

MLIT

New technology information provision system (NETIS)

Registration number QSK-080005-A

An Alternative Salt Damage prevention method to replace the electrochemical corrosion prevention method for concrete

Concrete structure reinforcing steel corrosion prevention method
(GF protect method)

(SLAG LEAD method)

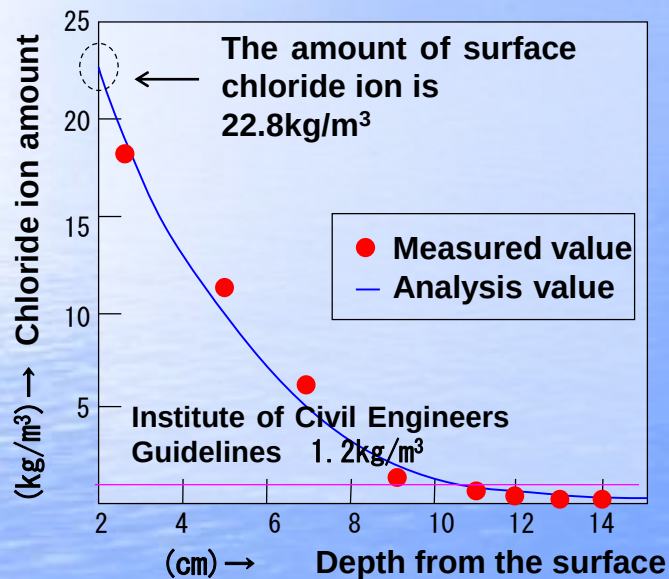
- **Summary of R & D**

For the purpose to prolong the life of concrete structures due to neutralization or salt damage. To prevent the corrosion in the reinforcing steel using nitrite and to maintain the structures by cross-section restoration using an embedded mold etc which are environmentally friendly methods to repair / reinforcement.

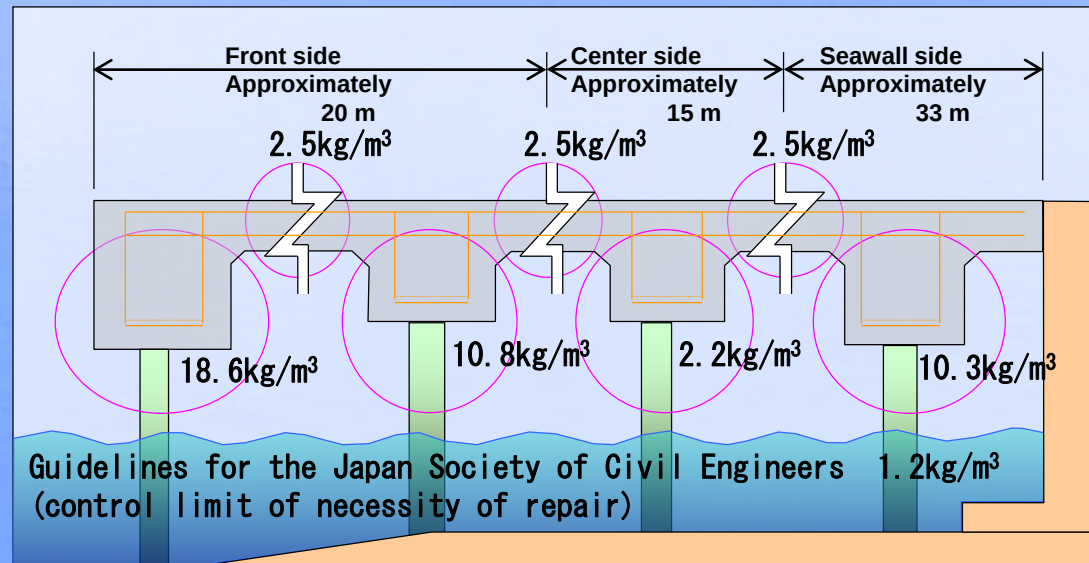
① Background

■ If there is chlorine ion in the reinforced concrete, the passive film of the reinforcing steel will be destroyed and a large damage such as deterioration of the concrete will occur

