Full-Scale Reflective Cracking Test Update

Presented to: FAA Airport Pavement Working Group Meeting

By: Hao Yin, Ph.D., P.E.
Gemini Technologies, Inc.
Support Contractor for FAA
http://www.gemitek.com/airportengineering.html

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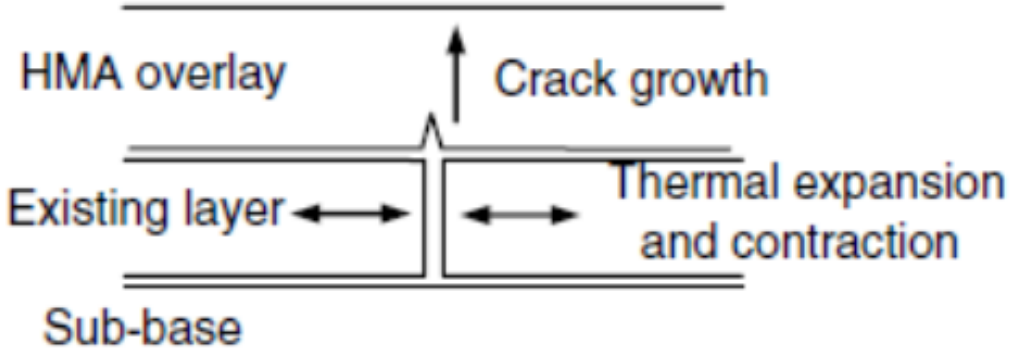
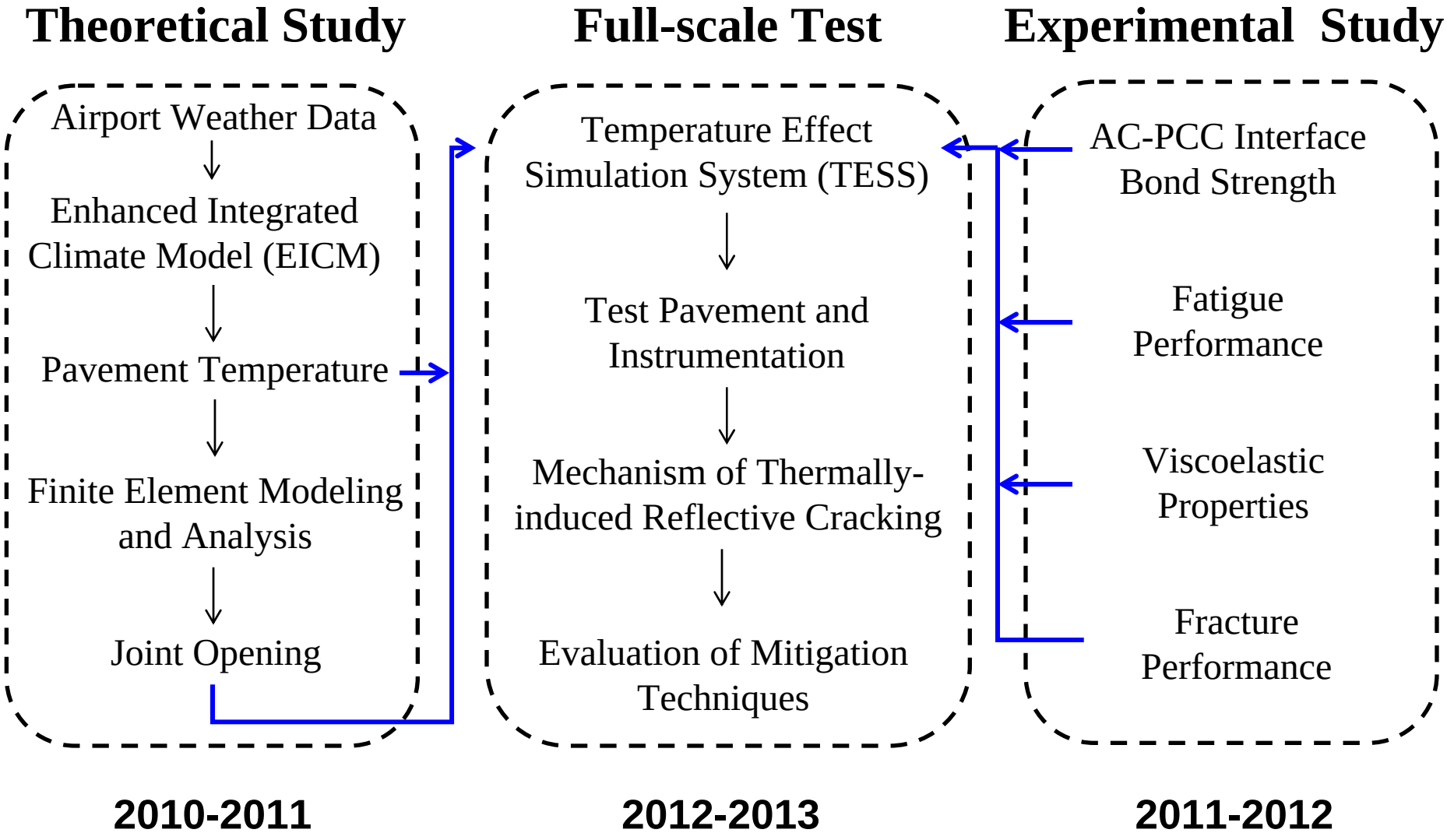
Objectives



- Simulate temperature load with mechanical load
- Understand the mechanism of thermally-induced reflective cracking
- Examine the “1-inch per year” rule-of-thumb
- Evaluate mitigation techniques

