# Bullet-proof Chip Seals: Now, There's No Reason Not to

A Summary of the NCHRP Report 680: Manual for Emulsion-Based Chip Seals for Pavement Preservation

by
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Colorado State University
*Knowledge to Go Places*

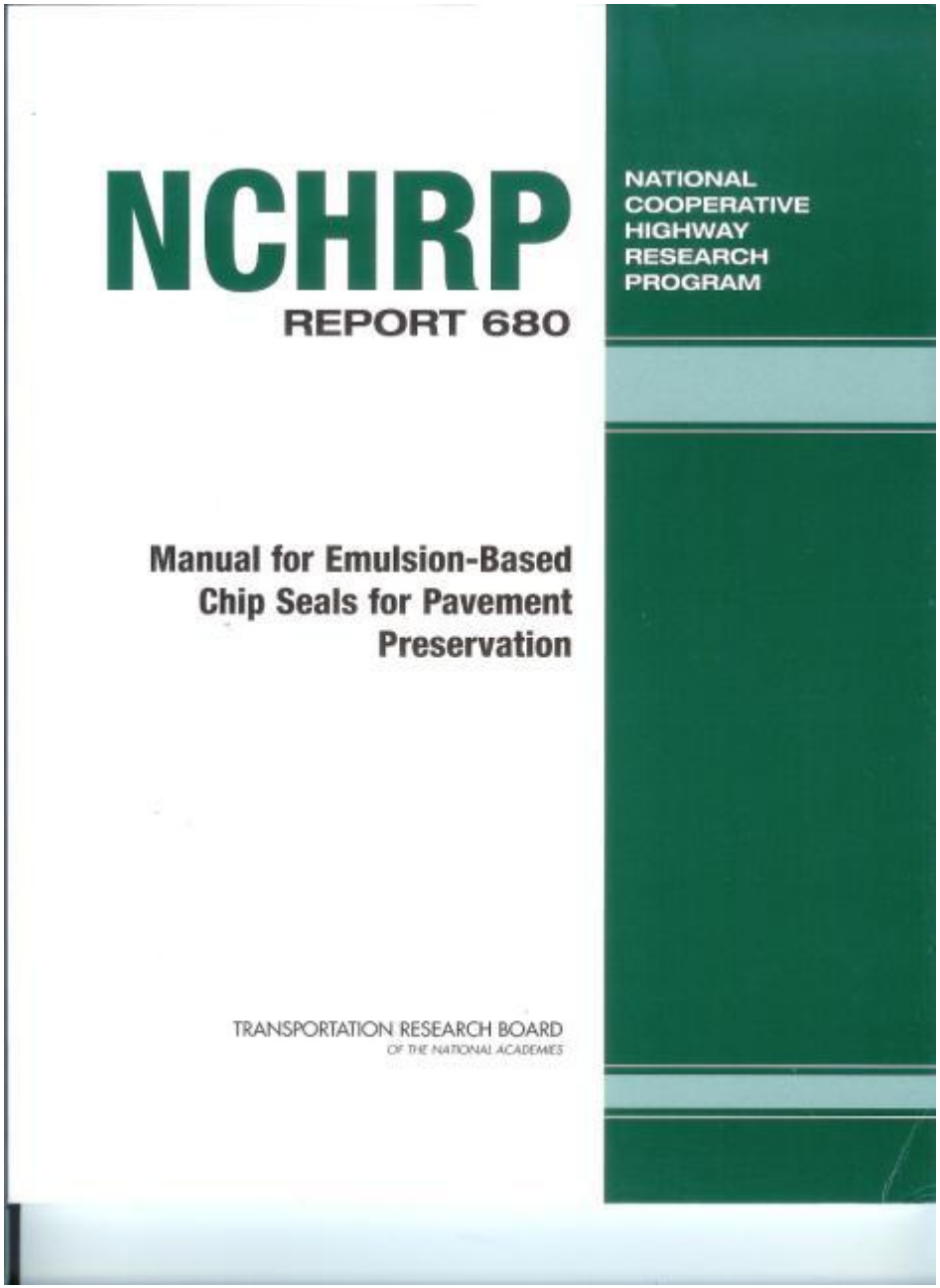
# Acknowledgements

National Cooperative Highway Research Program

Project 14-17 “Manual for Emulsion-Based Chip Seals for Pavement Preservation”

FHWA Federal Lands
City of Frederick, Colorado
Washington DOT

# Research Product

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# Traffic Control

# Keys to Successful Chip Seals

- Project Selection
- Overall Design
- Chip Seal Type
- Materials
- Specific Design
- Construction
- QA/QC
- Performance Expectation

# Keys to Successful Chip Seals

- Project Selection
  - Pavement Condition
  - Traffic
  - Geometry
  - Materials
  - Pavement Prep
  - Maintenance

# Keys to Successful Chip Seals

- Overall Design
  - Appropriate Pavements
  - Seal Type
  - Chip Seal Selection
  - Aggregate Size
  - Pavement Condition
  - Materials

# Keys to Successful Chip Seals

- Appropriate Chip Seal
  - Single
  - Single with ‘Choke’
  - Multiple

# Keys to Successful Chip Seals

- Materials Selection
  - Chip Gradation
  - Modified or Unmodified Emulsion
  - To Fog or Not to Fog
  - Emulsion-Aggregate Compatibility

# Keys to Successful Chip Seals

- Specific Design
  - Binder Application Rate
  - Chip Application Rate
  - Excess Chips for Constructibility?
  - Time Until Sweeping

# Keys to Successful Chip Seals

- Construction
  - Equipment Calibration
  - Operations
    - Pavement Preparation
    - Weather
    - Paper Joints
    - Chip Application Time
    - Roller Speed and Number
    - Initial Sweep
    - Traffic Control
    - Removing Traffic Control

# Keys to Successful Chip Seals

- QA/QC
  - Sieve Analysis
  - Moisture in ‘System’
  - Embedment Depth During Construction
  - Field Viscosity

# Who Thinks ‘Art’ is Part of Chip Seal Construction?

- Turning Traffic Loose/Sweeping
- Surface Texture
- Surface ‘Softness’
- Is That Emulsion the One You Expected?

