Performance Based Asphalt Mix Design for Develop & Deploy Performance Related Specifications

Nelson Gibson
FWHA - Research Civil Engineer

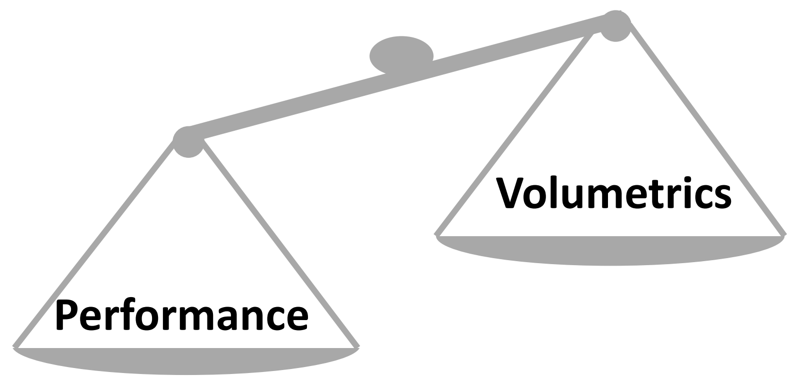
Jongsub Lee
National Research Council - Post Doctoral Fellow

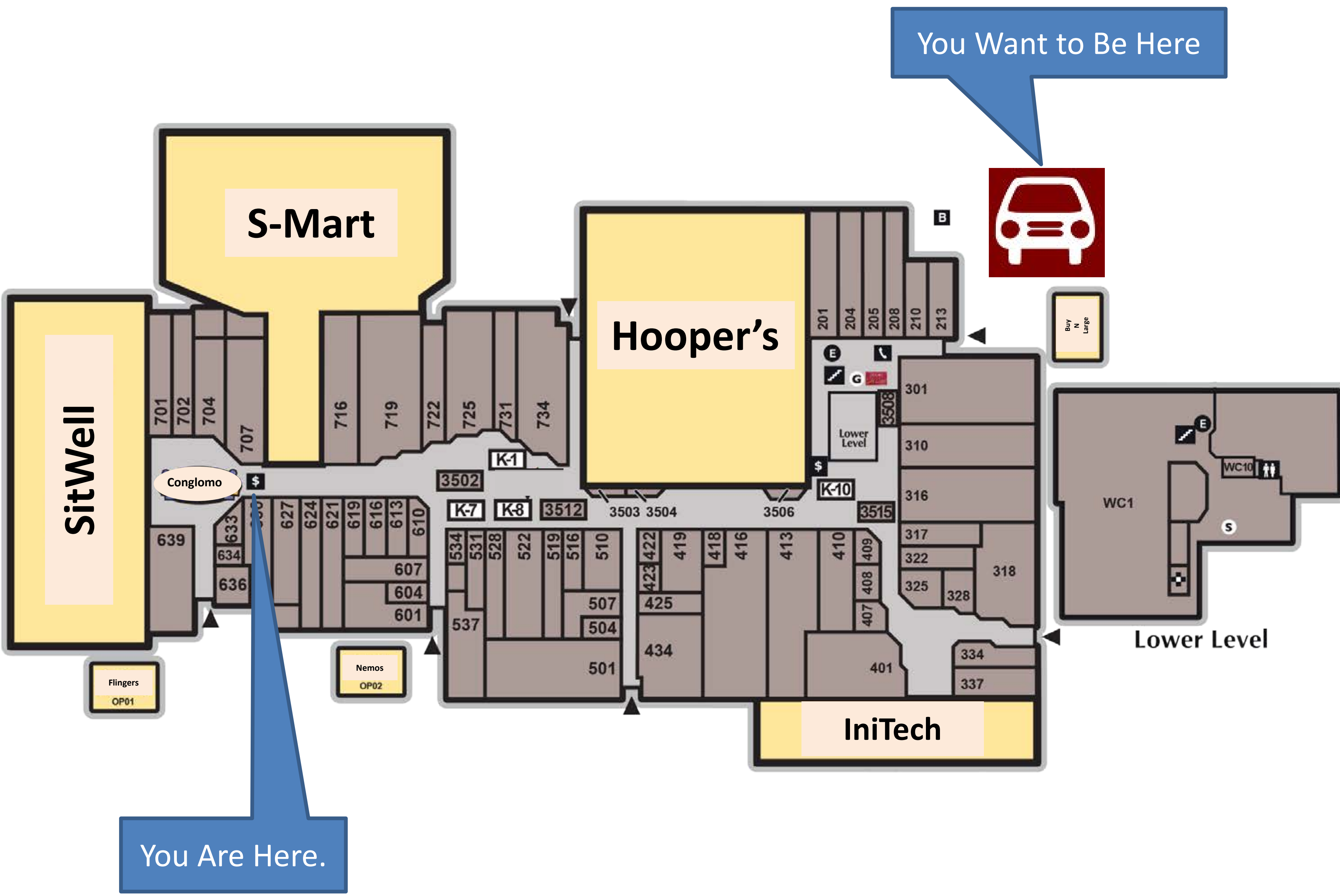
Objective & Outcomes

- Methodically document performance changes with variations in volumetric proportions of a fixed set of component materials

- Test them in the laboratory and predict performance.

- Provide tools and guidance on how volumetric targets can be changed to achieve desired performance.





You Want to Be Here
S-Mart
Hooper's
SitWell
IniTech
Conglomo
Flingers
OP01
Nemos
OP02
Buy N Large
Lower Level
WC1
WC10
K-1
K-7
K-8
K-10
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3503
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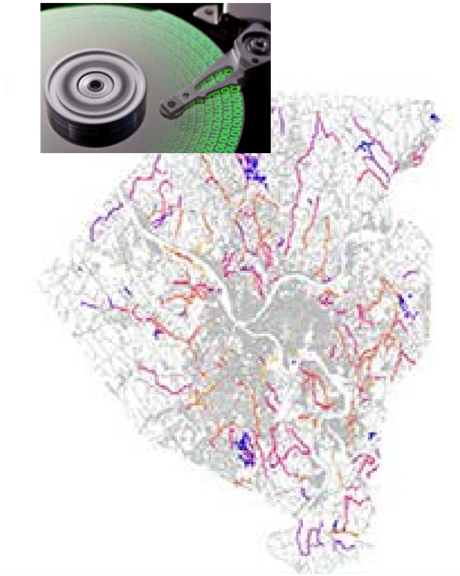
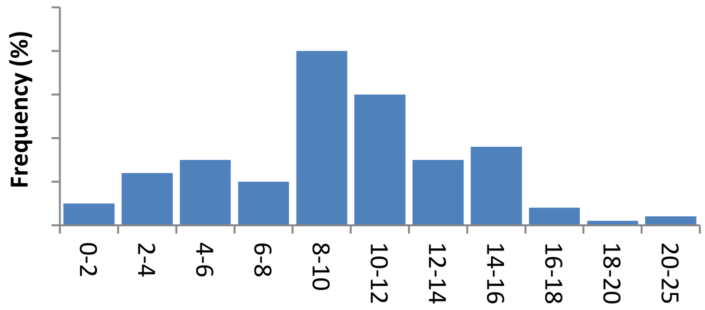
You Are Here.

Figure out 'where you are'

- STEP 1: Current network performance from Pavement Management Systems (PMS)





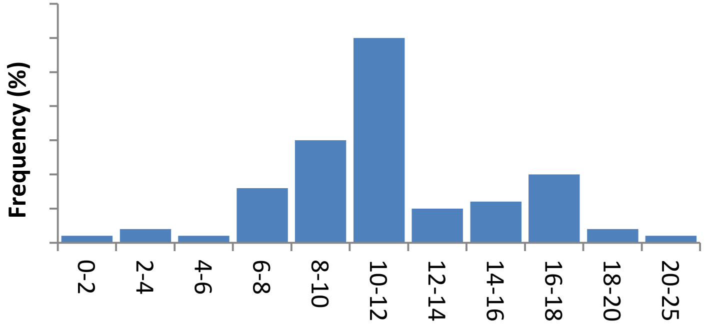


Figure out 'where you want to go'

- STEP 2: Establish new criteria as appropriate

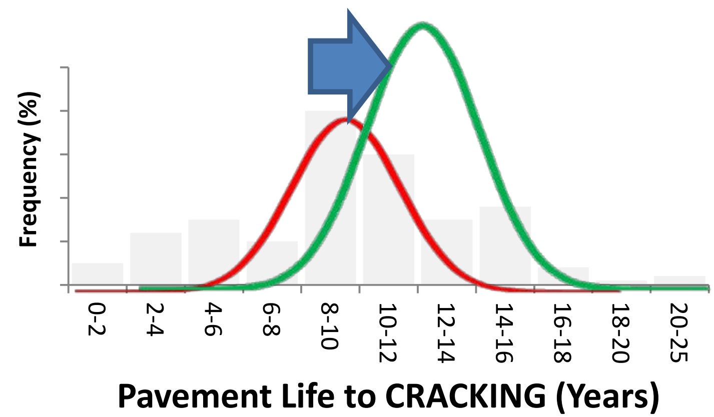
Represents desire to:

increase pavement life by 'x' years

or

improve performance by 'y'%

For Example
I think our State's mixes are dry.
How do I increase binder content?



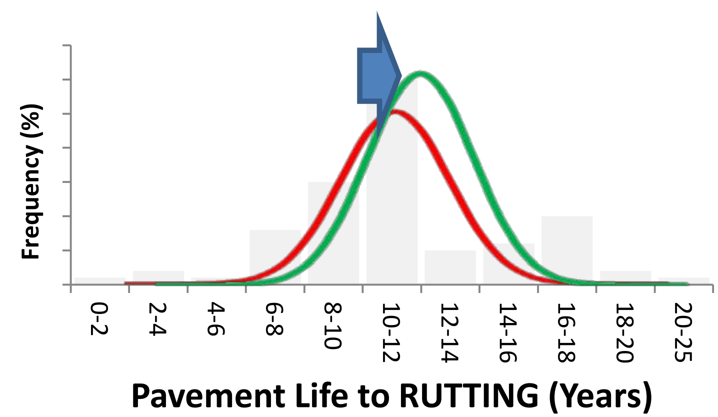
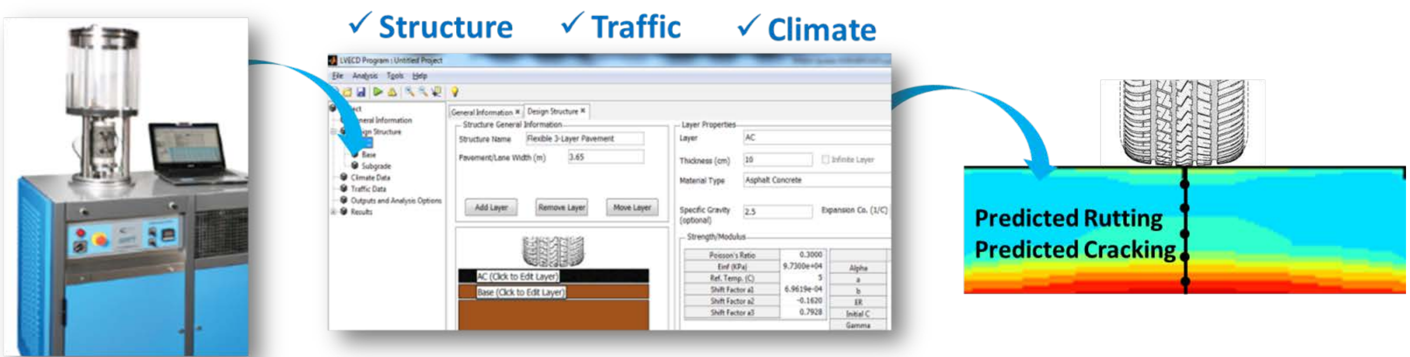
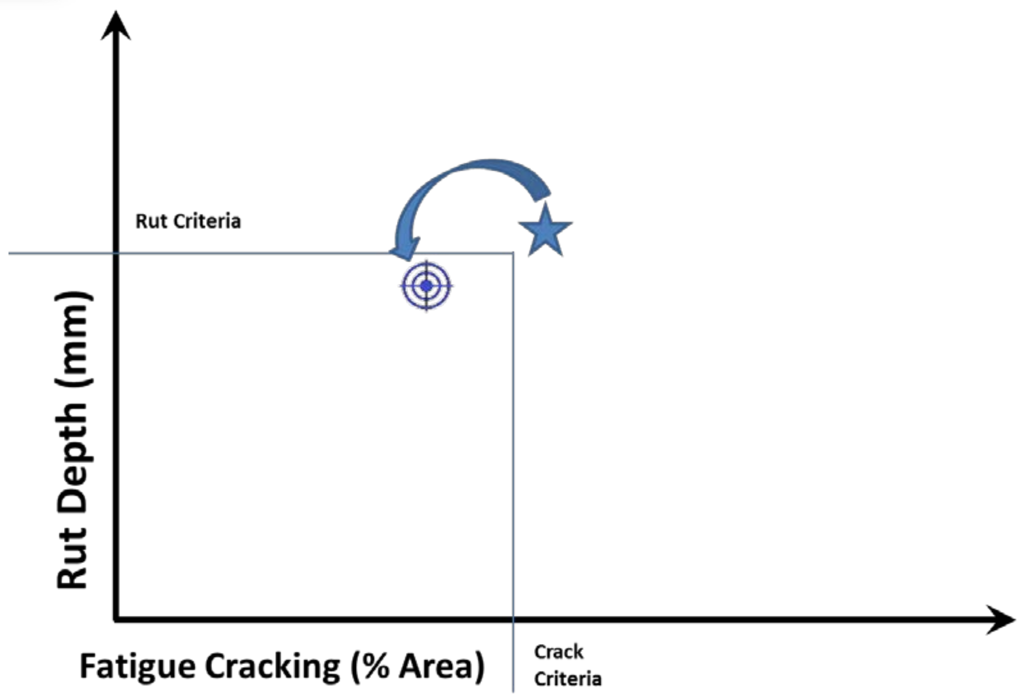


Figure out 'how to get there'

- STEP 3: Adjust mix designs to meet criteria.





