CONCRETE OVERLAY PERFORMANCE IN THE U.S.

Dan King, P.E.

Iowa Concrete Paving Association

Iowa Ready Mixed Concrete Association

ICPA IOWA CONCRETE PAVING ASSOCIATION

IRMCA IOWA READY MIXED CONCRETE ASSOCIATION

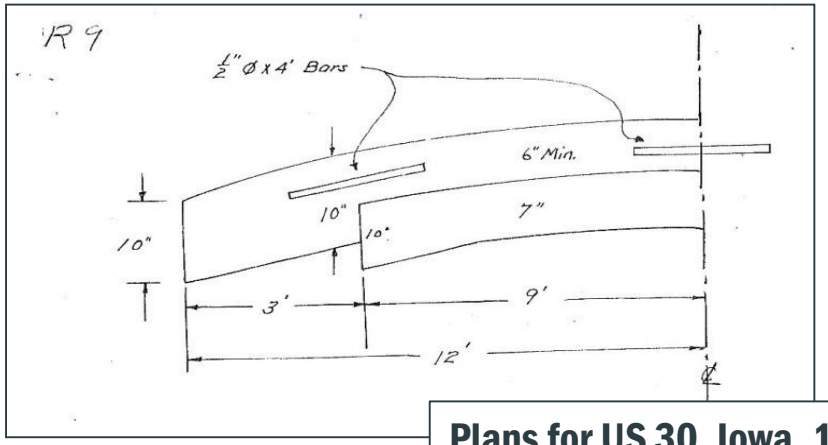
American Concrete Institute aci Iowa Chapter

OUTLINE

- Growth of concrete overlay construction
- Measuring concrete overlay performance
- Review of performance studies in the U.S.
- What do we gain by measuring performance?

GROWTH OF CONCRETE OVERLAY CONSTRUCTION

- Experimental projects throughout the mid-20th century
- Approx. 1970s-80s: early projects help establish concrete overlays in some U.S. states
- 1990s-present: further innovations in design, rate of adoption increases



Plans for US 30, Iowa, 1949

Storm Lake Airport, Iowa, 1971

GROWTH OF CONCRETE OVERLAY CONSTRUCTION

- **Substantial increase in concrete overlay construction in the U.S. since 2000:**

