



Update on Kansas Research

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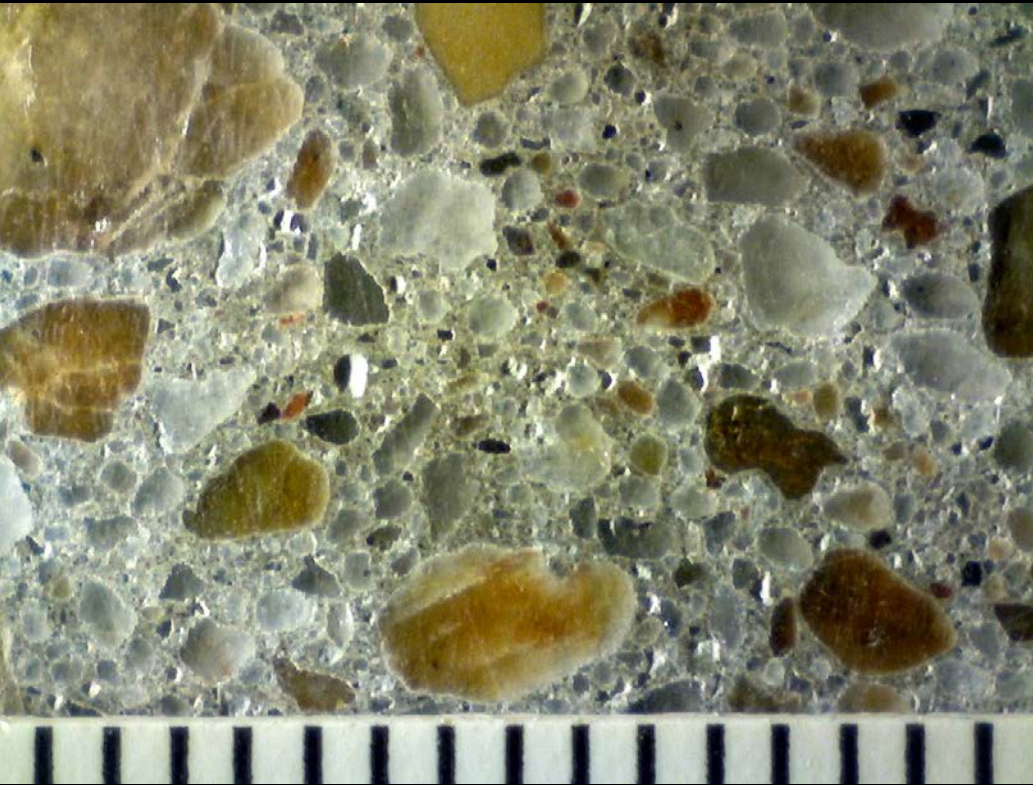
KDOT Research Teamwork

Randy Billinger, Luke Rosdahl, Matt Stadler, Mike Feiden, Geary Beeson, Jeff Henderson, Steve Beale, Andrew Jenkins, Jennifer Distlehorst, Ralph Pollock, Rod Montney, District 2



Outline

- The Kansas Special Pavement Section (SPS-2) Site for structural performance
- D-Cracking



SPS-2 in Kansas

Historical Overview

- SPS-2 structural performance study -
Examines effect of:
 - Climate
 - Traffic
 - Thickness
 - Base type
 - Lane Width
 - Strength
- I-70 Dickinson County near Abilene, KS
- Construction 1992

Opportunity Knocks

- What can we learn about the field performance of materials?

Concrete Mix Designs

Design Flex, psi	550	900	600
Cement, lb/yd ³	532	862	620
W/C	0.50	0.35	0.41
Air, %	6.5%	4.1%	6.0%

Coarse Aggregate - Limestone

- Quarry 2-021-03 in Dickinson Co.
- Beds 1,2,3,4,5 Towanda ledge
- Production Test Results (F/T to 300 cycles)

Mod S	Exp, %	DF
0.94	0.009	100
0.94	0.006	99
0.97	0.011	99

- KDOT Spec Limits in 1992:
 - Class 1 - 0.80, 0.025, 95
 - Class 2 – 0.80, 0.015, 98

Coarse Aggregate – Sandstone

- Calcite Cemented Sandstone
- Quarry 2-053-01
- Currently approved under new F/T testing specification (660 cycles)

Fine Aggregate

- Konza Sand, Junction City S13 T11S R5E Geary Co
- One of most ASR reactive sands in Kansas
- KTMR-23 results:

Days	Modulus of Rupture, psi	Expansion, %
180	653	0.036
365	354	0.089

MOR minimum = 550 psi

Exp max @ 180 = 0.050%

Exp max @ 365 days = 0.070%

Maintenance

- 2011 – Joint repair, stitching, crack sealing, crack filling

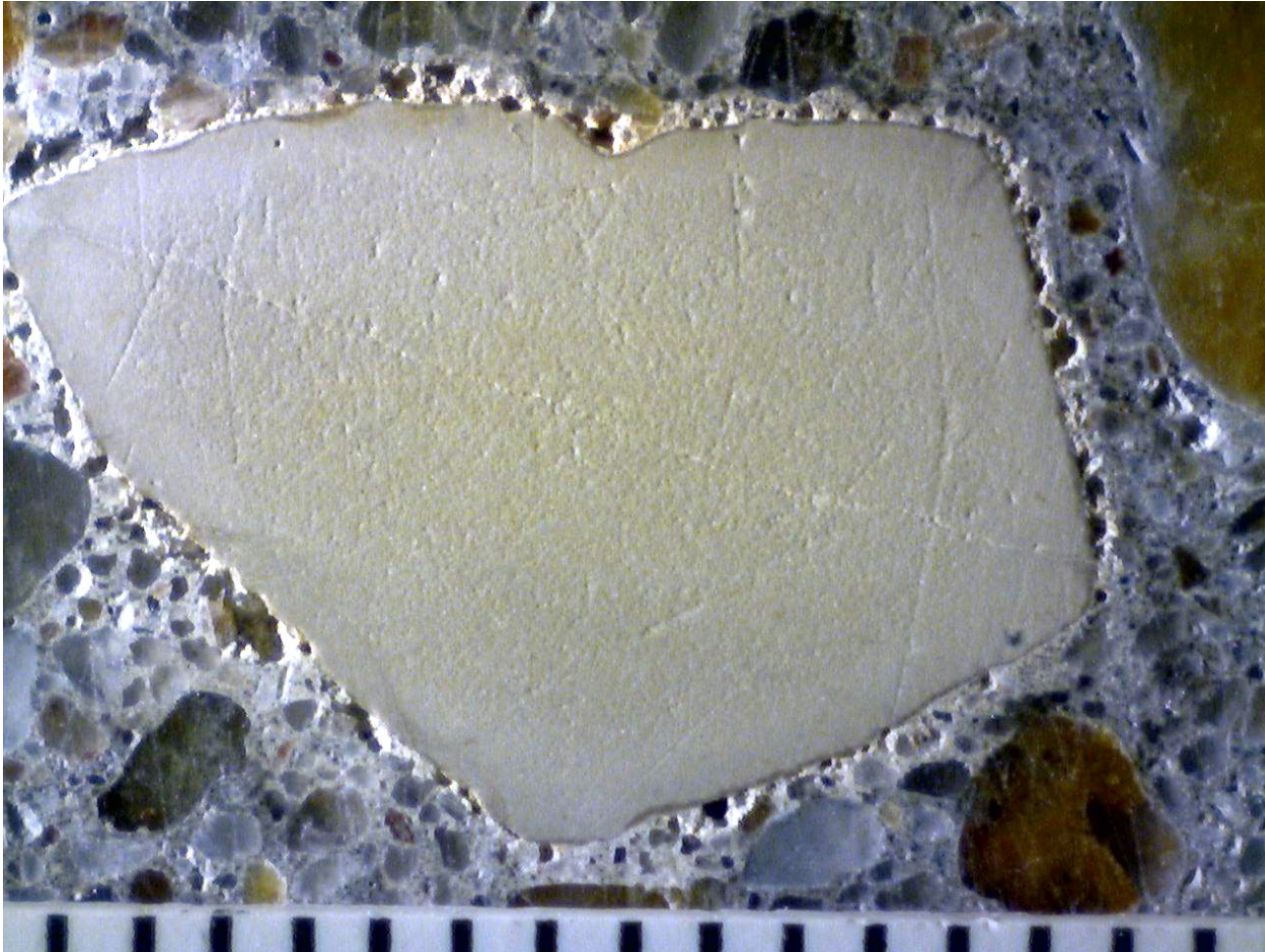
2013 KDOT Coring Effort

Section	Mix Design	Number of Cores	Boil Top 2 in. RCP Next 2 in.	RCP Top 2 in. Boil Next 2 in.	Strength	Hard Air	ASR
200203	550	4	1	1	1	1	
200204	900	4	1	1	1	1 *	1 *
200201	550	4	1	1	1	1	
200202	900	4	1	1	1	1 *	1 *
200206	900	4	1	1	1	1 *	1 *
200205	550	4	1	1	1	1	
200207	550	4	1	1	1	1	
200208	900	6	1	1	1	1	2
200212	900	6	1	1	1	1	2
200211	550	4	1	1	1	1	
200210	900	4	1	1	1	1 *	1 *
200209	550	4	1	1	1	1	
200213	600	12	3	3	3	3	
"Project"	600	8	2	2	2	2	