# Question

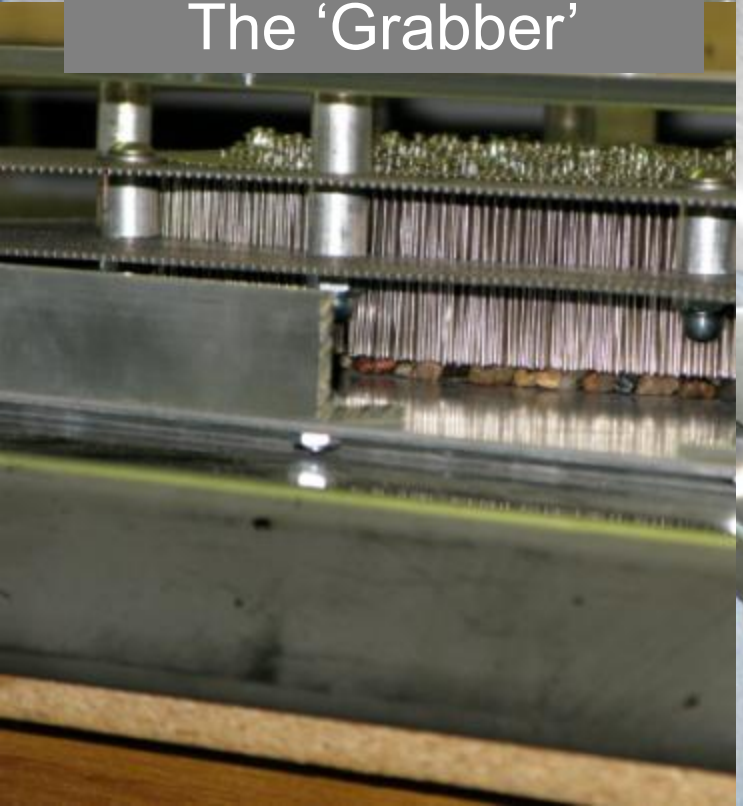
- Can a Lab Test be Used to Predict When to Broom/Turn Traffic Loose on a Chip Seal ?

- If Used:
  - Judgment Could be Improved,
  - Windshields Saved,
  - Reputations Maintained,
  - More Chip Seals Would be Built
  - The deficit would be eliminated
  - World Peace would follow

Chips at One-Stone Thickness

Template = 40% Embedment

“Pin-Art” Holds Chips The ‘Grabber’



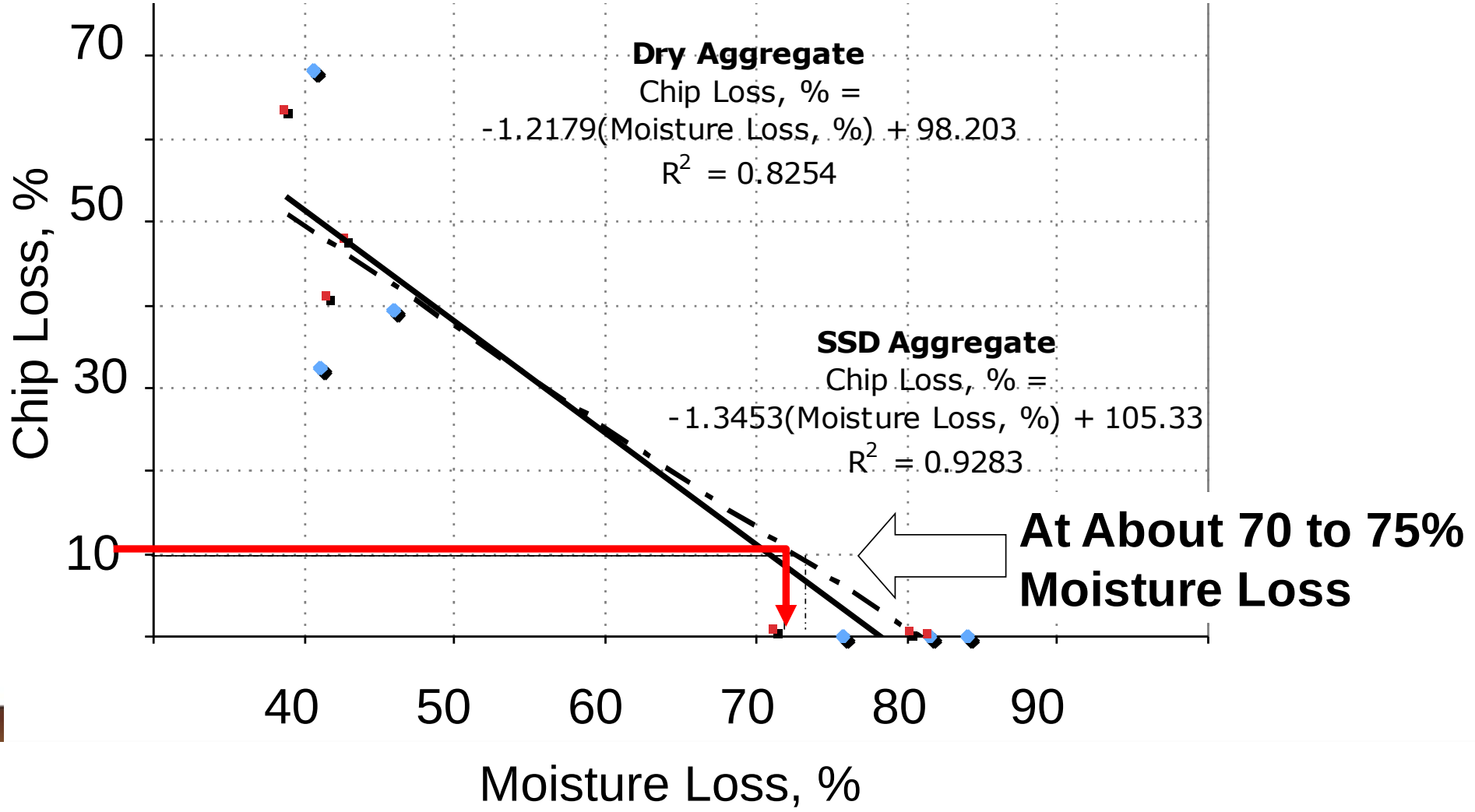
A Pneumatic Roller Would be an Improvement


