Implementation of M-E PDG in Maricopa County, Arizona

John Shi, PhD, PE

Materials Engineer

MCDOT

M-E PDG

Mechanistic-
Empirical
Pavement
Design
Guide

MCDOT Update

- **15 projects:** 8 new constructions
  4 overlays
  3 intersection improvements
- **4 types of AC mixes (24 samples):** 19 mm Superpave
  12.5 mm Superpave
  Rubberized Asphalt (Terminal Blend)
  Asphalt Rubber (AR)
- **3 types of binder:** Terminal Blend (PG **76-22**)
  Regular Binder (PG **70-10**)
  AR Binder (PG **64-16** w/ **Crumb Rubber**)
- **2 types subgrade soils (2 samples):** Silty/Sandy soil
  Clayey soil
- **One type of MAG AB:** From Rinker Plant in Phoenix, AZ
- **Samples were tested for material characterization:** ASU Lab
  MCDOT Lab
  MCTEC Lab

MCDOT Update

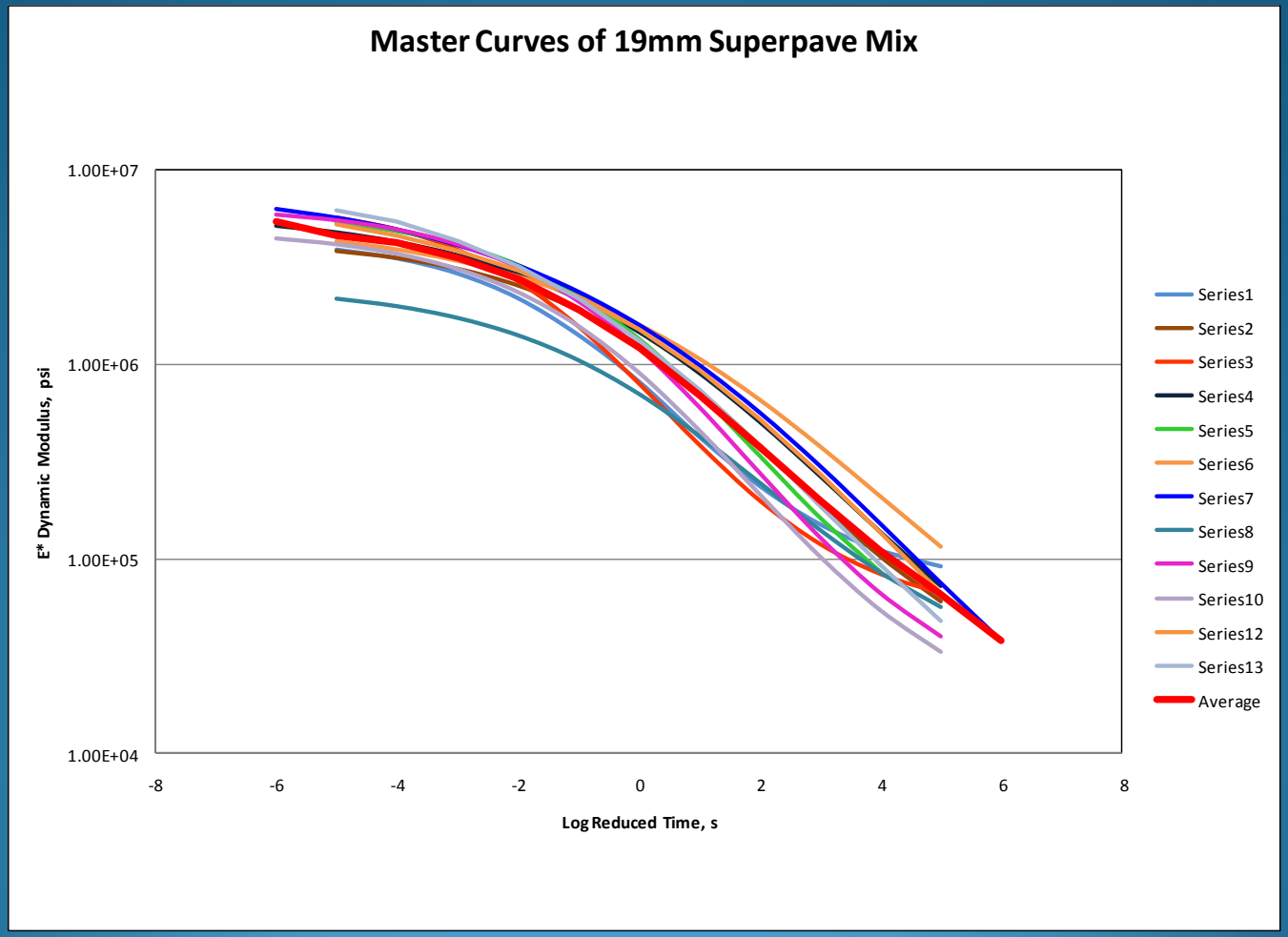
- Test run M-E PDG program for 3 of the 8 new construction projects
- Establish pavement distress evaluation for all of the 15 projects
- Compare observed distresses with predicted from M-E PDG in the calibration process
- Consider using ADOT data within the County

Pavement Material Characterization

Hot Mix Asphalt and Asphalt Binder

- Conduct Level 1, E* Test and other tests to obtain actual master curve and shift factor line
- Conduct conventional mix gradation, binder content, air voids, binder viscosity tests
- Use the predictive equation (correlation equation) to determine the master curve or parameters
- Compare the correlated properties with the actual tested.

Pavement Material Characterization



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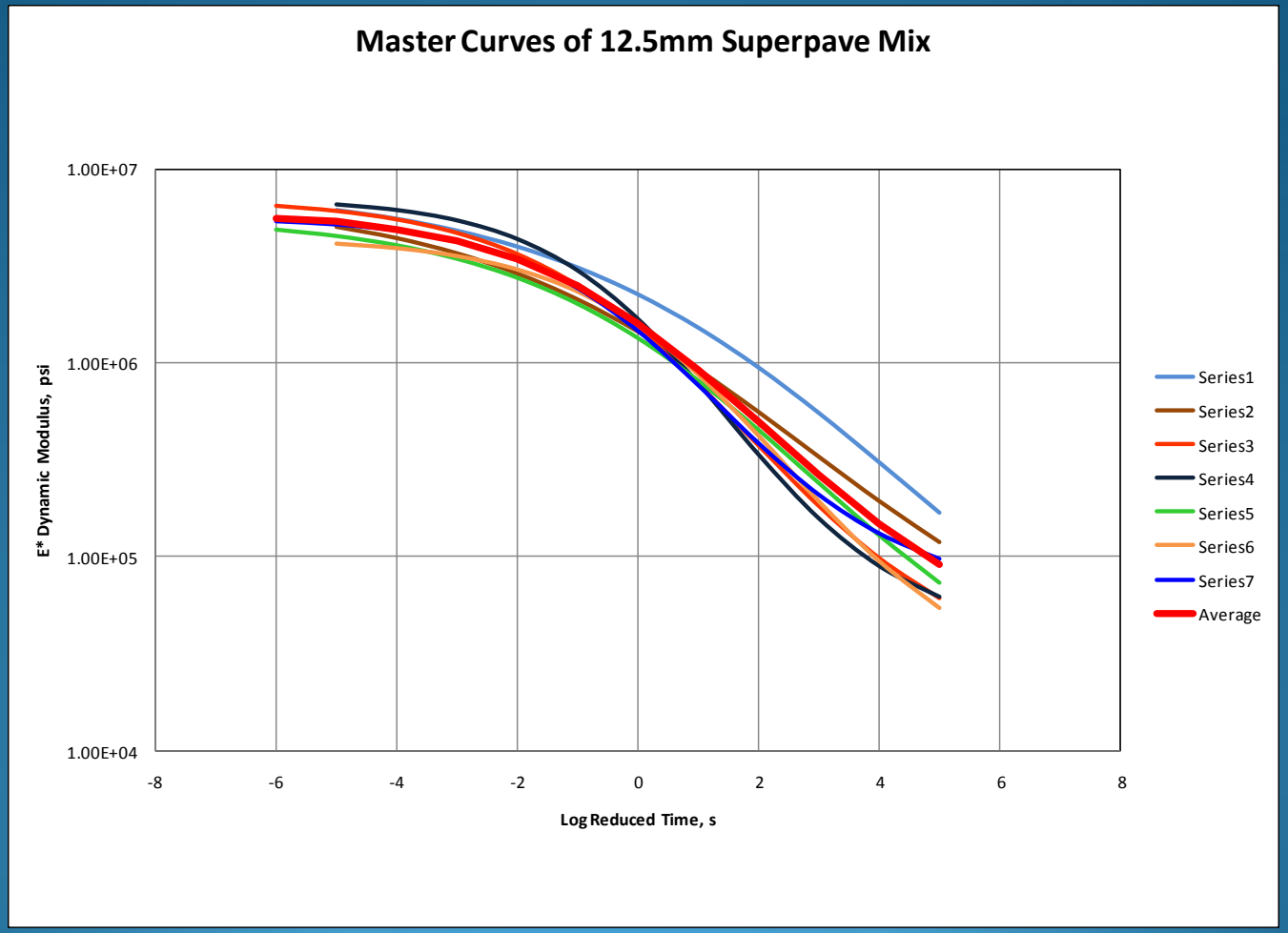