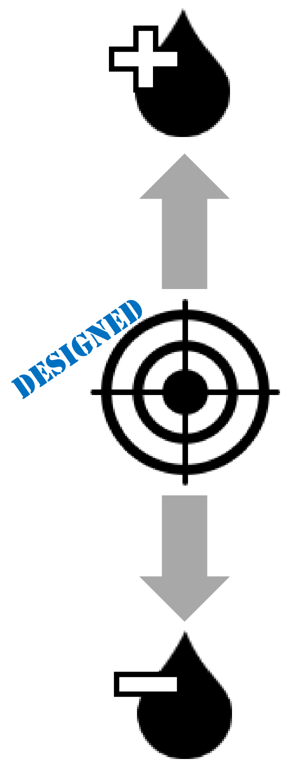
Mix Designs based on 2013 FHWA ALF

Coarse VMA-1 | **Coarse VMA-2** | **Coarse VMA-3**

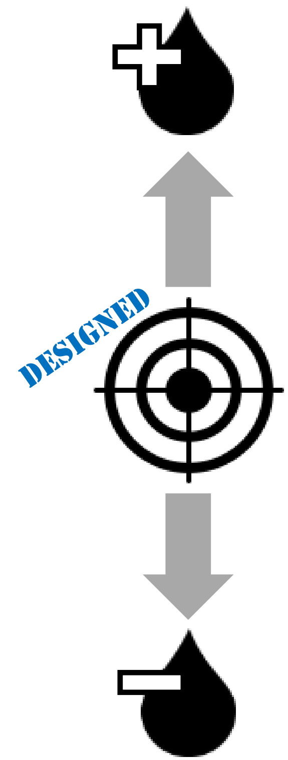
Mix Designs based on 2013 FHWA ALF

Coarse VMA-1

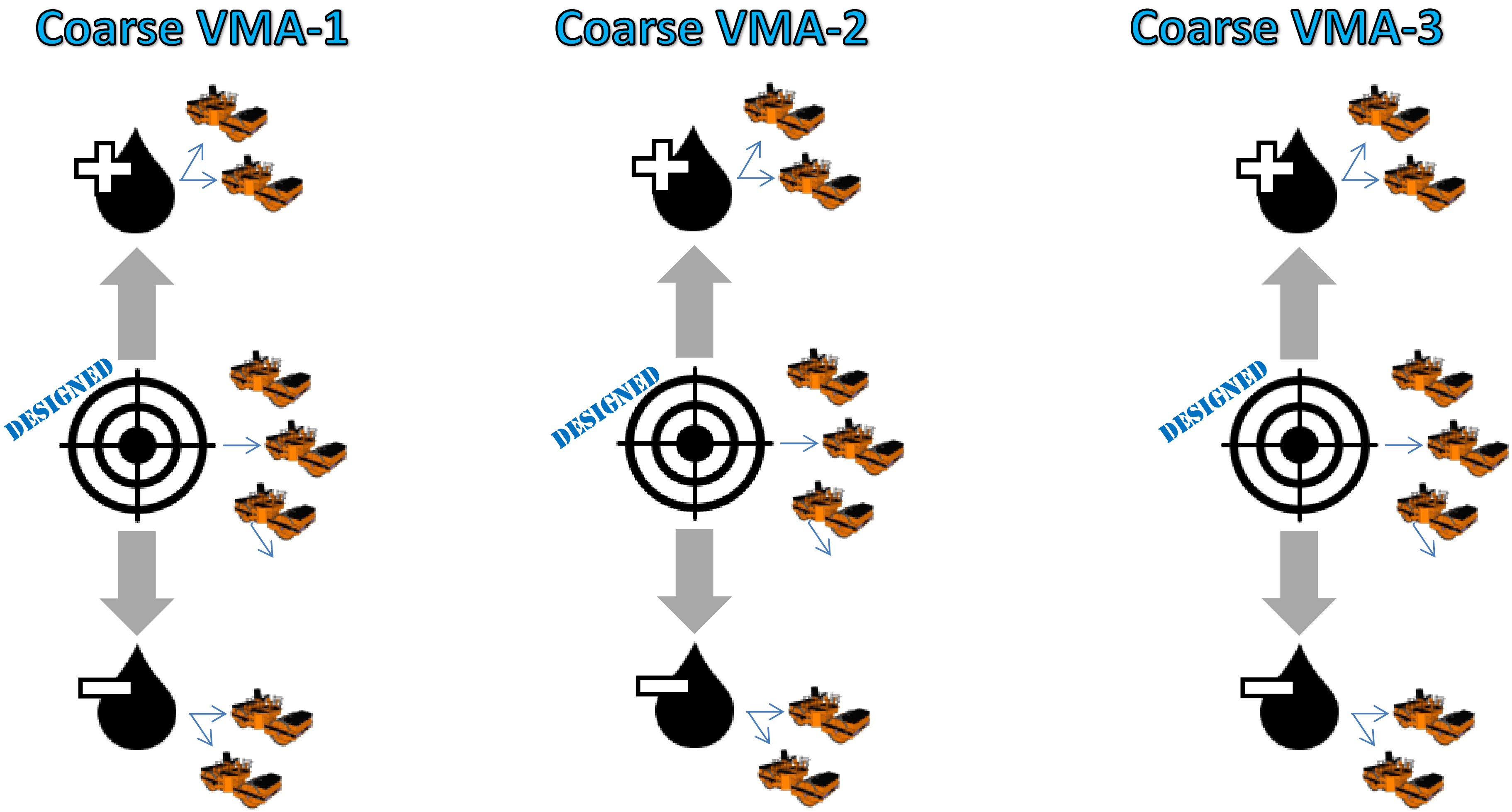
Coarse VMA-2



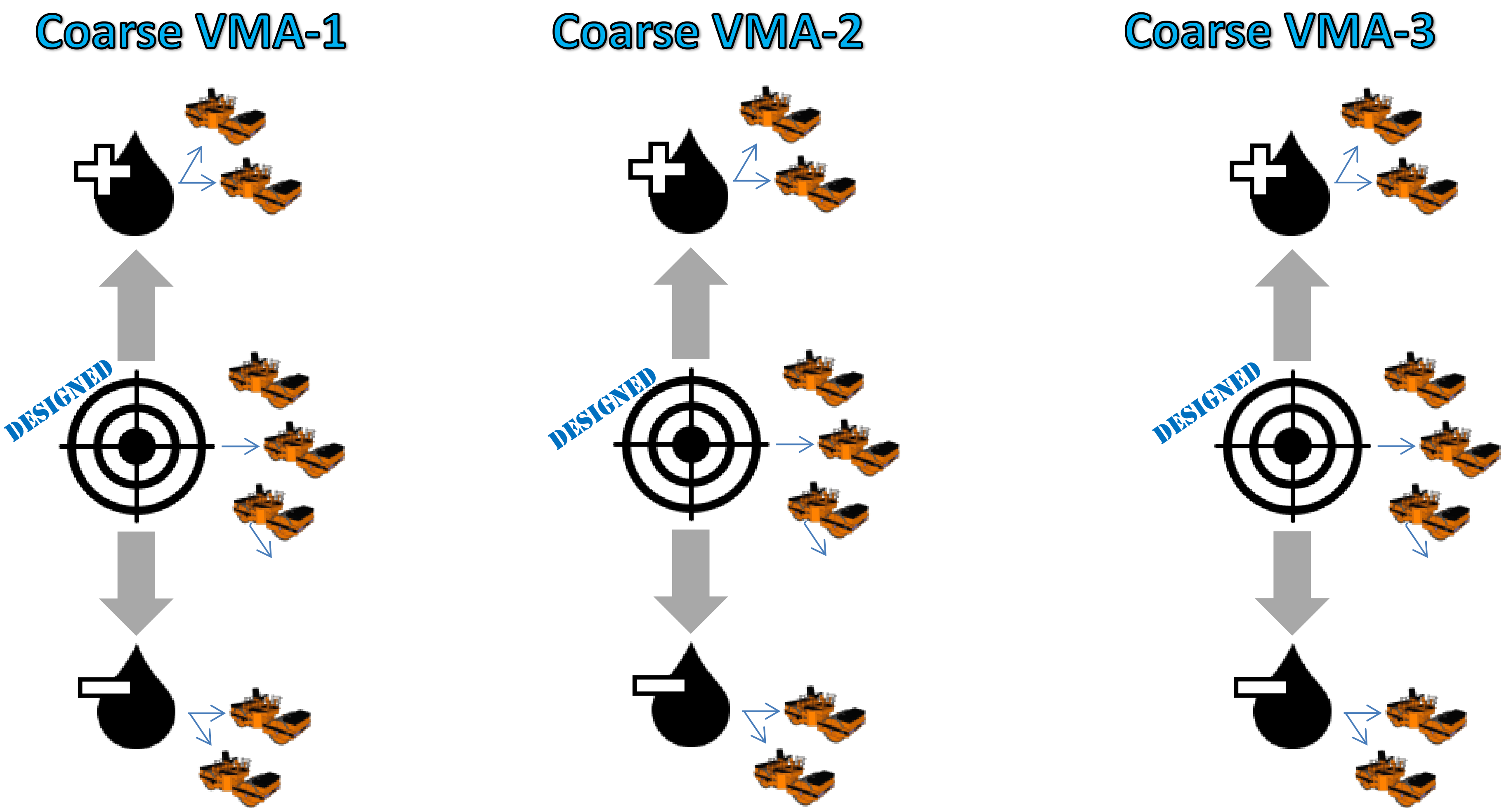
Coarse VMA-3



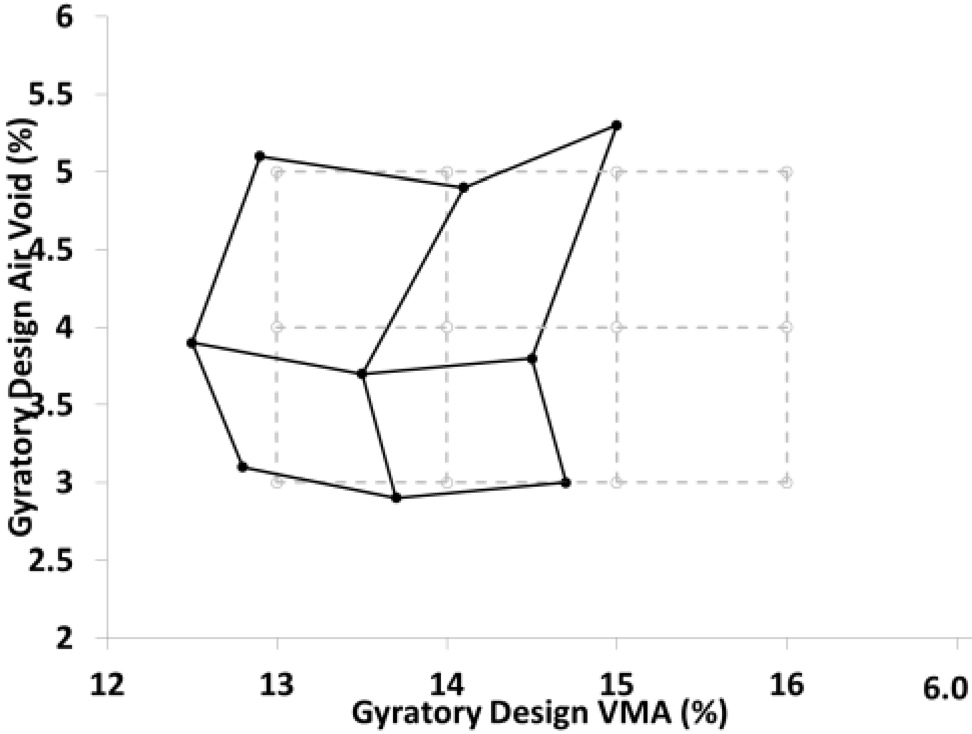
Mix Designs based on 2013 FHWA ALF



Mix Designs based on 2013 FHWA ALF



