Concrete Pavement Management and Preservation

Larry Scofield, IGGA/ACPA

IGGA International Grooving & Grinding Association
Your Pavement Preservation Resource® since 1972

ACPA

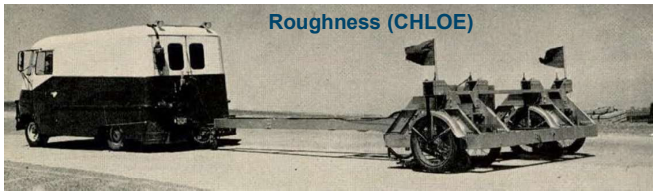
Presentation Outline

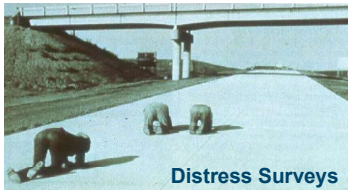
- Defining Pavement Performance
- Beginning of Pavement Management
- Concrete Pavements Outlast the Generation That Builds Them
- Portrayal of Pavement Performance
- So What is Different Today
- ACPA Survey of State PMS Practices (Sept 2016)
- FHWA P2 ETG Survey of PMS Practices (March 2017)
- Data Rich Environment

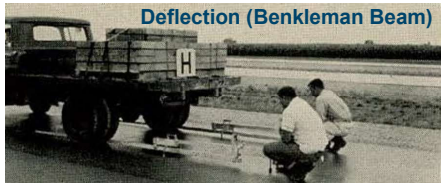
Concrete Preservation Activities

- Diamond Grinding or Diamond Grooving
- Partial Depth or Full Depth Patching
- Dowel Bar Retrofit
- Joint Sealing or Resealing
- Slab Jacking/Stabilization
- Slab Replacement
- Longitudinal Crack Stitching
- Buried Treasure

Defining Pavement Performance (AASHO Road Test)



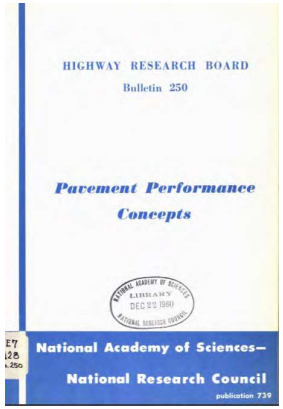




Pavement Performance: Serviceability Concept

William N. Carey

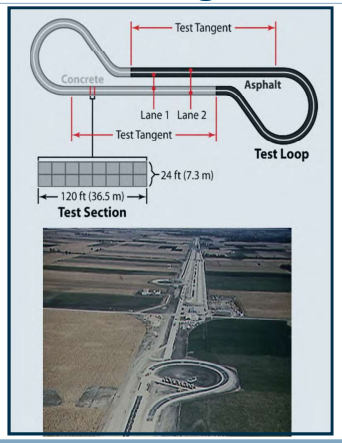
Paul Irick

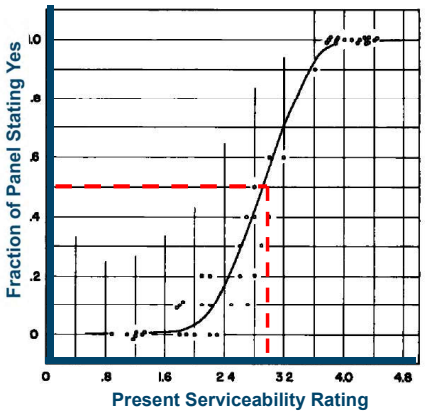


- **"a mathematical index is derived and validated through which pavement ratings can be satisfactorily estimated from objective measurements taken on pavements."**
- Roughness was found to represent 95% of the correlation to ride panel

- Highways are for the comfort and convenience of the traveling public
- Users opinions are largely subjective
- Highway Characteristics can be objectively measured
- Serviceability can be expressed by the mean evaluation of all users
- Pavement performance can be described if the serviceability is monitored from cradle to a given point in time

Consumer Acceptability Vs Present Serviceability Rating AASHO Road Test (1958-60)

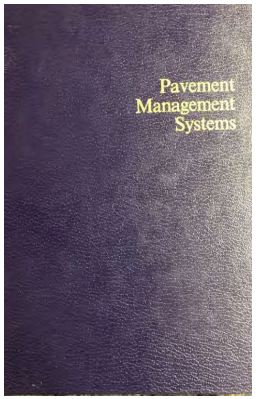




Beginning of Pavement Management

Dr. Ron Hudson

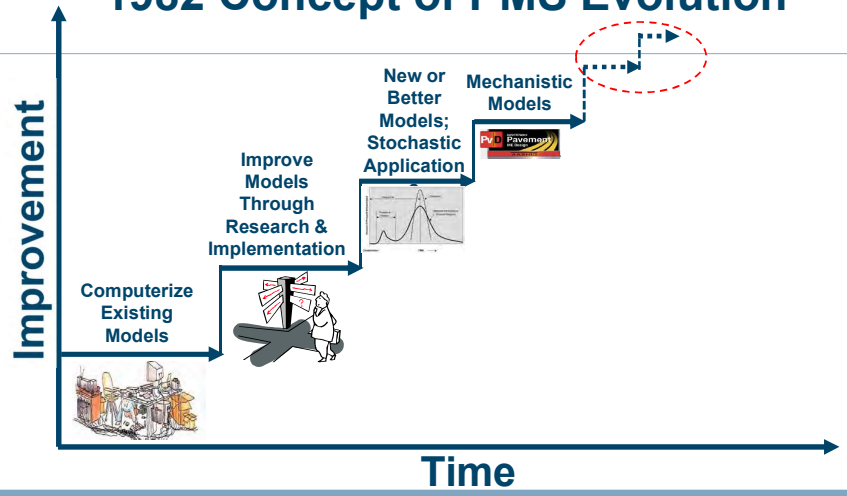
Dr Ralph Hass



- Original Edition 1978
- Reprinted in 1982
- Pavement Asset Management 2015

- PMS Concepts Began in 1960s
- At Time of Reprint Publication (1982), only One State Included Concrete in their PMS. PMS was generally developed around AC pavements.
- First State PMS was WSDOT in 1974
- First National PMS Conference was 1980; Only five states; AZ, CA, ID, UT, and WA had network level PMS used for project selection