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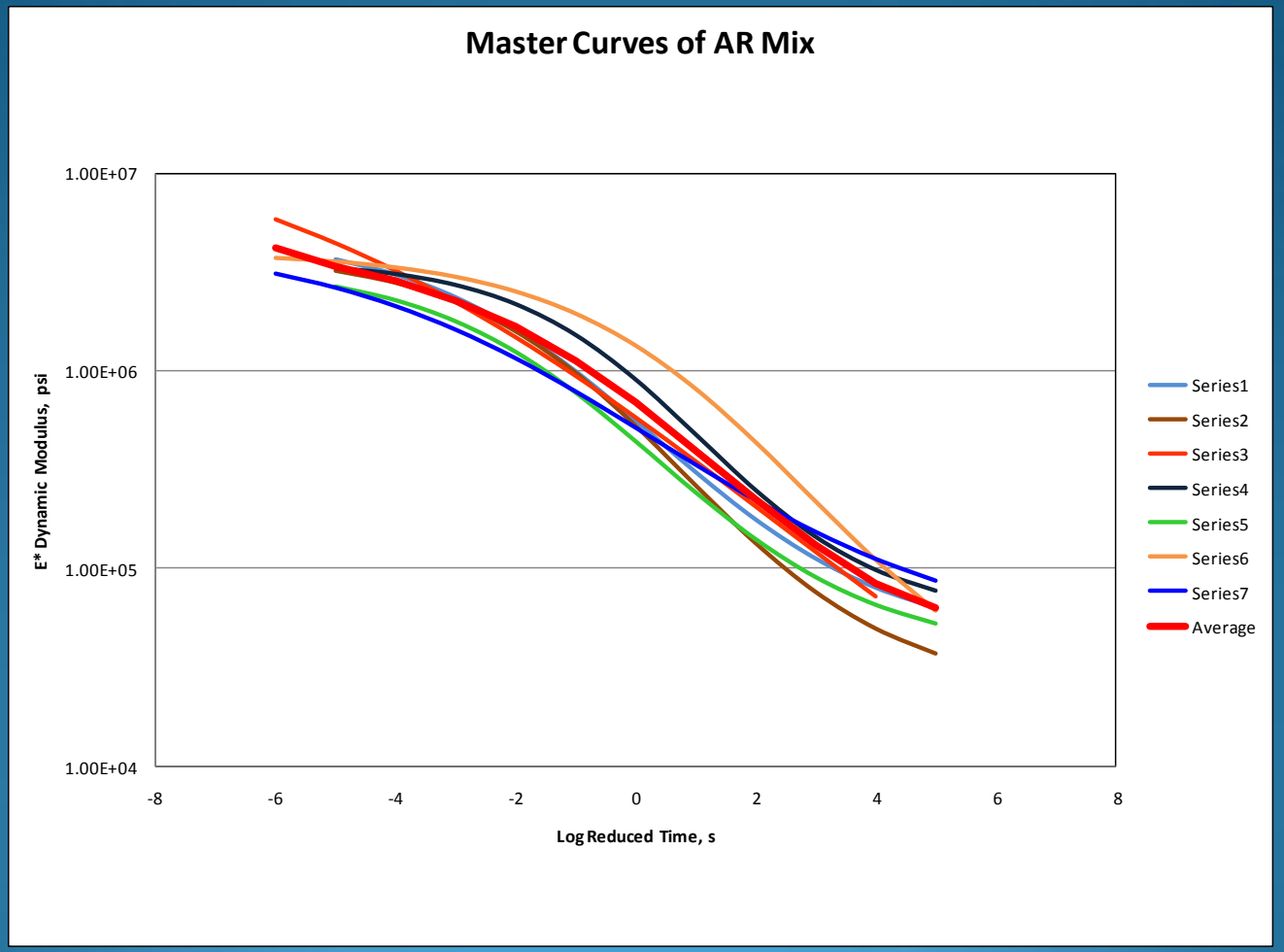

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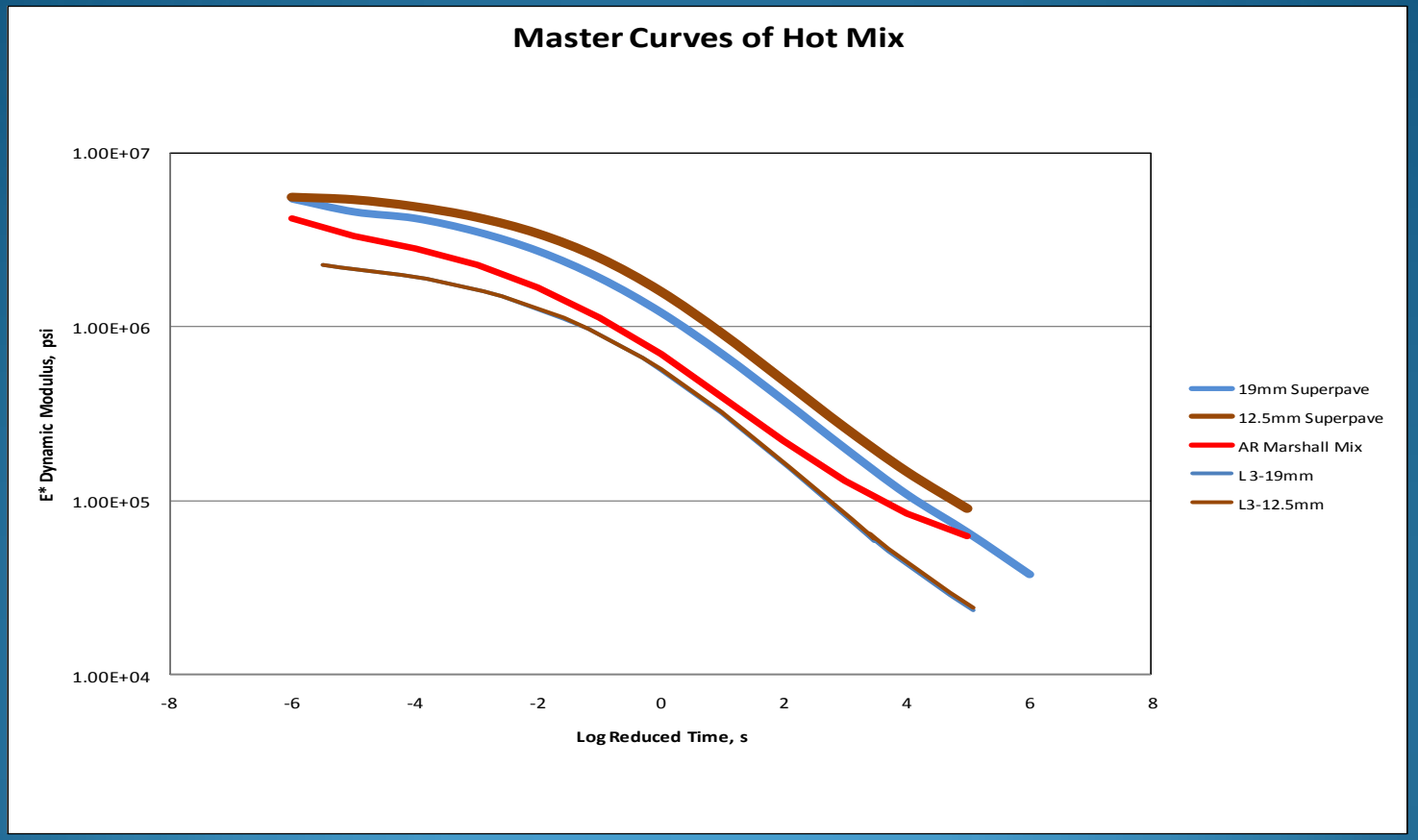

