

The Effect of Silane-Type Surface Penetrants to Control Scaling and Salt Damage of Highway Bridge Wheel Guard Concrete in Cold Region

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1. INTRODUCTION

- In cold regions, to ensure traffic safety of winter roads, the road administrators apply chloride-based deicers to the road.
- In such severe environment, concrete of highway bridges is affected by combine action due to freeze-thaw and deicing salt.



1. INTRODUCTION

- The combination of freeze-thaw and deicing salt is known to accelerate scaling (peeling of surface) and reinforcing bar corrosion.
- It's concern about the budgets increase for maintaining of structures. The deterioration control method that economical and easy is required.

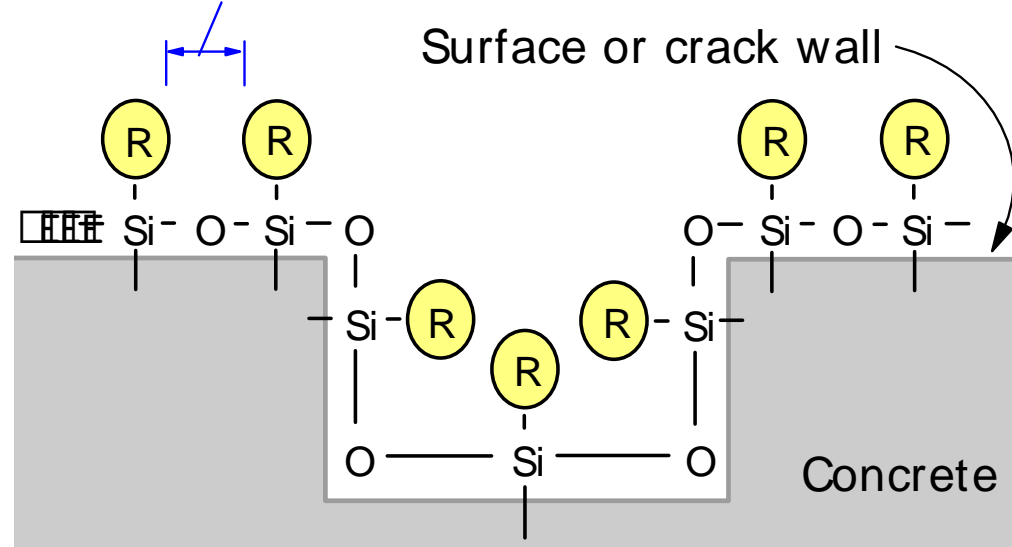


2. SILANE-TYPE SURFACE PENETRANTS

- Silane-type surface penetrants are permeating coating materials to control supply of water and chloride ion.



This length is shorter than the diameter of droplet. However, it's longer than the diameter of vapor.



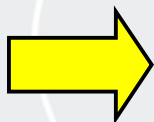
(R) : Hydrophobic group (Alkyl group)

3. PURPOSE

The advantage of silane-type surface penetrants (e.g.)

- Easy to use
- Relatively reasonable in price
- Surface colorlessly (not affect structure's appearance)
It can perform dairy visual check and maintenance easily.
- Permeated area are not degradation by ultraviolet rays
This is a penetration materials, unlike covering materials.

