

Development of Process-Saving Paint for Steel Structures



Metropolitan Expressway Company Limited
Shutoko Engineering Company Limited
Japan Engineering Corporation

Masahiro Ishibashi
Yoshifumi Nagata
Tetsuo Masakado

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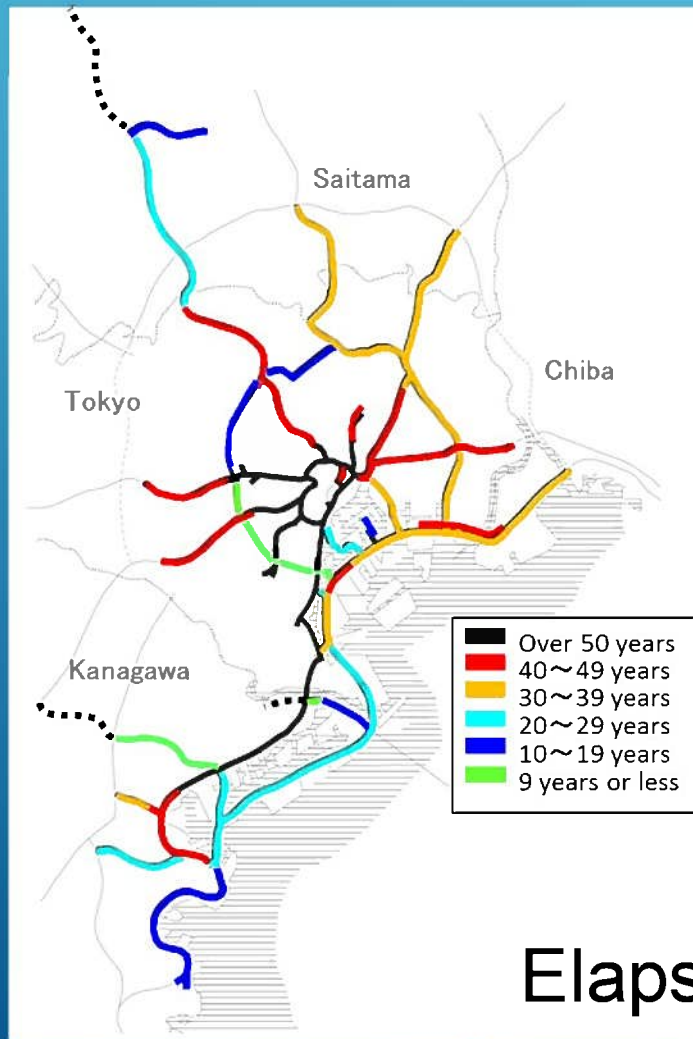
Development of a process-saving paint



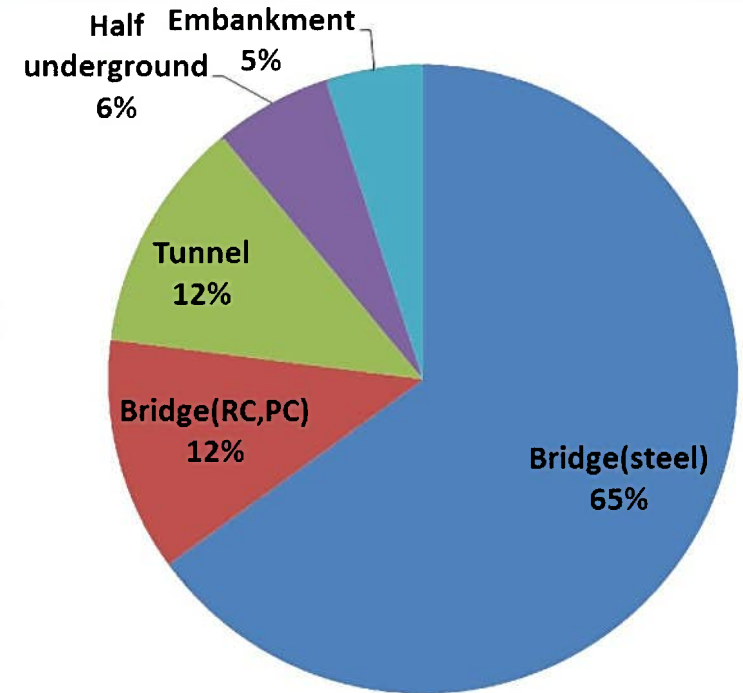
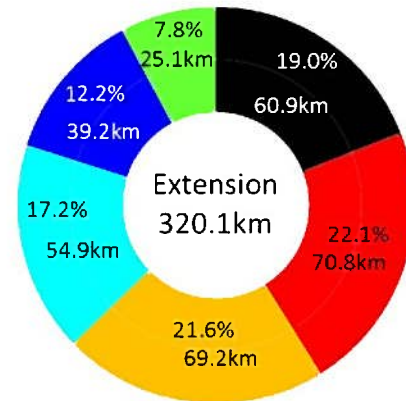
Overview of the Metropolitan Expressway