Approach

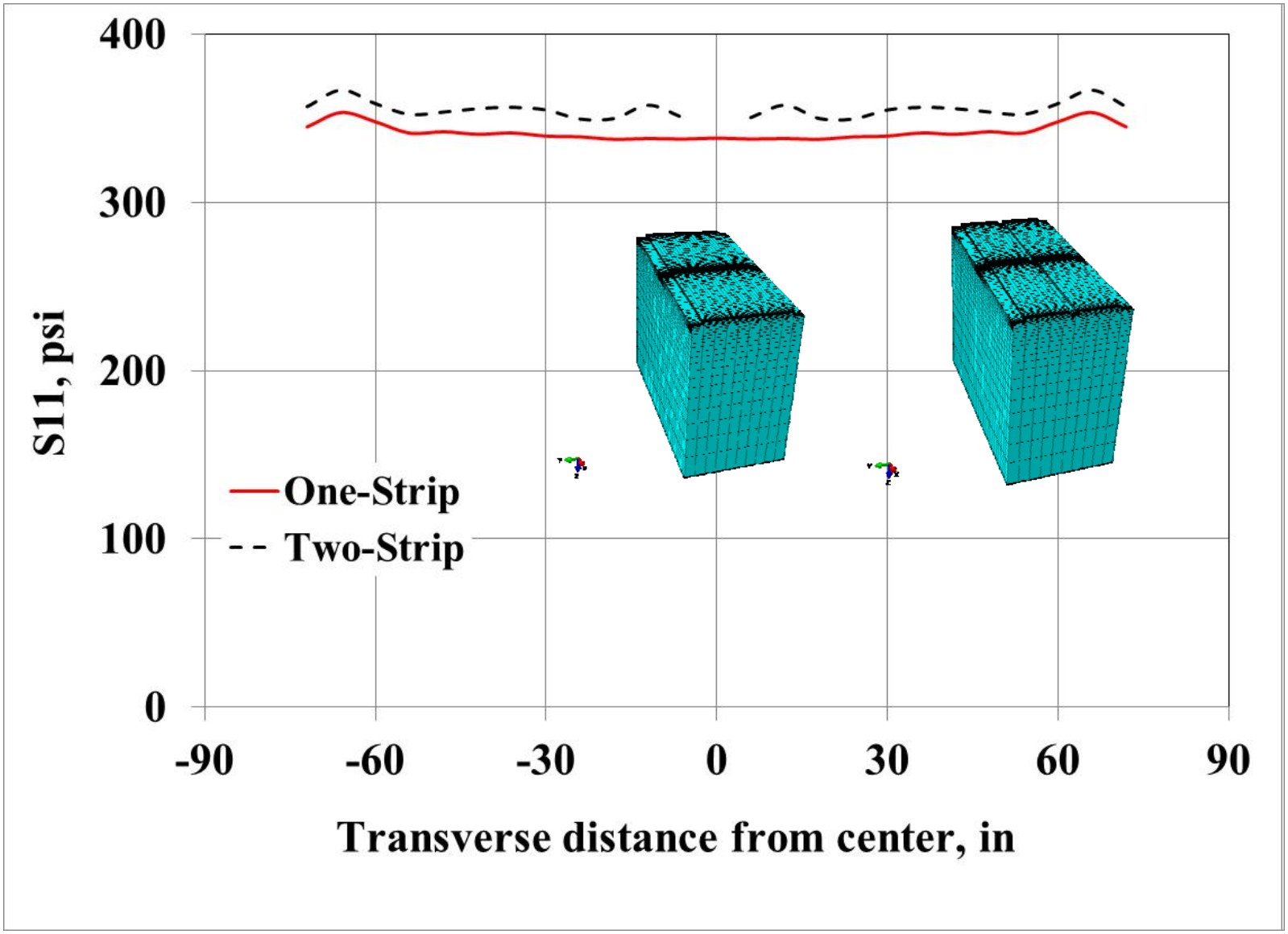

Theoretical Study
Full-scale Test
Experimental Study
Airport Weather Data
Enhanced Integrated Climate Model (EICM)
Pavement Temperature
Finite Element Modeling and Analysis
Joint Opening
Temperature Effect Simulation System (TESS)
Test Pavement and Instrumentation
Mechanism of Thermally-induced Reflective Cracking
Evaluation of Mitigation Techniques
AC-PCC Interface Bond Strength
Fatigue Performance
Viscoelastic Properties
Fracture Performance
2010-2011
2012-2013
2011-2012

Temperature Effect Simulation System (TESS)

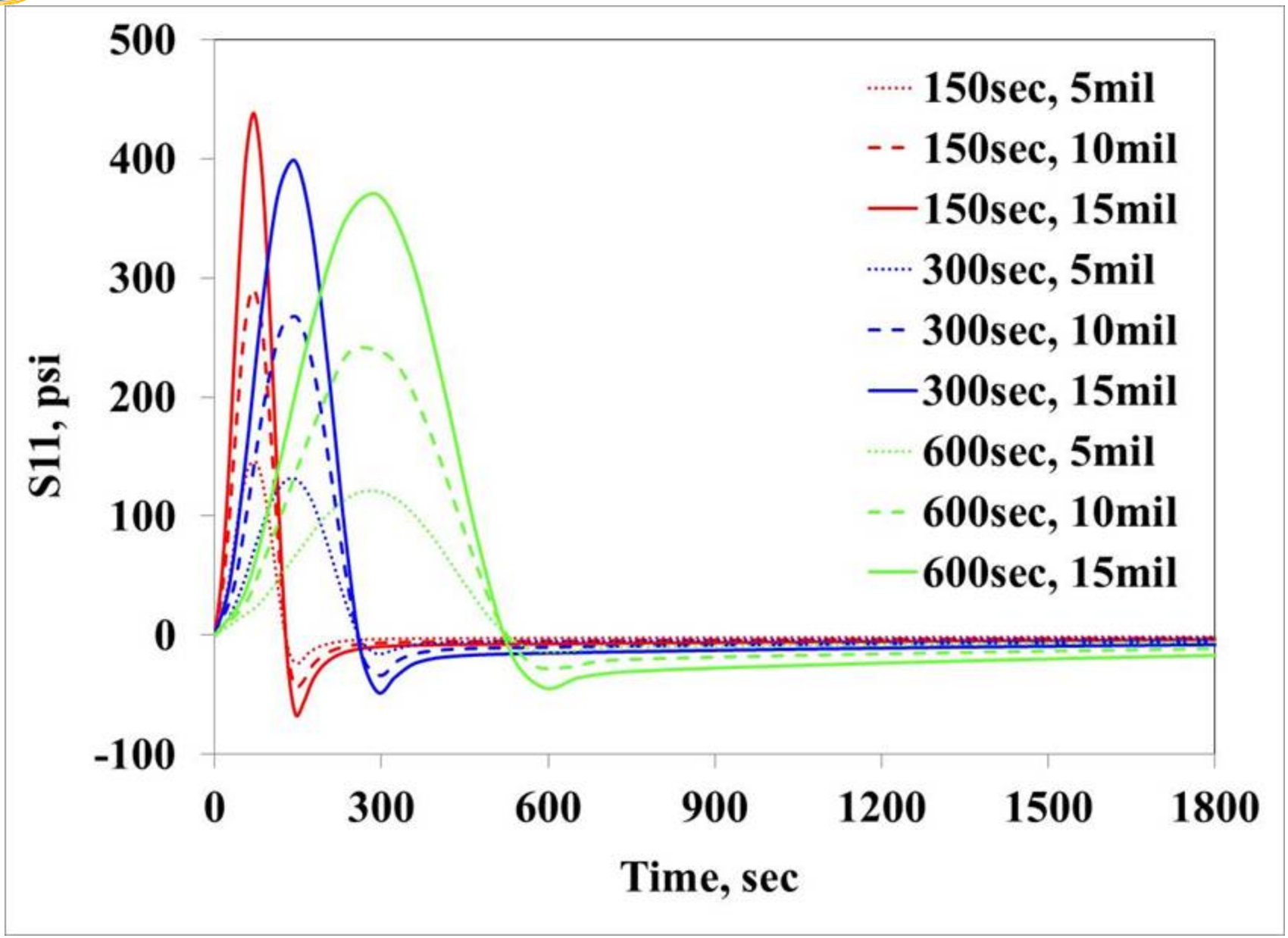
Overview

Tasks	2012							2013			
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
TESS Upgrade											
Theoretical Support											
Re-construction											
Instrumentation											
Shake-down											
Formal Test											
Data Analysis											

