

# BRIDGE PRESERVATION

A photograph of a multi-arched concrete bridge over a river. The bridge has several large, rounded arches. The water is dark and reflects the sky. In the background, there are bare trees and a clear blue sky. The overall scene is a natural setting with a man-made structure.

**Silane Penetrating Sealers  
the first Defense in Bridge  
Protection**



# WATER IS THE ENEMY!

**Salts dissolve in Water  
causing rebar corrosion**

**Water freezing in concrete  
causes Freeze/Thaw damage**

SPALLING



SCALING



CRACKING



# ALKALI SILICA REACTION (ASR)





REBAR CORROSION





# ALKYLTRIALKOXYSILANE

Organo-functional reactive chemical

**Isobutyl**

Tri-methoxy

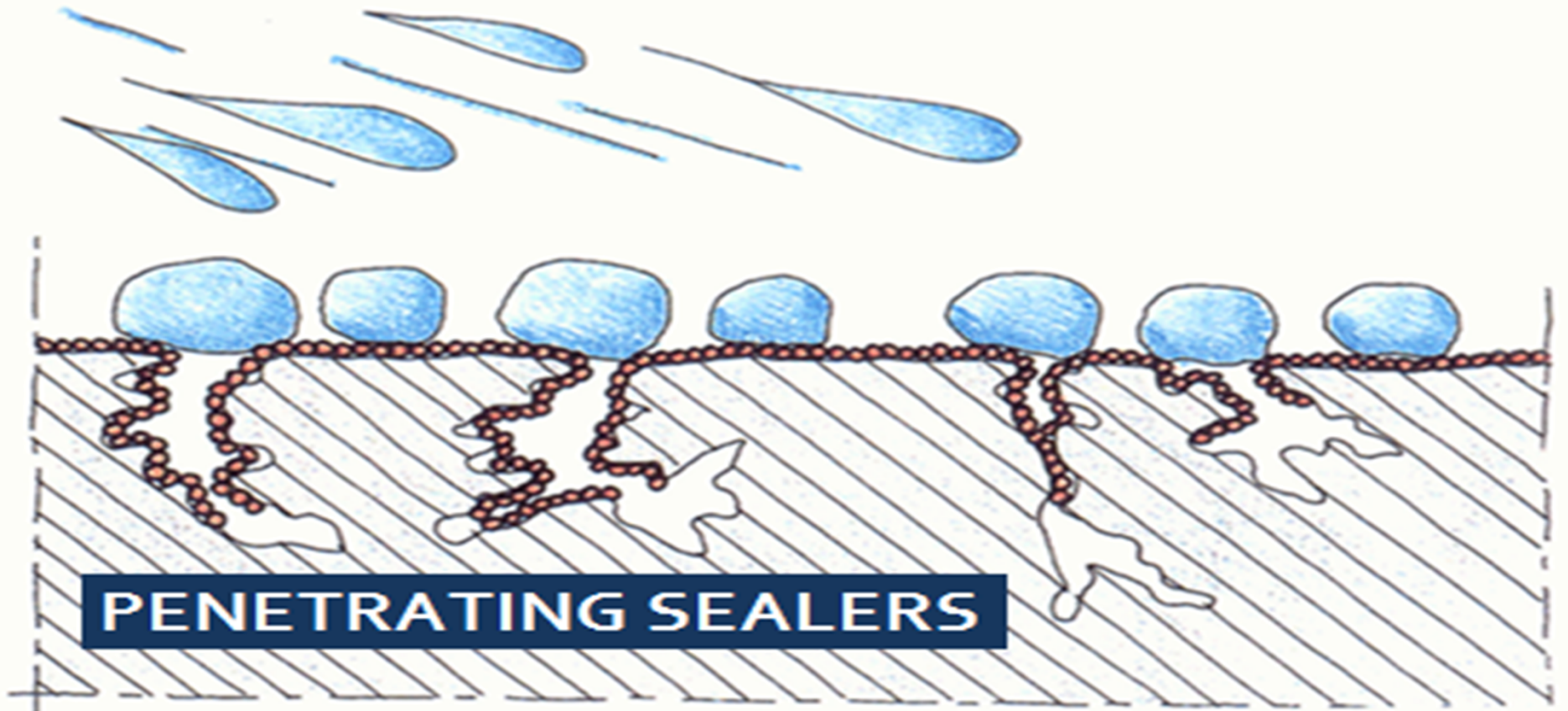
Tri-ethoxy

**Noctyl**

Tri-methoxy

Tri-ethoxyl

# SILANES MAKE CONCRETE HYDROPHOBIC

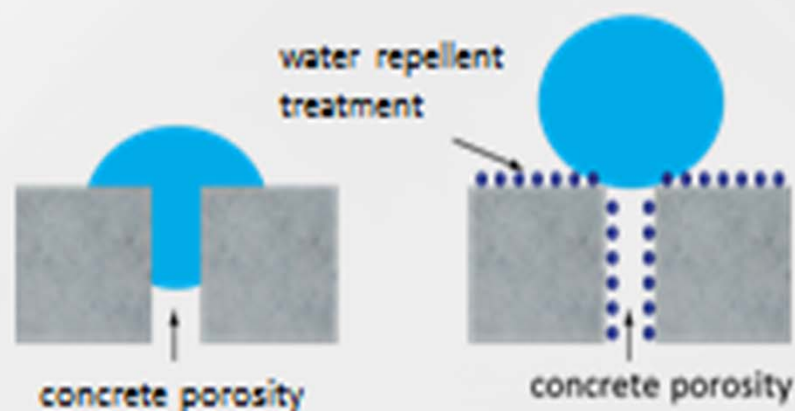


NATIONAL BRIDGE PRESERVATION PARTNERSHIP CONFERENCE 2014

PROTECTING THE BRIDGE TO SUSTAINABLE TRANSPORTATION

# From Hydrophilic to Hydrophobic

Water repellents penetrate the surface pores and cracks, so that they are internally lined but not filled.



Reduction of concrete surface tension:  
inter-molecular attraction of water molecules is much higher than the attraction of water into concrete

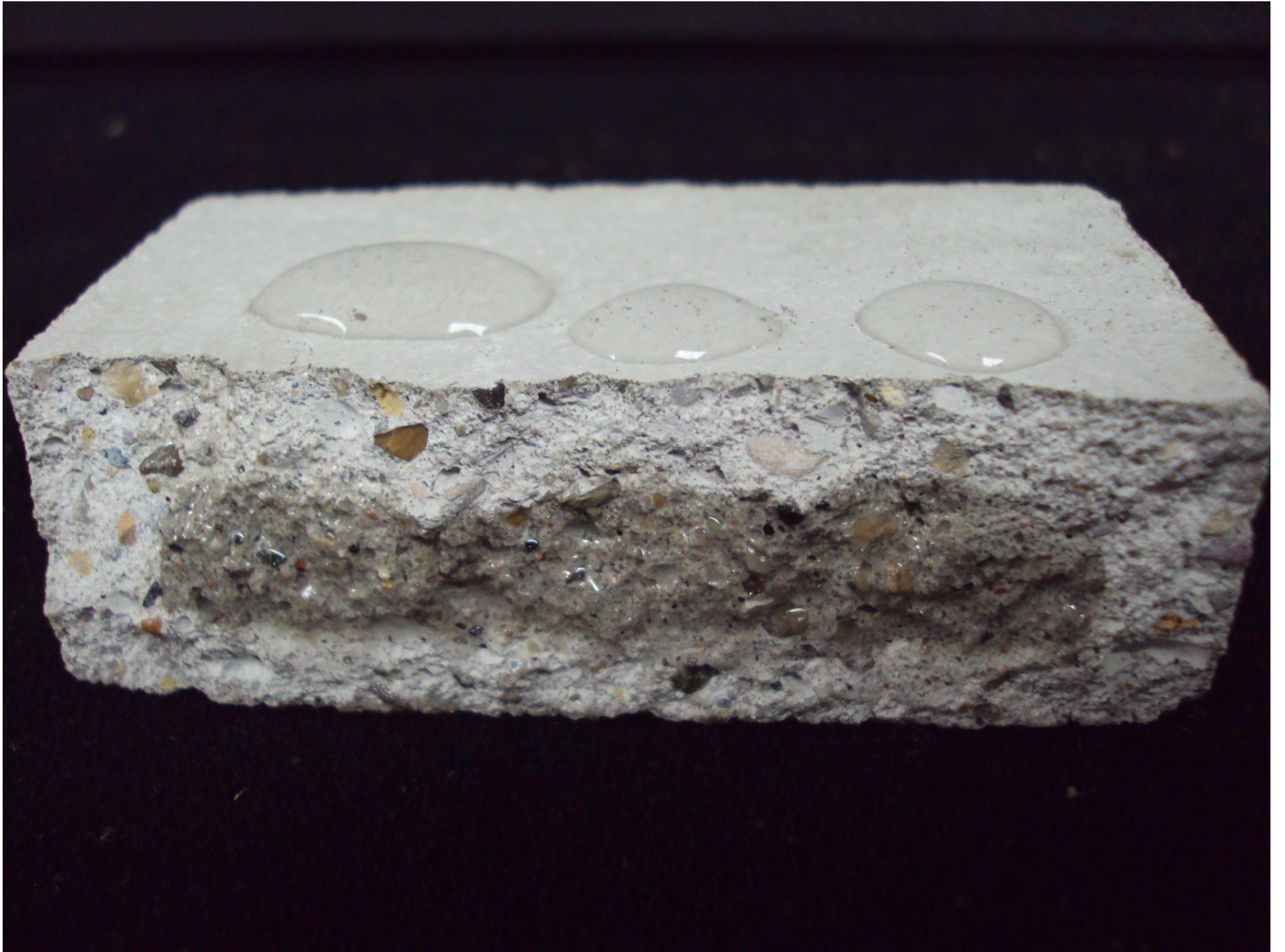
From hydrophilic (water-loving) to hydrophobic (water-hating) surface