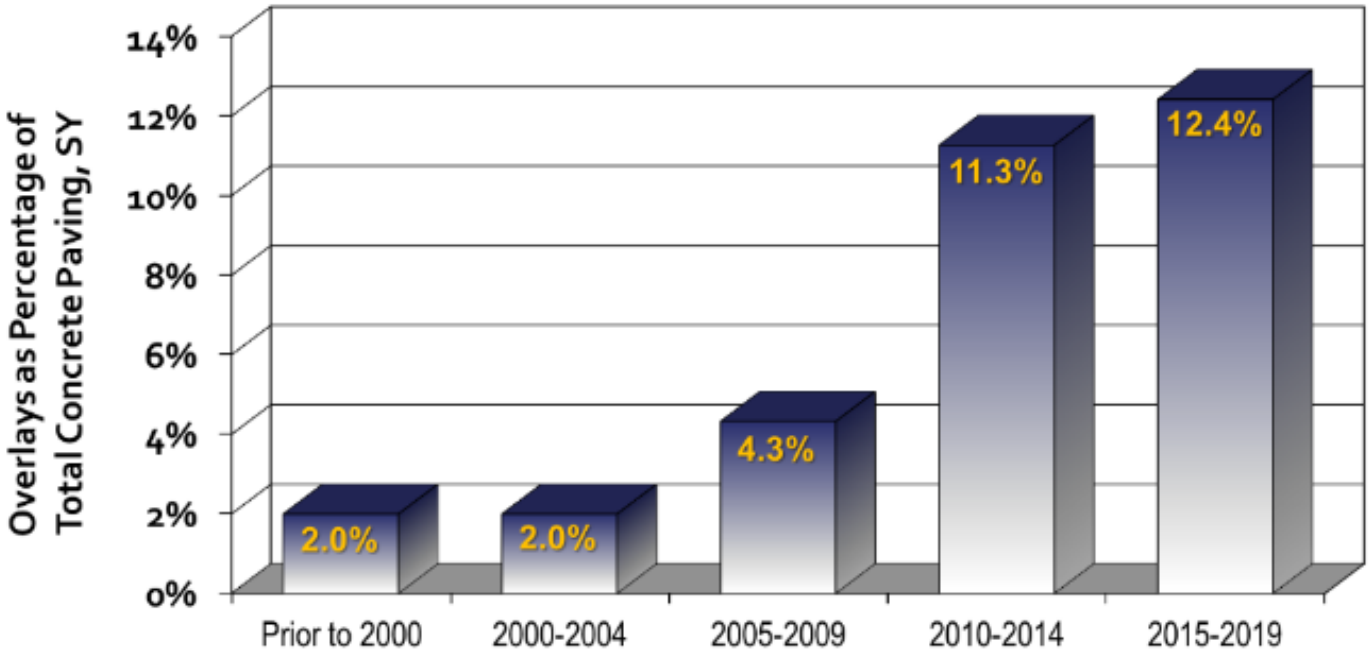


Image: ACPA

GROWTH OF CONCRETE OVERLAY CONSTRUCTION

- **Project snapshot (through 2020):**

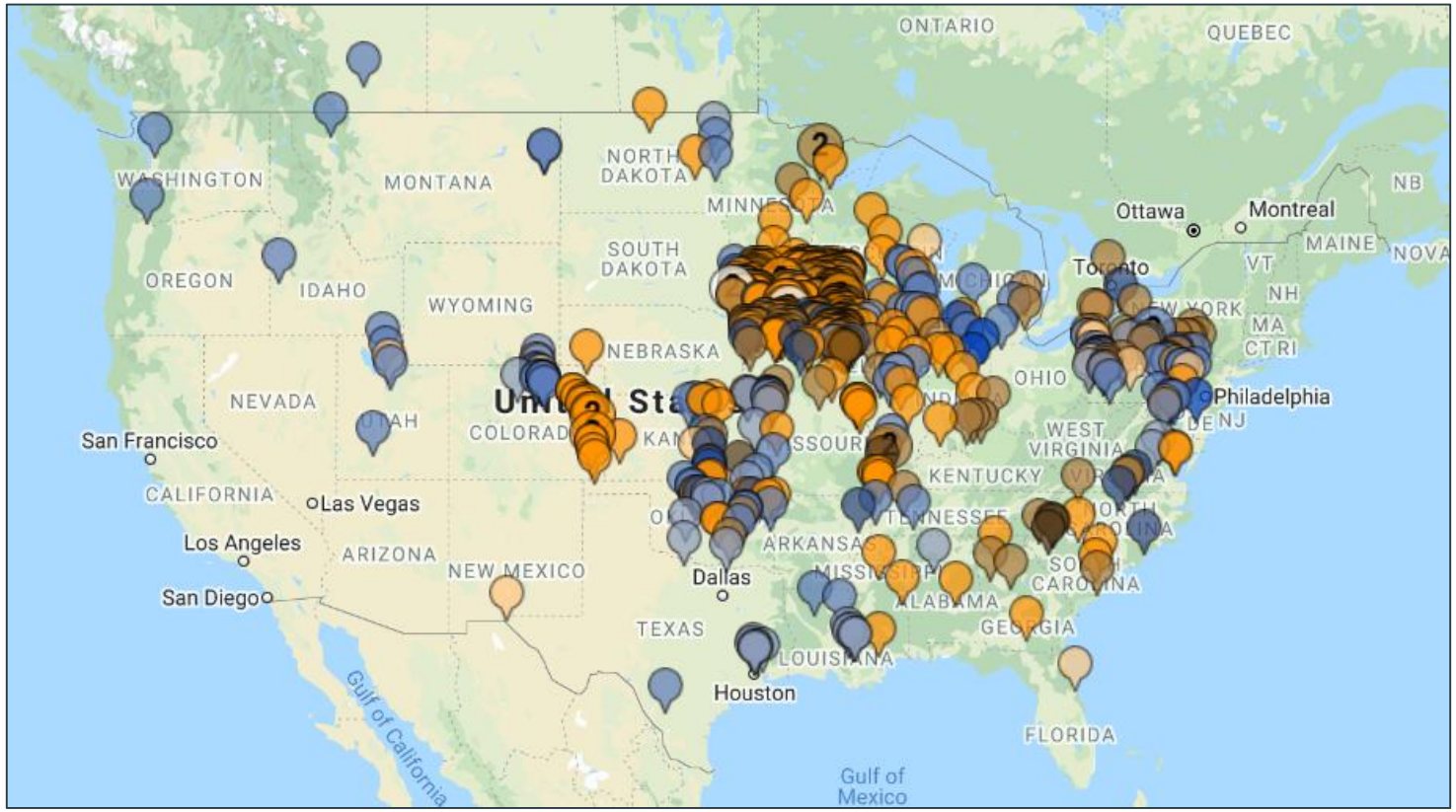


Image: ACPA

GROWTH OF CONCRETE OVERLAY CONSTRUCTION

- Concrete overlays are still very new to some areas of the country, but in many states they have become a regular part of the pavement network

Zumbro Falls, Minnesota

MEASURING CONCRETE OVERLAY PERFORMANCE

- With increasing interest and use, owners and agencies want to know:
  - What kind of performance life can we expect from our concrete overlays?
  - What's working with design, materials & construction? What hasn't worked?

Boone County, Iowa
Constructed 1977
Pictured 2016

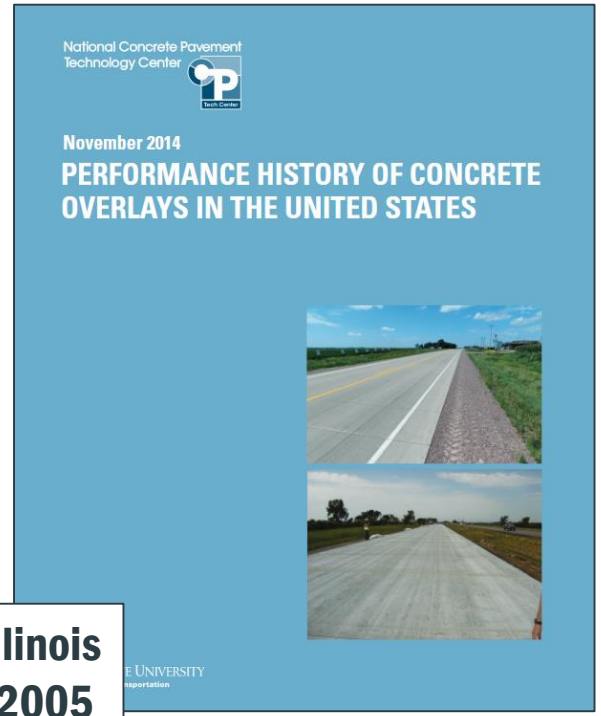
Tuscola, Illinois
Constructed 1999
Pictured 2012

MEASURING CONCRETE OVERLAY PERFORMANCE

- There have been good case studies of individual projects over the years
- Comprehensive reviews and data analyses have been less common
- Technology has also advanced rapidly
  - Thinner overlays with short joint spacing
  - Fiber-reinforced concrete
  - Geotextile interlayer

Image: IL-ACPA

Mundelein, Illinois
Constructed 2005



MEASURING CONCRETE OVERLAY PERFORMANCE

- As overlays become increasingly common, pavement performance is measured more frequently, and older projects begin to age…
- Some states have been able to produce more comprehensive reports of concrete overlay performance

MEASURING CONCRETE OVERLAY PERFORMANCE

- **Common methods for measuring pavement condition:**
  - **Automated pavement condition data collected by vans**
  - **Common metrics:**
    - **IRI (Int'l Roughness Index)**
    - **Cracked Slabs**
    - **Faulting**
    - **Friction**
    - **Joint Spalling**
    - **Patching**

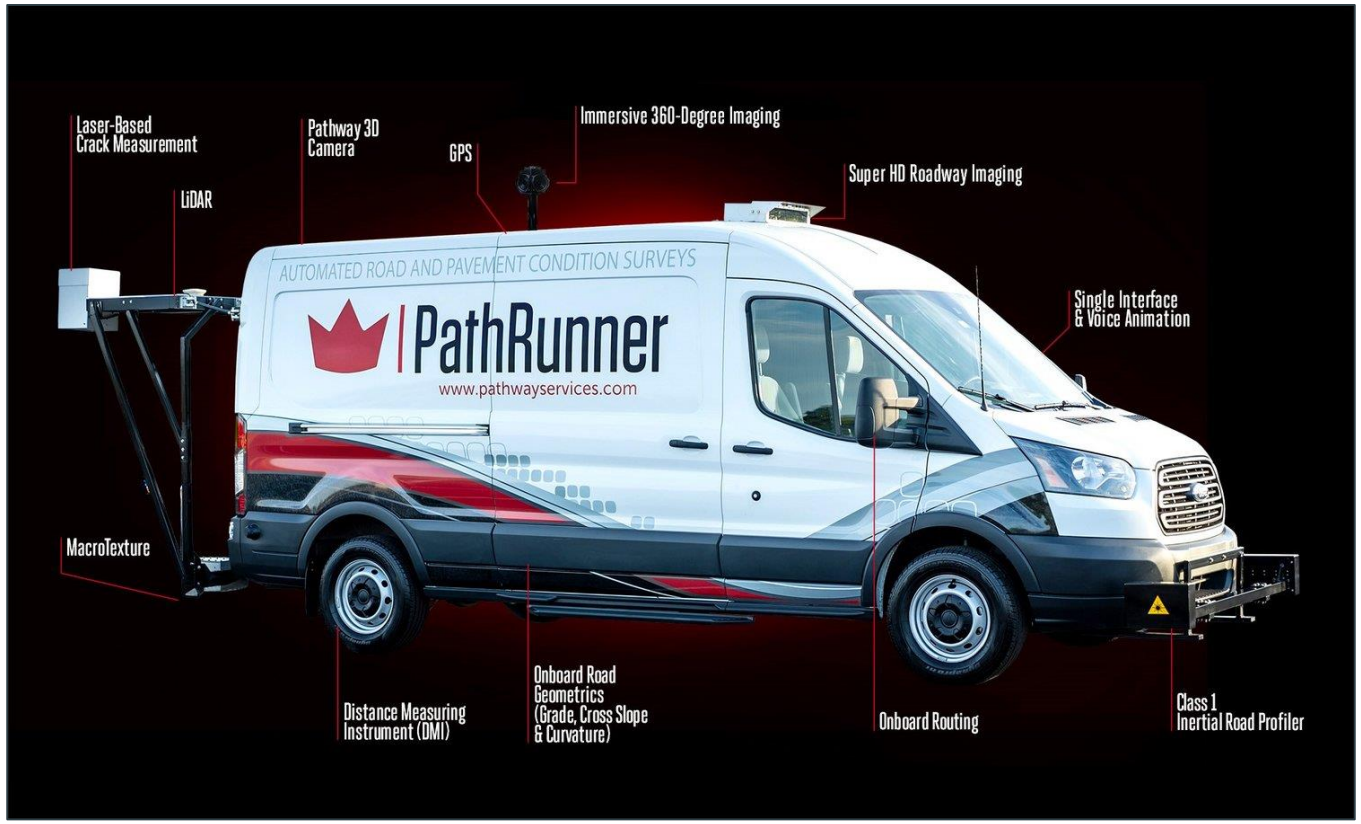


Image: Pathway Services

MEASURING CONCRETE OVERLAY PERFORMANCE

- Common methods for measuring pavement condition:
  - Indeces calculated to characterize overall condition or remaining service life