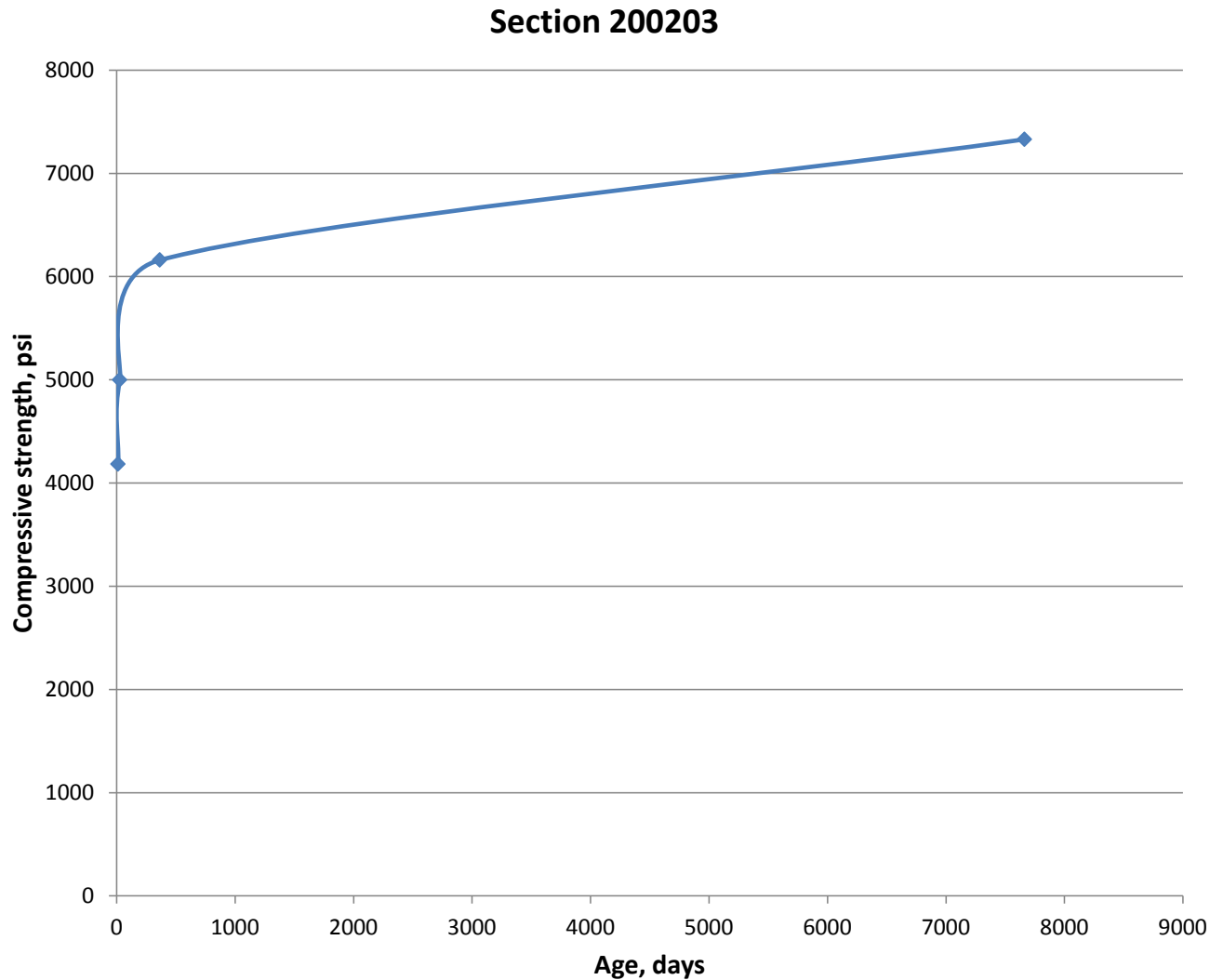


Results

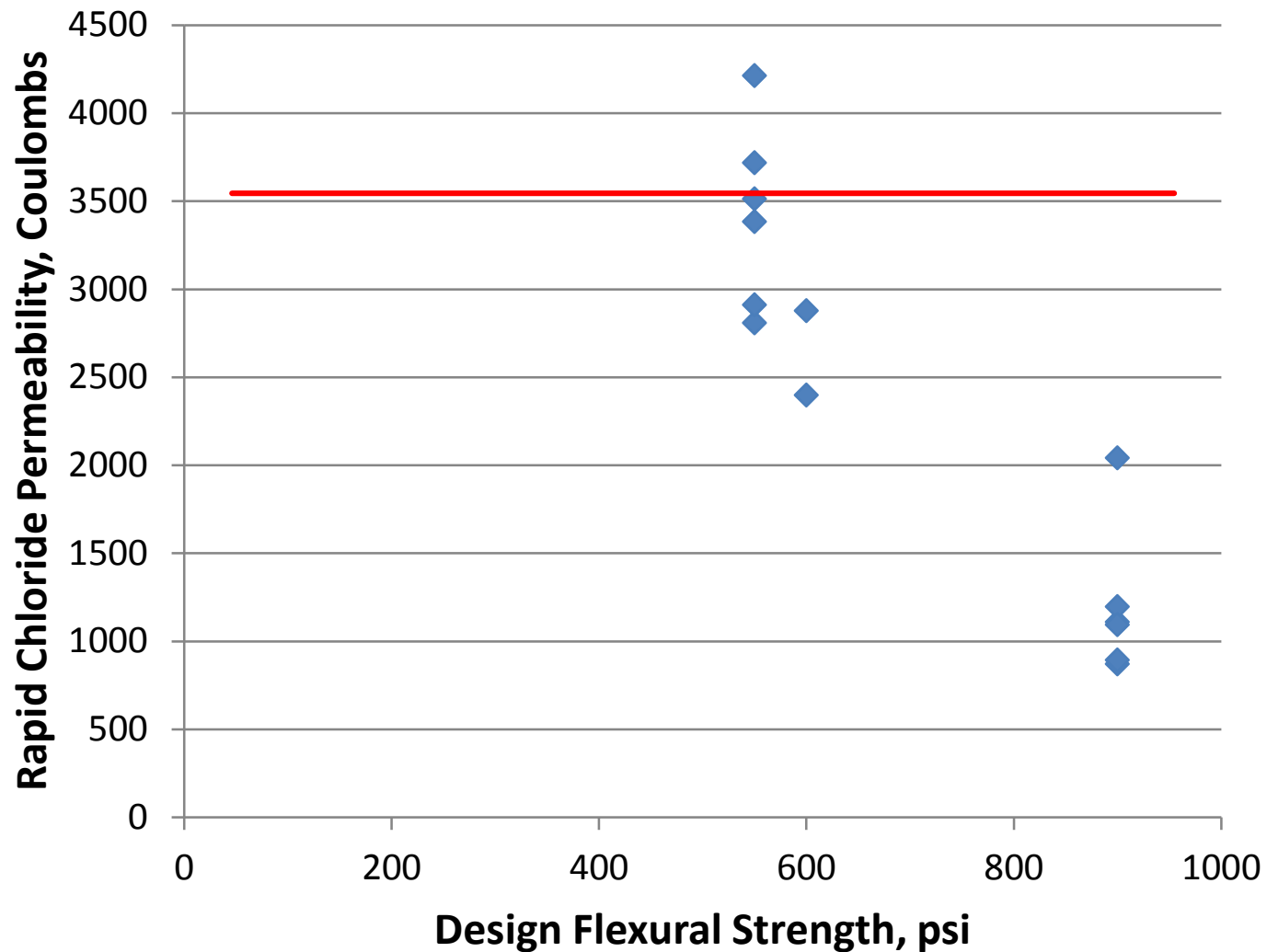
Permeability



Compressive Strength



RCP at 20 years



ASTM C457 Hardened Air

- Patching vs. No Patching



1993 EB Lanes



- Significant paste-related freeze/thaw deterioration
- Longitudinal and transverse joints

