westlux

Concrete Protection - Hydrophobic Impregnation

**Westlux Creme C & Westlux 1701**

# Introduction to Concrete Protection

## Infrastructure

- mostly post treatment
- engineering concrete
- rebar and concrete protection

A. Application : **Bridges, Tunnels, Quay Walls, Dams, etc.**

B. Main Benefits :

- **Increase Durability (protection from harmful pollutant).**
- **Reduction of maintenance cost (repair is much more expensive than protection by hydrophobic impregnation).**

C. Main Products :

- **WESTLUX 1701**
- **WESTLUX Creme C**

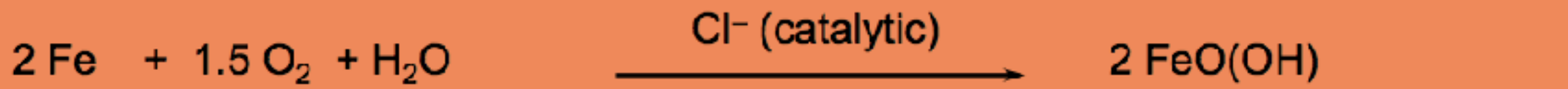
# CONCRETE PROTECTION IS TO PROTECT FROM WATER

All damages to concrete require water.
Hydrophobic impregnation thus prevents damages such as:

- chloride induced corrosion of rebar
- freeze-thaw damages, de-icing salts
- gasous pollutants
- carbonation
- alkali silica reaction
- ettringite formation

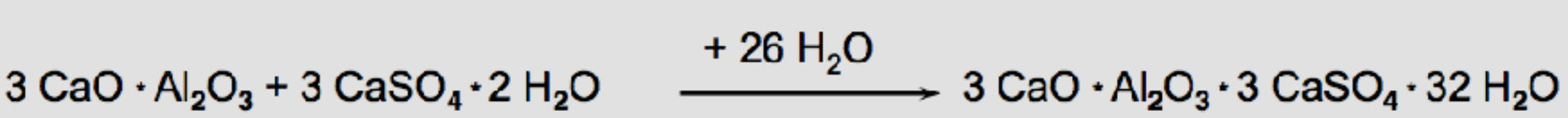
# CONCRETE DAMAGING PROCESSES

**1. Corrosion of reinforcement**




**2.5 times the volume of Fe**

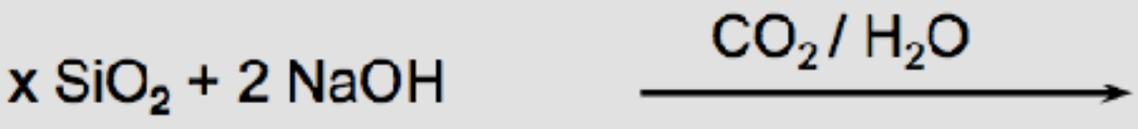
**2. The sulfate reaction**




tricalciumaluminate

**Ettringite: 8 times volume increase**

**3. The alkali silica reaction**




**voluminous silica gel**

# CONCRETE DAMAGES – TYPES OF CORROSION OF REINFORCING STEEL

## Corrosion by chlorides

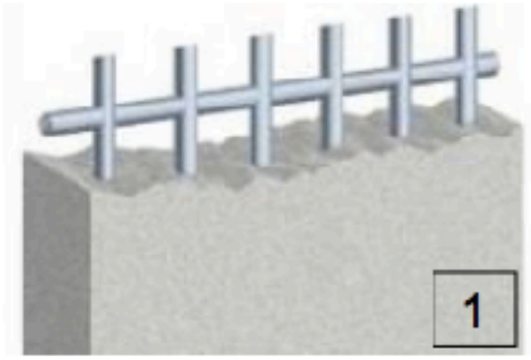
## Corrosion by carbonation

# CONCRETE DAMAGES – TYPES OF CORROSION OF REINFORCING STEEL

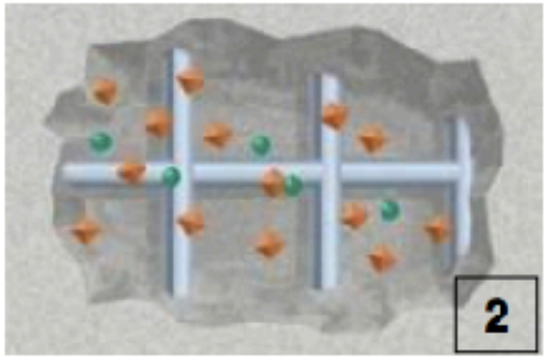
**Corrosion by chlorides**

- Chloride sources : sea water or de-icing salts (spray and splash).
- Chlorides penetrate into concrete, transported by water.
- Upon reaching the rebar, local corrosion (pitting) starts with chlorides acting as catalysts.
- Corrosion process thins the rebar, often invisible at surface.
- Corrosion occurs at any pH-value

