

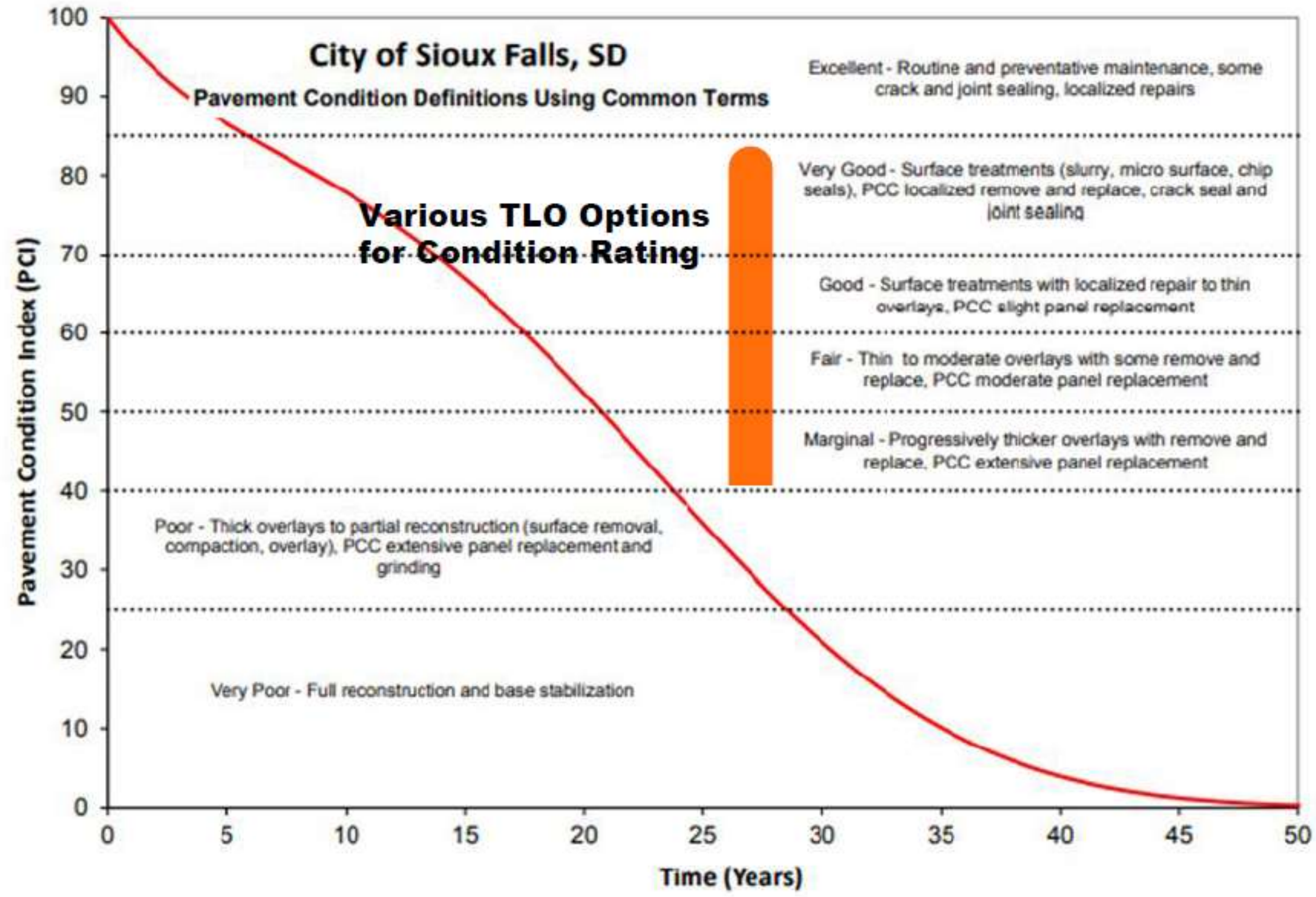


Figure 8 – Understanding the Pavement Condition Index (PCI) Score

Pavement Preservation Implementation Strategies and Options

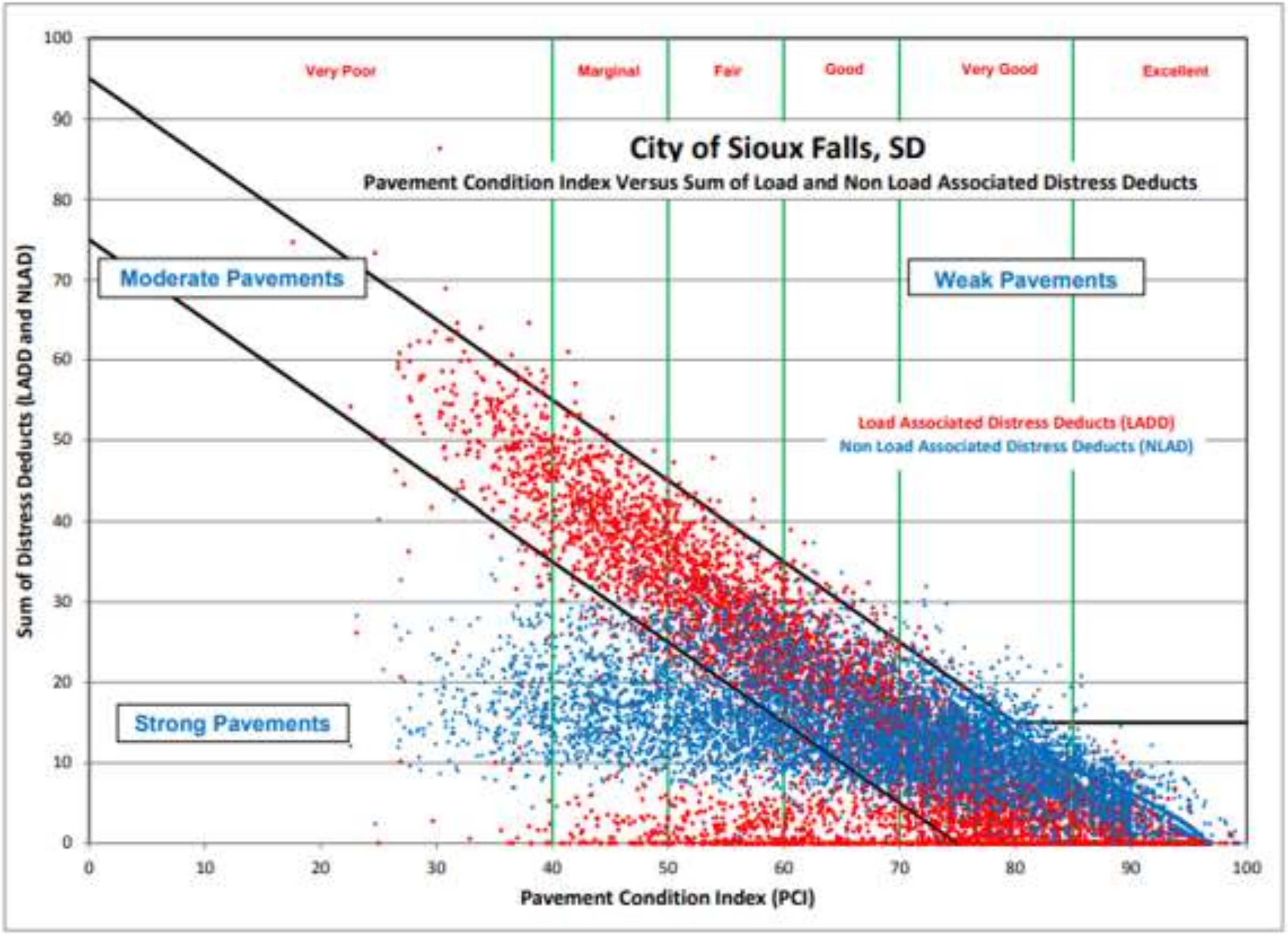


Figure 15 – Pavement Condition Index versus Sum of Distress Deducts

City of Sioux Falls

[1]IMS Infrastructure Management Services, May 2020, City of Sioux Falls Pavement Management Analysis Report

Pavement Preservation Implementation Strategies and Options

City of Sioux Falls

[1]IMS Infrastructure Management Services, May 2020, City of Sioux Falls Pavement Management Analysis Report

Good (PCI = 60 to 70) –Overlays

Asphalt streets rated as Good are ideal candidates for thinner surface-based rehabilitations and local repairs. Depending on the amount of localized failures, a thin edge mill and overlay, or possibly a surface treatment, would be a suitable rehabilitation strategy for streets rated as Good. Streets that fall in the high 60 - low 70 PCI range provide the greatest opportunity for extending pavement life at the lowest possible cost, thus applying the principles

Targeted Overlay Pavement Solutions (TOPS)

Every Day Counts
Innovation for a Nation on the Move

Solutions for integrating innovative overlay procedures into practices that can improve performance, lessen traffic impacts, and reduce the cost of pavement ownership.

Benefits

Safety

Improve surface and structural condition

Cost Savings

Less subsurface work is required. In urban areas, impacts to utilities and pedestrian facilities are minimized.

Performance

Targeted overlay solutions to high-maintenance areas such as intersections, bus lanes, ramps, and curved alignments can pay immediate dividends in terms of reduced maintenance needs, fewer work zones, and improved safety.

Targeted Overlay Pavement Solutions (TOPS)

Every Day Counts
Innovation for a Nation on the Move

Solutions for integrating innovative overlay procedures into practices that can improve performance, lessen traffic impacts, and reduce the cost of pavement ownership.

Approximately half of all infrastructure dollars are invested in pavements, and more than half of that investment is in overlays. By enhancing overlay performance, State and local highway agencies can maximize this investment and help ensure safer, longer-lasting roadways for the traveling public.

IMPROVED PAVEMENTS THAT LAST LONGER

Many of the pavements in the Nation's highway system have reached or are approaching the end of their design life. These roadways still carry daily traffic that often far exceeds their initial design criteria. Overlays are now available for both asphalt and concrete pavements that enable agencies to provide long-life performance under a wide range of traffic, environmental, and existing pavement conditions.

Concrete overlays now benefit from performance-engineered mixtures, including thinner-bonded and unbonded overlays with fiber reinforcement, interlayer materials, and new design procedures that improve durability and performance. Curing of a fiber-reinforced concrete overlay should follow the same practices as implemented for conventional concrete pavement. Asphalt overlay mixtures have also advanced significantly with the use of stone-matrix asphalt (SMA), polymer-modified asphalt (PMA), and other materials, designs, and agents that can increase rutting and/or cracking resistance, increase structural capacity, preserve the underlying structure, improve friction, and extend pavement life.