(3 VMA x 3 Design AV x 3 In Place AV) – 6 “extremes” = 21 different mixes



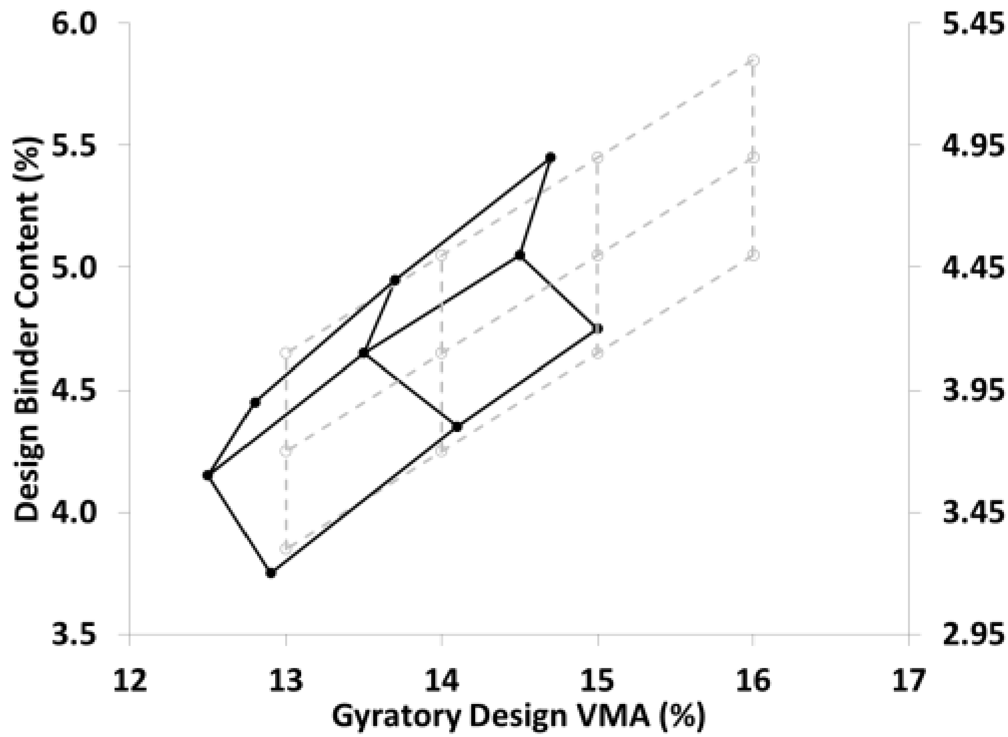
N_{design} = 65 Gyrations

12.5 mm NMAS

Laboratory Batched Study

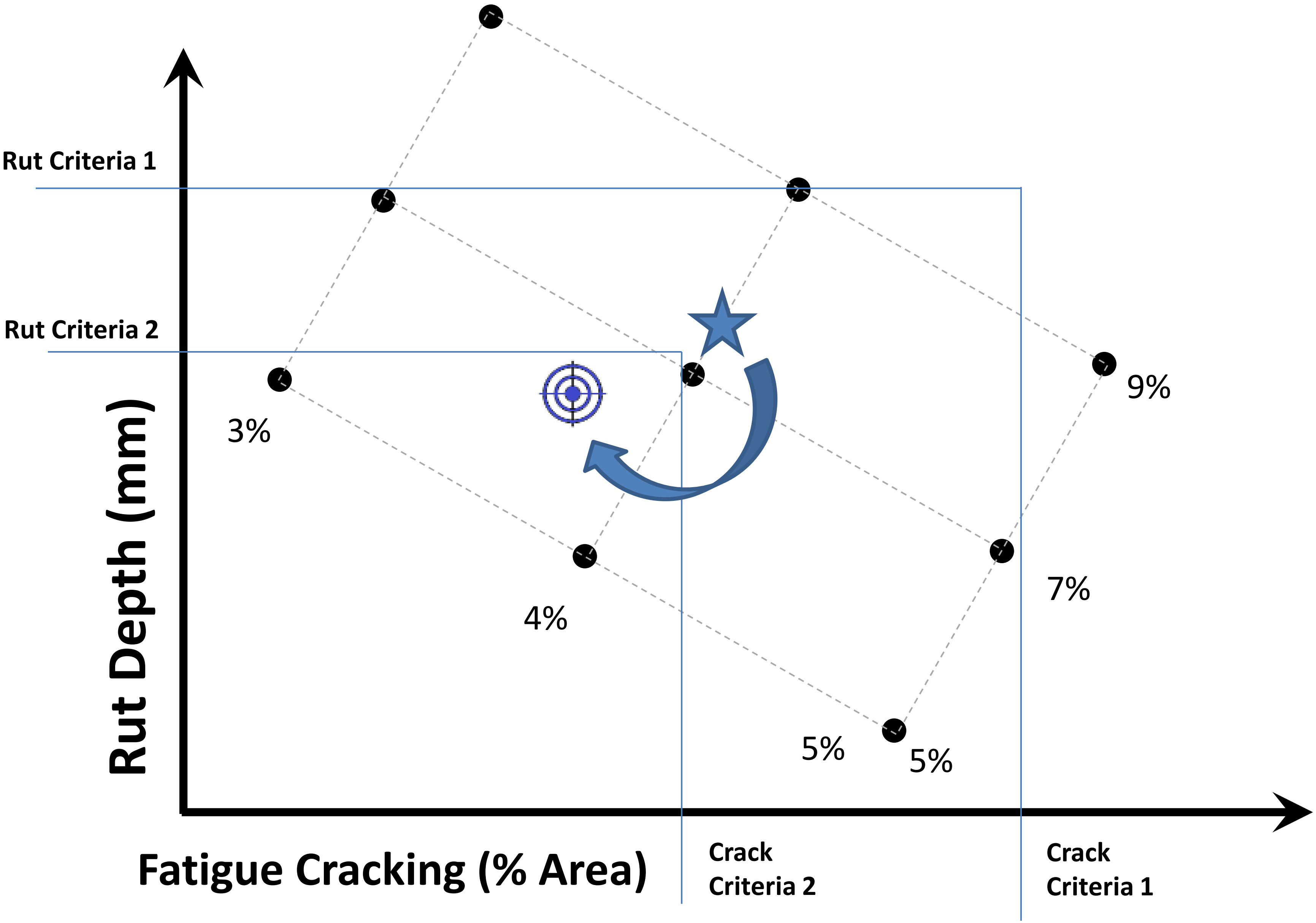
Performance Test Specimens' Compaction

Binder Content	**5% Air Void**	**7% Air Void**	**9% Air Void**
Low		✔	✔
Optimal	✔	✔	✔
High	✔	✔	



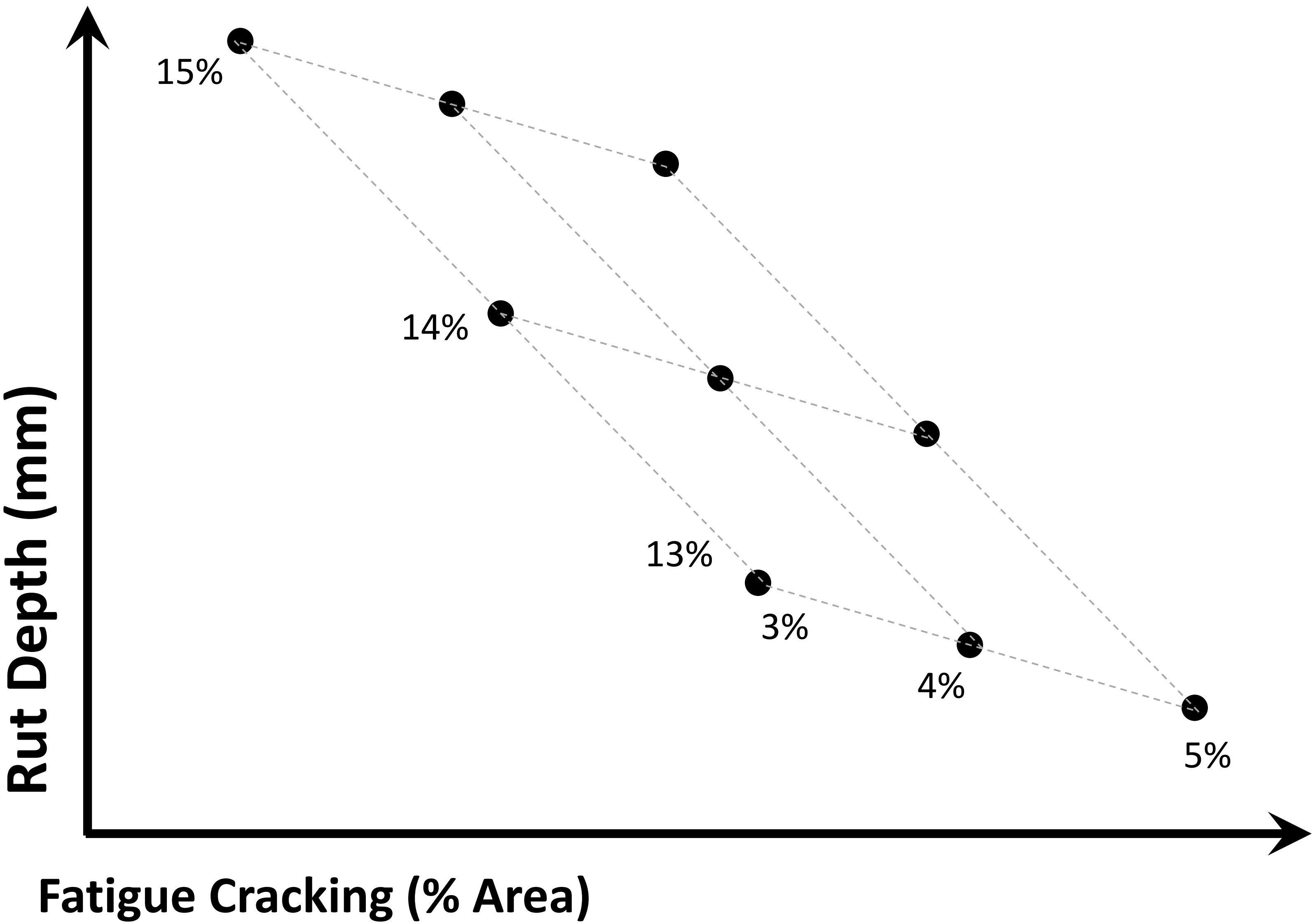
Fix : Design VMA

Effect of : Design Air Void (3, 4, 5%) & Compaction Air Void (5, 7, 9%)