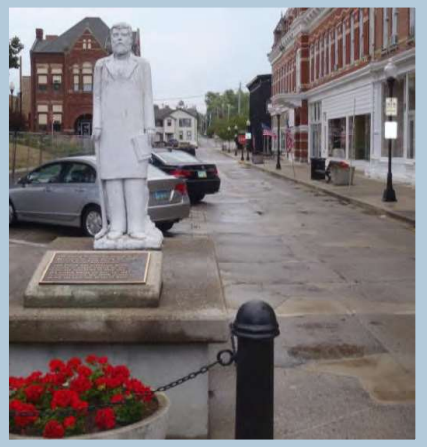
1982 Concept of PMS Evolution



Original Concept of Pavement Management– Circle of Life PMS Style

Concrete Pavements Out Last the Generation that Builds Them!

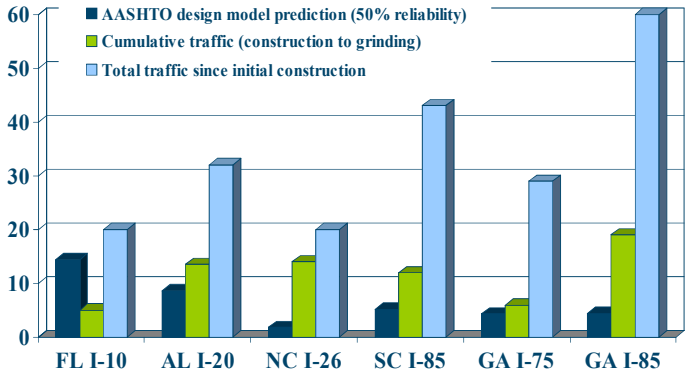
127 Years Old



Court Avenue Bellefontaine Ohio

Title Courtesy of Alan Meadors

Design Life Vs Actual Performance



Courtesy Dr. Michael Darter

Utah I-15 Survival Analysis Results

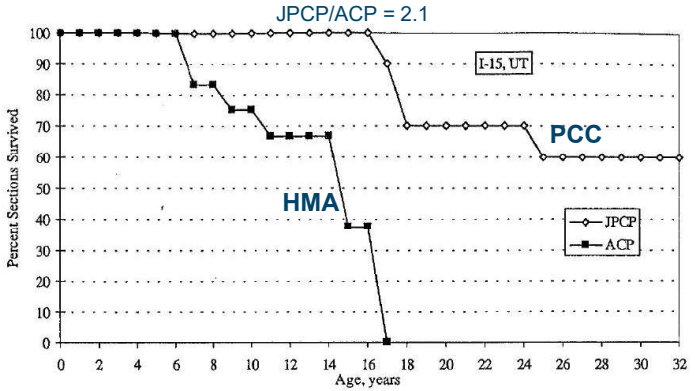
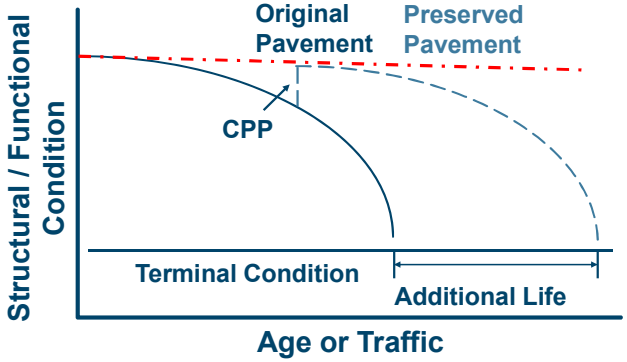
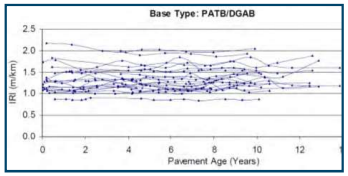


Figure 10. Age survival curves for original ACP and JPCP sections.

Courtesy Dr. Michael Darter

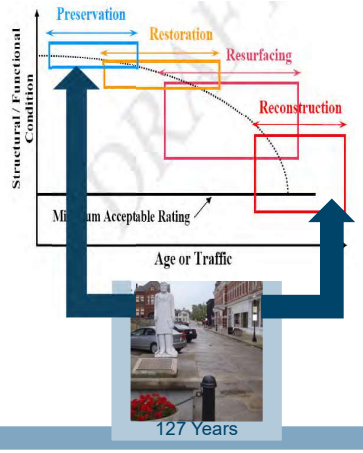
Portrayal of Pavement Performance





A Different Way to Think About Concrete Performance

- What About Early Repair of Construction Defects?
- Manage Individual Distresses/performance factors



127 Years

Things to Remember About PMS and Concrete Pavement

PMS

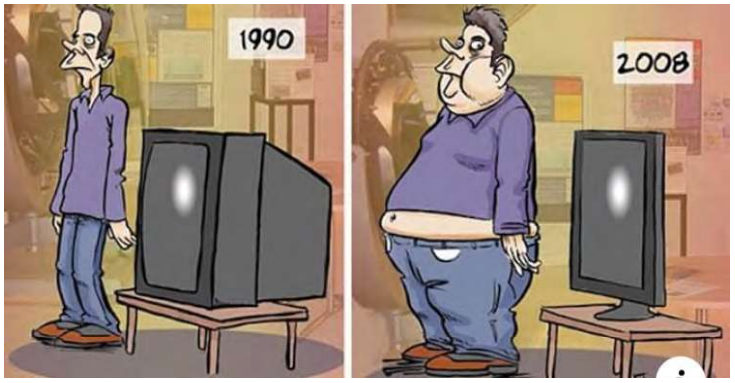
- Pavement Management is a Lagging System--- That is, damage to the pavement must occur prior to any ability to prevent or mitigate its occurrence
- Typically PMS Do Not Respond to Concrete Pavement Performance Until it Reaches A Specified Intervention Level
- Individual Performance Factors are Not Managed Separately- Composite Index
- Preservation is Often Not Included