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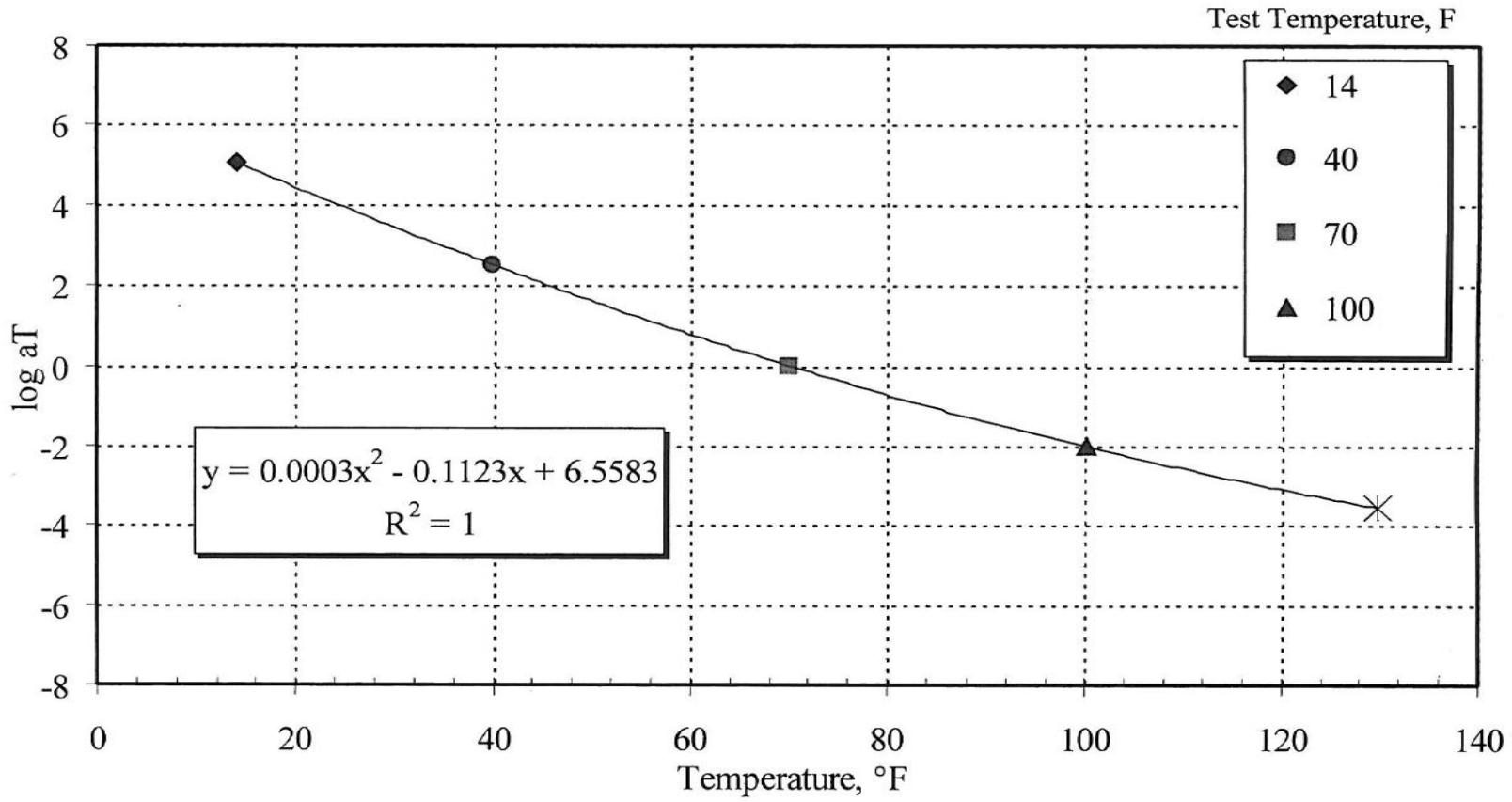


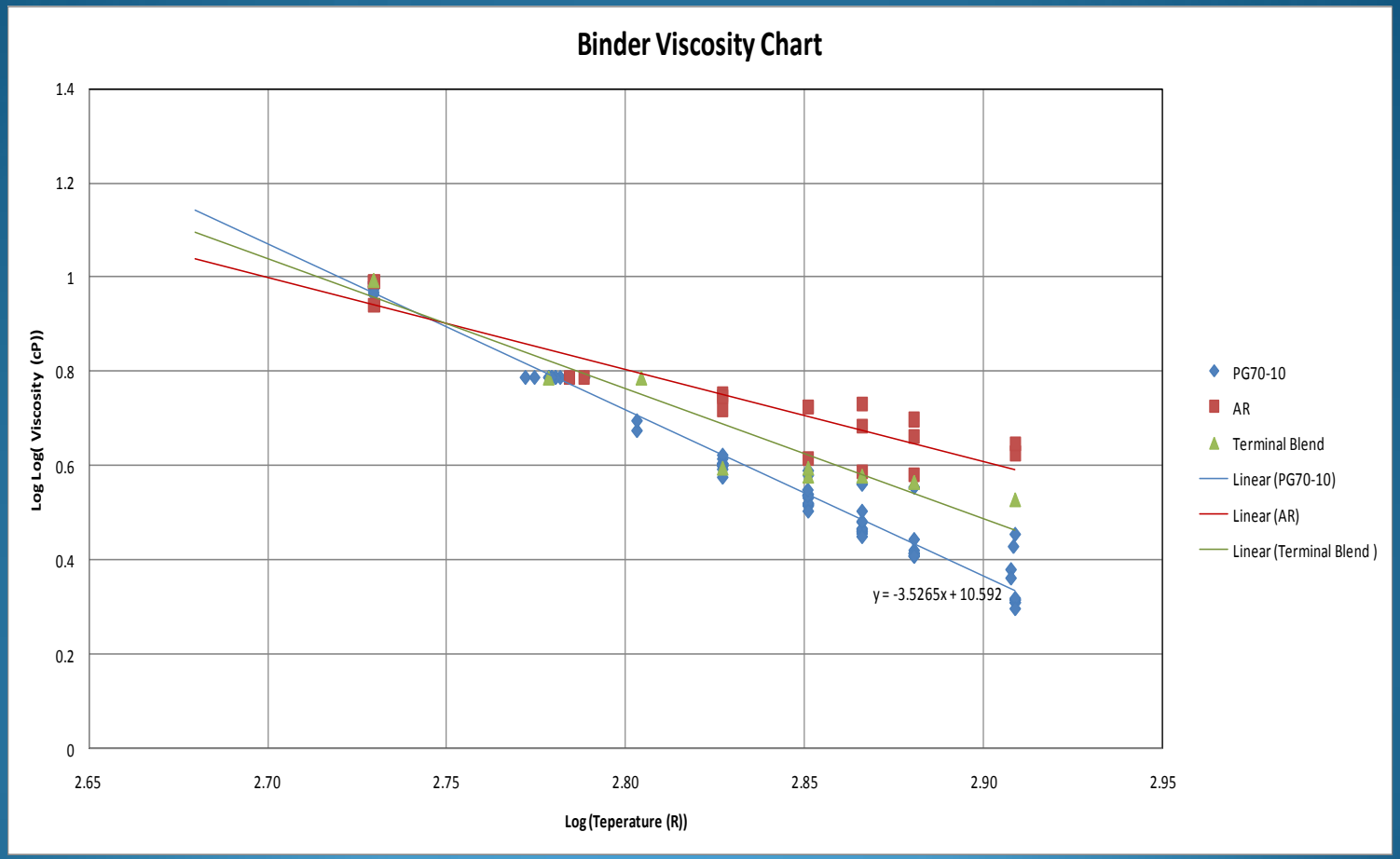
Figure B-51. Shift Factors Based on Average E* Data of Three Replicates (Sample No. 17, Indian School Road, 19 mm, Replicate 2)