10.6% of line extensions over 50 years

The extension of viaduct is very high at 65%



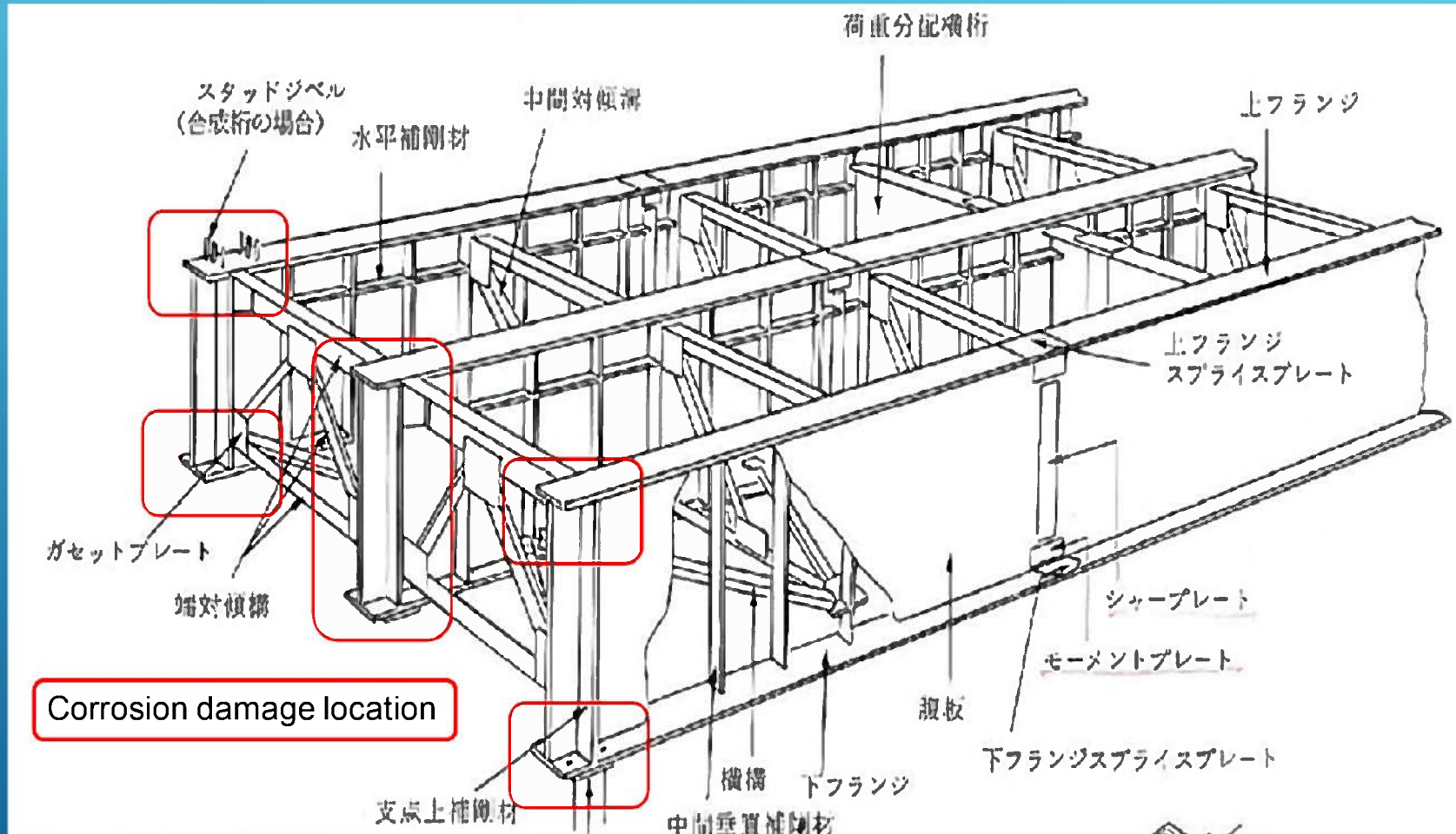
Elapsed years



Comparison of structure types

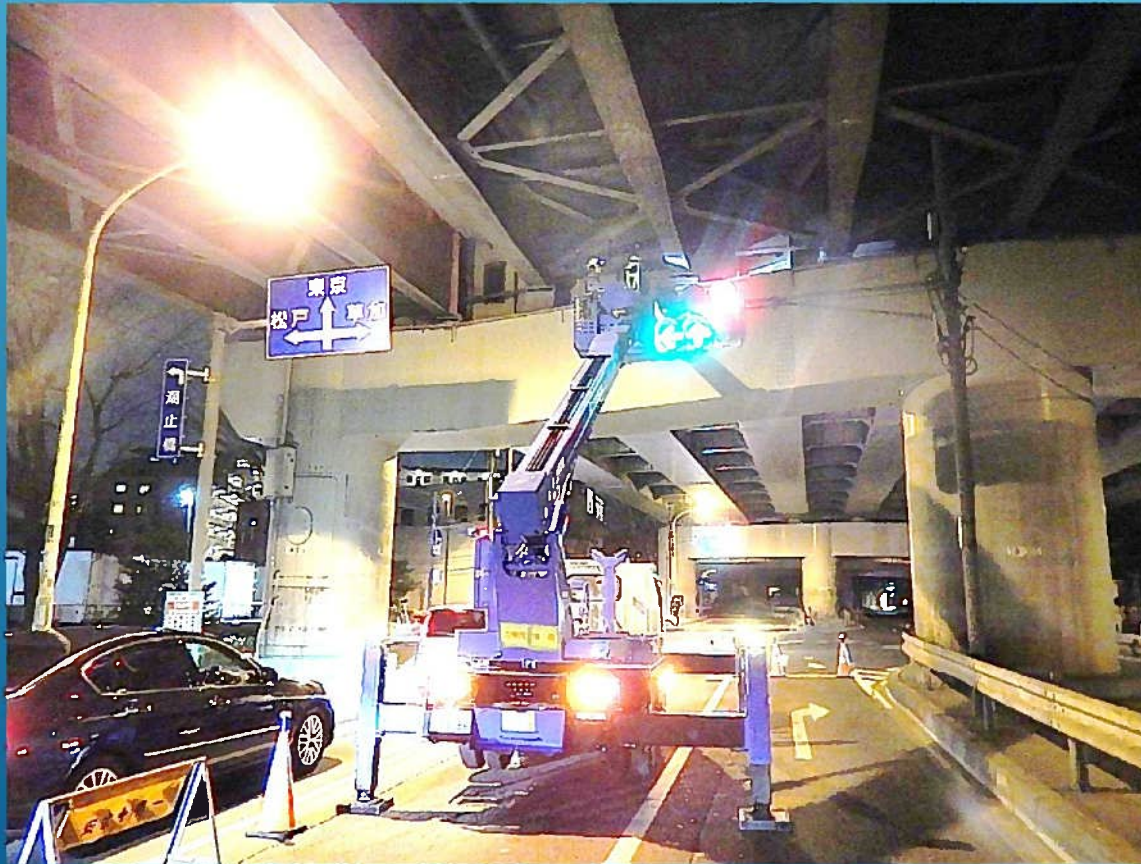
Damage status of steel girders

Corrosion damage location



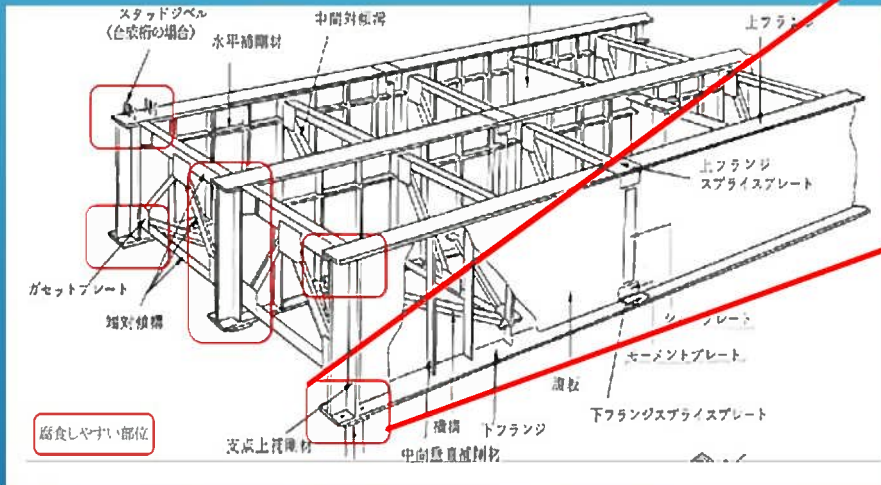
Damage status of steel girders

Difficult to approach corrosion damage
Night street regulations
an aerial work truck
Narrow working space



Damage status of steel girders

partial and small-scale corrosion



Damage status of steel girders



Corrosion damage repair

case study
a total of five coats



As the painting process requires 1 coat per day for a total of 5 days, with lane closures required each day, it imposes a significant burden in terms of time and money.