Concrete Pavement

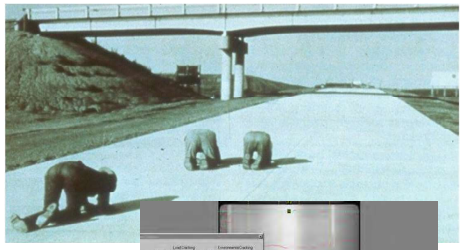
- Cracking in Concrete May Not Become Visible for Up to 2 Years
- Curl and Warp and Joint Opening Widths can Change After Construction
- Construction Defects May not Show Up for Many Years
- Treatment Life Versus Pavement Life

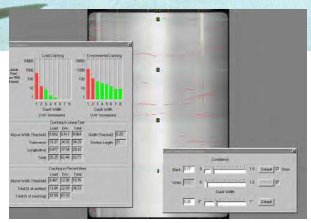
Photo Courtesy Amarjeet Benipal -- Caltrans

So What is Different Today



Then and Now Distress Identification





1962 NASA Command Center Dual IBM 7090 That's about .00015 gigabytes.

TxDOT 3D Automated Measurement System

Then and Now Distress Identification

Then

- Discrete Test Locations (Sampling)
- Manual Data Collection & Analysis
- Limited Computing Capacity
- Field Reviews Only
- Guestimates of Climate Data
- Little to No Ability to Evaluate Products or Test Sections
- Linear MP Location Data
- 2D Profile Measurements
- Limited to No Maintenance Data
- Questionable Traffic Data

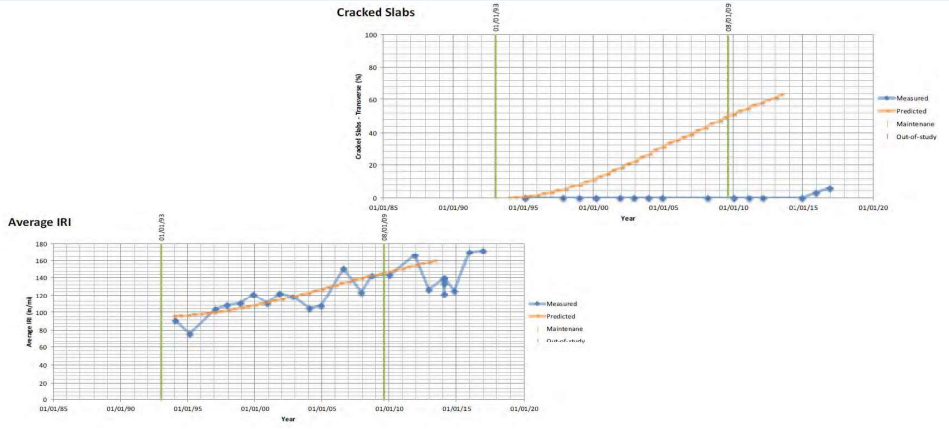
Now

- 100% Roadway Coverage
- Automated Data Collection & Analysis
- Almost Unlimited Computing Capacity
- In-Office Visual Review of Roadways
- Accurate Environmental Data
- Ability for PMS to Test Sections and Products
- GPS Coordinates
- 3D Profile Measurements
- Exact Maintenance Locations and Costs
- Better Traffic Data?

So What is Different Today

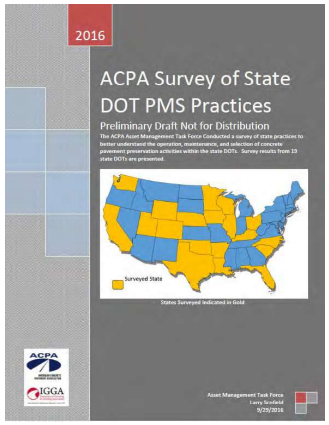
- We Can Now Predict Distress Over Time: Transverse Cracking, Faulting, Spalling, and Roughness
- We Can Compare Predicted to Observed Distresses and Begin Addressing Design, Materials, Specification, Construction, Maintenance Improvements
- Construction Properties Used to Do Cradle to Grave PMS

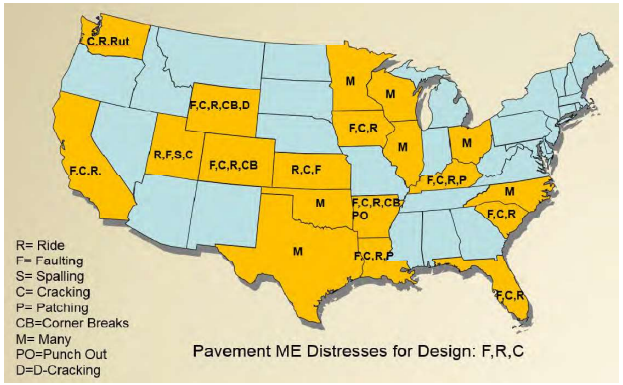
Comparing Observed to Predicted



Graphs Courtesy of NCE

ACPA Survey of State PMS Practices (Sept 2016)

