AZ LTAP

Sustainable Asphalt Pavements Workshop
March 22, 2017

Consideration of Local Soil Conditions Through Modified Correlated R-value Formulation

NCS GeoResources

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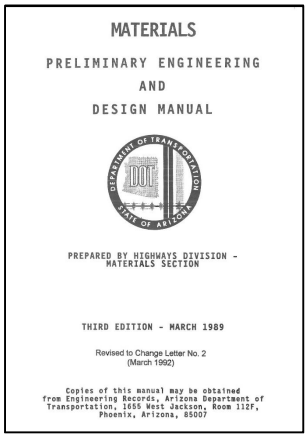
 1

Current Practice by Most Agencies within Arizona


MATERIALS

PRELIMINARY ENGINEERING
AND
DESIGN MANUAL

PREPARED BY HIGHWAYS DIVISION - MATERIALS SECTION

THIRD EDITION - MARCH 1989

Revised to Change Letter No. 2 (March 1992)

Copies of this manual may be obtained from Engineering Records, Arizona Department of Transportation, 1655 West Jackson, Room 112F, Phoenix, Arizona, 85007

$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN + 1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN + 1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

$$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3$$

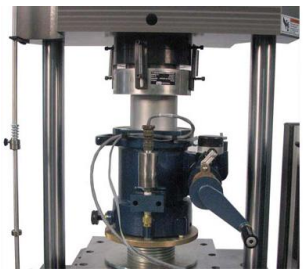
$$M_R = \frac{1815 + 225*(R_{mean}) + 2.40*(R_{mean})^2}{0.6(SVF)^{0.6}}$$

$$R_{mean} = \frac{N_t R_t \sigma_c^2 + N_c R_c \sigma_t^2}{N_t \sigma_c^2 + N_c \sigma_t^2}$$

 2

Tested (Measured) Resistance R-value, T or R_t

- AASHTO T190 or ASTM D2844



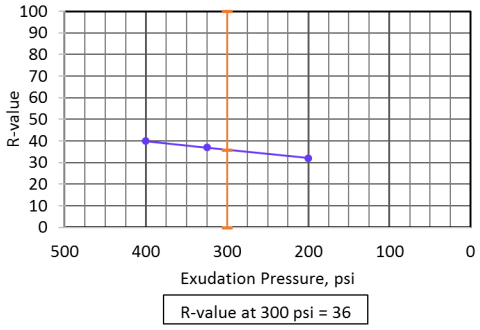


Photo Source: http://www.instron.us/en-us/testing-solutions/by-material/concrete/compression/astm-d2844

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ADOT Correlated R-value, C or R_c

log R-value at 300 psi = 2.0 – 0.006(Pass 200) – 0.017(PI)

where, Pass 200 = % passing a #200 sieve *(aka* % Fines). PI = Plasticity Index

BODY OF TABLE IS R-VALUE AT 300 psi EXUDATION PRESSURE

PERCENT PASSING #200 SIEVE

PI	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96
0	100	96	92	88	85	81	78	75	72	69	66	63	61	58	56	54	52	49	47	45	44	42	40	39	37	35	34	33	31	30	29	28	27
1	96	92	89	85	81	78	75	72	69	66	64	61	58	56	54	52	50	48	46	44	42	40	39	37	36	34	33	31	30	29	28	27	26
2	92	89	85	82	78	75	72	69	66	64	61	59	56	54	52	50	48	46	44	42	40	39	37	36	34	33	31	30	29	28	27	26	25
3	89	85	82	79	75	72	69	67	64	61	59	56	54	52	50	48	46	44	42	40	39	37	36	34	33	32	30	29	28	27	26	25	24
4	86	82	79	76	72	70	67	64	61	59	56	54	52	50	48	46	44	42	41	39	37	36	34	33	32	30	29	28	27	26	25	24	23
5	82	79	76	73	70	67	64	62	59	57	54	52	50	48	46	44	42	41	39	37	36	34	33	32	30	29	28	27	26	25	24	23	22
6	79	76	73	70	67	64	62	59	57	54	52	50	48	46	44	42	41	39	37	36	35	33	32	30	29	28	27	26	25	24	23	22	21
7	76	73	70	67	64	62	59	57	55	52	50	48	46	44	43	41	39	38	36	35	33	32	31	29	28	27	26	25	24	23	22	21	20
8	73	70	67	65	62	59	57	55	52	50	48	46	44	43	41	39	38	36	35	33	32	31	29	28	27	26	25	24	23	22	21	20	19
9	70	67	65	62	60	57	55	53	50	48	46	45	43	41	39	38	36	35	33	32	31	29	28	27	26	25	24	23	22	21	20	19	19
10	68	65	62	60	57	55	53	51	49	47	45	43	41	39	38	36	35	33	32	31	30	28	27	26	25	24	23	22	21	20	19	19	18

Table Source: Table 202.02-03, ADOT Preliminary Engineering and Design (PE&D) Manual

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Basis of ADOT Correlated R-value Equation

- As per ADOT Preliminary Engineering and Design (PE&D) Manual

"Extensive regression and correlation analyses have been performed using the gradation and the Plasticity Index, Liquid Limit and Sand Equivalent test as indicators and predictors of R-value. Of the many candidate equations and relationships considered, a family of curves was finally chosen as the best workable relationship between gradation and Plasticity Index."

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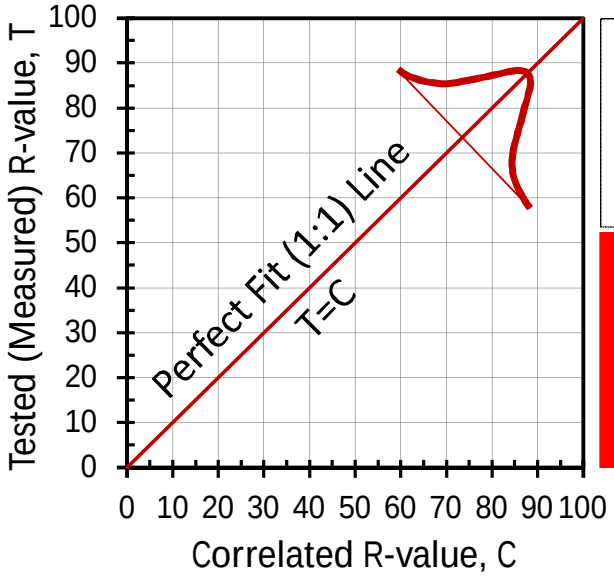
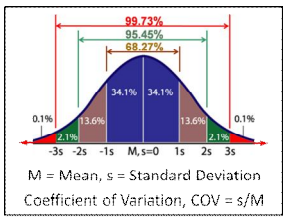
Concept of Correlated R-value





Note
The normal probability distribution function (PDF) is schematic and shown for discussion purposes. It's position or size on the chart is not to be literally scaled.