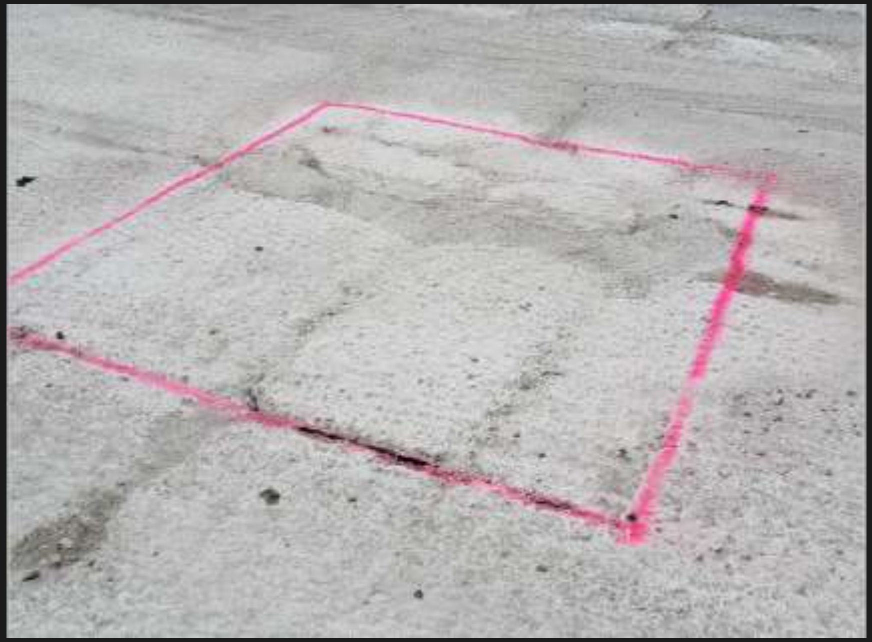
BENEFITS

- Safety. Thousands of miles of rural and urban pavements need structural enhancement and improved surface characteristics, such as smoothness, friction, and noise. Targeted overlay pavement solutions can improve the condition of highways significantly in a relatively short time.
- Cost Savings. Timely and well-designed overlay applications are consistently cost-effective because less subsurface work is required. In urban areas,

Thin-Lift Asphalt Overlay

Pavement Condition

After “Tap” Mill
Before Prep
Before TLO



41st Street – Sioux Falls, SD (2019)

Thin-Lift Asphalt Overlay

Pavement Condition

41st Street – Sioux Falls, SD (2019)

Pavement Preservation Implementation Strategies and Options

City of Sioux Falls

Figure 2 - Minn. Ave SBL near 22nd ST

Figure 4- 10th St. WBL downtown near 2nd ST

Performance of Thin Lift Asphalt Overlays

A Laboratory and Field Study of Engineered NMAS Superpave Mixtures of the City of Sioux Falls

CITY OF SIOUX FALLS

SOUTH DAKOTA STATE UNIVERSITY

Rouzbeh Ghabchi, Ph.D., P.E., Assistant Professor
Department of Civil and Environmental Engineering, Brookings, SD

Thin-Lift Asphalt Overlay

Existing Condition

Most of the City's high volume pavement inventory is PCCP

Common Distresses

- Potholes
- Faulting (vertical settlement)
- Extensive Maintenance Repairs Covering Many Repair Materials
- Differential Settlement
- Thermal Warping of Slabs
- Joint Damage
- Utility Cut-Outs
- Cases of chemical-induced Distresses such as D-cracking and alkali or dolomitic-silica reactivity (ASR/DSR)

Thin-Lift Asphalt Overlay

Available Options

Options

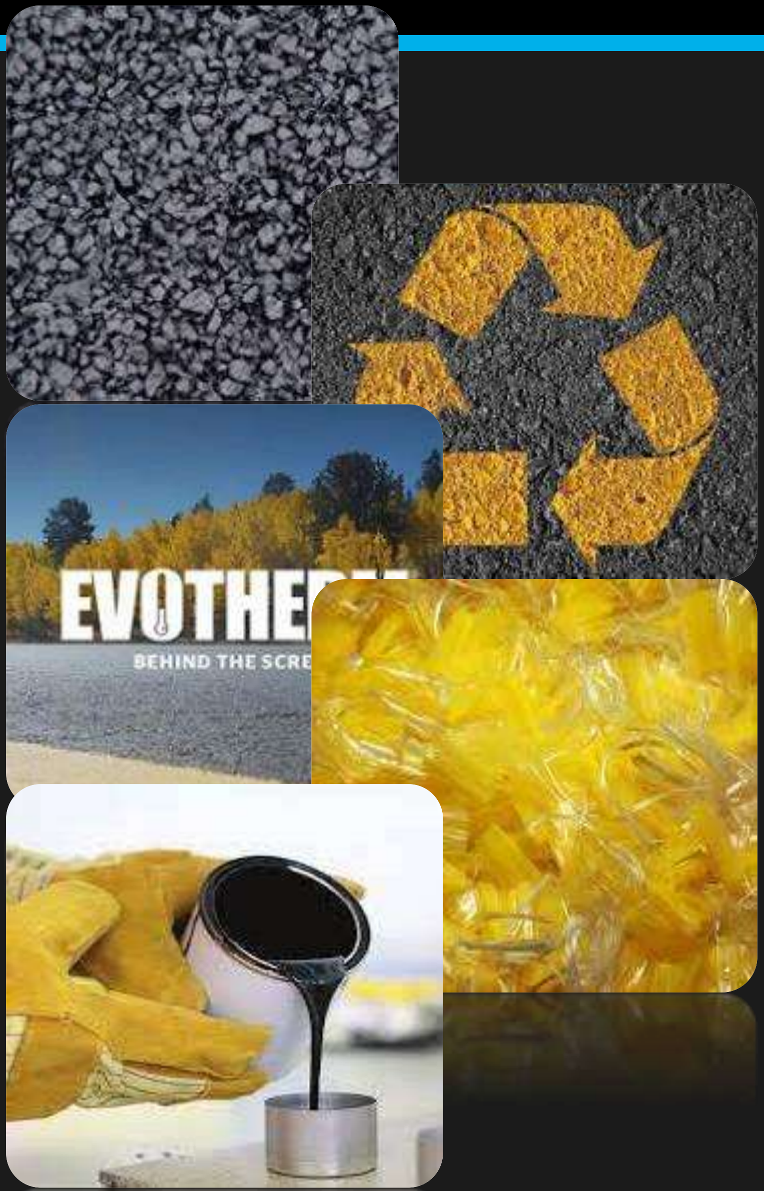
- Remove and Replace
  - Costly
  - Time-consuming
  - Impacts on adjacent and area businesses, residents, and roadway users

- Major to Minor Substrate (existing pavement) Repairs Followed by Thin Lift Overlays (TLO) of asphalt
  - Completed Relatively Quickly (days to weeks)
  - Low Cost
  - Less Impact on Businesses
  - Generally, Include Ancillary, such as ADA, and Accessibility Improvements (curb ramps and boulevard upgrades)

Thin-Lift Asphalt Overlay

Important Parameters

- Dense-graded Superpave mixtures with an NMAS < NMAS of SDDOT Mixes for TLO applications
- Impacts of the utilization of **RAP** for TLO applications
- Asphalt additives such as compaction aids (e.g., Evotherm®) and WMA
- Asphalt mixture additives FRAC (e.g., aramid fiber)
- Utilization of engineered PG asphalt binder including polymer-modified asphalt (PMA) and high polymer modified asphalt (HiMA)



Thin-Lift Asphalt Overlay

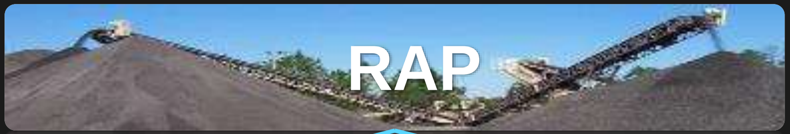
Important Parameters for Preservation Options

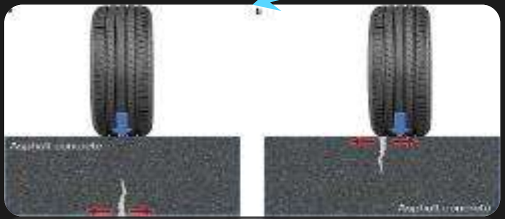
Dense-Graded TLO Mix

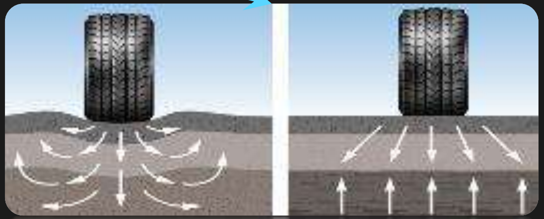
- TLO Thickness < 1.5”
- Min SDDOT NMAS = 1/2”
- Lift Thickness 3 - 4 x NMAS

TLO Mixes with Modified NMAS (3/8”)

Effect of FRAC on Performance of TLO







Effect of RAP on Performance of TLO

Effect of PMA and HiMA on Performance of TLO

Thin-Lift Asphalt Overlay

Proposed TLO Projects

Asphalt Mix No.	Project Site	NMAS (mm)	Virgin Binder Type	RAP (%)	FRAC (Yes/No)	Mix Collection Status
1	41st Street	9.5	PG 64-34	-	-	Collected (2019)
2	41st Street	9.5	PG 58-28	20%	Yes	Collected (2020)
3	41st Street	9.5	PG 58-34	20%	-	Collected (2020)
4	Cliff Avenue	9.5	PG 58-34	20%	-	2022
5	Cliff Avenue	9.5	PG 70-34	20%	-	2022


41st St. Between Kiwanis and Western (2019)


41st St. Between Kiwanis and Western (2019)


41st St. Between Kiwanis and Western (2019)

Thin-Lift Asphalt Overlay

Performance Assessment Options (Lab Tests)

Option 1

Option 1 – Limited Laboratory Tests

Mix 2 | Mix 1 | Mix 3 | Mix 4 | Mix 5

Collected TLO Mixes

Rutting

Moisture Damage

Cracking (Int. Temp.)