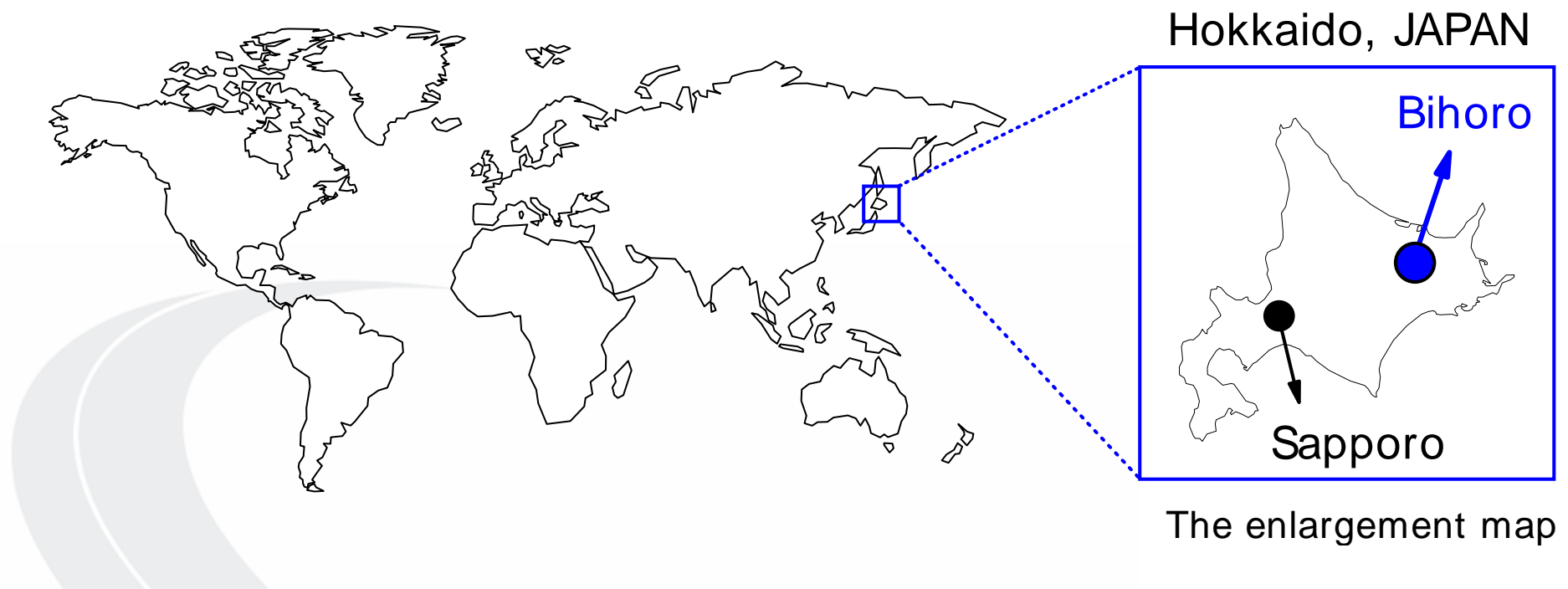
It is used to be for protection walls of building or stone sculpture.
More recently, it is using for durability improve of civil engineering structure.
However, it is not clear enough about applicability and effect in cold regions.



We tested silane-type surface penetrants on wheel guard concrete in cold regions, and observed how much the effect of control the concrete deterioration progress during 6th years after coated.