1993 Construction of EB

- Vertical planes of failure
- Close to joint

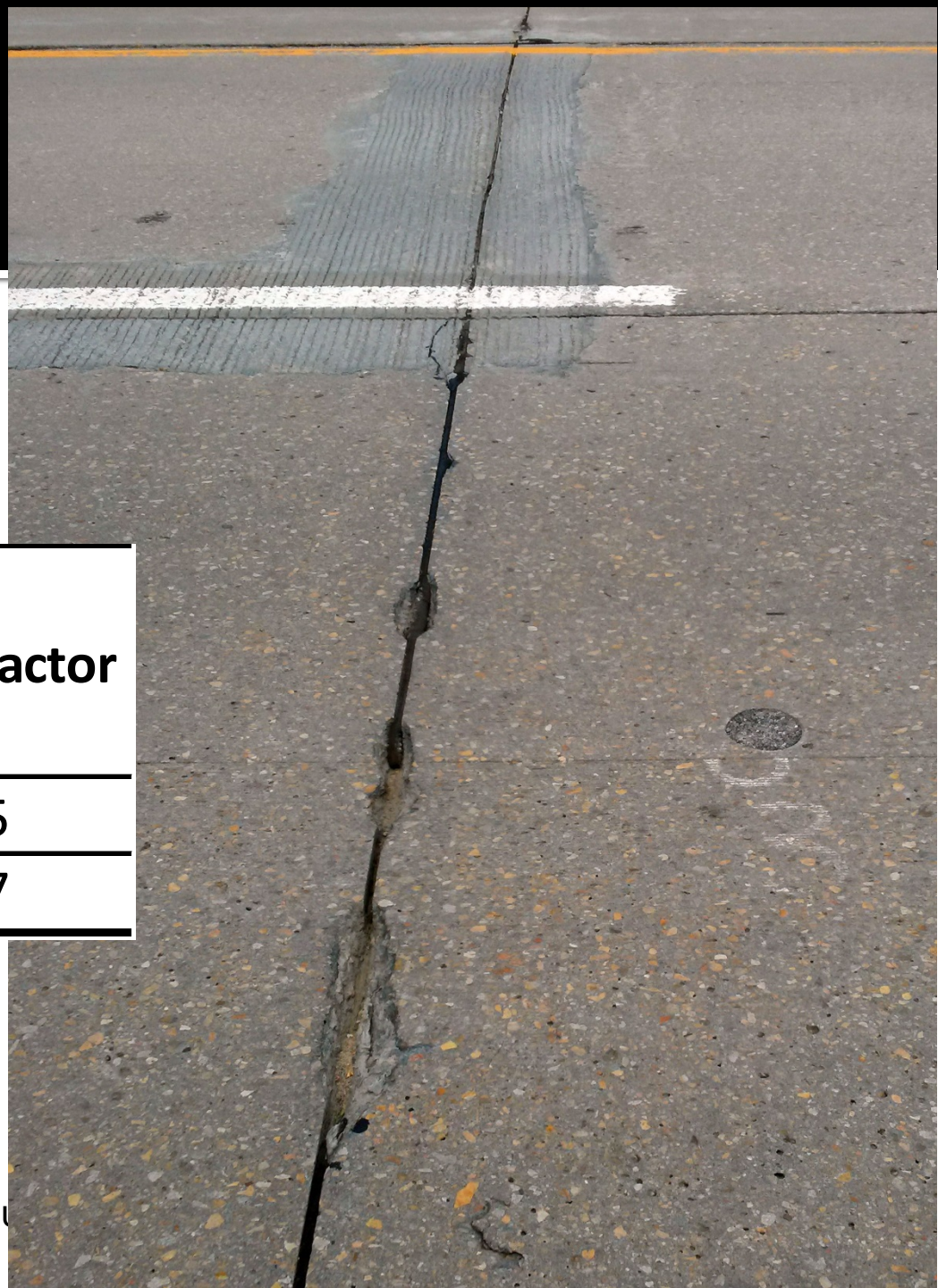




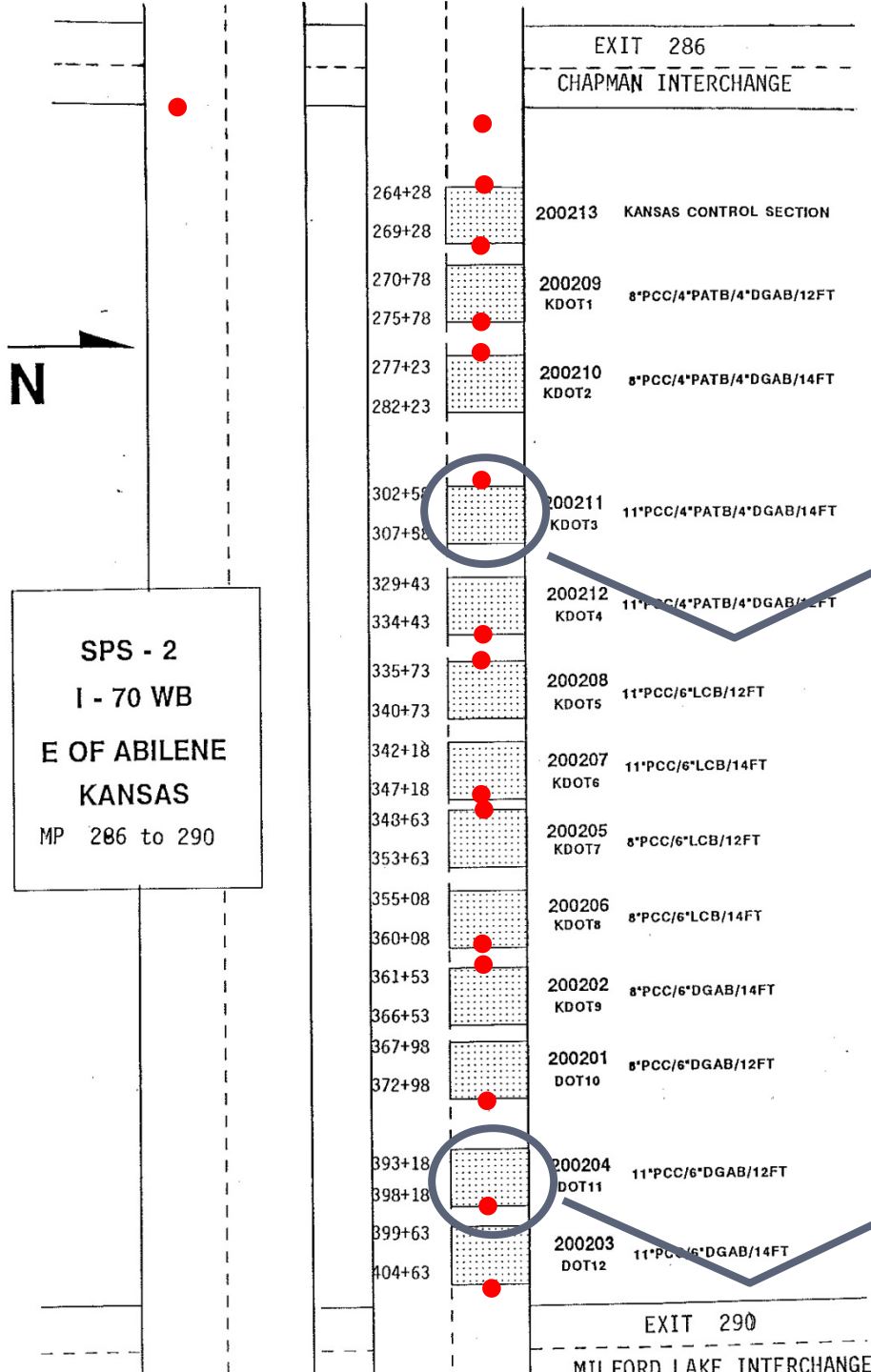
1993 EB Lanes

- ASTM C-457¹

Sample	Total Air %	Spacing Factor mm
Core 3	4.9	0.285
Core 4	4.8	0.187



¹Distlehorst, AVA 20-Year Follow Up Study, U



Core location – patching
Section – no patching

Core location – no map cracking
Section – map cracking starting
panels 3-4



Lessons Learned

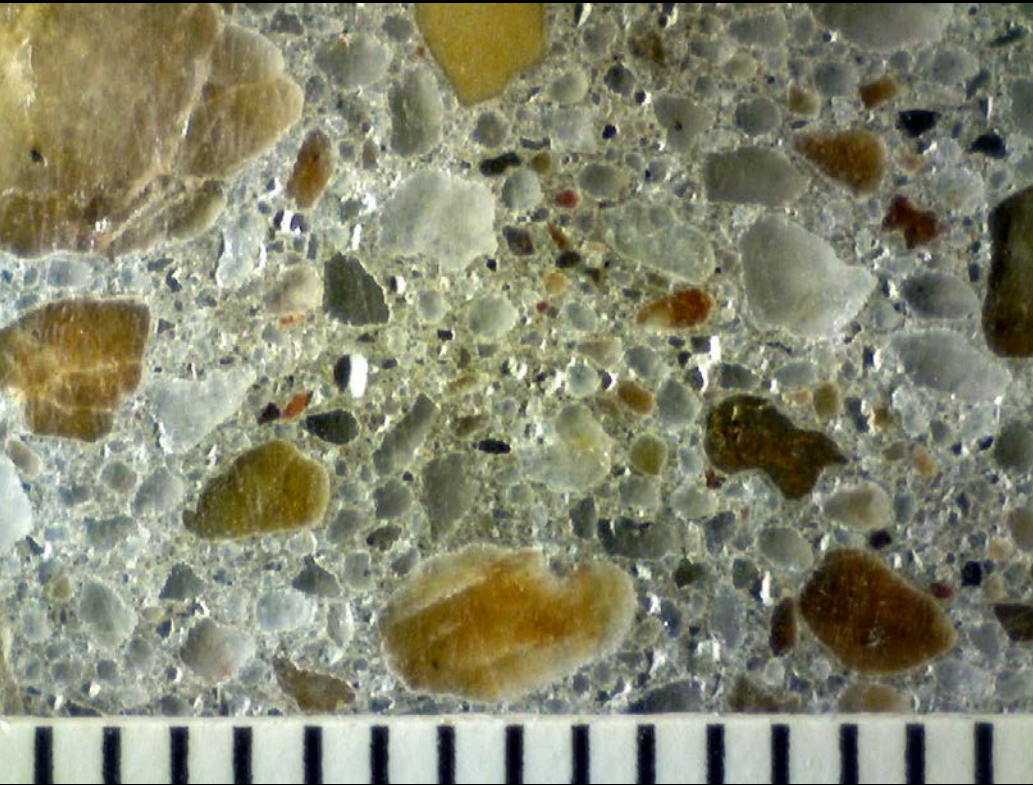
- Kansas does have limestone that will last 20 years. No D-cracking observed.

Lessons Learned

