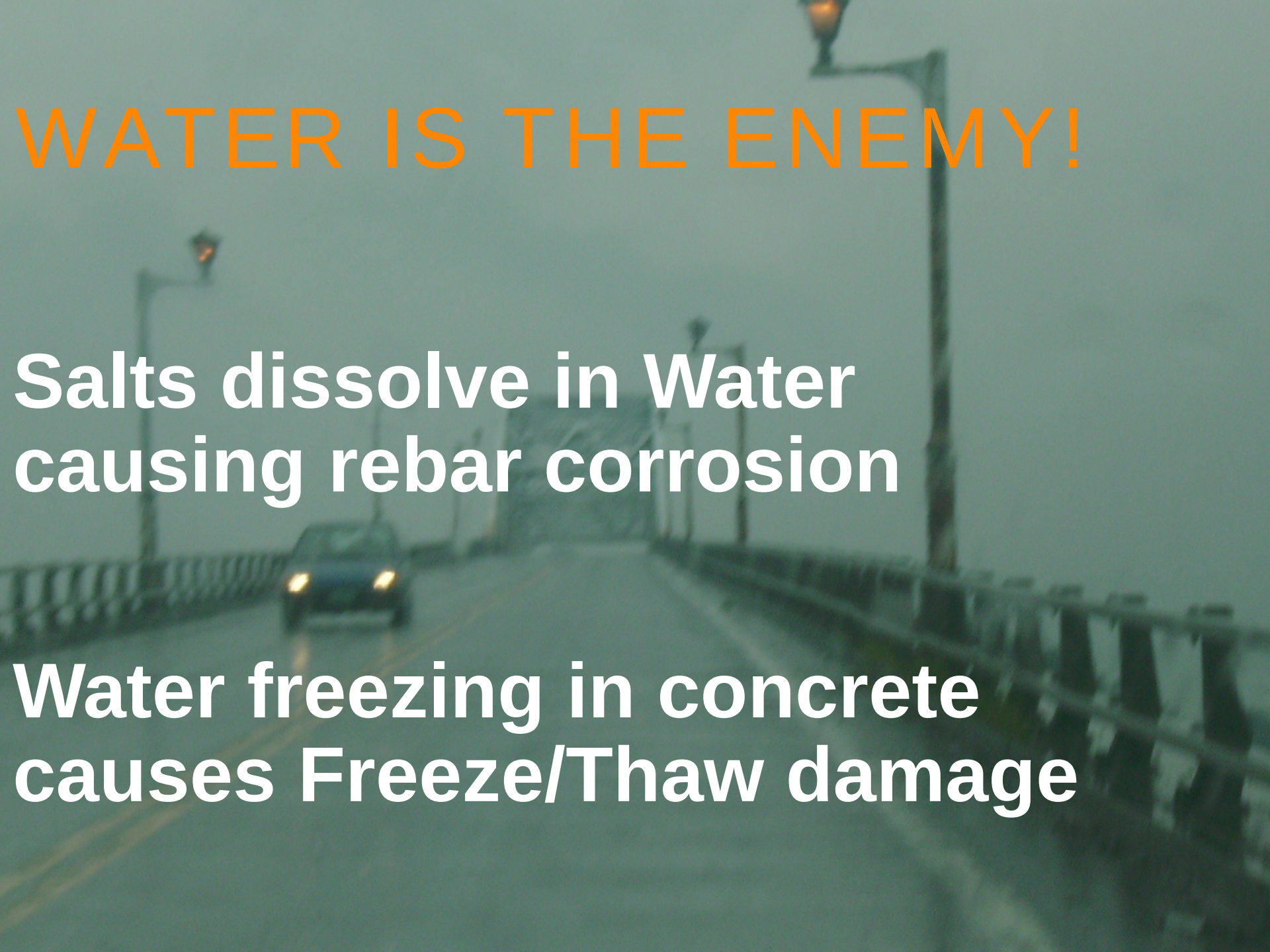