paint system	surface preparation	painting process	paint name	amount used g/m ²	layer number	painting interval
NS-P3 (Tokyo Metro Express Standard)	cleaning type 3	undercoat (first)	modified epoxy-based resin paint ※	(200)	1	1 day ~ 10 days
		undercoat (second)	modified epoxy-based resin paint	200	2	1 day ~ 10 days
		undercoat (third)	super thick film type epoxy-based resin paint	500	3	1 day ~ 10 days
		undercoat (fourth)	super thick film type epoxy-based resin paint	500	4	1 day ~ 10 days
		intermediate and final coat	thick film type epoxy-based resin paint	230	5	1 day ~ 10 days

※for the exposed parts

Corrosion damage repair

various types of process-saving paints began to be adopted experimentally in these specifications.



However, as the locations that were repaired using the process-saving paints began to exhibit corrosion again a few years later.

we conducted verification testing to compare the durability of different paints with the goal of selecting a more durable process-saving paint.

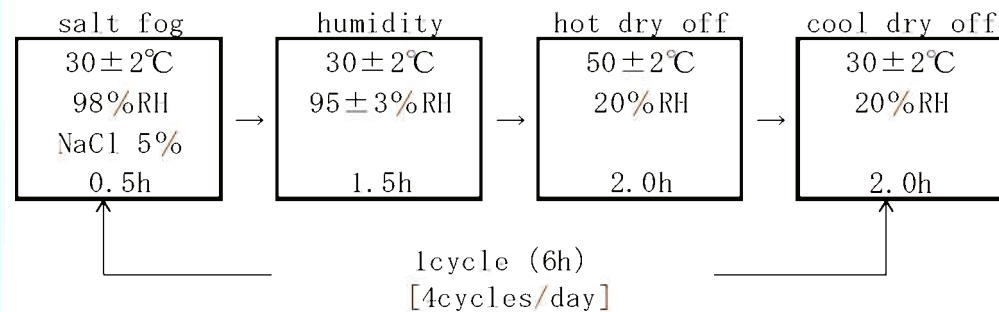
Durability comparison and verification tests

Flow of verification test



Durability comparison and verification tests

Test method close to real environment



test conditions	transition time
salt fog to humidity	within 10 minutes
humidity to hot dry off (50°C)	within 15 minutes
hot dry off (50°C) to cool dry off (30°C)	within 30 minutes
cool dry off (30°C) to salt fog	instantly