Pavement Material Characterization

Binder Properties

Binder Type	PG70-10 Level 1	PG70-10 Level 3	AR Binder	Terminal Blend
Ai	10.592	10.690	6.298	8.486
VTSi	-3.527	-3.566	-1.962	-2.758

Pavement Material Characterization



Pavement Material Characterization

Subgrade Material Database

- Create a user friendly GIS based database for MCDOT
- Soil units, defined in terms of Pedologic, AASHTO and USCS units, crossed by the major MCDOT streets and routes
- Soil unit material properties, including PI, P_{200}, R-Value if available, saturated hydraulic conductivity, soil classification, soil suction and expansion potential
- Groundwater table depth
- They will be used as input parameters required in the constitutive models recommended within the ME-PDG

Material Characterization

M_R for Soil and Aggregate Base

- Select input Level 2 in the future
- No Level 1 cyclic tri-axial tests required
- Commonly used R-value, PI, gradation, Proctor, swell potential tests will be needed
- M_R from correlations depend on moisture fluctuations
- EICM uses weather data and SWCC to predict M_R
- Level 1 and Level 2 tests performed during input characterization
- Verify correlation

Material Characterization

M_R for Soil and Aggregates Base (Cont'd…)

- Three water content values or suction levels selected
- Conduct cyclic tri-axial tests
- Determine the regression constant k_1, k_2, and k_3 corresponding to the moisture levels
- M_R can be obtained for given stress state and moisture condition
- Typical hot and cold condition stress levels for AB and subgrade provided
- Typical hot and cold condition M_R provided for the above mentioned moisture levels

Material Characterization

Parameter	AB (A-1-a or GP-GM)	Subgrade (A-4 or SM)	Subgrade (A-4 or SC)
P_{200}	6.8%	47.7%	47.4%
PI	NP	3	5
$\rho_{d,\,max}$	2.263 g/cm^3	1.935 g/cm^3	1.906 g/cm^3
w_{opt}	7.0%	12.5%	12.2%
SG	2.679	2.739	2.710
$M_{R,\,hot}$	46,620 psi	22,272 psi	16,851 psi
$M_{R,\,cold}$	16,600 psi	22,457 psi	21,782 psi
$M_{R,\,corr}$	40,500 psi	25,600 psi	21,318 psi

Material Characterization

Climatic Model Specific for MCDOT

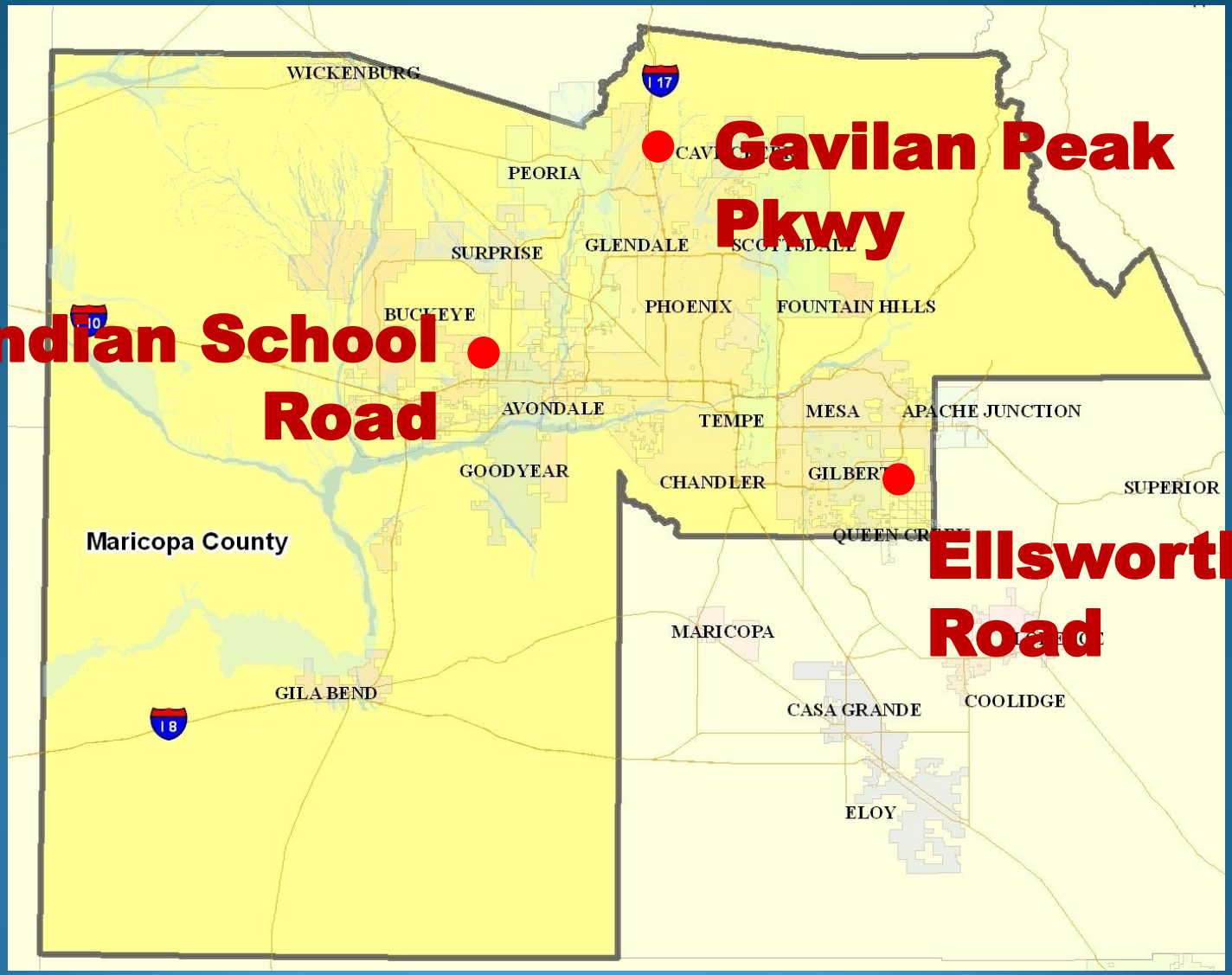
- **Default input climatic data files and typical climatic zones will be developed**

- **Data Sources include:**
  - The National Climatic Data Center **(NCDC)**
  - The Federal Highway Administration (**FHWA**) Long-Term Pavement Performance (**LTPP**) Database
  - The Arizona Meteorological Network (**AZMET**) Database

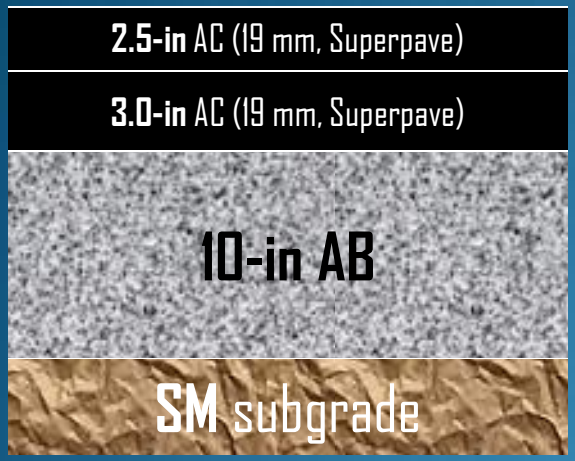
Traffic Characterization

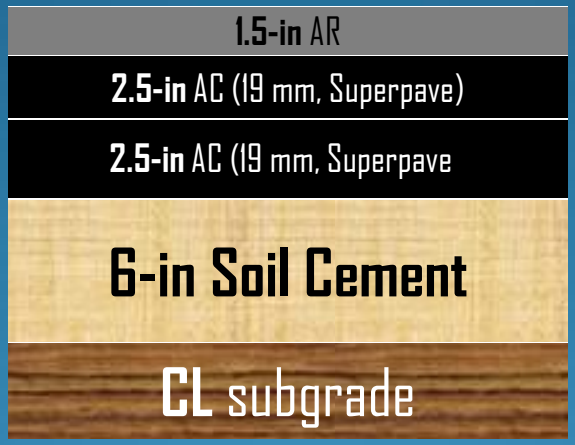
- Traffic data within the entire County for ME-PDG is not available
- Extremely costly to establish weigh-in-motion (WIM) sites and collect WIM data
- We used the national database values for our trials
- Most likely, the existing data such as AADT, Classification, direction counts, hourly counts will be used