# DESPITE CONCRETE'S DURABILITY, SERIOUS DAMAGES WHICH ENDANGER BUILDINGS FREQUENTLY OCCUR:

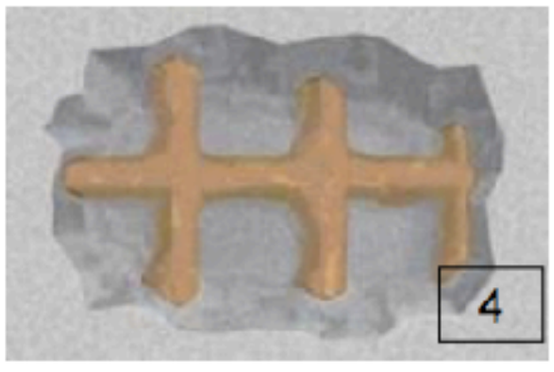



rebar passivates in an alkaline medium

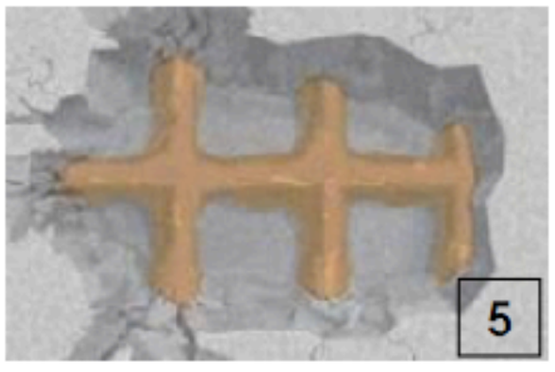



dissolved salts penetrate deep into the concrete

chloride ions reach the steel & dissolve the protective layer.




corrosion results in a volume expansion & a pressure build-up




Crack formation and spalling of concrete are the results.

The inside damages become visible on the outside.

# CHLORIDE CONTAMINATION OF REINFORCED CONCRETE

- Chloride contamination is a severe problem for the integrity and refurbishment of reinforced concrete.
- Determination of the chloride content (based on cement) is an absolute must. The **critical content of 0.4 %** must not be exceeded.
- A chloride content below 0.4 % weight (based on cement) bound in form of „Friedel salt“ (3 $CaO \bullet Al_2O_3 \bullet CaCl_2 \bullet 10\ H_2O$) is present in concrete.
- In practice the capability of the cement to bind chlorides is strongly influenced by the humidity around the rebar.

# CONCRETE DAMAGES – TYPES OF CORROSION OF REINFORCING STEEL

**Corrosion by carbonation:**

- rebar is protected by thin oxide layer (passivated) in alkaline concrete.
- carbon dioxide ($CO_2$) reduces concrete alkalinity by formation of calcium carbonate ($CaCO_3$).
- below pH value of 9.5 passivated layer is dissolved.
- surface corrosion of rebar begins.

# CARBONATION EXPLAINED

source: wikipedia.org; author: Bill Bradley (Billbeee)

carbonation reaction:
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

rate of carbonation depends on:

- humidity (maximum rate at 50–70%)
- w/c value / porosity (more pores = larger surface = higher rate)
- compressive strength
- age of the concrete (rate slows down with time)

depending on these factors carbonation can stop at certain depths

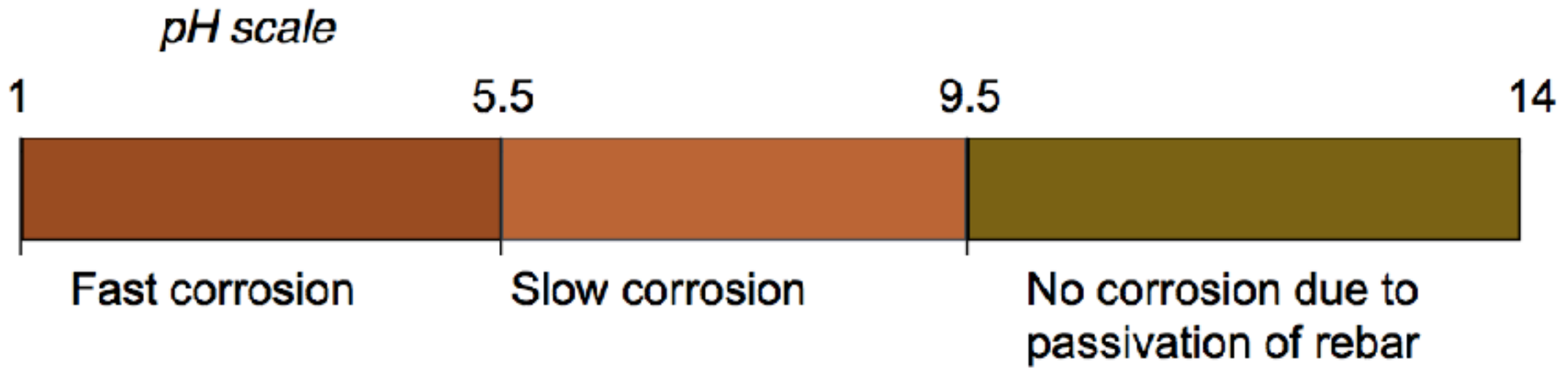
Carbonation occurs from the outside to the inside of concrete

# DETERMINATION OF CARBONATION DEPTH IN CONCRETE

- Cut drilled concrete sample core
- Treat the cut suface with pH indicator (Phenolphthalein 0.1 %)

- grey zone: carbonated
- pink area: not carbonated
- test according EN 14630
- shown here: 4 mm average

# REINFORCEMENT CORROSION



# OTHER TYPICAL CONCRETE DAMAGES

Rock pockets at edges can quickly become severely damaged spots. Must be reppaired immediately after detection

Discoloration, net cracking and break up

# WRONG DESIGN OR EXECUTION IS OFTEN RESPONSIBLE FOR DAMAGES

Surface is strongly weathered,
facilitated by insufficient compaction
pollutants can penetrate easily.