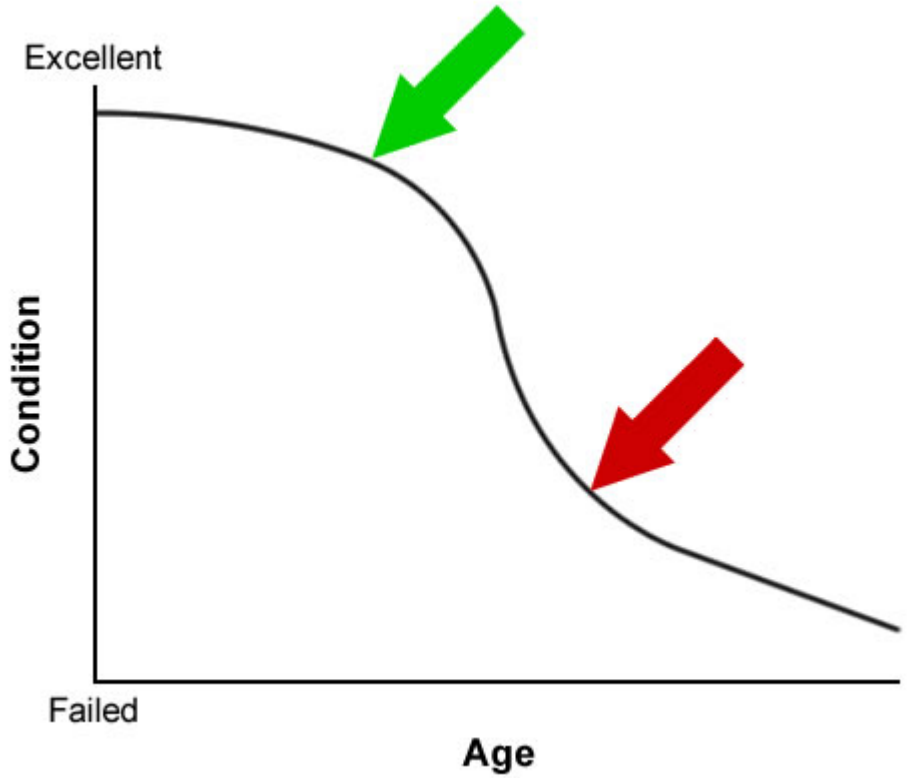
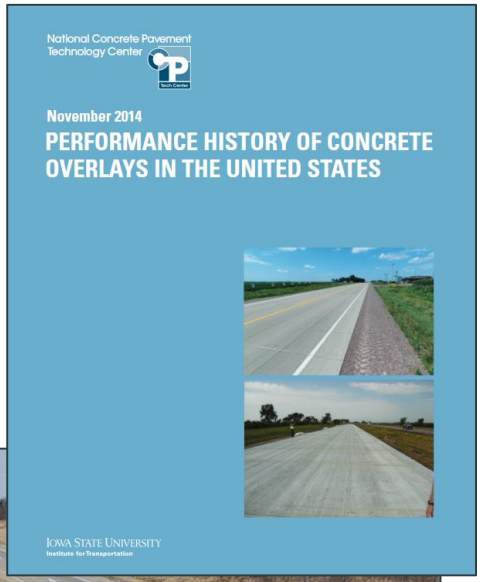
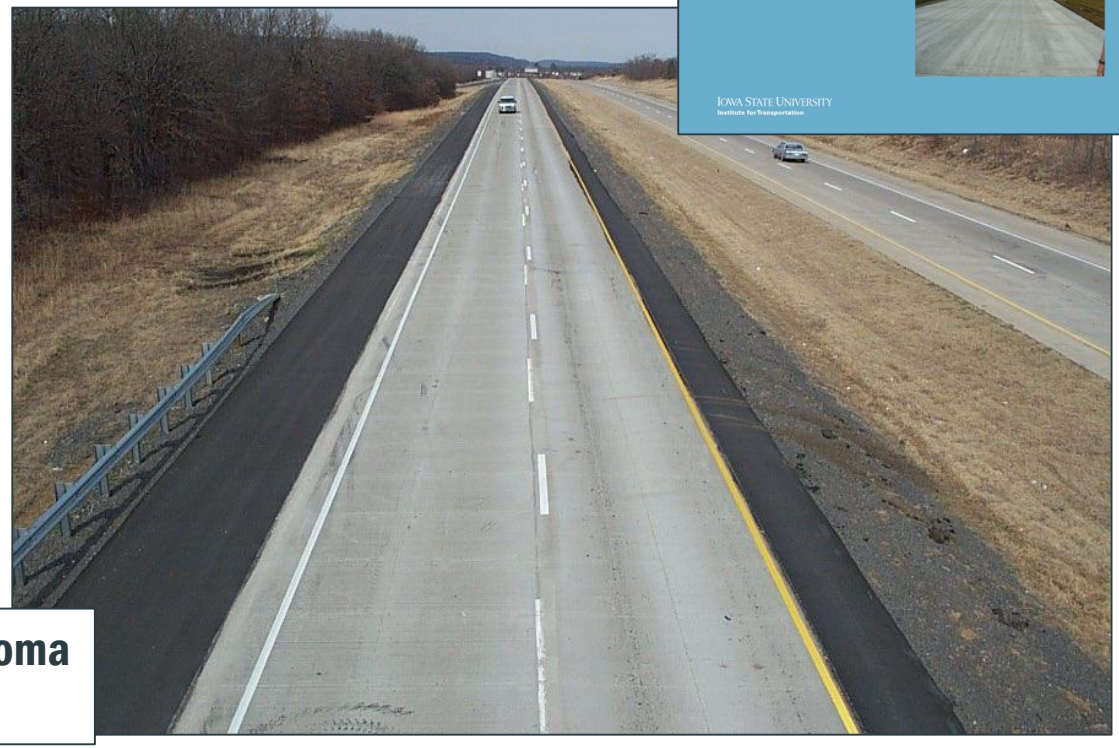


Image: Pavement Interactive

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- **National Project Review:**
  - + Case studies on PCC overlay projects in OK, MT, IL, CO, UT, IA, IN, MI, NC,
  - + Covers a variety of design types and contexts (traffic levels, rural, urban, interstate, etc.)
  - + Good, detailed reviews of individual projects, limited data





Pittsburg County, Oklahoma
Constructed 2001

Image: OK/AR-ACPA

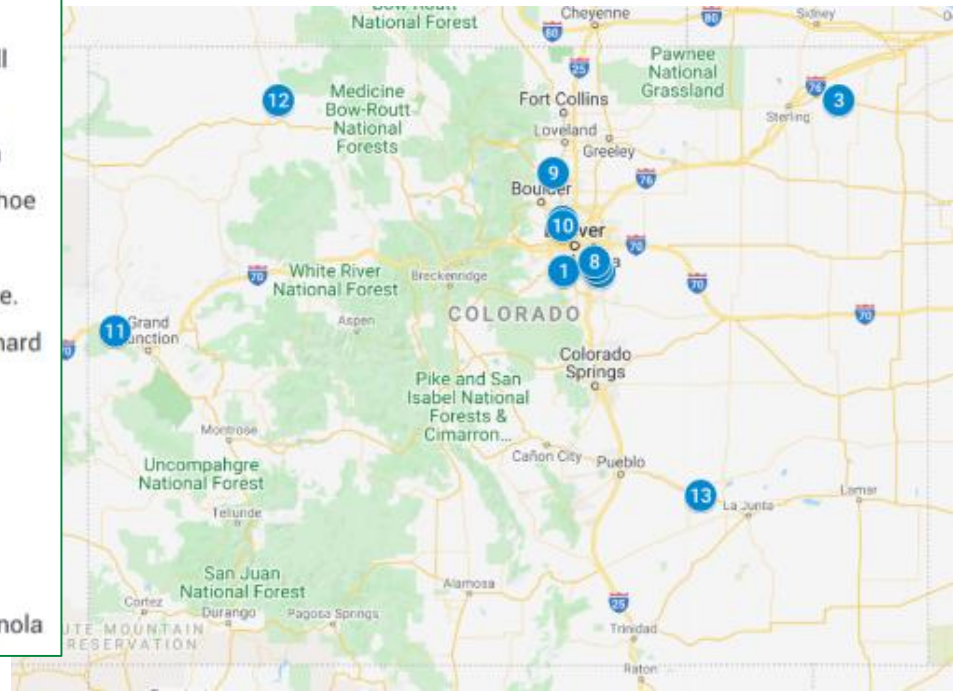
REVIEW OF PERFORMANCE STUDIES IN THE U.S.