NCHRP 14-17
“Broom Simulator”

# The Experiment

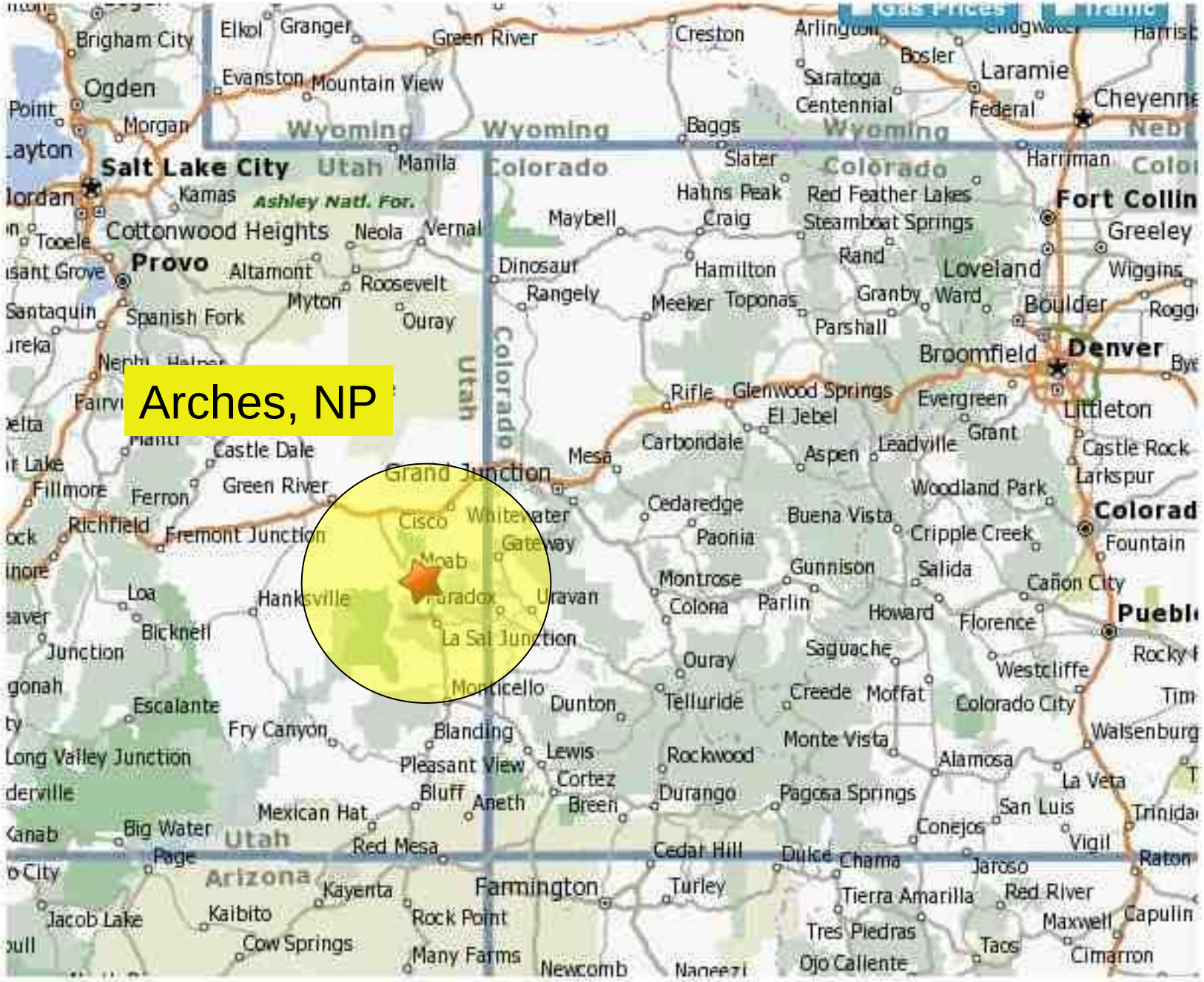
- AGGREGATES:
  - Basalt, Alluvial, Granite, Limestone
- EMULSIONS:
  - RS-2, RS-2P, CRS-2, CRS-2P, HFRS-2P
- EMULSION CURE:
  - 40%, 80%
- AGGREGATE MOISTURE:
  - Dry, SSD