Material | Distress | Test

Thin-Lift Asphalt Overlay

Performance Assessment Options (Lab Tests)

Option 1

Option 1 – Limited Laboratory Tests

Material

- PG 64-34
- PG 58-28, 20% RAP, Fiber
- PG 58-34, 20% RAP
- PG 70-34, 20% RAP

→ Asphalt Binders

Distress

- Rutting
- Low-Temp. Cracking

Test

→ PG Grade

Thin-Lift Asphalt Overlay

Performance Assessment Options (Lab Tests)

Option 1

Table 2. Proposed Test Matrix for Option 1

Asphalt Mix Testing Program (Option 1)							
Asphalt Mix No.	NMAS (mm)	Virgin Binder	RAP (%)	Fiber	Proposed Mix Tests*		
					HWT AASHTO T 324	SCB ASTM D 8044	TSR AASHTO T 283
1	9.5	PG 64-34	-	-	✓	✓	✓
2	9.5	PG 58-28	20%	Yes	✓	✓	✓
3	9.5	PG 58-34	20%	-	✓	✓	✓
4	9.5	PG 58-34	20%	-	✓	✓	✓
5	9.5	PG 70-34	20%	-	✓	✓	✓

Asphalt Binder Testing Program (Option 1)						
Asphalt Binder Blend No.	Virgin Binder	RAP (%)	Fiber	Proposed Binder Tests		
				DSR AASHTO T 315	BBR AASHTO T 313	PG Grade AASHTO M 320
1	PG 64-34	-	-	✓	✓	✓
2	PG 58-28	20%	Yes	✓	✓	✓
3	PG 58-34	20%	-	✓	✓	✓
4	PG 70-34	20%	-	✓	✓	✓

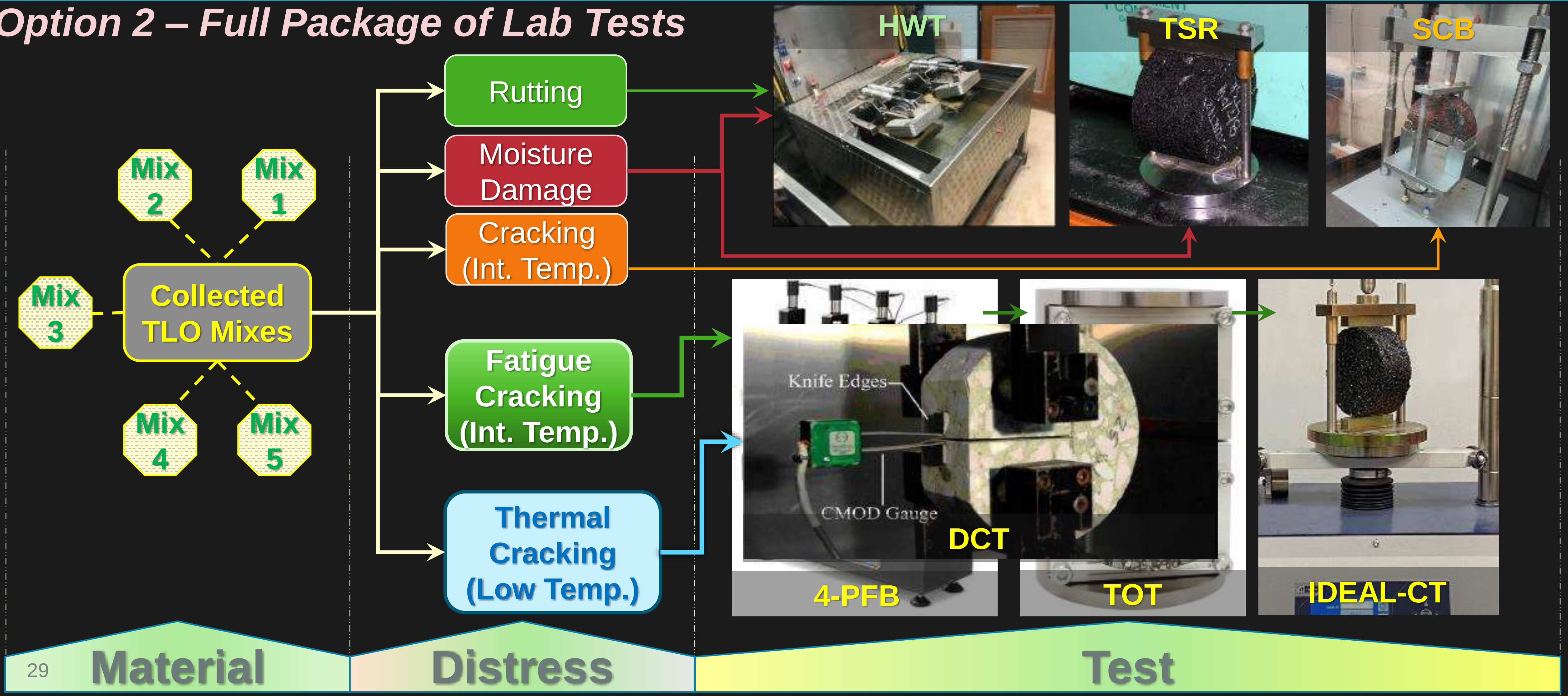
**Note: Tests on asphalt mixes will be conducted on samples compacted to have 7.0%±0.5% air voids.*

Thin-Lift Asphalt Overlay

Performance Assessment Options (Lab Tests)

Option 2

Option 2 – Full Package of Lab Tests



Thin-Lift Asphalt Overlay

Performance Assessment Options (Lab Tests)

Option 2

Option 2 – Full Package of Lab Tests

Material

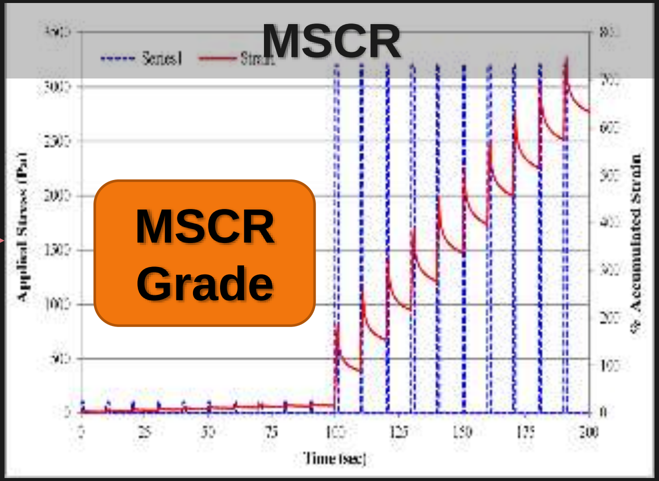
- **Asphalt Binders**
  - PG 64-34
  - PG 58-28 20% RAP Fiber
  - PG 58-34 20% RAP
  - PG 70-34 20% RAP

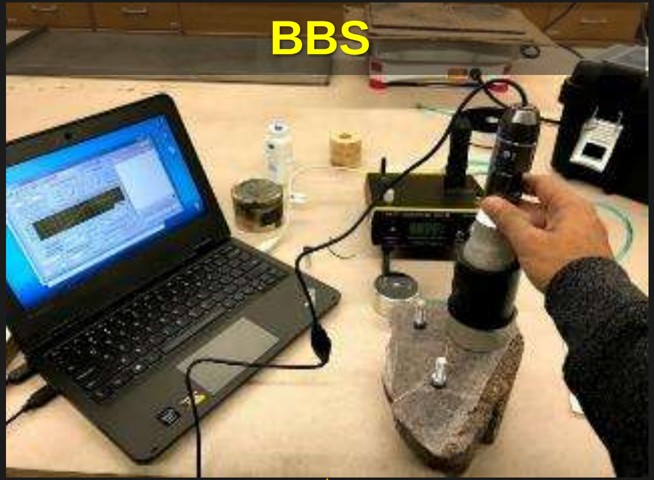
Distress

- Rutting
- Low-Temp. Cracking
- Traffic Temperature Dependent Rutting
- Moisture Damage and Adhesion Issues

Test

PG Grade





Thin-Lift Asphalt Overlay

Performance Assessment Options (Lab Tests)

Option 2

Table 3. Proposed Test Matrix for Option 2

Asphalt Mix Testing Program (Option 2)

Asphalt Mix No.	NMAS (mm)	Virgin Binder	RAP (%)	Fiber	Proposed Mix Tests*						
					HWT AASHTO T 324	SCB ASTM D8044	TSR AASHTO T 283	4-PFB AASHTO T 321	DCT ASTM D7313	TOT TEX-248-F	IDEAL-CT ASTM D8225
1	9.5	PG 64-34	-	-	✓	✓	✓	✓	✓	✓	✓
2	9.5	PG 58-28	20%	Yes	✓	✓	✓	✓	✓	✓	✓
3	9.5	PG 58-34	20%	-	✓	✓	✓	✓	✓	✓	✓
4	9.5	PG 58-34	20%	-	✓	✓	✓	✓	✓	✓	✓
5	9.5	PG 70-34	20%	-	✓	✓	✓	✓	✓	✓	✓

Asphalt Binder Testing Program (Option 2)

Binder Blend No.	Virgin Binder	RAP (%)	Fiber	Proposed Binder Tests						
				DSR AASHTO T 315	BBR AASHTO T 313	PG Grade AASHTO M 320	MSCR AASHTO T 350	BBS AASHTO T 361 (Wet/Dry)		
								Quartzite	Granite	
1	PG 64-34	-	-	✓	✓	✓	✓	✓	✓	
2	PG 58-28	20%	Yes	✓	✓	✓	✓	✓	✓	
3	PG 58-34	20%	-	✓	✓	✓	✓	✓	✓	
4	PG 70-34	20%	-	✓	✓	✓	✓	✓	✓	

