



**IRF WORLD ROAD
MEETING 2017**

/ 14-17 NOVEMBER / DELHI / INDIA /

**MAINTENANCE STRATEGY OF
COATING SYSTEM FOR BRIDGES
LOCATED IN SEVERE CORROSIVE
ENVIRONMENT**

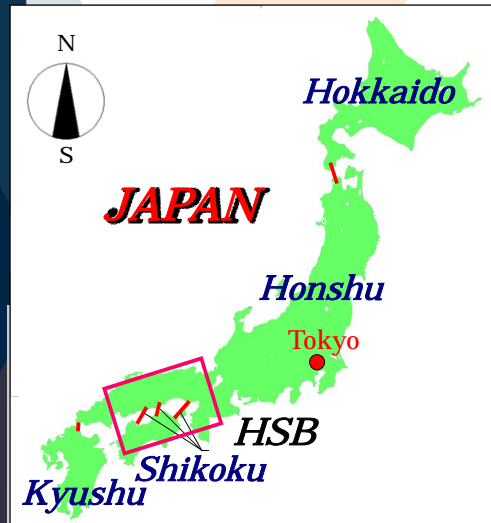
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1. Outline of HSB

Connects Honshu and Shikoku by 3 routes.
HSB consists of 17 long-span bridges,
including the Akashi Kaikyo Bridge.



2. Repainting Policy for Heavy-duty Coating System

Top layer <small>(weatherable)</small>	Polyurethane resin paint / Fluoropolymer paint	30 / 25 mm	255 / 250 mm
Third layer	Epoxy resin paint	30 mm	
Second layer (2)	Thick epoxy resin paint	60 mm	
Second layer (1) <small>(water proof)</small>	Thick epoxy resin paint	60 mm	
Base layer <small>(Galvanically protect)</small>	Inorganic zinc-enriched primer paint <i>↙ Mist coat for sealing</i>	75 mm	
Metal		<i>↙</i> ISO Sa2 1/2	

2. Repainting Policy for Heavy-duty Coating System

It is difficult to repaint the base layer on site.

on-site surface treatment for steel (ISO Sa2½)

on-site humidity for IZP (50%<RH%<80%)

It is expensive to repaint the all the layer on site.

\$170/m² for all layer repainting

\$ 55/m² for top and third layer repainting

2. Repainting Policy for Heavy-duty Coating System

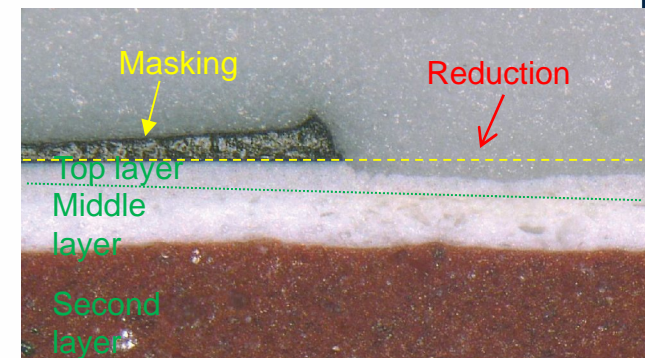
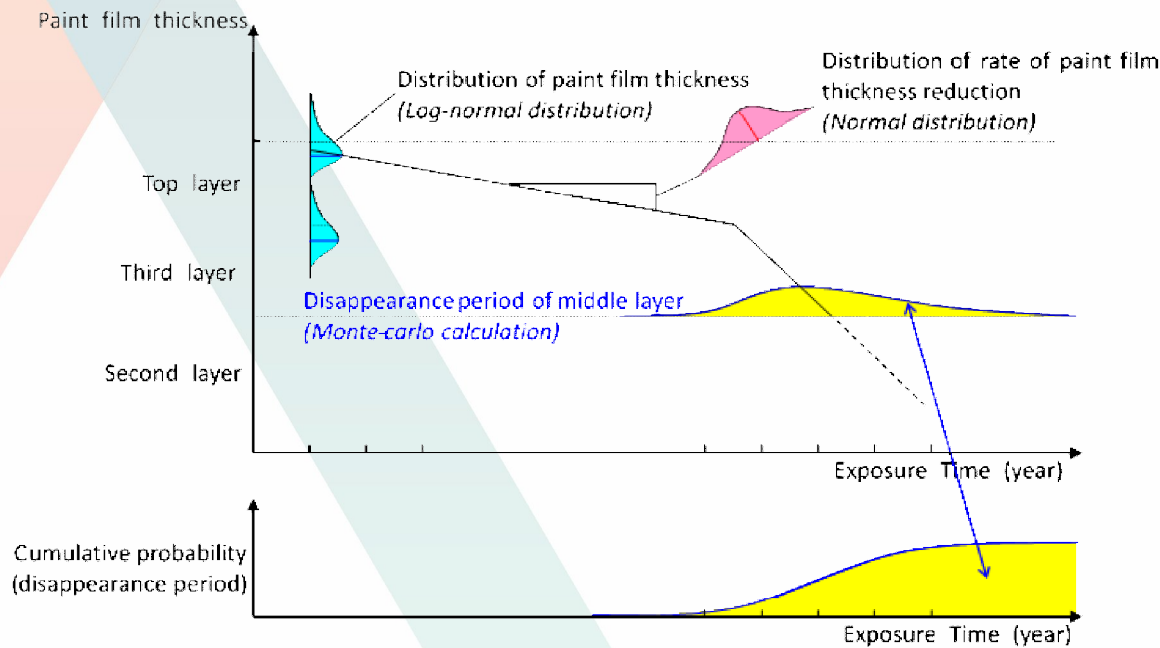
Top layer (Epoxy)	250 / 25 mm
Third layer (Epoxy)	250 mm
Second layer (Epoxy)	250 mm
Second layer (Epoxy)	250 mm
Base layer (Galvanized)	5 mm