# Field Site Aggregates - Lab Sweep Test Results



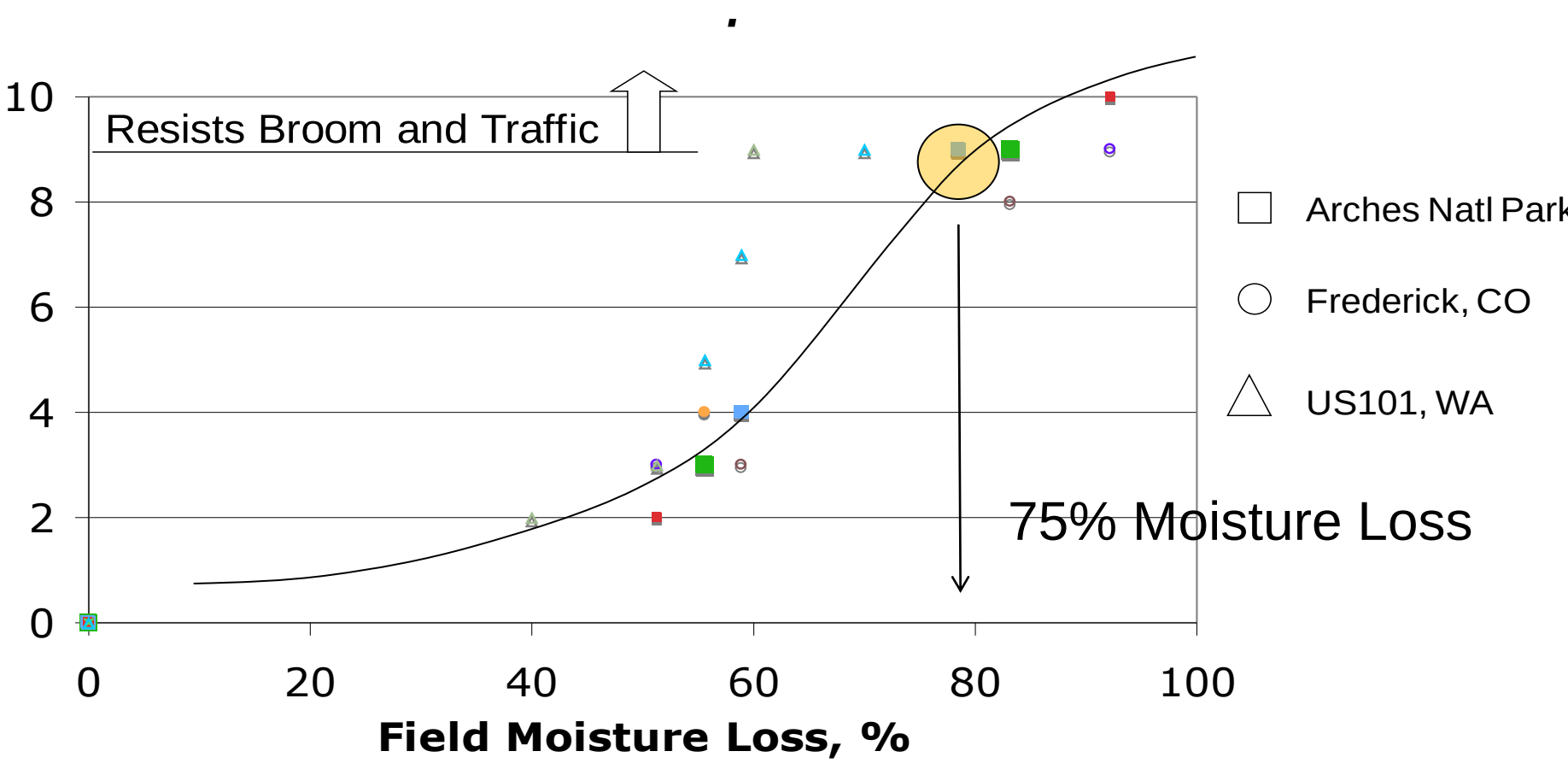
So the Lab Test Seems to Work,

Does This Relate to the Field?