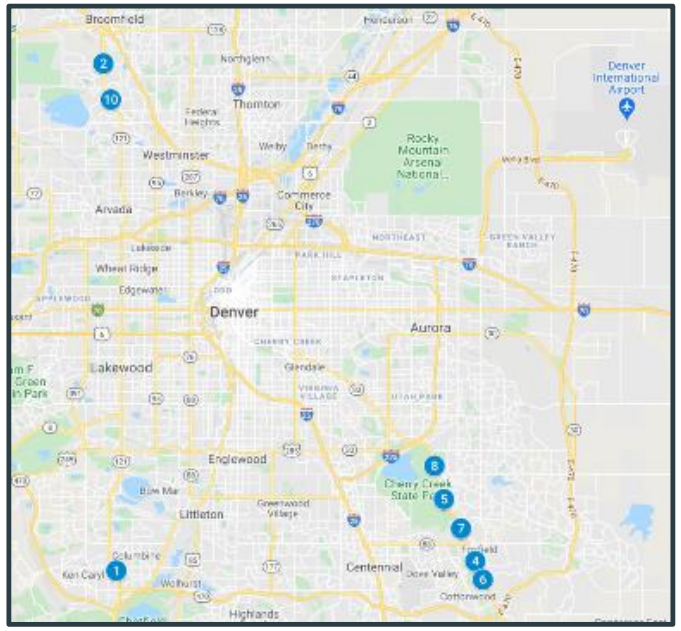
- **Informal/In-House Reviews of Concrete Overlays**
  - In many states, industry and agencies have tracked performance, but not always as part of a formal study
    - Varying project sample sizes and time series for data

Colorado

Thin Overlays (6" & less)

1. SH 121 - C-470 to Parkhill
2. SH 121- 104th to US 36
3. US 6 - Fleming to Haxtun
4. SH 83 - Pine Ln to Arapahoe
5. SH 83 - Rice to Orchard
6. SH 83 - S. of Jamison Ave.
7. SH 83 - Arapahoe to Orchard
8. SH 83 - N. of Quincy
9. SH 66 - US 36 to US 287
10. SH 121 - 88th to 104th
11. I-70 East of Mack
12. SH 13 - N. of Craig
13. US 50 - Fowler to Manzanola





Source: CO/WY-ACPA

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

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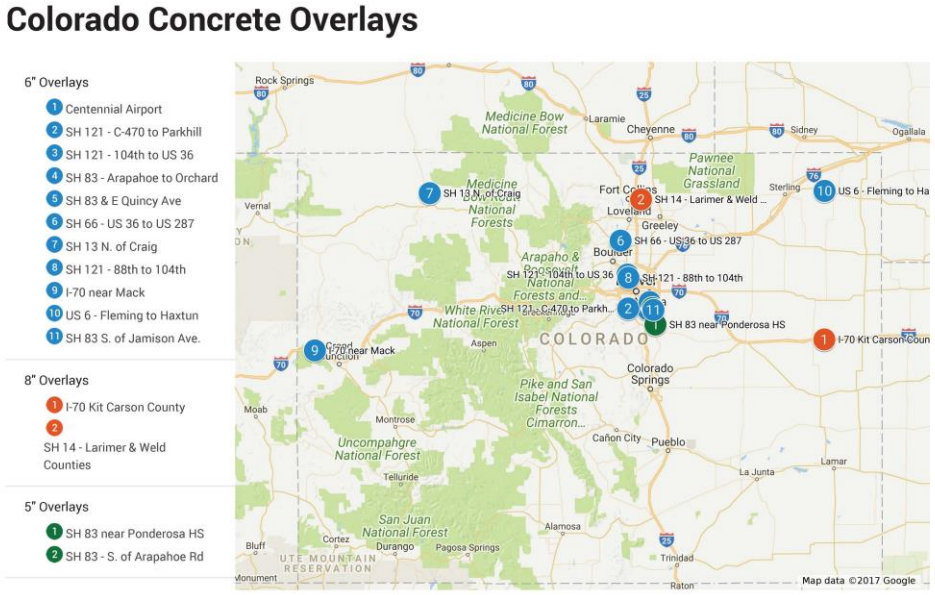
- Varying project sample sizes and time series for data



- CDOT has built over 1.5 million SY of 6" concrete overlays (see map) & over 10 million SY of concrete overlays of all thicknesses
- Many projects reaching 20 year design life w/ 8-10 years drivability life (DL) remaining

Source: CO/WY-ACPA

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- Illinois
  - 2014: Review of ultra-thin whitetopping (UTW) projects
    - Illinois was one of the earliest adopters of UTW/BCOA
    - Survey-driven study with limited data, but good sample size
  - 2018: Review of concrete overlays on interstate highways
    - Full project condition ratings with 20+ years of data on older projects

UTW/BCOA Projects in Illinois through 2014

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- Illinois
  - UTW
    - Many projects on track for 15-20 year service life
    - Innovations like fiber-reinforced concrete seem to improve performance and mitigate distresses observed on earlier overlays
  - Interstate Highways
    - Mostly thicker unbonded overlays, including CRCP, showing good long-term performance
    - 30-year projection to “poor” rating

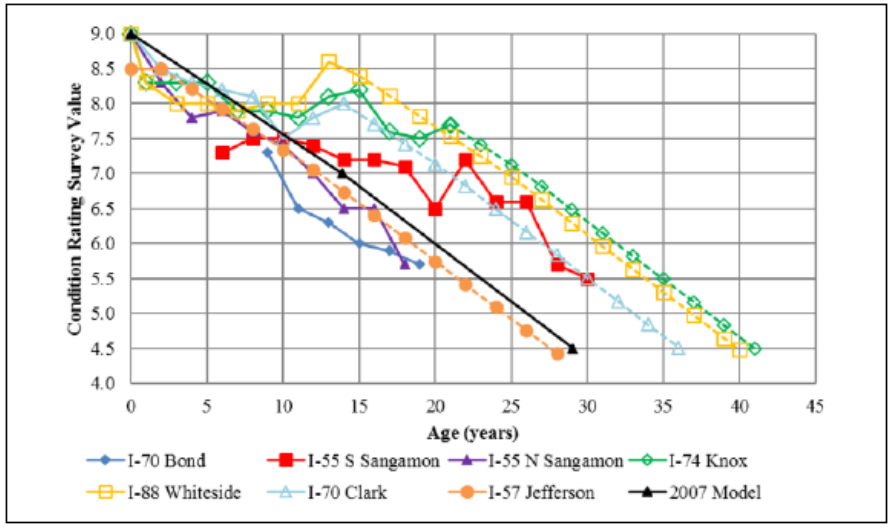


Figure 2. Unbonded concrete overlays condition rating survey values vs. age.

