University of Pittsburgh

Swanson School of Engineering

JPCP Joint Design

2025 Transportation Forum

Presenter:
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Associate Chair of Research
IRISE, Director of Research

March 19, 2025

The path we walk..

High School Graduation

4 to 5 (up to 10) yrs Living off Parents

First Job

Summers

Retirement

Min. of about

75,000 hrs

on the job

Defining Impact

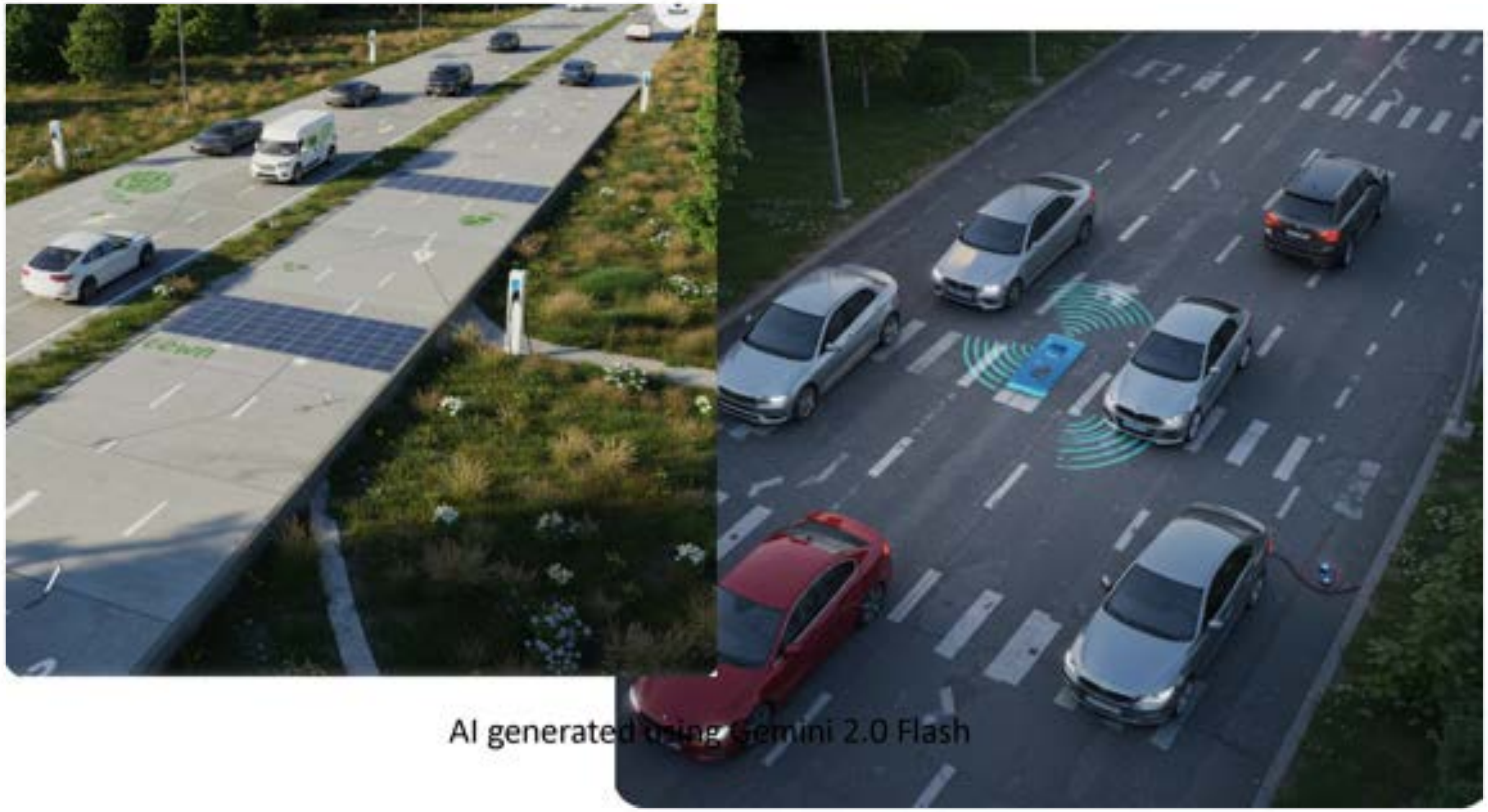
Academic definition:

NUMBERS….
Number of publications
Numbers of students
Number of research dollars
Number of committees served on
Etc……

Impact?

Quantifying true impact can be more of a challenge

Contribute to the transformation of research and ideas into practice….



AI generated using Gemini 2.0 Flash

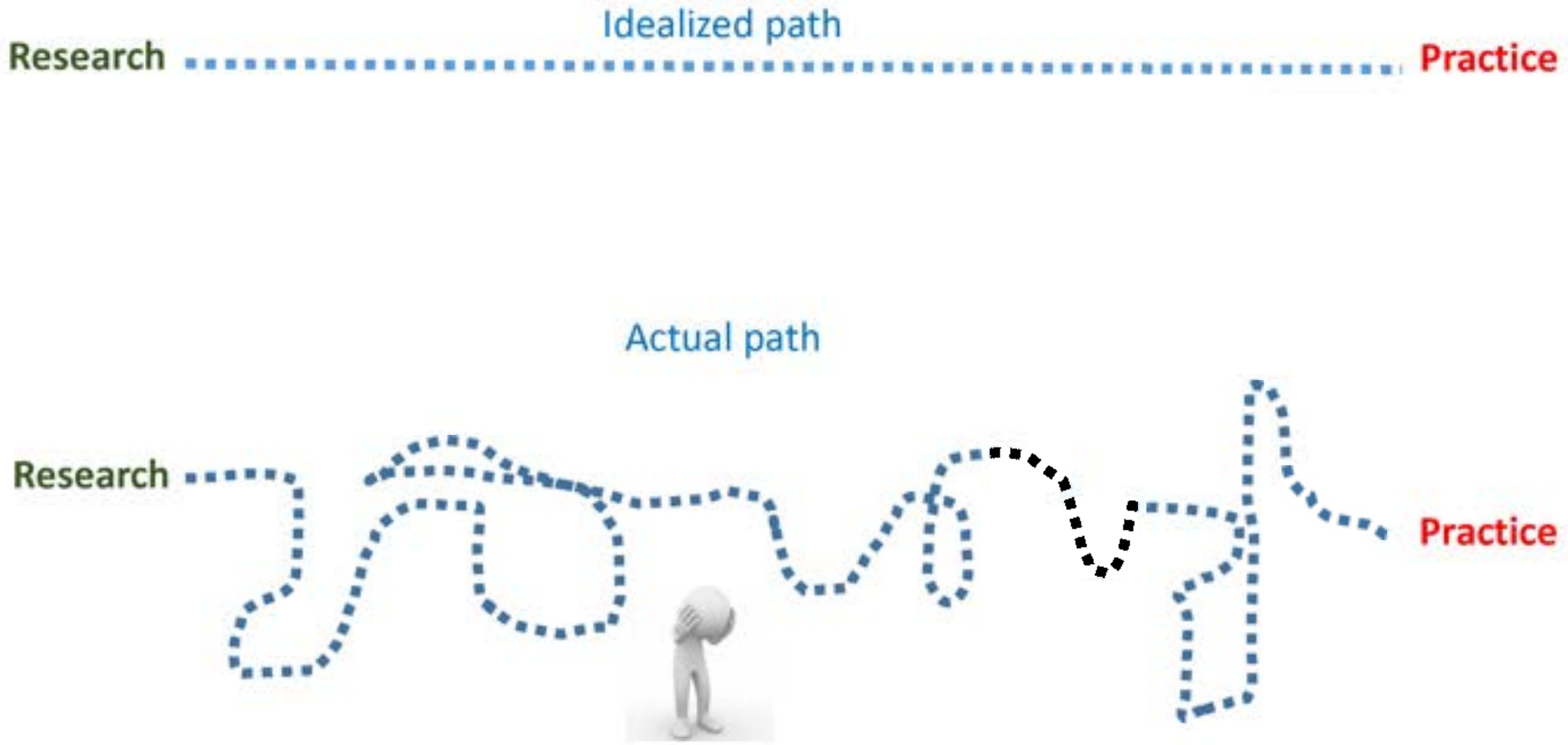
Contribute to the transformation of research and ideas into practice….