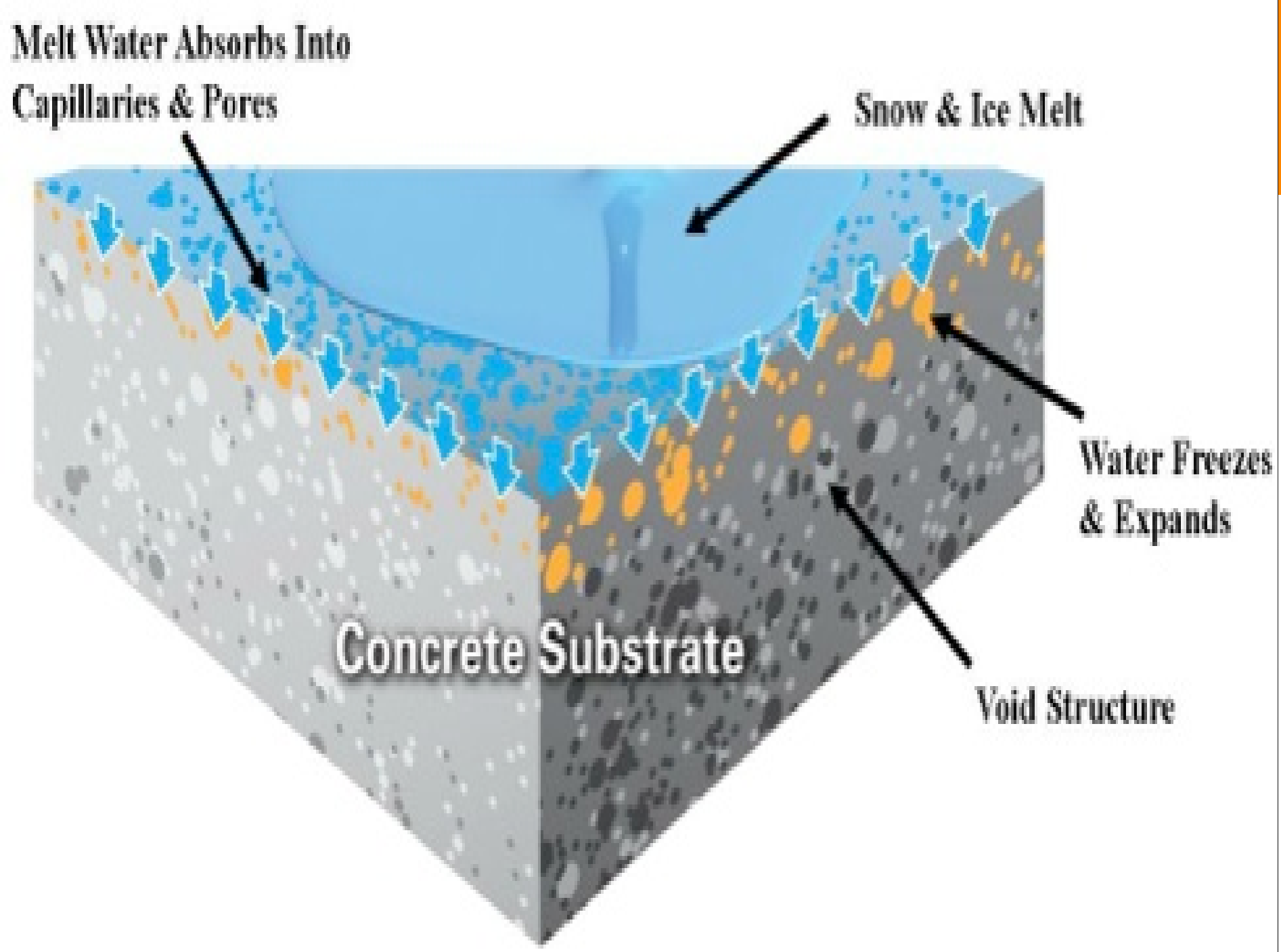