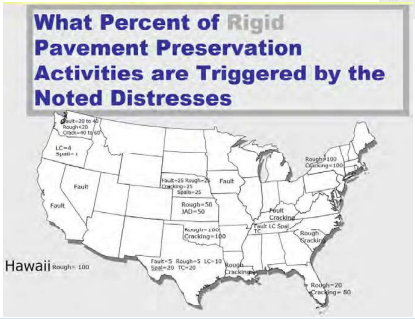


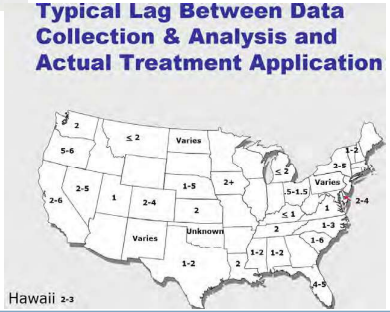


So What did ACPA Learn From Survey

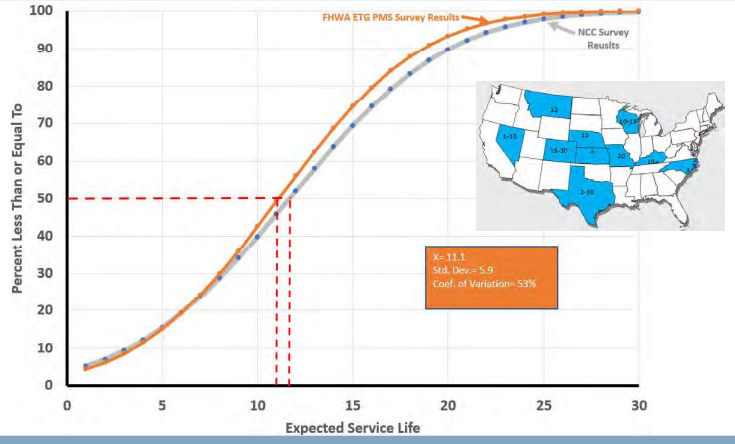
- Lots of Ways of Doing PMS (Triggers)
- About 60% of States Appear to be Managing Concrete Preservation with Triggers (i.e. 40% not Managing)
- No Consistent Methodology
- Most States Use Composite Statistics

FHWA Pavement Preservation ETG (March 2017)

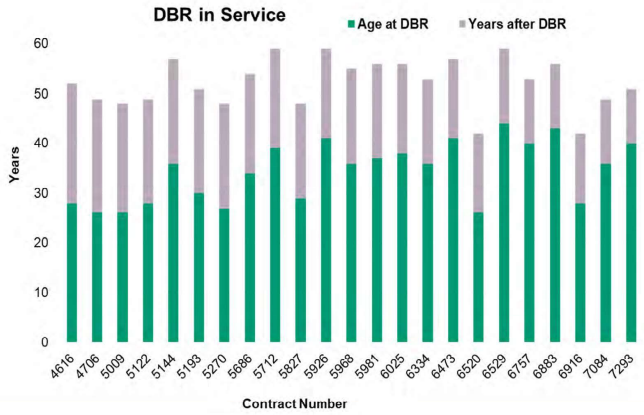




Partial Depth Repair Survival Analysis

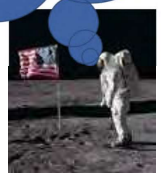


Data Rich Preservation Environment



Cradle to Grave Management!

Questions



Concrete Pavement Management & Preservation in Douglas County, CO

Angela Folkestad, PE
CO/WY Chapter - ACPA

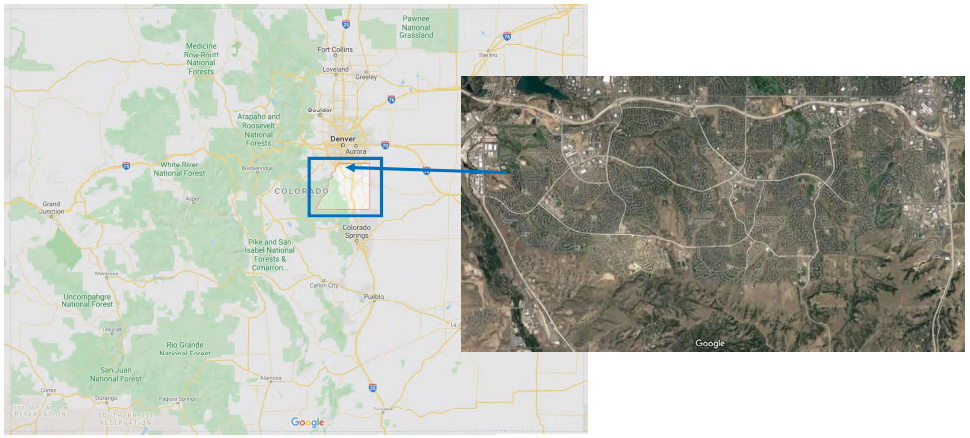
ACPA COLORADO/WYOMING CHAPTER

Count on CONCRETE

Special Thanks to…

DOUGLAS COUNTY
COLORADO

Where is Douglas County?



Douglas County Overview

- 2019 population estimate: 358,000
- 91% lives in urban areas which is 17.5% of the County land area
- Estimated populations of incorporated towns and cities:
  - Castle Pines: 11,340
  - Castle Rock: 69,000
  - Larkspur: 195
  - Lone Tree: 15,150
  - Parker: 57,405
- Estimated population of Unincorporated Douglas County: 202,400 (includes Highlands Ranch)

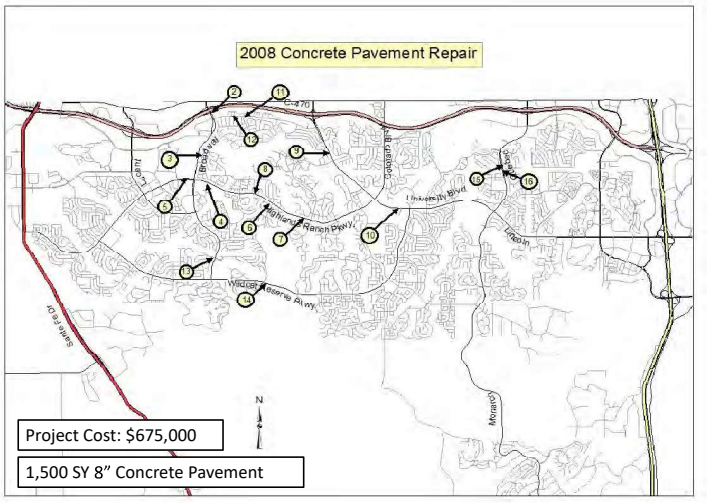
Douglas County Overview

Public Works Engineering manages 834 centerline miles of paved roads totaling 2,410 lane miles