AI generated using Gemini 2.0 Flash

- Idea development
- Research
- Design
- Construction
- Integration
- …

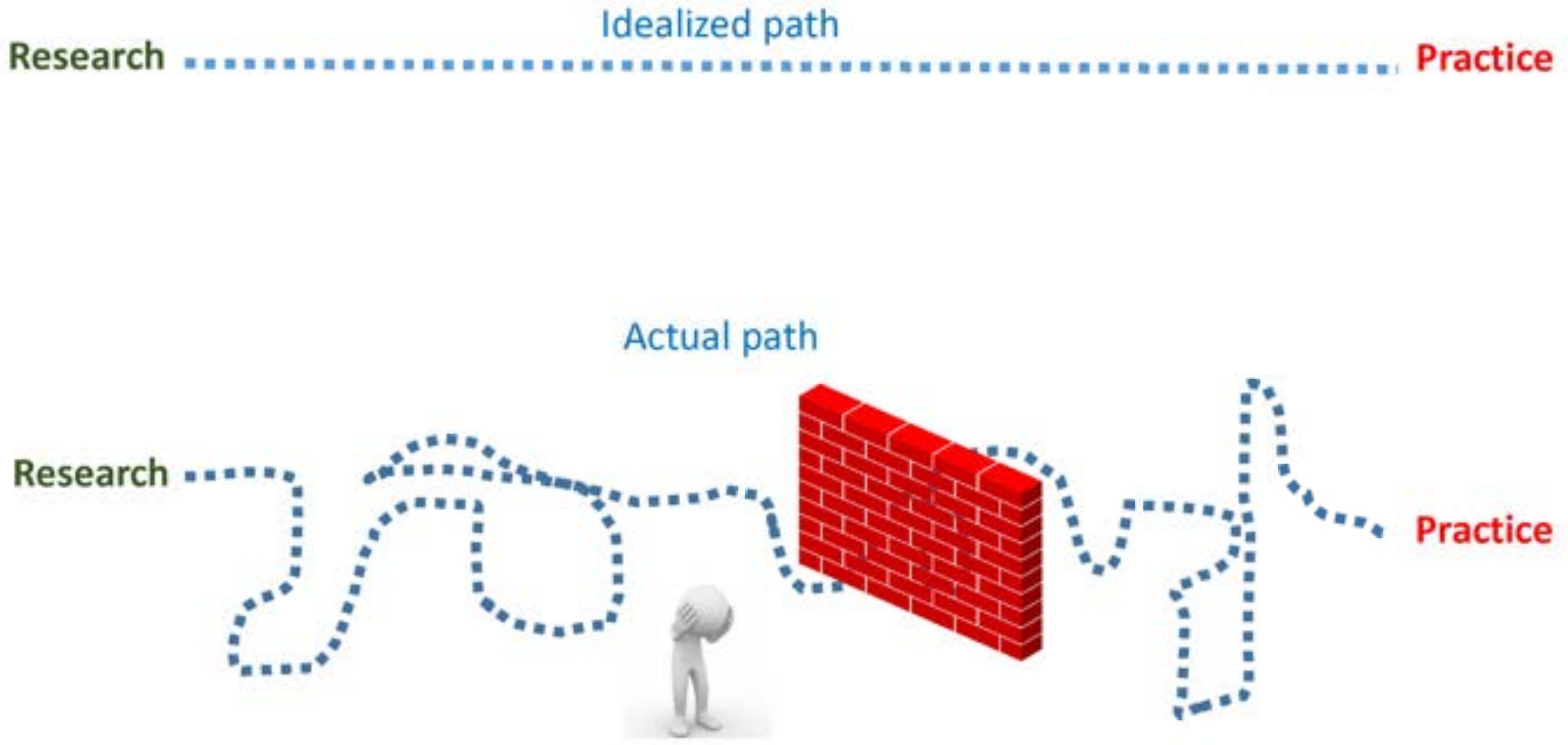
Transforming research into practice

Research starts with a guess



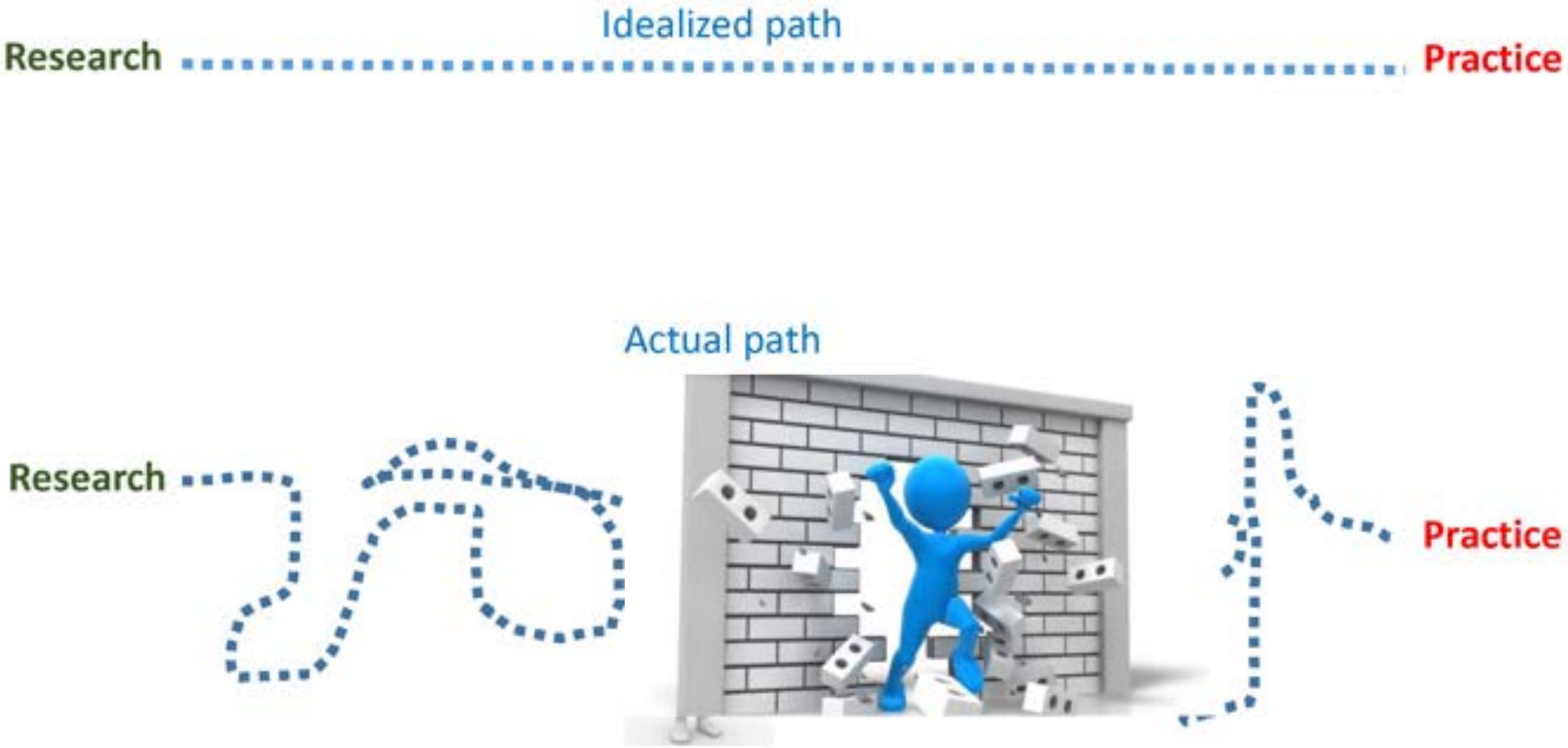
Transforming research into practice

Research starts with a guess



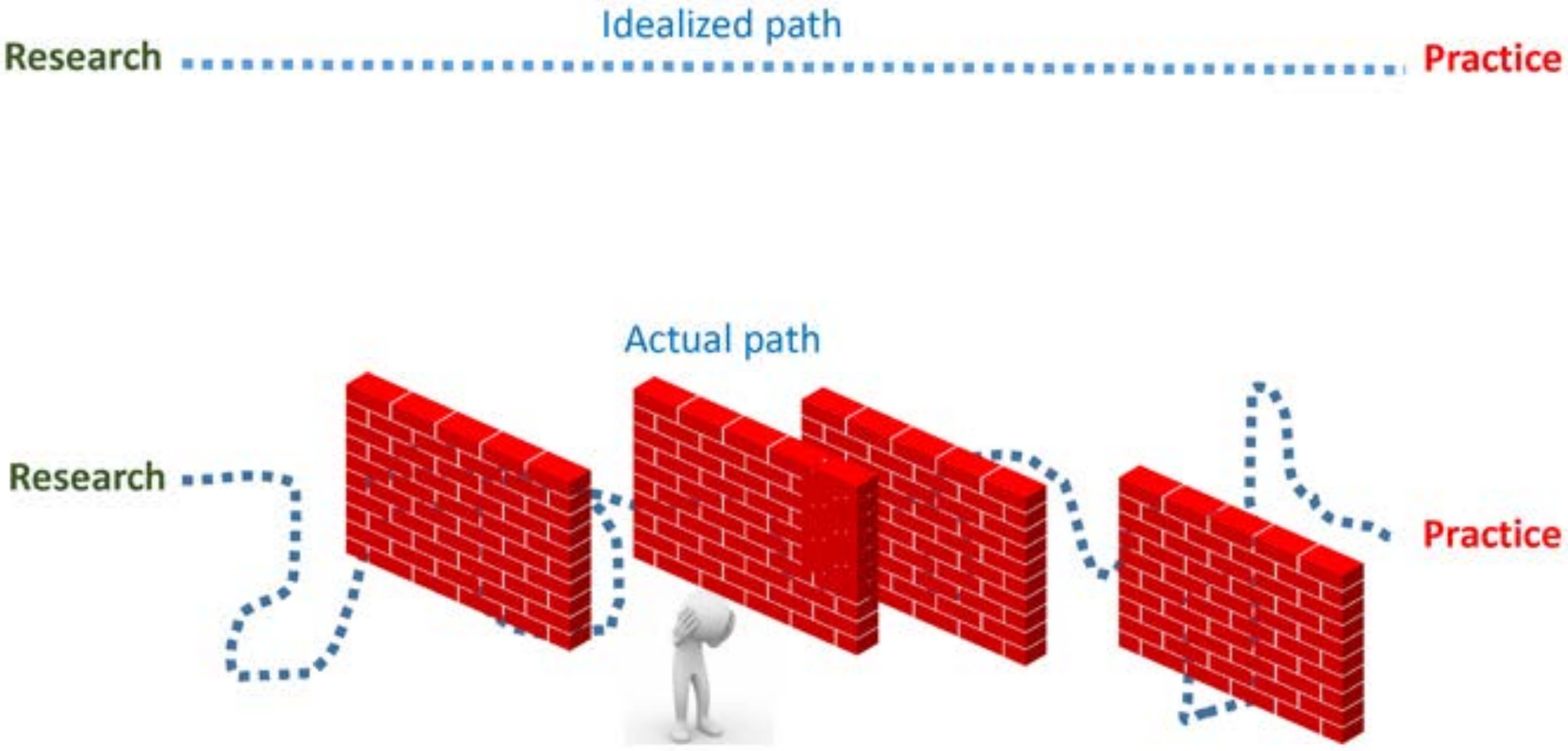
Transforming research into practice

Research starts with a guess

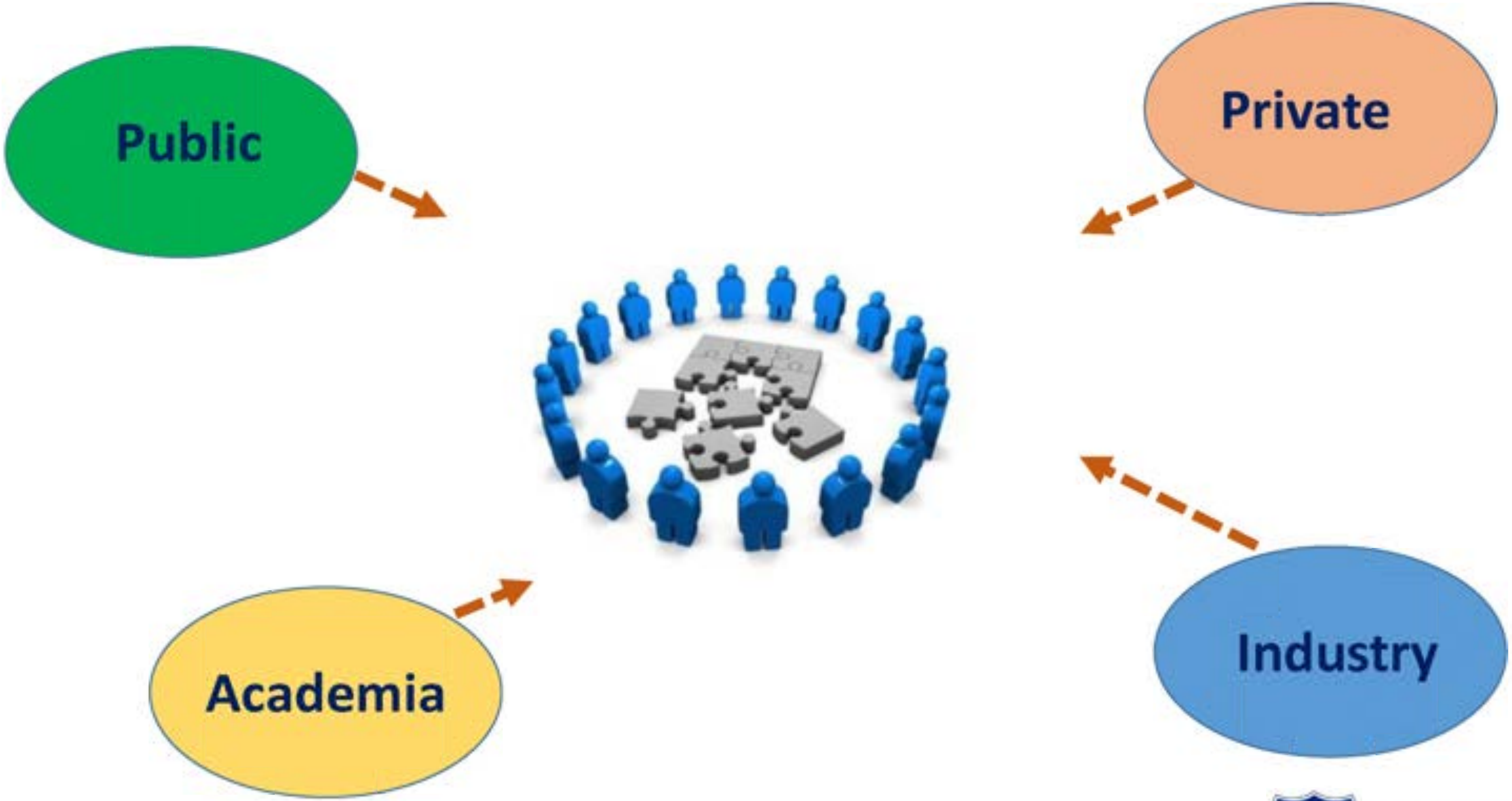


Transforming research into practice

Research starts with a guess



Breaking through barriers…



IRISE

Approach…

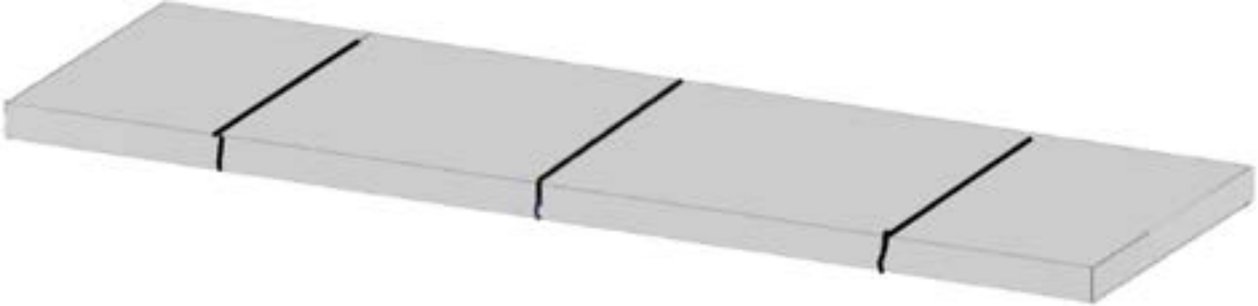
- Get all parties involved early in the process
- Maintain their involvement throughout the process

Working together…

- Identify a deficiency/challenging issue
- Develop impactful technology
- Benefit seen by all parties (buy-in)

Slab design philosophy

1. **Slab thickness** => prevent fatigue cracking
2. **Slab length (joint spacing)** =>
   a. Longer:
      - decrease costs associated with construction/maintenance of them
   b. Too long:
      - developing mid-slab cracking
      - hinder jt. performance



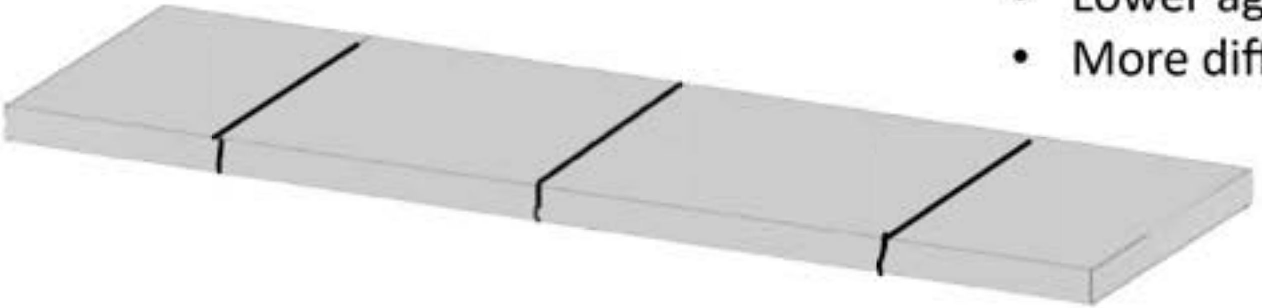
JPCP Slab design philosophy

1. **Slab thickness** => prevent fatigue cracking (rarely occurs)
2. **Slab length (joint spacing)** =>
   a. Longer:
      - decrease costs associated with construction/maintenance of them
   b. Too long:
      - developing mid-slab cracking
      - **hinder jt. performance**

hinder jt performance

Longer slab => larger joint opening