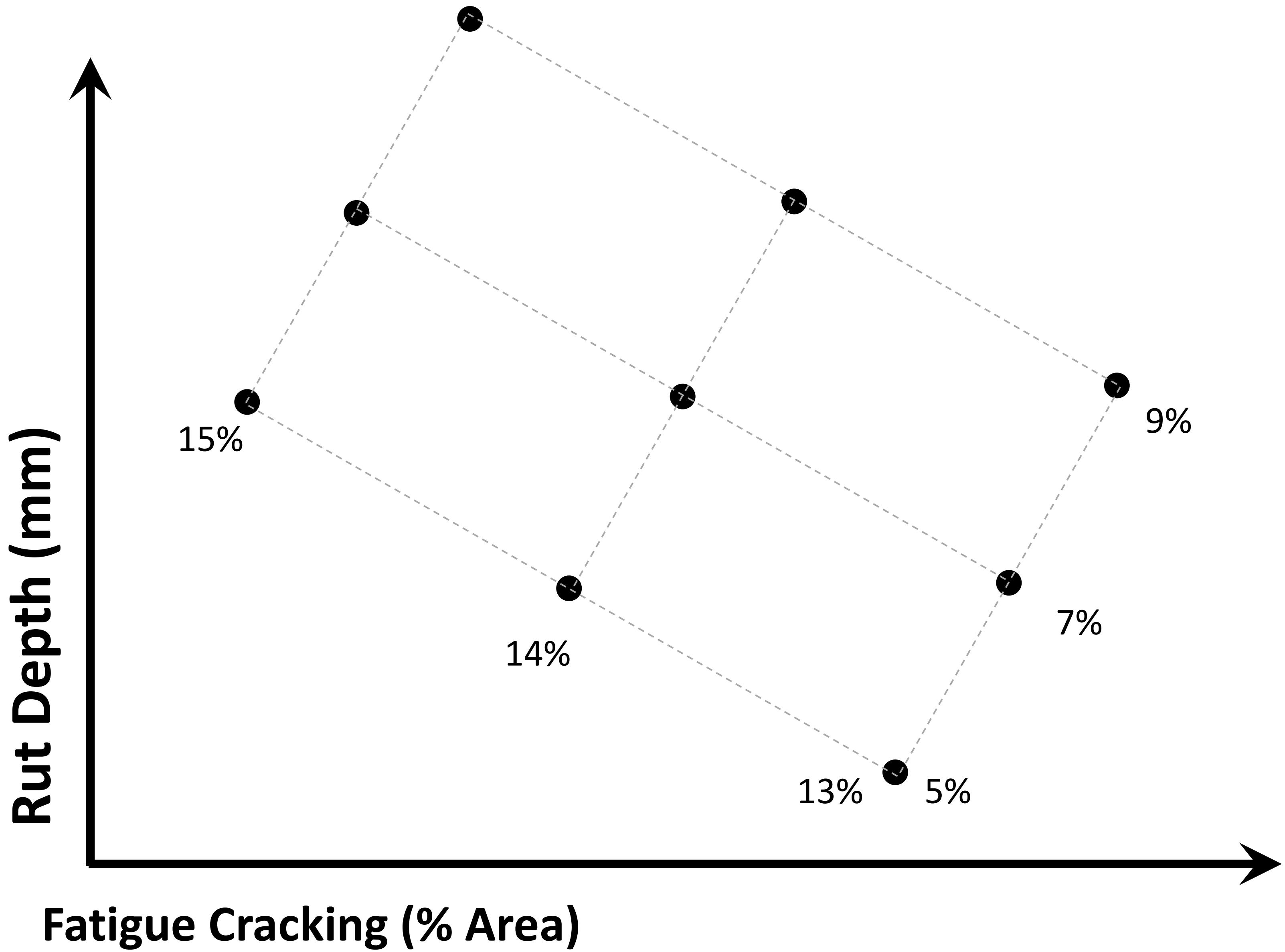
Fix : Compaction Air Void (5, 7, 9%)

Effect of : Design VMA (13, 14, 15%) & Design Air Void (3, 4, 5%)



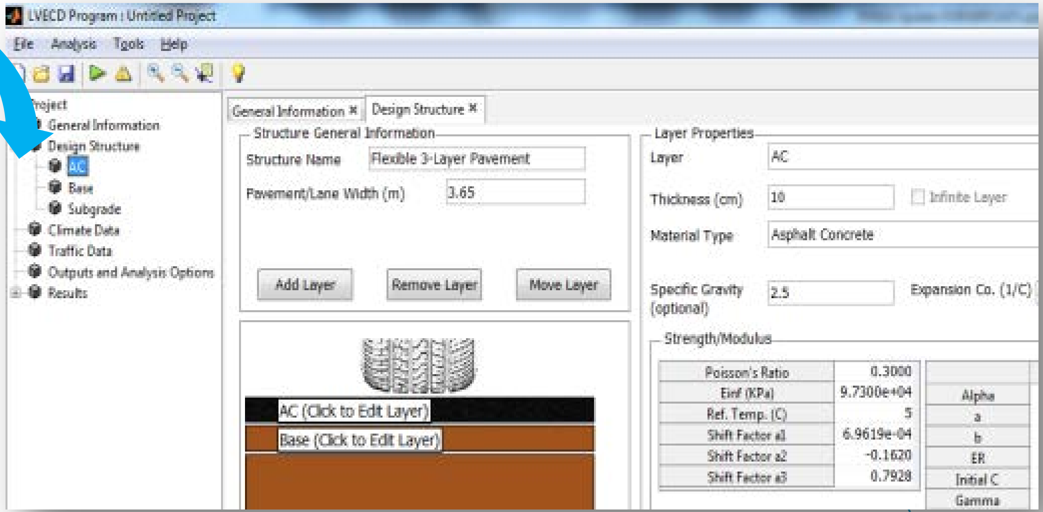
Fix : **Design Air Void**

Effect of : Design VMA (13, 14, 15%) & Compaction Air Void (5, 7, 9%)



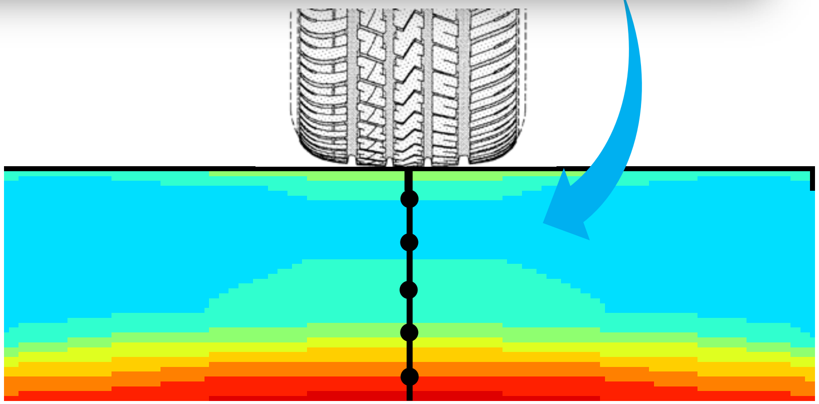
AMPT + Performance Prediction

✓ **Structure** ✓ **Traffic** ✓ **Climate**



Fatigue Test
AASHTO TP107

Rutting Test
Triaxial Stress Sweep (TSS)