- Example of concrete with low air and high spacing factors can last 20 years
- Appears we may be overdesigning PCCP thickness by as much as 50%

States with SPS-2 Sites

- Arizona, Arkansas, California, Colorado, Delaware, Kansas, Iowa, Michigan, Nevada, North Carolina, North Dakota, Ohio, Washington, Wisconsin

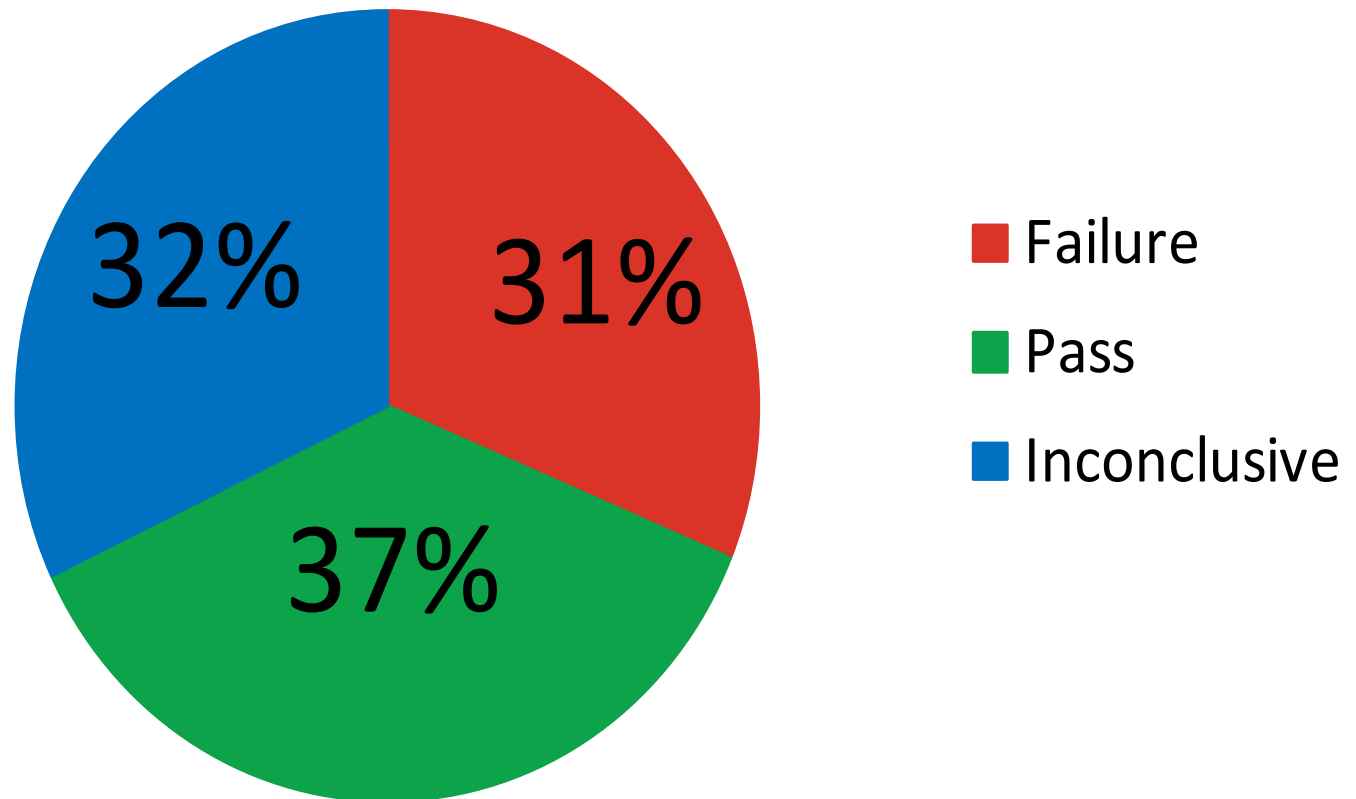


D-Cracking

Overview of 2010 Study

- Systematic surveys of 1100 miles of PCCP
- 131 projects
- >2100 lane-miles
- 10-30 years old
- Criteria
- Petrographic verification
- Not always traditional bottom-up
- Standards have increased