Bad flow design facilitates corrosion

# CAUSES OF REINFORCEMENT CORROSION

1. Chloride contamination combined with water leads to extreme damages, which can jepardize the stability of the construction structure.
2. Carbonation has reached the reinforment area. Ingress of water and influence of oxygen boost the corrosion of the steel.
3. Too low concrete cover (minimum: 4-5 cm).
4. Poor compaction associated with higher capillary water uptake, due to high porosity (high w/c ratio, low compressive strength).
5. Deep Crack formation (>> 2-3 mm).

# HOW TO PREVENT CONCRETE REINFORCEMENT CORROSION

Hydrophobic impregnation

- organosilicone products, such as alkyl silanes.
- deep penetration depth.
- results in the formation of a water repellant zone.
- prevents capillary uptake of pollutants into the concrete.

Before start of treatment, the type of concrete must be determined : new concrete, old concrete or old concrete in need of rehabilitation.

# HYDROPHOBIC IMPREGNATION OF NEW REINFORCED CONCRETE

- Wait a minimum of 28 days after concrete preparation before commencing treatment
- Remove residual release oil by washing with warm water right after the sheathing has been dismantled.
- When cleaning with water and surfactant, make sure to wash off surfactant thoroughly.
- The concrete surface must be equally dry (equilibrium moisture content) to prevent staining or low penetration depth.

Simple Test :
Tape PE sheet (50x50 cm) over the edges of the concrete. Over night there should be no darkening or condensation.

Better method : Moisture analyzer

# EFFICIENT METHODS TO MEASURE CONCRETE HUMIDITY

Capacitance meter

Calcium carbide tester

# HYDROPHOBIC IMPREGNATION OF OLD REINFORCED CONCRETE

- Before hydrophobic impregnation begins, check the condition of the concrete such as porosity, concrete cover, compressive strength, carbonation depth, tensile adhesive strength.
- Clean with high pressure (8-10 bar) warm water (60°C) to remove dirt, oil etc and leave to dry for at least 2 days (up to a week).
- Remove old coatings. Most effective method is by blasting with water or other blasting materials such as sand, glass powder, dry ice etc.
- Depending on the state of the surface (rough surface, rock pockets, spots) repair filling might be necessary before treatment can comence.

  Proper concrete humidity must be reached before start of treatment.

# CORRECT CONCRETE HUMIDITY IS THE KEY TO A SUCCESSFUL HYDROPHOBIC IMPREGNATION

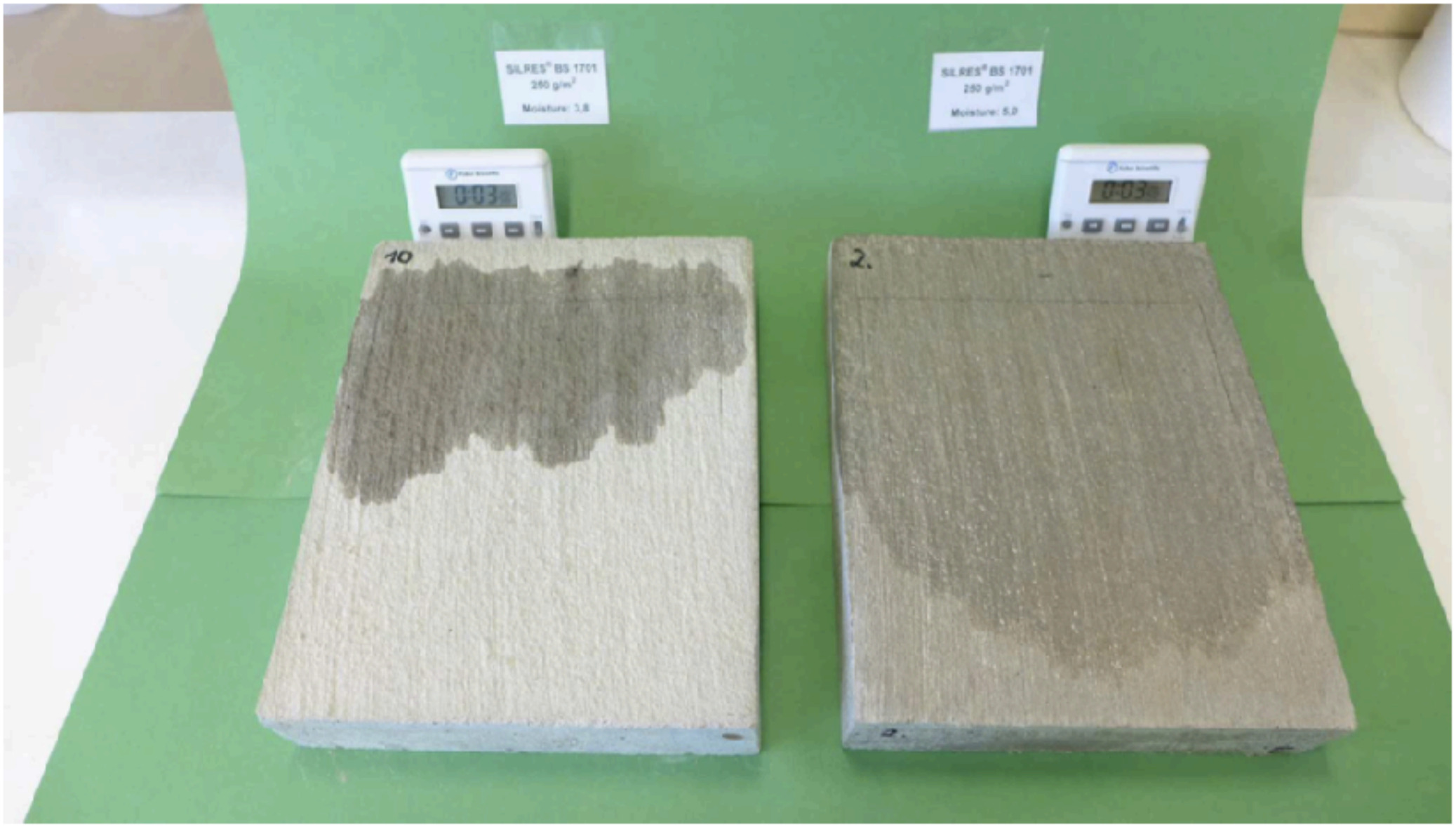
Concrete humidity should be at maximum values of :