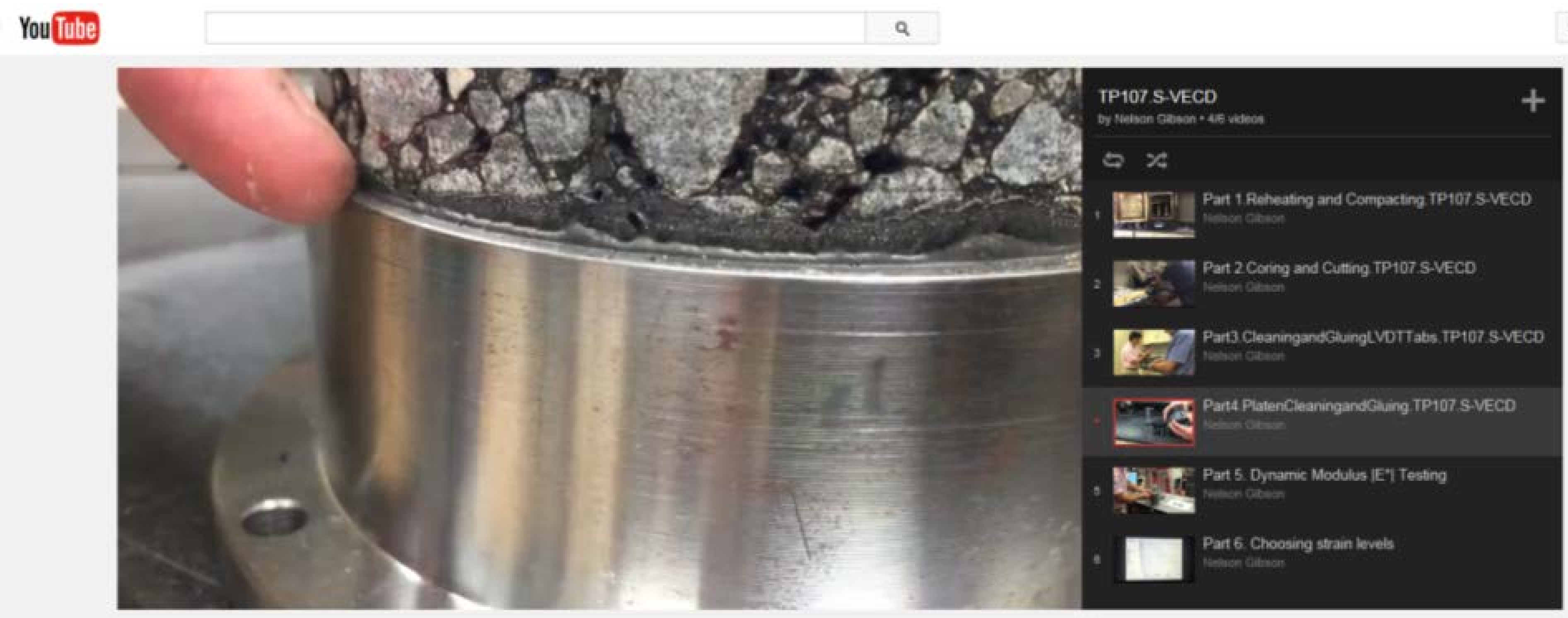


Predicted Rutting
Predicted Cracking

TP 107 Fatigue Test -Instructional Videos

- contact Nelson Gibson nelson.gibson@dot.gov

https://www.youtube.com/playlist?list=PLyLypK-



Scenario analyzed…

Structure

- 4-inch asphalt concrete
- 22-inch crushed aggregate base
- Subgrade

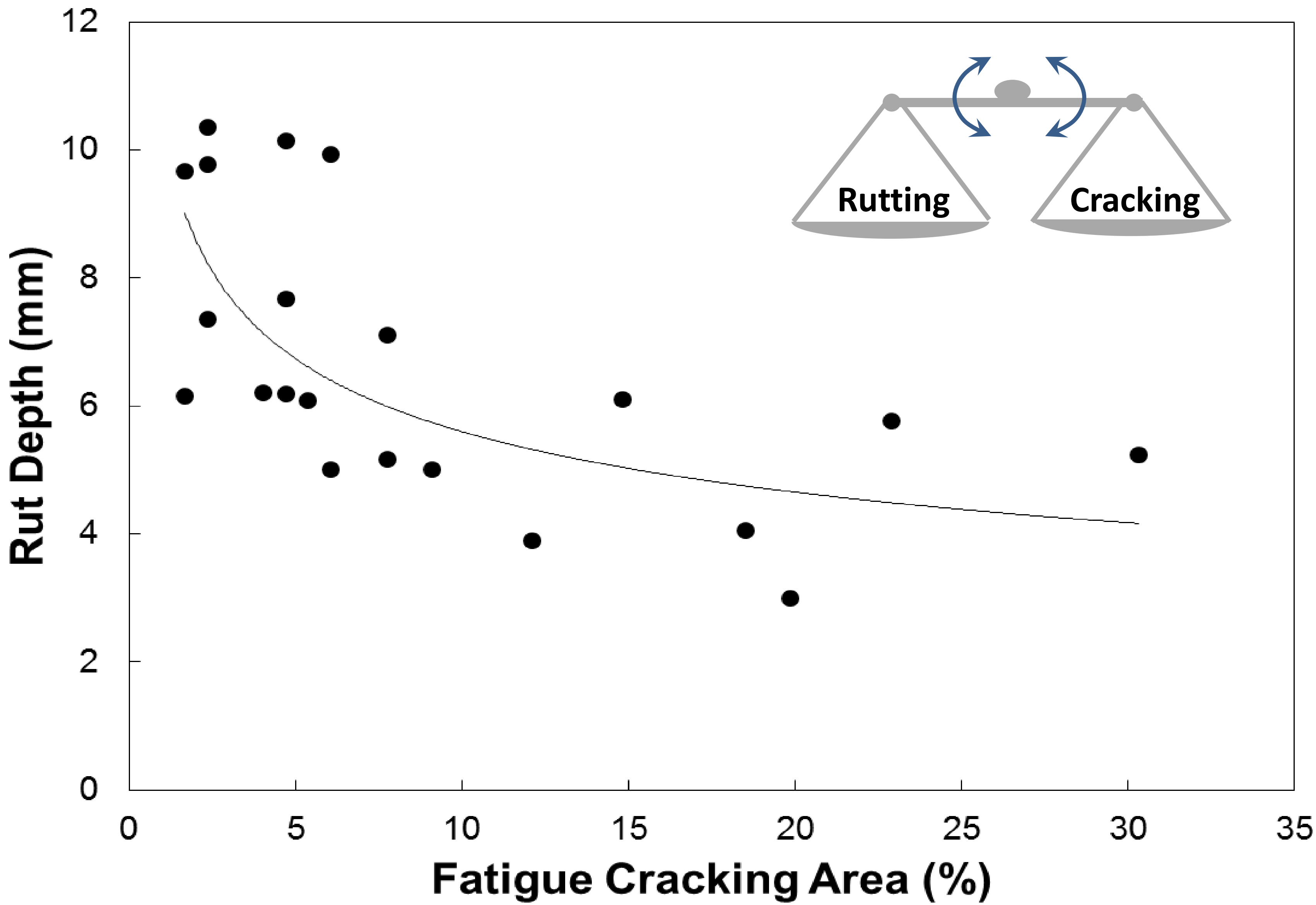
Traffic

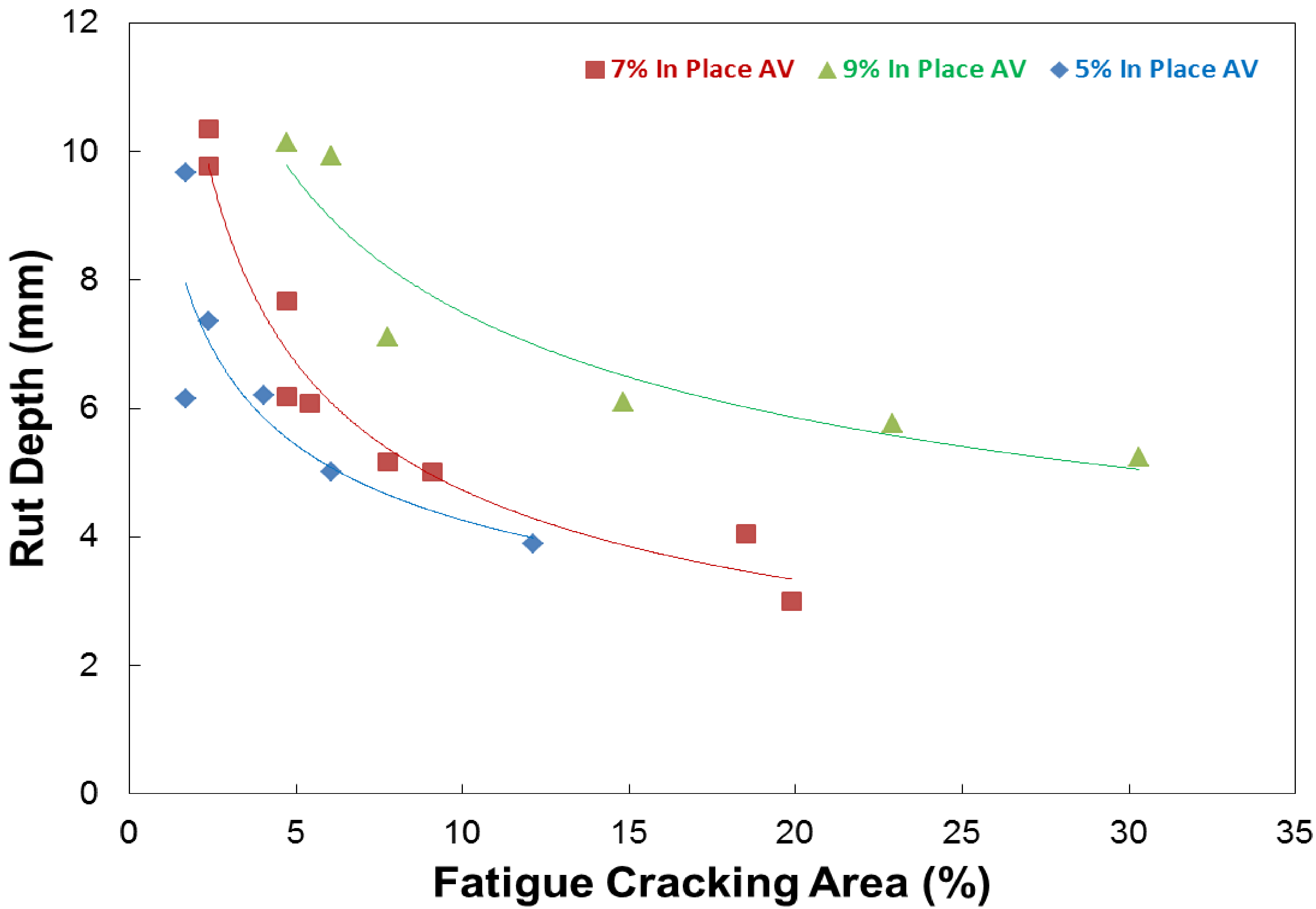
- 3 million ESALs in 20 years

Climate

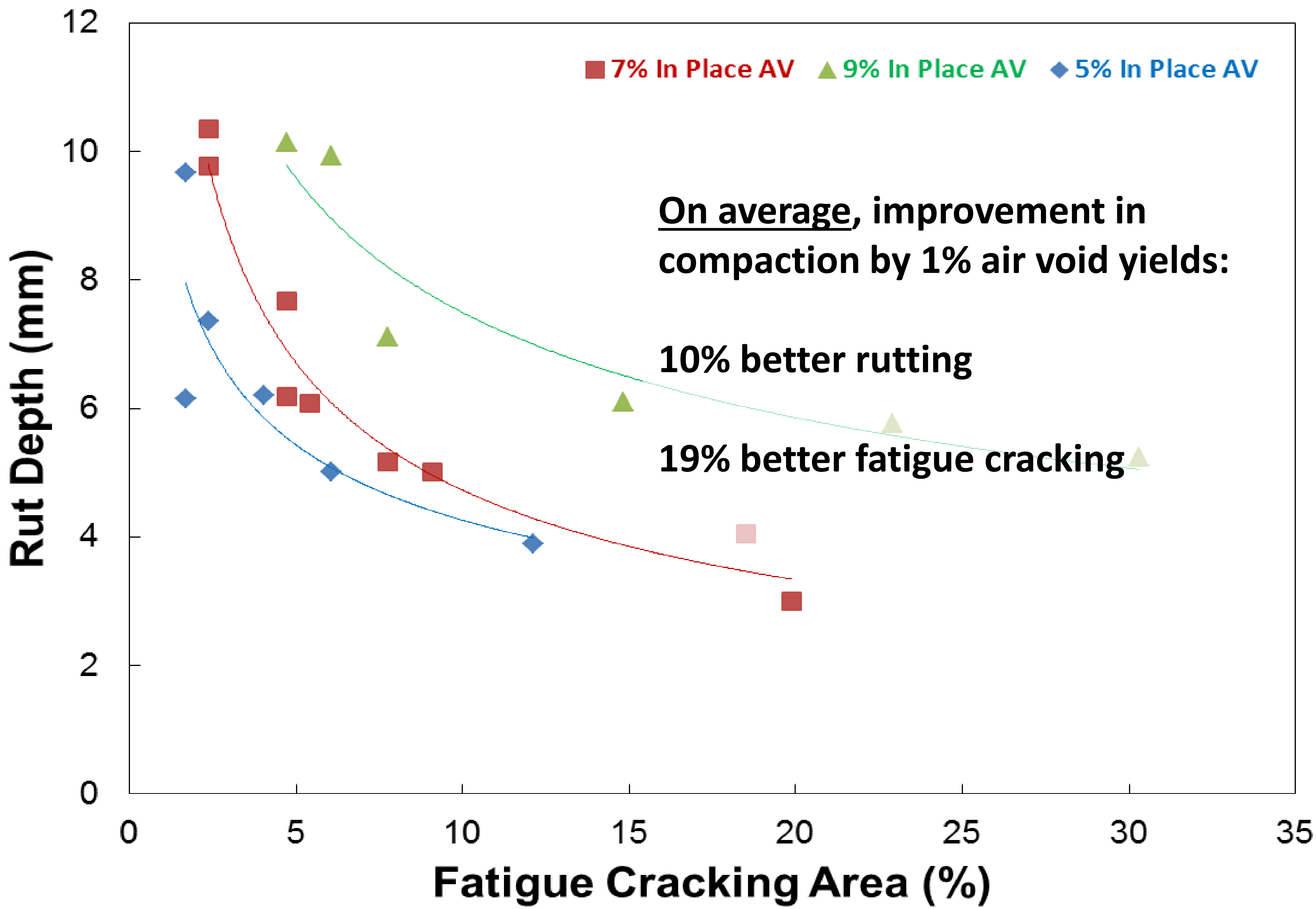
- DCA National airport weather station

Performance of ALL 21 Mixes

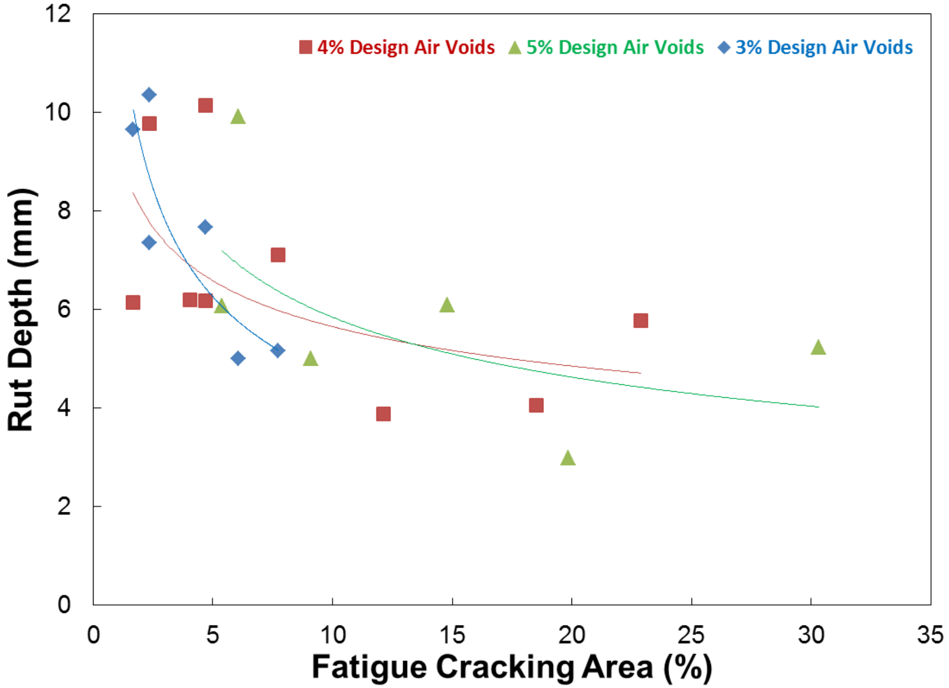


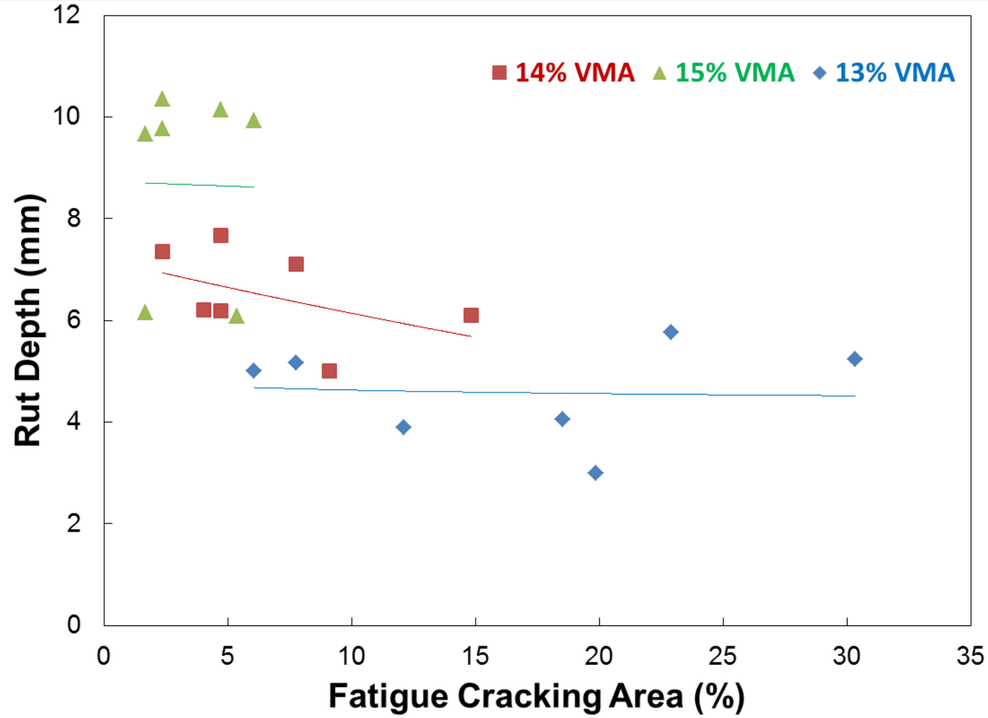


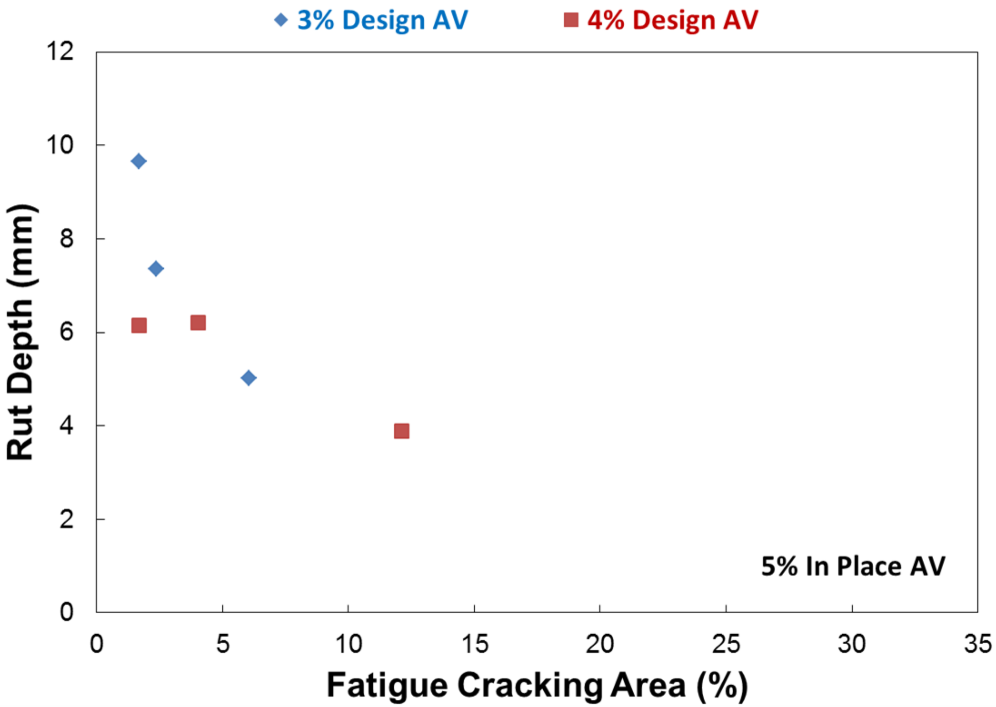
7% In Place AV
9% In Place AV
5% In Place AV
Rut Depth (mm)
Fatigue Cracking Area (%)