**Note: Tests on asphalt mixes will be conducted on samples compacted to have 7.0%±0.5% air voids.*



Asphalt Laboratory

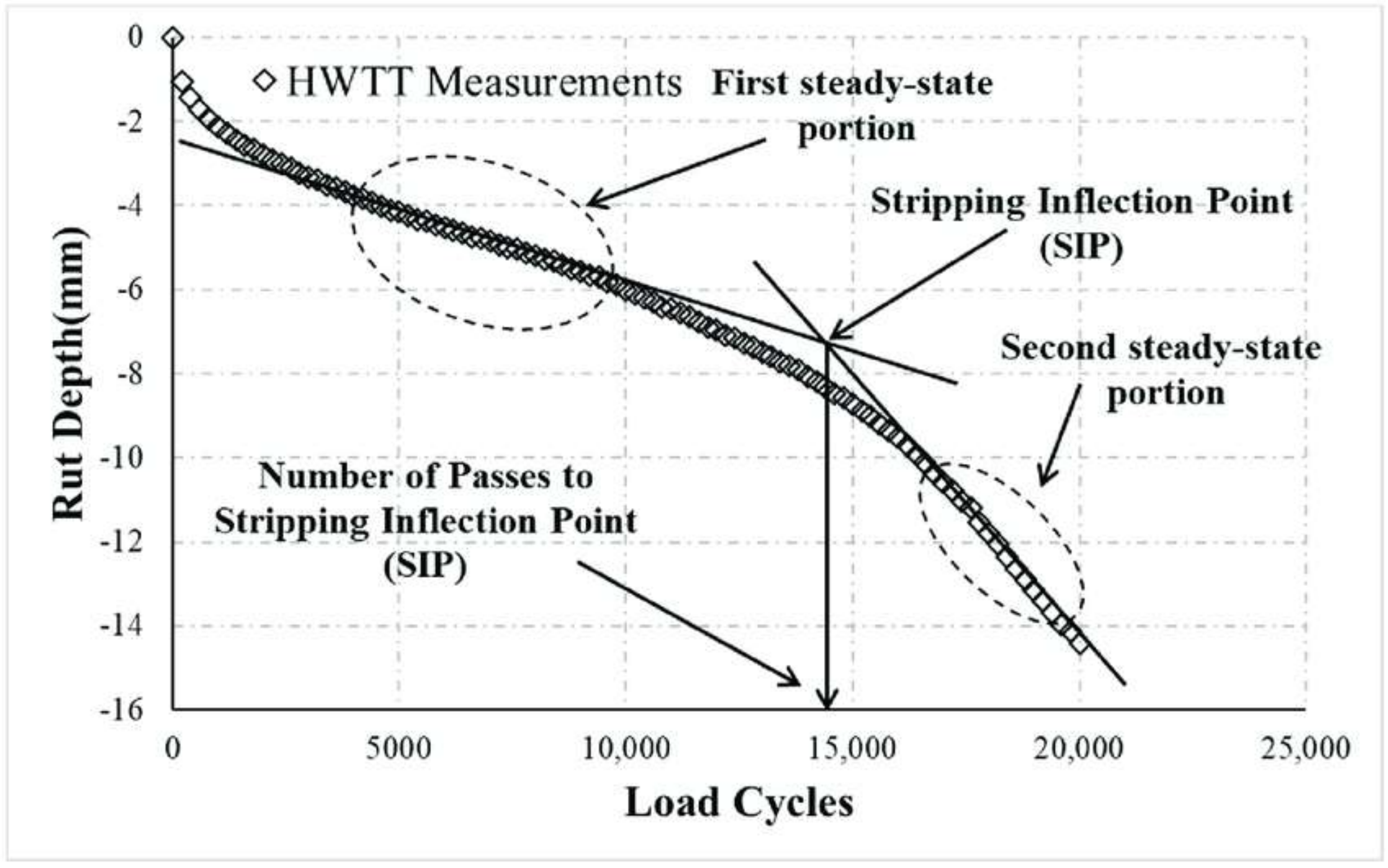
Summary of Existing Research Infrastructure and
Update on Recent Developments

South Dakota State University

Hamburg Wheel Tracking Test (HWT)

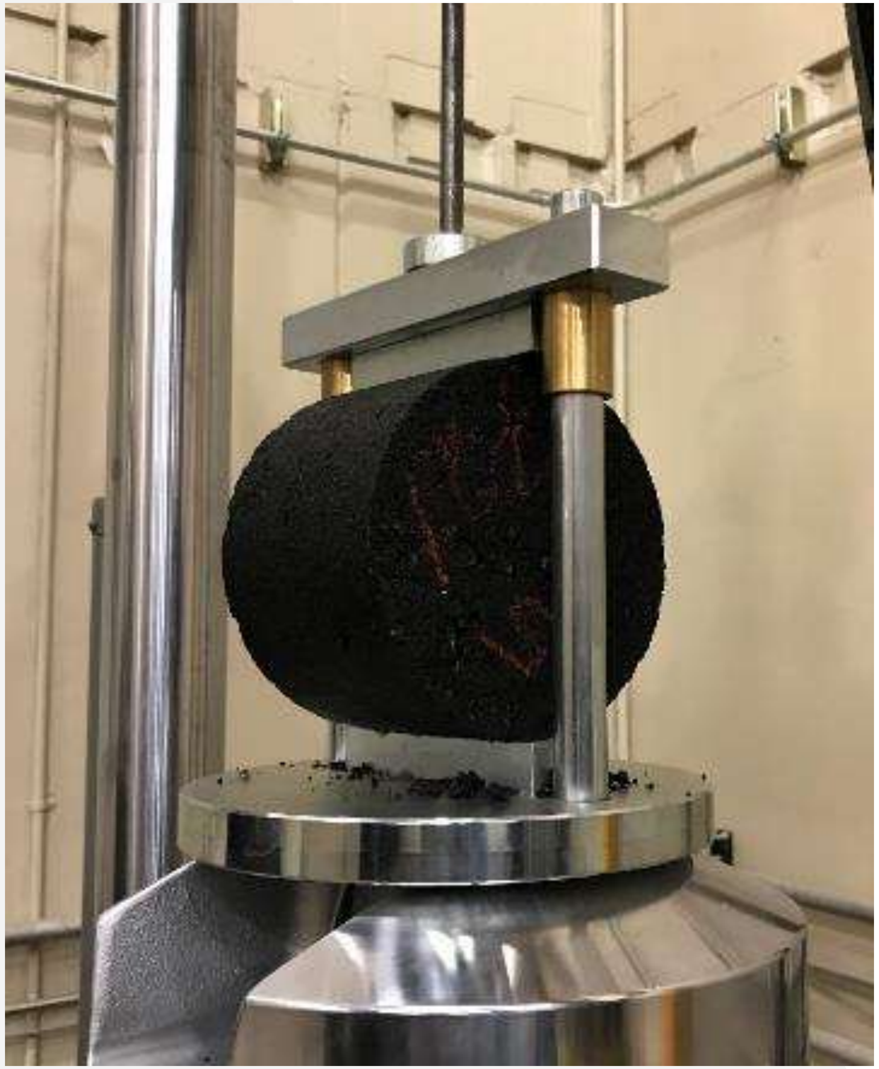
New!

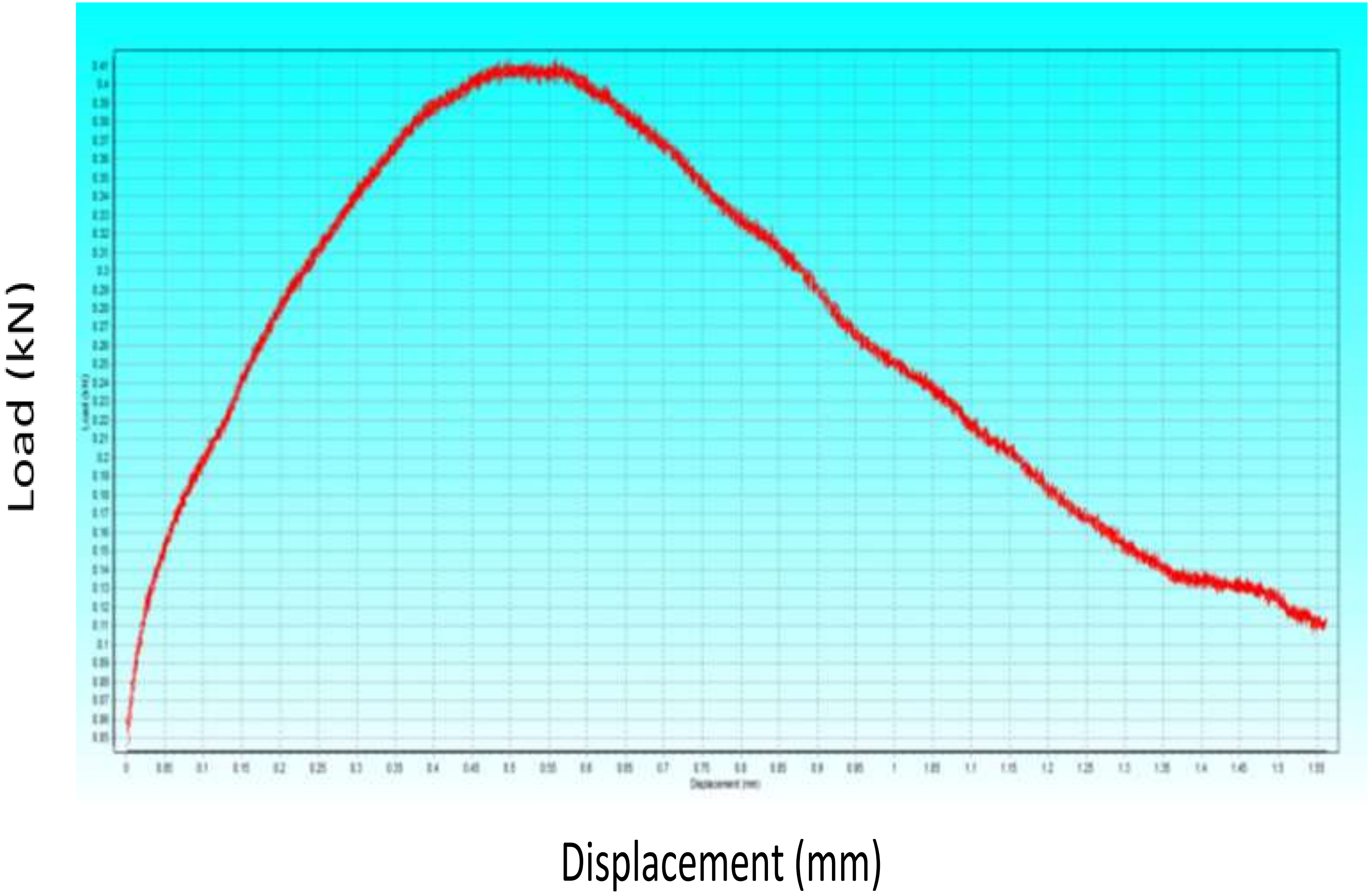
- Hamburg Wheel Tracking Device



TESTS

Tensile Strength Ratio (TSR)





IPC Asphalt Mix Performance Tester

New!