■ Relation between the depth from the surface and the amount of chloride ion



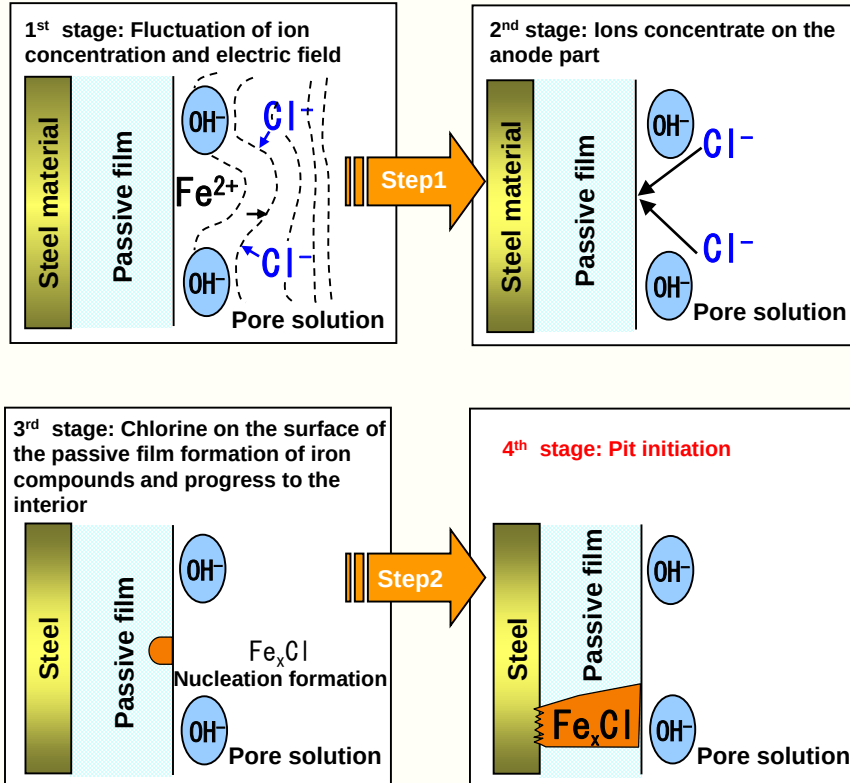
■ Illustration of surface chloride ion content on quay (pier / pier)



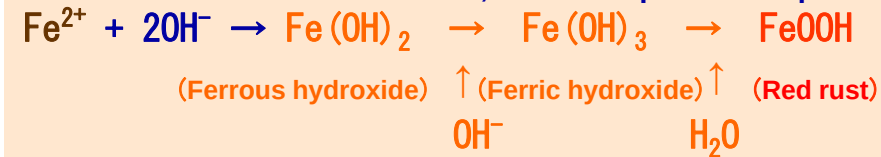
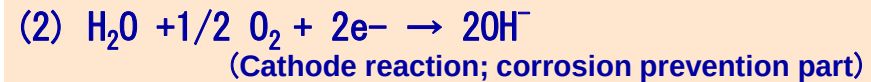
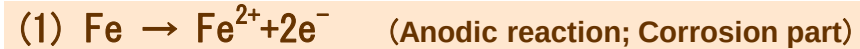
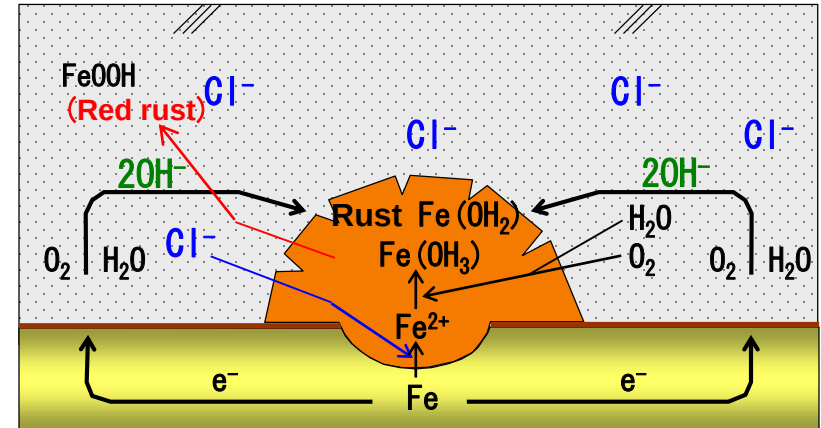
■ Reinforcing material incorporation (nitrite) Mortar (grout) establishes rebuilding technique of reinforcing steel passive film, protects rebar from chlorine ions remaining inside the existing concrete structure, and corrosion newly ingress from the outside We developed a method to eliminate or reduce factors.

② Corrosion potential of Reinforcing Bar

If the reinforcing bar inside a good condition concrete, the corrosion is less likely to occur because of the high alkalinity that concrete shows, because it forms "passive film" on the surface of it.