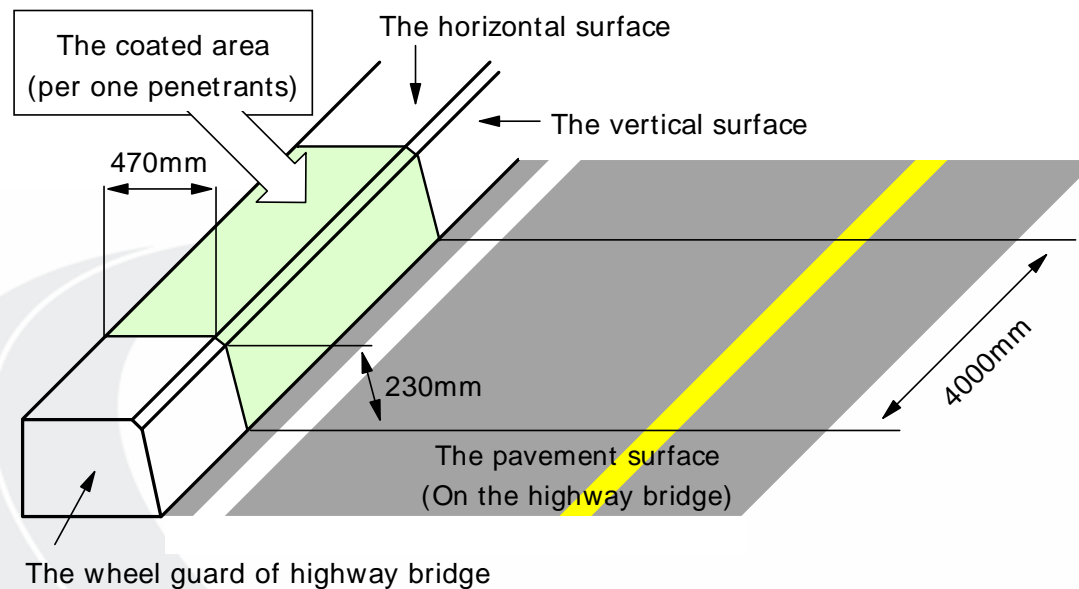
4. THE LOCATION OF HIGHWAY BRIDGE

- The location of highway bridge is in Bihoro-town, Hokkaido, JAPAN.
- The highway bridge length is 73m.
- The minimum temperature is -25°C .
- During winter, deicing salt spraying.



5. THE COATING WORK

- The coating work was conducted at highway bridge wheel guard after concrete placement (W/C=57%, W/B=52%) in October 2004.
- It's used the five commercial penetrants (No.1, 2, 3, 4, 5).
- The coated area of one materials is 4m-long.
- It was coated by manufacturers, in accordance with their original specifications.



5. THE COATING WORK

The silane surface penetrants used for test
(by original specifications of each manufacturers)

Name of material	No.1	No.2	No.3	No.4	No.5
Content of active ingredient(%)	42	43	80	10.5	90
Type	Aqueous	Aqueous	Aqueous	Solvent	Non-Solvent*
Application Quantity(g/m ²)	200	300	200	300	400

*) The diluted solution is another safety liquid (not aqueous, not solvent)

6. THE INVESTIGATIONS AND RESULTS

(1) WATER PERMEATION RATIO

- Water was poured into funnels.
- 24 hours later, the heights of water in funnels were measured.
- It calculated water penetration ratio.

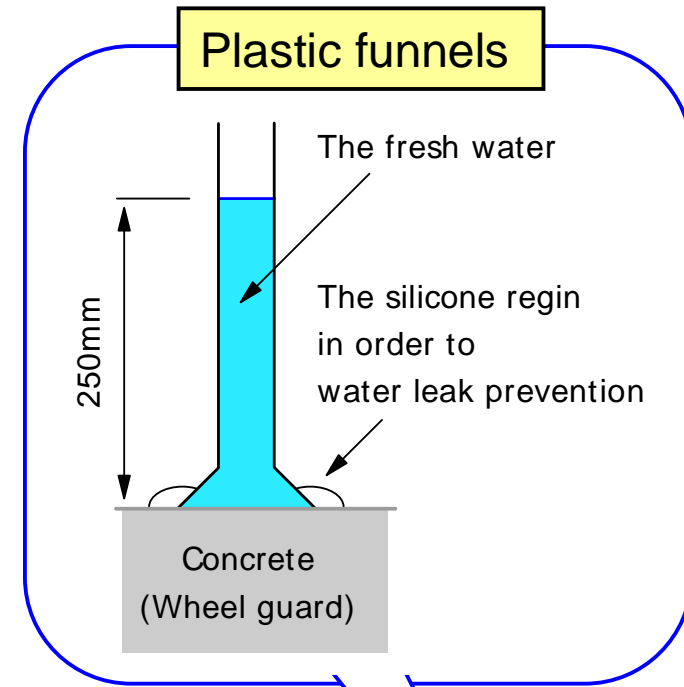
$$W_r = \frac{I_s}{I_n}$$

where,

W_r : water permeation ratio

I_s : water absorption of
the coated face (ml)