- Dynamic modulus
- Flow Number
- Flow time
- Uniaxial Fatigue/SVECD
- Overlay test
- Semi-Circular Bend
- Indirect Tensile Dynamic Modulus
- Four Point Bending Beam Fatigue

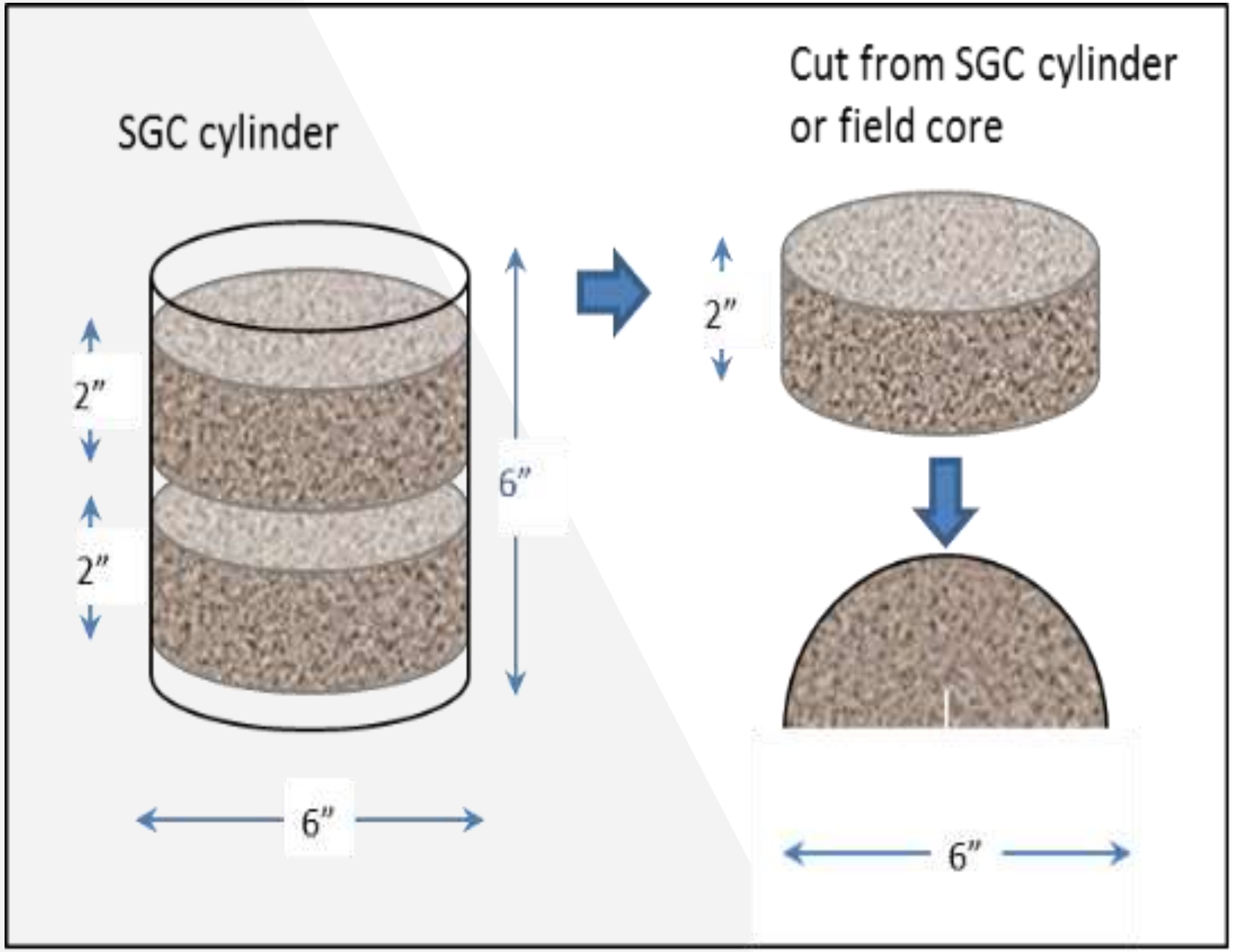
Semi-Circular Bend (SCB)

New!

Semi-Circular Bending (SCB) Test

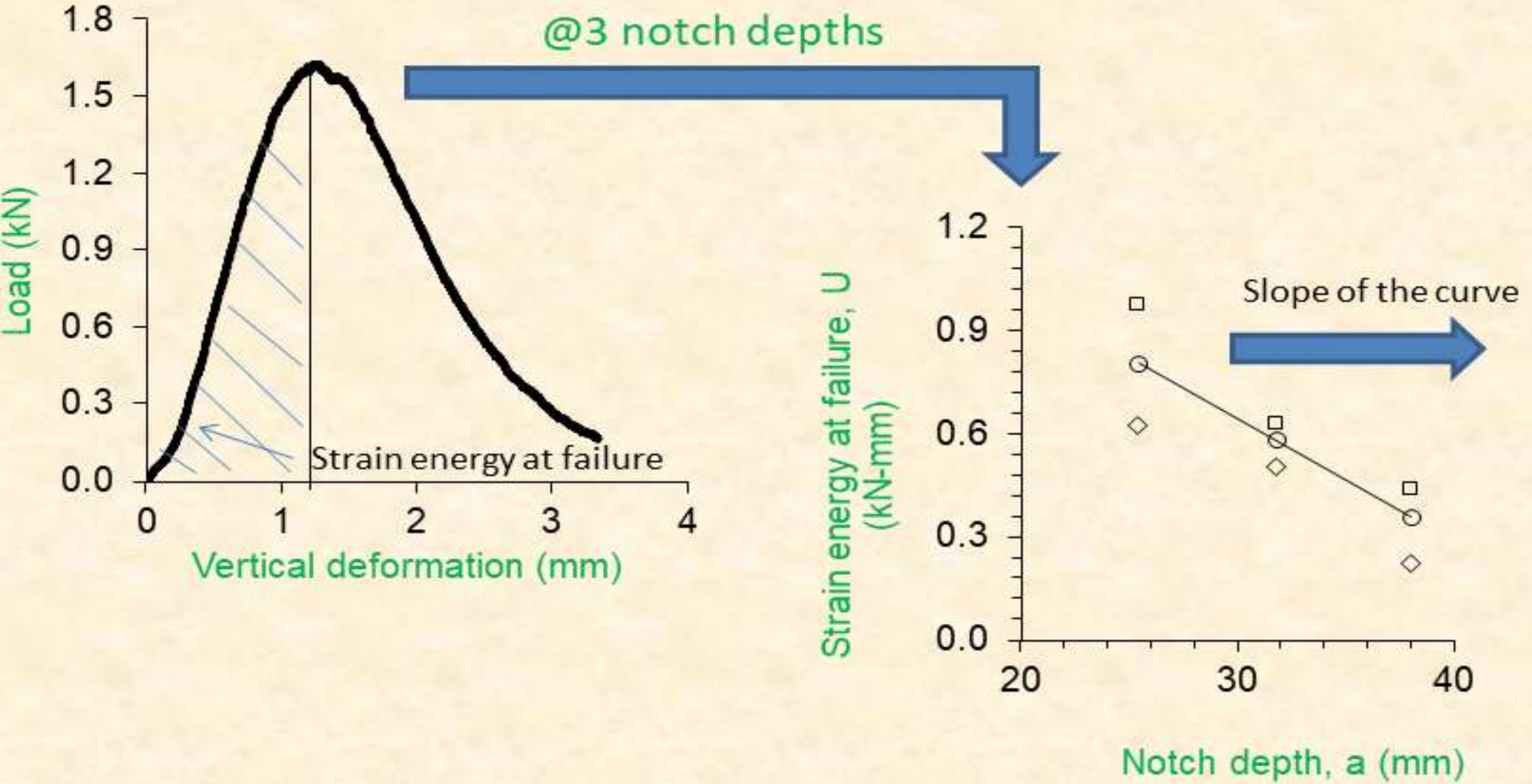
- Superpave® gyratory compacted samples
- Diameter:150 mm and height: 50 mm
- Test temperature: 20 °C
- Three notch depths of 25.4 mm, 31.8 mm, and 38 mm
- Rate of loading : 0.5 mm/min

Semi-Circular Bending (SCB) Test



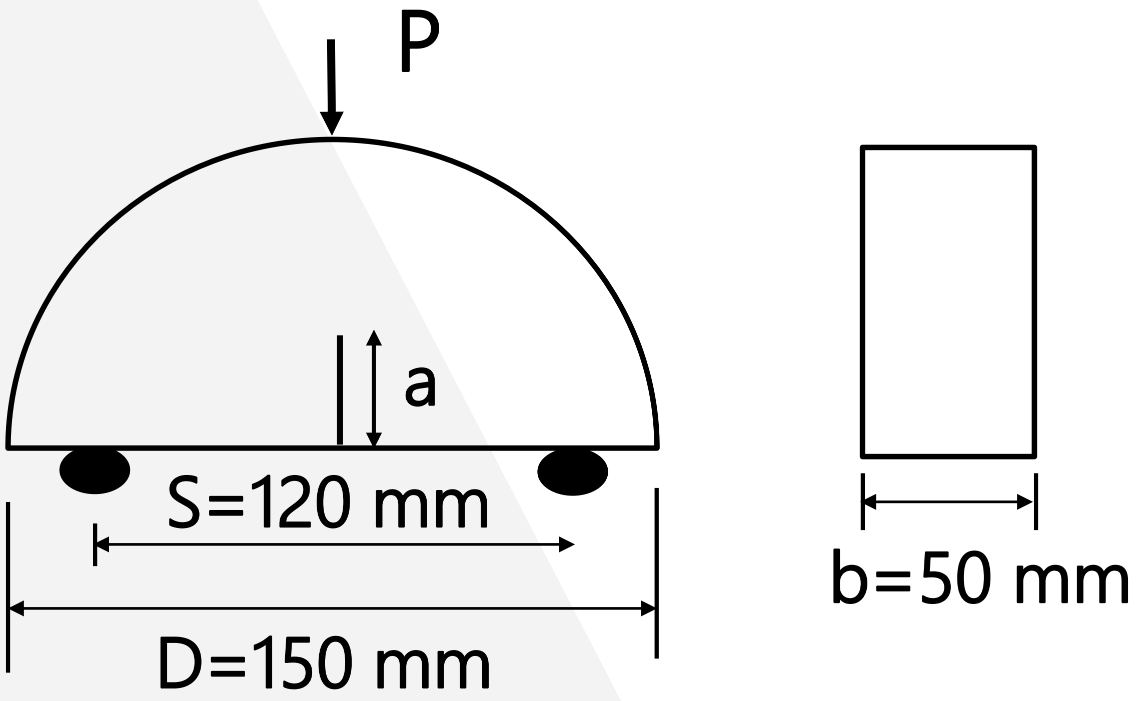
Semi-Circular Bending (SCB) test

Mechanistic approach for analysis of test results



$$\frac{dU}{da}$$

Semi-Circular Bending (SCB) test



$$J_c = -\left(\frac{1}{b}\right)\frac{dU}{da}$$

where:

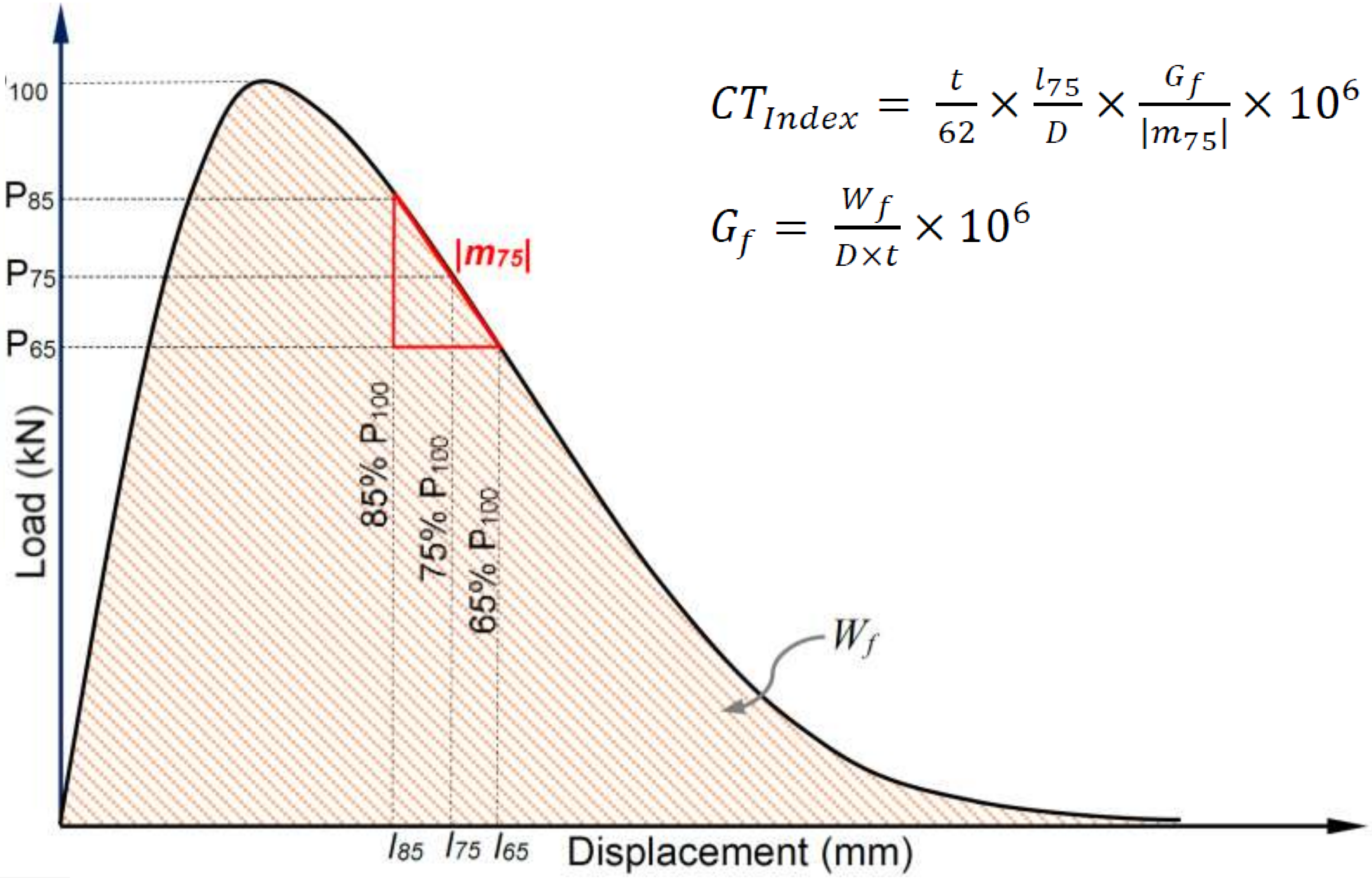
b **= SCB specimen thickness;**

a **= notch depth; and**

U **= strain energy**

(area under stress-strain curve)

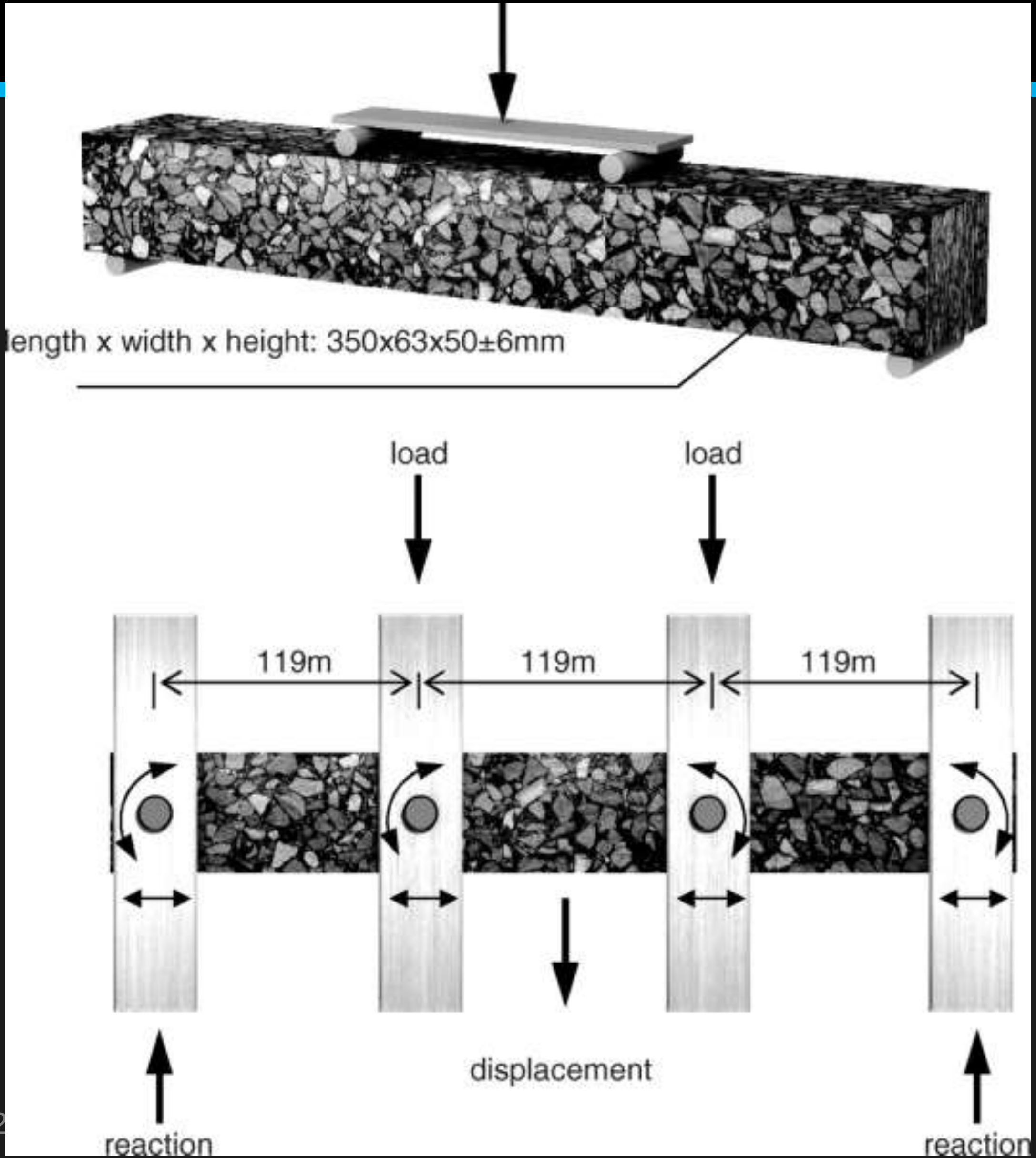
Indirect Tensile Asphalt Cracking Test (IDEAL-CT)



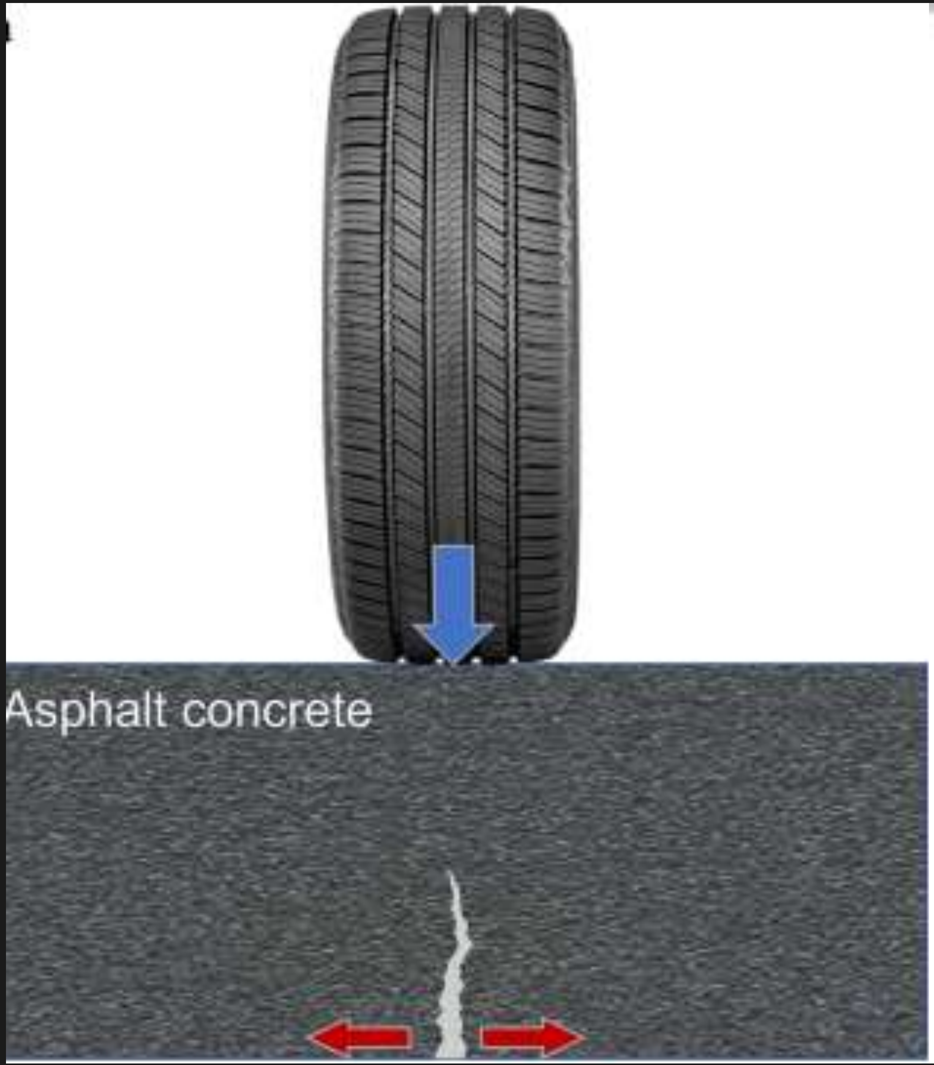
$$CT_{Index} = \frac{t}{62} \times \frac{l_{75}}{D} \times \frac{G_f}{|m_{75}|} \times 10^6$$