However, due to neutralization and salt damage (concrete pH decreases or a certain amount of Cl⁻ ion exists), destruction of this passive film breaks the electrochemical equilibrium and corrosion of reinforcing bar begins.



(Copper - copper sulfate electrode)

-126~-150
-151~-175
-176~-200

-201~-225
-226~-250
-251~-275
-276~-300
-301~-325
-326~-350

-351~-375
-376~-400
-401~-425

(mV)

(Pb Electrode)

+675~+651
+650~+626
+625~+601

+600~+576
+575~+551
+550~+526
+525~+501
+500~+476
+475~+451

+450~+426
+425~+401
+400~+376

(mV)

More than 90%
Corrosion Won't
Occur.

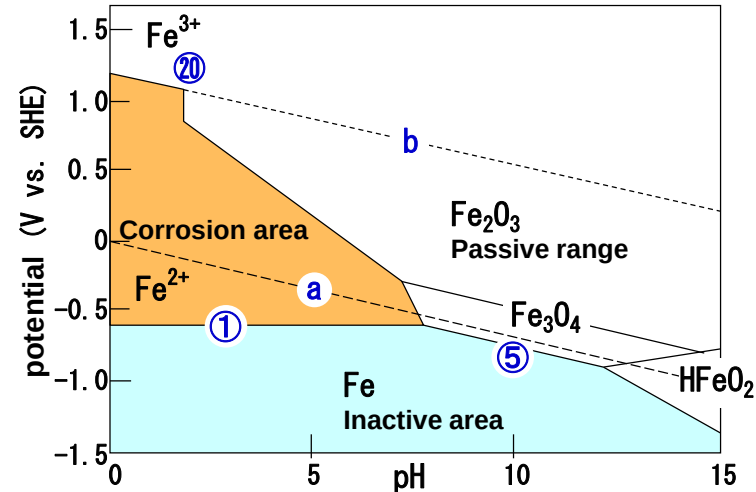
Corrosion
uncertainty

More than 90%
Corrosion will Occur

(Corrosion evaluation
standard of ASTM C 876)

Relation between the Iron potential-pH and Mechanism of the electrical corrosion prevention

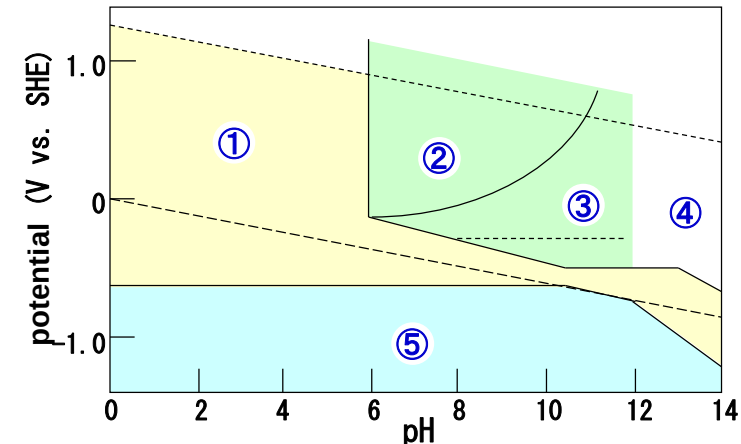
(a) Calculated value by chemical thermodynamics