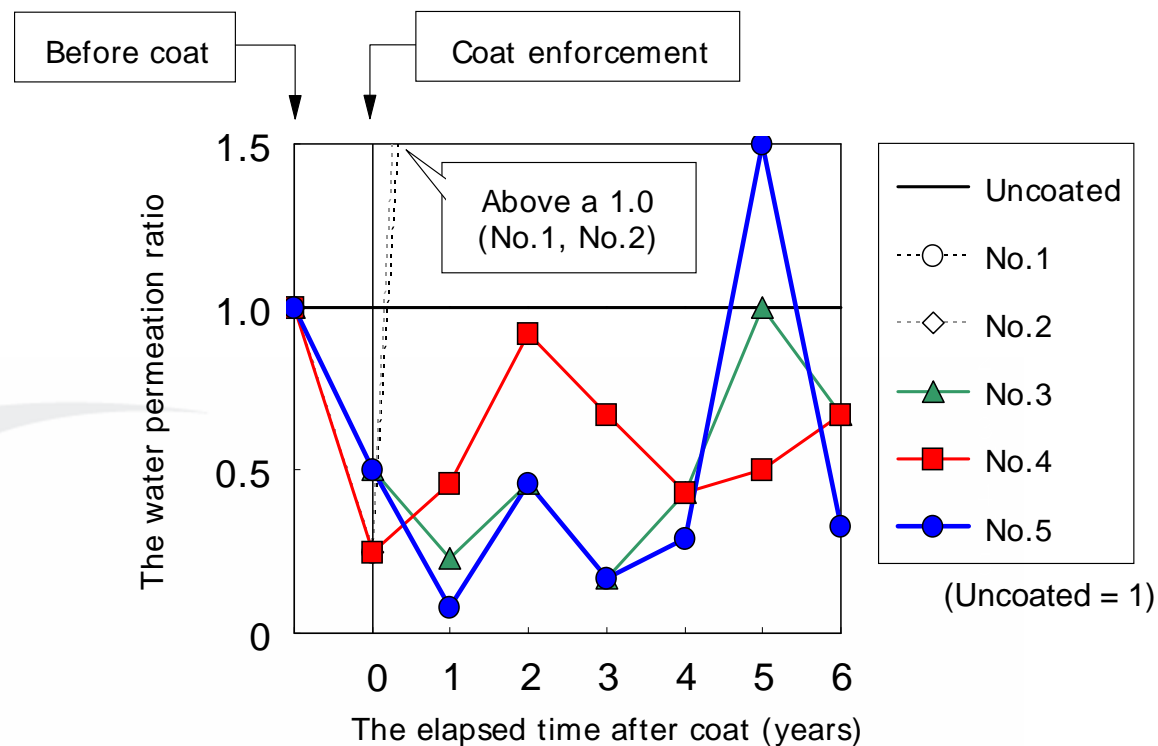
I_n : water absorption of
the uncoated face (ml)



6. THE INVESTIGATIONS AND RESULTS

(1) WATER PERMEATION RATIO

- The value of No.3, 4, 5 were 1 or lower in general.
- The persistence of control water absorbability varies by penetrants type. (When it choose suitable materials, an effect is expected)