BRIDGE
PRESERVATION
Silane Penetrating Sealers the first Defense in Bridge Protection



# WATER IS THE ENEMY!

**Salts dissolve in Water causing rebar corrosion**

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


Melt Water Absorbs Into
Capillaries & Pores
Snow & Ice Melt
Water Freezes
& Expands
Concrete Substrate
Void Structure


SPALLING

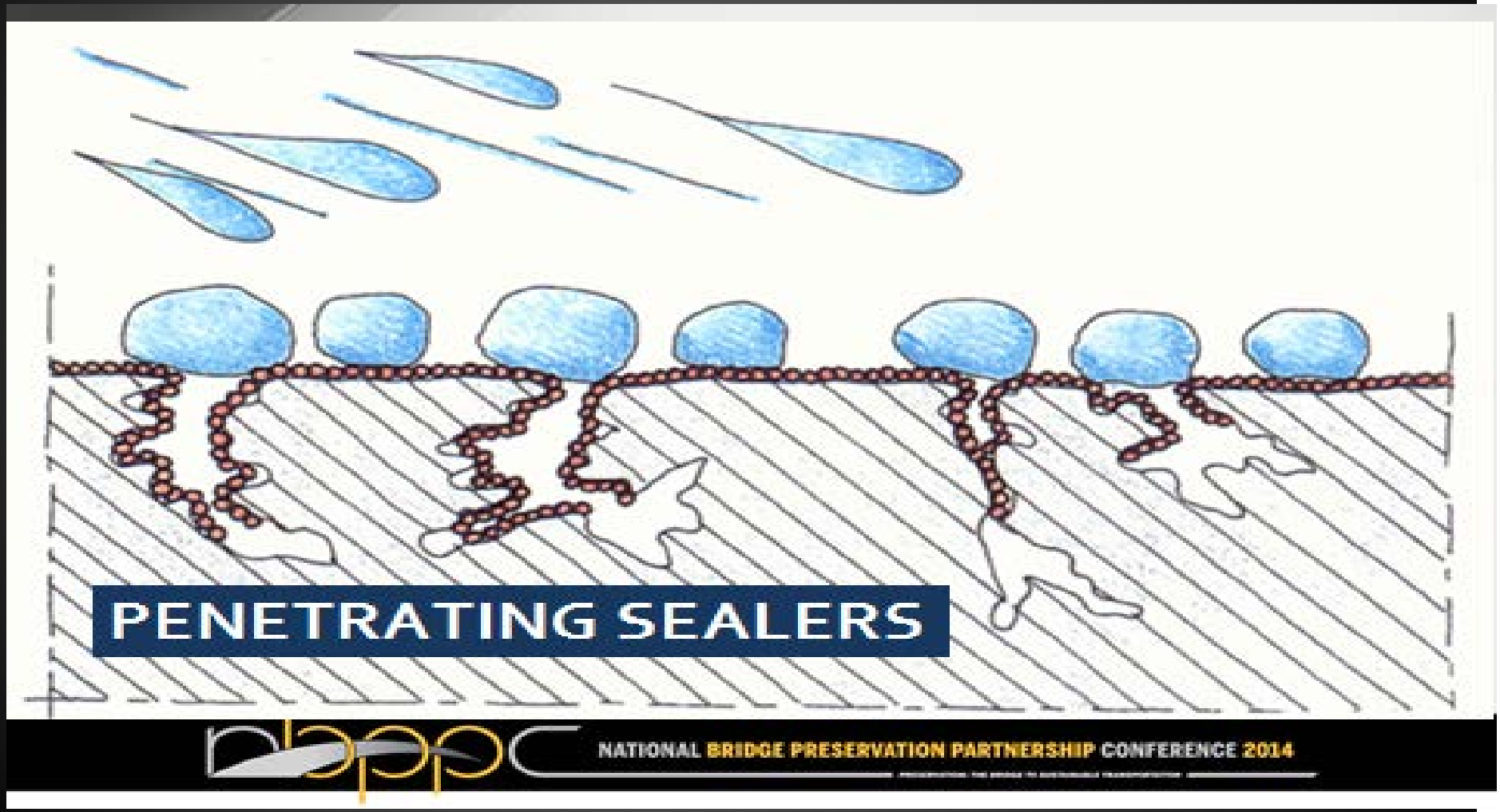

SCALING


REBAR CORROSION


CRACKING

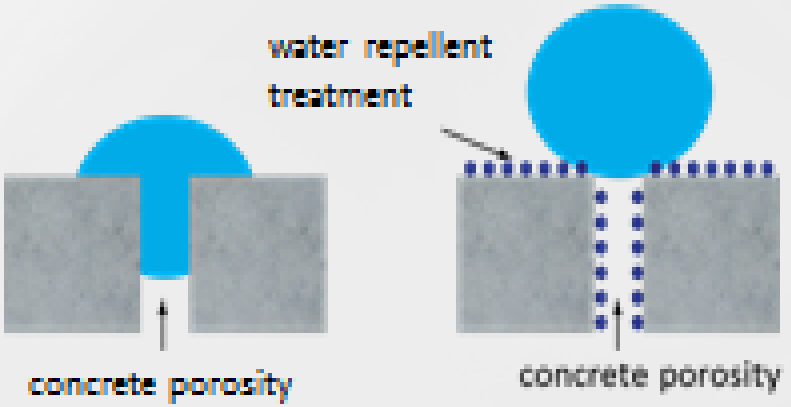
# ALKALI SILICA REACTION (ASR)