4.0 % (at 10 mm depth)
3.0 % (at 40 mm depth)

If humidity is below maximum values, start application immediately.

Concrete humidity must always be determined before application starts (in practice often not done at all)

# On Concrete with Moisture > 4% a silane (Westlux 1701) does not penetrate quickly enough and runs off (slabs @ 2.5 °; 250g/m2)




Concrete moisture level of 3.8 % (left) and 5.0 % (right)

# Characteristics of Westlux Creme C

Westlux Creme C:

•Rapid & Outstanding Penetration

•High & Verifiable Coverage Rates

•Loss-Free One-Step Application

•Low Evaporation

•Water Based; Solvent Free

Concrete Treated with Creme C:

•Excellent Water Repellency

•Water Vapor Permeability

•Optimum Resistance to Alkalis

•Treated Concrete can be Coated

# Comparison of Westlux Creme C to Conventional Liquid Impregnating Agents

The material can be applied without loss from dripping or trickling

Long contact with the surface leads to deep penetration

A single application is generally sufficient (airless spraying at 70-100 bar, brushing or use lambskin roller)

Up to 400 g/m² can be applied even to vertical surfaces and ceilings – without material loss (200 g/m² is usually sufficient for high-quality concrete)

After application it must be covered from rain for at least 24 hrs.