- 2,040 lane miles of asphalt
- **370 lane miles of concrete**

Prior to 2009 – Contracted Maintenance

- County was in a fast-paced growth
- Major infrastructure construction
- Limited funding
- Limited staff
- Slab replacement (worst first approach)



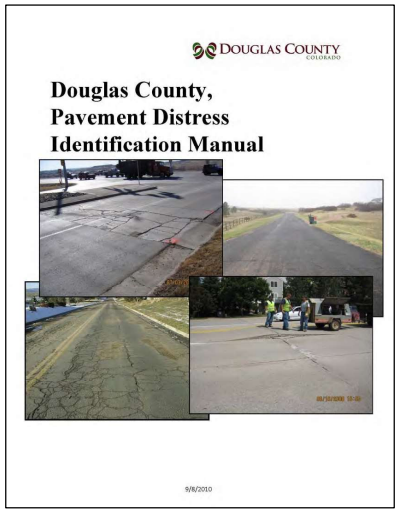
Planned Repairs

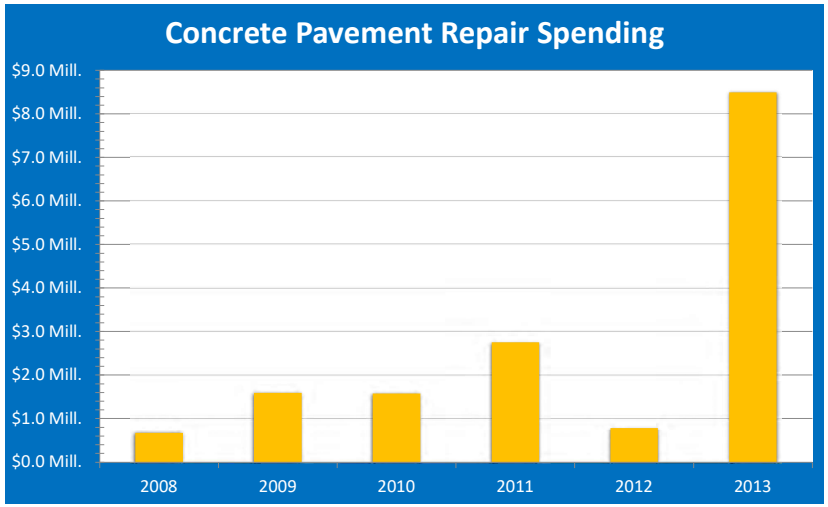
Emergency Repairs

1st Concrete Grinding Project was in 2008
SB Broadway: Salford to Gateway

2009 – Changes to Contracted Maintenance Program

- Reduced Infrastructure Budget – Increased budget for Contracted Maintenance Projects
- Increased staff size
- Started to Developed a Pavement Distress Identification Manual
- Started evaluating existing pavements in-house
- Used a pavement management program to maximize funding efficiency for the greatest benefit to the network
- Change from individual area repairs to larger segments based on a Pavement Condition Index





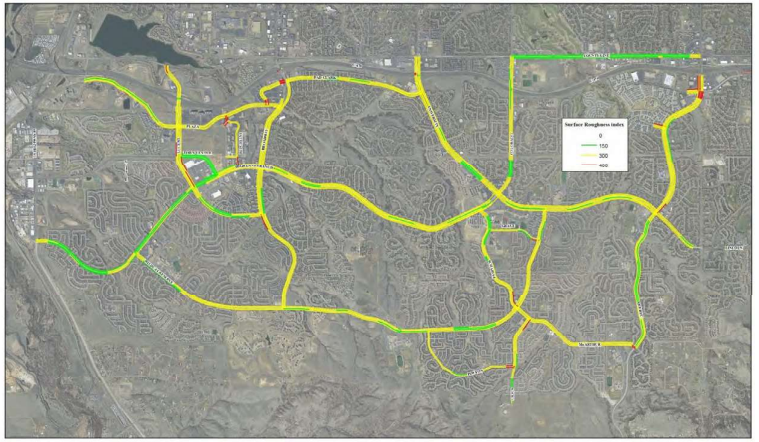
2013 Concrete Pavement Repair Program

- Determined that faulting and settlement of the concrete pavement needed to be evaluated in more detail
- Conferences with ACPA & IGGA to determine what options were available to correct deficiencies
- On site meeting with a CDOT representative who specialized in concrete pavement repair
- Determine how concrete pavement smoothness quantified
- What is a reasonable IRI threshold?