委託者	本州四国連絡高速道路株式会社 抜出管理センター
業務名	平成20年度 抜出管内長大橋機能保全業務 (塗装塗装機能保全) 北備讃瀬戸大橋 (補剛桁)
内容	主横・主構 (仮設足場範囲) [東西] 中塗り塗装作業状況
受託者	(株)ブリッジ・エンジニアリング

3. Deterioration prediction method for heavy-duty coating system

HSBE developed the deterioration prediction method for heavy-duty coating system.

(considering the dispersion of remaining thickness and consumption rate of paint film)



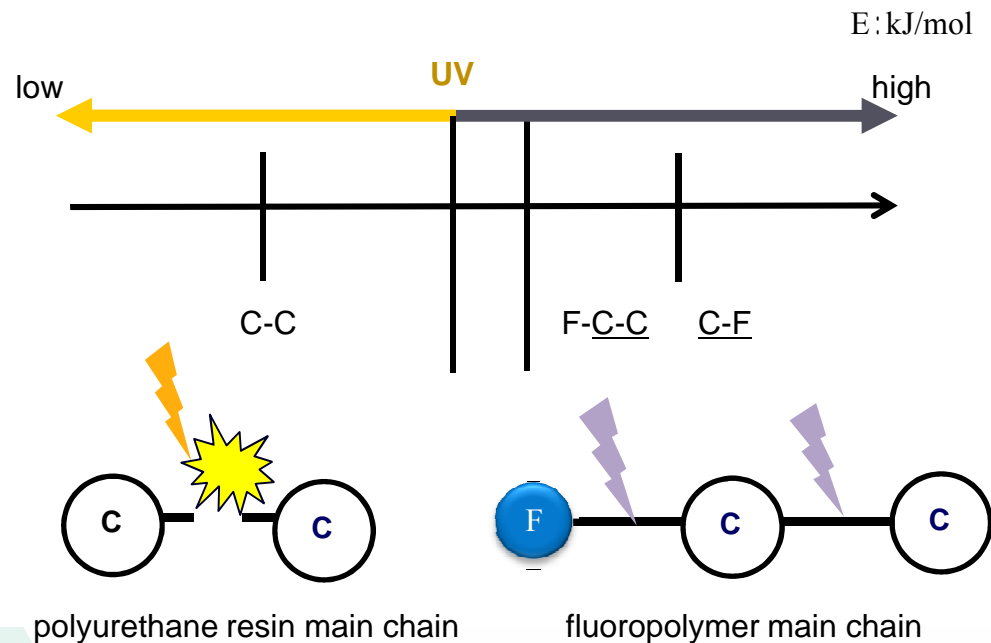
Honshu-Shikoku Bridge Expressway

4. Weather protection performance of Fluoropolymer Paint (FP)

- The high weathering performance paint, based on the latest findings/development at construction stage, is applied as a top layer of the heavy-duty coating system for HSB.
- Fluoropolymer paint (FP) was used instead of polyurethane resin paint (PP) after 1991.
consumption rate of paint film
PP:0.7 *mm/year* FP:0.5 *mm/year*

4. Weather protection performance of Fluoropolymer Paint (FP)

- Maximum photon energy of the UV of natural sunlight is larger than the bond energy of polyurethane resin main chain but smaller than the bond energy of fluoropolymer main chain.