The surface can be coated after treatment

**Westlux Creme C saves time and reduce costs.**

# Application of Westlux Creme C

**airless spraying**

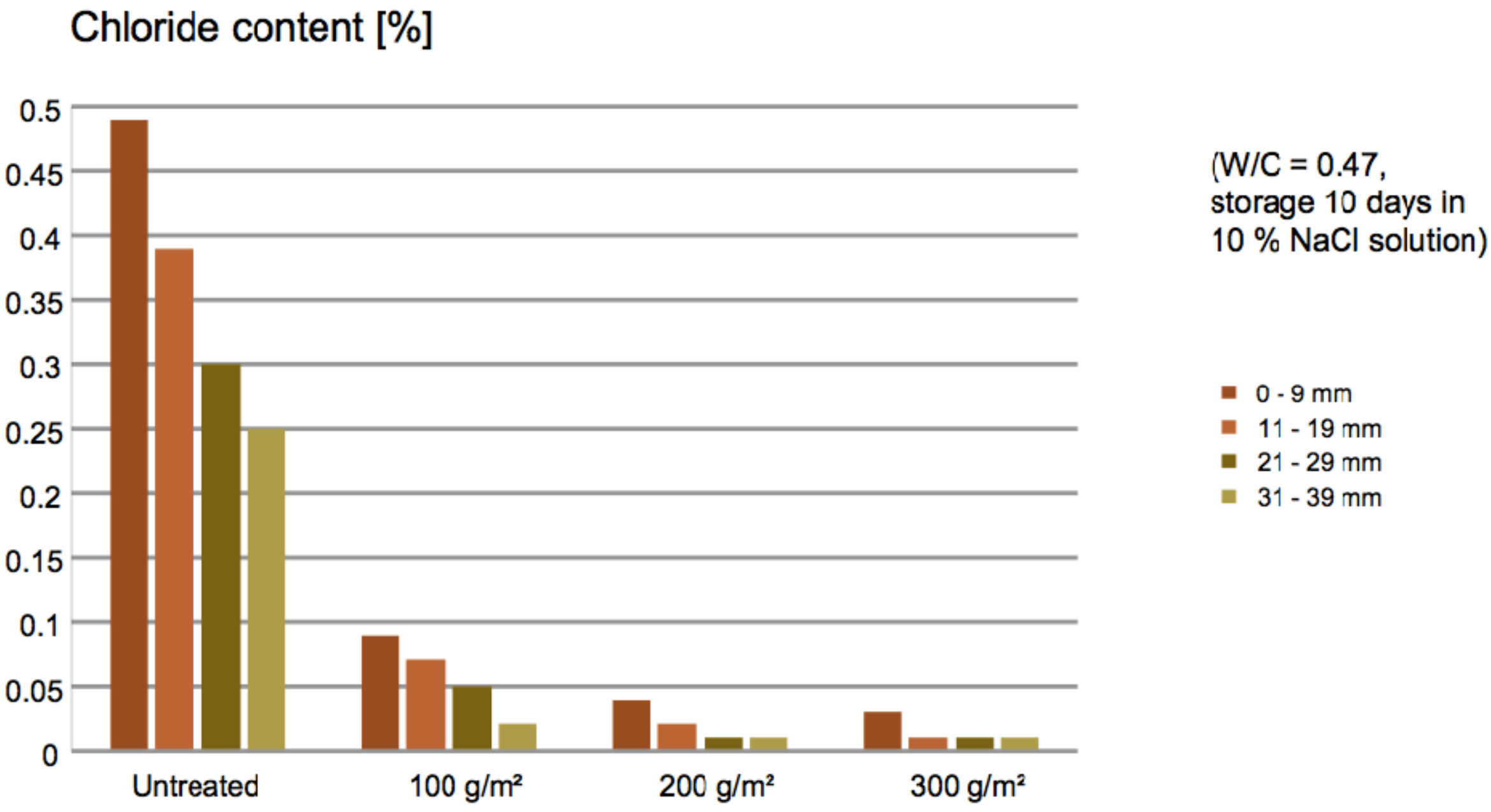
**lambskin roller**

freshly applied

after 30 min

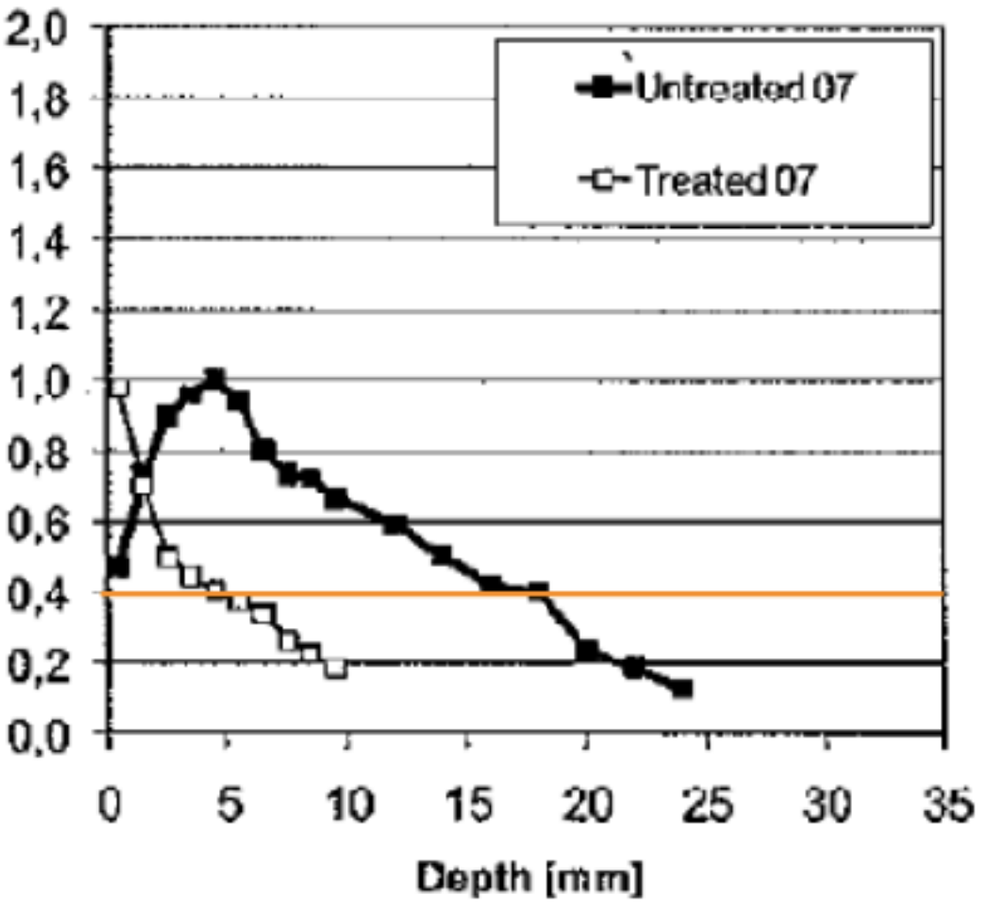
after 2 h

# Chloride Penetration in Concrete with and without Westlux Creme C Protection

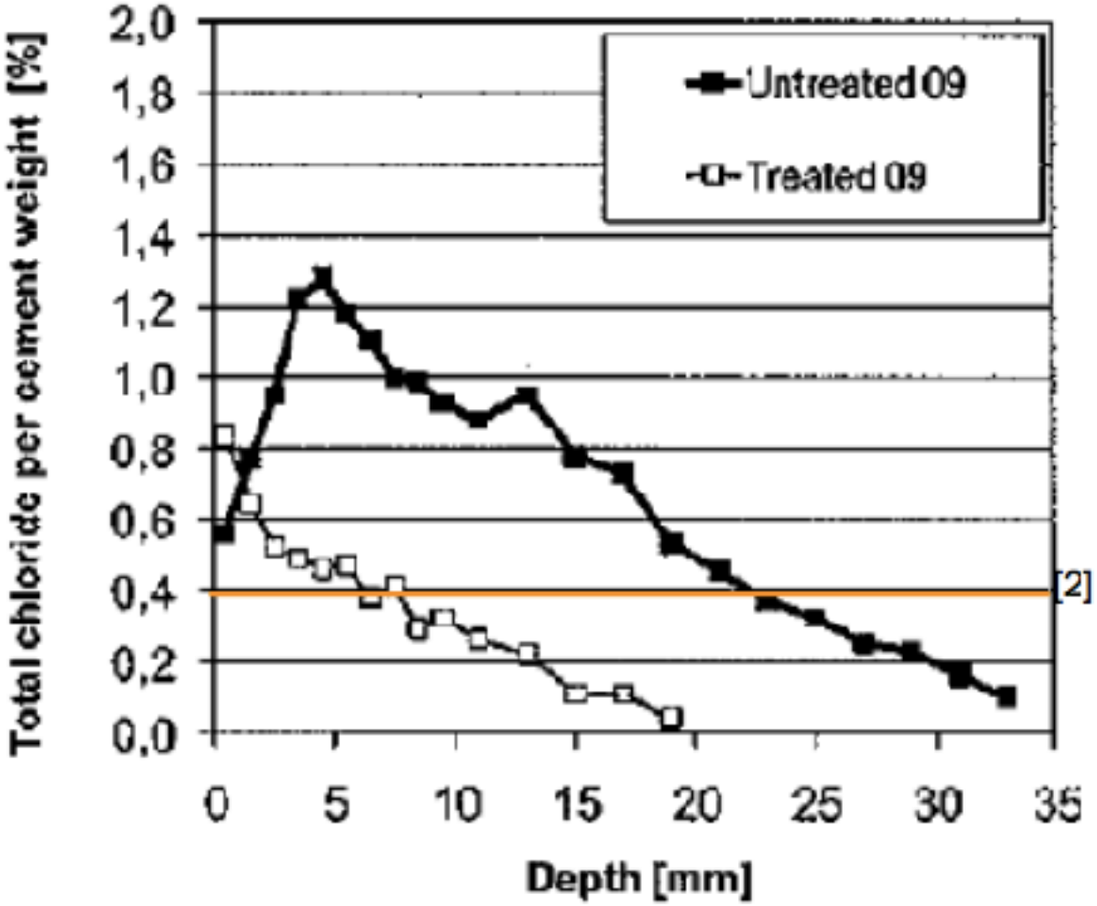