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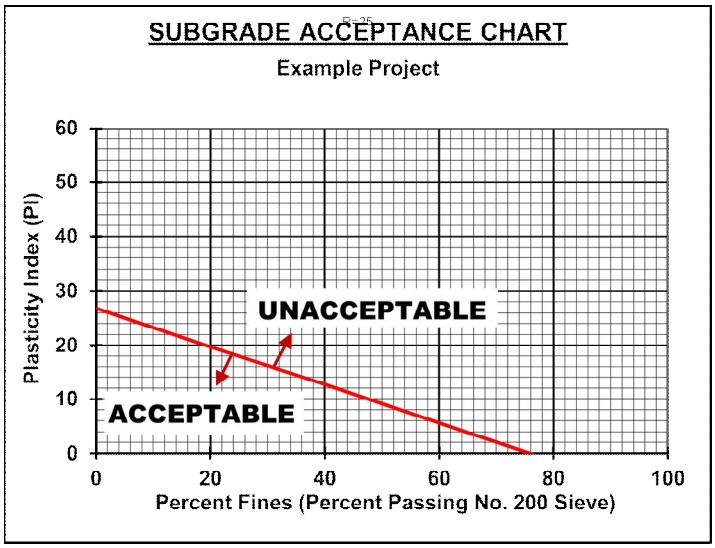
Subgrade Acceptance – ADOT



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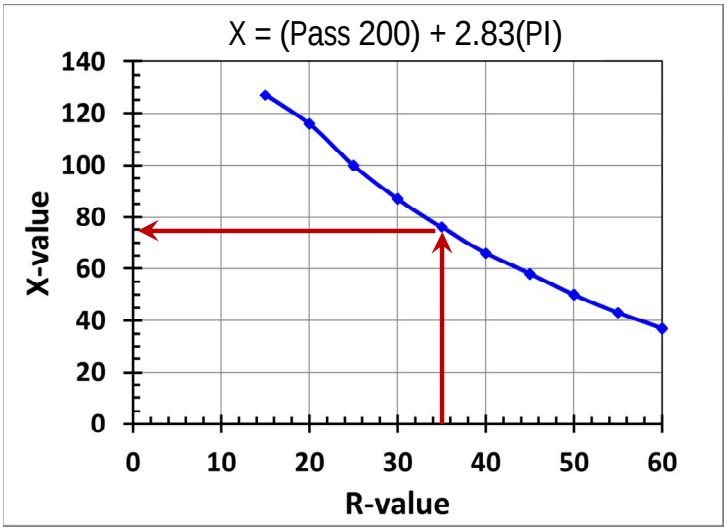
Subgrade Acceptance – ADOT



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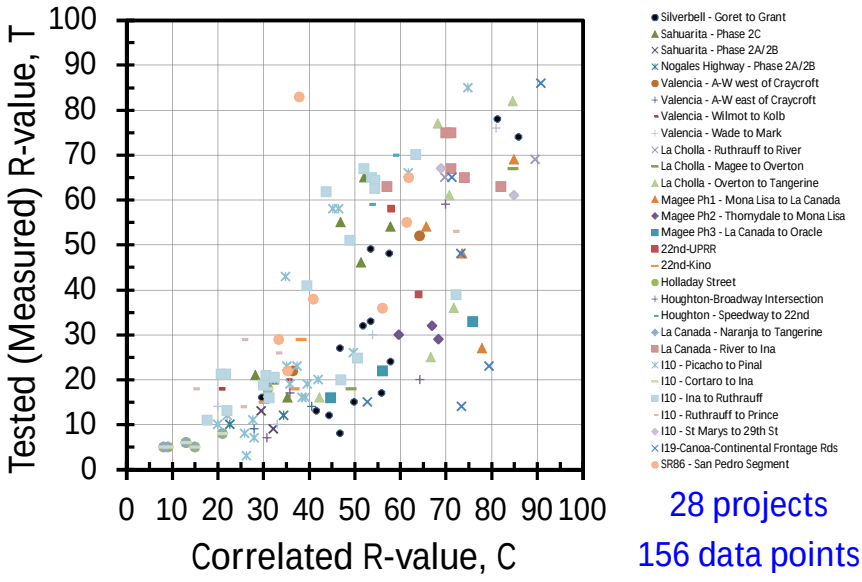
Projects in Tucson Metro Area - Correlated vs Measured R-values



28 projects

156 data points

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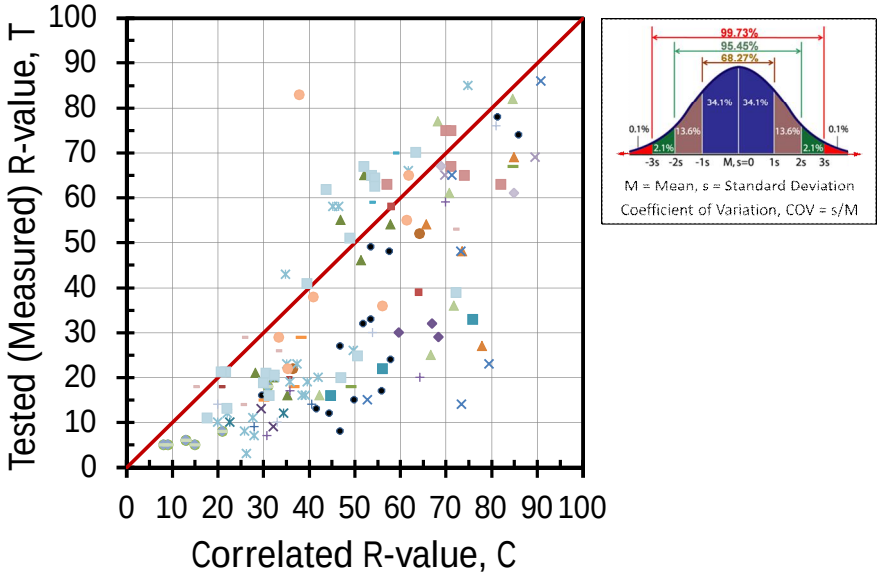
Projects in Tucson Metro Area - Correlated vs Measured R-values