Arches, NP
Brigham City
Elkol
Granger
Green River
Creston
Arlington
Bosler
Laramie
Saratoga
Centennial
Federal
Cheyenne
Ogden
Evanston
Mountain View
Point
Morgan
Wyoming
Wyoming
Wyoming
Baggs
Layton
Salt Lake City
Utah
Manila
Colorado
Slater
Colorado
Harriman
Jordan
Kamas
Ashley Natl. For.
Hahns Peak
Red Feather Lakes
Fort Collin
Maybell
Craig
Steamboat Springs
Greeley
Cottonwood Heights
Neola
Vernal
Tooele
Provo
Altamont
Dinosaur
Hamilton
Rand
Loveland
Wiggins
Santaquin
Roosevelt
Rangely
Meeker
Toponas
Granby
Ward
Boulder
Myton
Spanish Fork
Ouray
Parshall
Broomfield
Denver
Utah
Colorado
Rifle
Glenwood Springs
Evergreen
El Jebel
Littleton
Carbondale
Grant
Castle Dale
Mesa
Aspen
Leadville
Castle Rock
Fillmore
Ferron
Green River
Grand Junction
Woodland Park
Larkspur
Richfield
Fremont Junction
Cisco
Whitewater
Cedaredge
Buena Vista
Paonia
Cripple Creek
Fountain
Moab
Gateway
Montrose
Gunnison
Salida
Cañon City
Loa
Hanksville
Paradox
Uravan
Colona
Parlin
Howard
Florence
Bicknell
La Sal Junction
Saguache
Junction
Ouray
Westcliffe
Monticello
Telluride
Creede
Moffat
Colorado City
Escalante
Dunton
Fry Canyon
Blanding
Monte Vista
Walsenburg
Long Valley Junction
Pleasant View
Lewis
Rockwood
Alamosa
Cortez
La Veta
Bluff
Aneth
Durango
Pagosa Springs
San Luis
Mexican Hat
Breen
Conejos
Trinidad
Big Water
Utah
Red Mesa
Cedar Hill
Dulce
Chama
Vigil
Page
Arizona
Farmington
Jaroso
Raton
Kayenta
Turley
Tierra Amarilla
Red River
Jacob Lake
Kaibito
Rock Point
Tres Piedras
Maxwell
Capulin
Cow Springs
Many Farms
Taos
Cimarron
Newcomb
Ojo Caliente