# SILANES MAKE CONCRETE HYDROPHOBIC



# From Hydrophilic to Hydrophobic

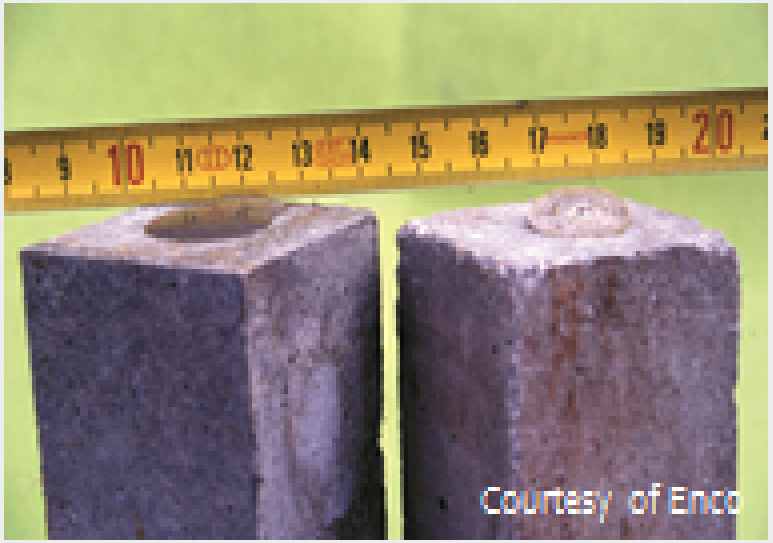
Water repellents penetrate the surface pores and cracks, so that they are internally lined but not filled.




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



# SILANES DOT TESTED FOR OVER 25 YEARS

| | |
|---|---|
| **Oklahoma DOT** | **1986** |
| **Texas DOT** | **1995** |
| **Indiana DOT** | **1992** |
| **Kansas DOT** | **1998** |
| **Iowa DOT** | **1999** |
| **Wisconsin DOT** | **2005** |
| **Missouri DOT** | **2007** |
| **Illinois DOT** | **2009** |

# CONTINUING UNIVERSITY STUDIES

**Purdue University**

**Oklahoma State University**

**Michigan Tech**

**University of Leeds, UK**

**University of Delft, Netherlands**

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

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## 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

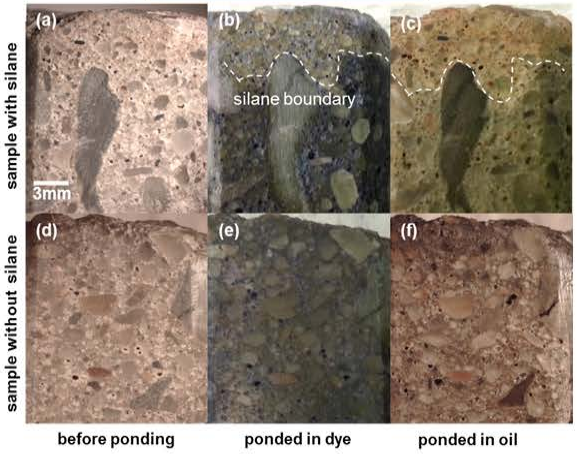
Cores that were approximately 18 mm in diameter by 25 mm in height were taken from the driving lane and shoulder of 60 bridge decks. Six cores were taken from each bridge for a total of 360 cores. This technique allowed two researchers to sample each bridge in about 1 h. Since the cores were small, this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