6. THE INVESTIGATIONS AND RESULTS

(2) SCALING AREA MEASUREMENT

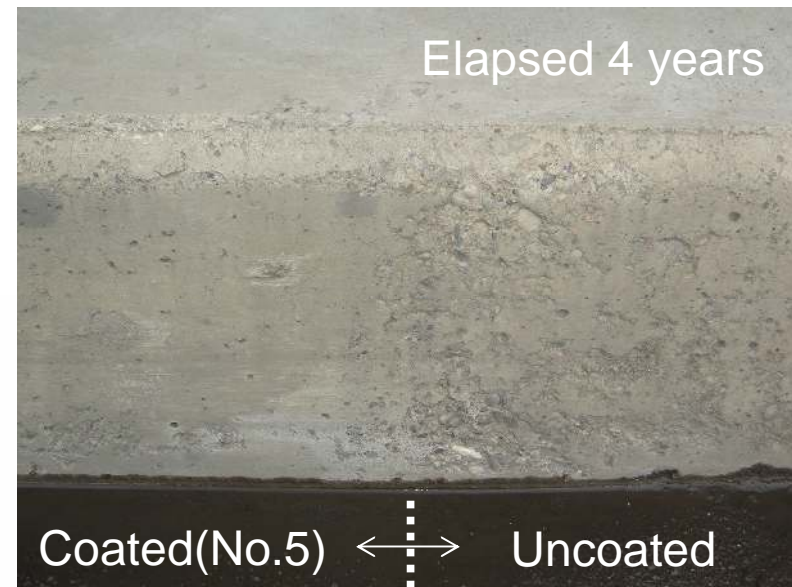
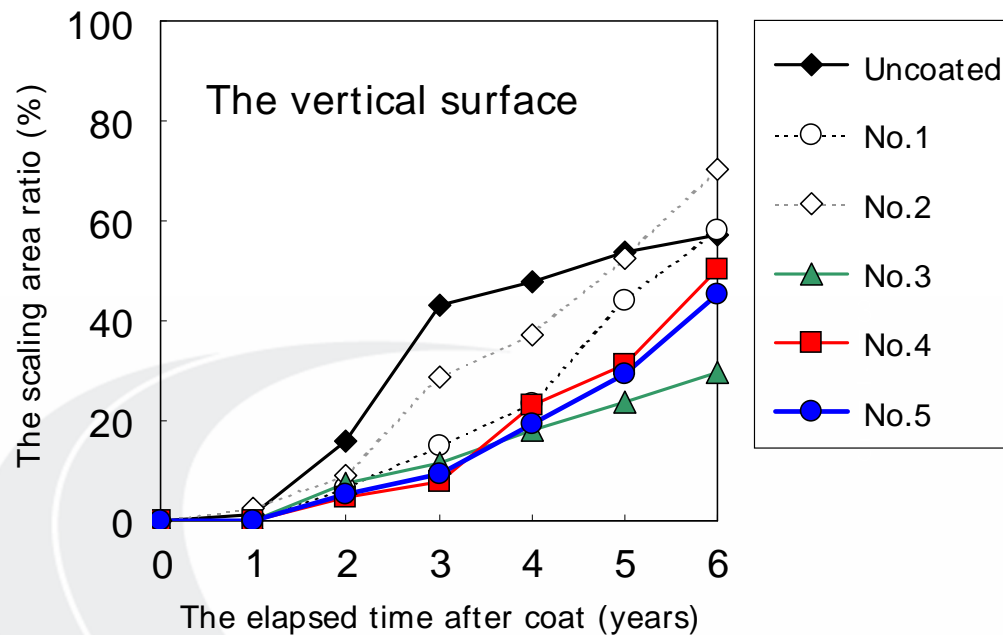
- The scaling area were marked using chalk, and photographed.
- It was calculated the ratio of scaling area among total tested area (Scaling area ratio).



6. THE INVESTIGATIONS AND RESULTS

(2) SCALING AREA MEASUREMENT

- In No.3, 4, 5 area, scaling area decreased 10% to 50% in comparison with uncoated.
- The tendency of effect was the same as result of water permeability ratio.



6. THE INVESTIGATIONS AND RESULTS

(3) CHLORIDE ION MEASUREMENT

- 6 years later, the concrete core were extracted from vertical surface. (It was conducted in No.3, 4, 5 area)
- The chloride ion content was applied by Mohr's Method.