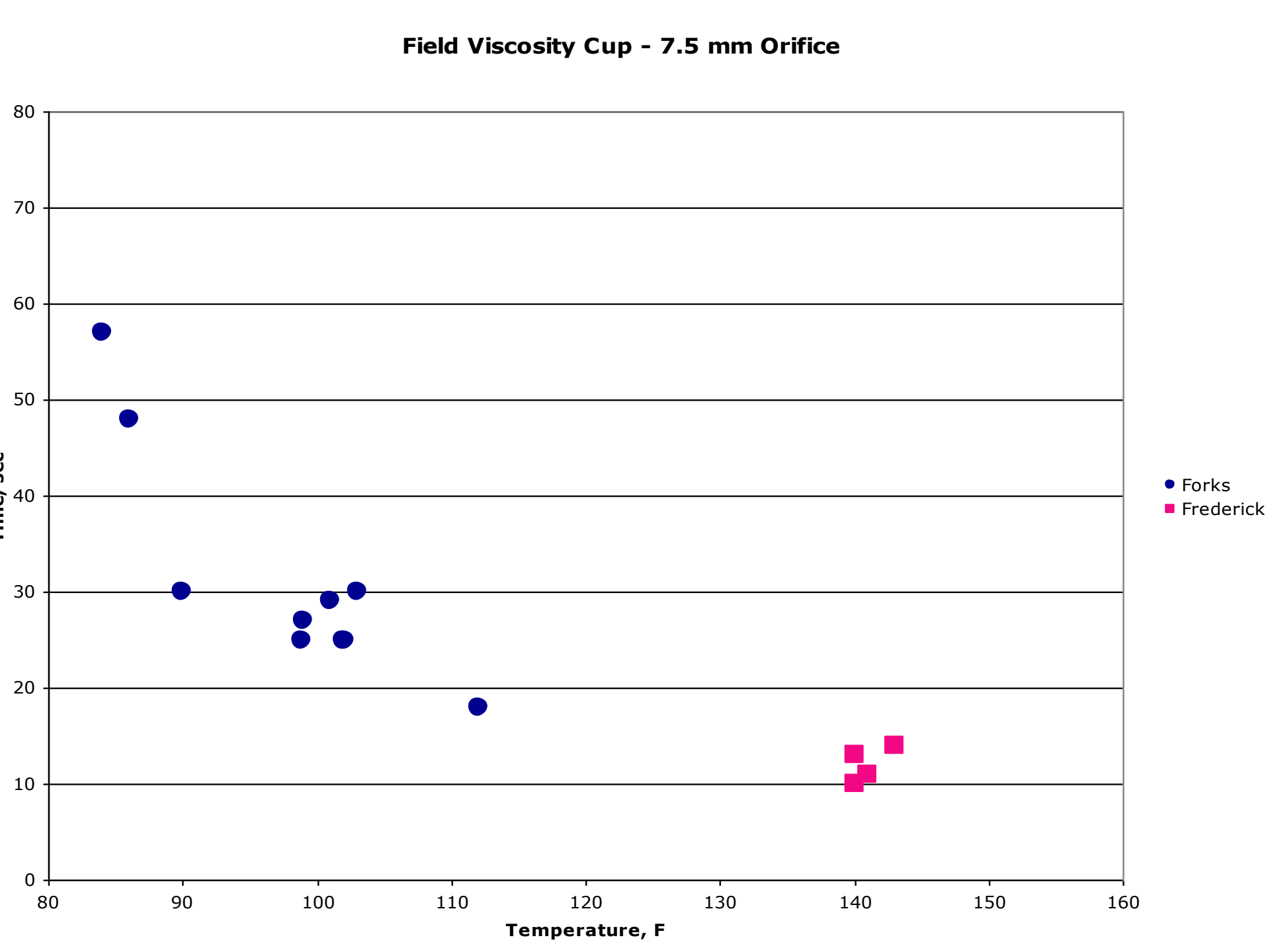

Frederick, CO
Ute Hwy
Hygiene
Longmont
Main St
66
7
66
30
85
24
19
25
13
Firestone
119
287
1
Boulder
Weld
Niwot
Mineral Rd
52
14
52
38
Fort Lupton
52
52
N Foothills Hwy
157
Erie
85
Wattenberg
37
76
Boulder
Arapahoe Rd
Lochbuie
93
42
Lafayette
7
Weld
Adams
Brighton
Louisville
E470
Superior
Eldorado Springs
Broomfield
Eastlake
Henderson
Plainview
Northglenn
Thornton
2
Denver
Int'l
Airport
Westminster
Dupont
Pena Blvd
36
270
Commerce City
Arvada
Montbello
Adams
Denver
Wheat Ridge
Golden
Applewood
Edgewater
Denver
Aurora
Watkins
36
70
70
Lakewood
Glendale


Forks, WA
Bamfield
Lake Cowichan
North Cowichan
Ferndale
Bellingham
Marietta
Geneva
North Saanich
Sidney
Waldron
Blanchard
Wickersham
Port Renfrew
Mill Bay
Central Saanich
Orcas
Anacortes
Sedro Woolley
Victoria
Lopez
River Jordan
Colwood
Sooke
Mount Vernon
Metchosin
Oak Harbor
McMurray
Oso
Clallam Bay
San De Fuca
Coupeville
Arlington
Joyce
Port Angeles
Port Townsend
Smokey Point
Sappho
Sequim
Port Hadlock
Everett
Forks
Port Ludlow
Mukilteo
Snohomish
Quilcene
Hansville
Gold
Edmonds
Monroe
Olympic Natl. Park
Mountlake Terrace
Brinnon
Shoreline
Seattle
Kalaloch
Bremerton
Queets
North E
Amanda Park
Quinault
Lilliwaup
Eldon
Belfair
Burien
Renton
Cedar F
Tahuya
Seatac
Kent
Taholah
Neilton
Grisdale
Gig Harbor
Black Diamond
Tacoma
Moclips
Humptulips
Matlock
University Place
Shelton
Parkland
Puyallup
Copalis Beach
Carlisle
McCleary
Olympia
Elk Plain
Carbonado
Ocean Shores
Hoquiam
Montesano
Roy
Lacey
Tumwater
Westport
Cosmopolis
Yelm
Eatonville
Markham
Littlerock
Grayland
Brooklyn
Oakville
La Grande
Centralia
Bay Center
South Bend
Chehalis
Cinebar
Pe Ell
Morton


Resists Broom and Traffic
10
8
6
4
2
0
0
20
40
60
80
100
Field Moisture Loss, %
75% Moisture Loss
Arches Natl Park
Frederick, CO
US101, WA

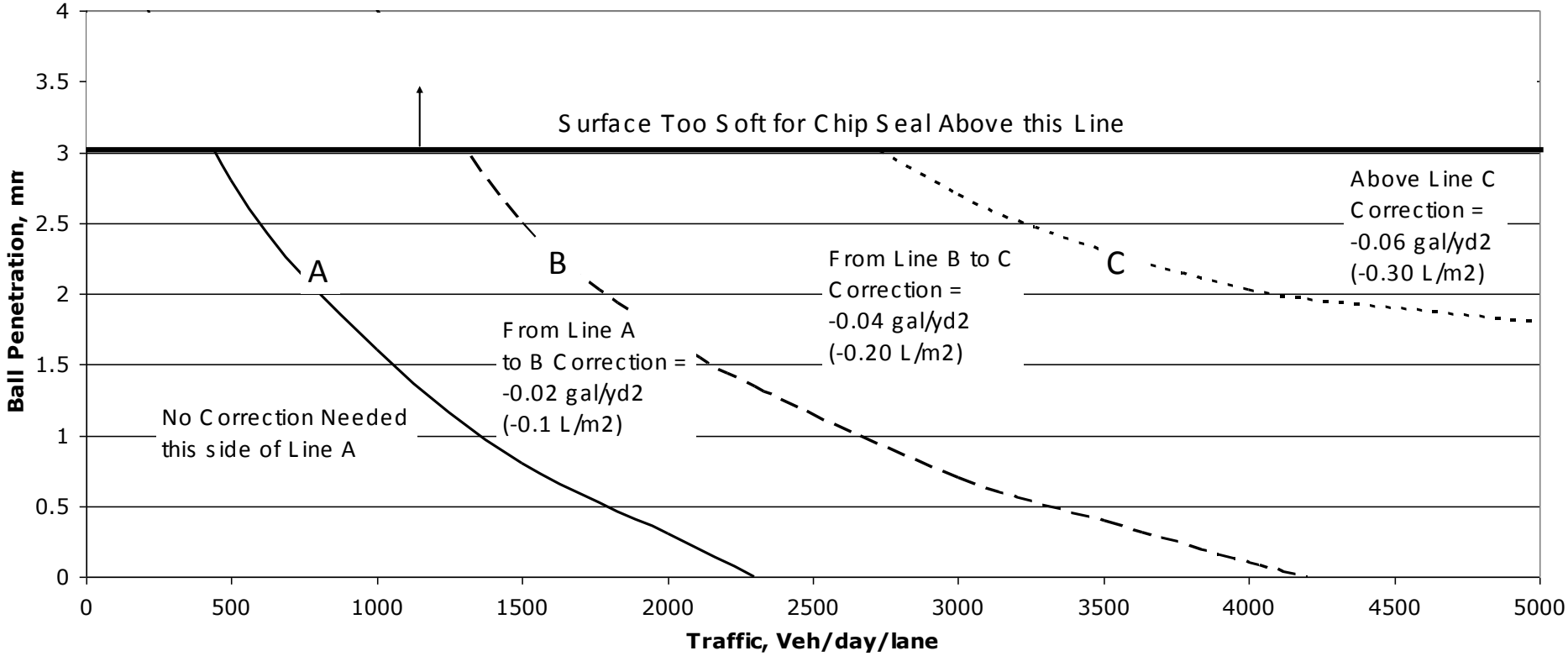
# Is the Emulsion What You Bought?