Source: Heckel and Wienrank (2018)

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- Iowa
  - Most extensive history of concrete overlay construction in the U.S.
    - Includes all types of concrete overlays – 506 total projects through 2015
    - 96 of these were constructed before 1990
    - Most of these overlays are on rural county highways

Mitchell County, IA, Constructed 2017

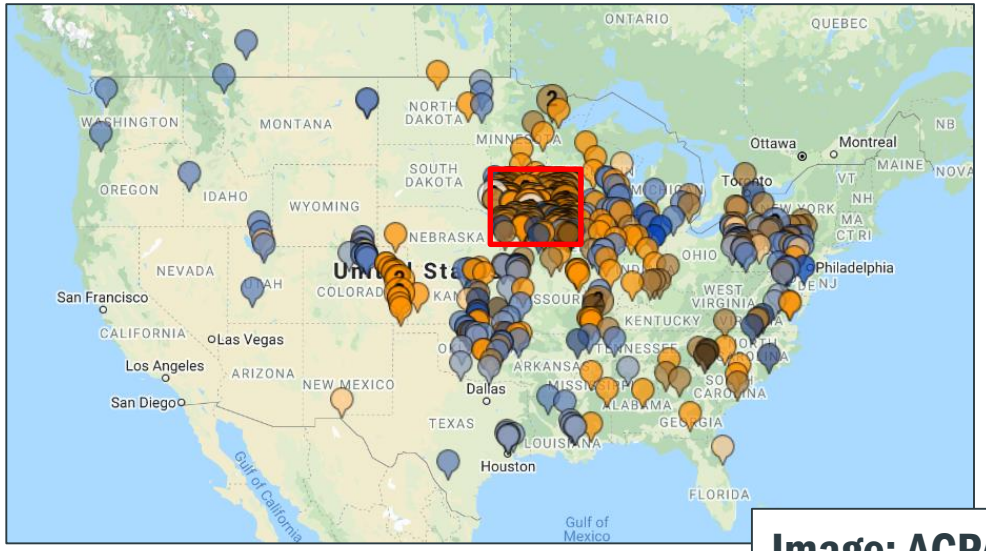
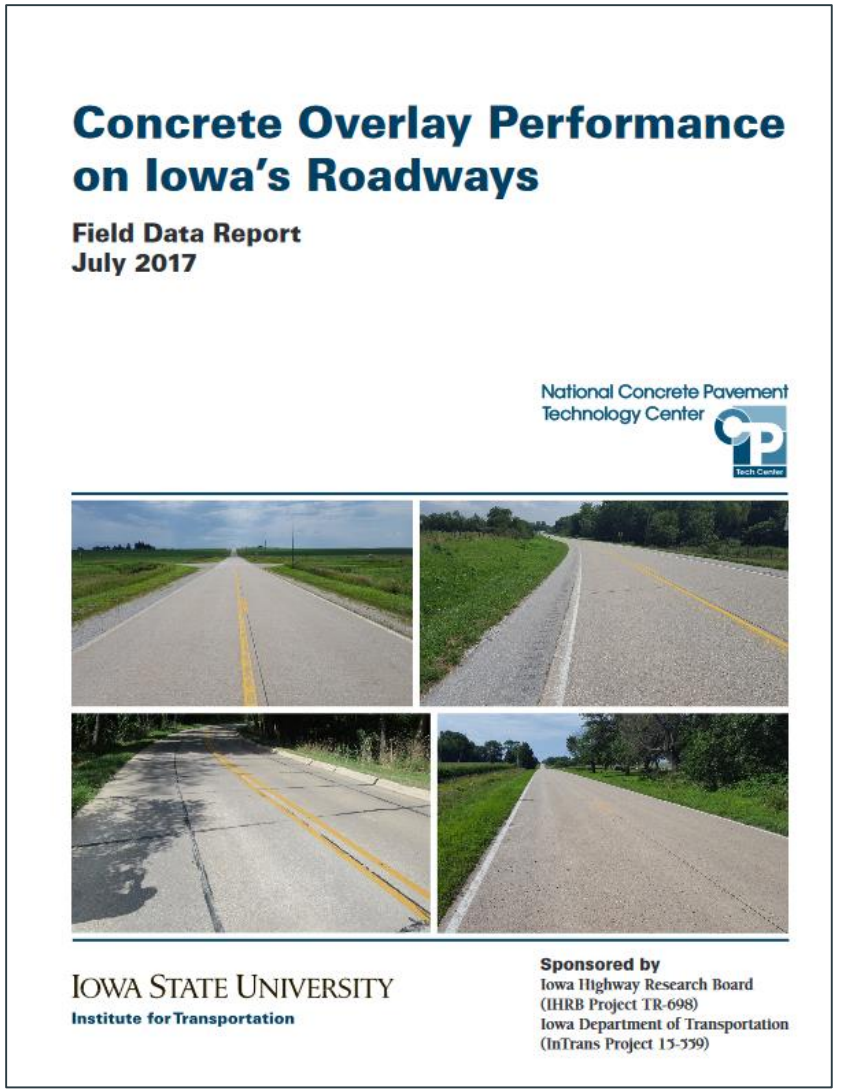


Image: ACPA

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

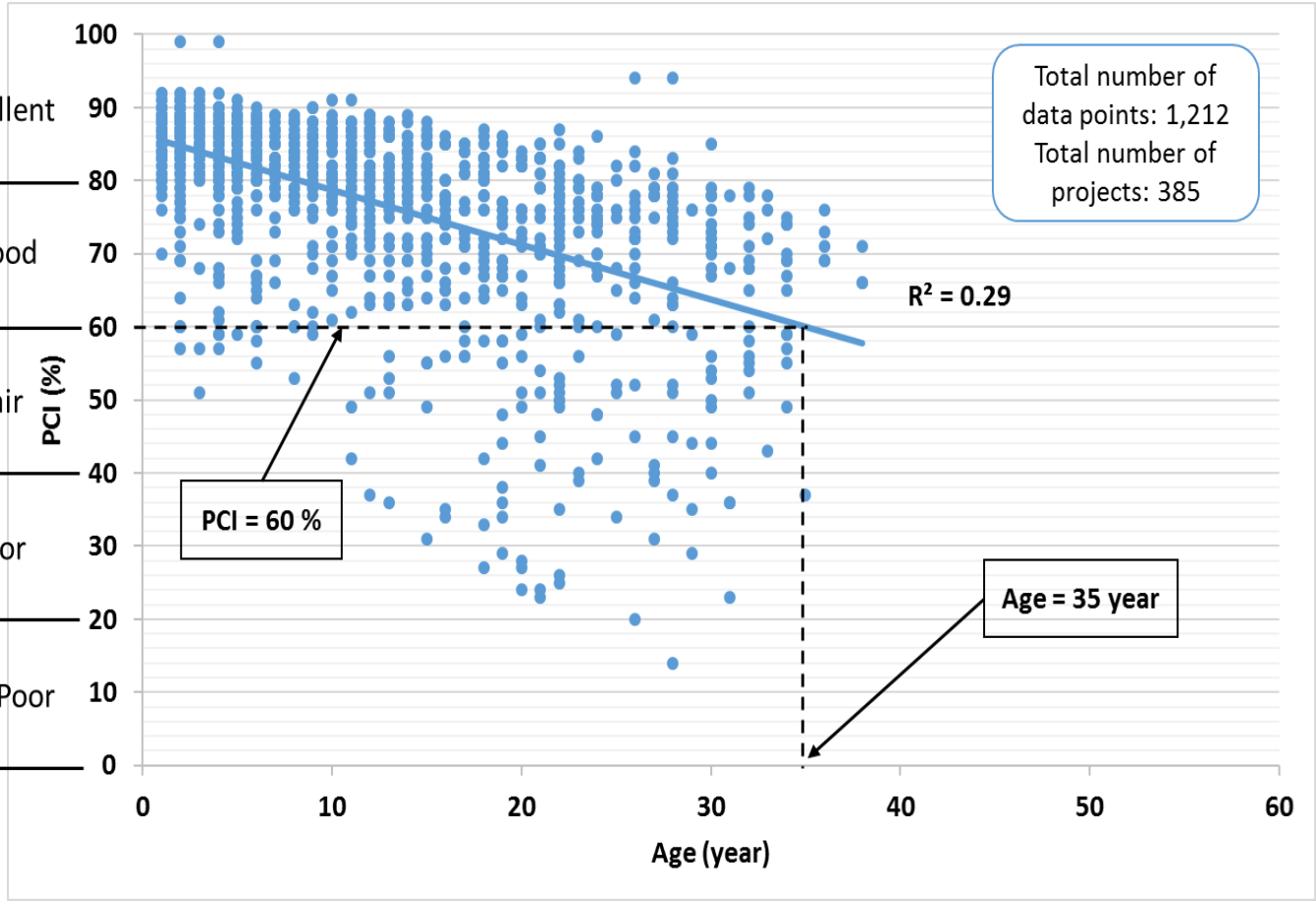
- Iowa
  - 2017 CP Tech Center study
    - Used condition data collected for local agencies to characterize concrete overlay performance in Iowa
  - Very comprehensive data set, and lots of data for older projects with 30+ years of service life



REVIEW OF PERFORMANCE STUDIES IN THE U.S.