Results



D-Cracked

54 Projects, 41%
[693 lane-miles, 32%]

Not D-Cracked

77 Projects, 59%
[1440 lane-miles, 68%]

<20yr Life

83 Projects, 63%
[1401 lane-miles, 66%]

FAIL

41 Projects, 31%
[523 lane-miles, 25%]

INCONCLUSIVE

42 Projects, 32%
[878 lane-miles, 42%]

>20yr Life

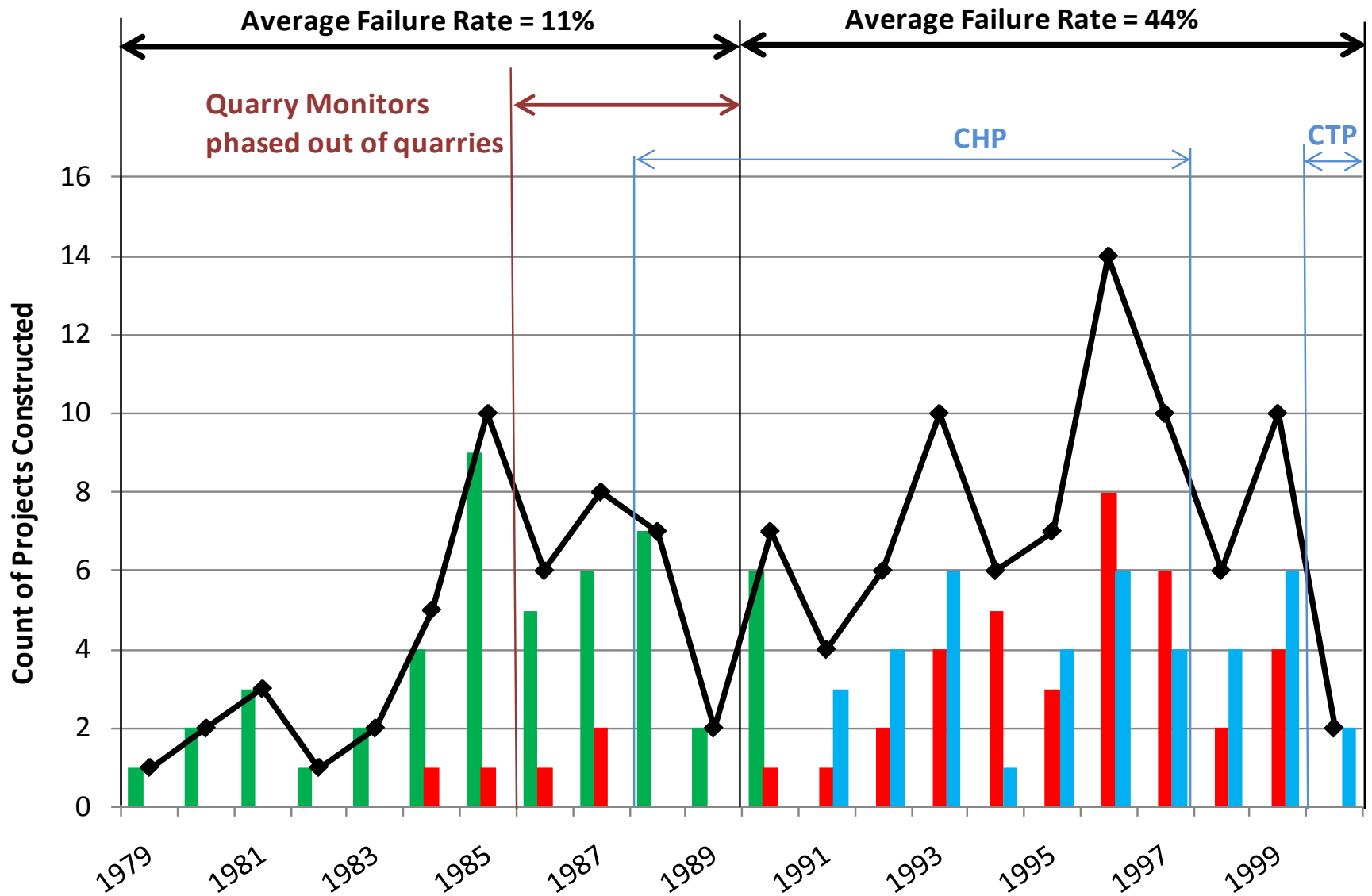
48 Projects, 37%
[732, lane-miles, 34%]

PASS

13 Projects, 10%
[170 lane-miles, 8%]

PASS

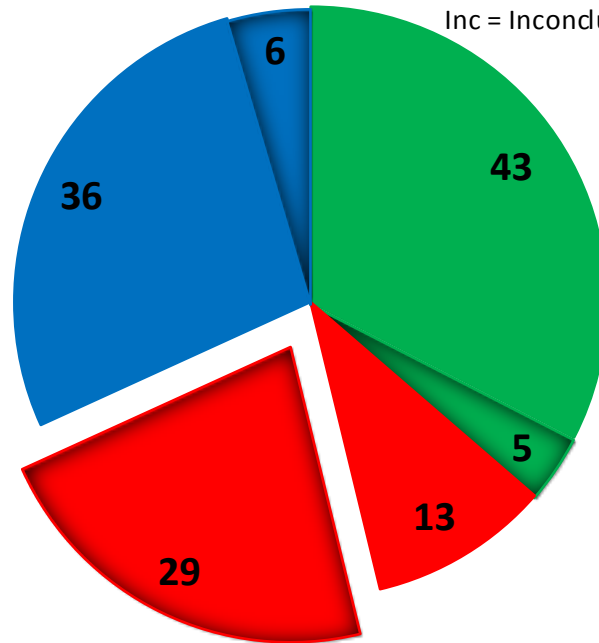
35 Projects, 26%
[562 lane-miles, 26%]



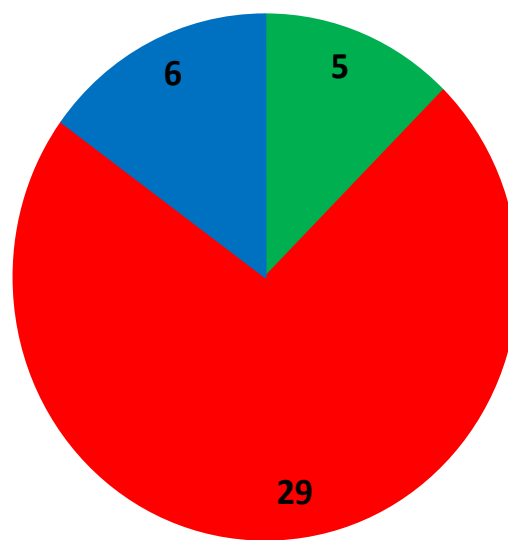
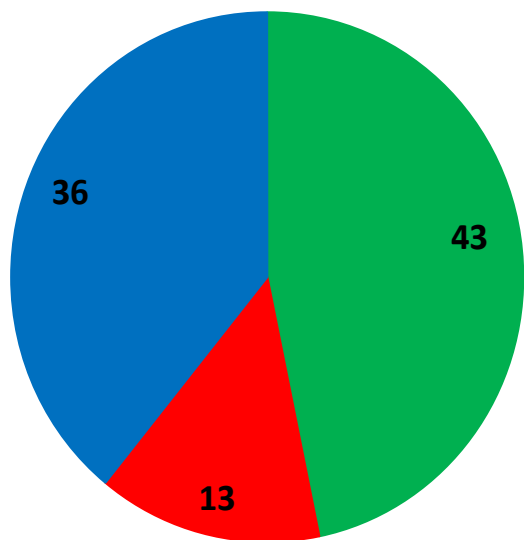
CHP = Comprehensive Highway Program 1988-1997
CTP = Comprehensive Transportation Program 2000-2009