20 to 70 seconds at 85 to 150F for a 6 mm orifice or
10 to 60 seconds at 85 to 140F for a 7.5 mm orifice


Field Viscosity Cup - 7.5 mm Orifice
80
70
60
50
40
30
20
10
0
80
90
100
110
120
130
140
150
160
Temperature, F
Forks
Frederick

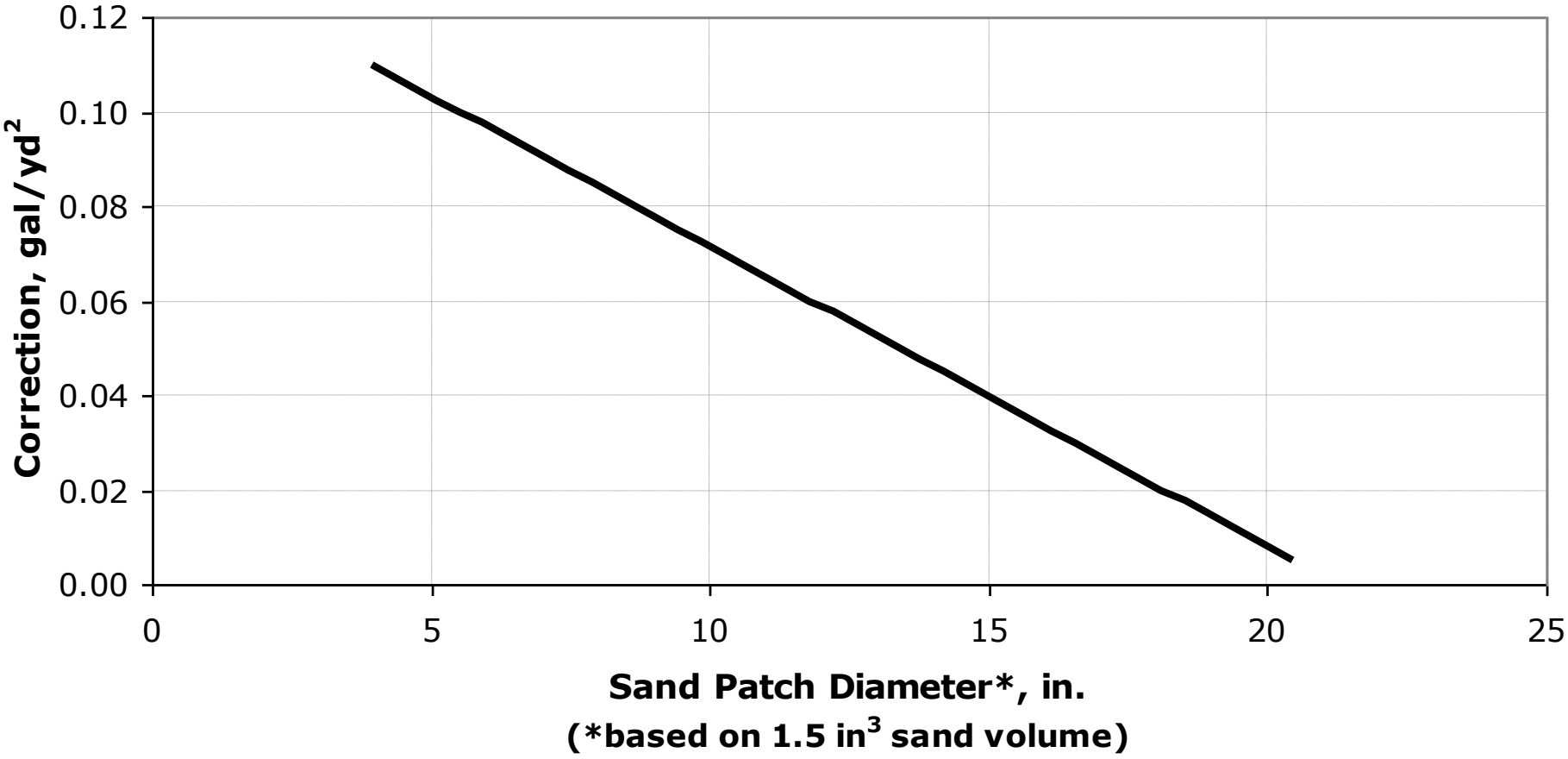
# Will Chips Disappear Into Substrate?