Combined cyclic corrosion test conditions



Testing machine

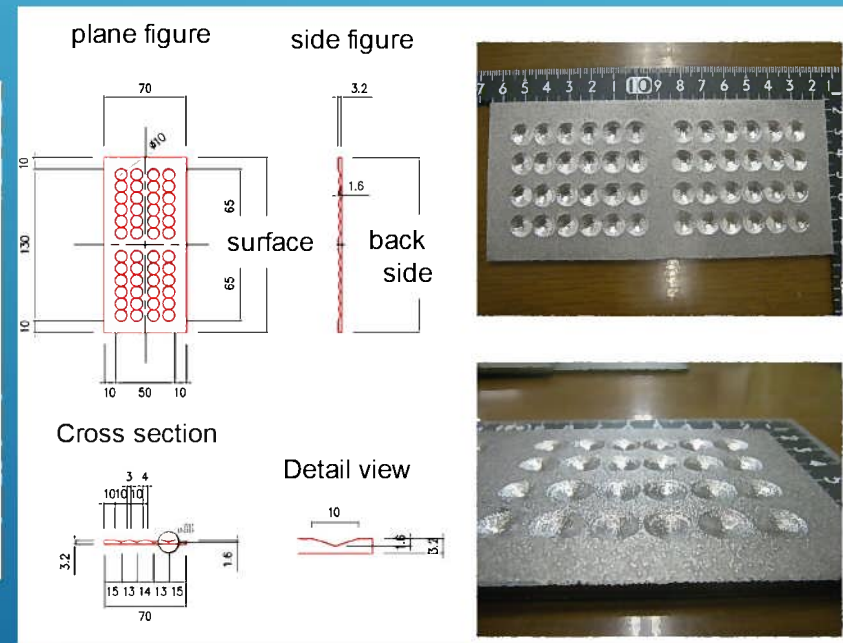
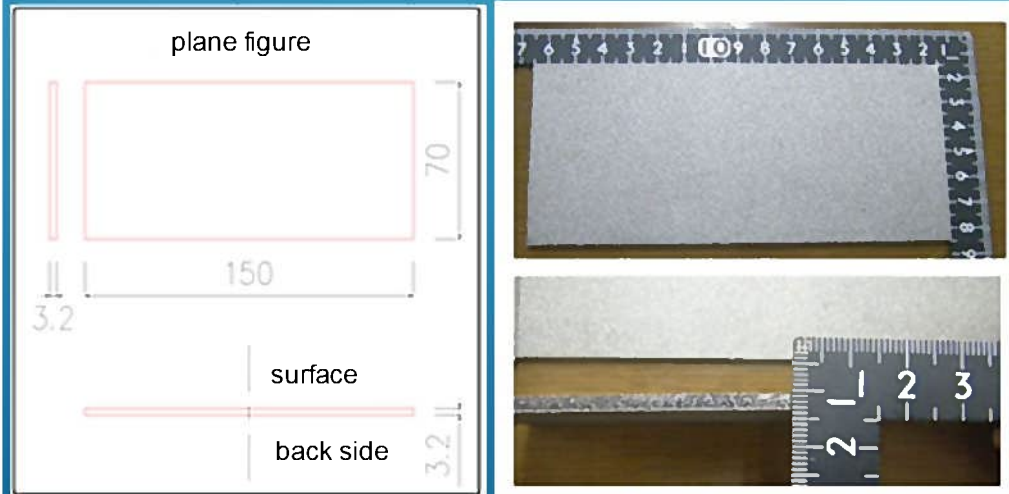
Exposure time(h) : max 180 days (4,320 hours)、720 cyclic
 Check : Every 7days (168 hours)

Durability comparison and verification tests

Repaint the damaged part of the existing structure.

We devised to make it closer to on-site conditions.

In order to reproduce the partial thickness reduction of steel due to corrosion, it was used as an uneven test piece

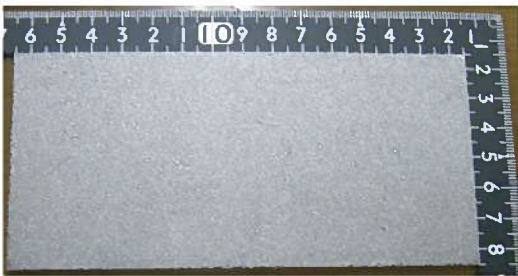
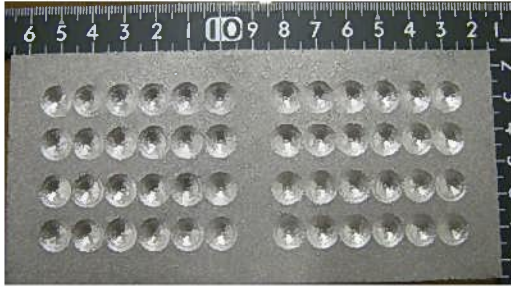