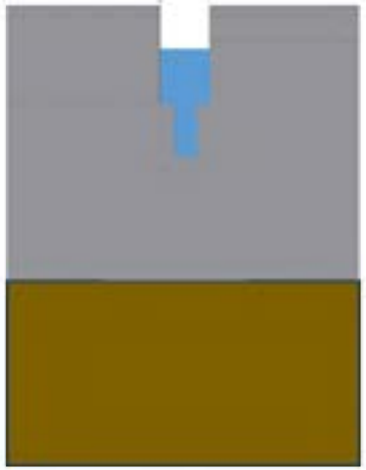
- Lower agg interlock load transfer
- More difficult to keep sealed



Joint performance – Concrete durability

- Durable concrete mixture – PEM
- Concrete < 85% saturated (Taylor et al. in 2012)
  - Avoid ponding in the joint
    - Well-sealed joint
    - Activated joints
    - Drainable base

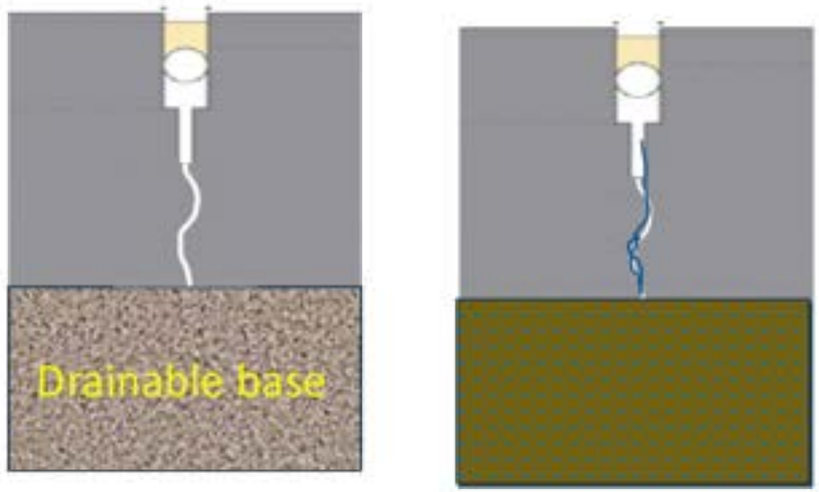
Reduced potential for PCC distress



Increased potential for PCC distress

Joint performance - Design

1. **Drainable base**
   (Erosion, pumping)
2. Effective load transfer
3. Joint sealing



Reduced potential
for pumping & erosion

Joint performance - Design

1. Drainable base
2. **Effective load transfer**
   (Faulting, corner breaks)
3. Joint sealing

a. Light truck traffic or short joint spacing:
- aggregate interlock

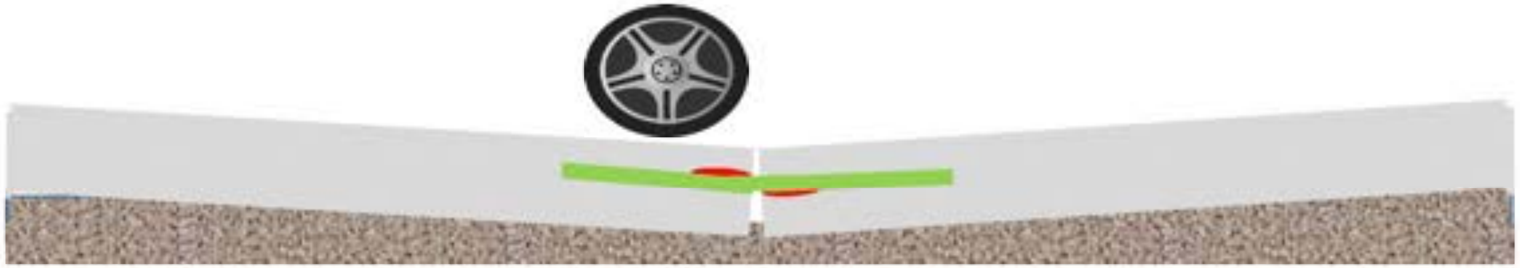
b. 20 to 30 yr- design life:
- epoxy coated dowels

c. Long-life pavement:
- Long-life dowels (zinc galvanized, zinc clad, stainless steel, FRP)

IRISE Dowel Corrosion

Goal: New faulting model that accounts for

- concrete damage based on
  - diameter
  - material stiffness
- dowel corrosion

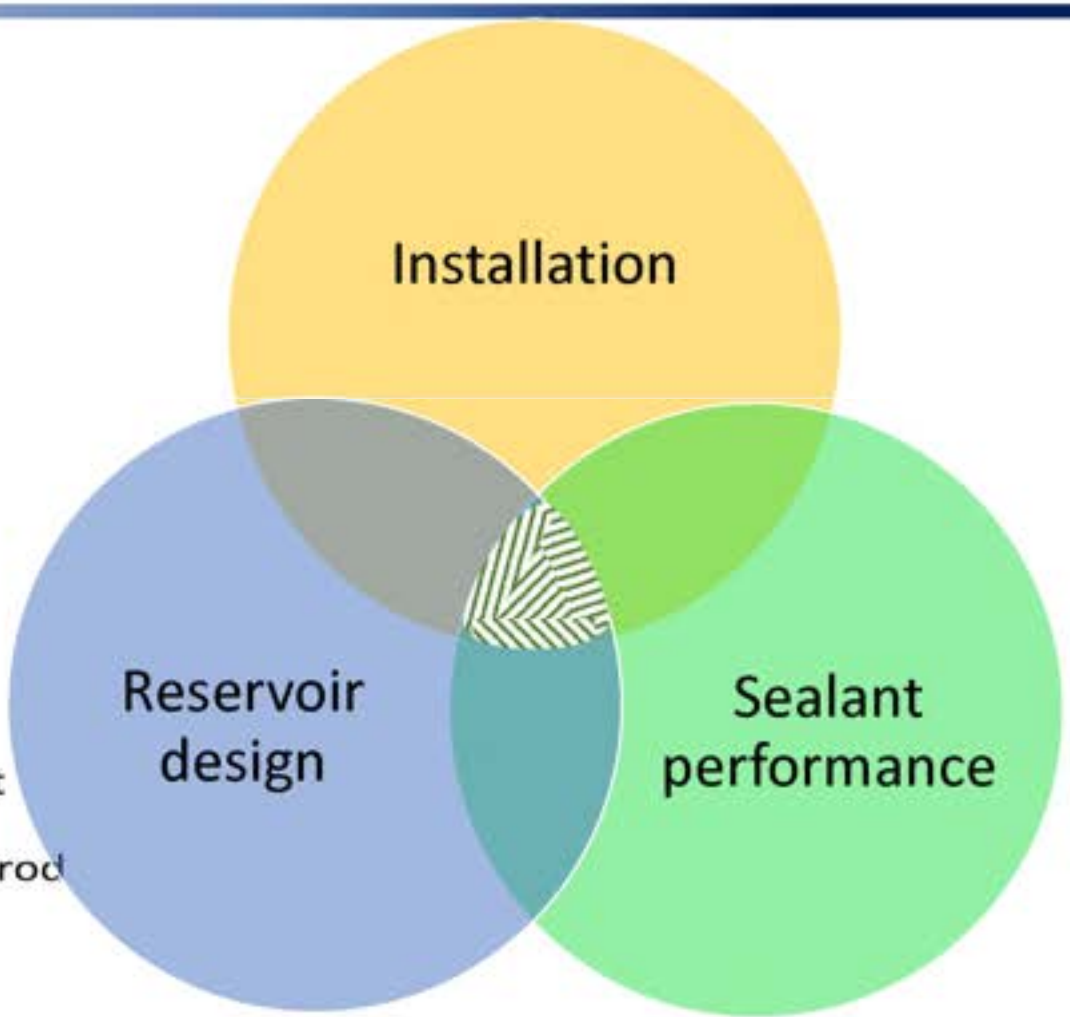


Joint performance - Design

1. Drainable base
2. Effective load transfer
3. **Joint sealing**
    - prevent entrance of **deicing salts**
      (Dowel corrosion – faulting, PCC durabiltiy)
    - prevent entrance of **water**
      (Pumping, erosion, dowel corrosion, PCC durability)
    - prevent **incompressibles (small pebbles and sand)**
      (Spalling, blowups)