Silanes are highly effective as chloride barriers for concrete

# Chloride Ingress is Significantly Reduced by Water Repellent Treatment (Eugenia Tunnel SE)



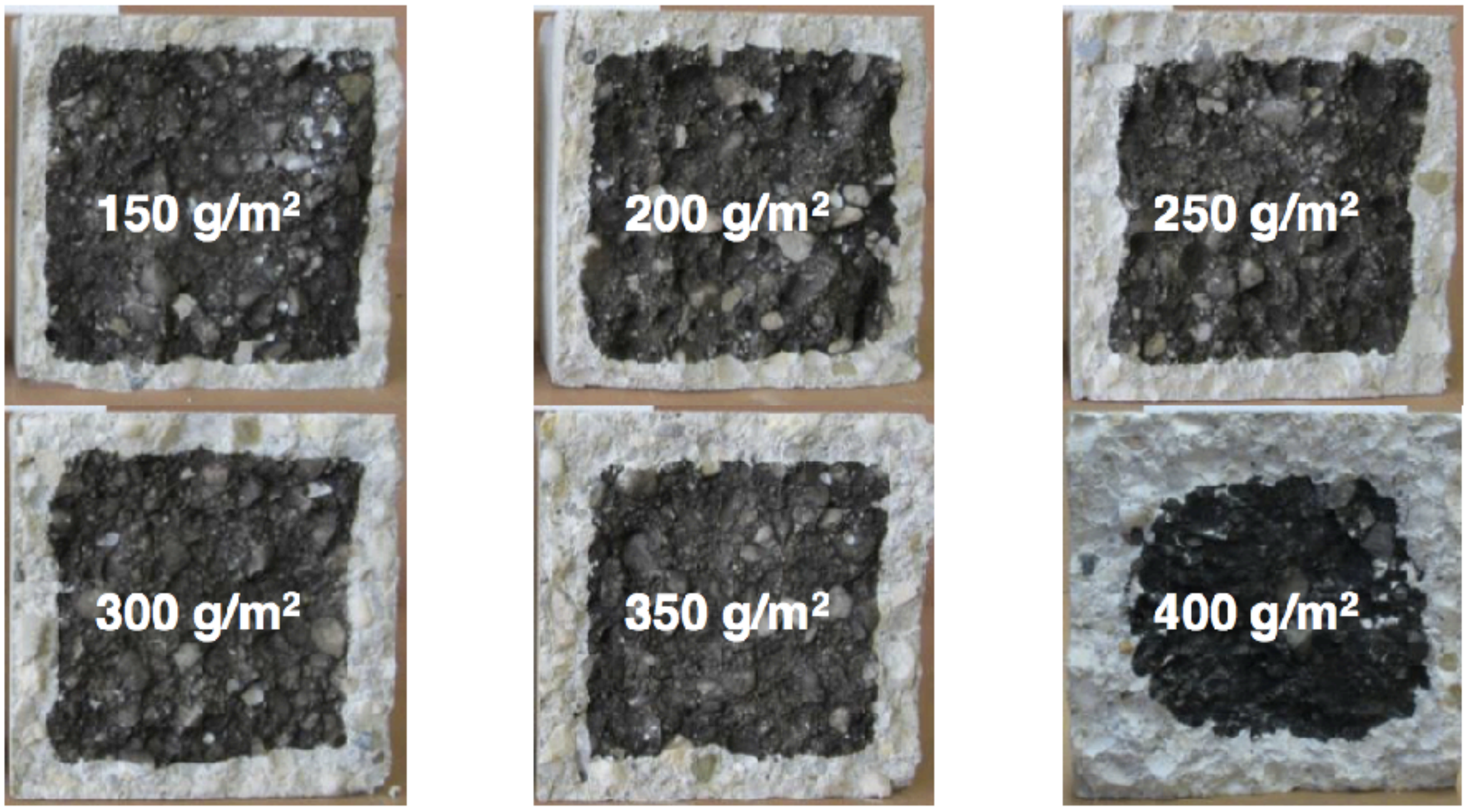

[2]




[1] Anders Selander, *Hydrophobic Impregnation of Concrete Structures*, Thesis, 2010, Swedish Cement and Concrete Research Institute (CBI), Stockholm.