NATIONAL BRIDGE PRESERVATION PARTNERSHIP CONFERENCE 2014

Preservation: The Bridge to Sustainable Transportation





# SILANES DOT TESTED FOR OVER 30 YEARS

<b>Oklahoma DOT</b>	<b>1986</b>
<b>Texas DOT</b>	<b>1995</b>
<b>Indiana DOT</b>	<b>1992</b>
<b>Kansas DOT</b>	<b>1998</b>
<b>Iowa DOT</b>	<b>1999</b>
<b>Wisconsin DOT</b>	<b>2005</b>
<b>Missouri DOT</b>	<b>2007</b>
<b>Illinois DOT</b>	<b>2009</b>

# CONTINUING UNIVERSITY STUDIES

**Purdue University**

**Oklahoma State University**

**Michigan Tech**

**University of Leeds, UK**

**University of Delft, Netherlands**

# WJE CORROSION PROTECTION TESTS

**1985 48 Week Salt Ponding test was performed  
40% Silane applied at 125 sq ft per gallon**

**Ingress of Chloride Ions was reduced by 97-98%  
Hydrophobic Concrete**

**Internal Electrical Resistance increased 2-3 times  
Water Vapor Transmission**

**Zero Re-bar corrosion over the 48 week test!**



# PERFORMANCE TESTED

## Test

## Performance

ASTM C-672

Freeze Thaw Scaling

0 @ 50 cycles

ASTM C-642

Moisture Absorption

90% reduction

AASHTO T-259/T260

Chloride Penetration

90% reduction

NCHRP 244 series II

Absorption & Chloride Ion  
penetration

85% reduction

Moisture vapor permeability 100%

NCHRP 244 series IV

Accelerated Weathering

95% reduction

## Treated Block

- 100% Silane
- 250sq ft. per gallon
- 3 hour time lapse
- **Zero water absorption.**

## Untreated Block

- 3 hour time lapse
- **5 mL of water absorbed.**

**OVERALL RESULT**  
**91% reduction in water**  
**absorption.**





# Determining the Effective Service Life of Silane Treatments in Concrete Bridge Decks



Mehdi Khanzadeh Moradillo, Bryan Sudbrink, M. Tyler Ley  
Department of Civil and Environmental Engineering, Oklahoma State University

## ABSTRACT

Silane is a commonly used surface treatment to reduce water entry into concrete. Current ODOT specifications require 3.2 mm of silane on all in service bridge decks. Only limited work has been done to show the effective lifespan of silane sealers. This work uses 360 cores taken from 60 Oklahoma bridge decks treated with silane that have been in-service between 6 and 20 years. Optical staining techniques were used to image silane depth. These findings will be helpful to practitioners to determine the long-term performance of silane coatings.