The summary of Mohr's Method

Core cut divide (depth 1,2,3,4cm)



Crush (to powder) and boiled



Silver nitrate was added.
(Silver chloride precipitation)

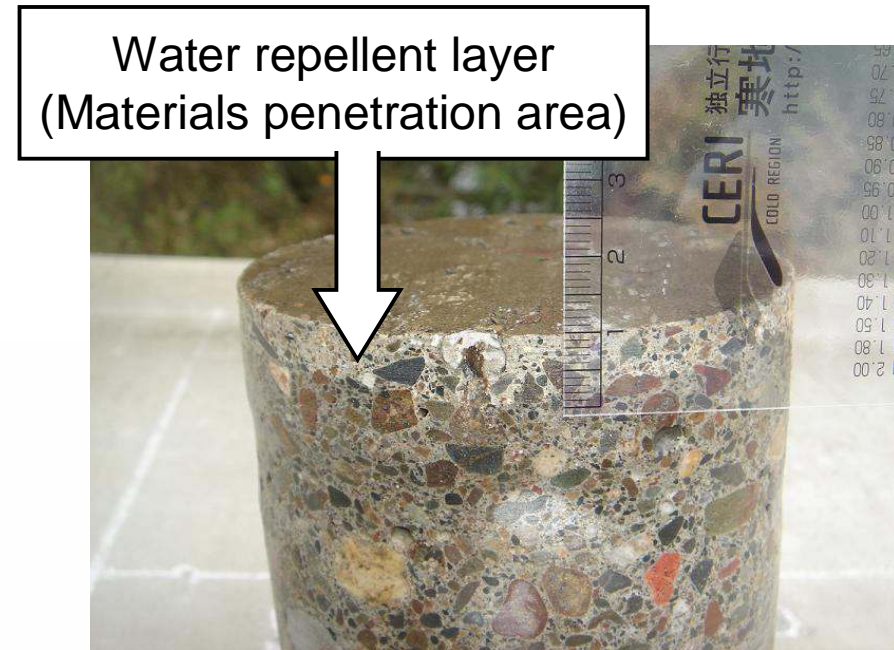
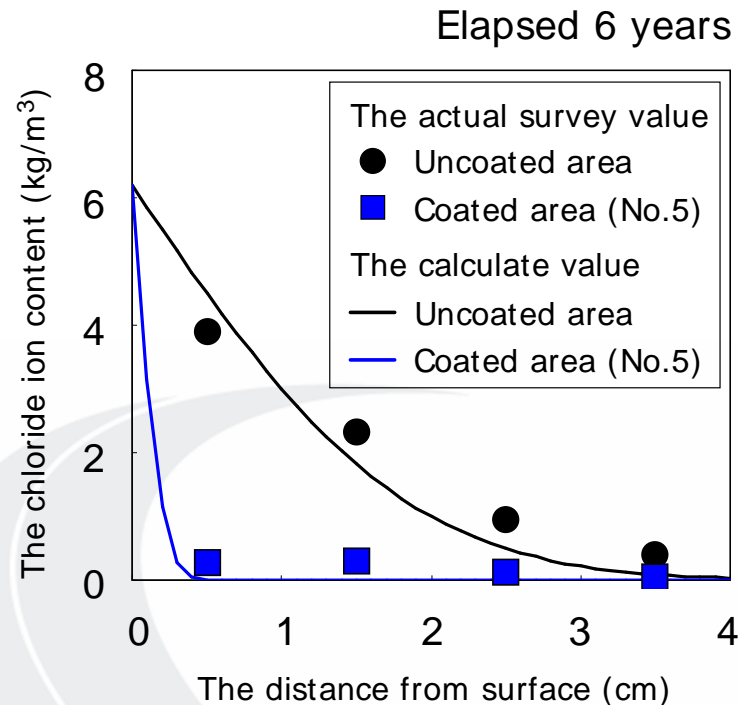


Silver nitrate amount measurement
Chloride ion content calculation

6. THE INVESTIGATIONS AND RESULTS

(3) CHLORIDE ION MEASUREMENT

- The chloride-ion content of coated area, e.g. No.5, is very less. (Effect of water repellent layer)
- The control of chloride ion penetration and corrosion is expected.