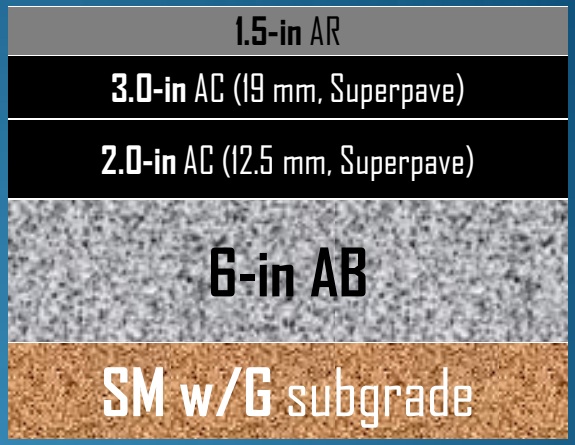
Tested Flexible Pavement Locations



Tested Flexible Pavement Structures







Ellsworth Rd

Currently owned by
City of Mesa

Indian School Rd

Currently owned by
City of Goodyear

Gavilan Peak Pkwy

Currently owned by
Maricopa County

Tested Flexible Pavements

Ellsworth Road

- Principal Arterial
- East Valley
- New Construction
- 2-Lane, 2-Way
- 5.5" AC
- 10" AB
- SM subgrade
- Initial IRI 65
- Opened in 2007
- Current ADT 29,000
- Current Trucks 5%
- Growth rate 7%

Indian School Road

- Principal Arterial
- West Valley
- New Construction
- 2-Lane, 2-Way
- 1.5" AR over 5" AC
- 6" soil cement
- CL subgrade
- Initial IRI 58
- Opened in 2008
- Current ADT 24,000
- Current Trucks 2%
- Growth rate 2%

Gavilan Peak Parkway

- Principal Arterial
- Northern Area
- New Road
- 2-Lane, 2-Way
- 1.5" AR over 5" AC
- 6" AB
- SM w/ G subgrade
- Initial IRI 62
- Opened in 2009
- Current ADT 7,800
- Current Trucks 8%
- Growth rate 4%

ME-PDG Runs—Cases*

Level 1 Runs				ESALs
Ellsworth Rd	Case 1	As-Built Pavement	Old Design Traffic	14.4 Million
	Case 2	As-Built Pavement	Actual Existing Traffic	17.8 Million
Indian School Rd	Case 1	As-Built Pavement	Old Design Traffic	7.9 Million
	Case 2	As-Built Pavement	Actual Existing Traffic	4.5 Million
Gavilan Peak Pkwy	Case 1	As-Built Pavement	Old Design Traffic	7.0 Million
	Case 2	As-Built Pavement	Actual Existing Traffic	2.3 Million

Level 3 Runs				ESALs
Ellsworth Rd	Case 1	As-Built Pavement	Old Design Traffic	14.4 Million
	Case 2	As-Built Pavement	Actual Existing Traffic	17.8 Million
Indian School Rd	Case 1	As-Built Pavement	Old Design Traffic	7.9 Million
	Case 2	As-Built Pavement	Actual Existing Traffic	4.5 Million
Gavilan Peak Pkwy	Case 1	As-Built Pavement	Old Design Traffic	7.0 Million
	Case 2	As-Built Pavement	Actual Existing Traffic	2.3 Million

* ME-PDG Version 1.100 was used to run these cases

ME-PDG Runs—Distress Target and Reliability

Performance Criteria	Units	Distress* Target	Reliability * Target
Terminal IRI	in/mile	172	90
Longitudinal Cracking (Surface Down)	ft/mile	1000	90
Alligator Cracking (Bottom Up)	%	100	90
Transverse Cracking (Thermal)	ft/mile	100	90
Rutting (AC Only)	in	0.25	90
Rutting (Total)	in	0.75	90

* Distress and Reliability targets are the default values in the program.

ME-PDG Runs—Results

Ellsworth Road

Level 1 Case 1

Performance Criteria	Distress Predicted				Reliability Predicted				Acceptable			
	L1 C1	L1 C2	L3 C1	L3 C2	L1 C1	L1 C2	L3 C1	L3 C2	L1 C1	L1 C2	L3 C1	L3 C2
Terminal IRI in/mi **172, Rel. 90%**	111.6	108.4	116.2	118.8	97.43	98.24	95.96	94.75	P	P	P	P
Longitudinal Cracking (Surface Down) ft/mi **1000, Rel. 90%**	749	441	501	732	72.11	78.05	76.81	72.42	F	F	F	F
Alligator Cracking (Bottom Up) % **100, Rel. 90%**	1.9	1.4	1.6	2.4	99.94	99.99	99.99	97.38	P	P	P	P
Transverse Cracking (Thermal) ft/mi **100, Rel. 90%**	1	1	1	1	99.99	99.99	99.99	99.99	P	P	P	P
Rutting (AC Only) in **0.25, Rel. 90%**	0.41	0.35	0.50	0.56	9.24	17.01	3.63	1.99	F	F	F	F
Rutting (Total) in **0.75, Rel. 90%**	0.66	0.59	0.78	0.84	74.34	90.57	41.64	30.23	F	P	F	F

Overall Best

Overall Best

Overall Best

ME-PDG Runs—Results

Indian School Road Road

Performance Criteria	Distress Predicted				Reliability Predicted				Acceptable			
	L1 C1	L1 C2	L3 C1	L3 C2	L1 C1	L1 C2	L3 C1	L3 C2	L1 C1	L1 C2	L3 C1	L3 C2
Terminal IRI in/mi **172, Rel. 90%**	100.7	96.2	115.9	100.8	99.39	99.75	95.94	99.41	P	P	P	P
Longitudinal Cracking (Surface Down) ft/mi **1000, Rel. 90%**	122	48.0	1910	302	87.46	93.23	51.56	81.22	F	P	F	F
Alligator Cracking (Bottom Up) % **100, Rel. 90%**	2.4	1.2	7.7	1.9	98.85	99.99	88.99	99.99	P	P	F	P
Transverse Cracking (Thermal) ft/mi **100, Rel. 90%**	1	1	1	1	99.99	99.99	99.99	99.99	P	P	P	P
Rutting (AC Only) in **0.25, Rel. 90%**	0.27	0.20	0.51	0.27	39.54	77.73	3.12	39.42	F	F	F	F
Rutting (Total) in **0.75, Rel. 90%**	0.54	0.45	0.85	0.55	97.26	99.96	26.11	96.64	P	P	F	F