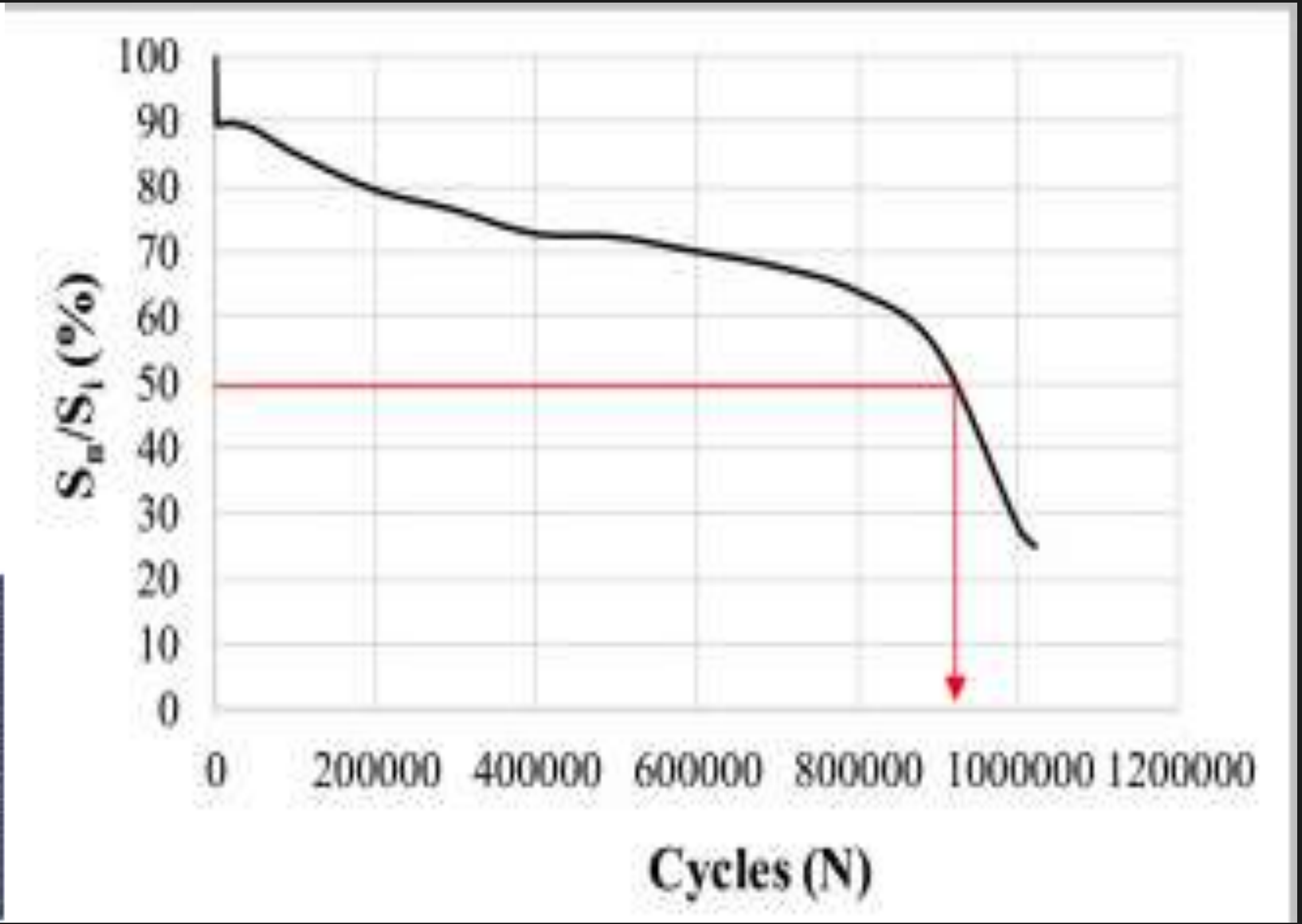
$$G_f = \frac{W_f}{D \times t} \times 10^6$$