## SAMPLE ACQUISITION

Cores that were approximately 18 mm in diameter by 25 mm in height were taken from the driving lane and shoulder of 60 bridge decks. Six cores were taken from each bridge for a total of 360 cores. This technique allowed two researchers to sample each bridge in about 1 h. Since the cores were small, this minimized damage and patching to the bridges.

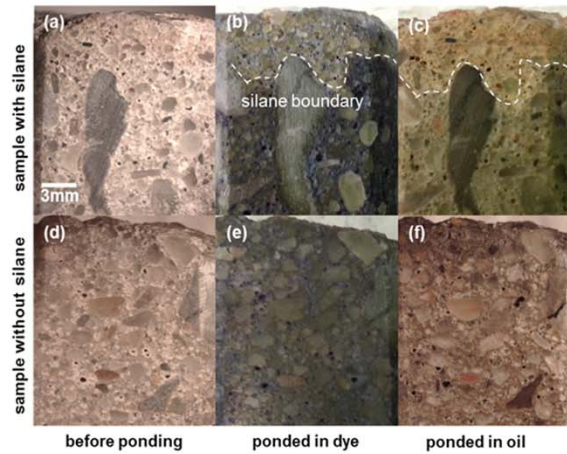


Example of cores were taken from bridge decks

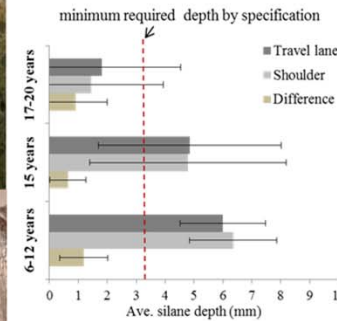
## SAMPLE TESTING

- > A cross section of each core was exposed by polishing with 120 grit sandpaper for 5 minutes.
- > Each sample was inspected with two techniques to determine the presence of the silane.
- > First, the core is ponded in blue dye for 30 minutes. The dye stains the concrete that is not treated with the silane.
- > Next, the depth of the silane was measured at six different points by using a caliper and an optical microscope and an average was reported for each core.
- > Next, the core was polished to remove the dye from the exposed surface and then ponded in mineral based cutting oil for 60 seconds. The oil will wet the surface of the concrete that does not contain the silane sealer.
- > The depth is then measured as described previously with the optical microscope and calipers.
- > These depths are compared to 3.2 mm as this is the minimum depth required at construction.