Transverse Jt. sealant performance

Installation
Sealant performance
Reservoir design



Transverse Jt. sealant performance

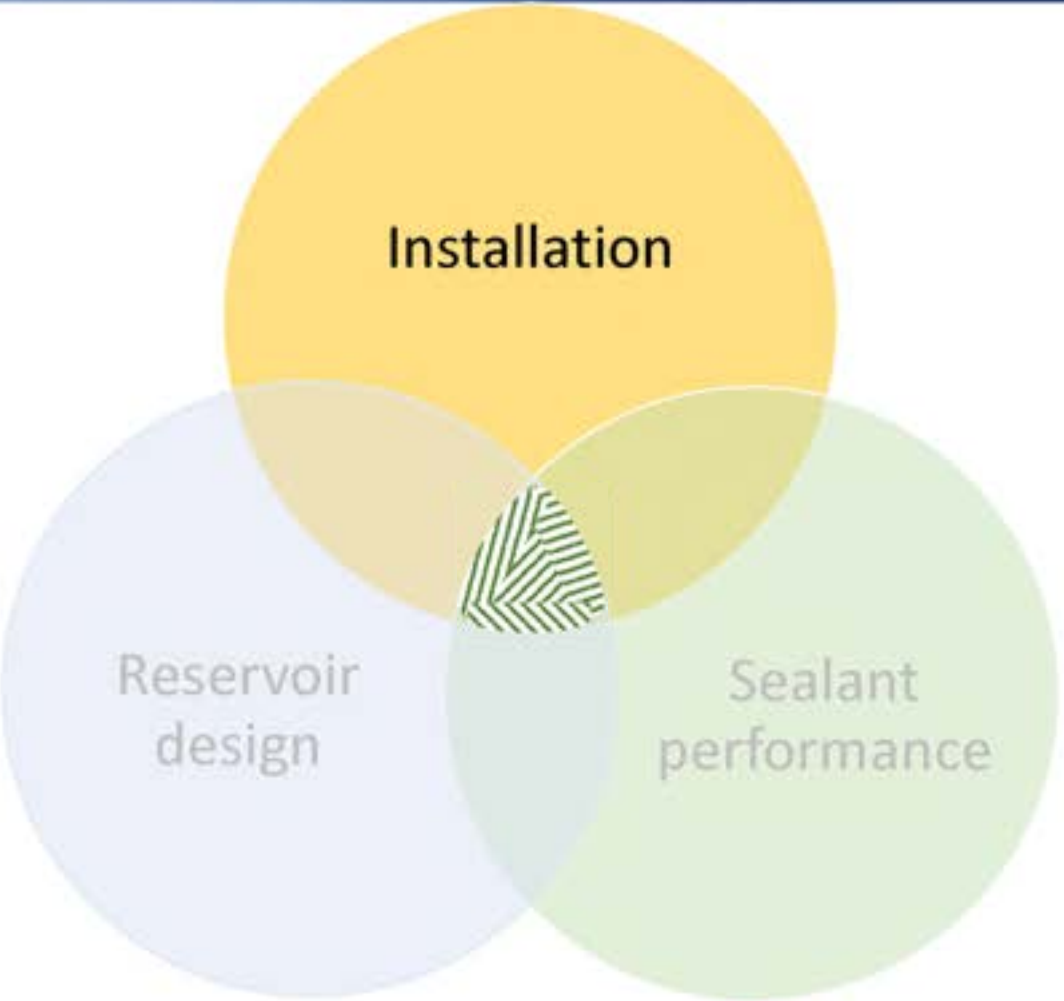
Installation

- Wipe test (is this sufficient?)
- Wet saw vacuum

Sealant performance

Reservoir design

Wet Saw after power washing and vacuum



Task C: Transverse Jt. sealant performance

Installation

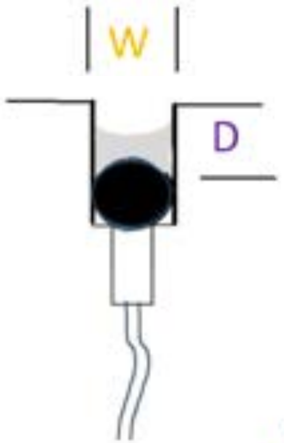
Sealant performance

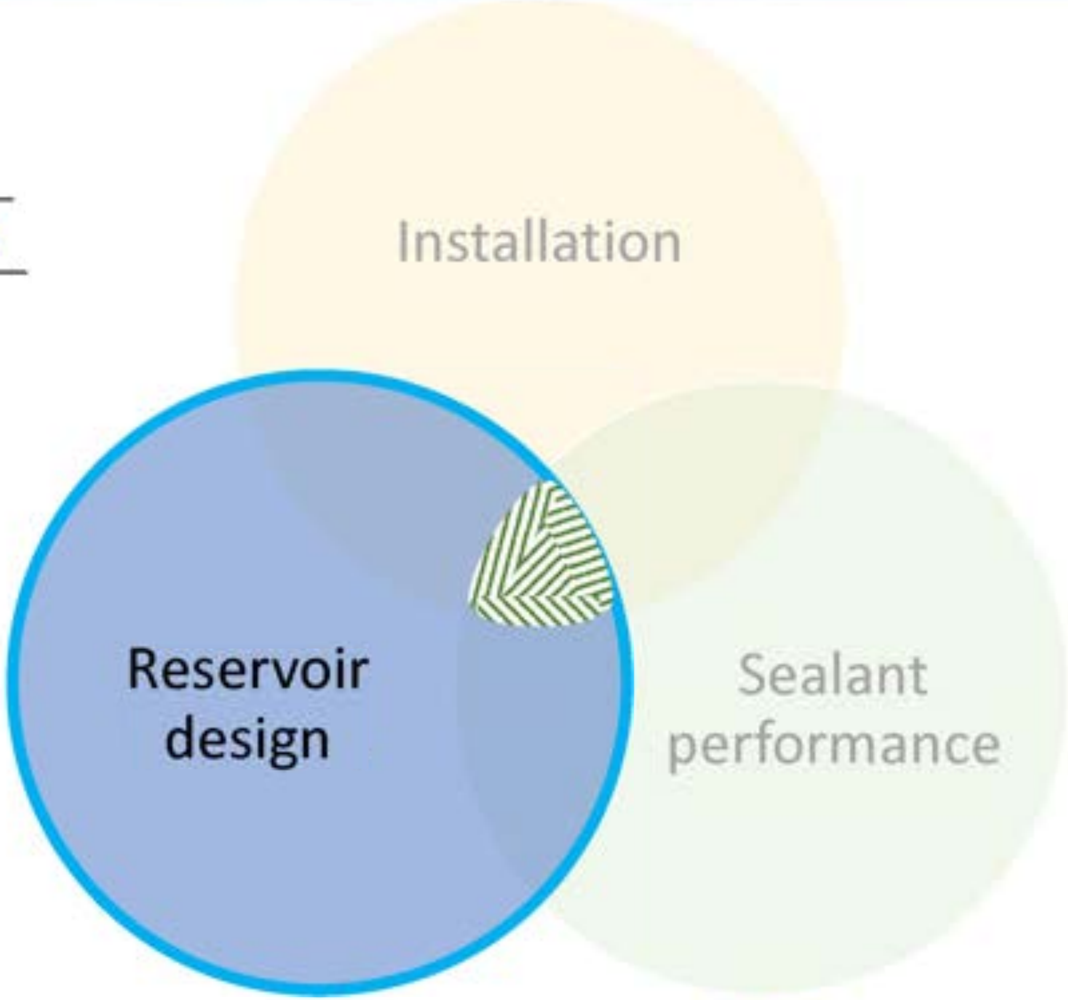
Reservoir design

- Single cut (fill)
- Reservoir

  AASHTO 93 Guide

  1. Allowable strain = $\Delta L/W$
  2. Shape factor = D/W





Task C: Transverse Jt. sealant performance

Installation

Sealant performance

Reservoir design

- Single cut (fill)
- Reservoir

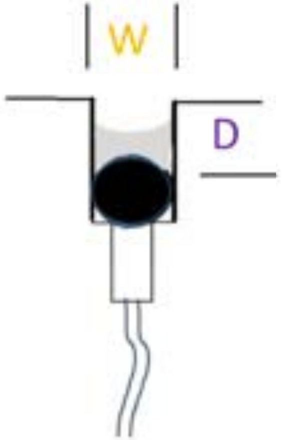
  AASHTO 93 Guide

  1. Allowable strain = ΔL/ W

     Cohessive failure

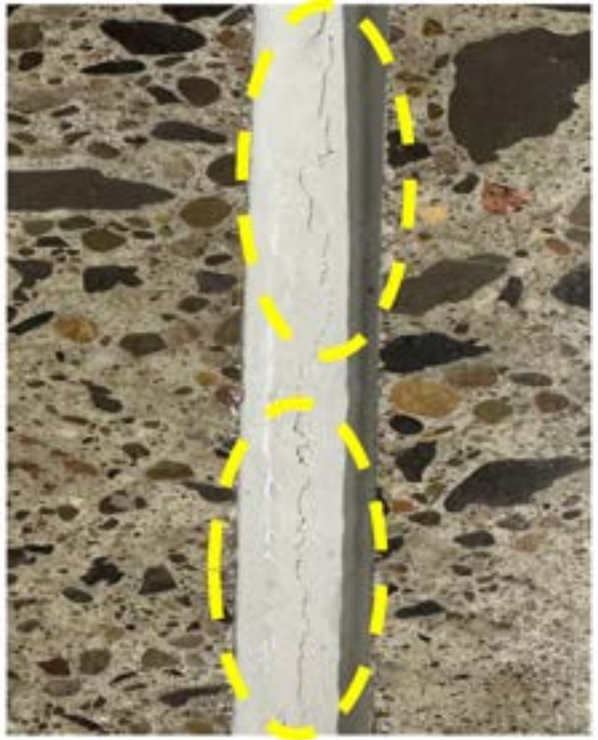
  2. Shape factor = D/W

     Adhesive failure



Adhesive Failure

Cohesive Failure



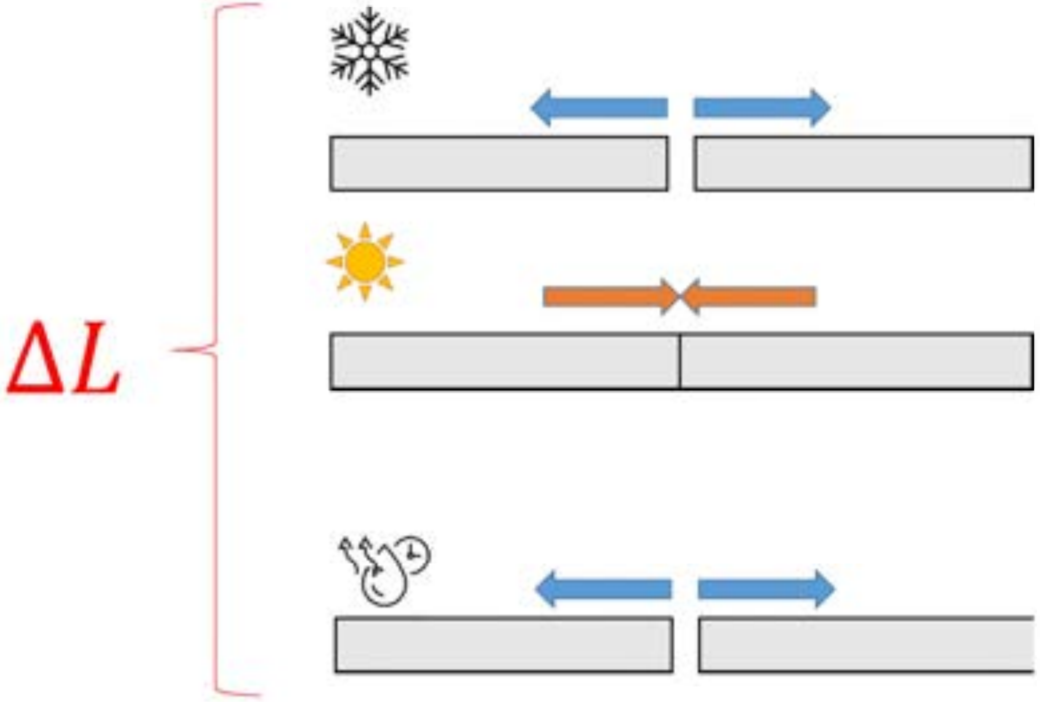
Task C: Transverse Jt. sealant performance

Installation

Sealant performance

Reservoir design

- AASHTO 93 Guide
  1. Allowable strain = ΔL/ W
  2. Shape factor = D/W