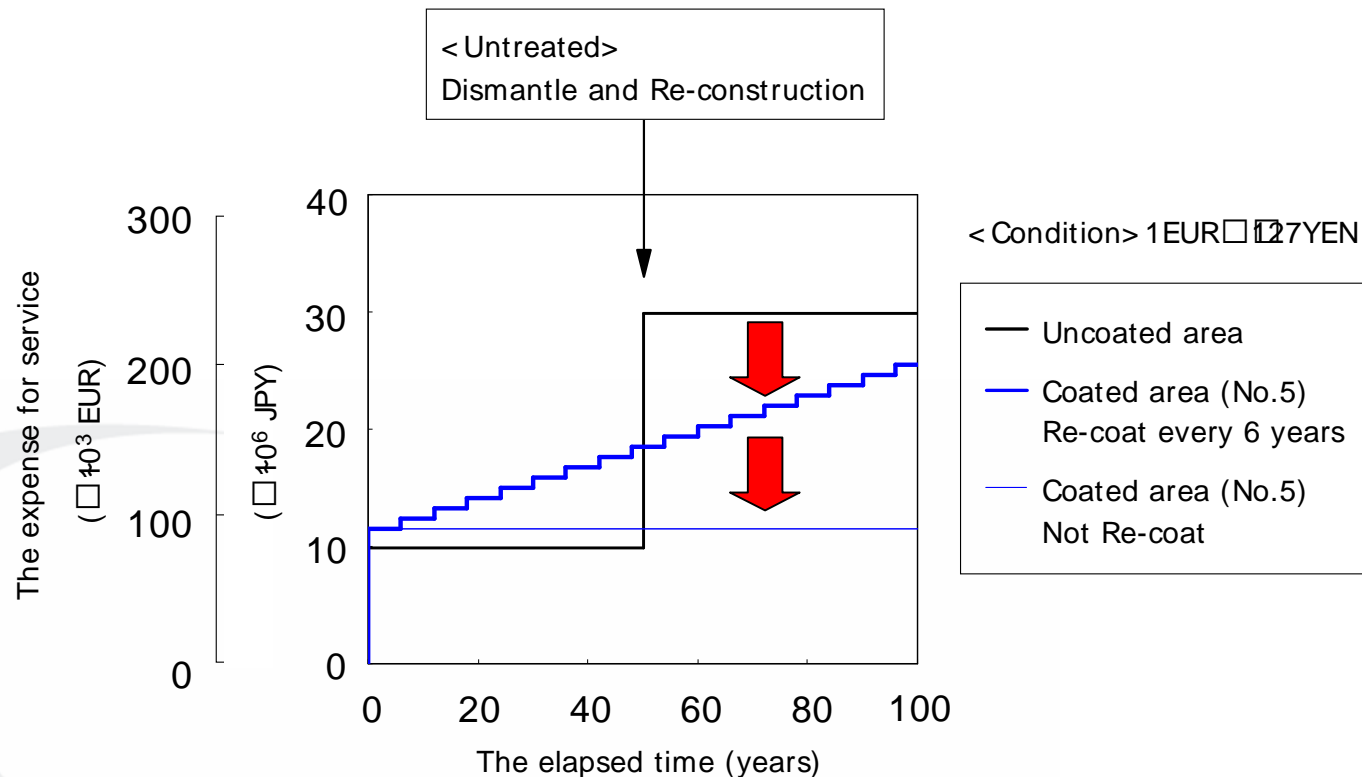


Spray a core section with water (No.5)

6. THE INVESTIGATIONS AND RESULTS

(4) TRIAL CALCULATION OF WHEEL GUARD MAINTENANCE COSTS FOR 100-YEAR SERVICE (COMPARE UNCOATED AND E.G. NO.5)

- Actual expenses may vary by conditions, but, in this research, the silane-type surface penetrants may help cut such expenses by between 15-60%.



7. CONCLUSION

- **Water absorption** was less coated area than uncoated area.
- The silane-type surface penetrants help delay of **scaling progress**, although trends vary by s kind of materials.
- The silane-type surface penetrants have ability to greatly retard **chloride ion supply**.
- According to this research, the silane-type surface penetrants can help lower **the maintenance cost of wheel guard for 100 year service** by 15-60%.

Thank you very much for your kind attention