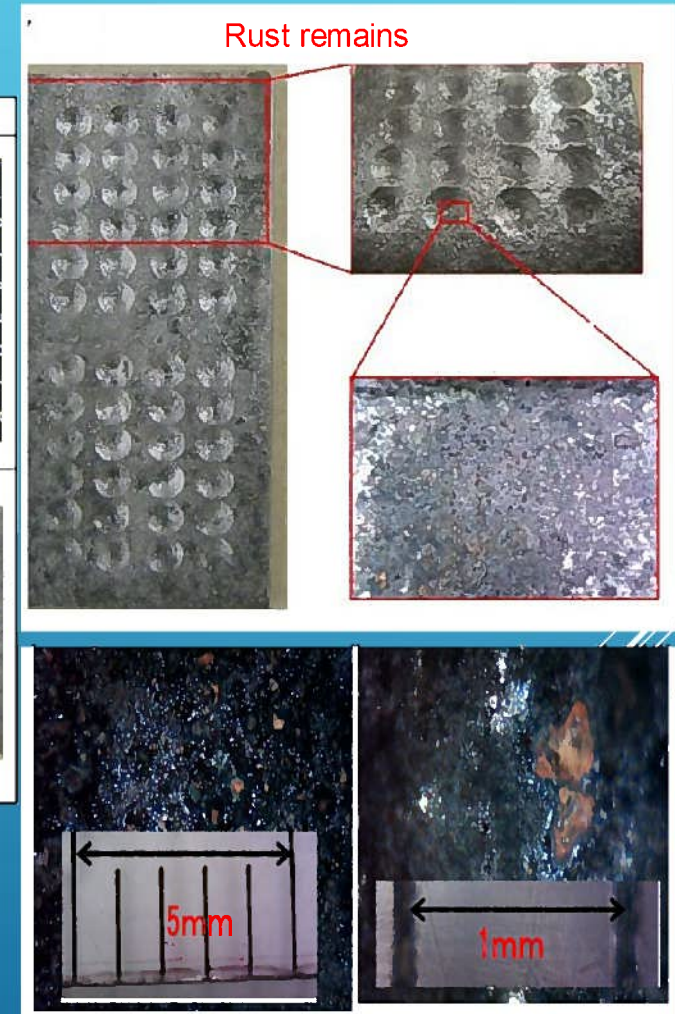
Durability comparison and verification tests

- ① cleaning type 1 (blasting)
- ② cleaning type 3 (disk grinder processing)



Durability comparison and verification tests

		standard test specimen	bumpy test specimen
surface preparations	cleaning type 1		
	cleaning type 3		



Cleaning type 3

Durability comparison and verification tests

Test paints (process-saving paints)

sign	process-saving paints (test paints)	undercoat total number of coats	undercoat total thickness μ m	undercoat total working time	surface preparation cleaning type 1 (expousure time 4,320h)		surface preparation cleaning type 3 (expousure time 2,160h)	
					standard test specimen	bumpy test specimen	standard test specimen	bumpy test specimen
A	solvent-free	2	150	1 day	○	○	○	○
B	zinc-based	2	400	1 day	○	○	○	○
C	magnetite-based A	2	45	2 days	○	○	○	○
D	aluminum-based	1	70	1 day	○	○	○	○
E	magnetite-based B	1	70	1 day	○	○	—※1	○
F	solvent-free epoxy resin	1	1,000	1 day	○	○	—	—

※1 no-tested

Durability comparison and verification tests

Cleaning type 3		0 h		720 h		1,440 h		2,160 h	
		standard	bumpy	standard	bumpy	standard	bumpy	standard	bumpy
A	solvent-free								
B	zinc-based								
C	magnetite-based A								
D	aluminum-based								
E	magnetite-based B	-		-		-		-	
F	solvent-free epoxy resin								








































Corrosion progresses

Quality standards
(Tokyo Metropolitan Expressway)

cyclic corrosion test				criteria
test paint			exposure time (h)	
epoxy-based undercoat paint	single paint film	ordinary part	720h (30days)	showing no abnormalities
		cross-cut part		crack & blistering widths $\leq 4.0\text{mm}$

Durability comparison and verification tests








































Cleaning type 1, standard test specimen

		0 h	720 h	1,440 h	2,160 h	2,880 h	3,600 h	4,320 h
A	solvent-free							
B	zinc-based					cancel	cancel	cancel
C	magnetite-based A							
D	aluminum-based							
E	magnetite-based B							
F	solvent-free epoxy resin							

Corrosion progresses

Durability comparison and verification tests

Cleaning type 1, bumpy test specimen

		0 h	720 h	1,440 h	2,160 h	2,880 h	3,600 h	4,320 h
A	solvent-free							
B	zinc-based					cancel	cancel	cancel
C	magnetite-based A							
D	aluminum-based							
E	magnetite-based B							
F	solvent-free epoxy resin							