4. Weather protection performance of Fluoropolymer Paint (FP)

on-site exposure (20 years)

Polyurethane resin paint



Minami Bisan-seto Bridge (1987-2007)

Fluoropolymer paint

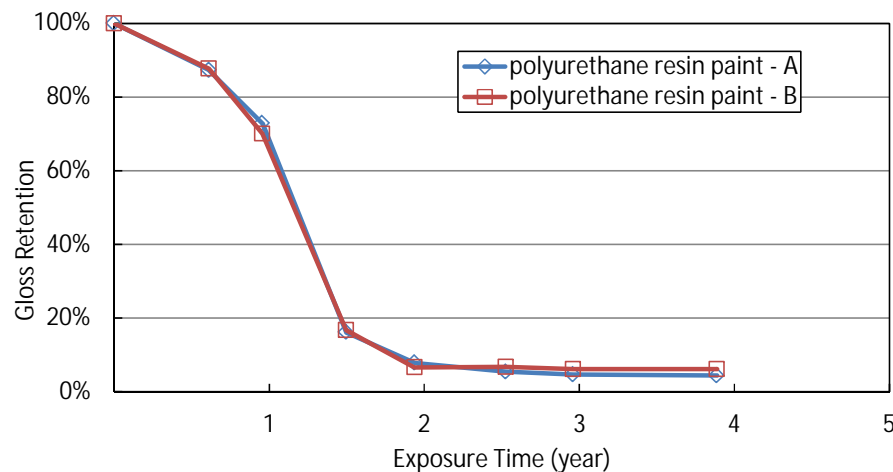


Akashi-Kaikyo Bridge (1995-2015)

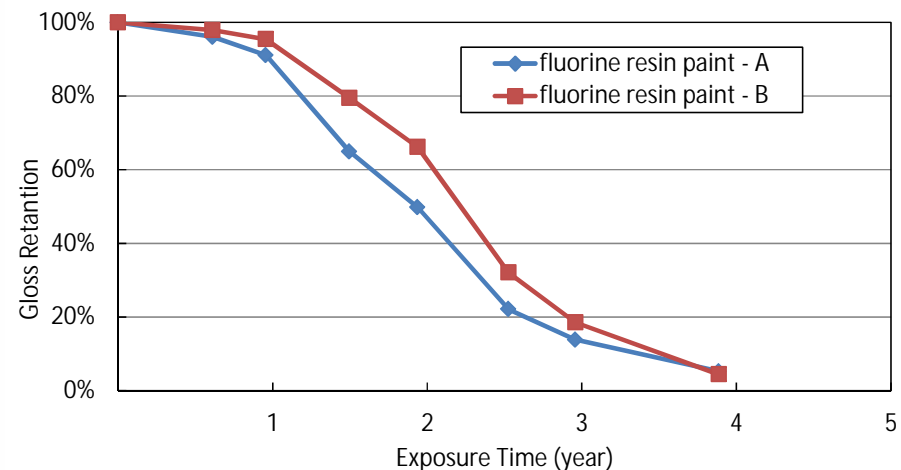
4. Weather protection performance of Fluoropolymer Paint (FP)

Result of weathering test at the Miyakojima island.
(most severe weathering condition in Japan)