TITAN
STAINLESS
HARDENED

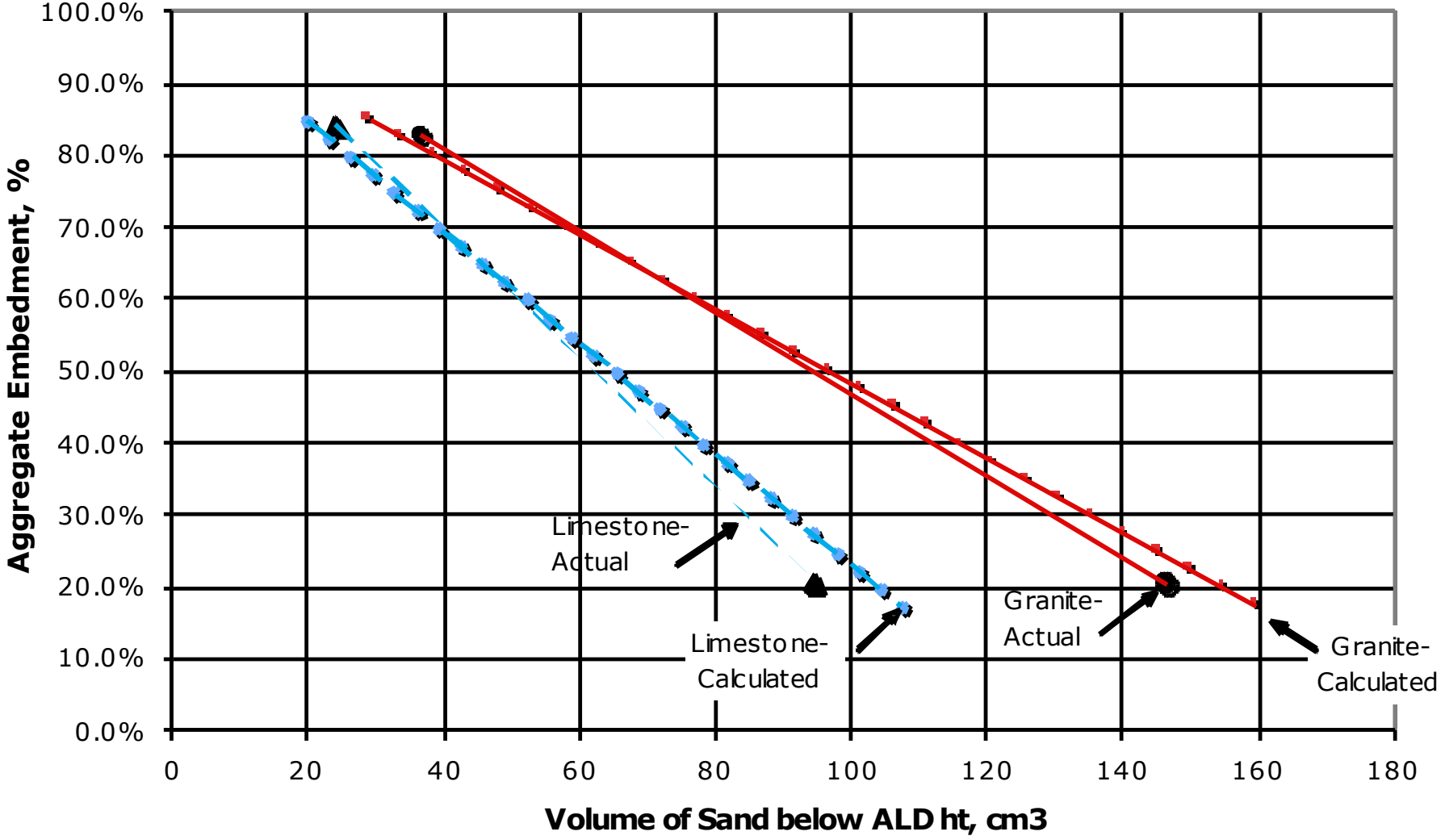

Surface Too Soft for Chip Seal Above this Line
A
B
C
No Correction Needed
this side of Line A
From Line A
to B Correction =
-0.02 gal/yd2
(-0.1 L/m2)
From Line B to C
Correction =
-0.04 gal/yd2
(-0.20 L/m2)
Above Line C
Correction =
-0.06 gal/yd2
(-0.30 L/m2)
Ball Penetration, mm
Traffic, Veh/day/lane
0
0.5
1
1.5
2
2.5
3
3.5
4
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

# Will Pavement Texture Swallow Emulsion?

## Surface Texture Correction
## U. S. Customary Units



# How Much are the Chips Embedded ?


100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Aggregate Embedment, %
0
20
40
60
80
100
120
140
160
180
Volume of Sand below ALD ht, cm3
Limestone-Actual
Limestone-Calculated
Granite-Actual
Granite-Calculated

# Conclusions

- The amount of water remaining in the chip seal (emulsion, chips, substrate) seems to have an effect on chip retention.

# Conclusions

- The Modified Sweep Test may provide a means to Determine What Moisture Content is Appropriate Before Opening To Traffic/Sweeping.

# Conclusions

- Significantly higher chip loss was measured for test specimens fabricated with dry aggregates compared with saturated surface dry aggregates.

# Conclusions

- Simple, Practical, Quantitative Methods are Recommended for:
    * Estimating When ‘Traffic/Broom Ready’
    * Embedment Depth
    * Surface ‘Softness’
    * Emulsion Viscosity
    * Surface Texture


Thank You !