One-strip vs. Two-strip



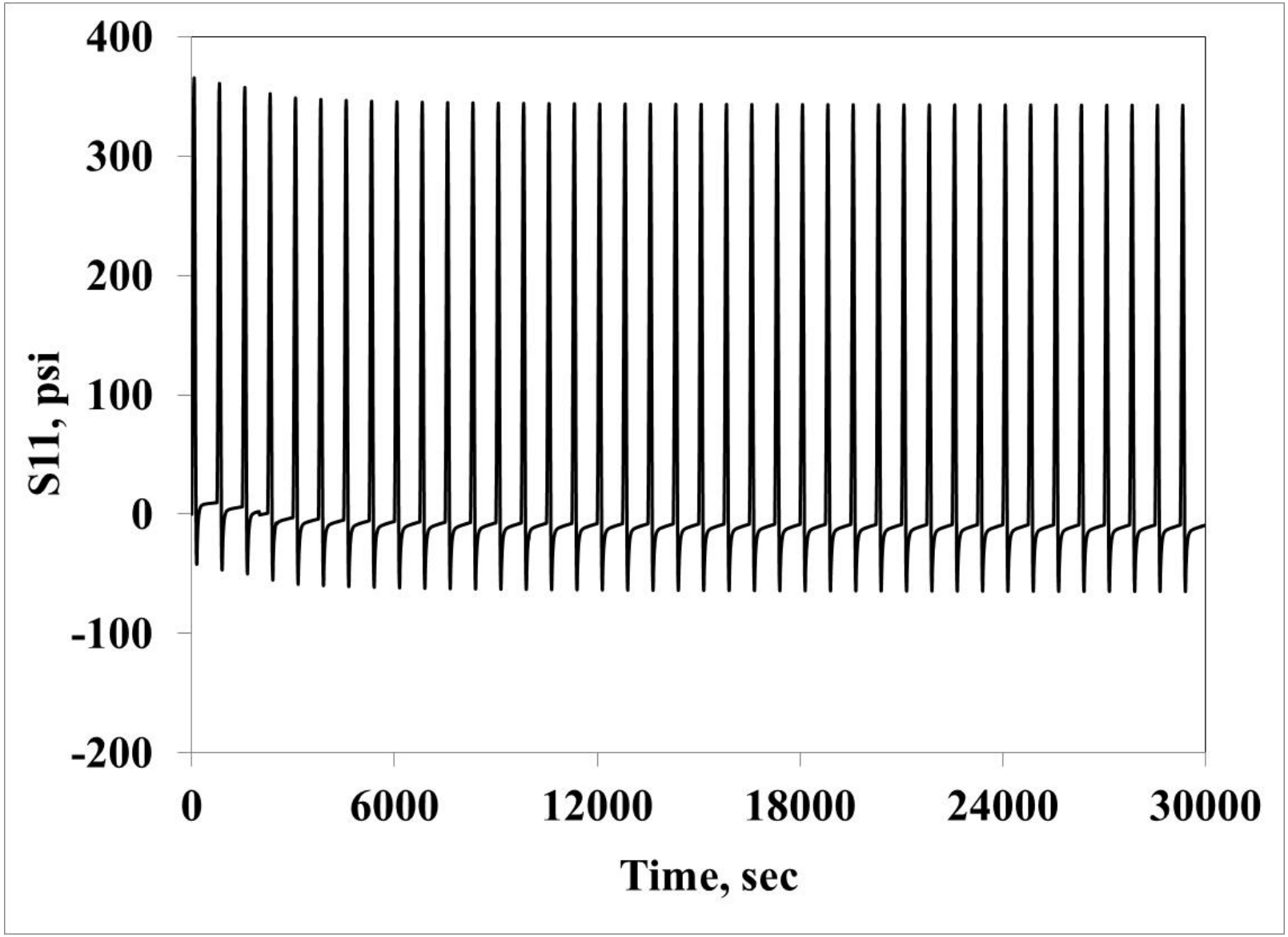
Overlay Stress Relaxation



FE Simulation Matrix

Case #	Joint Opening, mil	Cycle Time, sec		
		Loading Time	Rest Period	Total
1	15	600	0	600
2	15	600	300	900
3	14	300	0	300
4	14	300	300	600
5	14	300	600	900
6	12	150	0	150
7	12	150	150	300
8	12	150	300	450
9	12	150	600	750

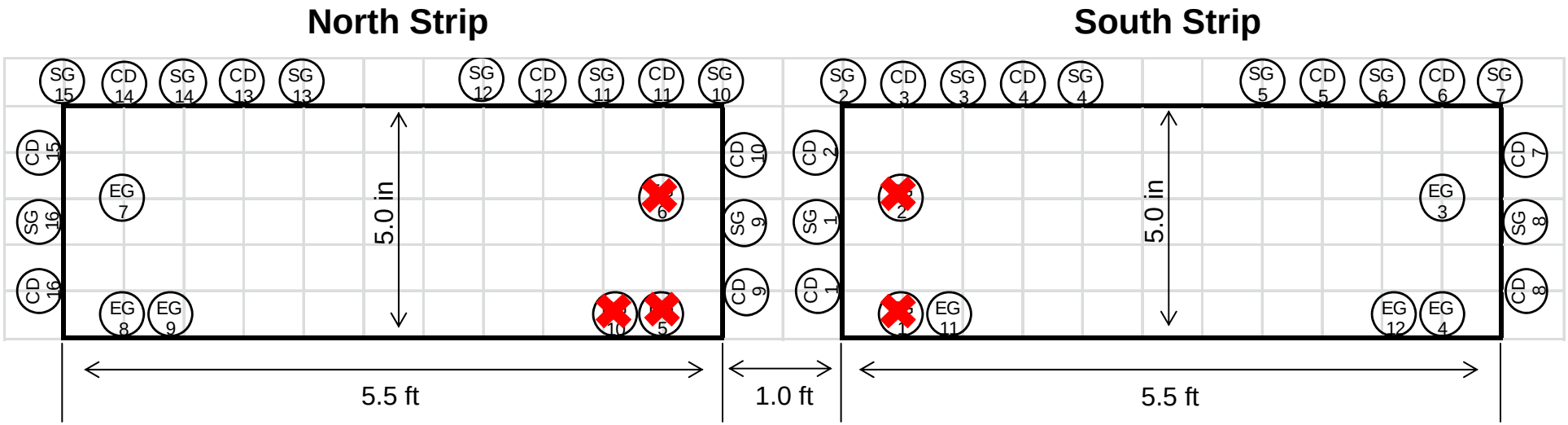
Overlay Stress Relaxation

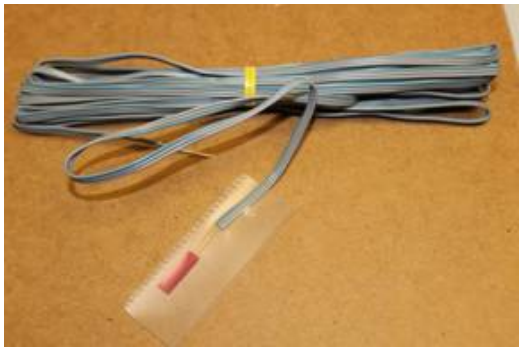


Overlay Paving

Test Pavement

Instrumentation Layout





Surface Strain Gage (SG)