Example of cores were taken from bridge decks

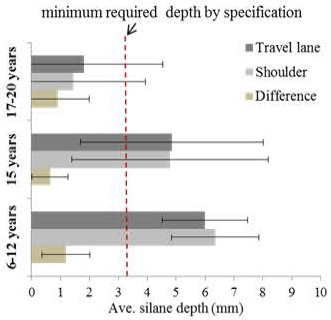
## SAMPLE TESTING

- 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

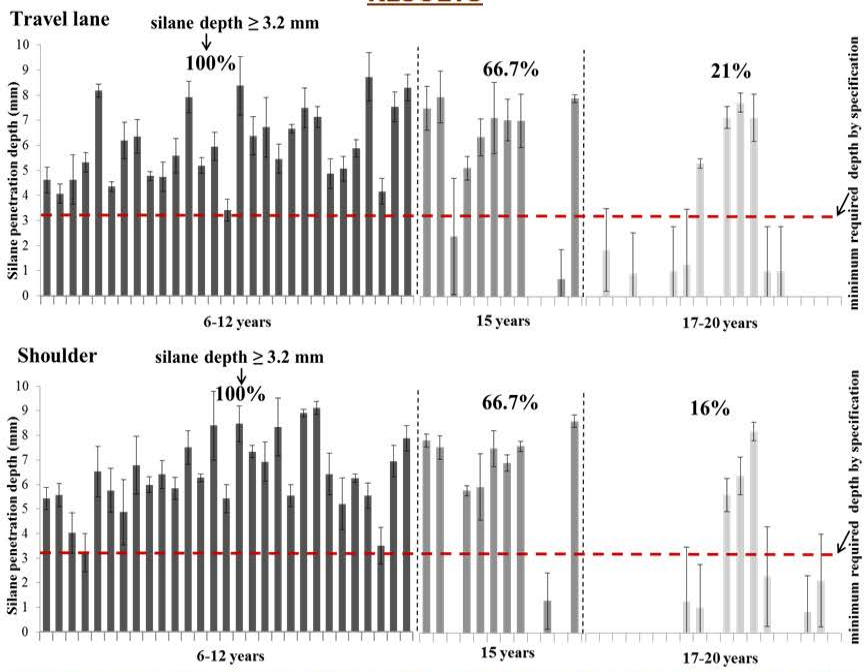



## COMPARISON




Summary from all bridge decks

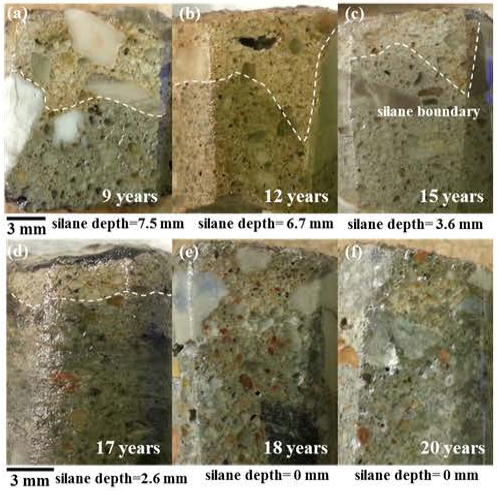
## RESULTS




Average silane visual detection depth of samples from bridge decks in travel lane and shoulder