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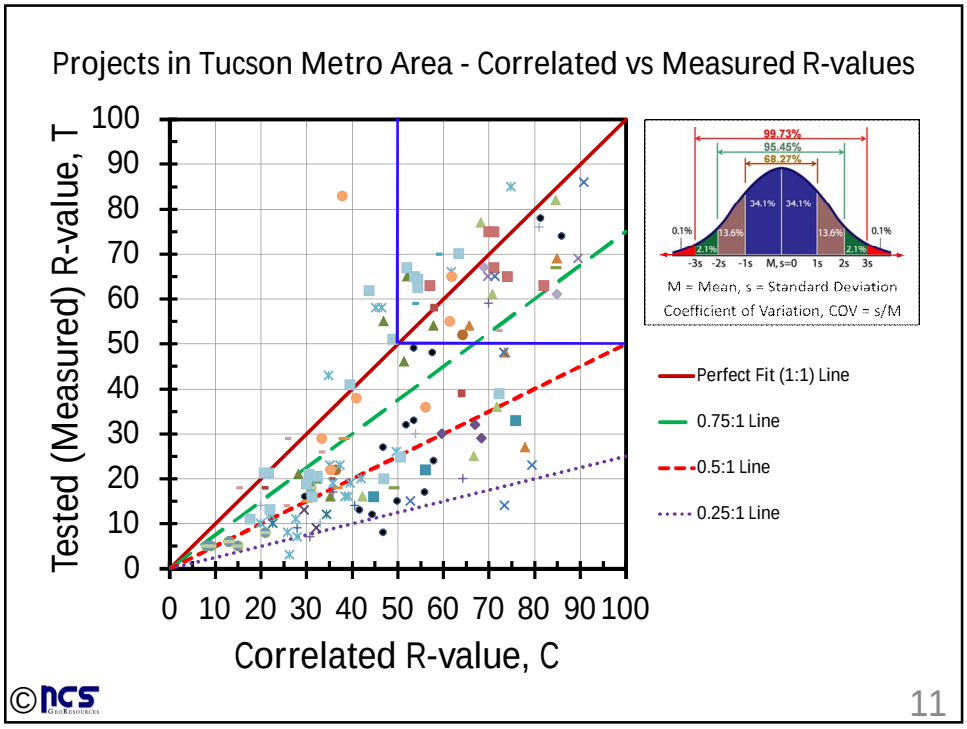
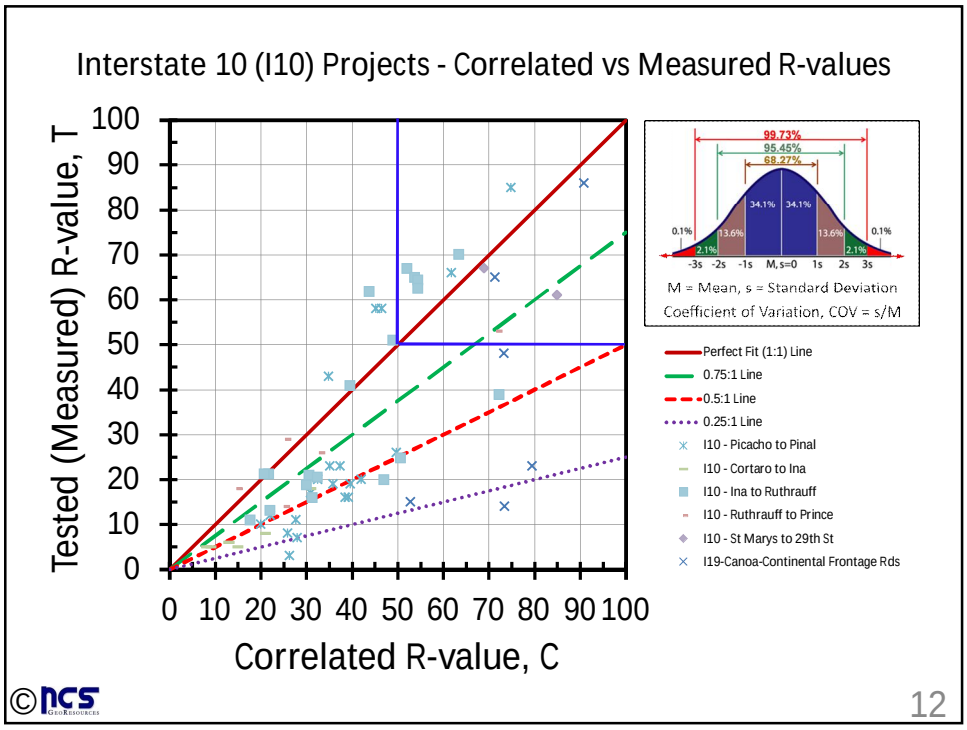