## TESTING PROCEDURE



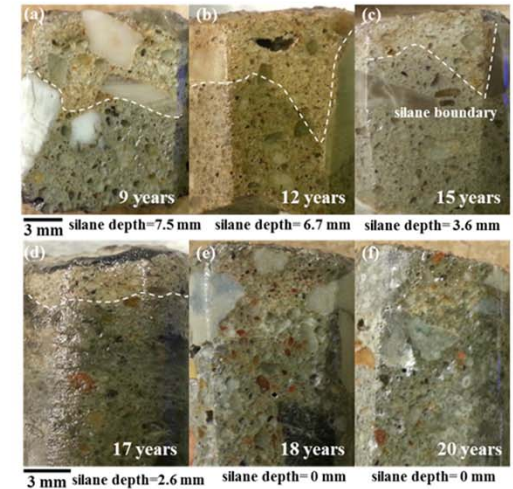
## COMPARISON



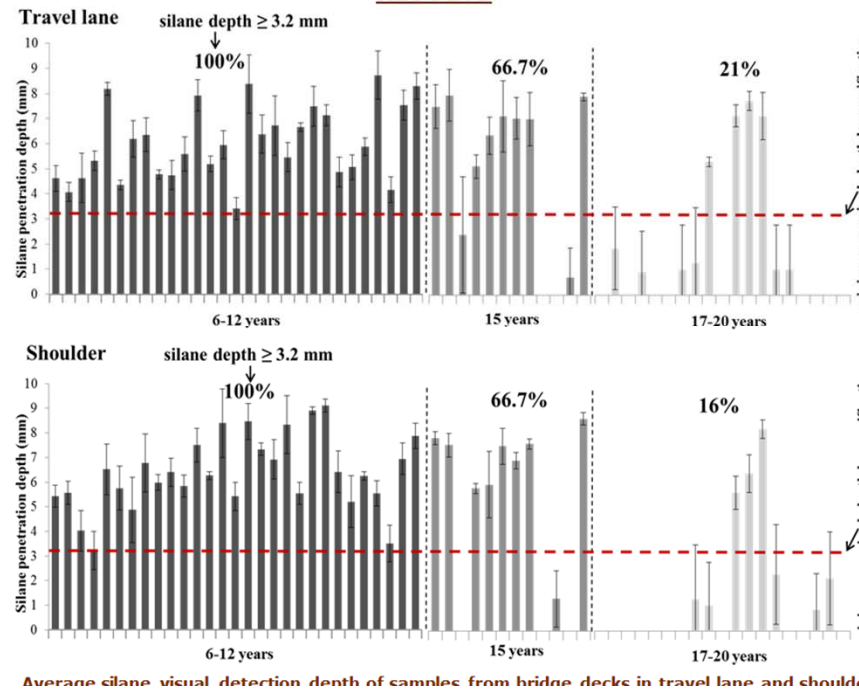
Summary from all bridge decks

## DETERIORATION MECHANISM

The silane deterioration seems to move from the bulk of the concrete towards the surface. One possible cause for the deterioration could be the attack of the silane by the alkaline pore solution of concrete.



## RESULTS



## DISCUSSION AND CONCLUSIONS

- > After 12 years of service, 100% of the bridge decks were found to have a silane layer greater than the minimum specified value of 3.2 mm
- > After 15 years of service, only 68% and after 17 to 20 years only 16% of the bridges showed evidence of a silane layer greater than 3.2 mm in thickness
- > The average depth of silane is decreasing with time.
- > For bridges with 17 to 20 years of service, the average layer thickness reduced by 75%.
- > Removal of the silane by abrasion was minimal over the first 20 years of service for the investigated bridges
- > The deterioration by the alkaline pore solution appears to be a more important silane deterioration mechanism for these materials and exposure level