a Hydrogen generation, b Oxygen reduction

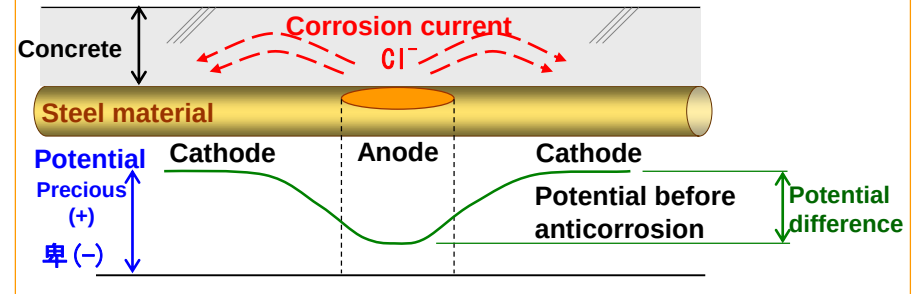


(b) Local corrosion occurrence in an environment containing 10⁻² M NaCl

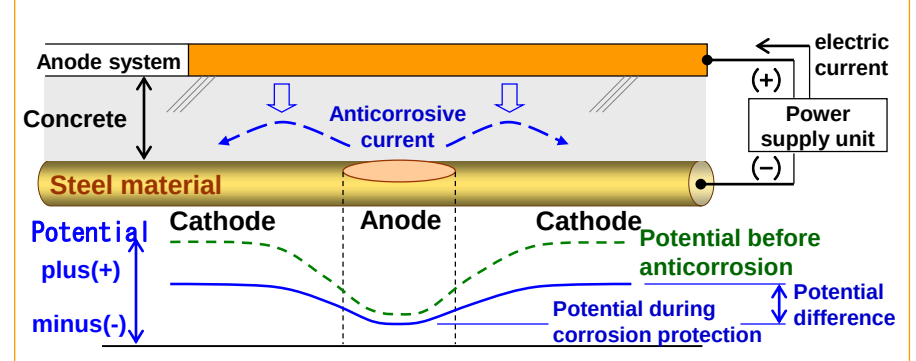


① Overall corrosion area ② Pitting area ③ incomplete Passive range
④ Complete passive range ⑤ Inactive area

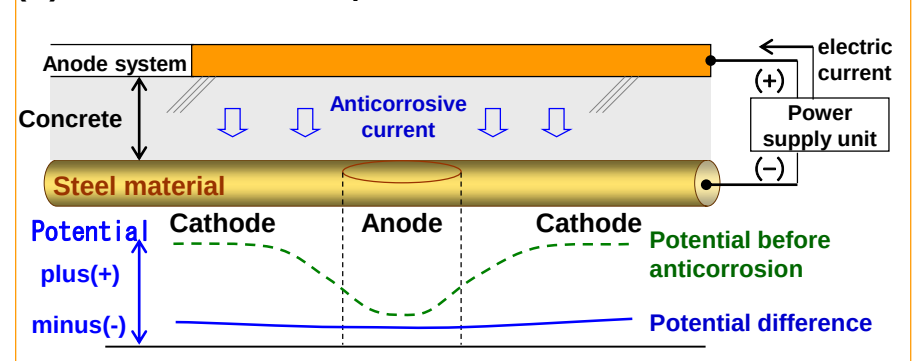
(a) Corrosion of steel materials
(before corrosion prevention)