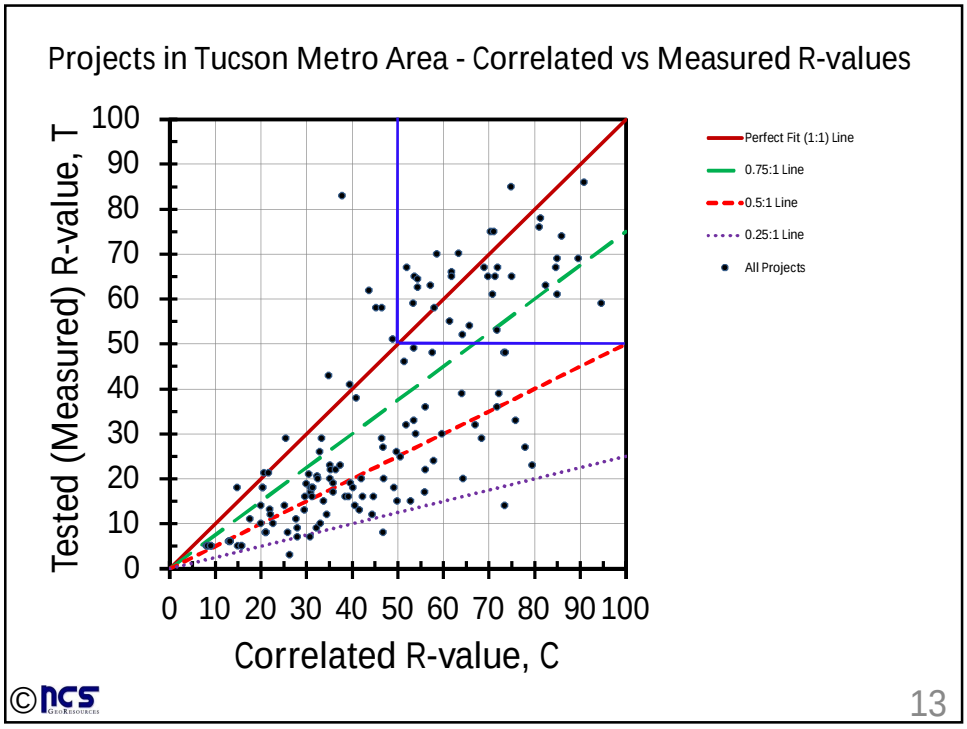
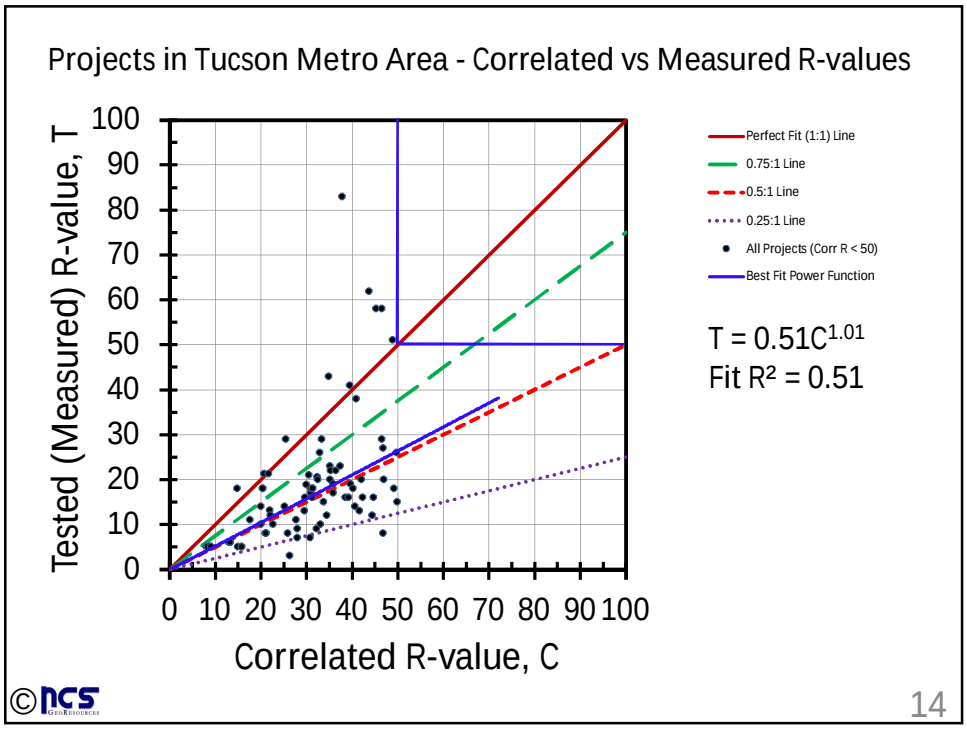
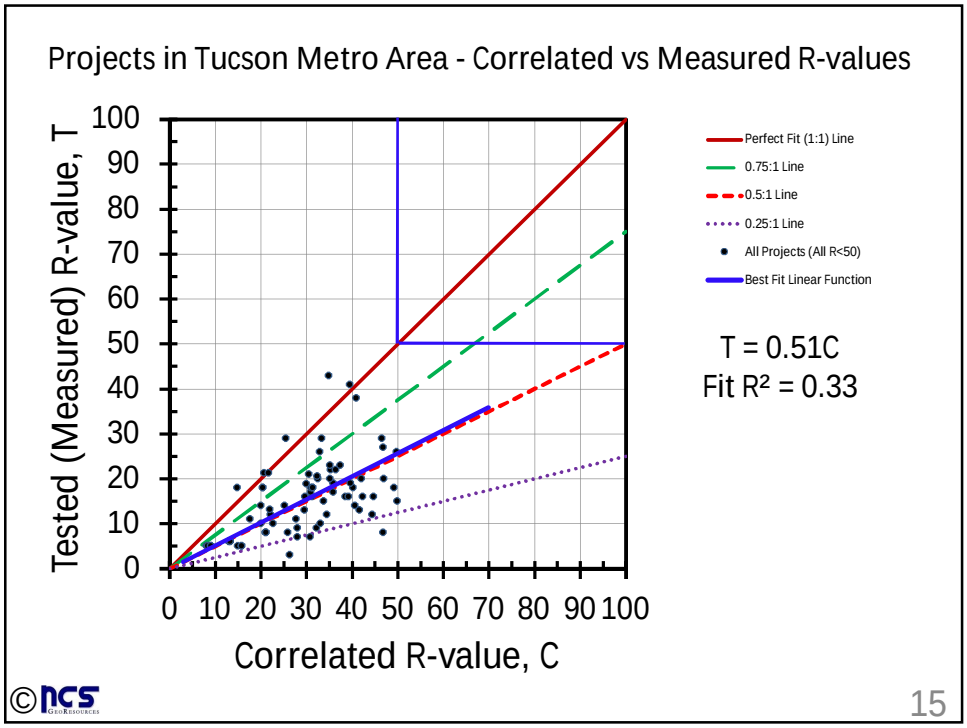
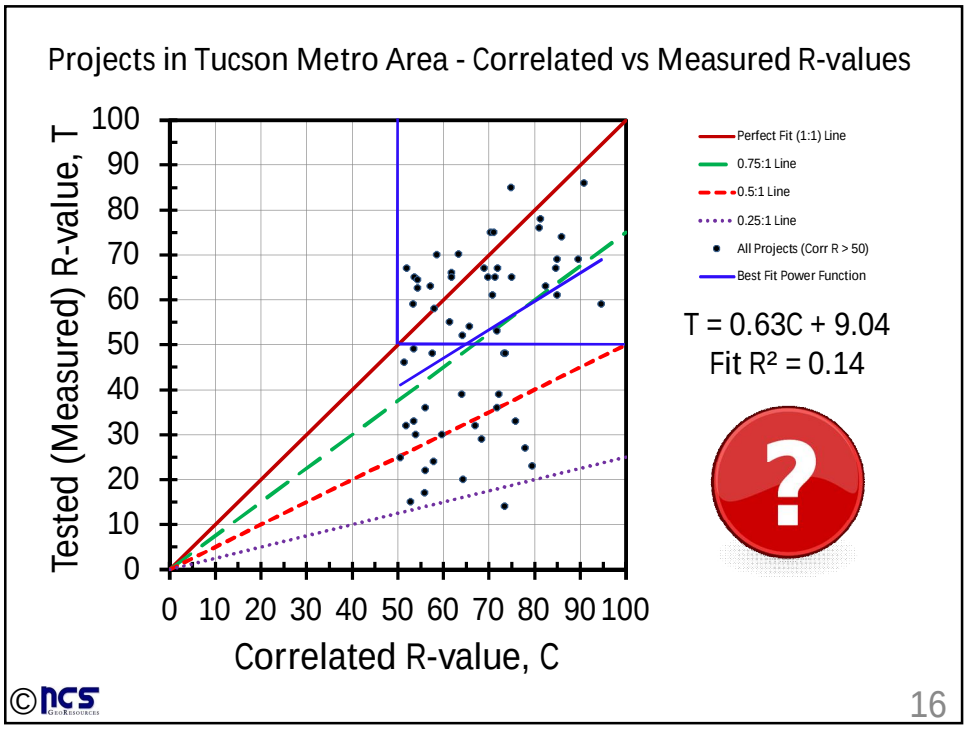