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35

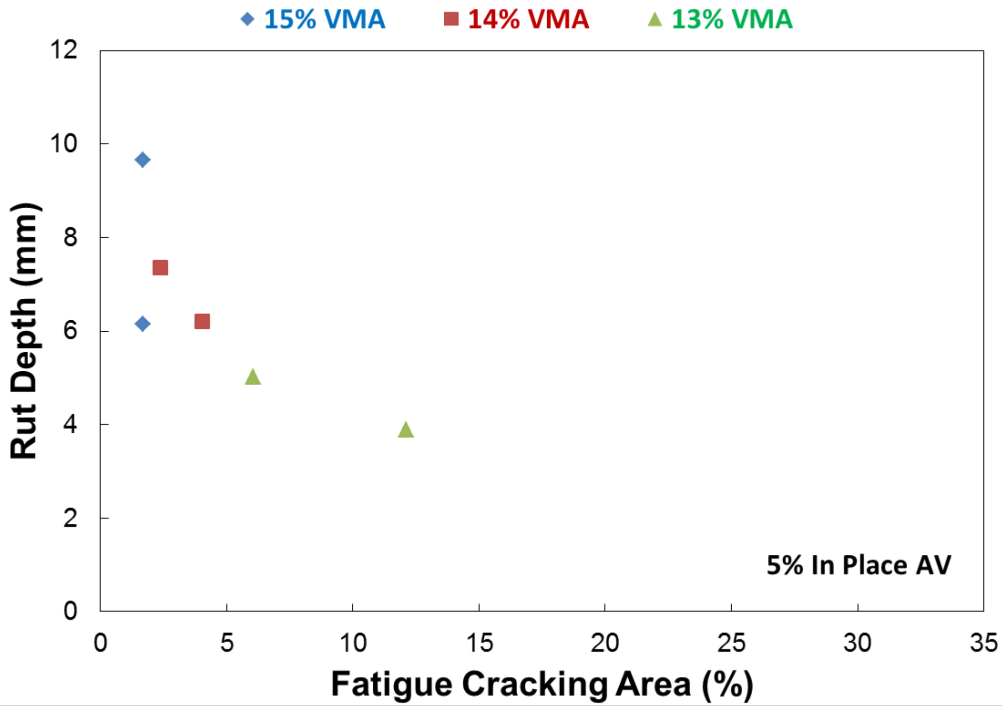


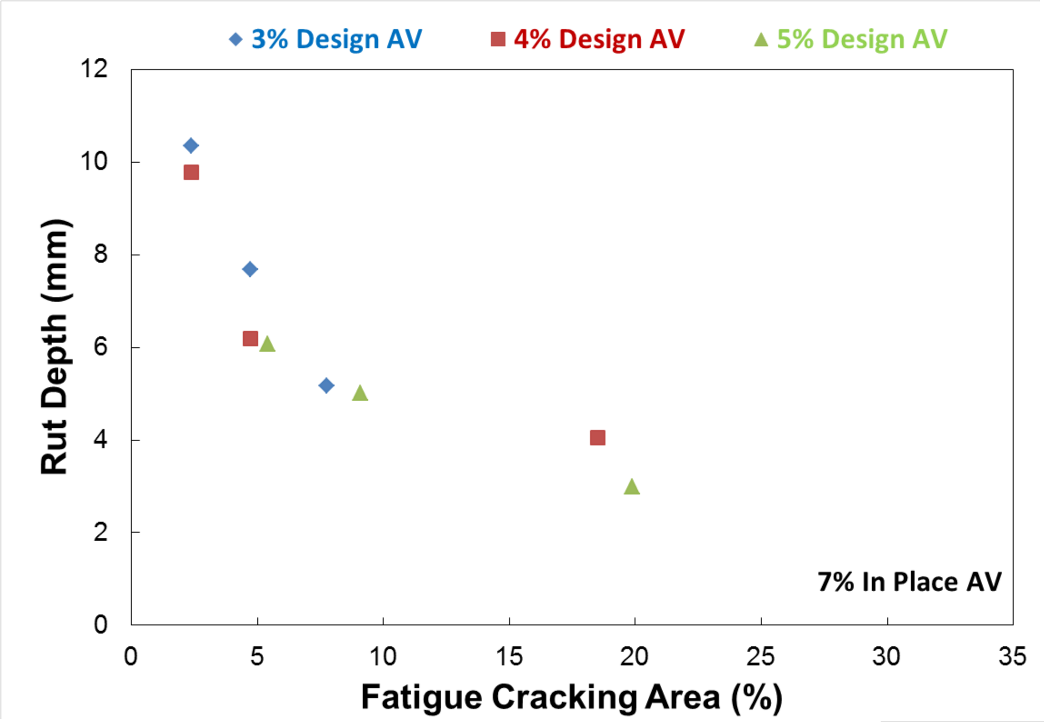
7% In Place AV
9% In Place AV
5% In Place AV
On average, improvement in compaction by 1% air void yields:
10% better rutting
19% better fatigue cracking
Rut Depth (mm)
Fatigue Cracking Area (%)
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35


4% Design Air Voids
5% Design Air Voids
3% Design Air Voids
Rut Depth (mm)
Fatigue Cracking Area (%)
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35

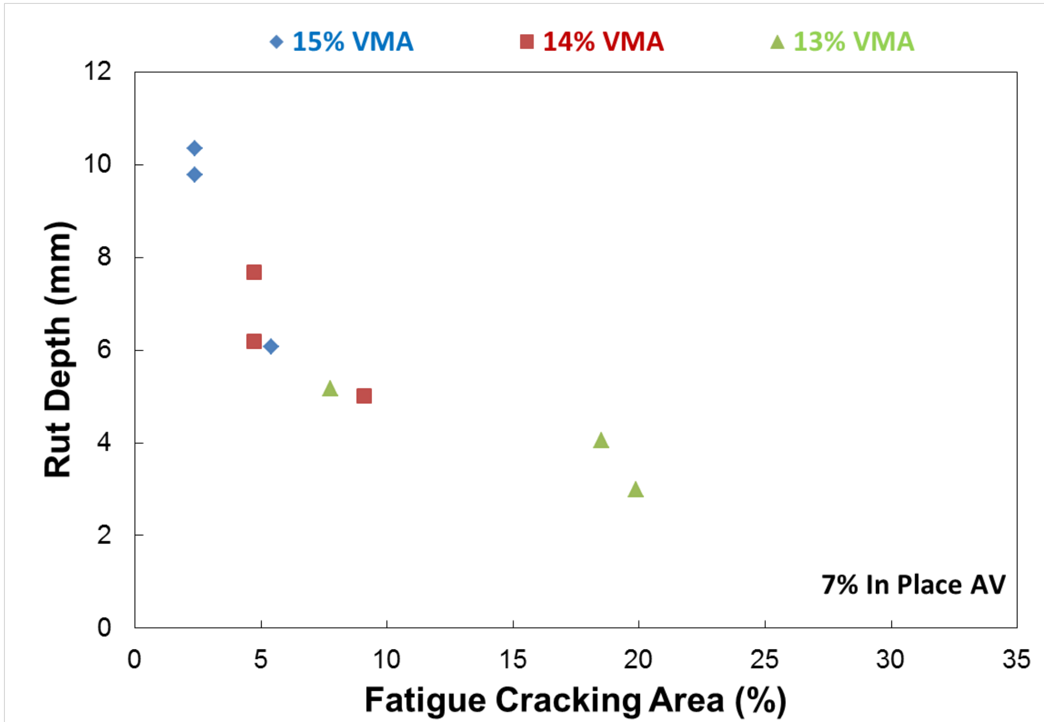

14% VMA
15% VMA
13% VMA
Rut Depth (mm)
Fatigue Cracking Area (%)
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35


3% Design AV
4% Design AV
Rut Depth (mm)
Fatigue Cracking Area (%)
5% In Place AV