(b) When the corrosion prevention electric current is insufficient

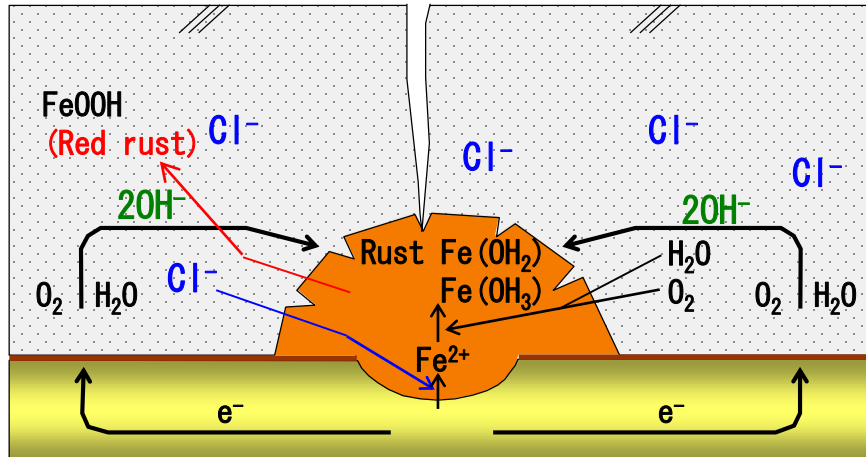


(c) When the corrosion prevention electric current is sufficient

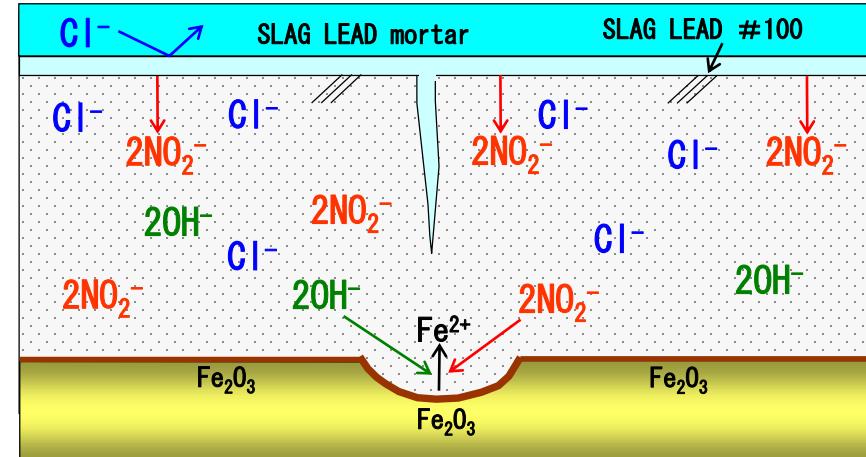


③ Antirust effect of SLAG LEAD # 100 · # 110

Corrosion concept

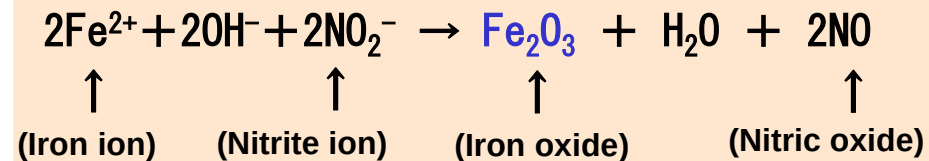
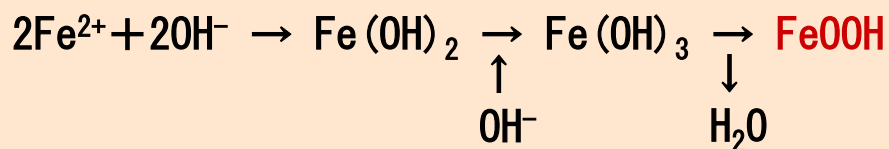
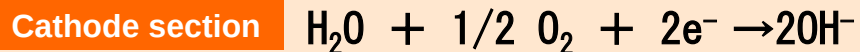
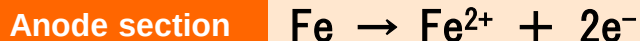


Rust proof concept of SLAG LEAD



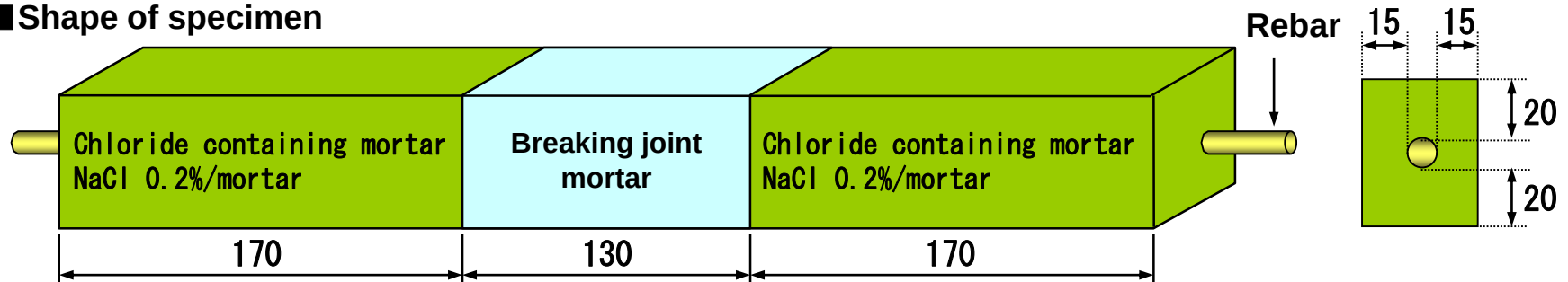
Antirust effect of SLAG LEAD # 100 · # 110

The passive film is a dense iron oxide (Fe_2O_3), the chloride ion (Cl^-) dissolves the passive film, iron of the metal and elutes as bivalent Fe^{2+} . Nitrite ion (NO_2^-) reacts with divalent Fe^{2+} to regenerate the passive film ($2\text{Fe}^{2+} + 2\text{OH}^- + 2\text{NO}_2^- \rightarrow \text{Fe}_2\text{O}_3 + \text{H}_2\text{O} + 2\text{NO}$).



④ Differences in corroded reinforcing bars due to different types of breaking joint mortar

■ Shape of specimen



■ contents of the test

By comparing the type of Breaking joint mortar, we compare corrosion and suppression situation of rebar.