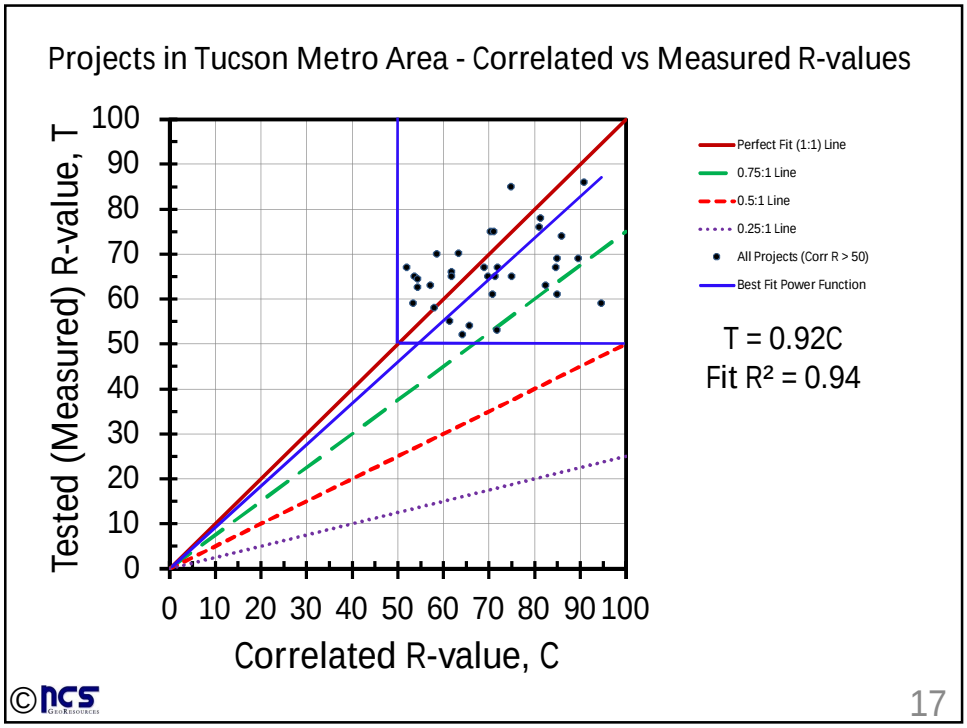


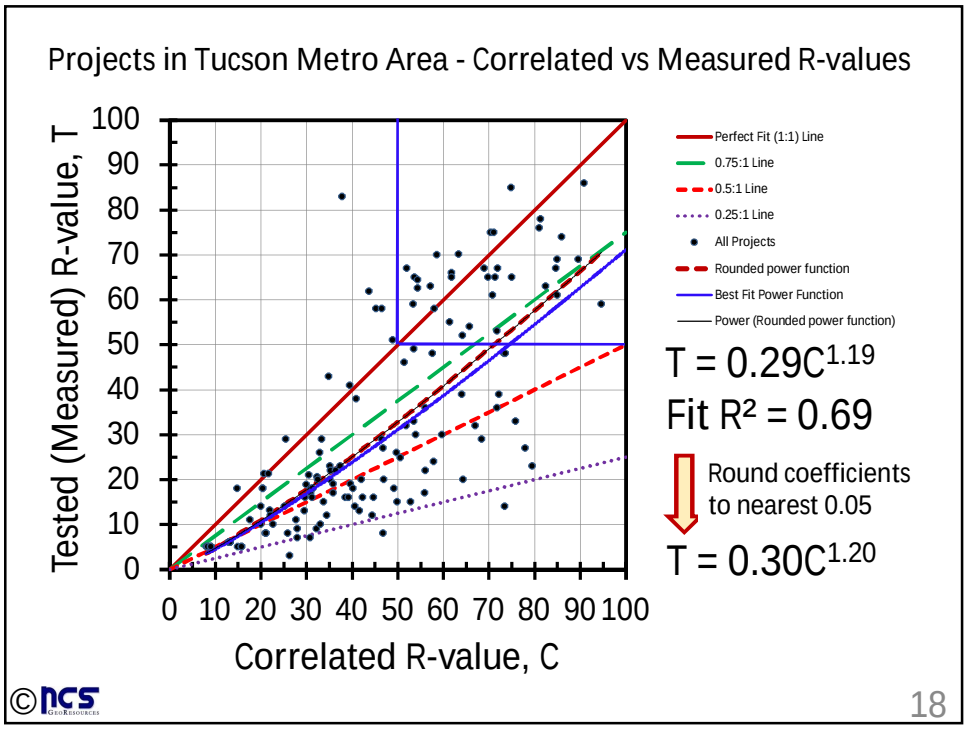




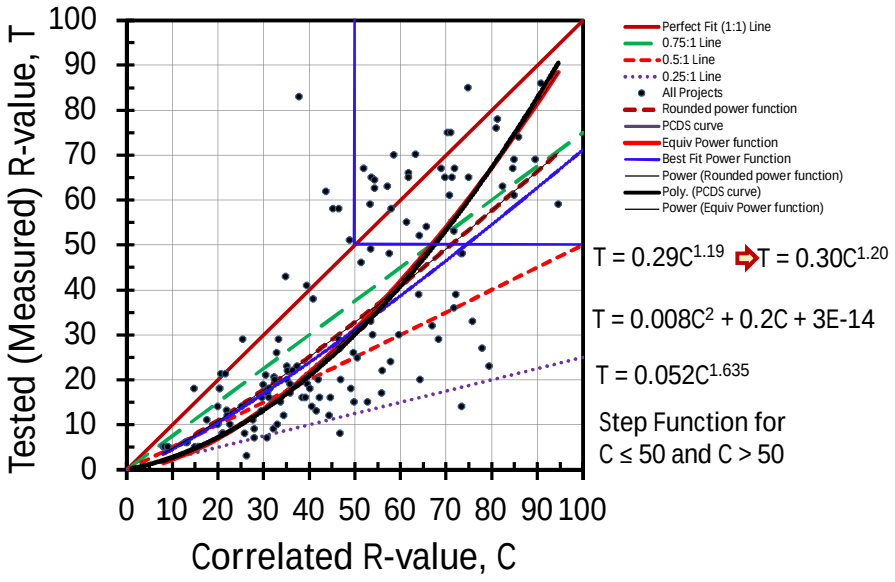








Projects in Tucson Metro Area - Correlated vs Measured R-values



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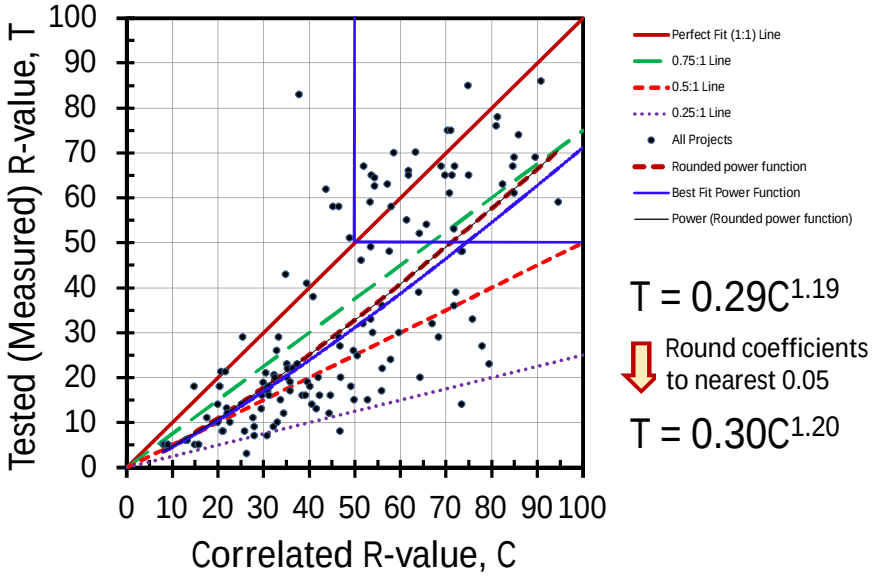
Projects in Tucson Metro Area - Correlated vs Measured R-values



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Power Curve Adjustment of ADOT Equation versus New Equation

1. Power adjustment approach of ADOT equation as follows:

   $C_{Pima} = x\ C_{ADOT}^{y}$

   where, x = 0.30 and y = 1.20

   C_{Pima}= Pima County Correlated R-value

   C_{ADOT}= ADOT (base) Correlated R-value given as follows:

   log C_{ADOT} (value at 300 psi) = 2.0 – 0.006(Pass 200) – 0.017(PI)

2. Potential new equation(s) for Pima County

   log C_{Pima} (value at 300 psi) = 1.88 – 0.007(Pass 200) – 0.020(PI)

   log C_{Pima} (value at 300 psi) = 1.8772 – 0.0072(Pass 200) – 0.0204(PI)

Note: Other Equations were also investigated, e.g., R = *func* (#4 sieve, #40 sieve, #200 sieve, PI, LL, USCS, AASHTO Group, etc.)