Overall Best

Overall Best

Overall Best

ME-PDG Runs—Results

Gavilan Peak Parkway

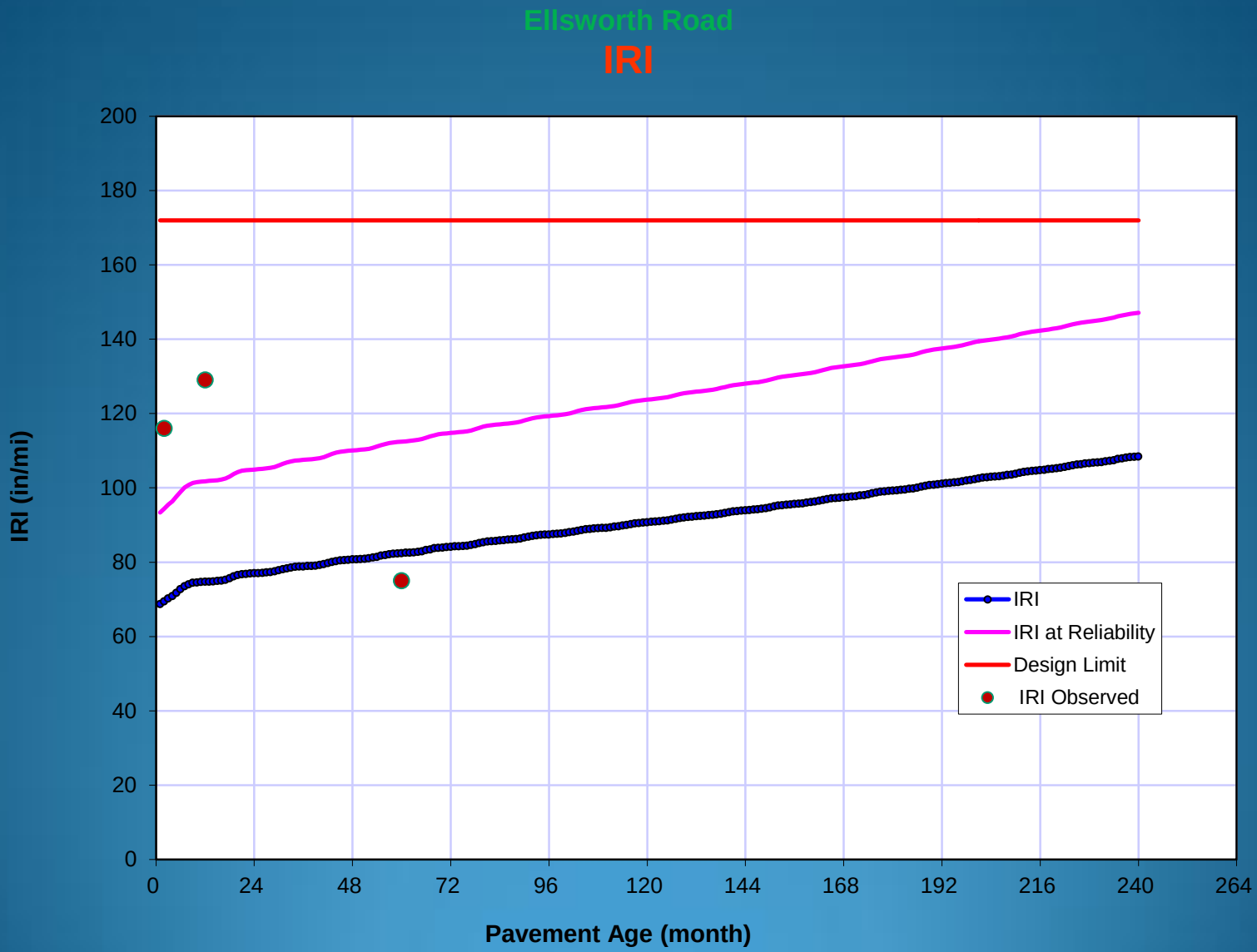
Performance Criteria	Distress Predicted				Reliability Predicted				Acceptable			
	L1 C1	L1 C2	L3 C1	L3 C2	L1 C1	L1 C2	L3 C1	L3 C2	L1 C1	L1 C2	L3 C1	L3 C2
Terminal IRI in/mi **172, Rel. 90%**	95.7	91.5	100.6	93.2	99.76	99.90	99.42	99.86	P	P	P	P
Longitudinal Cracking (Surface Down) ft/mi **1000, Rel. 90%**	75.3	2.4	79.5	1.6	73.57	97.86	73.21	98.94	F	P	F	P
Alligator Cracking (Bottom Up) % **100, Rel. 90%**	0.6	0.3	0.7	0.2	99.99	99.99	99.99	99.99	P	P	P	P
Transverse Cracking (Thermal) ft/mi **100, Rel. 90%**	1	1	1	1	93.61	93.61	93.61	93.61	P	P	P	P
Rutting (AC Only) in **0.25, Rel. 90%**	0.24	0.18	0.36	0.22	52.69	89.30	15.31	68.53	F	F	F	F
Rutting (Total) in **0.75, Rel. 90%**	0.43	0.33	0.55	0.37	99.97	99.99	95.39	99.99	P	P	P	P

Overall Best

Overall Best

Overall Best

Comparison of Results



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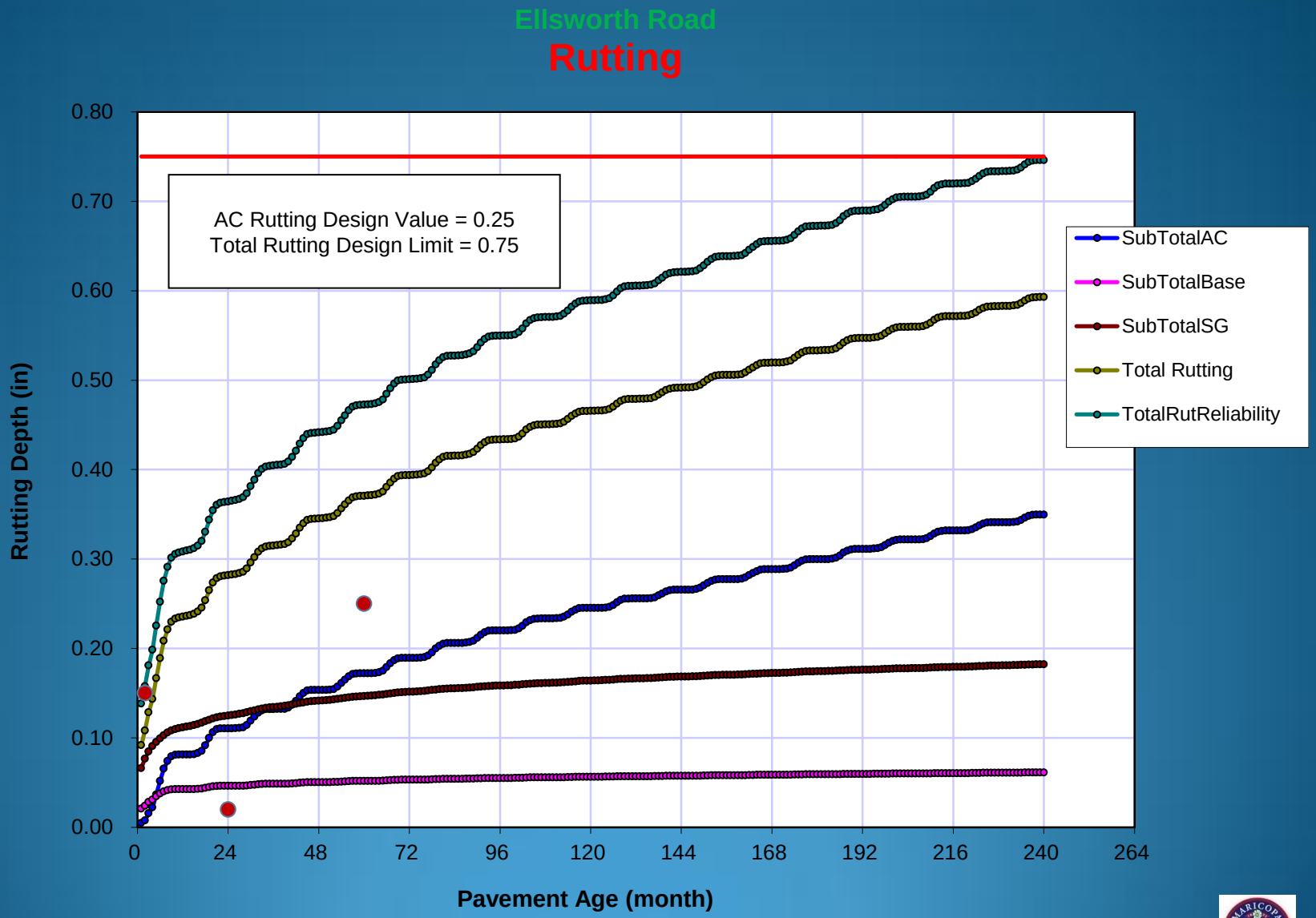