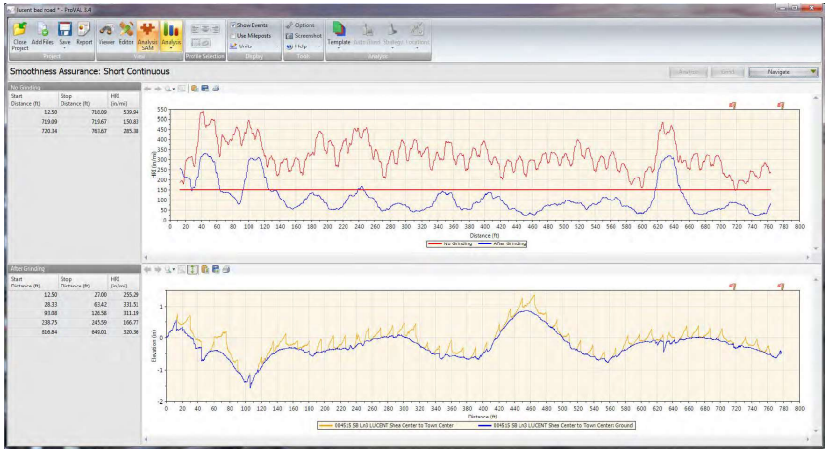
Summary from Discussions

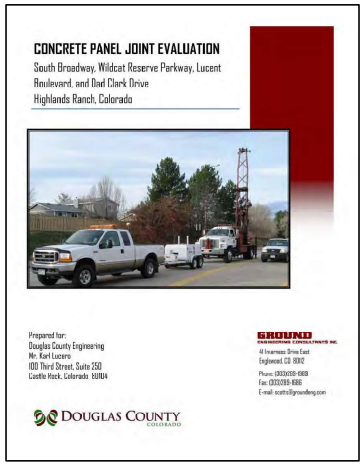
- Collect IRI data per lane and per segment for all concrete pavement
- Evaluate load transfer efficiency of the pavement
- Determine pavement thickness
- Perform subsurface evaluations

IRI Results for Concrete Pavement

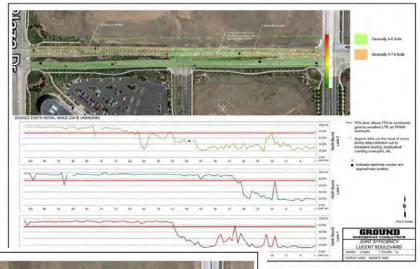


ProVal to Predict Grinding Improvements

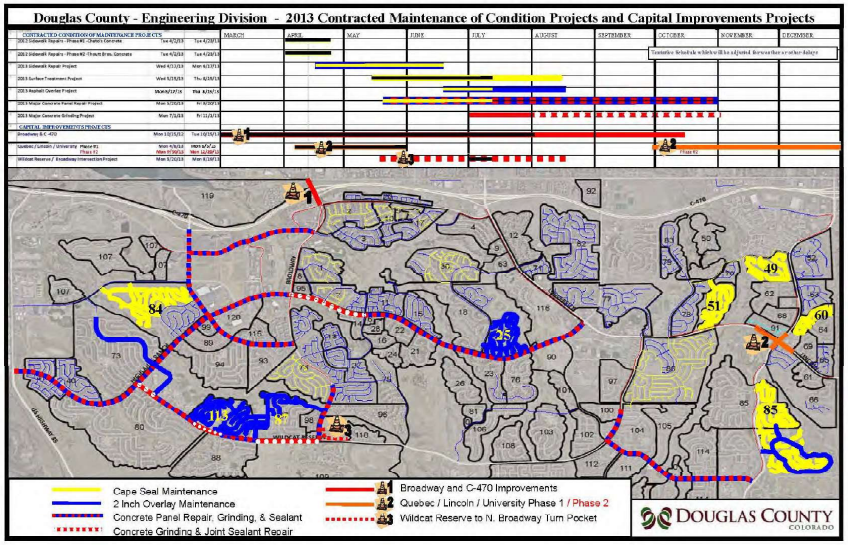


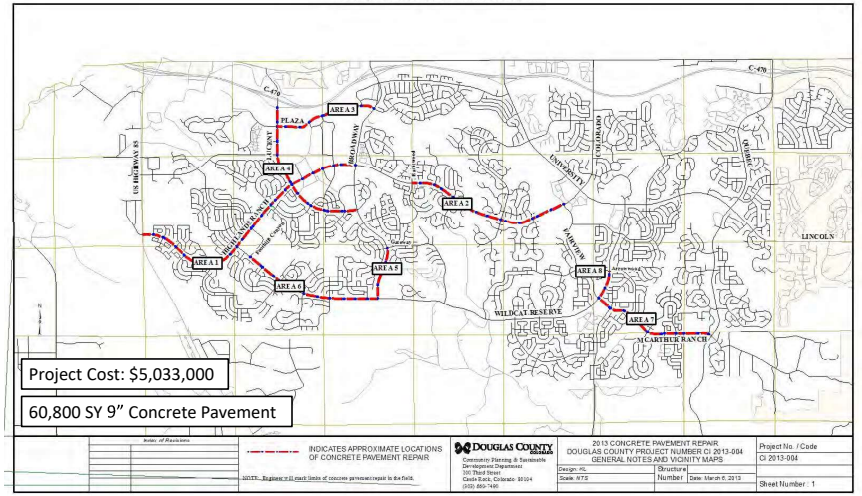


Load Transfer Efficiency



Pavement Thickness


Douglas County - Engineering Division - 2013 Contracted Maintenance of Condition Projects and Capital Improvements Projects
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
Tentative Schedule subject to change
CAPITAL IMPROVEMENTS PROJECTS
Cape Seal Maintenance
2 Inch Overlay Maintenance
Concrete Panel Repair, Grinding, & Sealant
Concrete Grinding & Joint Sealant Repair
Broadway and C-470 Improvements
Quebec / Lincoln / University Phase 1 / Phase 2
Wildcat Reserve to N. Broadway Turn Pocket
DOUGLAS COUNTY
COLORADO


DOUGLAS COUNTY COLORADO
2013 CONCRETE PAVEMENT REPAIR PROJECT
DOUGLAS COUNTY PROJECT NUMBER CI 2013-004
AREA 1
AREA 2
AREA 3
AREA 4
AREA 5
AREA 6
AREA 7
AREA 8
PLAZA
WILDCAT RESERVE
MCARTHUR RANCH
LINCOLN
Project Cost: $5,033,000
60,800 SY 9" Concrete Pavement
INDICATES APPROXIMATE LOCATIONS OF CONCRETE PAVEMENT REPAIR
DOUGLAS COUNTY
2013 CONCRETE PAVEMENT REPAIR
DOUGLAS COUNTY PROJECT NUMBER CI 2013-004
GENERAL NOTES AND VICINITY MAPS
Project No. / Code
CI 2013-004
Sheet Number : 1