Allowable strain and Shape factor = f (sealant type)

Task C: Predicted reservoir resign width

$$\Delta L_{design(Old)} = CL(\Delta T\alpha + \varepsilon_{DS})$$

$$\Delta L_{design(New)} = L(C_{Therm}\Delta T\alpha + C_{D.S.}\varepsilon_{DS})$$ **Smart Pavement Data**

Where,

- L = 15 ft
- C_{therm} = 1 (Field value)
- ΔT = 85°F - 20°F = 65°F
- α = 5.71/°F (Lab value)
- $C_{D.S.}$ = 0.20 (Field value)
- ε_{DS} = 630 με (Lab value)
- C = 0.65 (Old value)

Therefore,

- ΔL_{design} = 0.084 in
- ΔL_{design} = 0.114 in

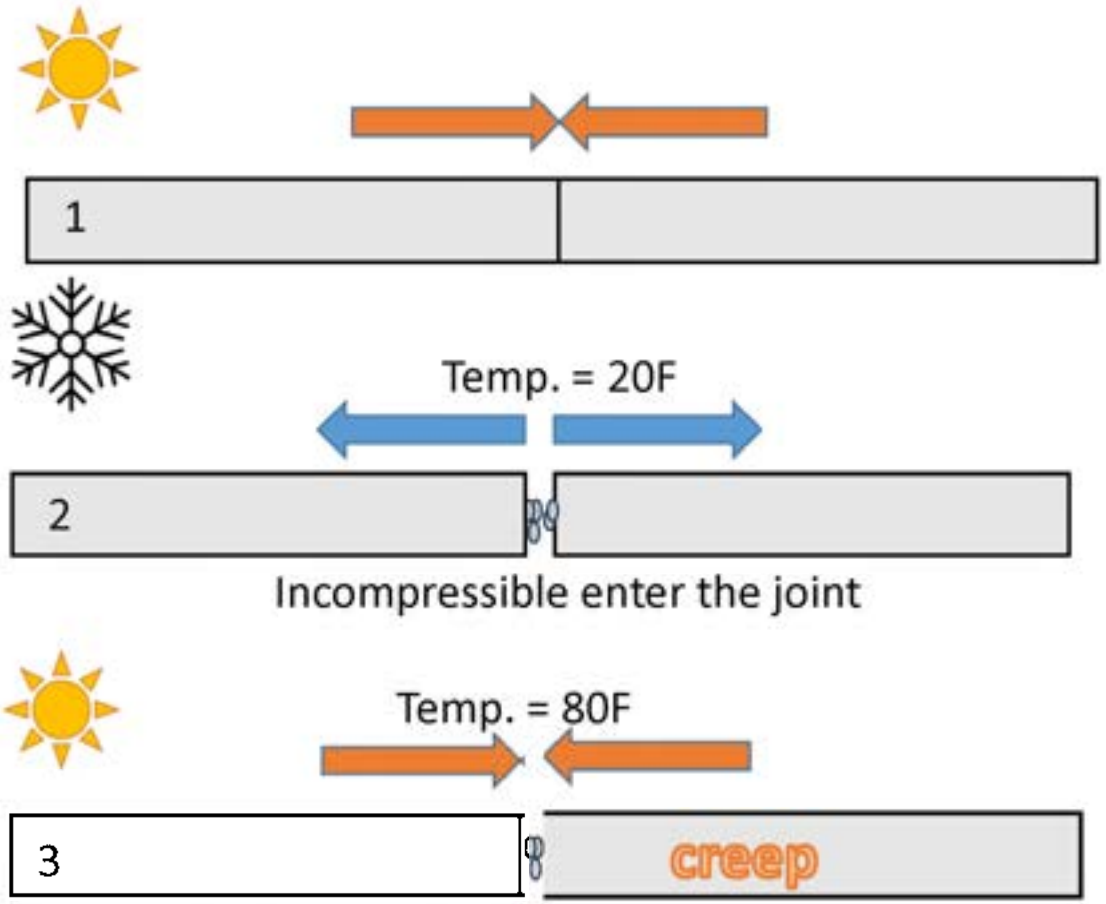
Field measured joint widths

Project	Pavement Construc. Year	Type of Sealant	Age of Pave. (Years)	Age of Sealant (Years)	Ave. Jt. Width (in)	Max. Jt. Width (in)	Min. Jt. Width (in)	Max. Jt. Opening (in)	Min. Jt. Opening (in)
A02N	2003	Type IV	18	2	0.50	0.63	0.43	0.25	0.06
A02S	2006	Type IV	15	2	0.42	0.51	0.35	0.14	-0.02
A05	2015	Type II	6	4	0.38	0.55	0.28	0.18	-0.10
A08A	2002	Type II	20	1	0.59	0.71	0.47	0.33	0.10
A10	2014	Silicone	8	8	0.54	0.59	0.43	0.21	0.06
A12A	2016	Type II	5	5	0.50	0.51	0.47	0.14	0.10
A12B	2018	Type IV	3	3	0.48	0.55	0.43	0.18	0.06

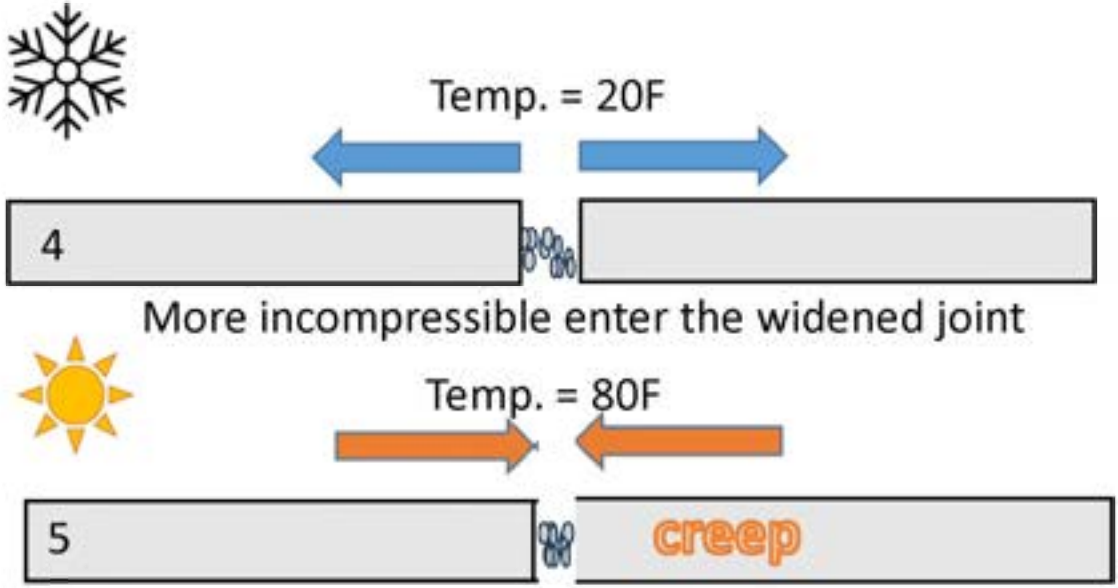
Theoretical ΔL @ 20F = 0.084 in

Thanks to Lydia Peddicord (PennDOT)