Four-Point Beam Fatigue Test

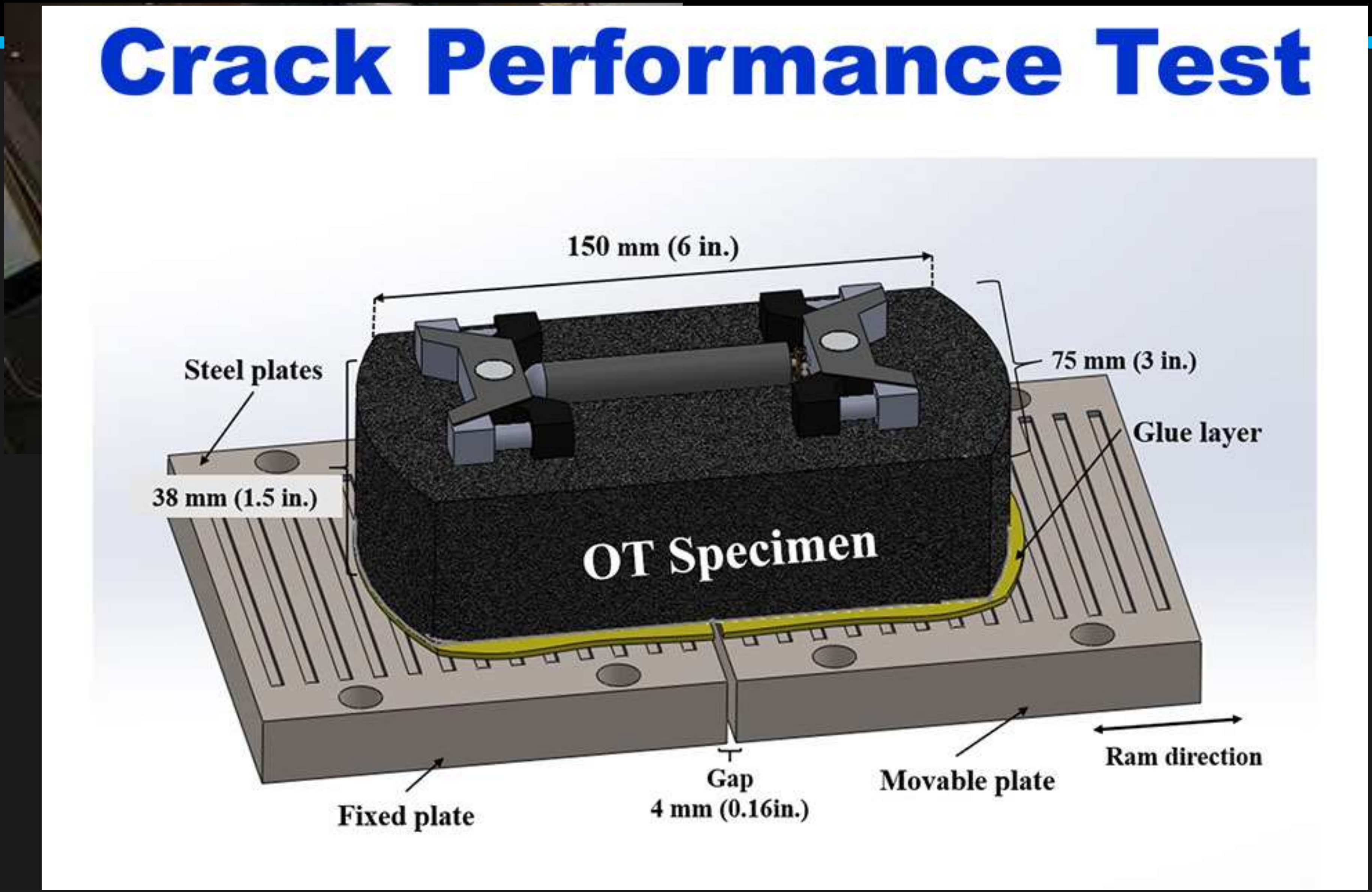


Four-Point Beam Fatigue Test

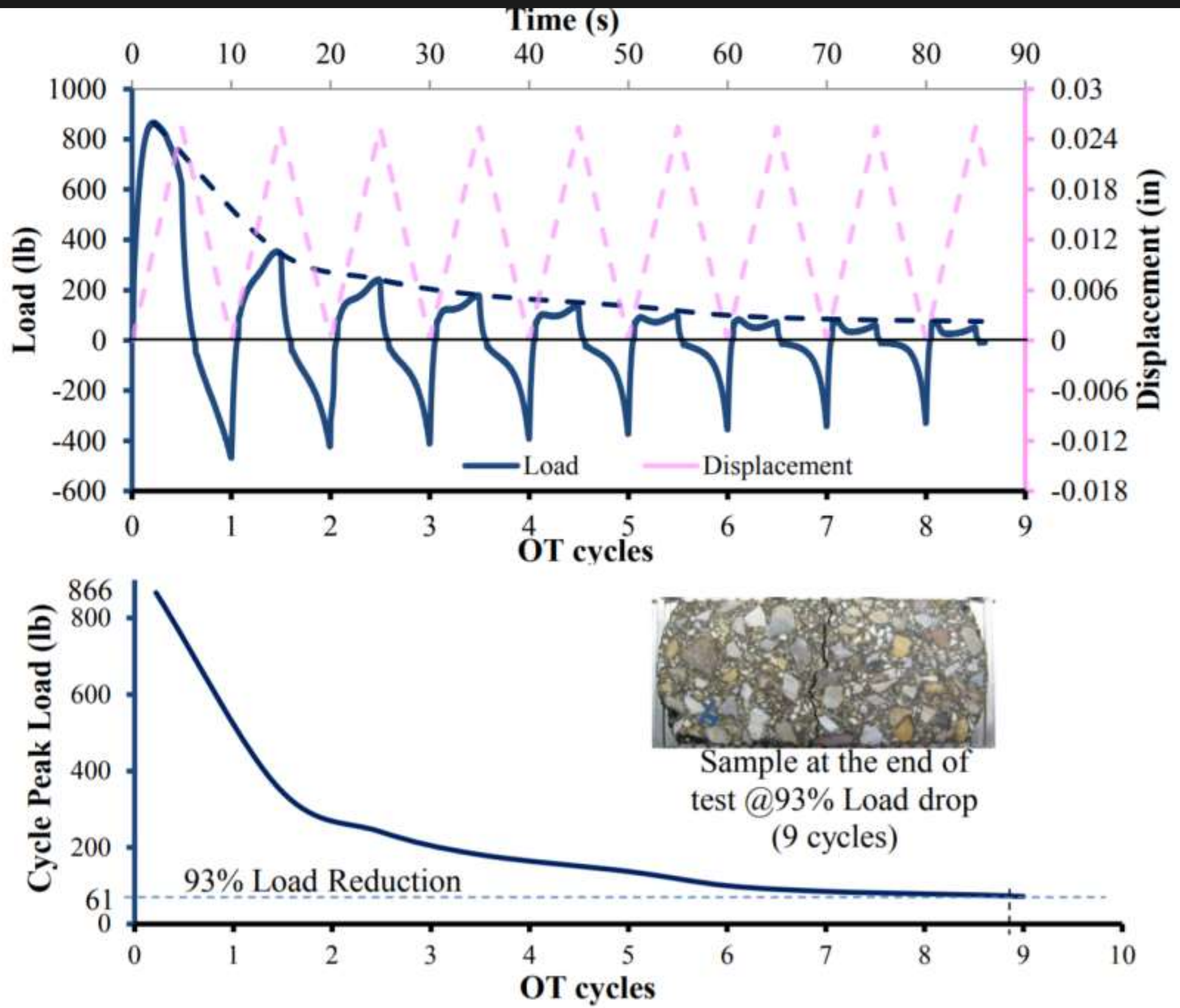




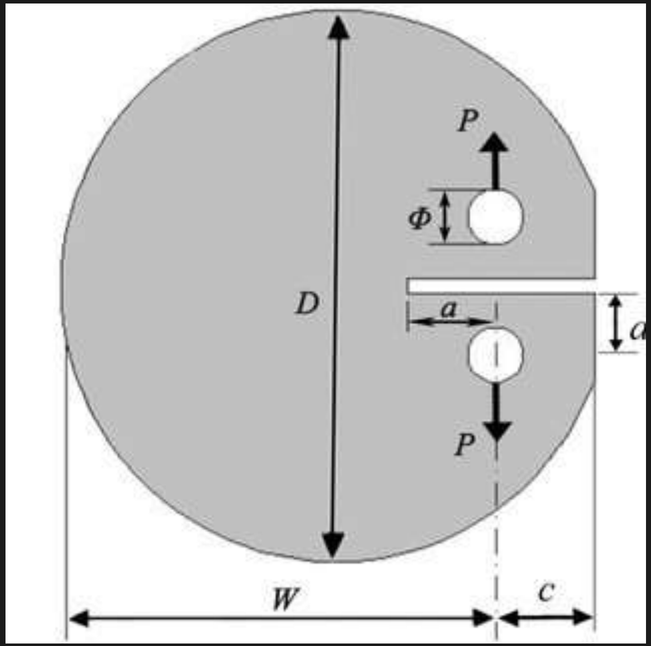
Texas Overlay Test (TOT)



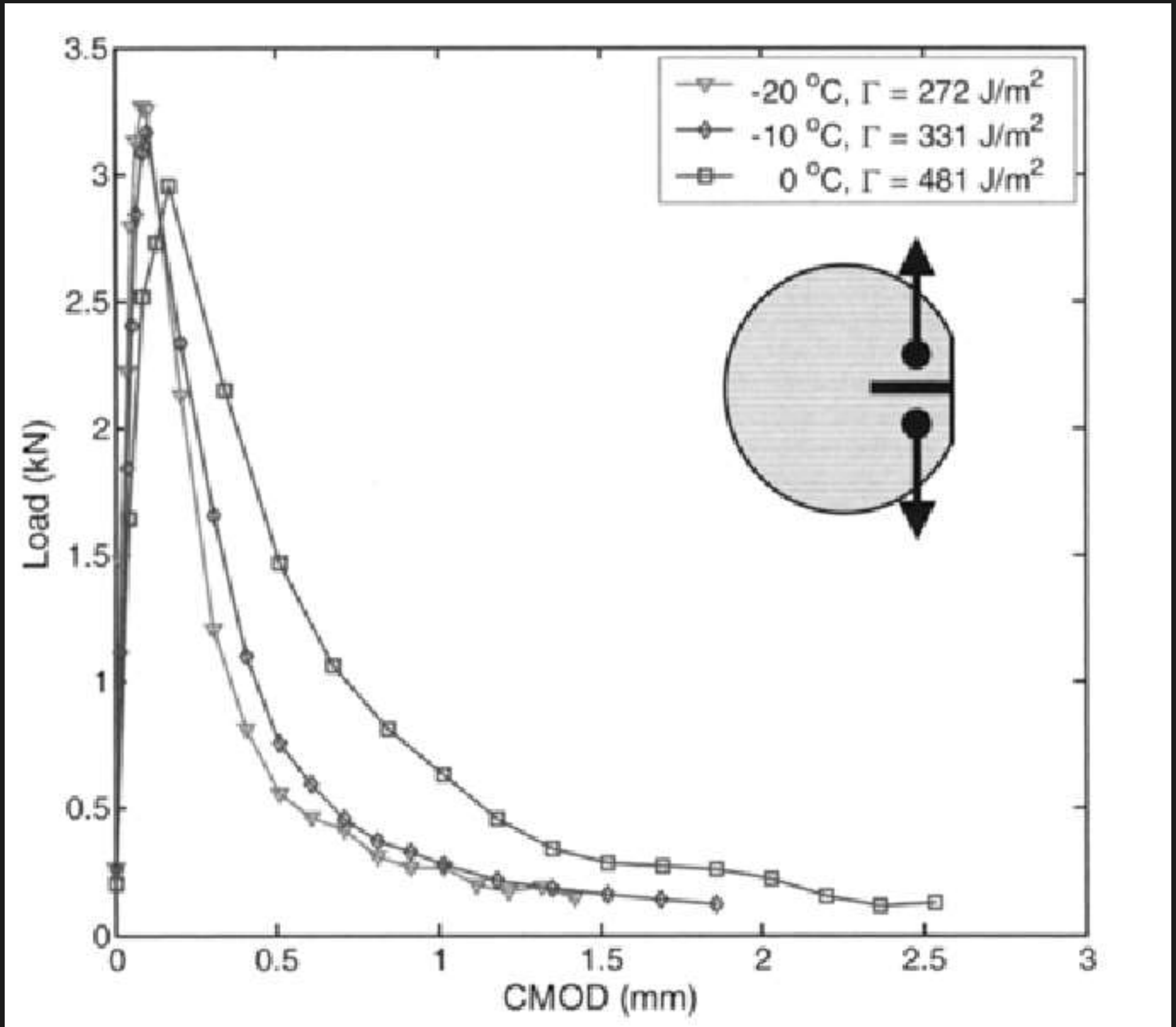
Texas Overlay Test (TOT)



Disc-Shaped Compact Tension (DCT) Test

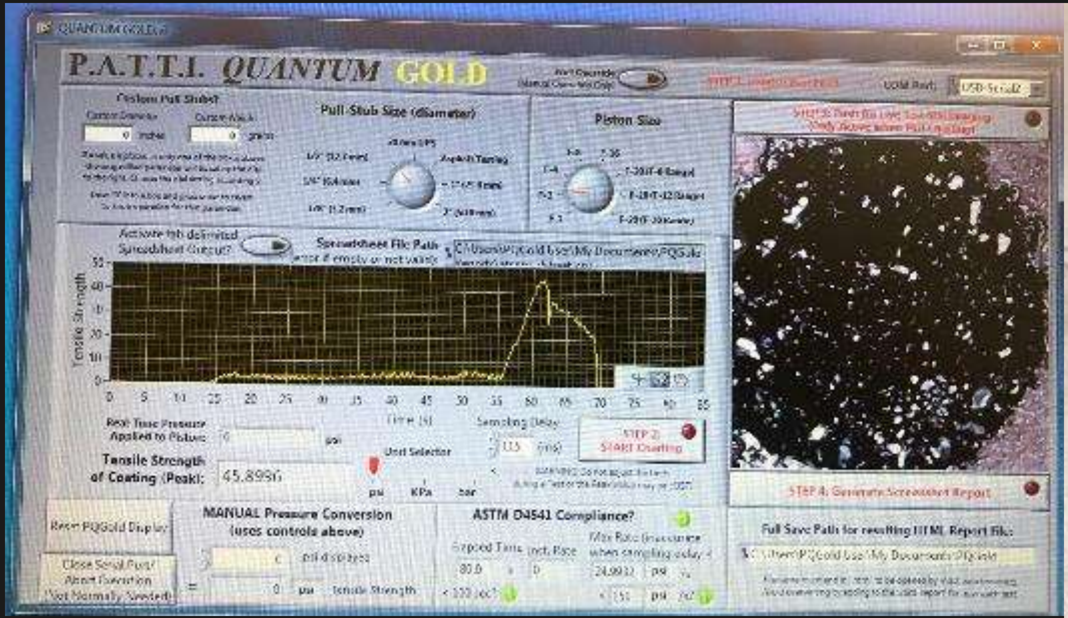


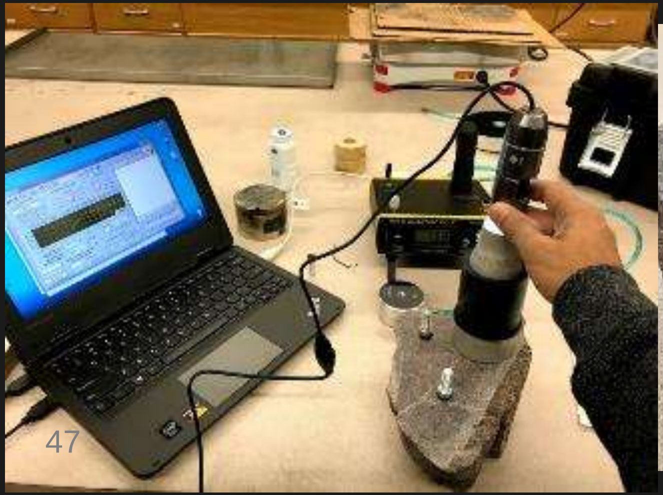
Recommended Dimensions (mm)	
D	150
W	110
ϕ	25
a	27.5
d	25
C	35



Binder Bond Strength Tester (BBS)

New!





What is Next?

- Balanced (Performance-Based) Mix Design
- Thin-Lift Performance/Specification
- Effect of Field Density on Mix Performance
- …

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MPC
MOUNTAIN-PLAINS CONSORTIUM

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HIGHWAYS TO DRIVEWAYS

South Dakota LTAP
Local Transportation Assistance Program

Thank You!