## 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.

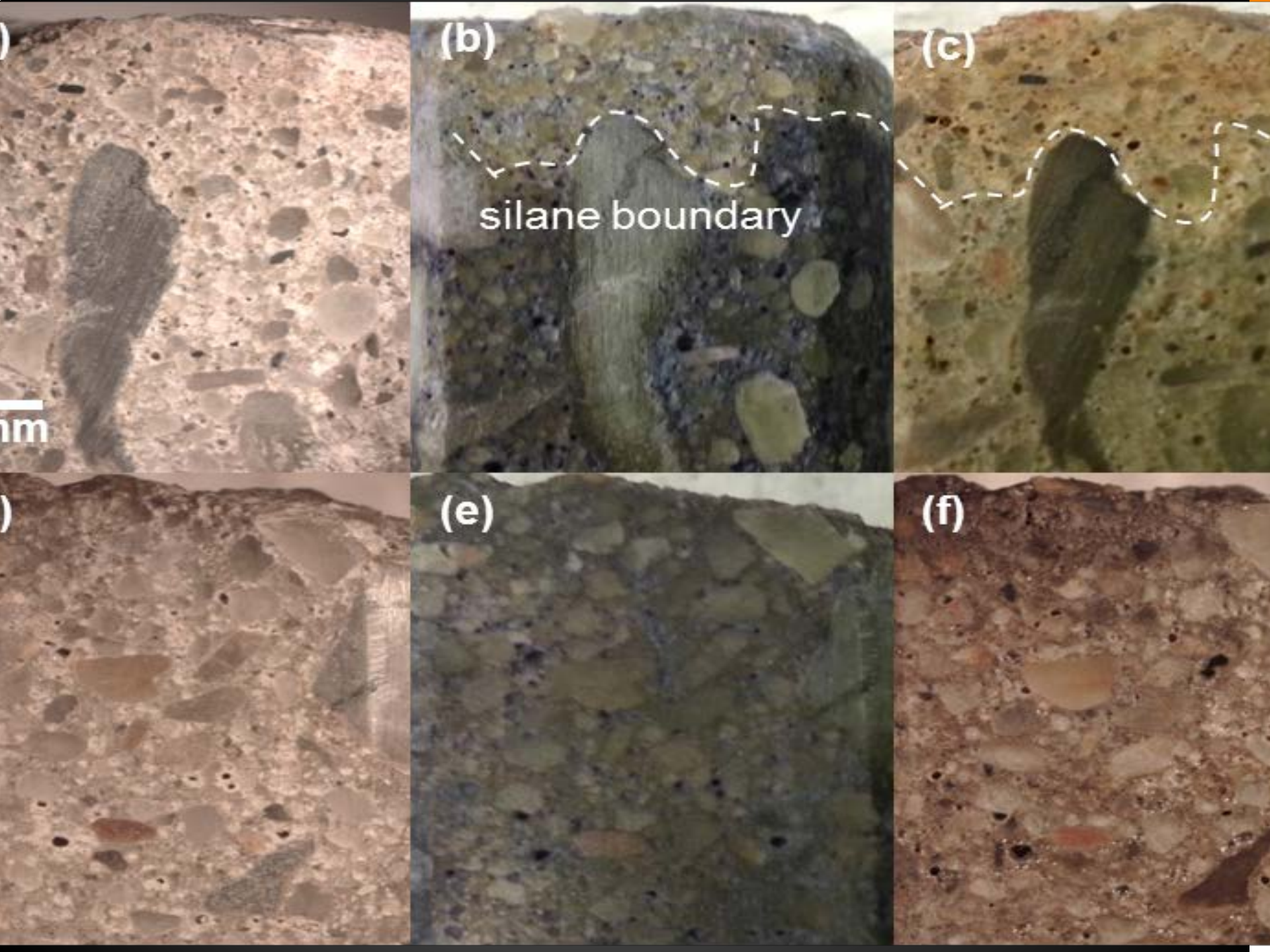


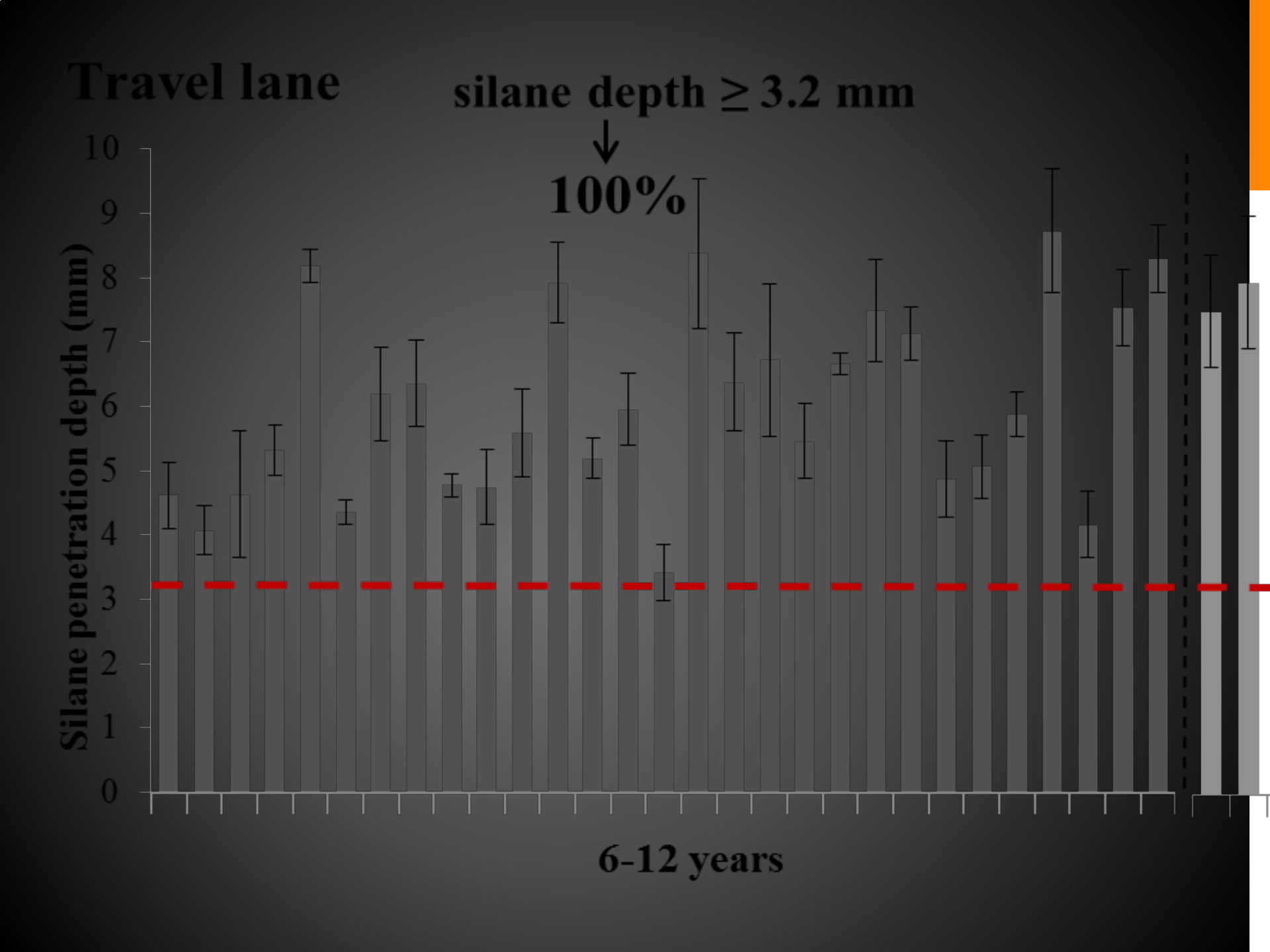

## DISCUSSION AND CONCLUSIONS

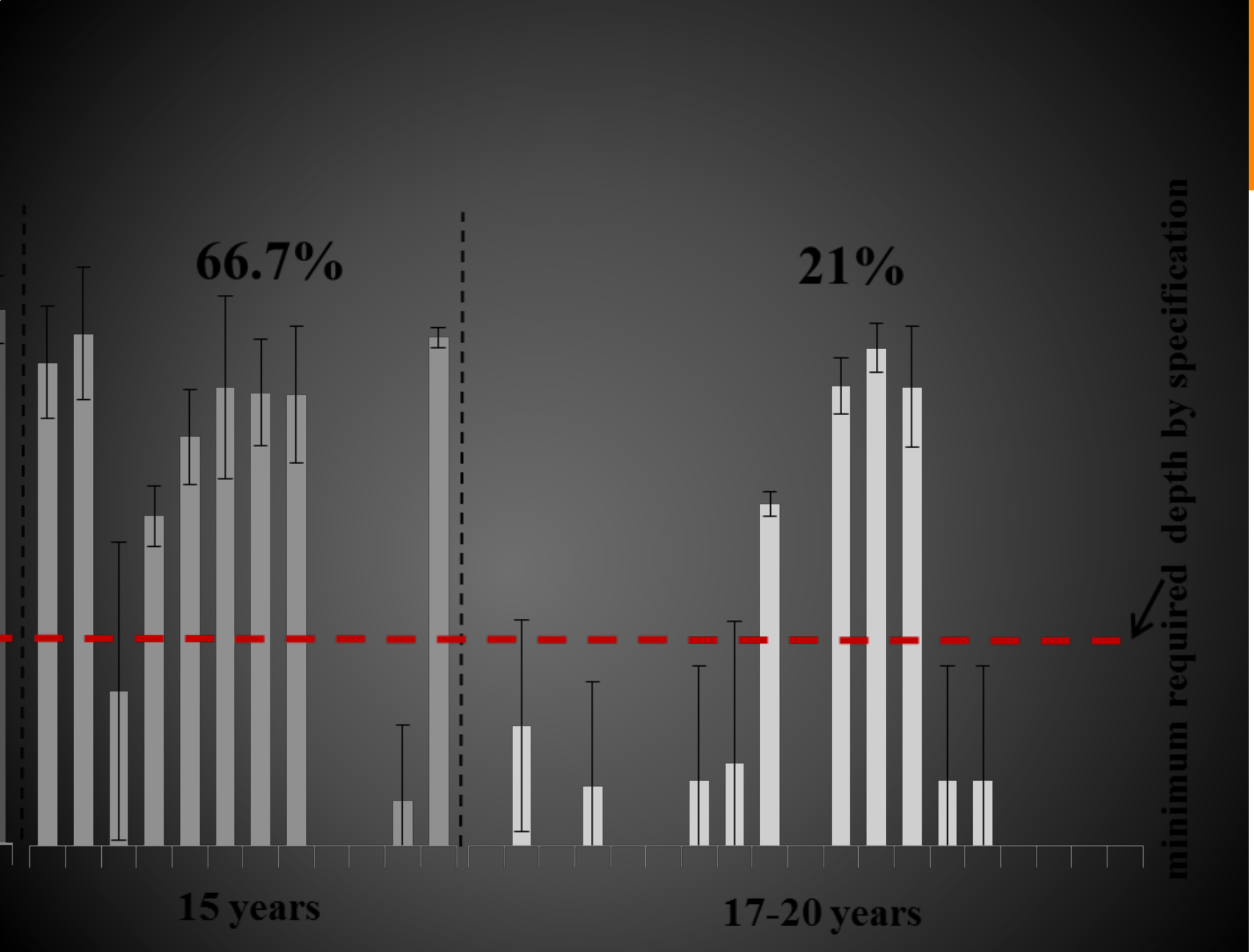
- After 12 years of service, 100% of the bridge decks were found to have a silane layer greater than the minimum specified value of 3.2 mm
- After 15 years of service, only 68% and after 17 to 20 years only 16% of the bridges showed evidence of a silane layer greater than 3.2 mm in thickness
- The average 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.