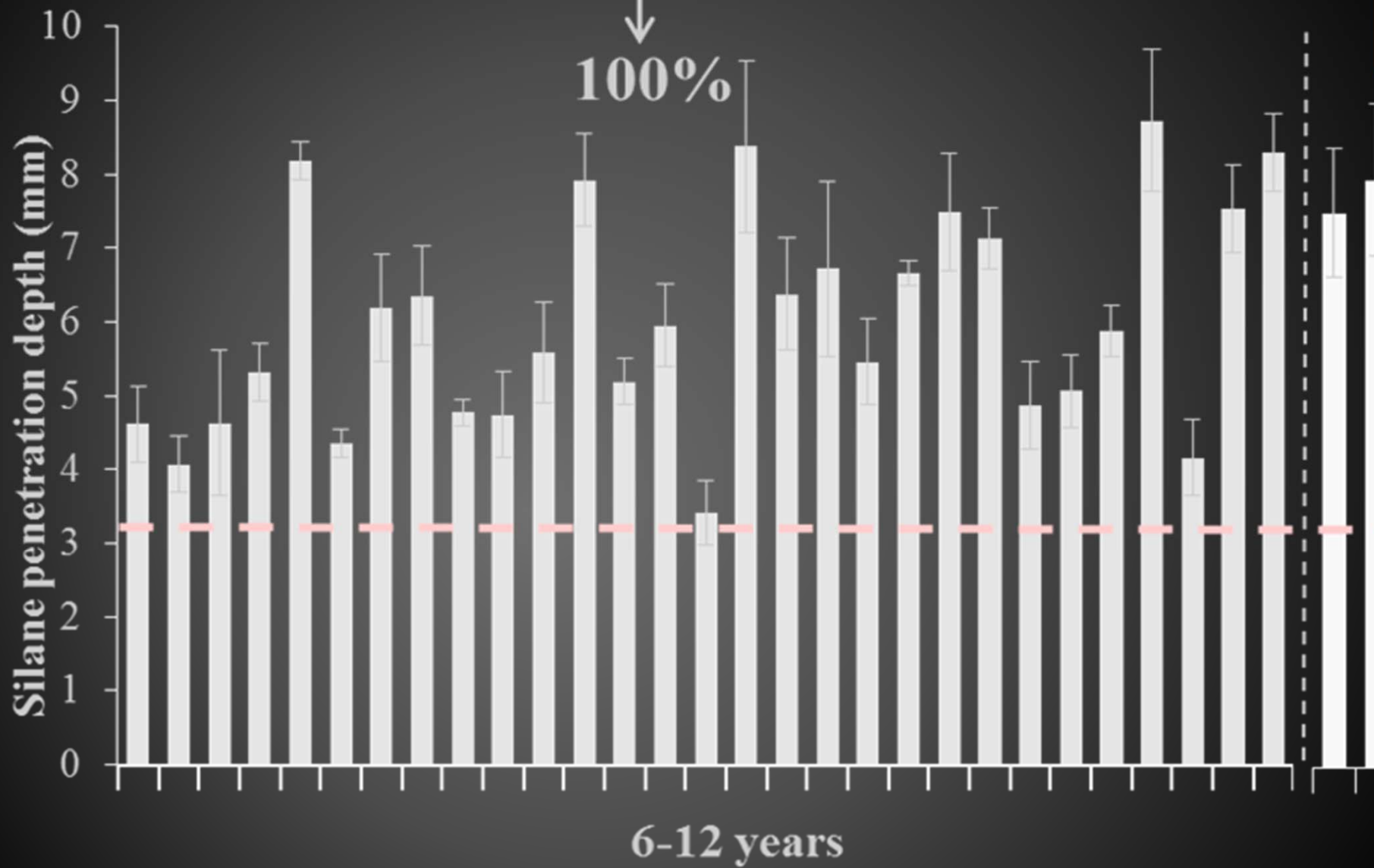
## ACKNOWLEDGEMENT

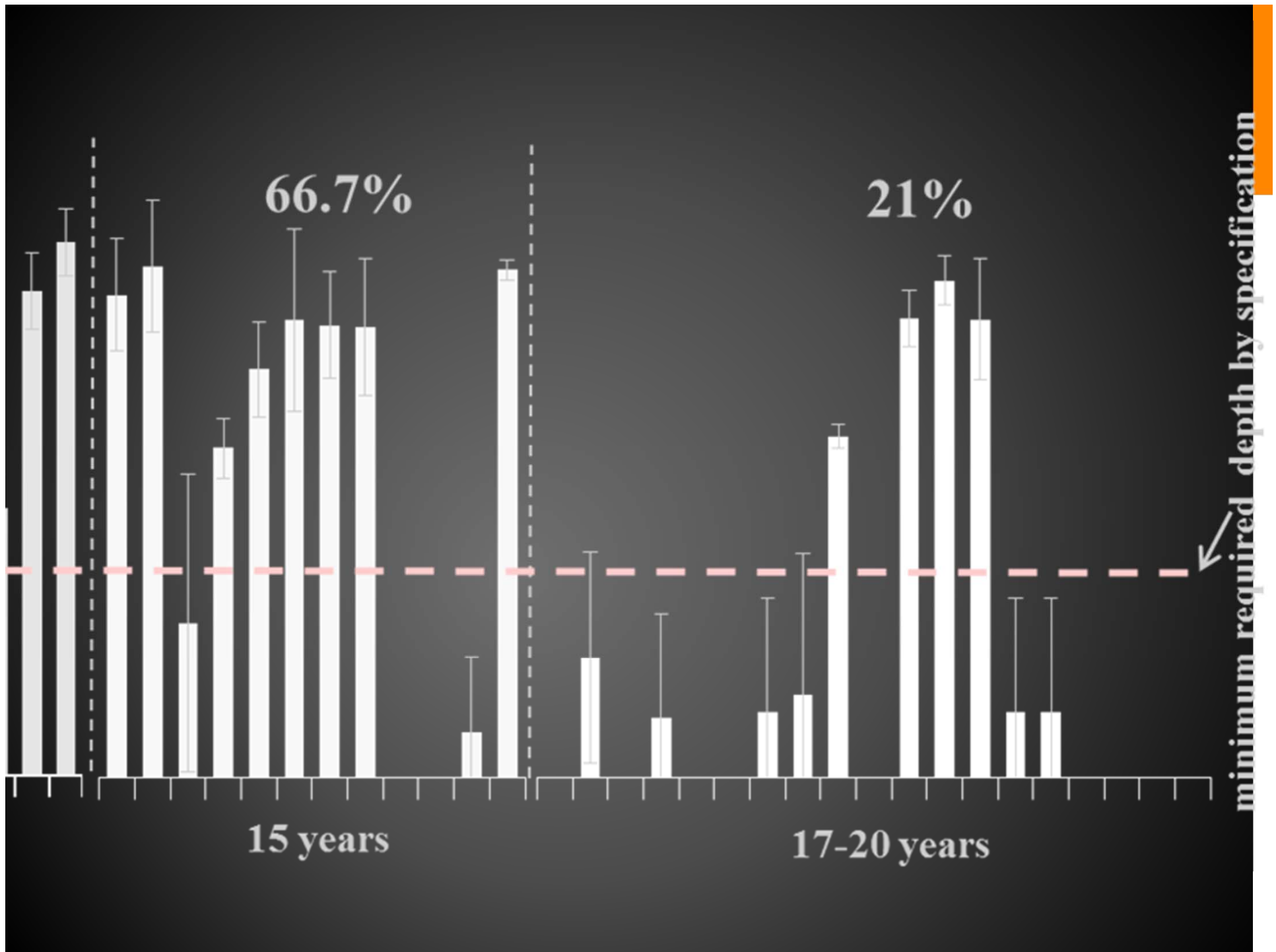
The authors gratefully acknowledge the financial support from the Oklahoma Department of Transportation (ODOT). The authors would like to thank Mr. Jake Leflore, Mr. Colin Fleishacker, Mr. Chad Stevenson, and Mr. Jeffery Terronez for their assistance with conducting of the field experiments.