INDICATES APPROXIMATE LOCATIONS OF CONCRETE PAVEMENT REPAIR
DOUGLAS COUNTY
2013 CONCRETE PAVEMENT REPAIR
DOUGLAS COUNTY PROJECT NUMBER CI 2013-004
GENERAL NOTES AND VICINITY MAPS
Project No. / Code
CI 2013-004
Area 4
Sheet Number : 9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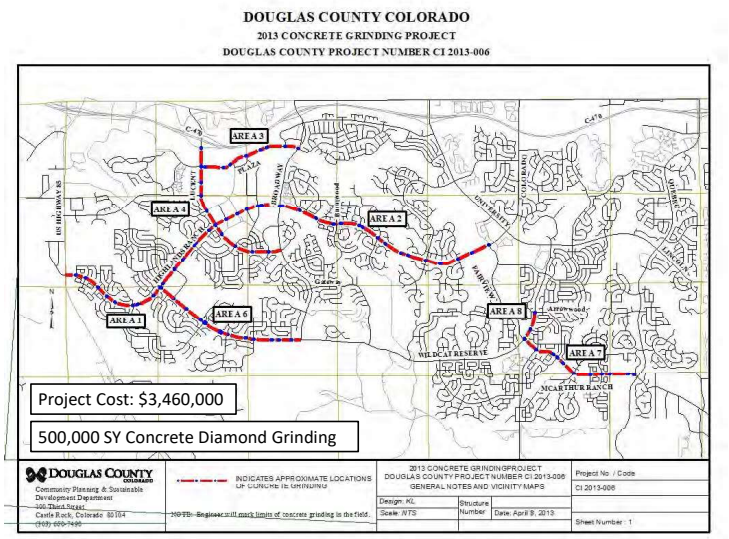


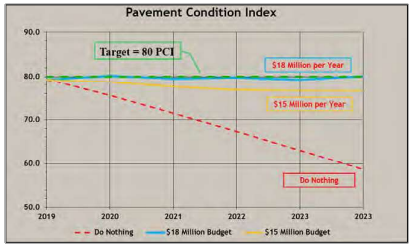
Diamond Grinding Specs

Focused on Improvement of Ride

- HRI ≤ 80 & max. grinding depth of 0.5”
  When initial HRI ≤ 150
- HRI ≤ 150 & max. grinding depth of 0.5”
  50% improvement over initial HRI if ≤ 150 wasn’t achievable

Pavement Management System Rebuild 2018-2019

- Assets redefined
  - “paving sector” for local streets
  - “supersegment” for arterial streets
- Automated data collection performed, shifting from manual collection of data
- Indexes and curves redefined based on current data
- Analysis was simplified



Reformatted Inventory Tables

Original Inventory Table

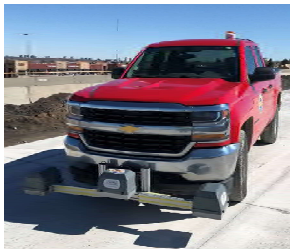
ROAD	FROM_DESCRIPTION	FROM	TO_DESCRIPTION	TO	Length	ElementID	PCI	PMP_Sector	Sector_From	Sector_TO
CREEKSIDE LN	CREEKSIDE WAY	0	TOWN CENTER DR	539.659	539.659	037380-000000	63	LS007	0	539.659
CREEKSIDE PT		0	CREEKSIDE WAY	261.344	261.344	003365-000000	46	LS007	539.659	801.003
CREEKSIDE WAY	PLAZA DR	0	EDINBURGH LN	580.193	580.193	023150-000000	69	LS007	801.003	1381.196
CREEKSIDE WAY	EDINBURGH LN	580.193	EDINBURGH LN	627.038	46.845	023150-000580	75	LS007	1381.196	1428.041
CREEKSIDE WAY	EDINBURGH LN	627.038	OLD TOM MORRIS CIR	1252.633	625.595	023150-000627	75	LS007	1428.041	2053.636
CREEKSIDE WAY	OLD TOM MORRIS CIR	1252.633	OLD TOM MORRIS CIR	1300.678	48.045	023150-001253	87	LS007	2053.636	2101.681
CREEKSIDE WAY	OLD TOM MORRIS CIR	1300.678	CREEKSIDE LN	1635.607	334.929	023150-001301	82	LS007	2101.681	2436.61
CREEKSIDE WAY	CREEKSIDE LN	1635.607	CREEKSIDE PT	1906.837	271.23	023150-001636	73	LS007	2436.61	2707.84
CREEKSIDE WAY	CREEKSIDE PT	1906.837	S HUNTERS WAY	2176.047	269.21	023150-001907	83	LS007	2707.84	2977.05
GREENSBOROUGH CIR	GREENSBOROUGH DR	0	GREENSBOROUGH DR	920.883	920.883	026340-000000	78	LS007	2977.05	3897.933