(b)
silane boundary
(c)
(e)
(f)


Travel lane
silane depth ≥ 3.2 mm
100%
Silane penetration depth (mm)
0
1
2
3
4
5
6
7
8
9
10
6-12 years


66.7%
21%
minimum required depth by specification
15 years
17-20 years

# 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**

# APPLICATION

**Surface preparation**

- **Sweeping**
- **Power washing**
- **Shot blasting**


ROADWAY TECHNOLOGIES
405-567-3706
PRAGUE, OKLAHOMA

# APPLICATION

**Hand Spray**

**Walk behind spray bar**

**Truck or trailer mounted spray bar**


MONROE
330932 D

# 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**

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
DIVISION OF STRUCTURE EARTHQUAKE ENGINEERING & DESIGN SUPPORT
OFFICE OF SPECIFICATIONS & ESTIMATES
P. O. BOX 942874
SACRAMENTO, CA 94274-0001

# COMPARATIVE BRIDGE COSTS

JANUARY 2012

The following tabular data gives some **general guidelines** for structure type selection and its relative cost. These costs should be used just for **preliminary estimates** until more detailed information is developed.

These costs reflect the "**bridge cost**" only and ***do not*** include items such as: time related overhead, mobilization, bridge removal, approach slabs, slope paving, soundwalls or retaining walls.

The following factors *must* be taken into account when determining a price within the cost range:

| Factors for Lower end of Price Range | Factors for Higher end of Price Range |
|---|---|
| Short spans, Low Structure Height, No Environmental Constraints, Large Project, No Aesthetic Issues, Dry Conditions, No Bridge Skew | Long spans, High Structure Height, Environmental Constraints, Small Project, Aesthetic Issues, Wet Conditions (cofferdams required), Skewed Bridges |
| Urban Location | Remote Location |
| Seat Abutment | Cantilever Abutment |
| Spread Footing | Pile Footing (Large Diameter Piling) |
| No Stage Construction | 2 Stage Construction |

Factors that will increase the price over the high end of the Price Range 25%-150%

| |
|---|
| Structures with more than 2 construction stages |
| Unique substructure construction |
| Widenings less than 15 Ft. |

| STRUCTURAL SECTION | (STR. DEPTH / MAX SPAN) SIMPLE | CONTINUOUS | COMMON SPAN RANGE **feet** | **COST RANGE **$ / Square foot** | REMARKS |
|---|---|---|---|---|---|
| RC SLAB | 0.06 | 0.045 | 16 - 44 | 115-345 | THESE ARE THE MOST COMMON TYPES AND ACCOUNT FOR ABOUT 75% OF BRIDGES ON CALIFORNIA STATE HIGHWAYS. |
| RC T-BEAM | 0.07 | 0.065 | 40 - 60 | 120-200 | |
| RC BOX | 0.06 | 0.055 | 50 - 120 | 130-200 | |
| CIP/PS SLAB | 0.03 | 0.03 | 40 - 65 | 100-240 | |
| CIP/PS BOX | 0.045 | 0.04 | 100 - 250 | 100-225 | |
| PC/PS SLAB | 0.03 (+3" AC) | 0.03 (+3" AC) | 20 - 50 | 125-250 | NO FALSEWORK REQUIRED. |
| PC/PS | 0.06 (+3" AC) | 0.055 (+3" AC) | 30 - 120 | 120-230 | |
| BULB T GIRDER | 0.05 | 0.045 | 90 - 145 | 110-200 | |
| PC/PS I | 0.055 | 0.05 | 50 - 120 | 110-190 | |
| PC/PS BOX | 0.06 | 0.045 | 120 - 200 | 140-250 | |
| STRUCT STEEL I GIRDER | 0.045 | 0.04 | 60 - 300 | 170-425 | NO FALSEWORK REQUIRED. |

**NOTE:** Removal of a box girder structure costs from $8 - $15 per square foot.

**Average Cost/SQFT are calculated using "Bridge Costs Only" as defined by the Federal Highway Administration

# 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!**

# 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**
- **Recoatable**
- **No masking of windows**
- **VOC compliant**
- **Deeper Penetration**

## WATER BASED SILANES

- **Lower VOC**
- **Slower dry times**
- **Windows must be masked**
- **Use solvent based to recoat**

# SILANE VS SILOXANE

## SILANE

**Deeper penetration**

**Higher solids**

**Longer life expectancy**

## SILOXANE

**Better water beading**

**Lower cost**

**Less penetration**

**High water vapor transmission**

# QUESTIONS?

**Thank you**

**Tim Woolery**

**Advanced Chemical Technologies**