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Advantages of Using Power Curve Adjustment Approach

1. Not generate an “urban legend” with “sacred” values
2. Can develop project-specific x and y parameters
   – Readily available power function trendline fit in Microsoft Excel®
3. Create a more transparent design approach
   – Ensure consistency of methodology application across designers and local agencies
4. Can continue to use other ADOT design steps
5. No change in slope of equation for X-value used in Materials Design Report, i.e., X = (Pass 200) + 2.83(PI)
   – Subgrade acceptance charts have the familiar look requiring no changes in the end-application by the field personnel

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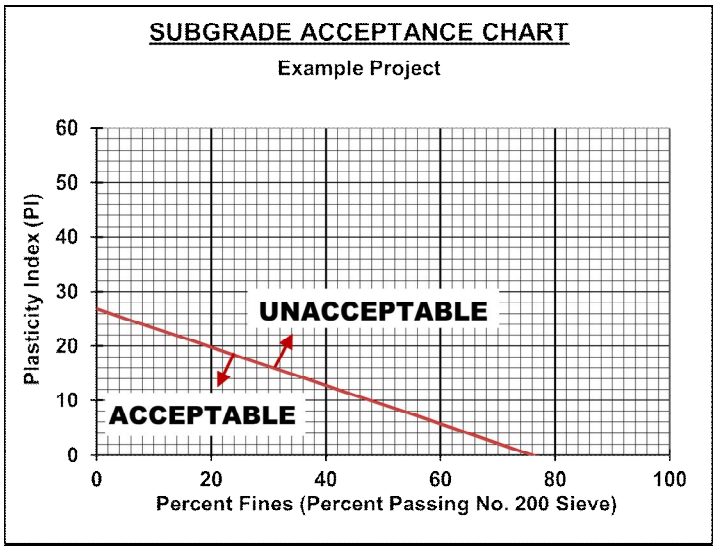
Subgrade Acceptance – ADOT



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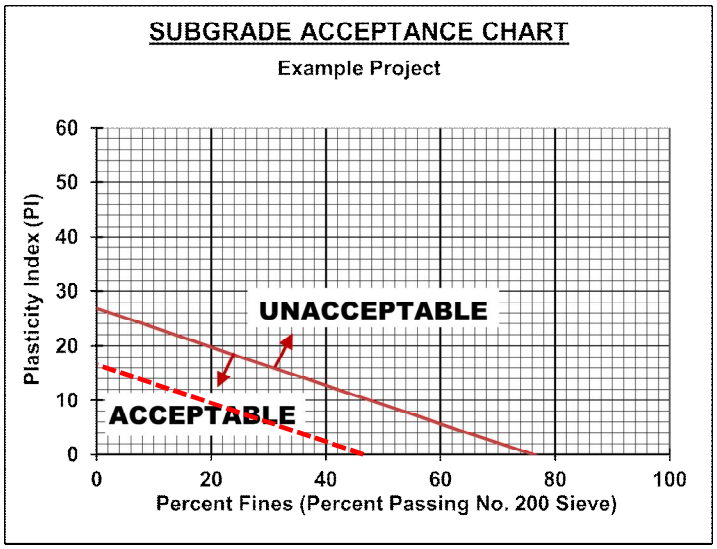
Subgrade Acceptance – ADOT



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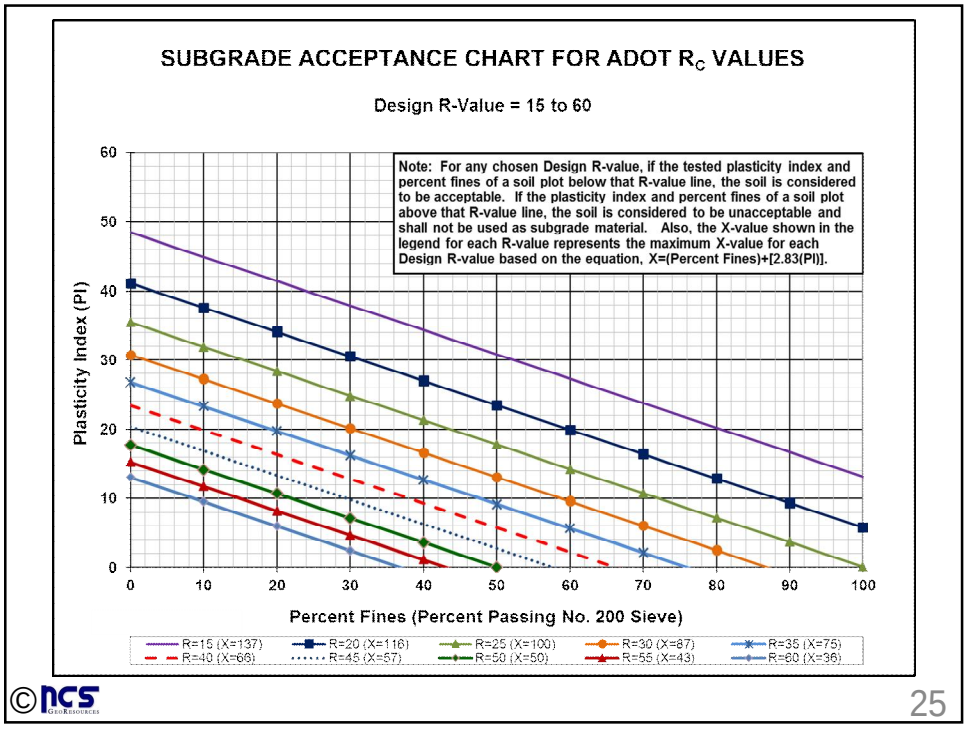

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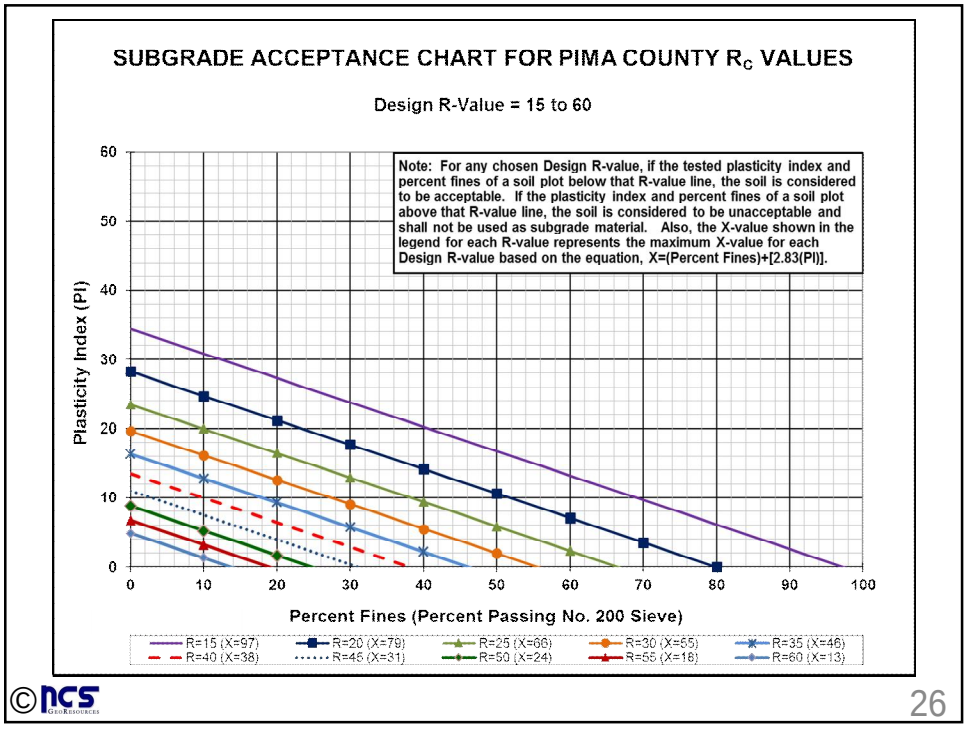

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Sustainable – Euphemism for What?