Polyurethane resin paint



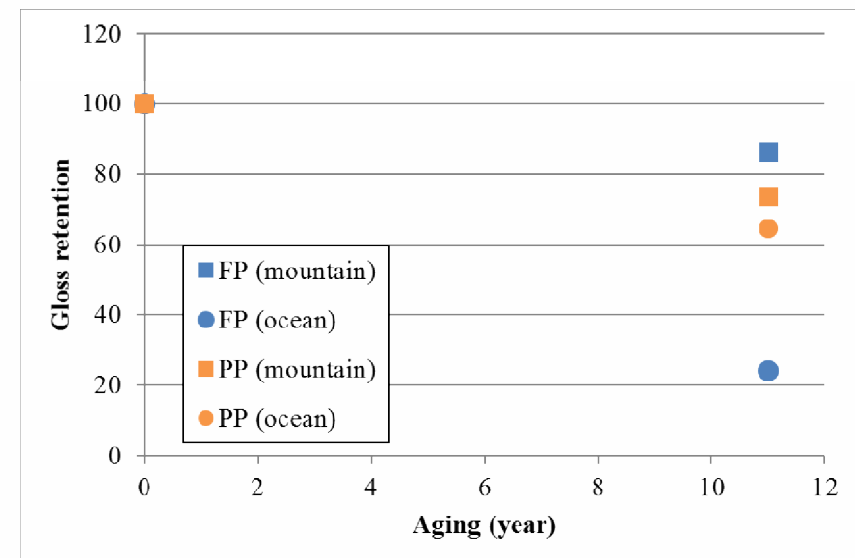
Fluoropolymer paint



Decrease of gloss retention of FP is slower than that of PP

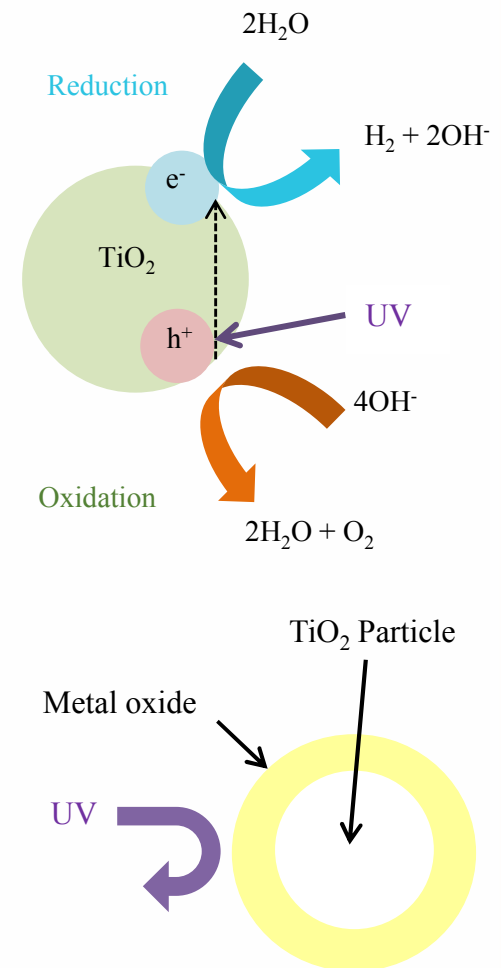
5. High durable FP

- The chalking of top layer was found at a bridge 10 years after repainting, though FP is supposed to have higher weathering performance than PP.
- In order to clarify this phenomenon, HSBE carried out various studies.



5. High durable FP

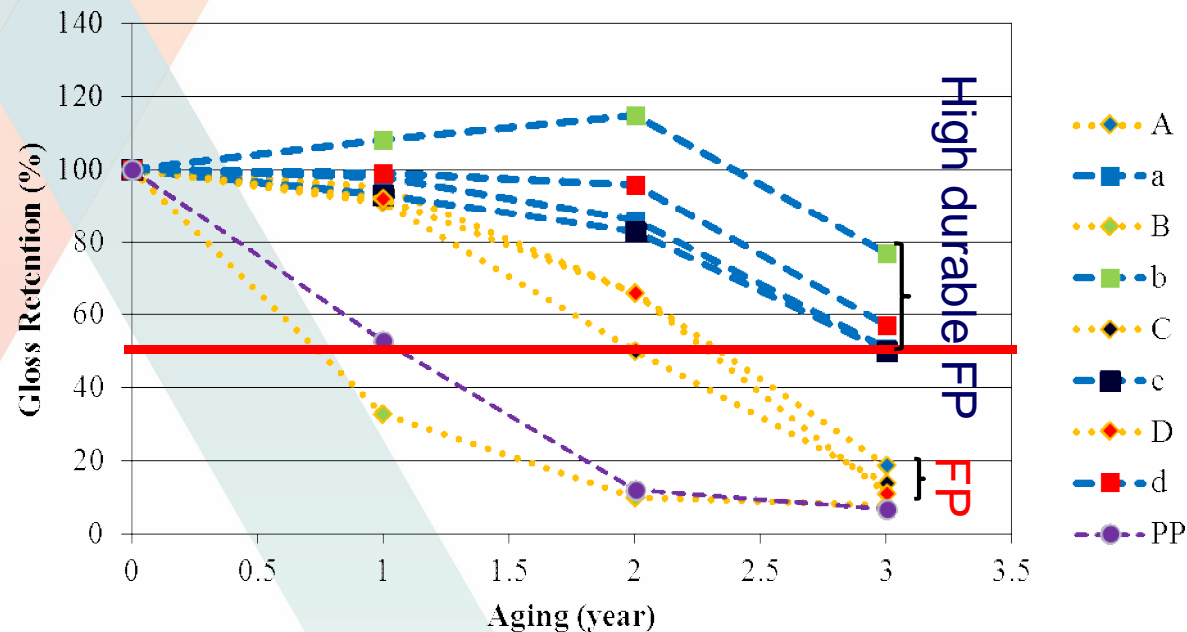
- As a result, it was found that the deterioration of fluoropolymer is caused by the **photocatalytic reaction of titanium(IV) oxide**, which is included in the light color paint.
- The **High durable fluoropolymer paint (HFP)**, which works against the photocatalytic reaction, was developed



5. High durable FP

Result of weathering test at the Miyakojima island.