Pass Fail Inc Total

A = Quarry with acceptable performance history
U = Quarry with unacceptable performance history
Inc = Inconclusive, < 20 yrs old

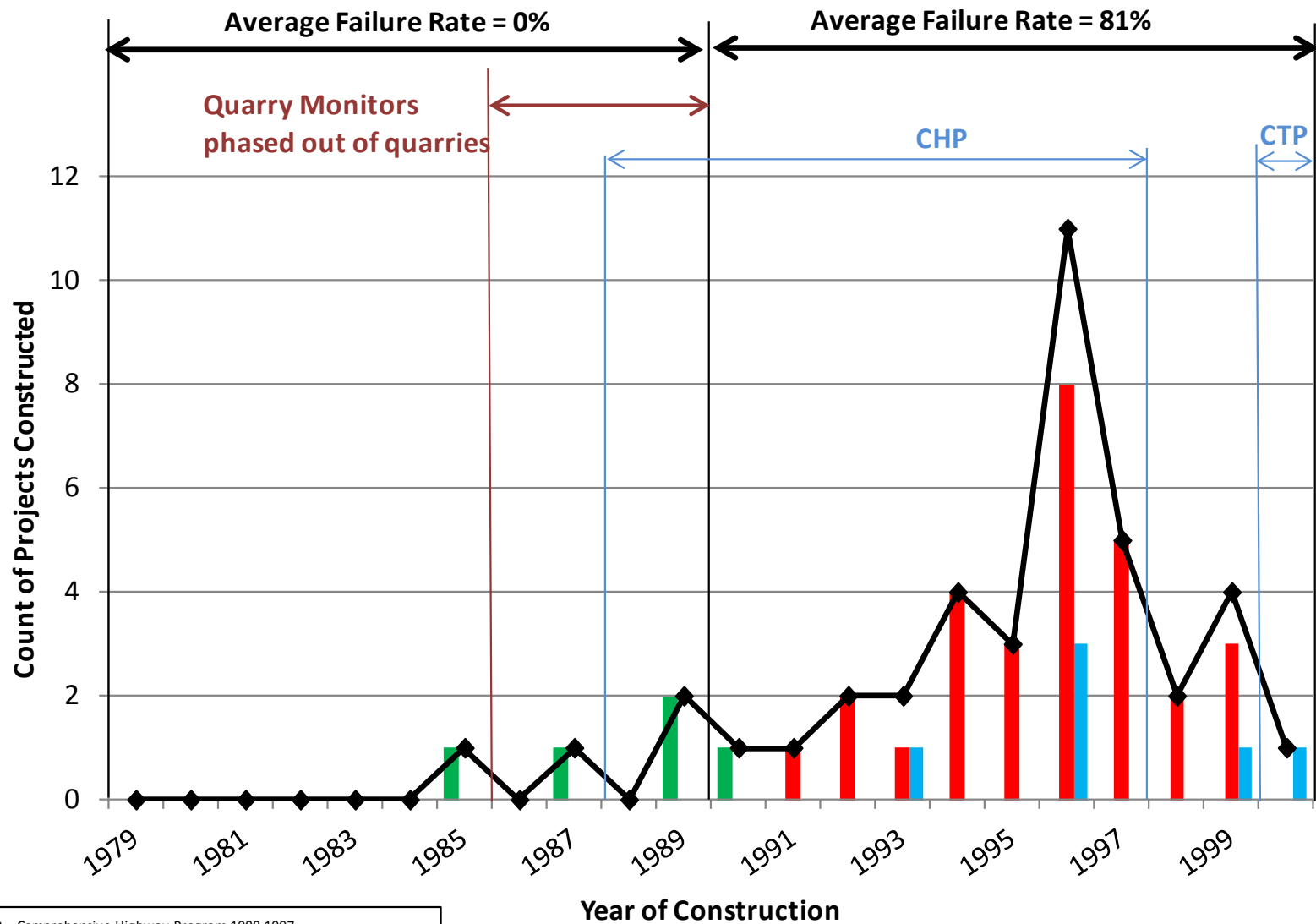


- Pass - A
- Pass - U
- Fail - A
- Fail - U
- Inc - A
- Inc - U



- Pass
- Fail
- Inc < 20 yrs

Inc = Inconclusive, <20 yrs old

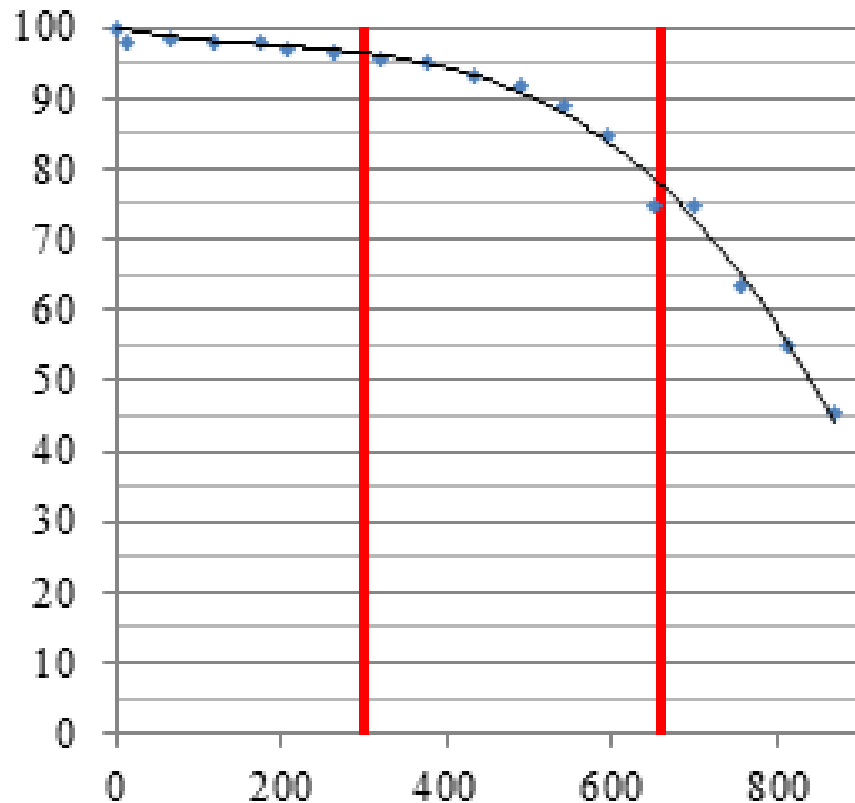


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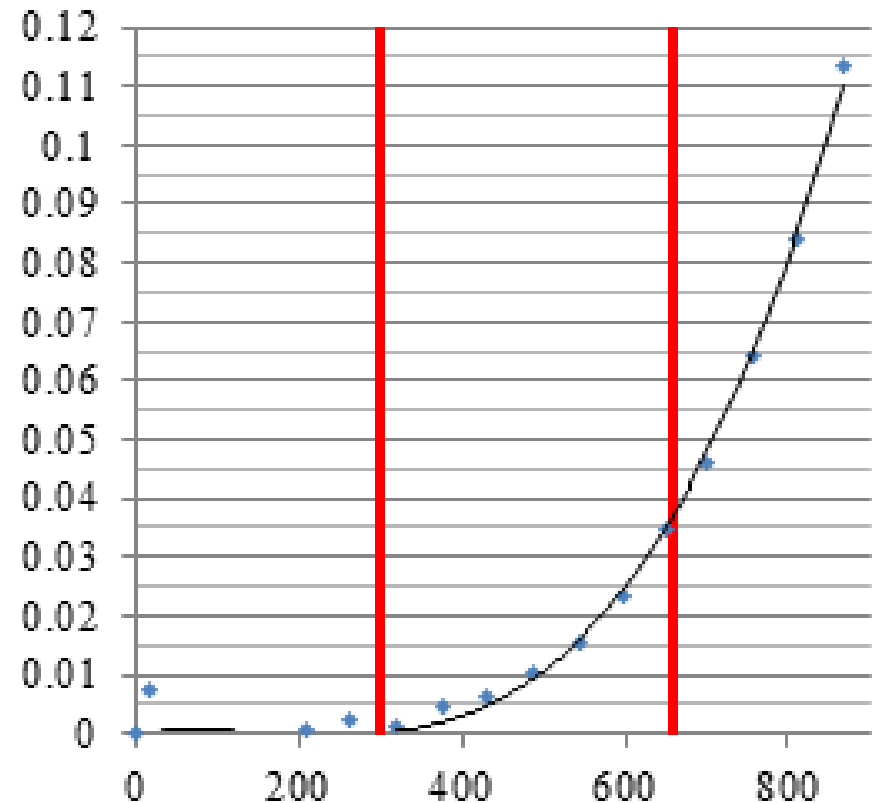
Pass Fail Inc Total

F/T Testing of Limestone with Poor Service History