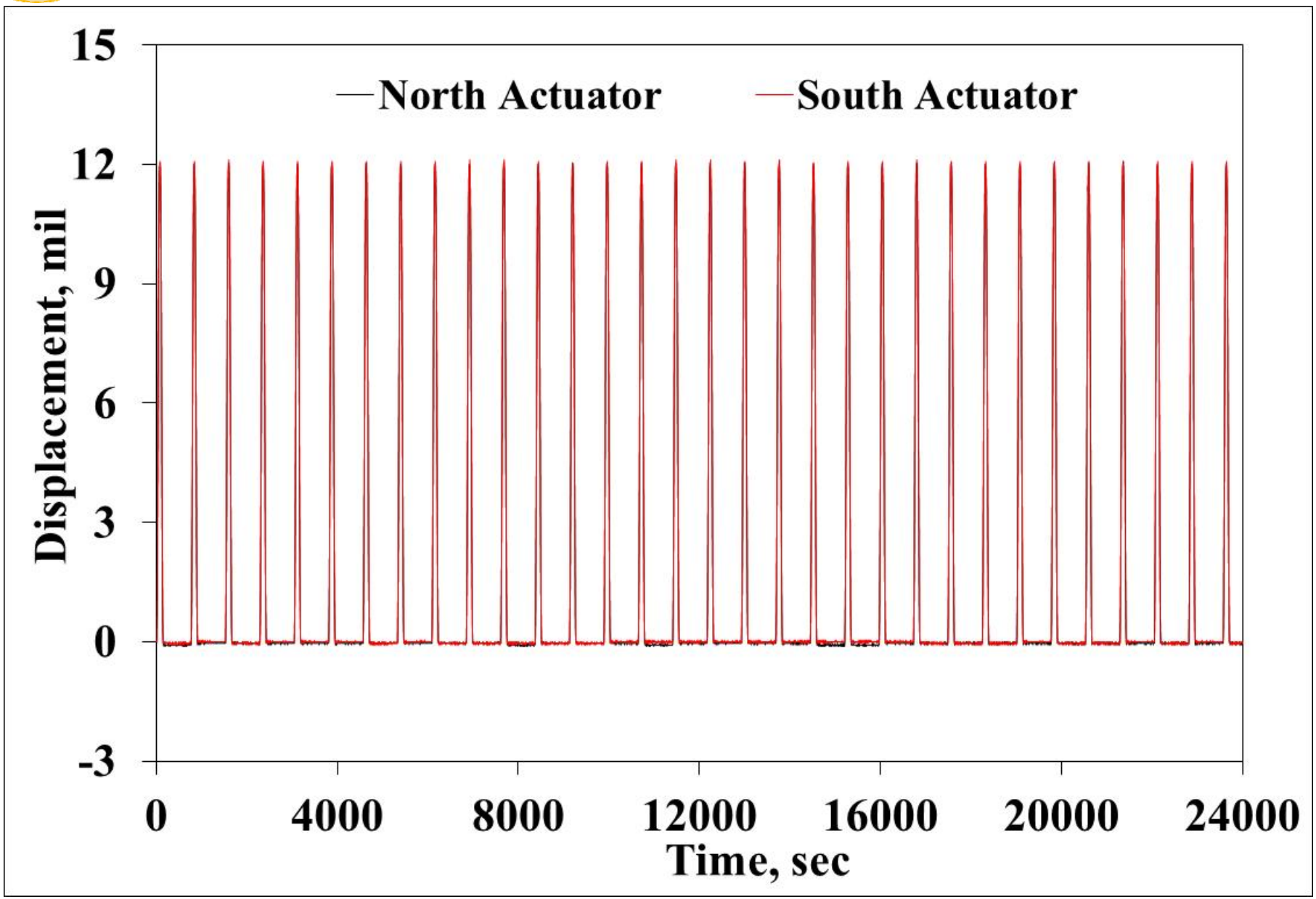
Embedded Strain Gage (EG)

Crack Detector (CD)