A-D: FP, a-d: high durable FP



The interim standard for “High durable fluoropolymer paint for top layer” was established as “HBS K 5630-2010” (the gloss retention that shall be kept over 50% after 3 years)

6. Thick Film paint system for repainting

- VOC (Volatile Organic Compounds) will be reduced by 20 ~ 50%.
- Repainting work cost and period will be reduced (including cost for scaffolding and labor etc...).

Layer	Current	thickness	Thick film paint
Top layer	Fluoropolymer paint	25 μm	Thick film paint
Third layer	Epoxy resin paint	30 μm	(Total 55 μm)
Second layer (2)	Epoxy resin paint	60 μm	Epoxy resin paint
Second layer (1)	Epoxy resin paint	60 μm	Epoxy resin paint
Base layer	IZP	75 μm	IZP
Metal			

Weathering test



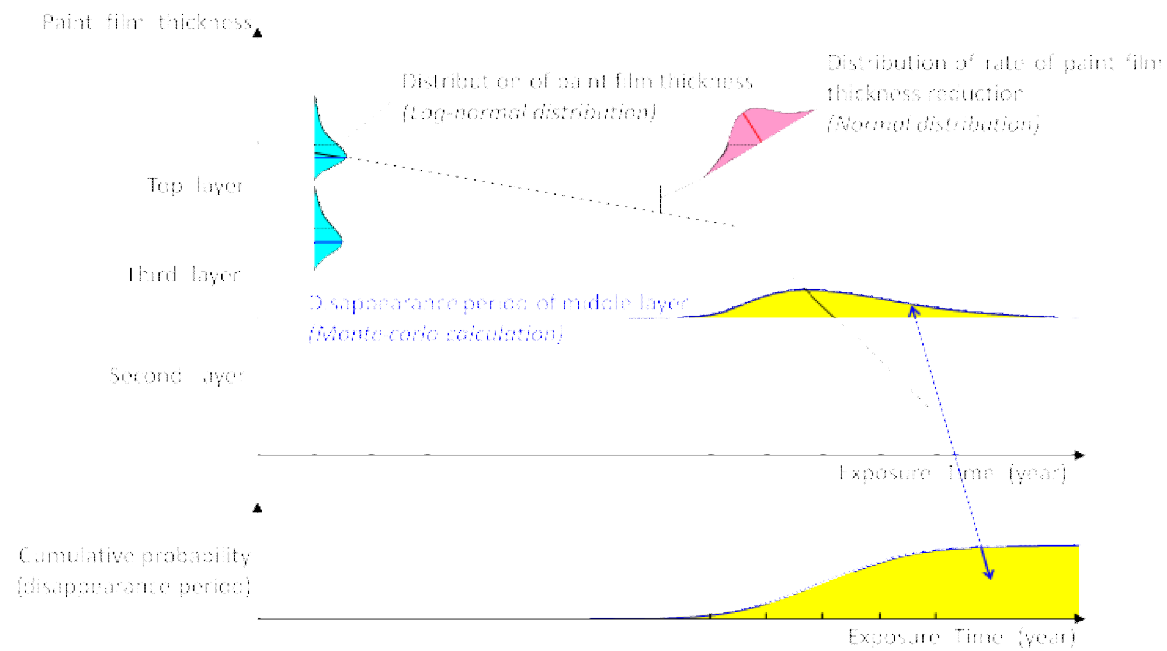
Akashi-Kaikyo Bridge

7. Conclusion

- The repainting cycle by preventive maintenance is based on the deterioration prediction of paint film.
- The repainting cycle by preventive maintenance is able to be extended by using the Fluoropolymer Paint instead of Polyurethane resin Paint.
- “Highly durable Fluoropolymer Paint”, which works against the photocatalytic reaction by the titanium oxide, was developed.
- We will continue the development of thick film paint .

Thank you for your kind attention !