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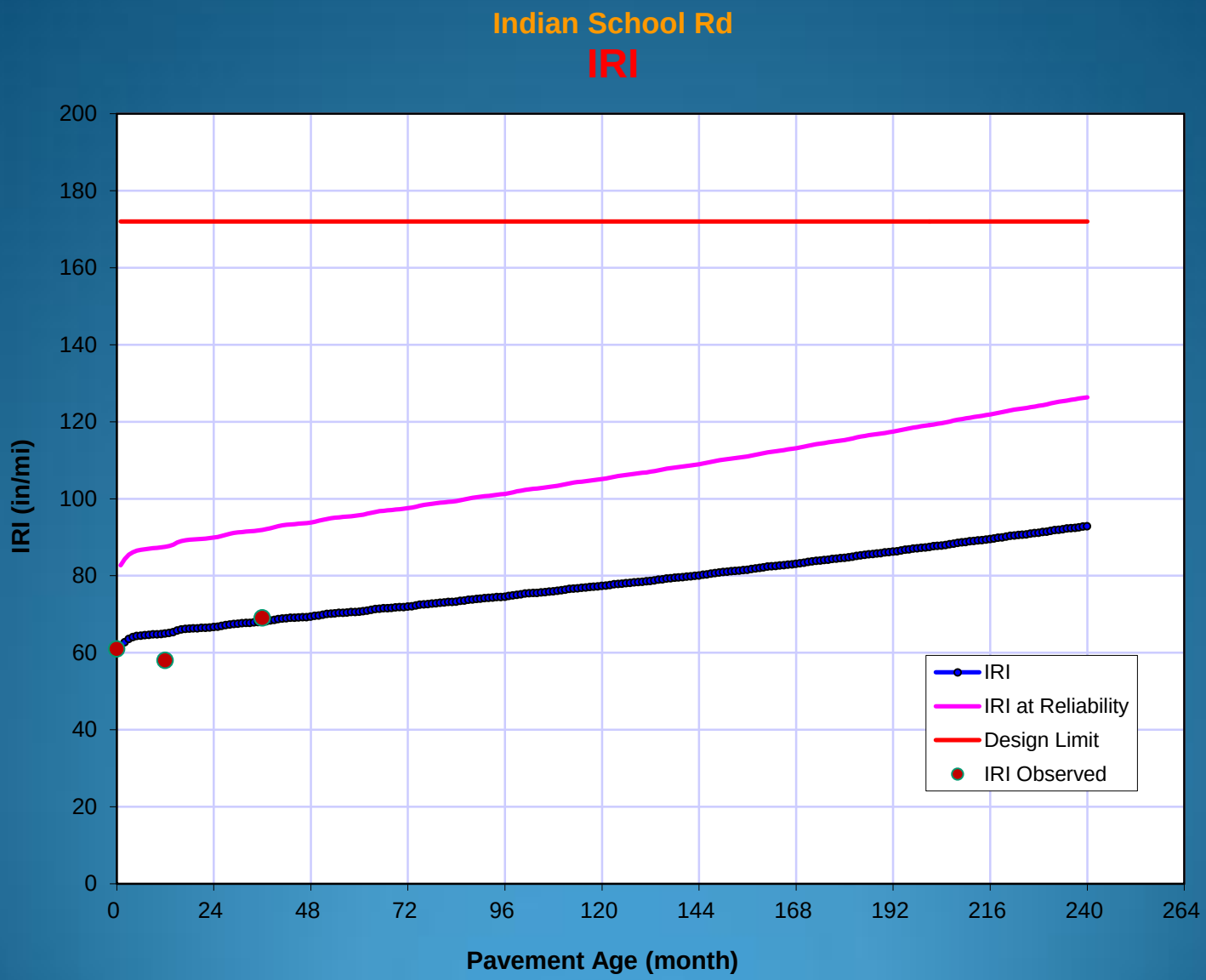

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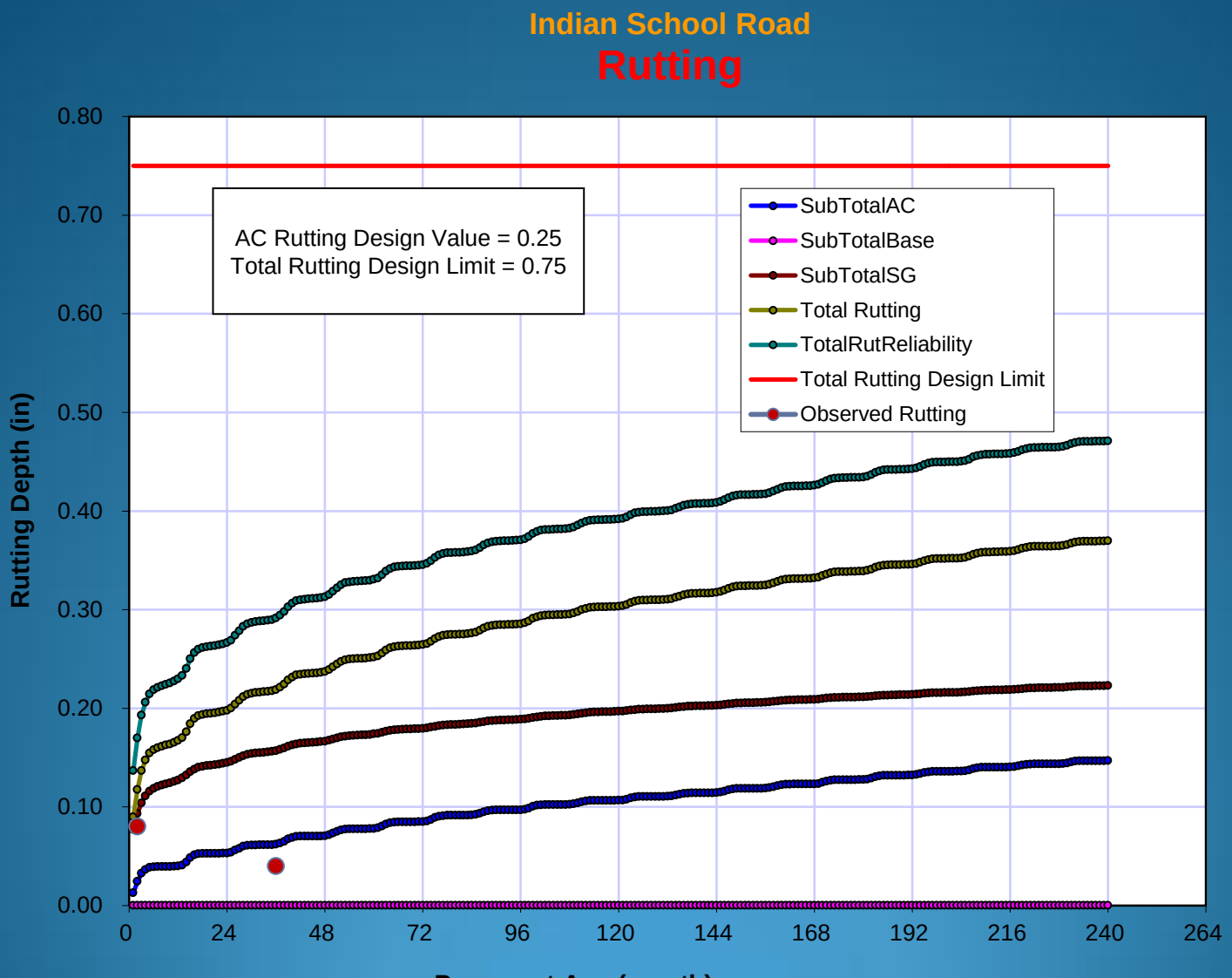