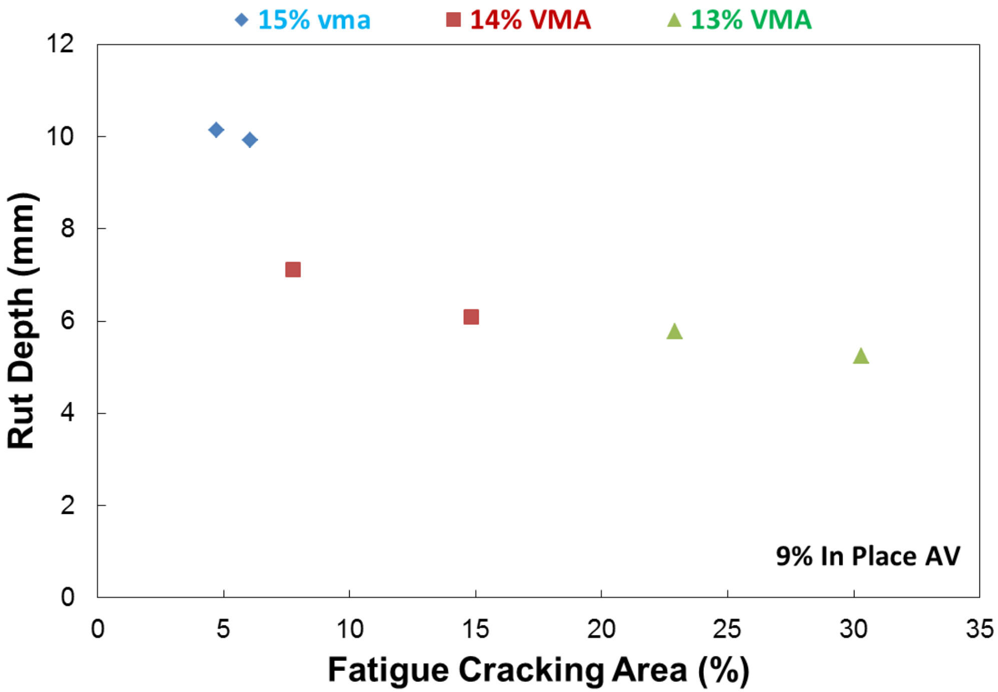

15% VMA
14% VMA
13% VMA
Rut Depth (mm)
Fatigue Cracking Area (%)
5% In Place AV

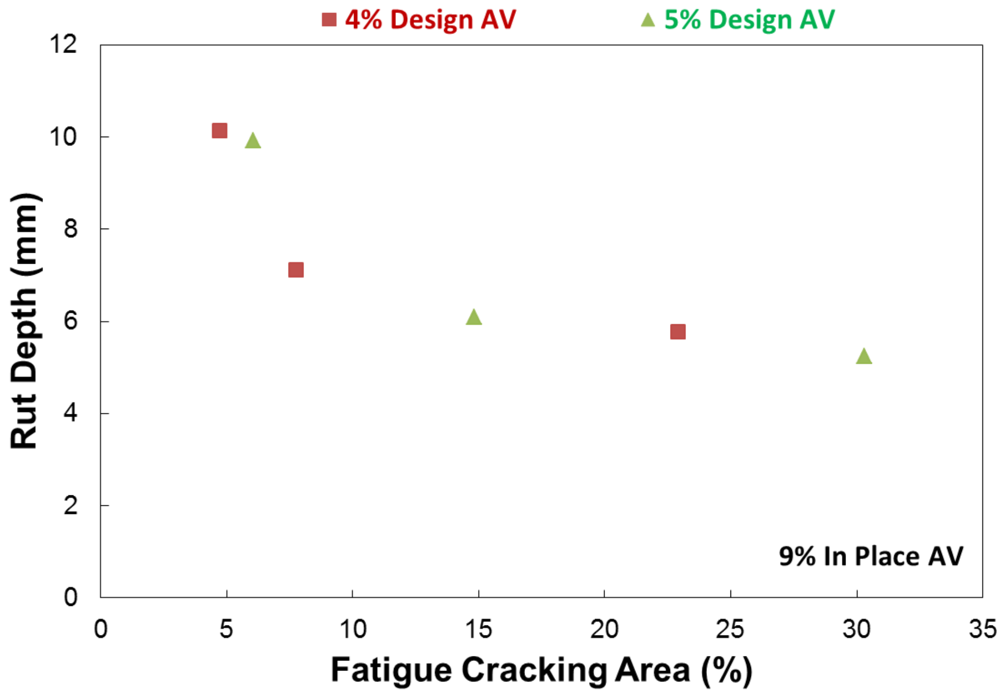


3% Design AV
4% Design AV
5% Design AV
Rut Depth (mm)
Fatigue Cracking Area (%)
7% In Place AV



15% VMA
14% VMA
13% VMA
Rut Depth (mm)
Fatigue Cracking Area (%)
7% In Place AV


15% vma
14% VMA
13% VMA
Rut Depth (mm)
Fatigue Cracking Area (%)
9% In Place AV
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35


4% Design AV
5% Design AV
Rut Depth (mm)
Fatigue Cracking Area (%)
9% In Place AV
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35

$$100\% \; x \; \frac{\left(\Delta Rutting / \Delta \; Design \; AV\right)}{Average \; Rutting} = \textbf{-22\%}$$

For Every 1% increase in design air voids there is a 22% decrease in rutting

-6% to -37%
depending on in place compaction & Design VMA

$$100\% \; x \; \frac{\left(\Delta Cracking / \Delta \; Design \; AV\right)}{Average \; Cracking} = \textbf{40\%}$$

For Every 1% increase in design air voids there is a 40% increase in cracking

14% to 65%
depending on In Place Compaction & Design VMA

$$100\% \; x \; \frac{\left(\Delta Rutting / \Delta \; Design \; VMA\right)}{Average \; Rutting} = \mathbf{32\%}$$

For Every 1% increase in design VMA there is a 32% increase in rutting

25% to 39%
depending on in place compaction & Design Air Void

$$100\% \; x \; \frac{\left(\Delta Cracking / \Delta \; Design \; VMA\right)}{Average \; Cracking} = \mathbf{-73\%}$$

For Every 1% increase in design VMA there is a 73% decrease in cracking

-60% to -87%
depending on In Place Compaction & Design Air Void

Further Refinement

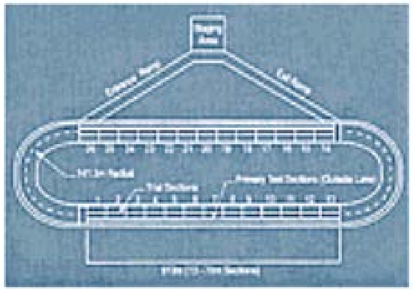
- These relationships can be expanded and sharpened rather than the single general rule
- Can be defined for different pavement structural configurations
  - "Thick" mill & fill
  - Perpetual Pavement
  - Thin Overlay

Utilities

1. Adjusting Mix Design Volumetrics Before the Project

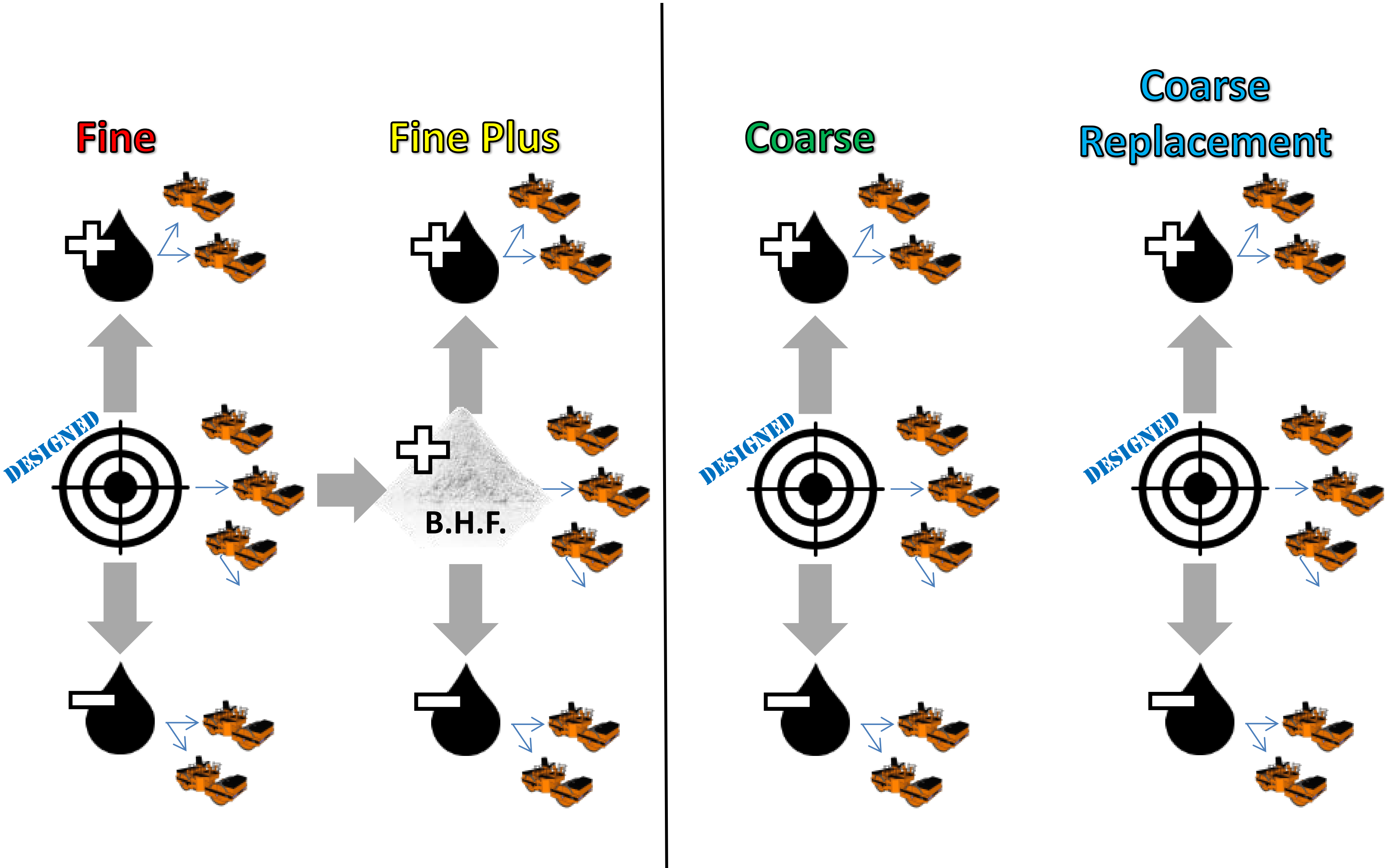
2. Quickly adjusting expected performance due to ordinary variations in production volumetrics and compaction

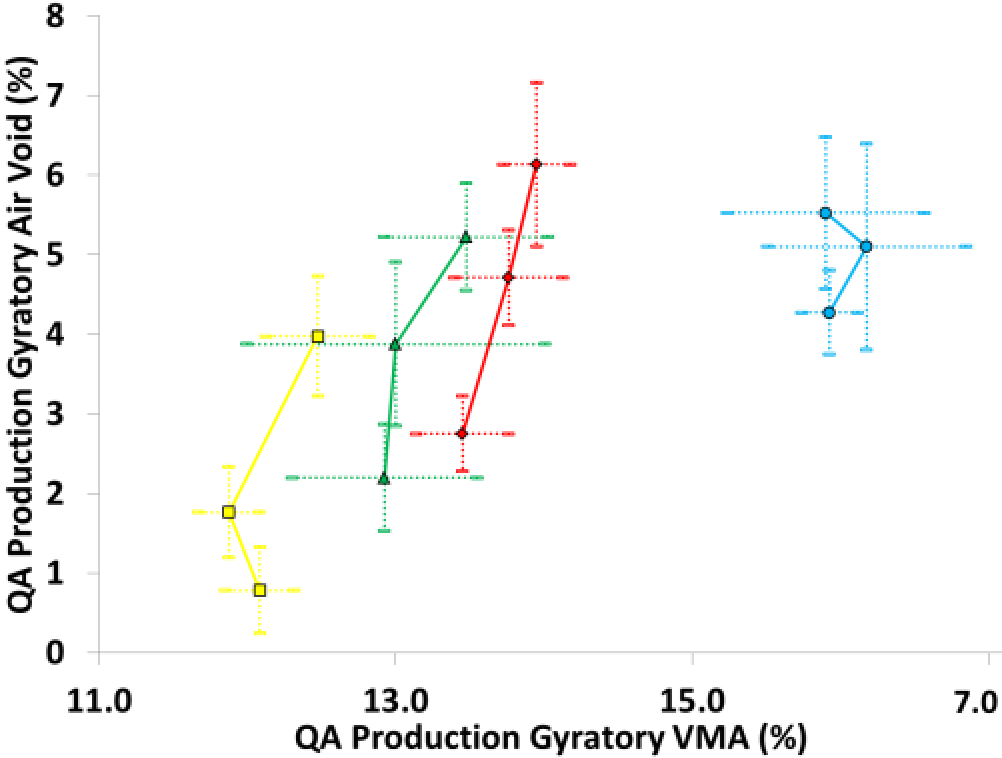
Adding WesTrack Materials


Layout of Test Track
(not to scale)

- The relationships we have developed are not intended to be a “global” / “universal”
- They are intended to be relativistic rules
- Checking these relationships with the WesTrack experiment materials
  - Fine graded x 2
  - Coarse graded x 2

WesTrack (1995-1999)