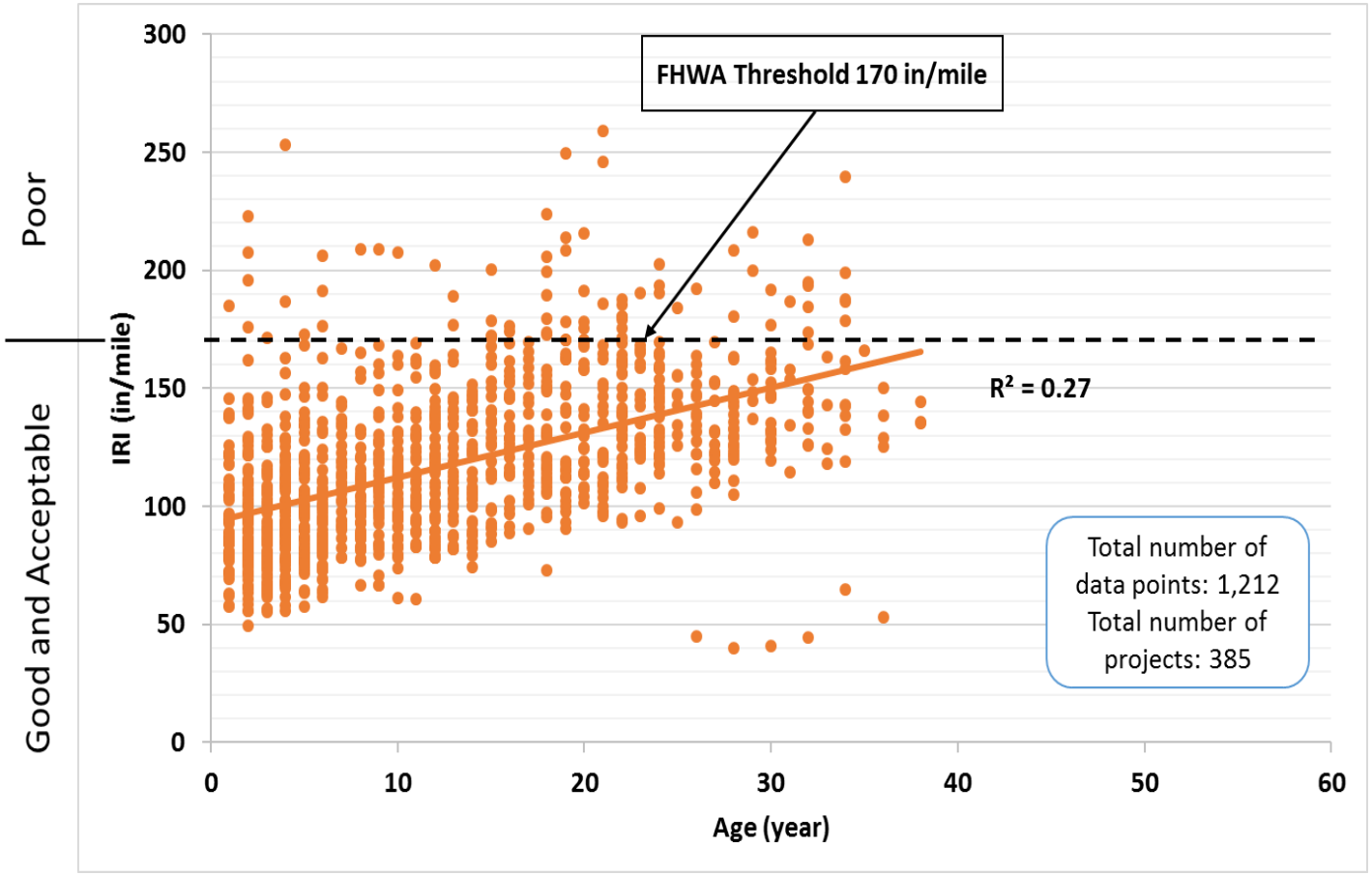
Results (PCI):

All overlay types together



REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- **Results (IRI):**
  - **All overlay types together**



PERFORMANCE HISTORY OF IOWA'S CONCRETE OVERLAYS

- Key findings and trends:
  - Good performance from each of BCOA, UBCOA & UBCOC
    - Overlays of asphalt performed slightly better than UBCOC
  - Thickness
    - Thicker overlays performed better for all overlay types (e.g. for BCOA, 6 in. > 5 in. > 4 in.)
  - Transverse joint spacing
    - Good early performance from BCOA short slab designs
    - Older designs with conventional joint spacing performed well over longer periods of time
  - Traffic – inconclusive
    - Most of these projects are low volume, <1,000 vpd

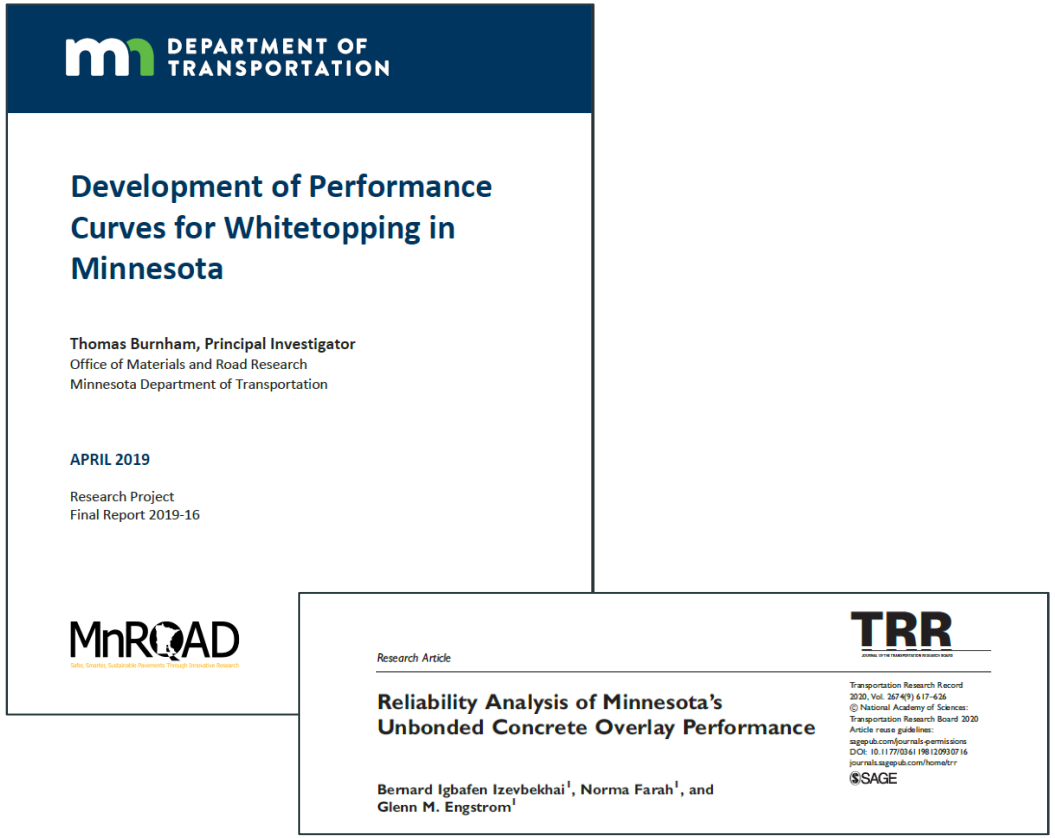
PERFORMANCE HISTORY OF IOWA'S CONCRETE OVERLAYS

- **Lessons learned from Iowa performance history:**
  - Based on performance history to date, can design concrete overlays to last 30+ years
  - Concrete overlays are very well-suited to county highways
  - Good success to date on other types of highways as well