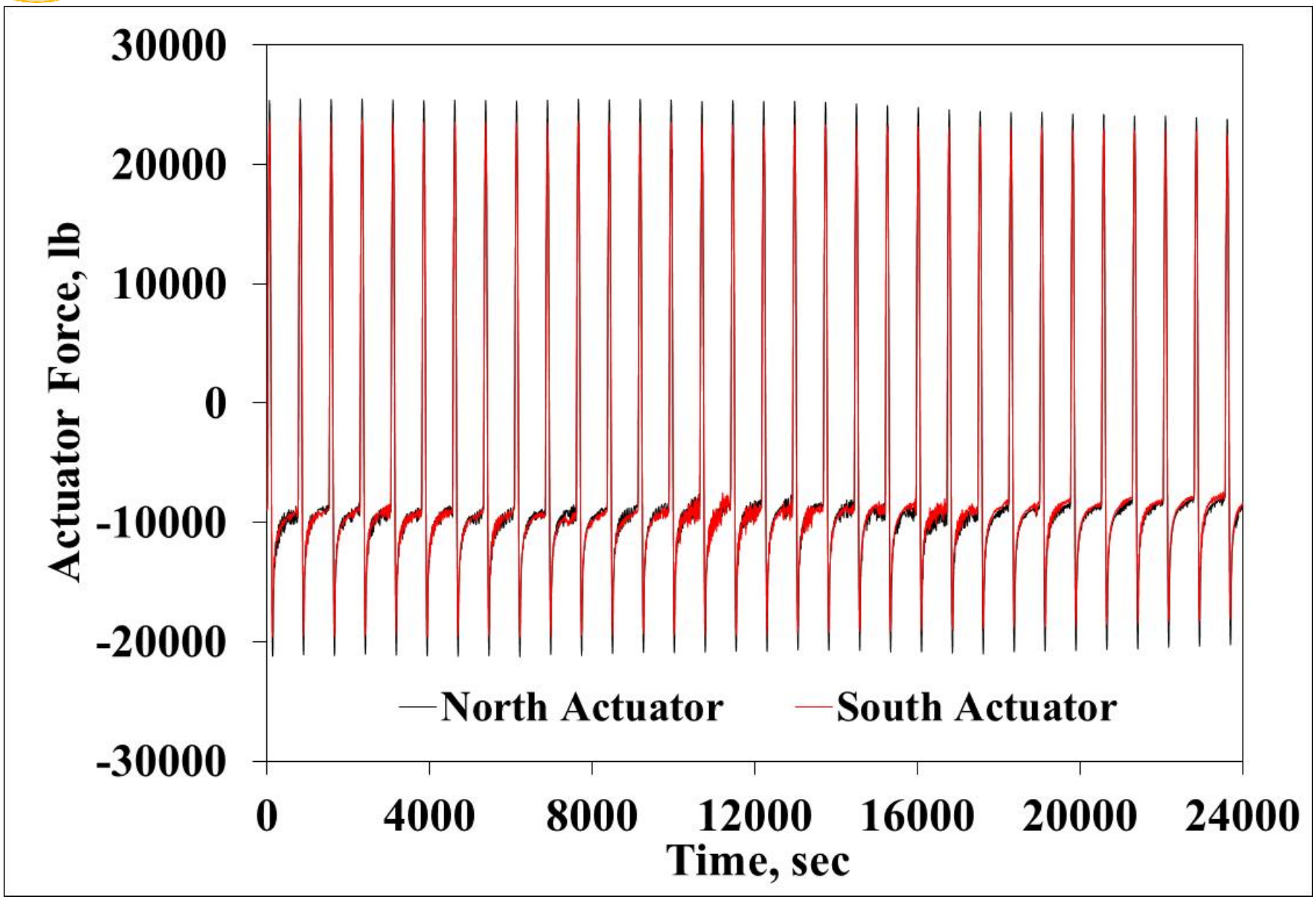
Test Summary

- Started on Jan 24
  - Target AC-PCC temperature: 29-31ºF
  - Maximum Horizontal Displacement (Joint Opening): 0.012 in
  - Cycle Time: 150 sec loading and 600 sec rest period
  - About 120 cycles per day
- Ended on Mar 8
  - Total of 4869 cycles