New Inventory Table

Road	From	To	ElementID	Length	PCI	STREET_NAME	STREET_FROM	STREET_FROM_ADD	STREET_TO	STREET_TO_ADD
LS007	0	539.659	037380-000000	539.659	63	CREEKSIDE LN	CREEKSIDE WAY	0	TOWN CENTER DR	539.659
LS007	539.659	801.003	003365-000000	261.344	46	CREEKSIDE PT		0	CREEKSIDE WAY	261.344
LS007	801.003	1381.196	023150-000000	580.193	69	CREEKSIDE WAY	PLAZA DR	0	EDINBURGH LN	580.193
LS007	1381.196	1428.041	023150-000580	46.845	75	CREEKSIDE WAY	EDINBURGH LN	580.193	EDINBURGH LN	627.038
LS007	1428.041	2053.636	023150-000627	625.595	75	CREEKSIDE WAY	EDINBURGH LN	627.038	OLD TOM MORRIS CIR	1252.633
LS007	2053.636	2101.681	023150-001253	48.045	87	CREEKSIDE WAY	OLD TOM MORRIS CIR	1252.633	OLD TOM MORRIS CIR	1300.678
LS007	2101.681	2436.61	023150-001301	334.929	82	CREEKSIDE WAY	OLD TOM MORRIS CIR	1300.678	CREEKSIDE LN	1635.607
LS007	2436.61	2707.84	023150-001636	271.23	73	CREEKSIDE WAY	CREEKSIDE LN	1635.607	CREEKSIDE PT	1906.837
LS007	2707.84	2977.05	023150-001907	269.21	83	CREEKSIDE WAY	CREEKSIDE PT	1906.837	S HUNTERS WAY	2176.047
LS007	2977.05	3897.933	026340-000000	920.883	78	GREENSBOROUGH CIR	GREENSBOROUGH DR	0	GREENSBOROUGH DR	920.883

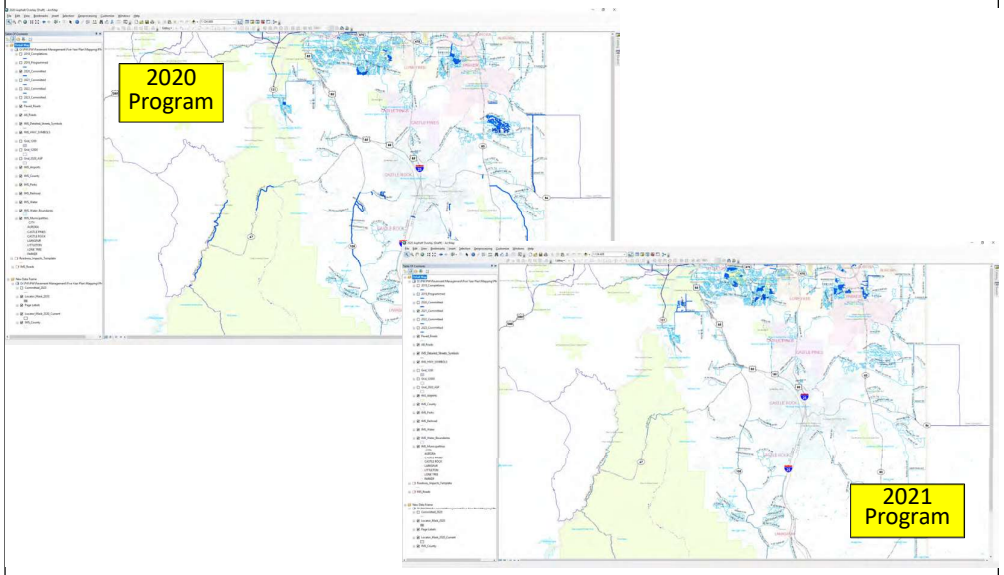
Automated Data Collection

- **Distress**: Collected cracking, divided slabs, patches, scaling & joint spalling data in 2017
- **Ride Quality**: Collected MRI data in 2017 & 2018



Simplified Analysis

- Four Concrete Treatments
  - Panel Replacement
  - Grinding
  - Joint Resealing
  - Reconstruction
- All costs per square yard
- Modified Triggers
  - Panel Replacement & Reconstruction Triggered by % of Damaged Slabs
  - Grinding Triggered by Panel Replacement in Prior Year
  - Sealing Triggered by Panel Replacement in Prior Year



Concrete Rehabilitation Strategies

Concrete panel replacement is used to replace damaged sections on concrete roadways – precedes concrete grinding – includes dowel bars.

Year	Total Area (SY)	Cost	Cost/SY
2019	7,420	$ 1,181,775.02	$ 159.27
2018	22,460	$ 2,547,339.86	$ 113.42
2016	20,387	$ 2,460,202.00	$ 120.68
2016	48,786	$ 4,375,225.70	$ 89.68

Concrete Rehabilitation Strategies

Diamond Grinding is performed on roads in good condition, but with poor ride, to restore ride quality - follows concrete panel repairs and is generally followed by joint sealing.

Year	Total Area (SY)	Total Project Cost	Grinding Cost/SY
2015	389,245	$ 2,124,049.50	$ 3.50
2014	285,961	$ 1,322,462.35	$ 3.53
2013	443,342	$ 1,953,151.46	$ 3.63

Concrete Rehabilitation Strategies

- **Joint Sawing and Resealing** is used on roads in good condition and follows diamond grinding.

Year	Total Length (LF)	Cost	Cost/LF
2017	52,731	$ 115,480.85	$ 2.19
2016	716,013	$ 1,453,819.96	$ 2.03
2015	57,043	$ 210,233.96	$ 3.69
2014	600,573	$ 700,993.32	$ 1.17
2013	563,744	$ 687,767.68	$ 1.22

Concrete Rehabilitation Strategies

Concrete Reconstruction is utilized for complete replacement of a concrete roadway when cracked/damaged slabs > 50%.

Year	Project	Total Area (SY)	Total Project Cost	Concrete Cost/SY
2019	Belford Ave.	12,855	$ 1,727,621	$ 59.00
2018	Meridian Ph. 1	23,454	$ 3,022,900	$ 56.51
2017	Oswego	12,634	$ 1,394,746	$ 55.74
2017	Lansing Circle	4,065	$ 369,589	$ 64.13

Multi-Year Pavement Preservation Program in Highlands Ranch 2013-2016

Year	Contract Amount	Lane Miles	Cost/Lane Mile
2013	$ 8,495,392	58	$ 146,472
2014	$ 7,199,111	48	$ 149,981
2015	$ 7,081,332	29	$ 244,184
2016	$ 3,747,829	20	$ 187,391
Total	***$ 26,523,664***	***155***	***$ 171,120***

Overall Average: $24.31/SY

Thank you!

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