1. Is the industry using fancy and empty words?
2. Are pavements being designed to fail?
3. Are we using design procedures (old or new) without fully understanding the issues related to input data development processes?
4. Are local agencies blindly following lead agencies?
5. Are lead agencies blindly imposing their rules on local agencies?
6. Are maintenance costs increasing?
7. Are taxpayer dollars being wasted?

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New Guidelines for Pima County Projects (also used by Pima Association of Governments (PAG))

1. Calculate the ADOT correlated R-value (C_{ADOT})
   $\log C_{ADOT}$ (value at 300 psi) = 2.0 – 0.006(Pass 200) – 0.017(PI)

2. Calculate the Pima County correlated R-value (C_{PIMA}) as follows:
   $C_{PIMA} = x\ C_{ADOT}^{y}$
   where x = 0.30 and y = 1.20

3. The R_{mean} is the design R-value. Since the correlated R-value has been adjusted above, the design R-value is also the construction control R-value.

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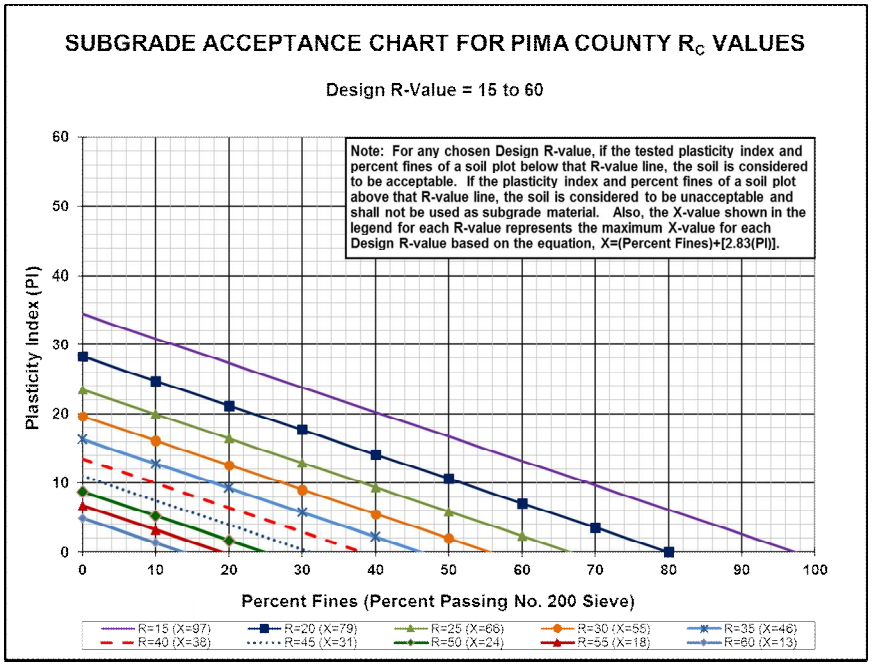

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New Guidelines for Pima County Projects (also used by Pima Association of Governments (PAG))

- Recognize that a site-specific correlation may provide cost saving opportunities
- Perform sufficient number of actual R-value laboratory tests (typically anticipated to be 10-20 per geologic formation) in order to develop site-specific correlated R-values (R_C) using the power function trendline option in Microsoft Excel®
- When site-specific correlation is used, a site-specific subgrade acceptance chart must also be created based on the x and y values for the power function