Sealant failure: joint widths can widen over time…

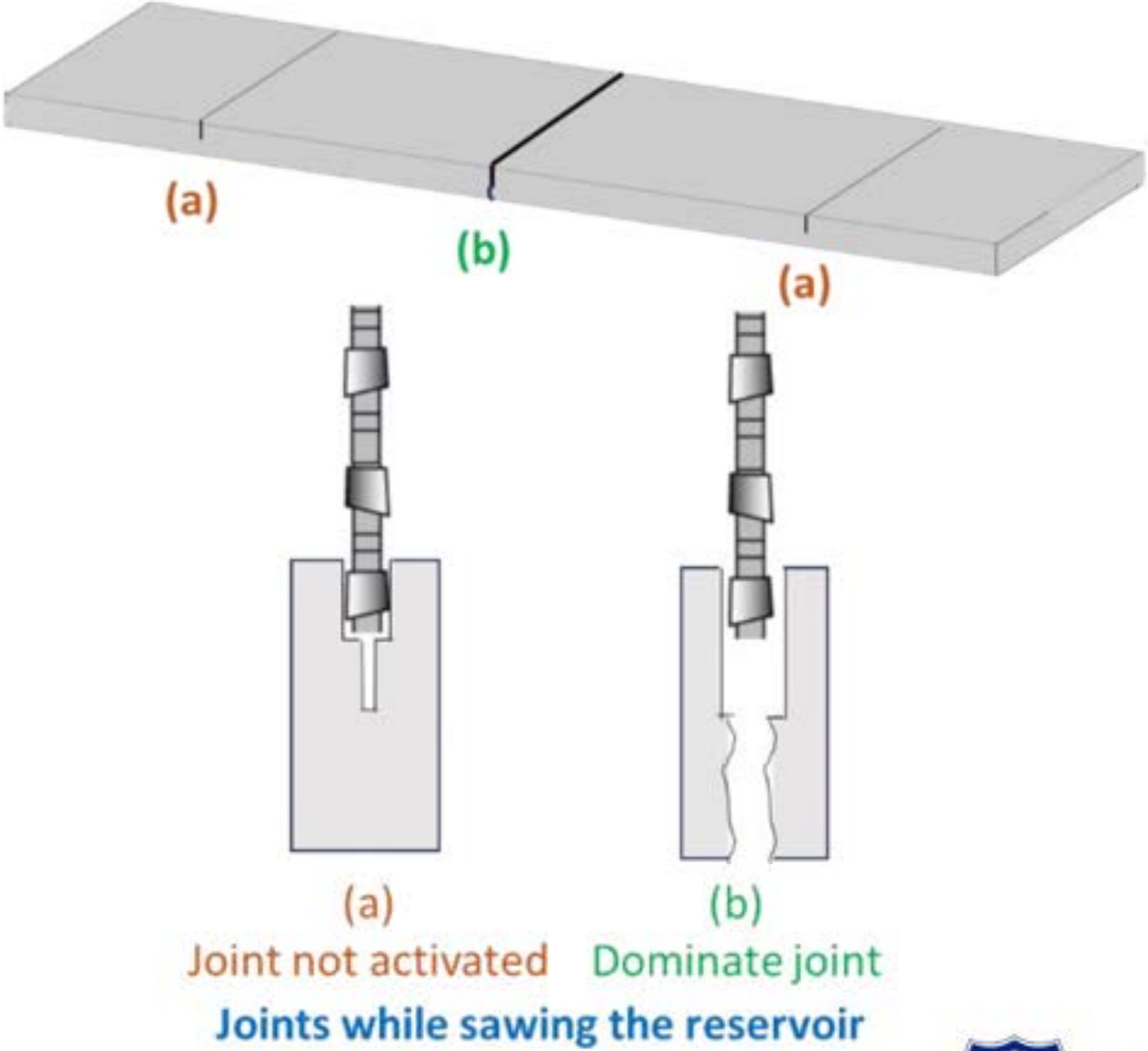


1. Incompressible restrict joint closure
2. Stress builds up
3. Stress relaxation through creep so joint width at zeros stress increases

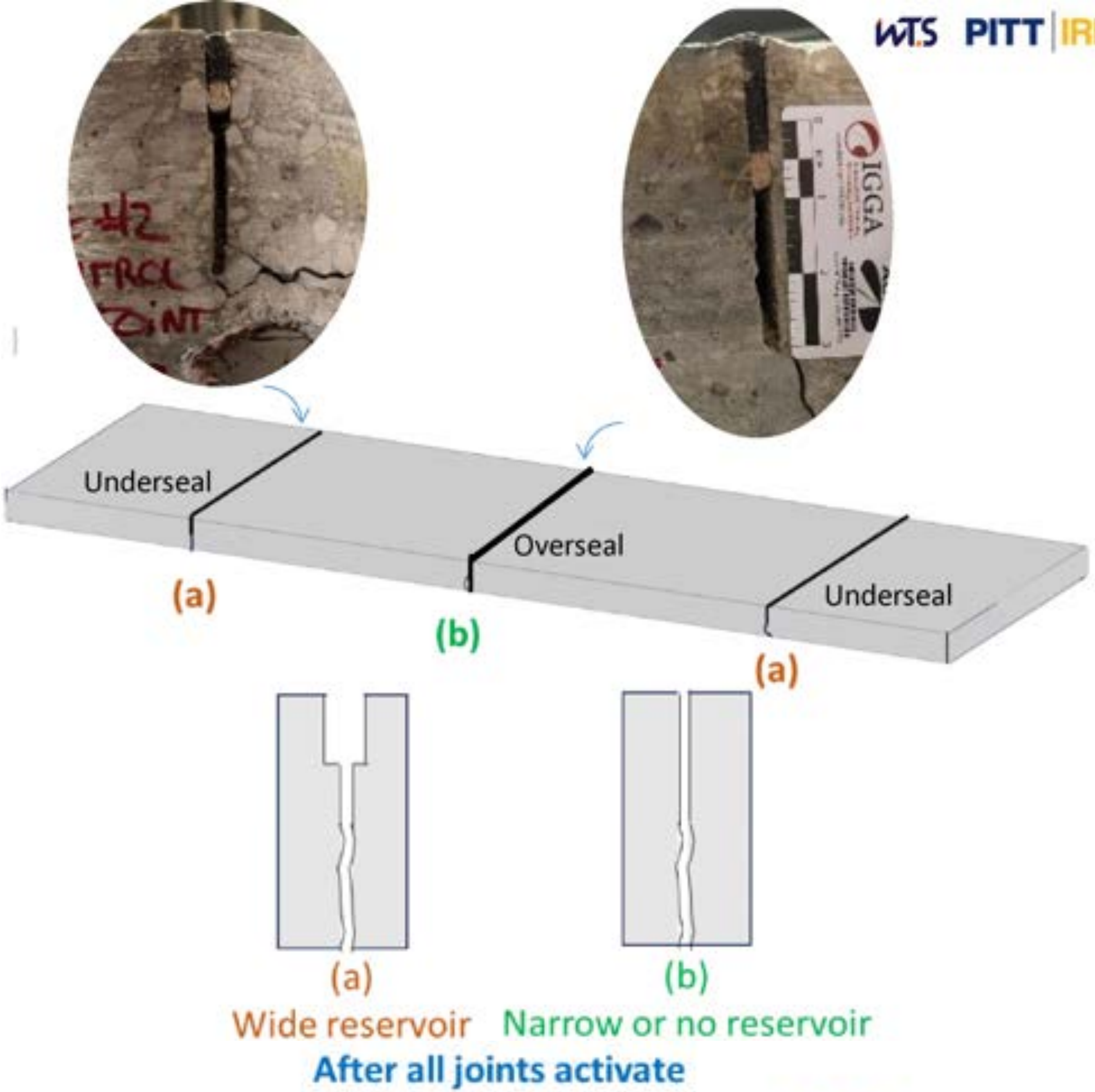


1. Incompressible restrict joint closure
2. Stress builds up
3. Stress relaxation through creep so joint width at zeros stress increases again

Sealant failure: dominant joints



Sealant failure: dominant joints



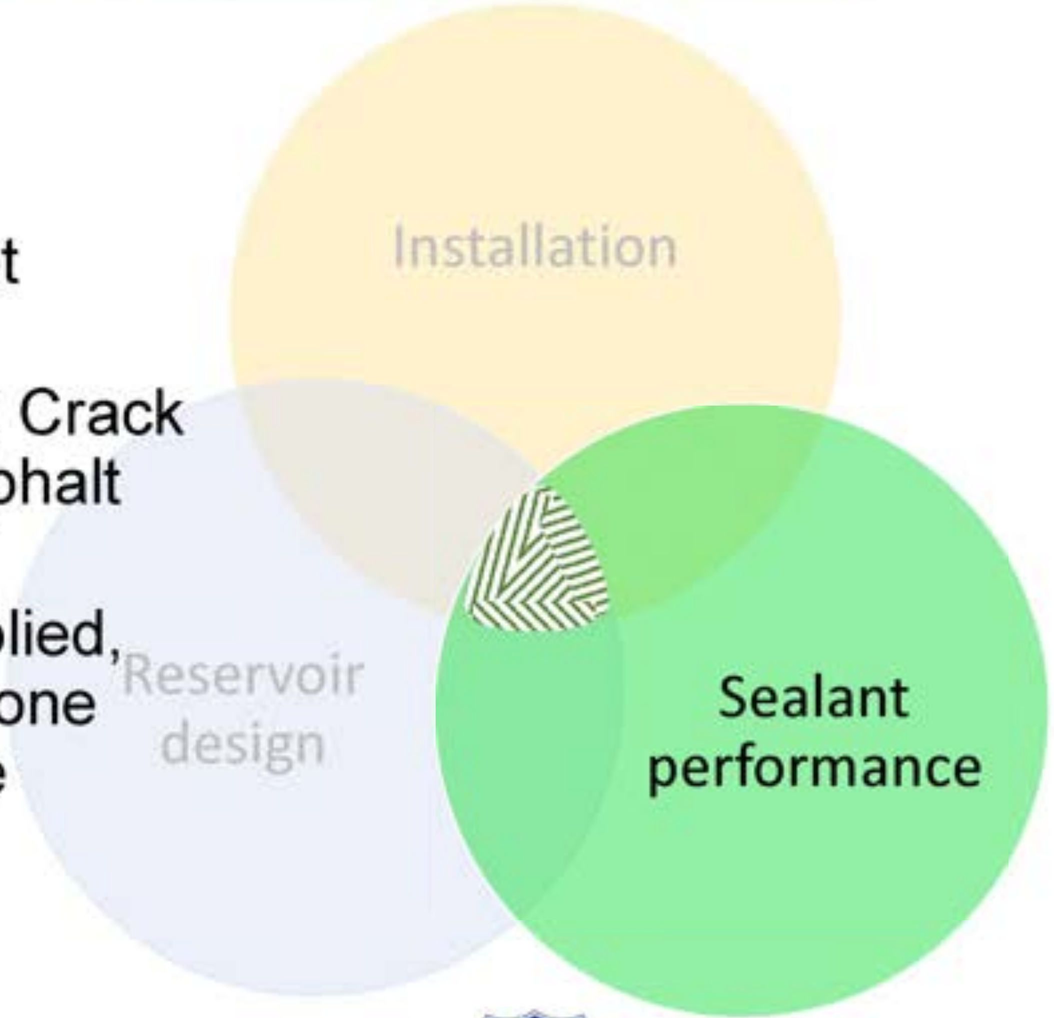
Transverse Jt. sealant performance

Installation

Sealant performance

- Silicone vs ~~Type II and~~ Type IV (Type IV still not performing as previous?)
  - ASTM D6690: Standard Spec. for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
  - ASTM D5893: Standard Spec. for Cold-Applied, Single-Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

Reservoir design



Sealant materials

Sealant meets material specs/performance requirements

- Adhesion/cohesion requirements in ASTM 5329
- Closed-cell backer rod
- **Fatigue exposure typically not considered**