Corrosion progresses

Durability comparison and verification tests

Width of deterioration of the cut part

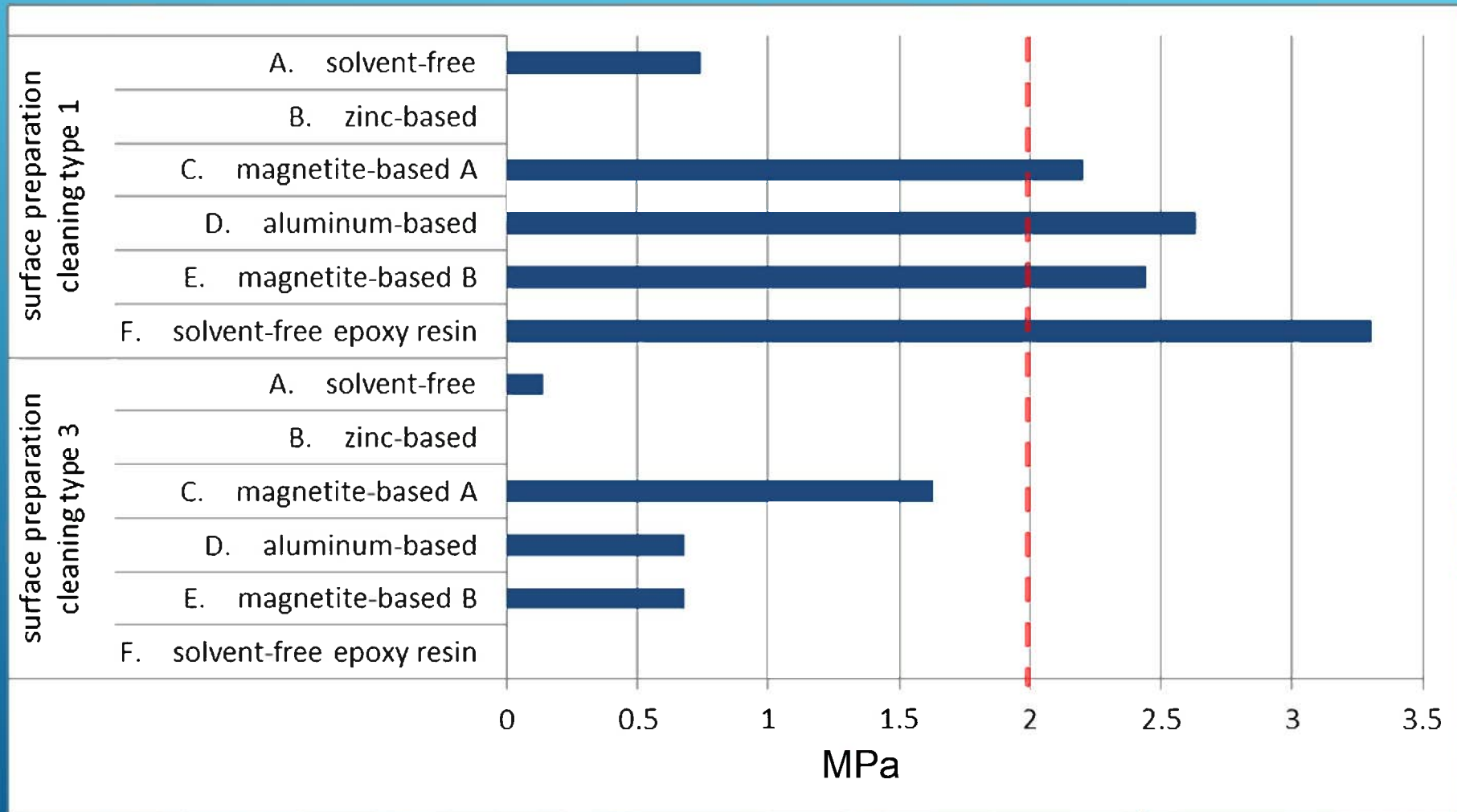
bumby test specimen		exposure time (h)					
		720	1,440	2,160	2,880	3,600	4,320
surface preparation cleaning type 1	A solvent-free	0.45	0.75	5.00	5.00	5.00	5.00
	B zinc-based	0.45	0.45	0.45	Paint peeling		
	C magnetite-based A	0.45	0.65	1.80	1.00	2.00	3.00
	D aluminum-based	0.50	0.95	0.70	7.00	9.00	9.00
	E magnetite-based B	0.45	0.60	1.30	7.00	7.00	7.00
	F solvent-free epoxy resin	0.45	0.45	0.45	0.45	0.45	0.45
surface preparation cleaning type 3	A solvent-free	0.5	0.6	0.7	-	-	-
	B zinc-based	0.45	0.45	0.45	-	-	-
	C magnetite-based A	0.45	0.45	0.5	-	-	-
	D aluminum-based	0.45	0.55	0.7	-	-	-
	E magnetite-based B	0.45	0.5	0.7	-	-	-
	F solvent-free epoxy resin	-	-	-	-	-	-