[2] Concrete can store up to 0.4 % $Cl^-$ in form of the Friedel salt 3 CaO • $Al_2O_3$ • $CaCl_2$ • 10 $H_2O$. (Thumb rule!)

# Effect of Dosage on Penetration Depth - Westlux Creme C; W/C = 0.70



# EFFECTS OF WRONG PREPARATION II – TOO HIGH DILUTION RATE GIVES LOW PENETRATION DEPTH

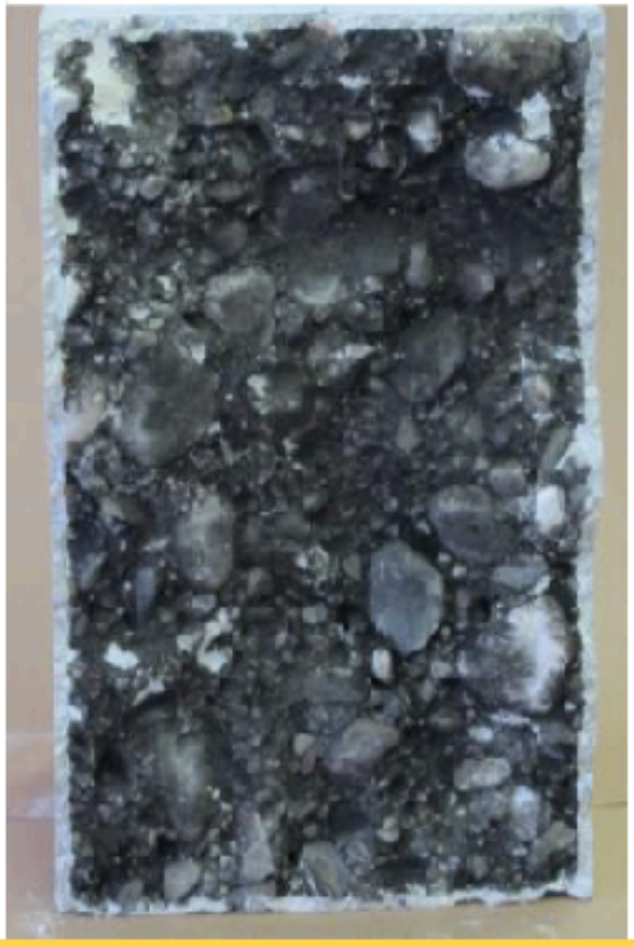
Water Based Product

(1 : 9 Dilution)

**0 – 2 mm**

Water Based Product

(1 : 3 Dilution)



**3 – 4 mm**

**Westlux 1701 - Pure Silane**

**8.5 – 11.5 mm**

# Westlux - PRODUCTS FOR CONCRETE PROTECTION

| WESTLUX | Description | Application |
|---|---|---|
| Creme C | Iso-octyltriethoxysilane Based Creme (80% Activities) | Water Repellent Treatment for steel reinforced concrete |
| 1701 | Iso-octyltriethoxysilane (Active Content: > 98%) | Water Repellent Treatment for steel reinforced concrete |

## SUMMARY – INFRASTRUCTURE CONCRETE PROTECTION

Effectiveness of concrete protection depends highly on knowledge of consultants and applicators.

Proper preparation and check condition of concrete.

- cleaning
- repair filling of surface
- moisture content & porosity
- Compressive strength
- chloride content
- carbonation depth
- penetration depth
- concrete cover

Penetration depth of hydrophobic impregnating agent depends on:

- dosage or dilution rate (for water based)
- humidity (water in pores)
- porosity

**Hydrophobic impregnation gives long term protection**

# Reference Projects In Asia

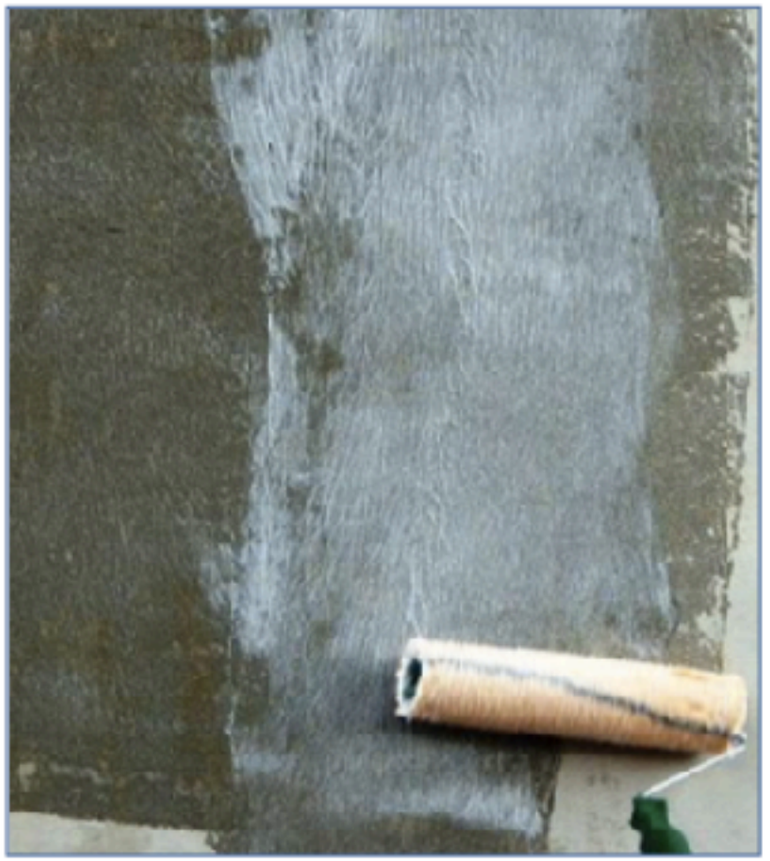
# Three Gorges Dam, China (2007) - 1701

## Three Gorges Dam, China (330g/m2)

| | |
|---|---|
| **Location** Province | Yichan City, HuBei |
| **Application area** | 3800m2 |
| **Application time** | June 2007 |