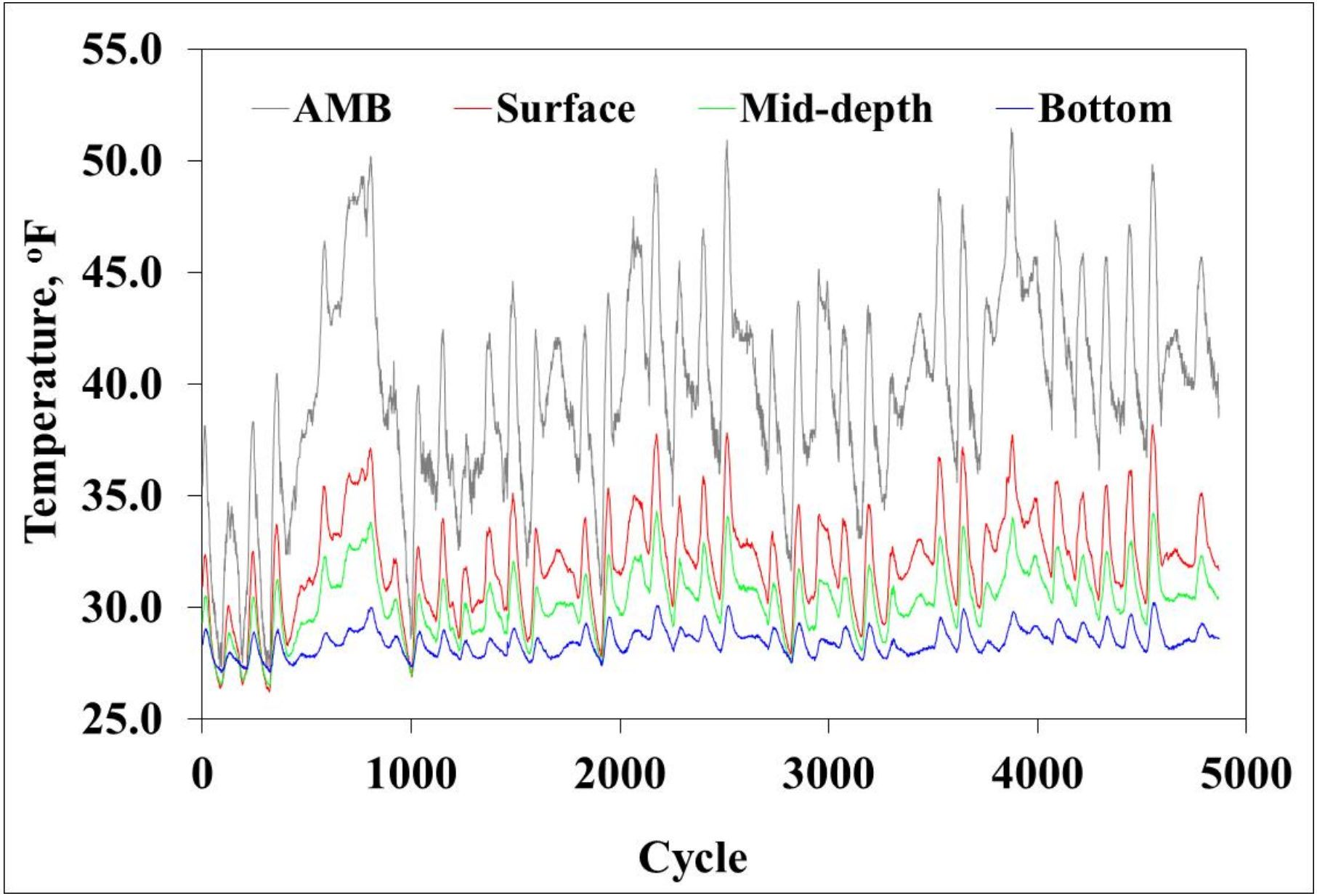
TESS – Displacement



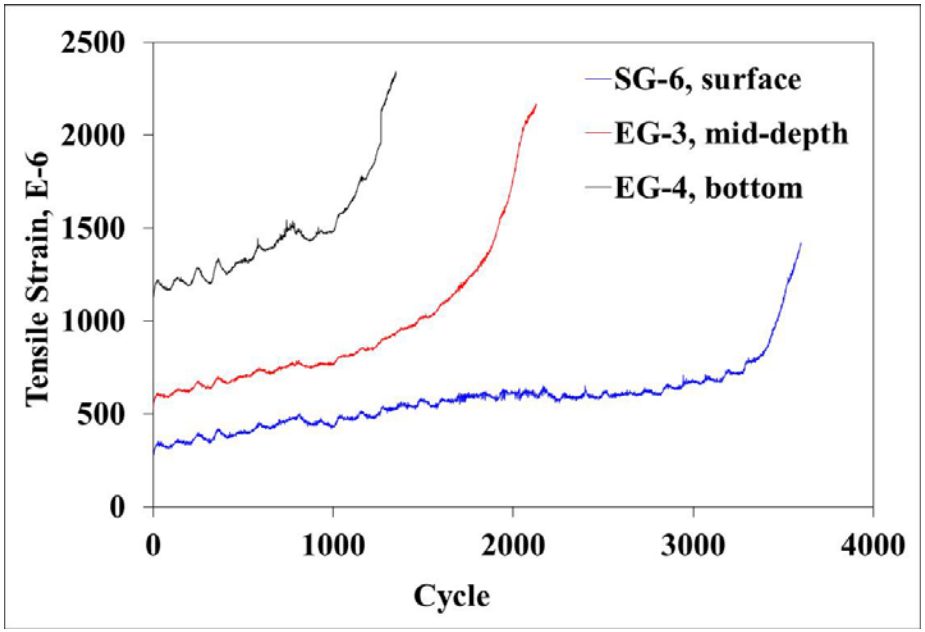
TESS– Actuator Force

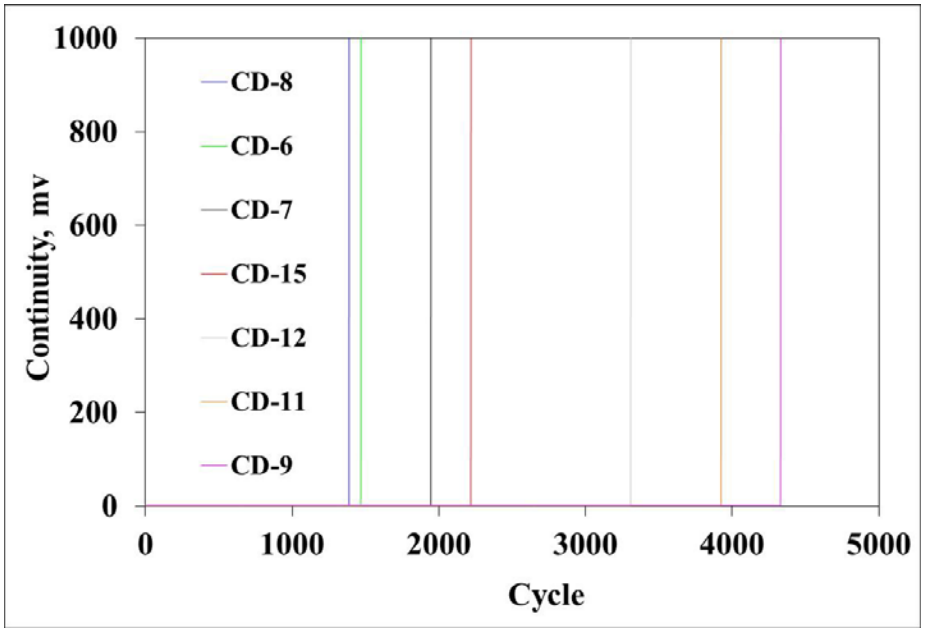


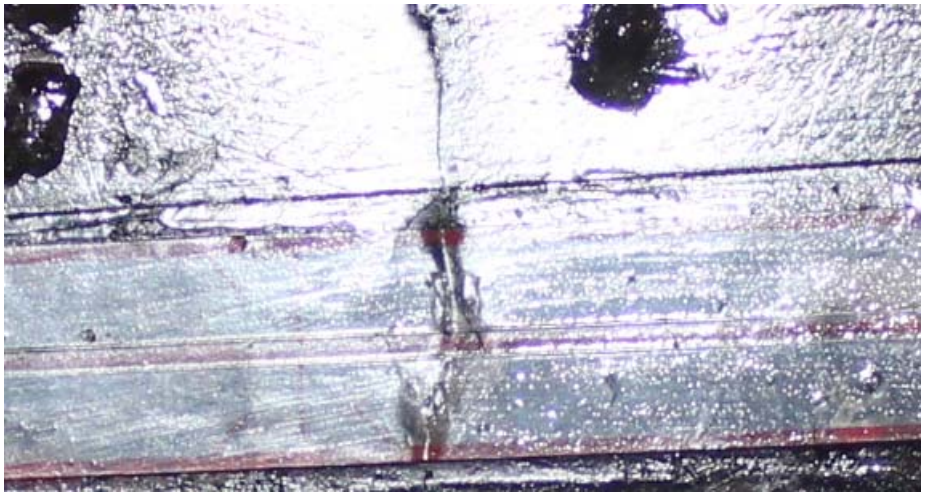
TESS – OL Temperature

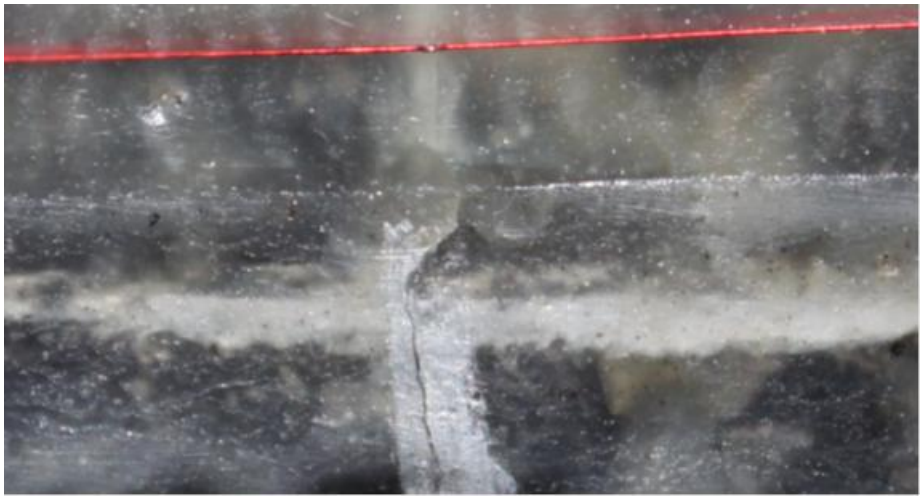


Crack Detection



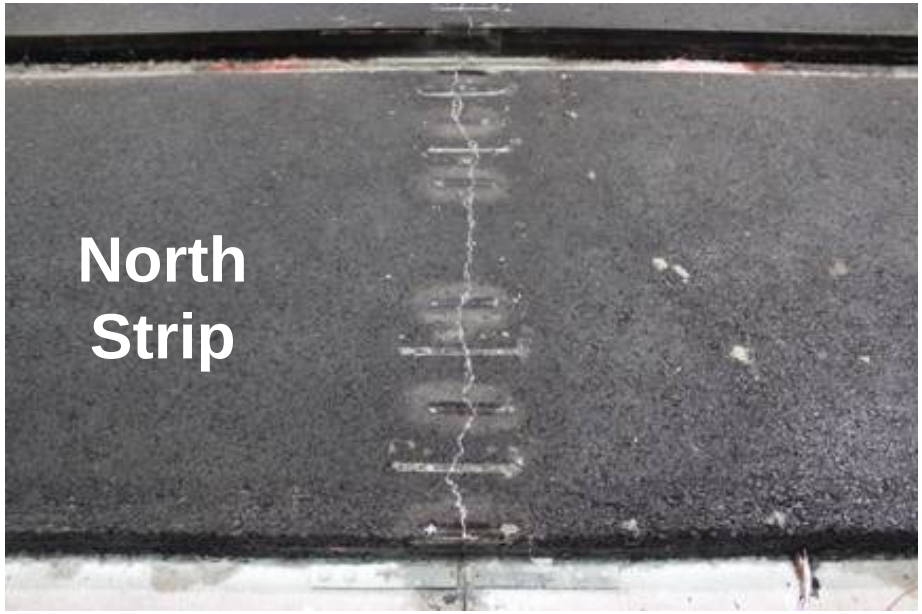


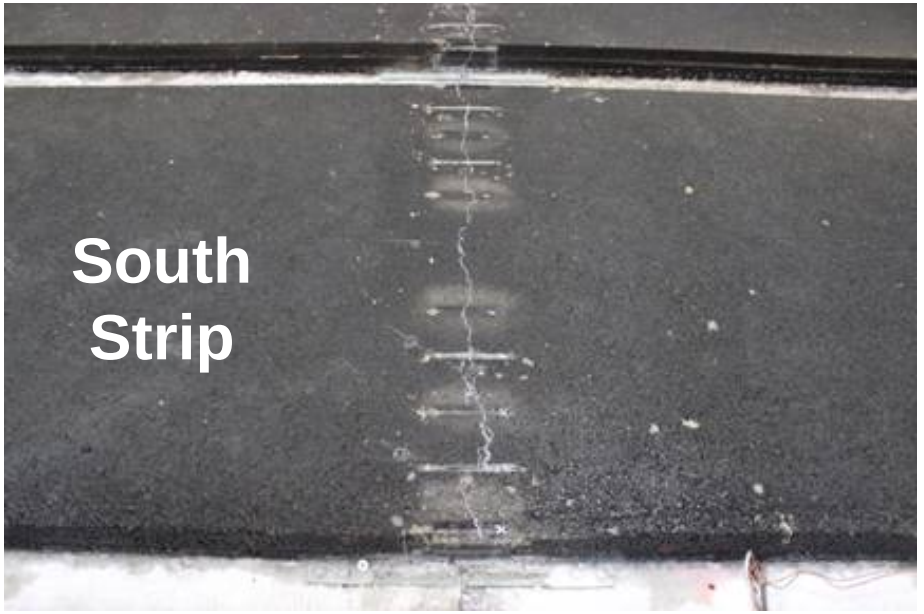




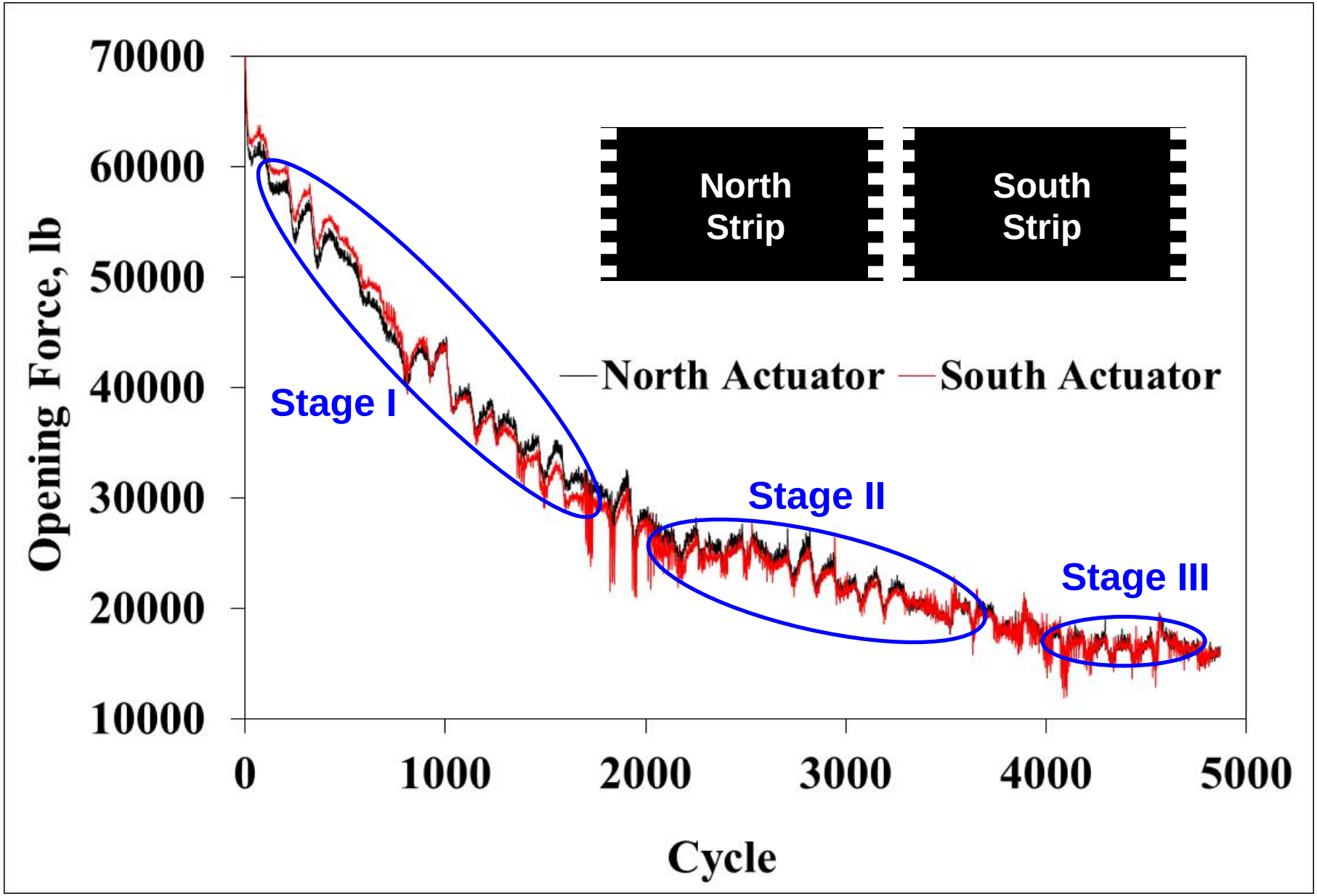
Visual Examination

Test Monitoring

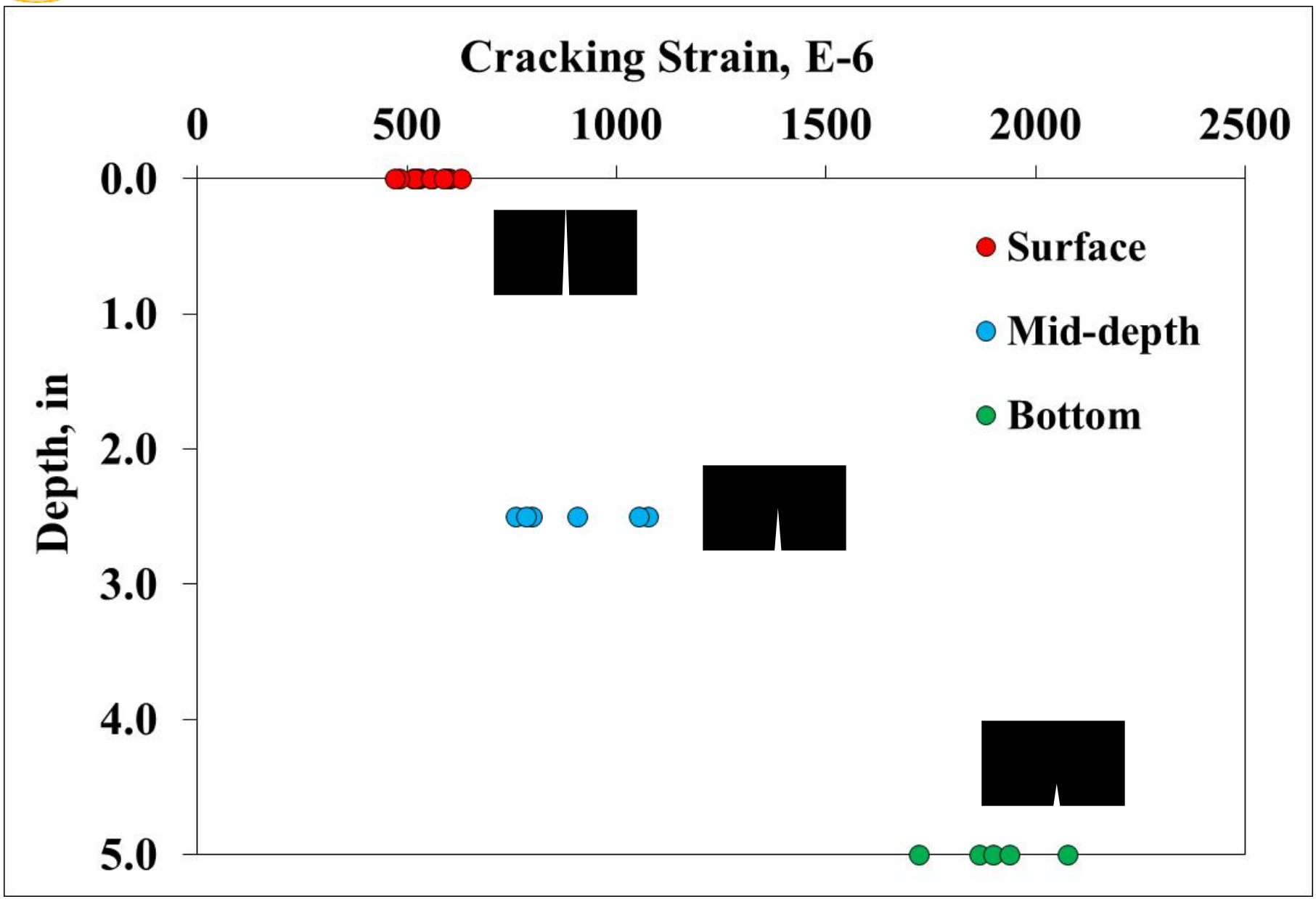




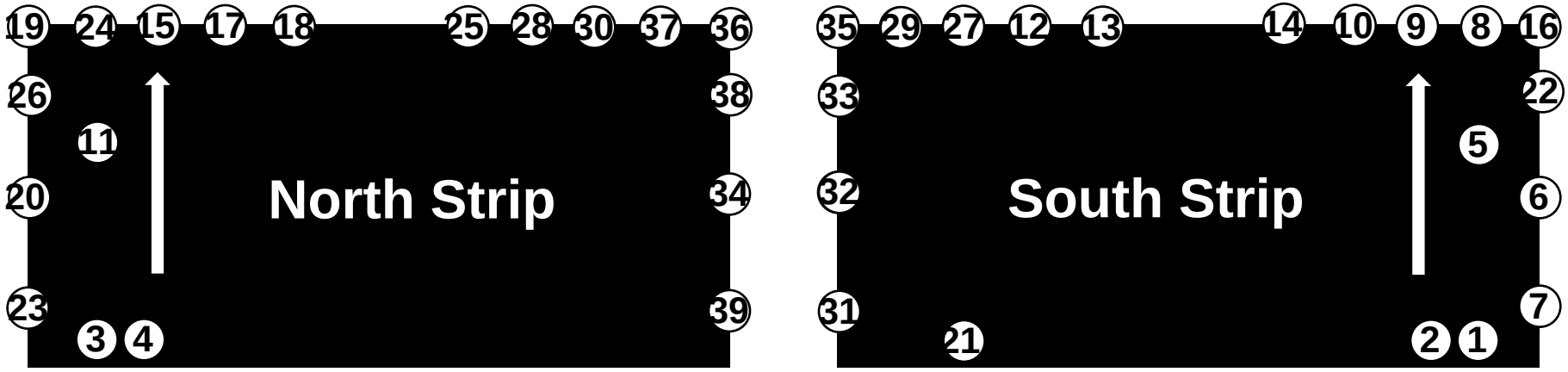
Test Results – Force Decay



Test Results - Cracking Strain



Test Results - Crack Map



709 cycles

Event ID	1	2	3	4	5	6	7	8	9	10
Sensor ID	EG-4	EG-12	EG-8	EG-9	EG-3	SG-8	CD-8	CD-6	SG-6	CD-5
Cycle	902	1008	1009	1010	1237	1259	1389	1469	1478	1537
Event ID	11	12	13	14	15	16	17	18	19	20
Sensor ID	EG-7	CD-4	SG-4	SG-5	SG-14	SG-7	CD-13	SG-13	SG-15	SG-16
Cycle	1563	1598	1608	1637	1718	1814	1866	1867	1877	1904
Event ID	21	22	23	24	25	26	27	28	29	30
Sensor ID	EG-11	CD-7	CD-16	CD-14	SG-12	CD-15	SG-3	CD-12	CD-3	SG-11