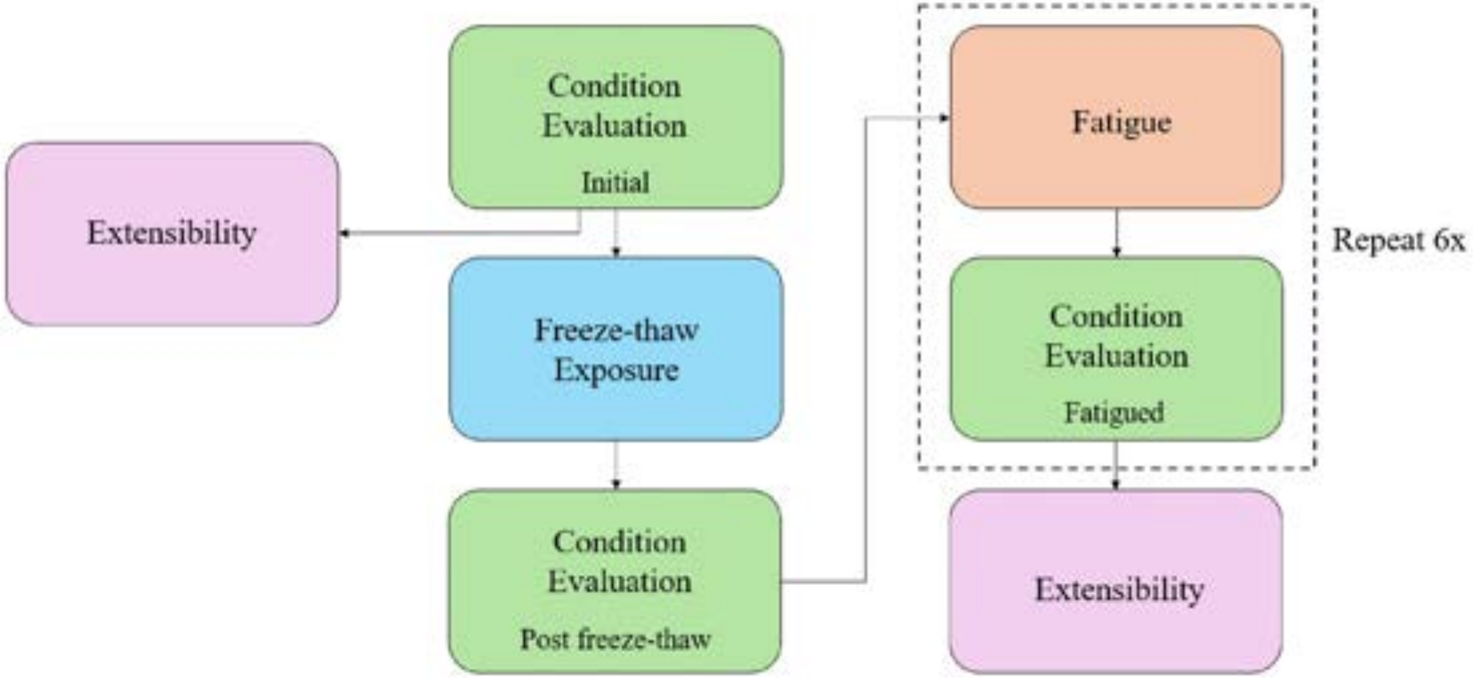
Objective 1: Characterize 42 yrs of simulated fatigue

Simulated field conditions:

- Exposure:
  - Freeze-thaw cycles
- Fatigue
  - Joint opening/closing (thermal loading)
  - Vertical (vehicle loading)

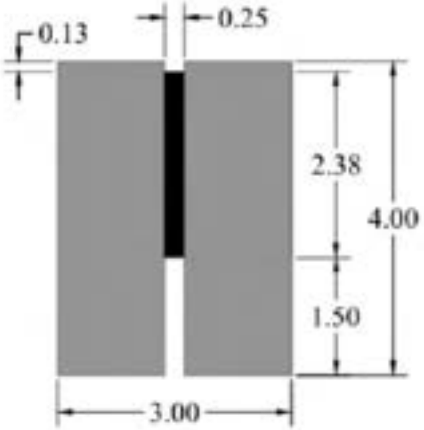
Condition assessment:

- Joint permeability
- Sealant stiffness

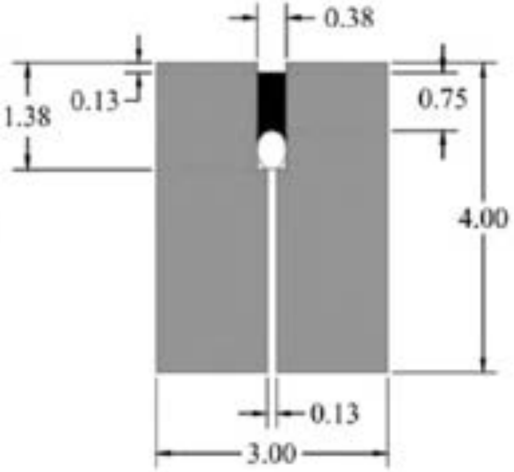


Joint designs and materials

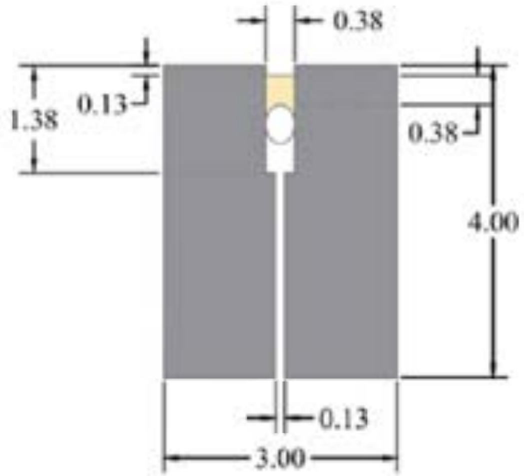
- Asphalt: P&T Products Dura-Fill 3405 LM (K)
- Silicone: Sikasil 728 Non-Sag Silicone Sealant
- Asphalt filled
  - ACPA recommendation
  - Sealant W:D = 1:9.5
- Asphalt reservoir
  - Detail D Pub 72M
  - Sealant W:D = 1:2
- Silicone reservoir
  - Joint Type P Pub 72M
  - Sealant W:D = 1:1



Asphalt filled



Asphalt reservoir

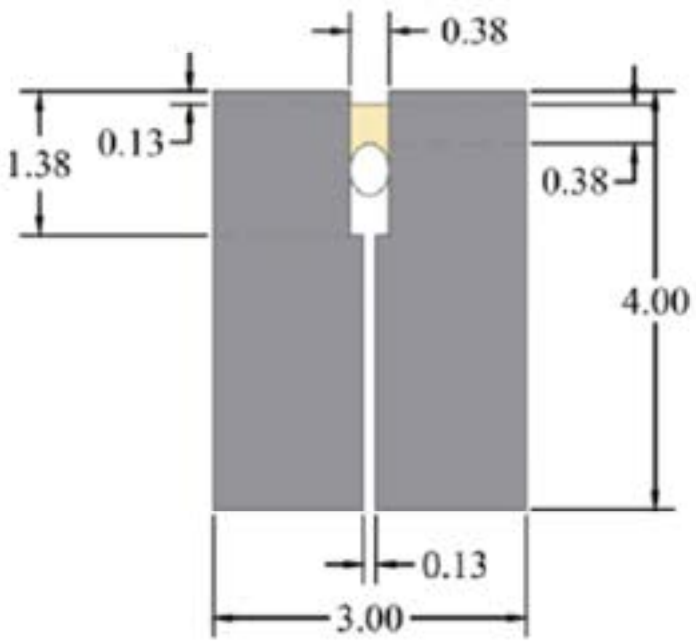


Silicone reservoir

Joint designs and materials

Pavement CamoSeal by Main Street Materials

- Caltrans Approved (Recently)
- Joint Type P Pub. 72M
- Sealant W:D = 1:1



Joint designs and materials

Pavement CamoSeal by Main Street Materials

- Poor performance in preliminary testing
- Joint opening/closing: immediate adhesive & cohesive failure
- Vehicle loading: immediate cohesive failure


Manufacturer suggested different blend better suited for colder climates

Joint designs and materials

Pavement CamoSeal by Main Street Materials

- Poor performance in preli ng
- Joint opening/closing: i adhesive & cohesive f
- Vehicle loading: imme ohesive failure

Manufacturer suggest rent blend better suited for c climates

Fatigue – Joint Opening/Closing

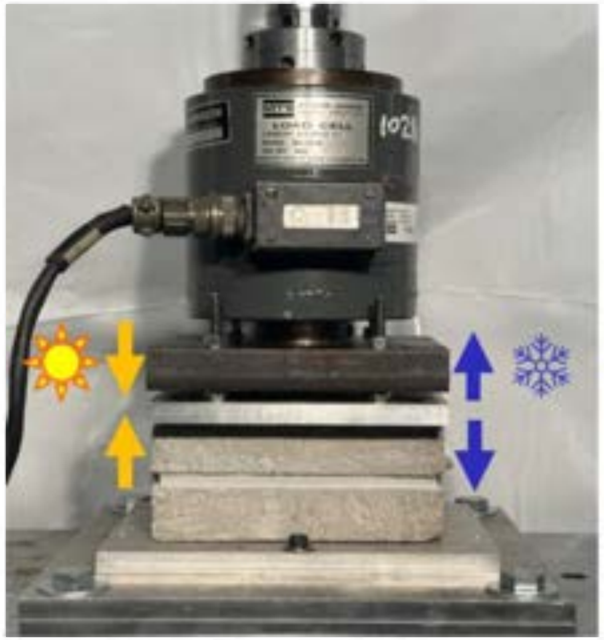
Initial protocol:

- Cycle between +53 and +78 mils (SR-22 TC data: ave. daily low -1 std dev ~ ave. daily high +1 std. dev.)
- 5,100 cycles (~42 yrs)

No damage accumulation under typical conditions

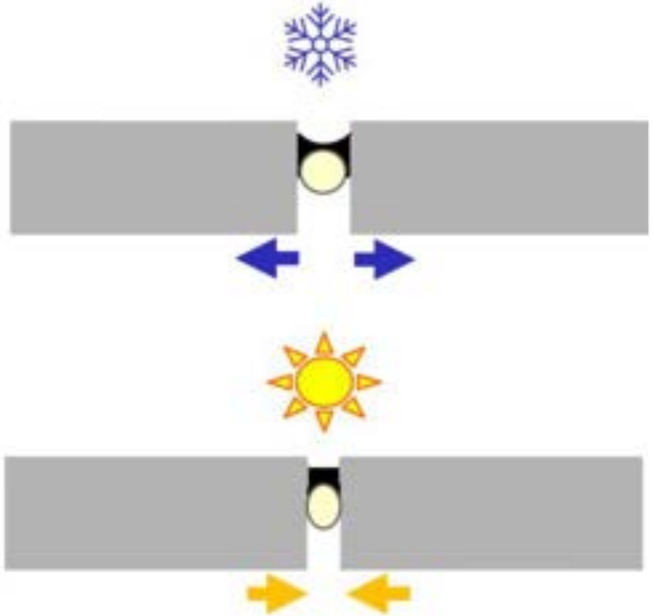
Revised protocol:

- Cycle between +53 and +186 mils (PennDOT joint sealant survey)