Fine Fine Plus
Coarse Coarse Replacement

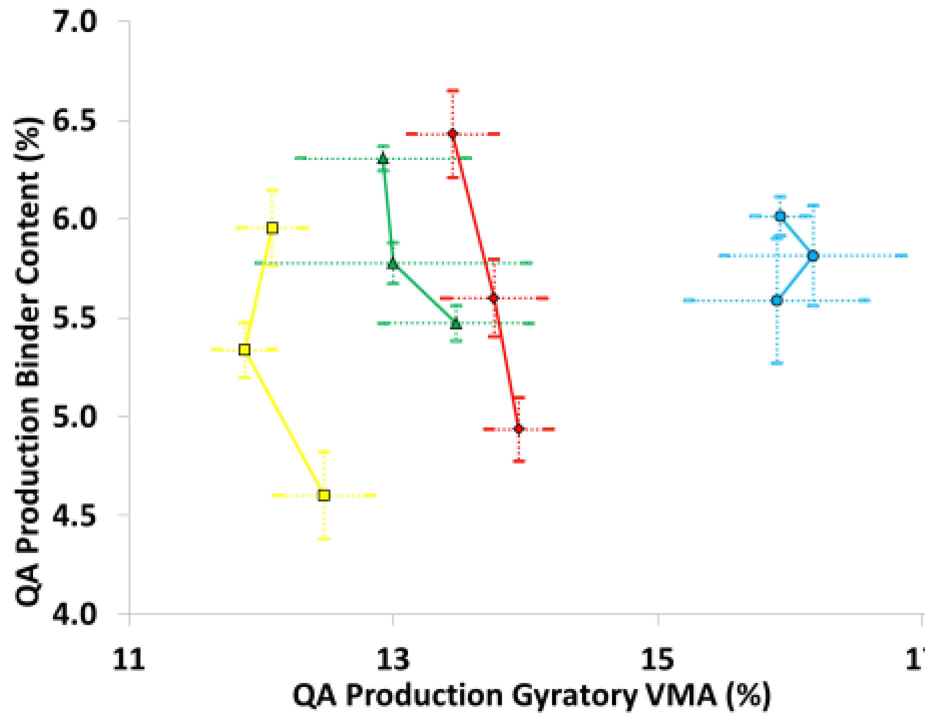
N_{design} = 96 Gyrations

19 mm NMAS

QA data from production

Field Compaction Targets

Binder Content	4% Air Void	8% Air Void	12% Air Void
Low		✔	✔
Optimal	✔	✔	✔
High	✔	✔	



Thank You

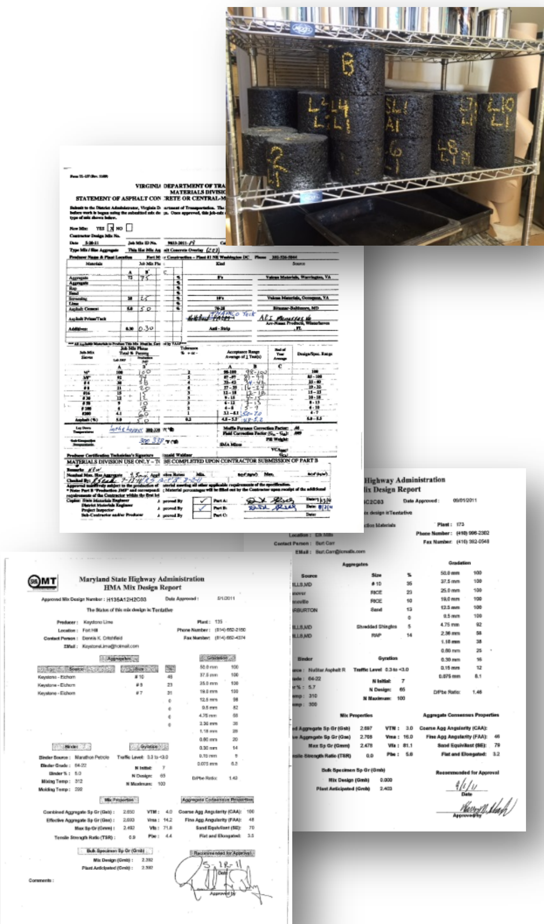

TRANSPORTATION RESEARCH CIRCULAR
Number E-C173 June 2013
Glossary of Transportation Construction Quality Assurance Terms
SIXTH EDITION

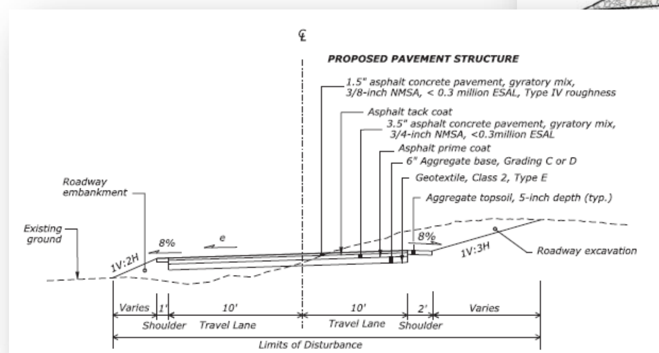
Performance Based	Performance Related
Engineering Properties	Materials & Construction Characteristics
Models Predict Performance	Correlation Database
not amenable to timely acceptance testing	amenable to acceptance testing at the time of construction


How do I get out of here?

Figure out 'where you are'

- STEP 1: ID. current mixes going into current structures





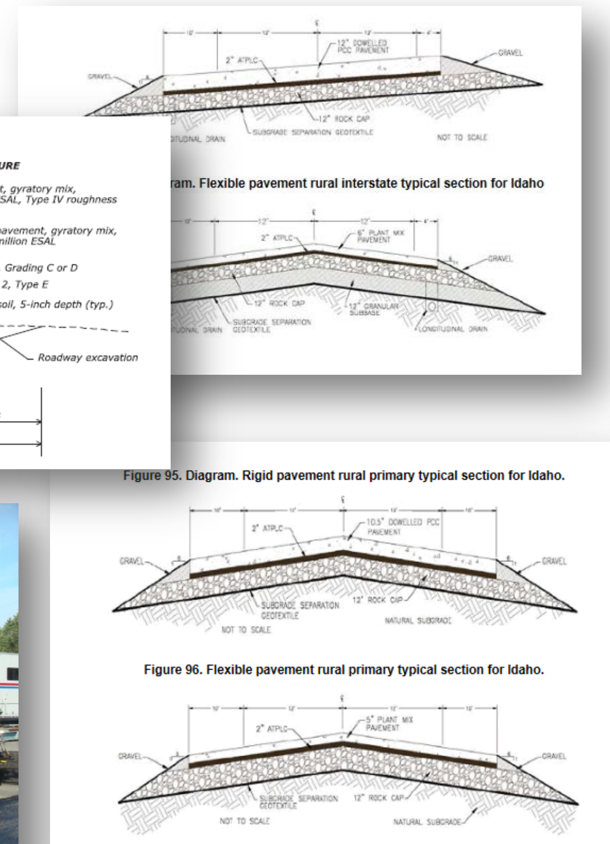
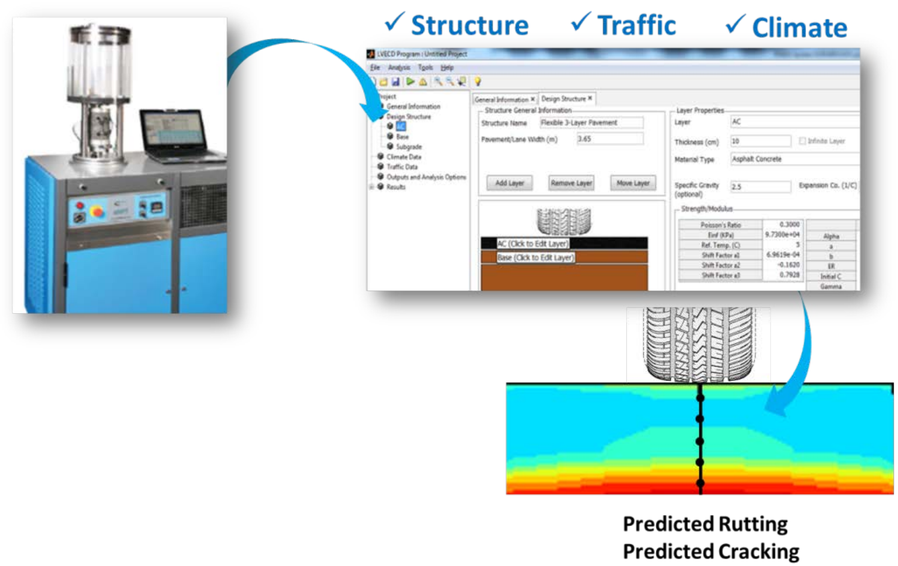
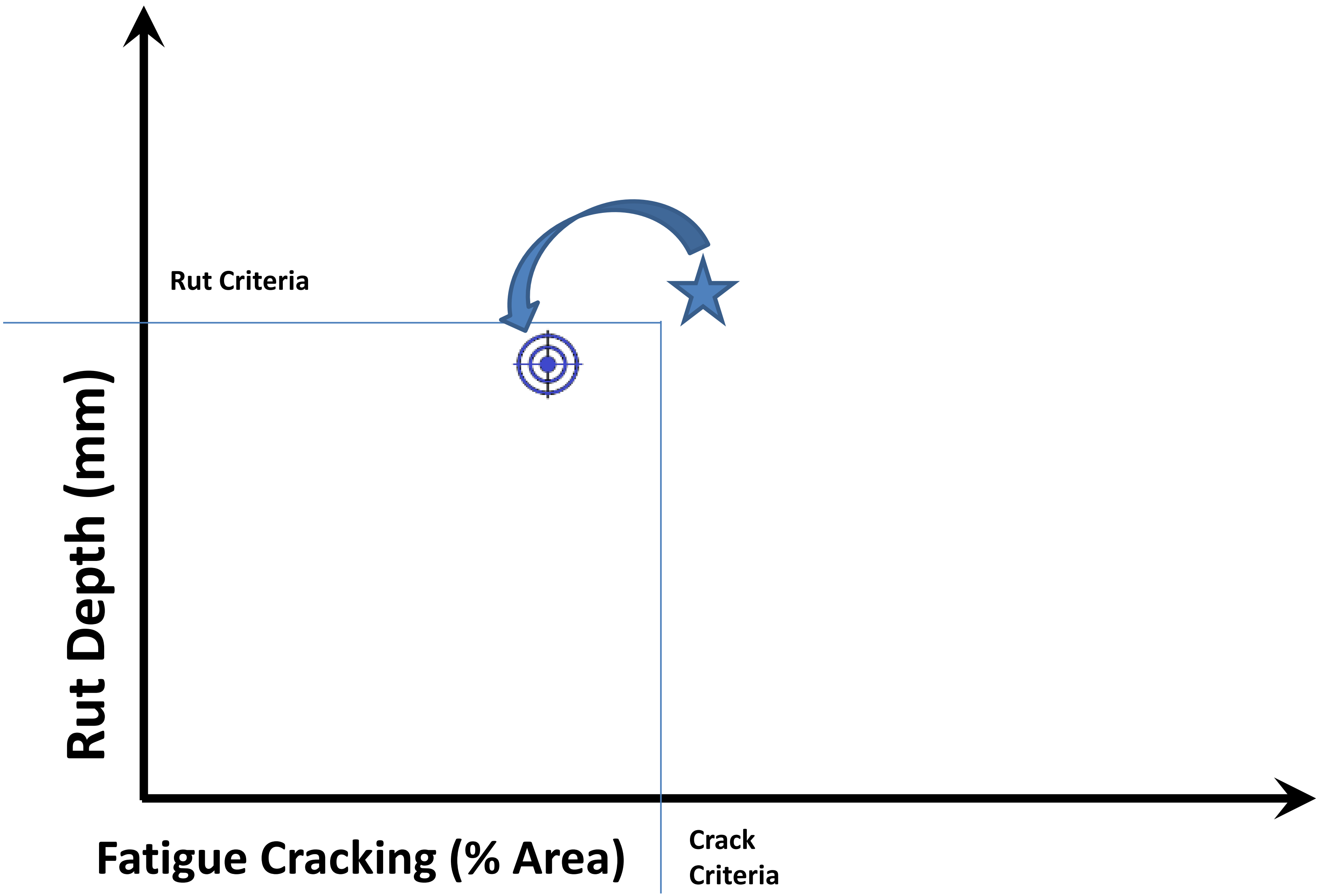


Figure out 'where you are'

- STEP 2: Document performance in the field and performance predicted by PRS tools





Rut Criteria
Rut Depth (mm)
Fatigue Cracking (% Area)
Crack
Criteria