unit: mm

Durability comparison and verification tests

Paint adhesion

Cleaning type 1 was inferior to cleaning type 3.



Durability comparison and verification tests

In our testing, most of the paints satisfied the standards of the Tokyo Metropolitan Expressway . namely, **at 30 days (720 h) of cycle testing, the paints showed no abnormalities**, and the width of cracking and blistering was less than 4.0 mm.

However, beyond 30 days, most of the paints showed reduced durability. In contrast, **the solvent-free epoxy resin paint**, whose durability did not degrade even **after 180 days (4,320 h) of cycle testing**, proved to be a highly durable process-saving paint.

Improvements to solvent-free epoxy resin paint

【 Outline of solvent-free epoxy resin paint 】

Solvent-free ultra-thick film type epoxy resin paint.

Application of 1,000 μ m or more is possible with one layer.

Paint that combines the corrosion resistance of epoxy resin with the wear resistance of ceramic powder.

This paint used for painting on bows.



pot life (25°C)	20 minutes
curing time (25°C)	16 hours
heatproof temperature	180°C
ignition point	none
flash point	main agent: 204.4°C curing agent: 93.3°C
fire service act (in Japan)	main agent: designated combustibles curing agent: dangerous goods 4-class /petroleums III

Improvements to solvent-free epoxy resin paint

Workability problems and improvements


















	workability problems	after improvement
① viscosity	high viscosity and unsuitable for brushing	reduced viscosity to brush paint
② pot life	short (20 minutes)	improve to 50~60 minutes
③ curing time	long (16 hours)	improve to 8 hours (top coating is possible in 10 minutes)

Improvements to solvent-free epoxy resin paint

We improved its workability by changing the mixing ratio of the main agent and the curing agent. Owing to the possibility that our improvements might change the durability of the paint, we performed durability verification testing (combined cyclic corrosion testing) of the improved paint.

The adhesion test results were between 2.68 and 8.93 MPa, satisfying the standard of 2.0 MPa required for adhesion, and demonstrating that the durability did not change after the improvements.



symbol	exposure time	0 hour (0 day)	2,160 hours (90 days)	4,320 hours (180 days)	6,480 hours (270 days)	8,640 hours (360 days)
F-1	bumpy test specimen					
F-2						
F-3	standard test specimen					

Improvements to solvent-free epoxy resin paint

Construction status



Improvements to solvent-free epoxy resin paint

paint system	surface preparation	painting process	paint name	amount used g/m ²	layer number	painting interval
NS-P3 (Tokyo Metro. Express. Standard)	cleaning type 3	undercoat (first)	modified epoxy-based resin paint ※	(200)	1	
		undercoat (second)	modified epoxy-based resin paint	200	2	1day ~10days
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※for the exposed parts



Reduced installation time by 4 days

painting process	paint name	paint system	amount used g/m ²	layer	painting method	painting interval
undercoat	solvent-free epoxy resin paint	-	1,000	1	brushing	10minutes ~
finalcoat	water-based polyurethane resin paint	SDK W-531 ※	120	1		

※ Tokyo Metropolitan Expressway Standard

Conclusions

We conducted durability comparison and verification testing with the goal of applying a more durable process-saving paint for partial and small-scale corrosion damage repair. Our testing confirmed that the solvent-free epoxy resin paint had excellent durability.

but because it was ultra-thick, its workability was low. Therefore, we made improvements to the paint to enhance its workability.

Applying this paint, we were able to repair the affected areas in only one day of work, compared with the five days that were required in the past.

Thus, it was possible to reduce costs by 70% and work time by 80%.

An aerial photograph of a dense urban area, likely in Japan, featuring a complex multi-level highway interchange with several curved ramps. The surrounding city is filled with numerous high-rise buildings and smaller structures. The image is framed by a light blue header and a darker blue footer with a white diagonal line.

Thank you for your attention