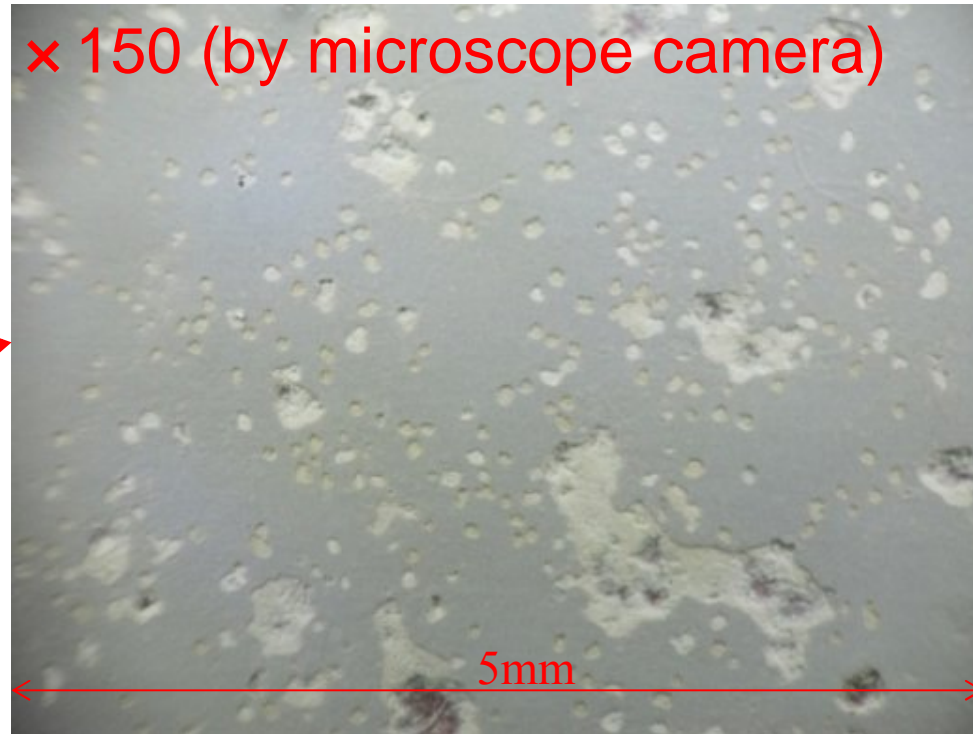
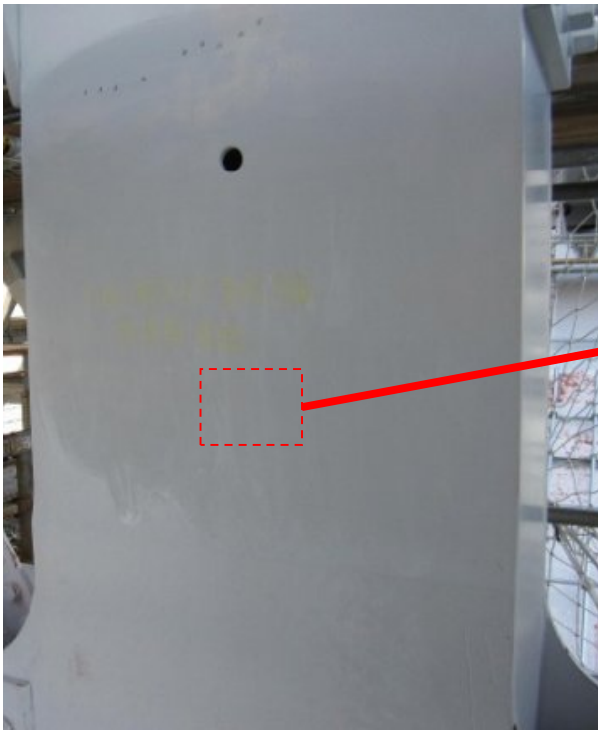
It is expensive to repaint the all the layer on site.

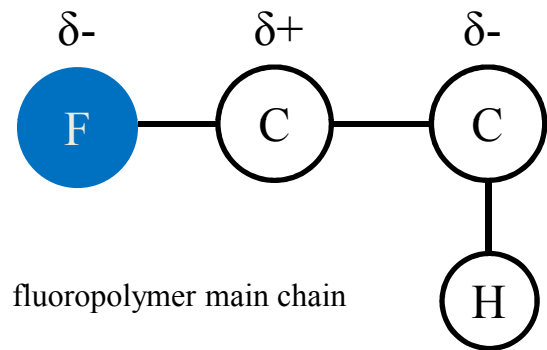
\$170/m² for all layer repainting

\$ 55/m² for top and third layer repainting

Example of local peeling of paint

Minami Bisan-seto Bridge (difficult to find by visual inspection)