Pottawattamie County, IA, Constructed 1993

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- **Minnesota**
  - For many years, thick unbonded overlays of concrete have been employed as a long-term rehab solution in MN
  - More recently, wider-scale adoption of thinner whitetopping projects as well
  - Pair of recent studies (2019-2020) to establish predictive performance curves for both types of overlays



DEPARTMENT OF TRANSPORTATION

Development of Performance Curves for Whitetopping in Minnesota

Thomas Burnham, Principal Investigator
Office of Materials and Road Research
Minnesota Department of Transportation

APRIL 2019

Research Project
Final Report 2019-16

MnROAD

Research Article

Reliability Analysis of Minnesota's Unbonded Concrete Overlay Performance

Bernard Igbafen Izevbekhai[1], Norma Farah[1], and Glenn M. Engstrom[1]

TRR

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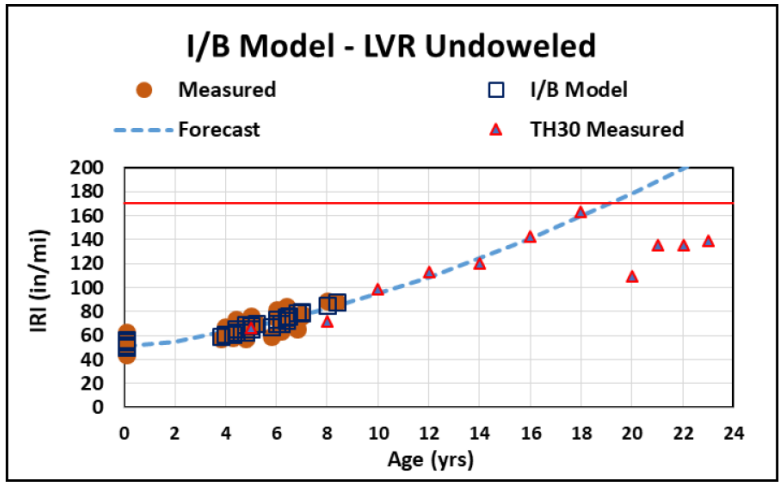
REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- **Whitetopping Study:**
  - Tended to be on lower-volume roads
  - Good early performance for many projects through about 9 years, projected for approx. 20-year service life based on IRI data
  - Faulting observed on some projects with heavy truck traffic

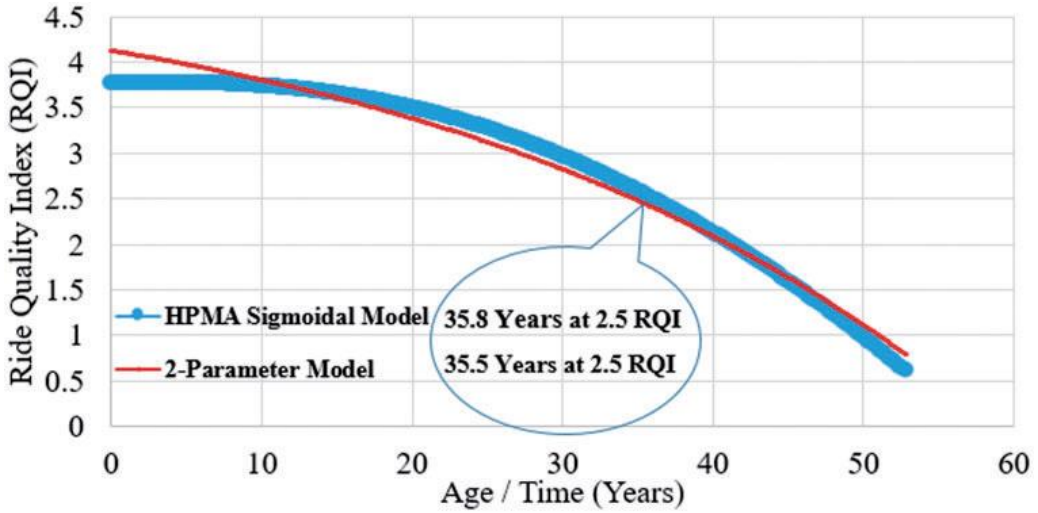


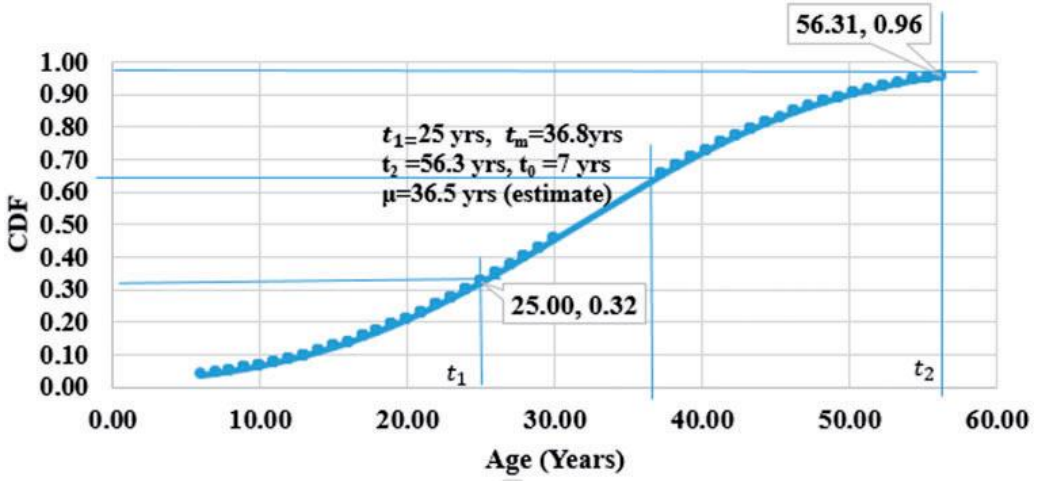
Source: Burnham et al. 2019

Andover, MN
Constructed 2011
Pictured 2016

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- **Unbonded Overlay Study:**
  - **Service life projection of approx. 35 years obtained from modeling of ride quality data**





Source: Izevbekhai et al. 2020

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- Unique findings, problems and challenges:
  - An overlay can be planned for the right application and well-designed, but good materials are still needed!

Pottawattamie County, Iowa
Constructed 1992/1999
Pictured 2016

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- Unique findings, problems and challenges:
  - Joints falling in the wheel path has caused problems in thin overlays with shorter joint spacings
  - Design procedures able to account for this issue

Tuscola, Illinois
Constructed 1999
Pictured 2012

Delaware County, Iowa
Constructed 2002
Pictured 2020

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

- Unique findings, problems and challenges:
  - Joint misalignment/sliding panels
    - Factor in blowups in thin overlays?
    - Can we mitigate these issues by using fibers, filling joints?

Decatur, Illinois
Constructed 1998
Pictured 2012

REVIEW OF PERFORMANCE STUDIES IN THE U.S.