Cycle	1919	1947	1973	2090	2182	2220	2309	3309	3376	3444
Event ID	31	32	33	34	35	36	37	38	39	
Sensor ID	CD-1	SG-1	CD-2	SG-9	SG-2	SG-10	CD-11	CD-10	CD-9	
Cycle	3578	3612	3707	3794	3820	3910	3926	4202	4331	

567 cycles

Conclusions

- TESS is reliable to simulate temperature load mechanically
- Fracture Mode I controls the initiation of thermally-induced reflection cracks
- Inclusion of a rest period effectively allows HMA overlay to relax
- “1-inch per year” rule-of-thumb is quite conservative for thermally-induced reflective cracking
- Two-strip overlay can be used for “control vs. alternative”

Evaluation of Mitigation Techniques

Mitigation Techniques

- Break/crack and seat, and rubblization
- Saw and seal
- Thick HMA overlay
- Mixture modification
- Reinforcement of HMA overlay
- Interlayer system

Selection Criterion

- Existing PCC pavement condition
- Research scope
- Construction constraint
- Field implementation

Strain Relieving Interlayer

The strain relieving interlayer is an asphalt-rich, highly polymer modified asphalt and fine aggregate HMA. Due to its low stiffness, the interlayer will exhibit large horizontal deformations, which will be accompanied with a dissipation of energy.

General volumetric requirements of such mixture include:

- Air voids: 0.5-2.5%
- Voids in Mineral Aggregate (VMA): 16.0% minimum
- Asphalt content: 7.0% minimum

Once the above volumetric requirements are met, a series of performance based tests will be conducted to certify fatigue performance and fracture resistance:

- Complex modulus test: 10, 40, 70, and 100 ^{o}F
- IDT creep test: -10, 10, and 32 ^{o}F
- DC(T) fracture test: 10 and 32 ^{o}F
- Texas overlay test: 0.010, 0.012, and 0.015-in displacement at 32 ^{o}F

Tentative Schedule

Tasks	2013								
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Overlay Removal	■								
Pavement Design		■	■						
Theoretical Support		■	■	■					
HMA Mix Design		■	■	■	■				
Laboratory Test			■	■	■				
TESS Upgrade		■	■	■	■				
Re-construction					■	■			
Instrumentation		■	■	■	■	■	■		
Shake-down							■		
Formal Test							■	■	■