The biggest hydro power generation project in China. The concrete of the power generation plant was protected with **W. Silane as the 1st** step, the main dam will be protected as the 2nd step.

# Wuhan Yangluo Yangtze river bridge, China (2007)



- *Wuhan Yangluo Yangtse River was built in 2007. The World's eighth-longest Span Suspension Bridge.*
- *To protect concrete structure against chemical environment(acid rain) and sea water.*
- *Protection Area: main tower, anchor concrete parts*

# Wuhan Yangluo Yangtze river bridge
## Application procedure

Polishing concrete

Drying and cleaning concrete

Applying **Westlux Creme C** by roller

Applying from bottom to up

Drill Core sample

Impreg. quality control

# Fujian LNG pier, China **(2006)** - Creme C

- *Location: Putian City, Fujian Province*
- *To protect concrete structure against sea water*
- *Application area: tidal zone part of precast concrete basement*

# Boardwalk, Singapore **(2010)** - 1701

## Boardwalk linking Vivo City and Sentosa, Singapore

**Location** Singapore

Silane applied on cross beams at precast stage in Malaysia, touched up and on pile caps on site. Cross beams and pile caps in splash zone.

# Maritime Port of Singapore Authority

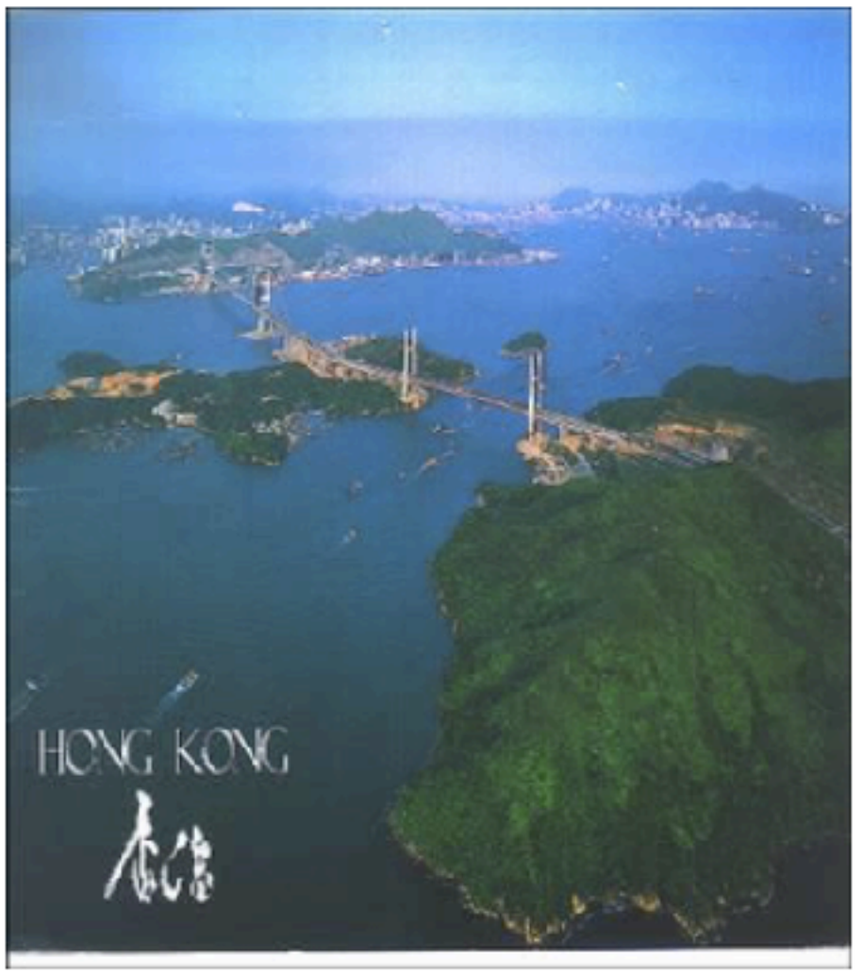
**Location** Singapore

Reinforced concrete WHARF

Silane applied on tidal & splash zone of cassions and culverts fabricated near site

Protection against corrosive sea water

# Tsingma Bridge, Hong Kong **(1999)** - Creme C



## Tsingma Bridge, Hong Kong

2160m long, main tower height is 206m

# Okumiomote Dam, Asai, Japan **(1999)** - Creme C

**Asai,Okumiomote Dam, Japan**

Project completed in 2002

# Geoga Bridge, Korea **(2008)** - Creme C

## GeoGa Bridge, Korea

- GeoGa Bridge, Korea, 2008

Jl. Pergudangan Gedangan Permai B-8, Sidoarjo, East Java, Indonesia

Phone (031) 8010 670 Fax (031) 8010 309

westluxindonesia@gmail.com

www.westlux.net