Electronegativity

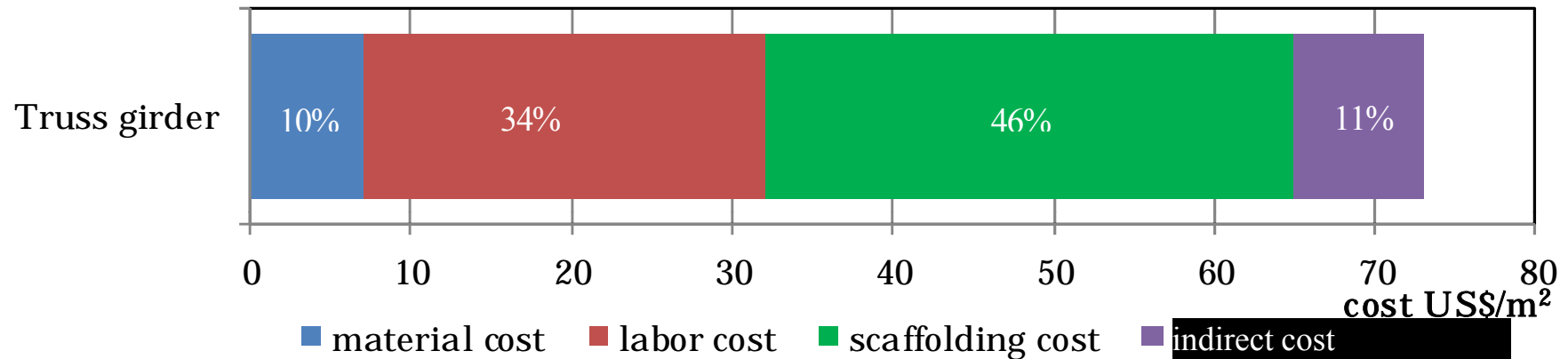
Easy to receive one electron.