**Travel lane**

**silane depth  $\geq 3.2$  mm**

**100%**





# SURFACE PREPARATION

Sweeping

Power washing

Shot blasting









# APPLICATION

- Hand Spray
- Walk behind spray bar
- Truck or trailer mounted spray bar











# WRITING SPECIFICATIONS

**Be consistent - application rates per % of Silane**

**20% @ 60 sq. ft. per gallon**

**40% @ 125 sq. ft. per gallon**

**100% @ 300 sq. ft. per gallon**

**Get what you pay for - Measure gallons used per bridge**

**Weather matters - 24-48 hours after a rain event**

# COSTS OF SILANES

## **20% Silanes**

**Apply at 60 square feet per gallon**

**11.61 grams of Silane per square foot**

**\$15.00 per gallon**

**\$0.25 per square foot**

**Retreat every 6-10 years**

# COSTS OF SILANES

**40% Silanes**

**Apply at 125 square feet per gallon**

**11.14 grams of Silane per square foot**

**\$20.00 per gallon**

**\$0.16 per square foot**

**Retreat every 6-10 years**



# COST OF SILANES

**100% Silanes**

**Apply at 300 square feet per gallon**

**11.61 grams of Silane per square foot**

**\$35.00 per gallon**

**\$0.12 per square foot**

**Retreat every 6-10 years**

# DO THE MATH

**150 ft. X 38 ft. Bridge**

**5,700 square feet @ \$140.00 per square foot**

**\$800,000.00**

**5,700 square feet treated with Silane at 125 square feet per gallon**

**Requires 45.6 gallons of a 40% Silane**

**45.6 gallons of Silane at \$20.00**

**\$912.00 to protect an \$800,000.00 Investment!**

# WHY SILANES

**Silanes Work**

**Silanes are easy to apply**

**Silanes are very cost effective**

**Silanes last for years**

**Silanes don't change skid resistance**

**Silanes dry fast 30 minutes to 2hours**

# CONCLUSION

**Silanes are a tested, studied and proven bridge protective treatment**

**Its never too late to start a Silane program**

**Silanes are cost effective**

**Silanes are easy for local crews to apply**

**Silanes have an extensive life span 6-12 years**

# SOLVENT VS WATER

## SOLVENT BASED SILANES

**Fast dry times**

**Re-coatable**

**VOC compliant**

**Deeper Penetration**

## WATER BASED SILANES

**Lower VOC**

**Slower dry times**

**Use solvent  
based to recoat**

**QUESTIONS?**

**Thank you**

**Tim Woolery**  
**Advanced Chemical Technologies**