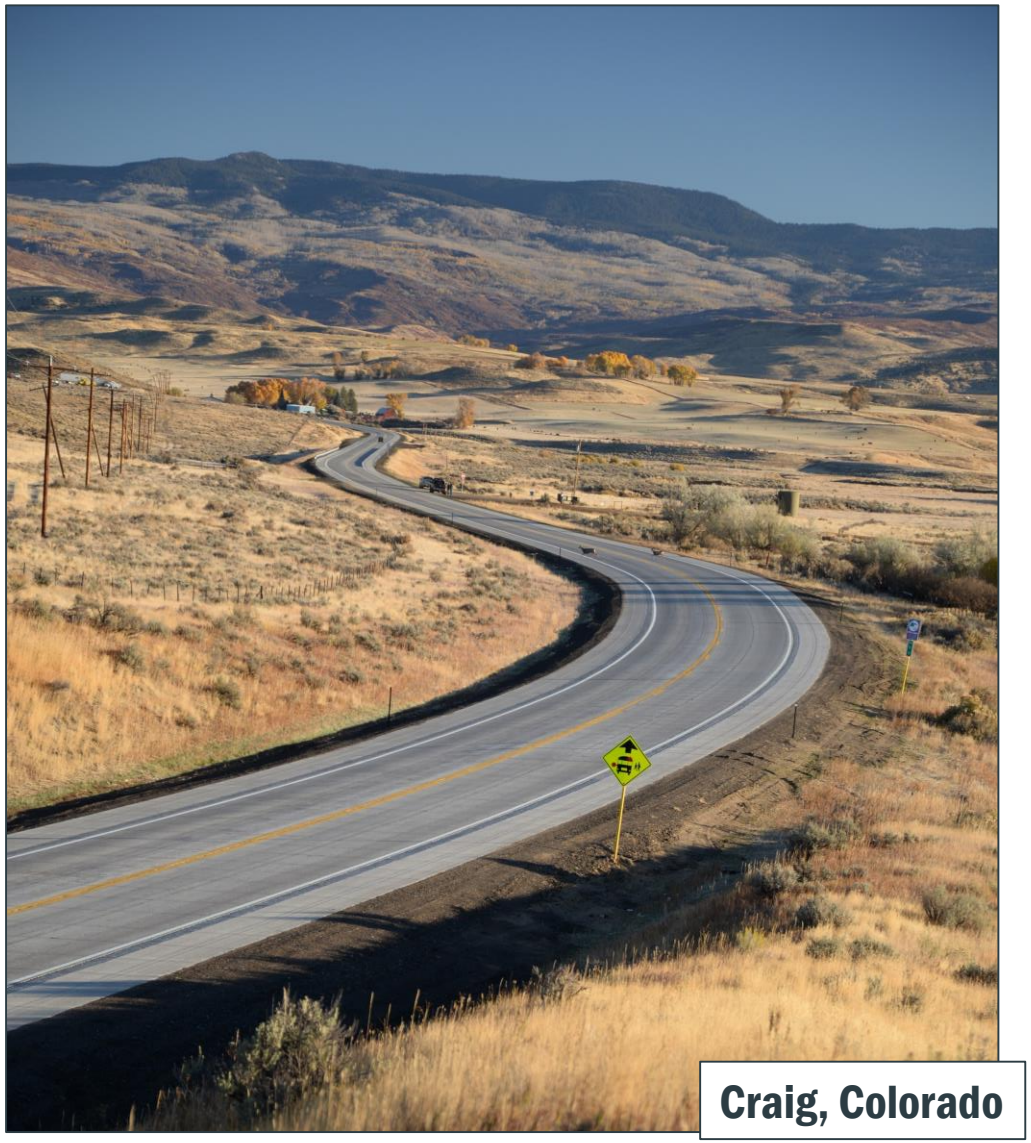
- Unique findings, problems and challenges:
  - Un-activated joints (cracks fail to initiate at certain intervals)
    - Does this cause dominant joint behavior, distress?
    - Should we adjust design or construction practices to account for this?
    - Do fibers play a role?

Mitchell County, IA

MN: Early loading to try to activate more joints

WHAT DO WE GAIN BY MEASURING PERFORMANCE?

- Documenting and demonstrating the performance of concrete overlays will help give owners and agencies confidence in adopting and following through with this relatively new technology



Craig, Colorado

Image: CO/WY-ACPA

WHAT DO WE GAIN BY MEASURING PERFORMANCE?

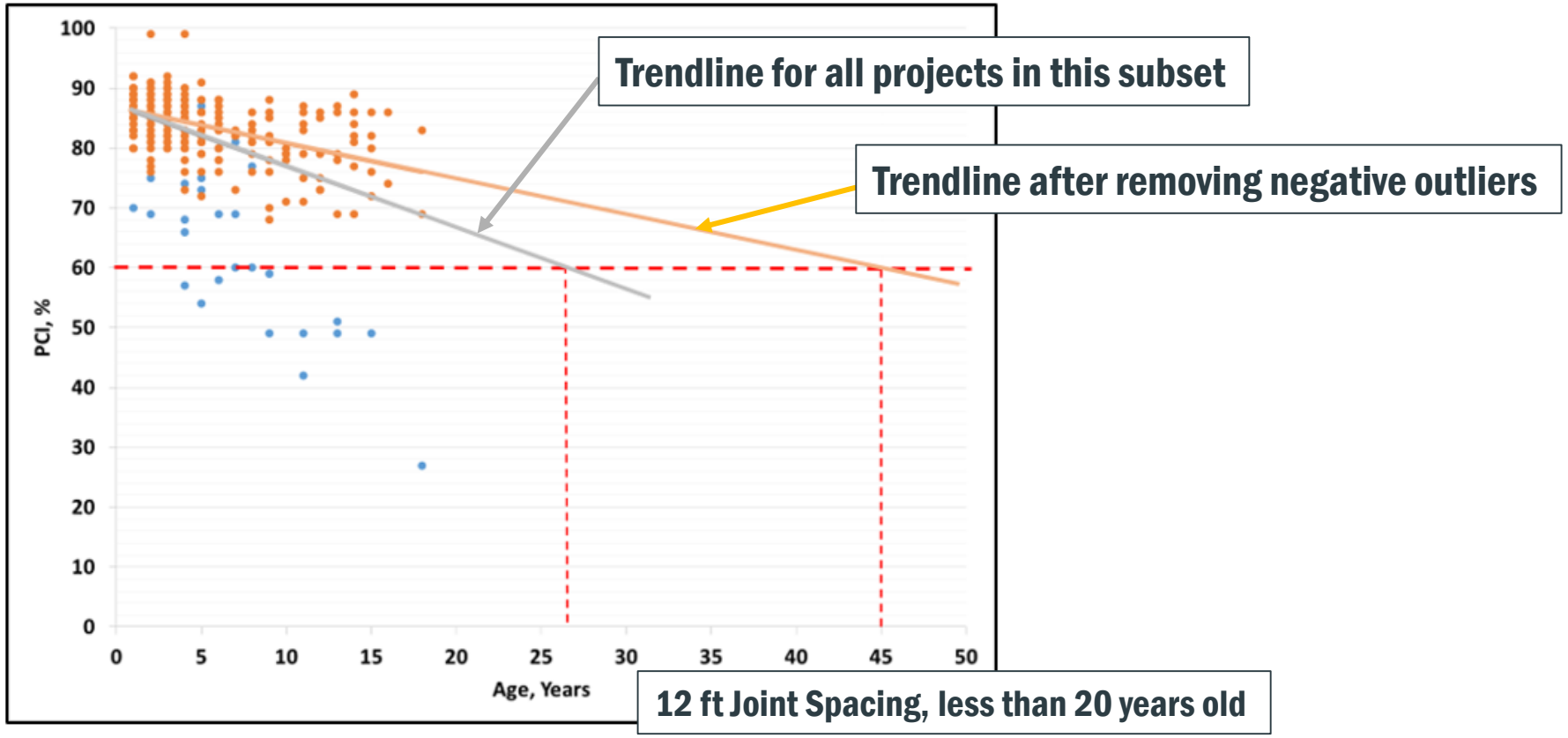
- We can also use this information to improve our design and construction processes

Clare, Michigan

Image: Michigan Concrete Association

WHAT DO WE GAIN BY MEASURING PERFORMANCE?

- With proper materials, construction and design, there is still plenty of room to improve performance!
  - Subset of Iowa data:



CONCLUSIONS

- To date, performance studies have been helpful to understanding and improving our design and construction practices for PCC overlays
- In a variety of environments, concrete overlays have successfully achieved and exceeded intended service life
- Some unique cases still pose challenges in design and construction
- With continued growth of concrete overlay construction, we should gain access to even better data for characterizing overlay performance
- Concrete overlays are poised to continue maturing into a regular part of our pavement network

THANK YOU!