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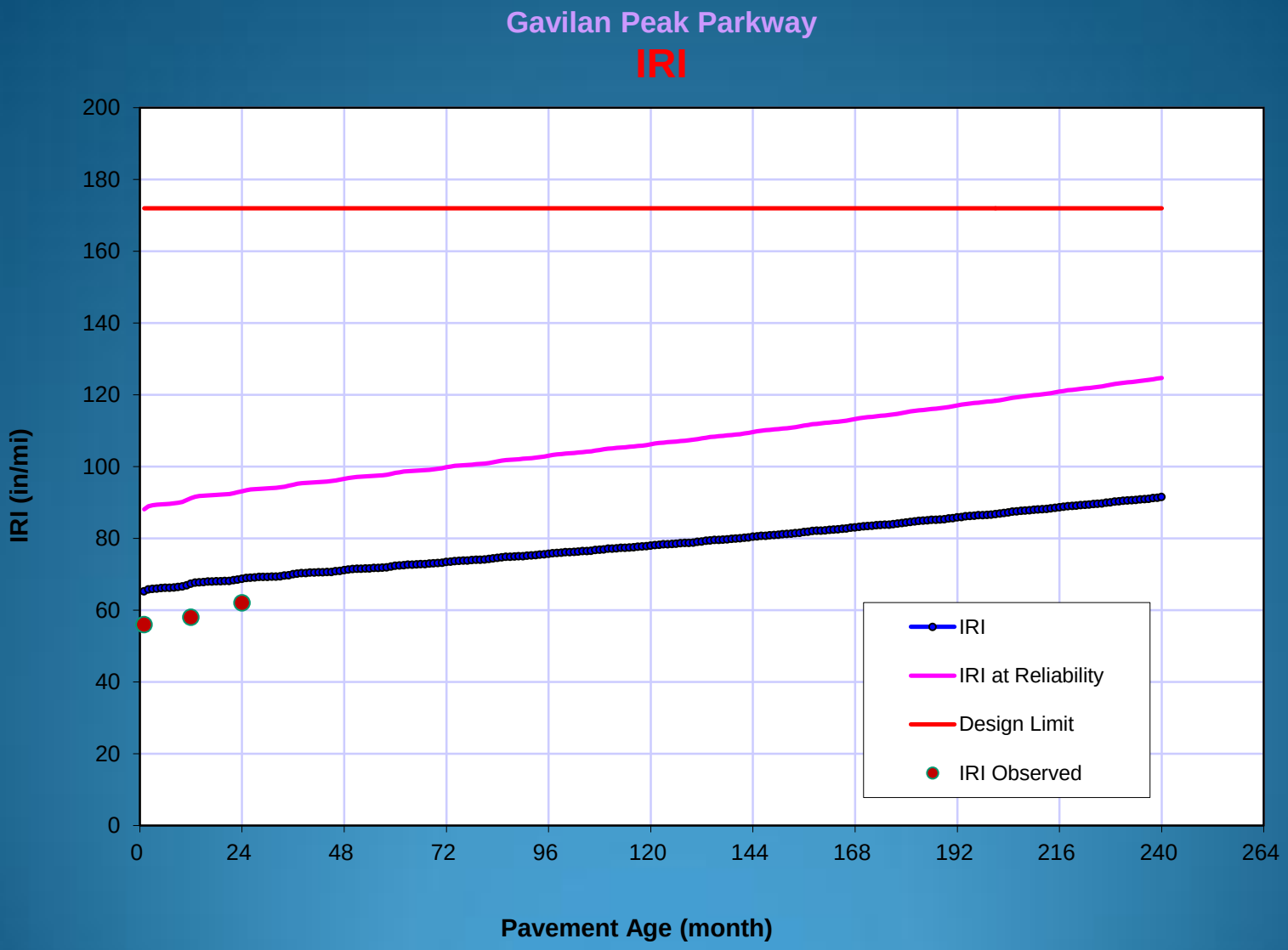
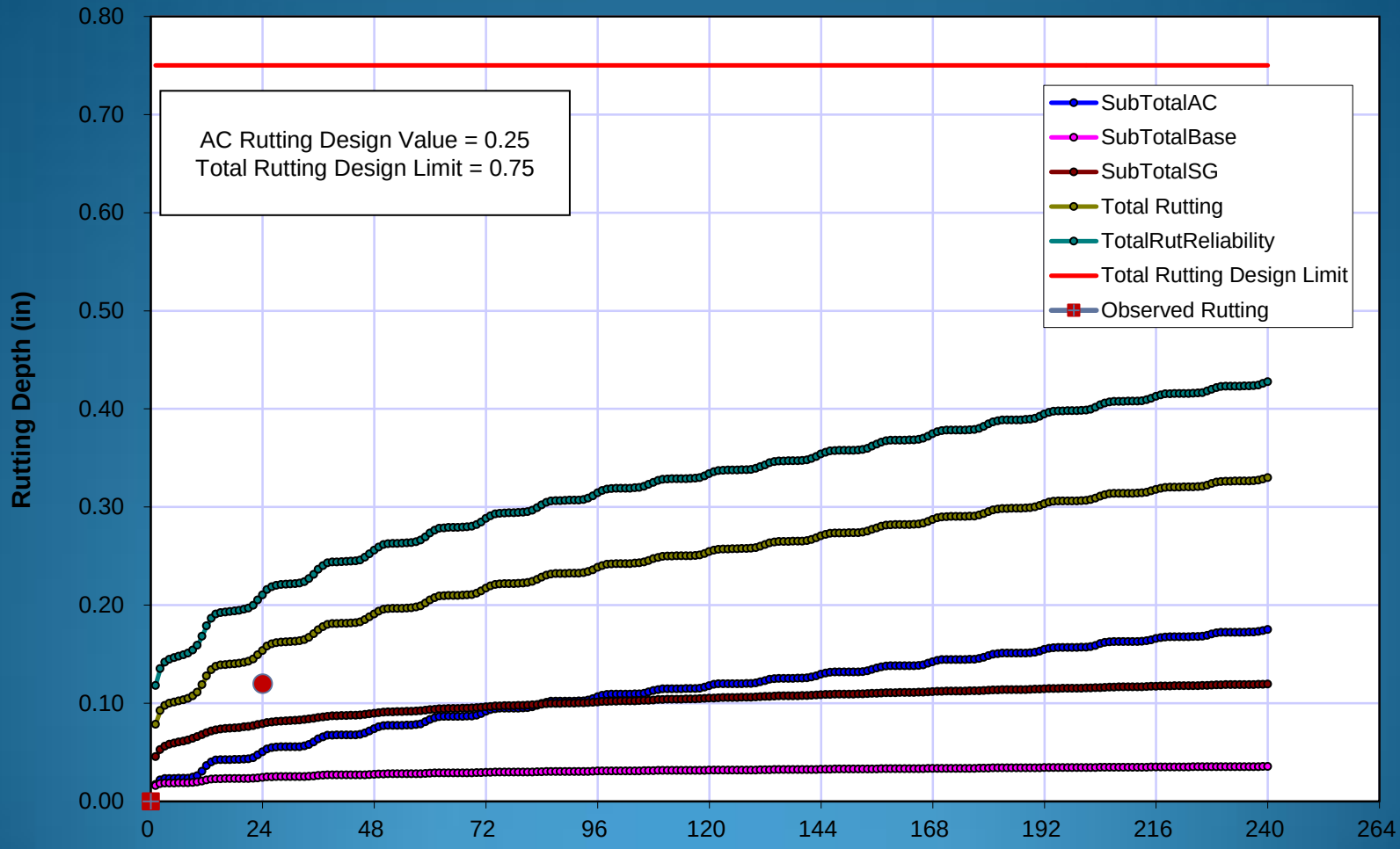


Comparison of Results

Gavilan Peak Parkway
Rutting



Analysis of Results

Based on the results:

- Level 1 (L1) runs with Current Traffic (C2) generally indicated the predicted distress was lower &reliability was higher
- Level 3 runs generally produced failing results
- Measured IRI values were lower than the Predicted IRI from L1 runs, so far
- Measured IRI values were lower than 50% reliability prediction
- Measured Rutting values were also lower than 50% reliability prediction
- Some instances distress was acceptable but not the reliability

Conclusions

- Level 1 runs can be used to optimize the pavement design for site conditions
- Level 3 runs may produce conservative pavement sections
- The program can be calibrated to produce realistic results for Maricopa County
- The national data used for reliability predictions can be replaced if enough data is available within the County
- The desired calibration can be obtained over several years of data collection & comparison

Future Work

- Only 3 County sites were subject to analysis at this time, but there are 5 more County sites with data necessary to run the program
- All these 8 sites will be analyzed at least for seven years
- All these 8 sites will be subject to constant distress monitoring and IRI measurements
- ADOT has several sites with data within the County, and these sites also will be added to the pool so that the results are statistically sound
- The program will be calibrated to County specific conditions once enough measured and predicted comparisons are available
- County specific adjustments will be verified

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Mike Mamlouk, PhD, PE

Professor—Dept. of Civil, Environmental and Sustainable Engineering, ASU

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Matthew Witczak, PhD, PE

Professor—Dept. of Civil, Environmental and Sustainable Engineering, ASU

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