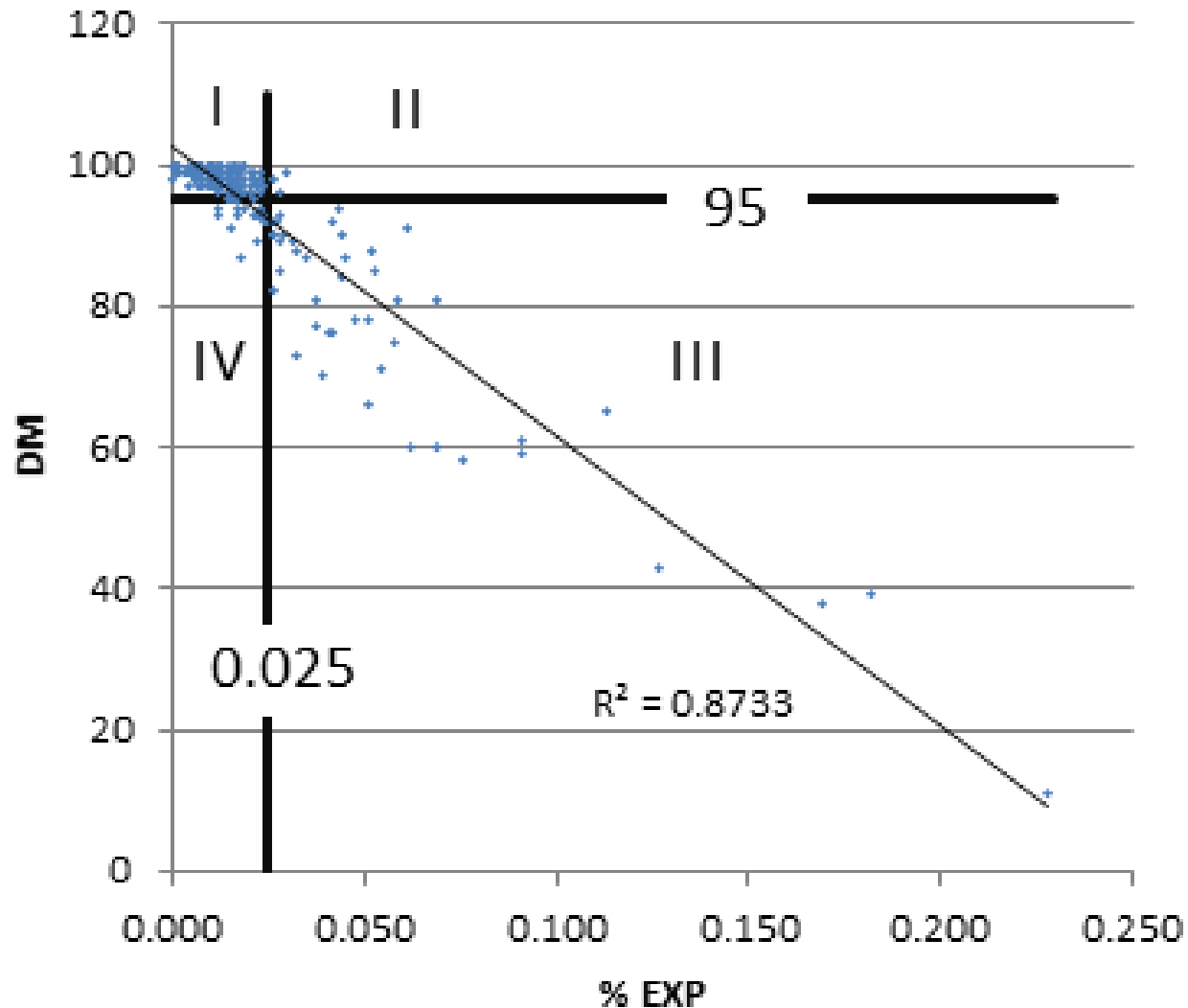
RDME



%E



Dynamic Modulus and Expansion



Highlights

- Material Source appears to be the major factor in Kansas D-Cracking
- D-cracking can be top-down
- ASTM C666 can be reviewed for clarification
- DM and Exp results are usually in agreement
- Kansas is using extended F/T testing

Disclaimer

- KDOT makes no warranties, guarantees, or representations for accuracy of this information and assumes no liability or responsibility for any errors or omissions.

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