Hard

Easy

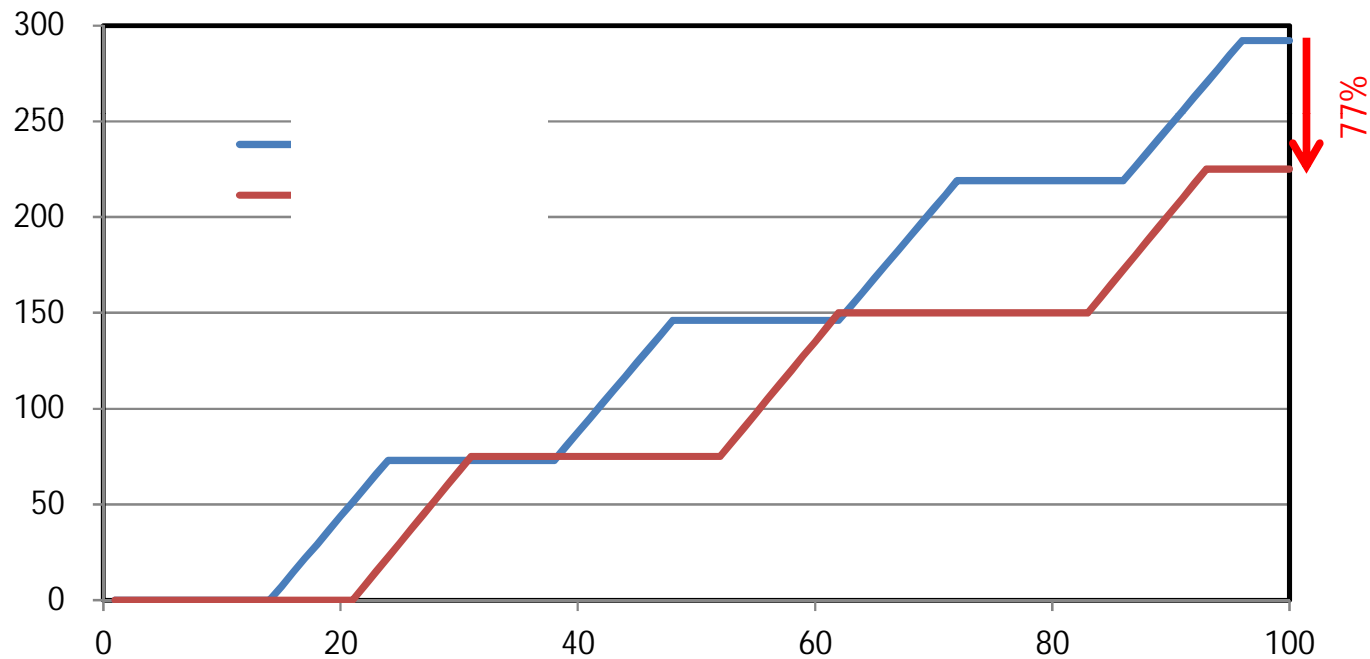


Breakdown of repainting cost

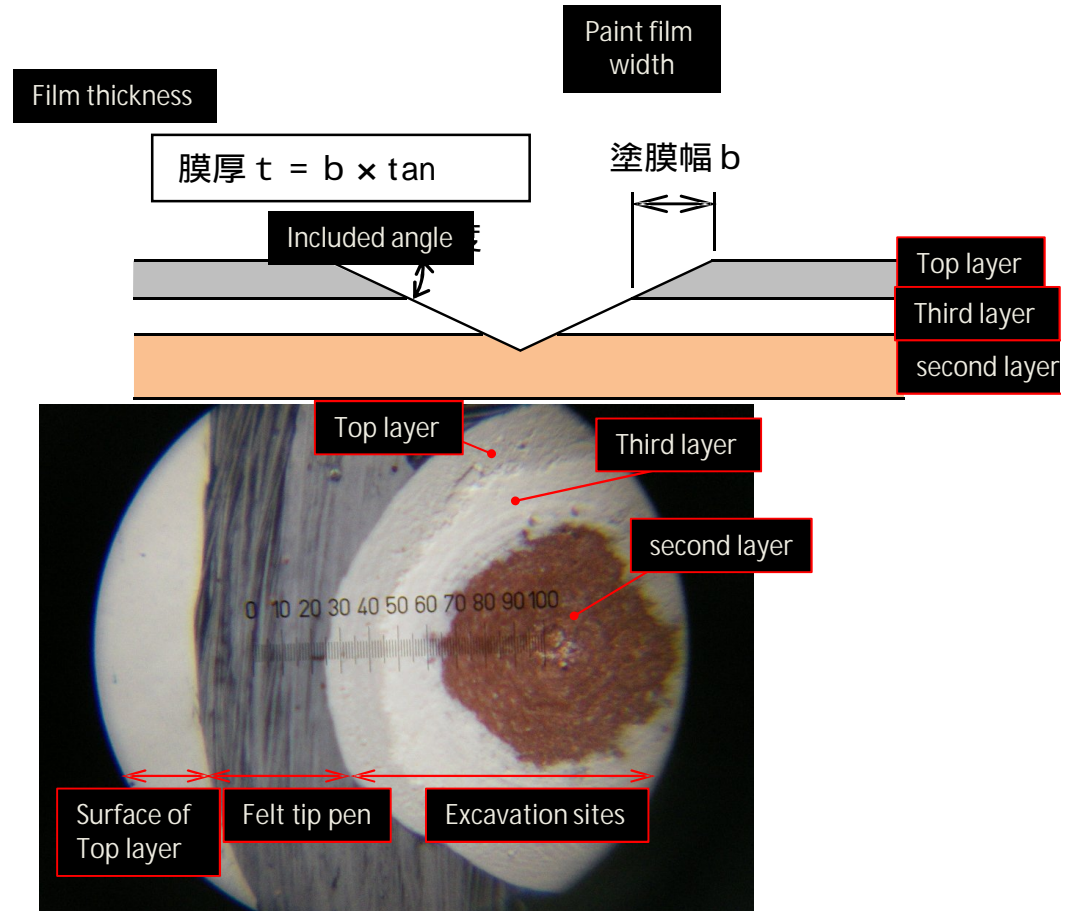


Cost reduction effect of FP

The life cycle cost for 100 years is reduced over 20% .
(repainting area = 1,000,000m²)



On-site inspection



Cost reduction effect of FP

Calculation condition/result of deterioration prediction

Material	Item	Remaining thickness		Consumption rate	Exposure time (lower layer)
		Top layer	Middle layer		
PP	Probability distribution model	Log-normal	Log-normal	Normal	24 years
	Mean	25mm	30mm	0.7mm/year	
	Coefficient of variation	0.4	0.4	0.3	
FP	Probability distribution model	Log-normal	Log-normal	Normal	31 years
	Mean	25mm	30mm	0.5mm/year	
	Coefficient of variation	0.4	0.4	0.3	

The repainting cycle of FP can be 1.3 times longer than that of PP.

Since the HFP of weathering test has been exposed only five years and the consumption is very small, repainting cycle of HFP is not calculated yet.