- Haversine wave @ 1 Hz
- Test temp. = 20°F

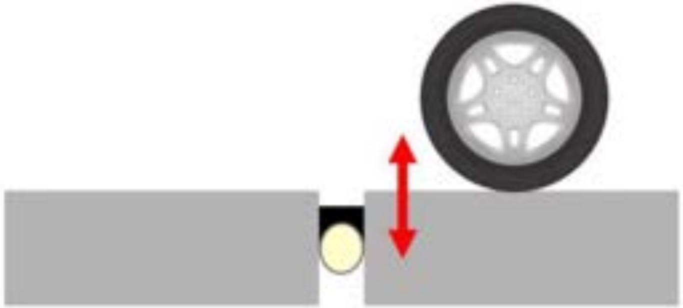
Joint opening Nov. – Feb. months



Fatigue – Vehicle loading

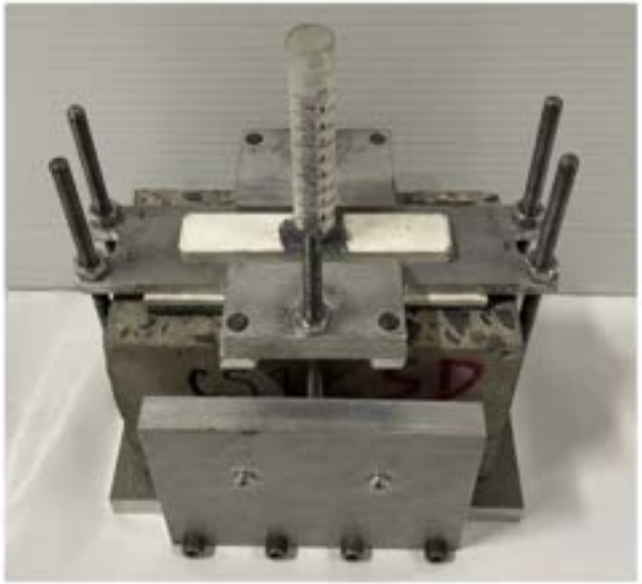
- Cycle +/- 10 mils
- 42 years (30,000 cycles @ 5 Hz
- Haversine wave
- Test temp. = 20°F

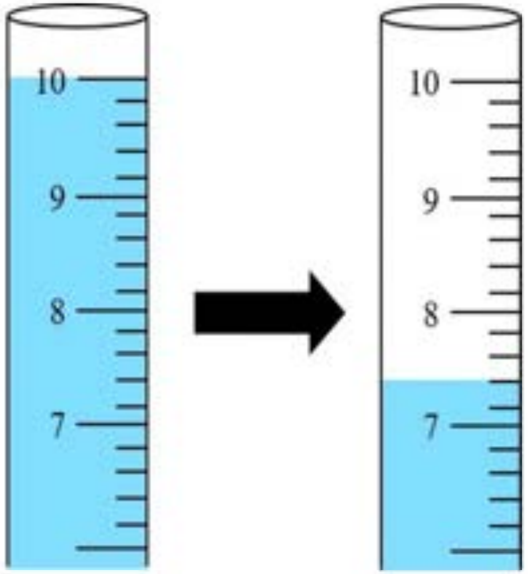
Vehicle loads

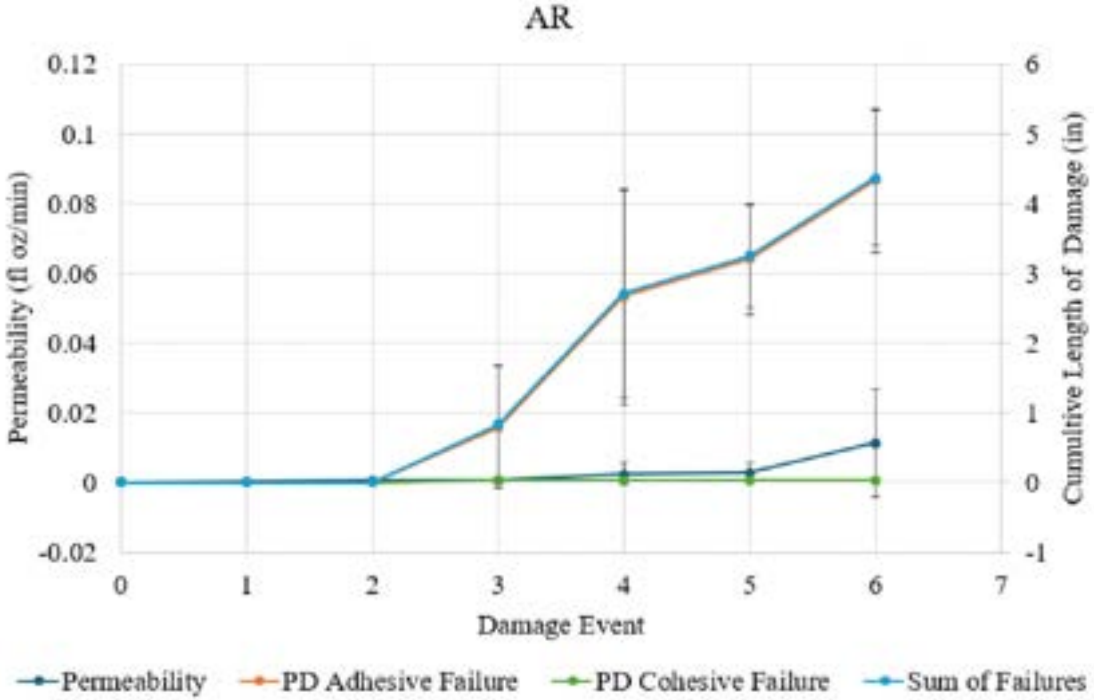


Condition Evaluation: joint permeability

Permeability Apparatus

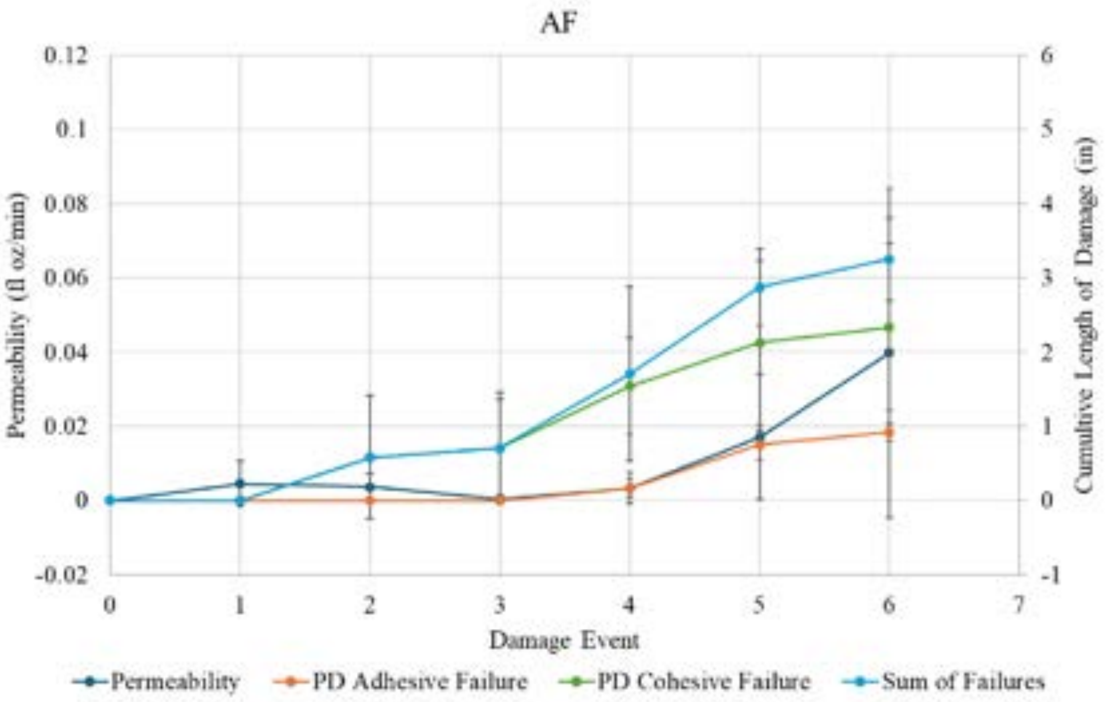






Findings: Permeability and damage accumulation

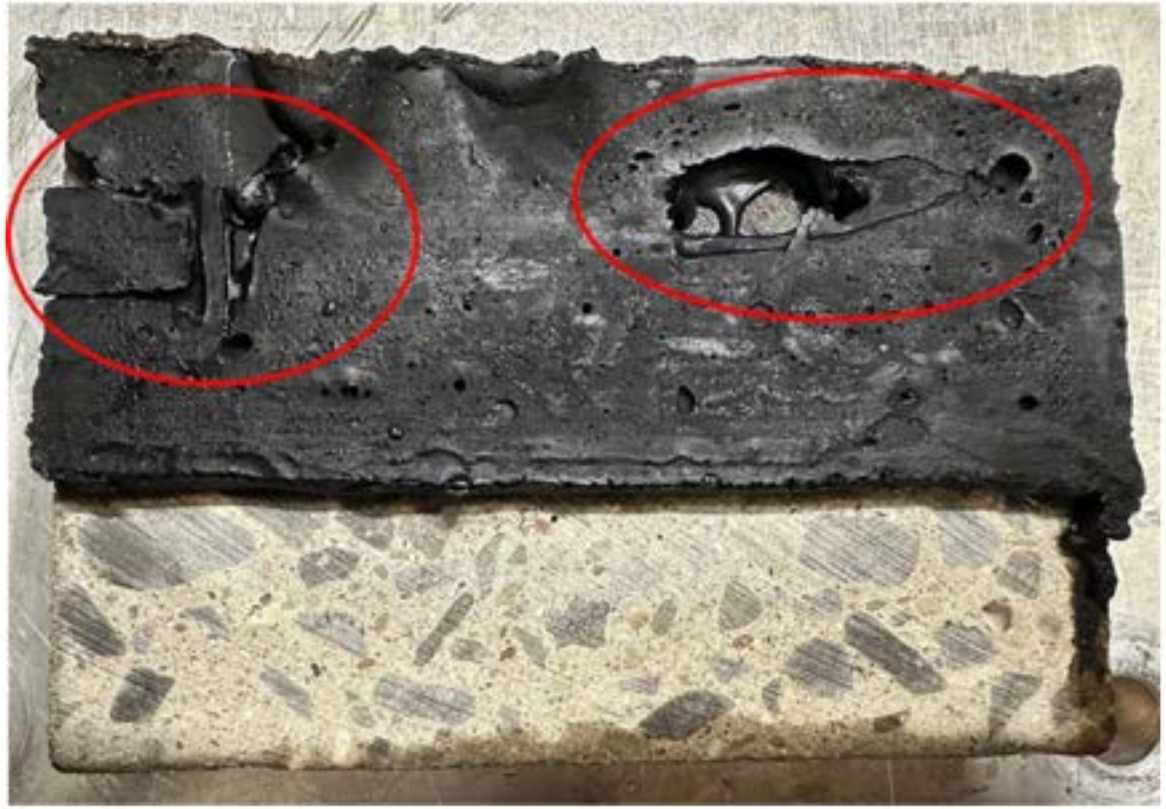
- Damage does not occur due to vehicle loading
- Asphalt filled
  - PD adhesive & cohesive damage
- Asphalt reservoir
  - PD adhesive damage
- Silicone reservoir
  - Minimal damage
  - FD adhesive failure from poor seal
  - Minimal change in permeability



Findings: sealant stiffness

- Variability in asphalt filled joint performance
- Difficult to fully fill narrow joint
- Voids/gaps in bulk sealant
- Lower apparent stiffness

Imperfections in sealant for asphalt filled joint



Findings: Extensibility

- Typical joint openings (0.04 to 0.07 in) sufficiently large to fail asphalt filled joint
- Performance better for silicone reservoir design than asphalt designs

Loss in performance from oxidation not considered

Acknowledgements

- IRISE Consortium members
- Edward Skorpinski (PA Turnpike Commission)
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- Lydia Peddicord (PennDOT)
- Tom Bryan (Bryan Concrete) and Justin Bryan (Neville Aggregates)
- Jack Parkhurst (University of Pittsburgh)
- Katey Doman (Tye Bar)

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Thank you

Questions?

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