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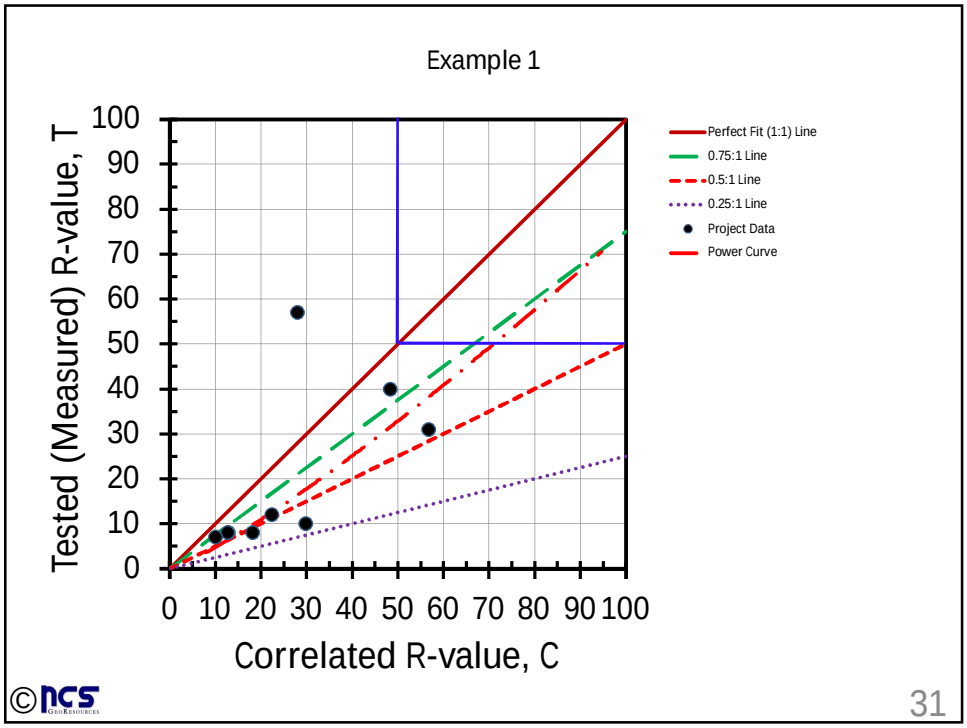
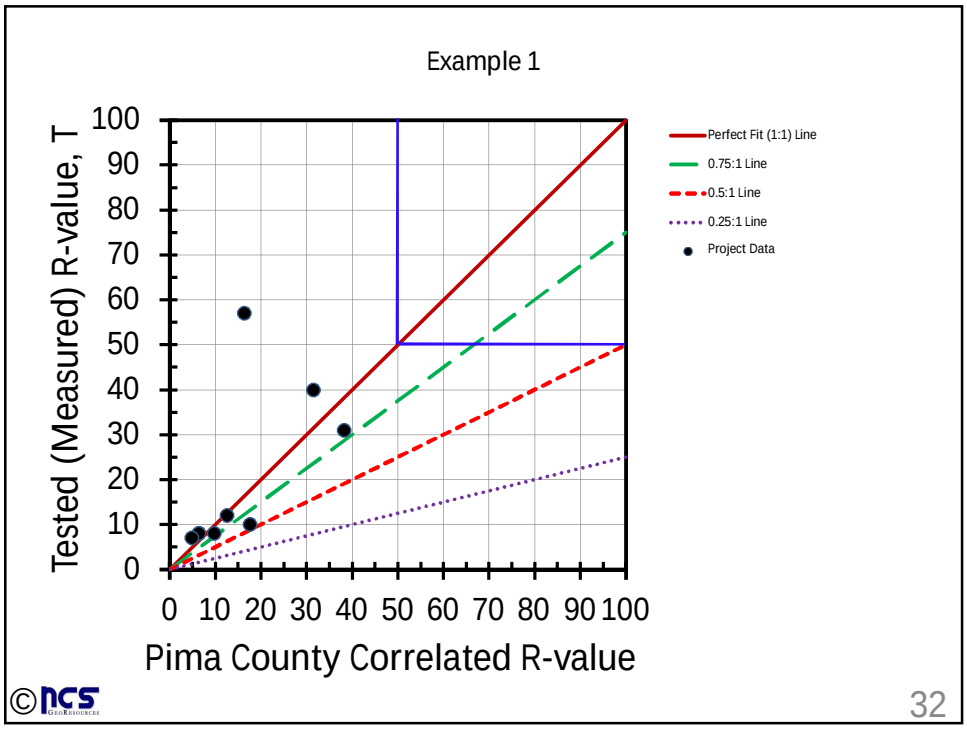
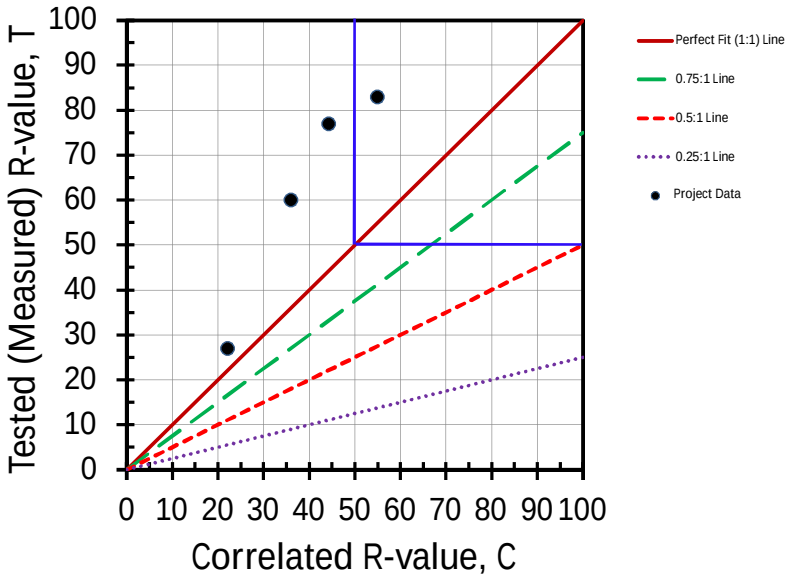




Example 2 – Preliminary Testing



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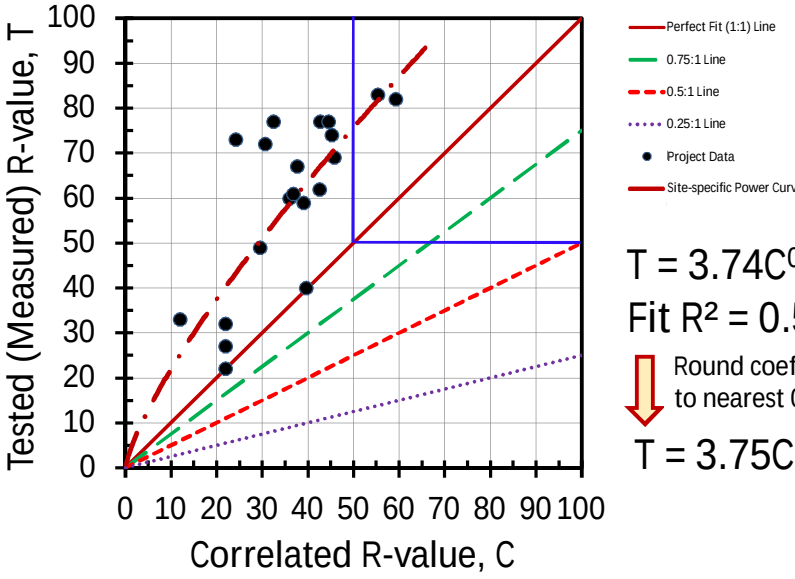
Example 2 – Additional Testing



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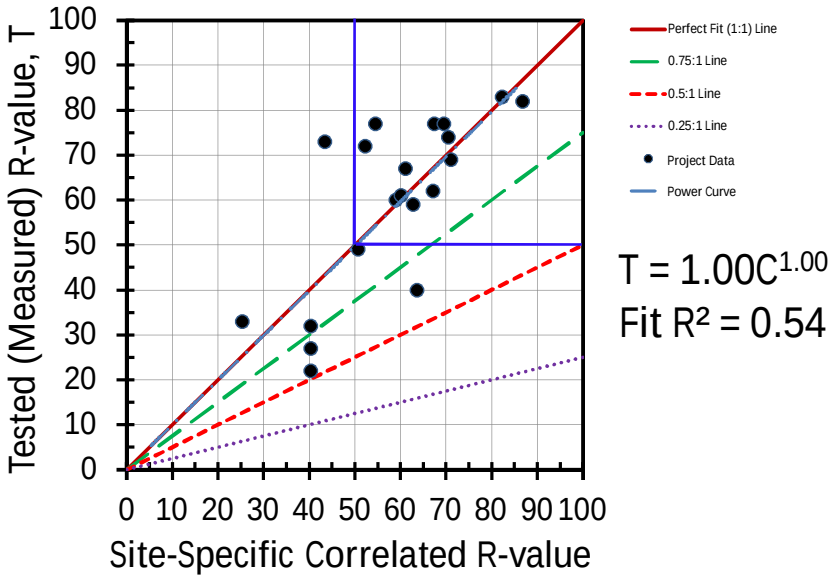
Example 2



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Some Other Causes for Potential Subgrade Issues

- Volume change behavior
  - Native (in situ) collapse-susceptible soils
  - Native (in situ) expansive soils
  - Compacted soils
- Wetting and drying induced changes in performance characteristics of native and compacted soils

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n More Issues

1. Sampling and testing procedures
2. Mitigation of poor subgrade
3. Why do we get different R-values from different labs?

…….

n-2 …….

n-1 …….

n Need another workshop……

Key Message

Recognize and fix the underlying issues with (mis)characterization of subgrade stiffness and construction quality control (QC)

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AZ LTAP

Sustainable Asphalt Pavements Workshop
March 22, 2017

Consideration of Local Soil Conditions Through Modified Correlated R-value Formulation

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