Breaking joint mortar

- A. Chloride containing mortar (NaCl 0.2% / mortar)
- B. Ordinary cement mortar
- C. Polymer cement mortar
- D. Anticorrosive agent mixed mortar

■ Test results

Breaking joint mortar	Corrosion situation of rebar 170 130 170 ■ : Normal part ■ : Corrosion part	Corrosion area ratio %		
		left	center	right
Mortar containing Chloride NaCl 0.2% / mortar		100	81	79
Ordinary cement Mortar		99	23	100
Polymer cement Mortar		72	13	97
Anticorrosive agent mixed mortar SLAG LEAD # 100 # 450		0	0	41

(70 ° C. - Relative humidity 90% or more - 48 hr / 15 ° C. - Relative humidity 60% - 48 hr) × corrosion state of rebar after 15 cycles

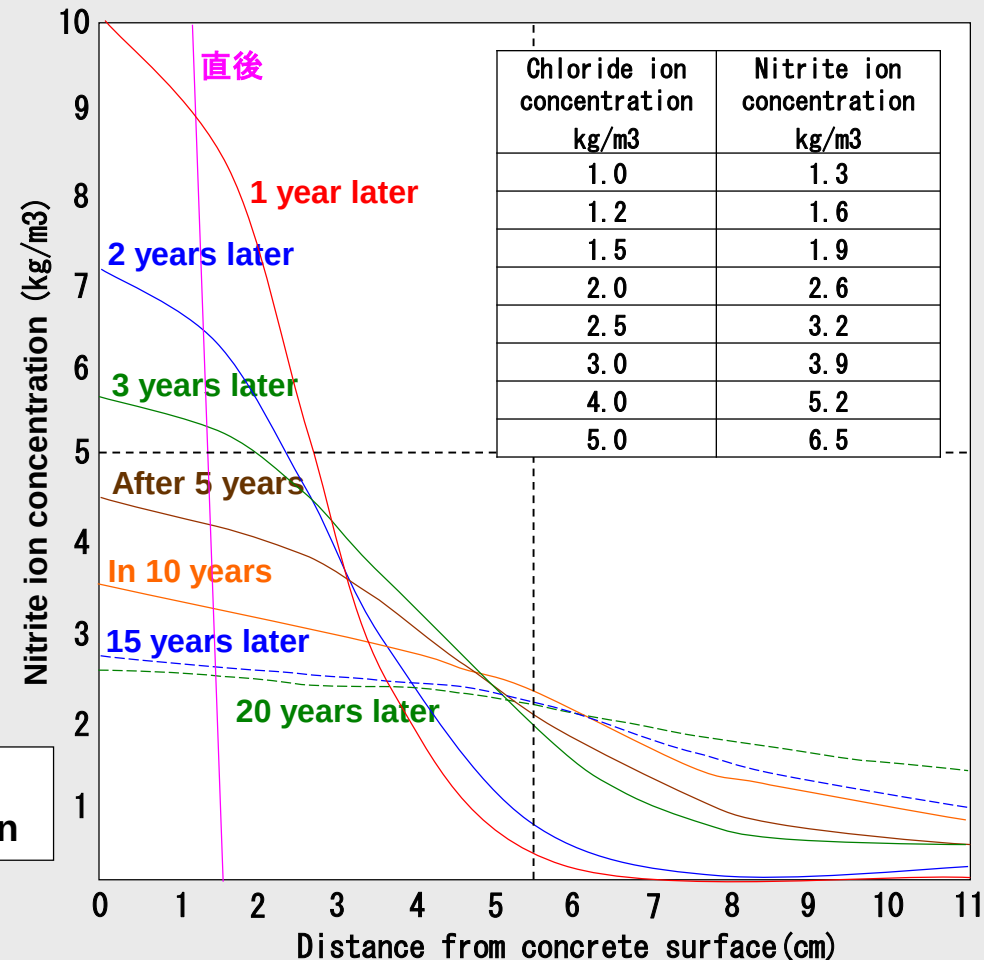
⑤ Diffusion of lithium nitrite

- 1 . Test point ▪ Lower structure of expressway
- 2 . Expiration years ▪ 10 years
- 3 . Coating volume ▪ 40% lithium nitrite aqueous solution 200g/m²
▪ mortar brush coating(containing 4.7% of lithium nitrite) 0.5mm thickness

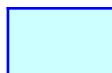
Expressway pier Expiration 10 years



Application of coloring liquid:
The brown color part is diffusion zone of nitrite ion



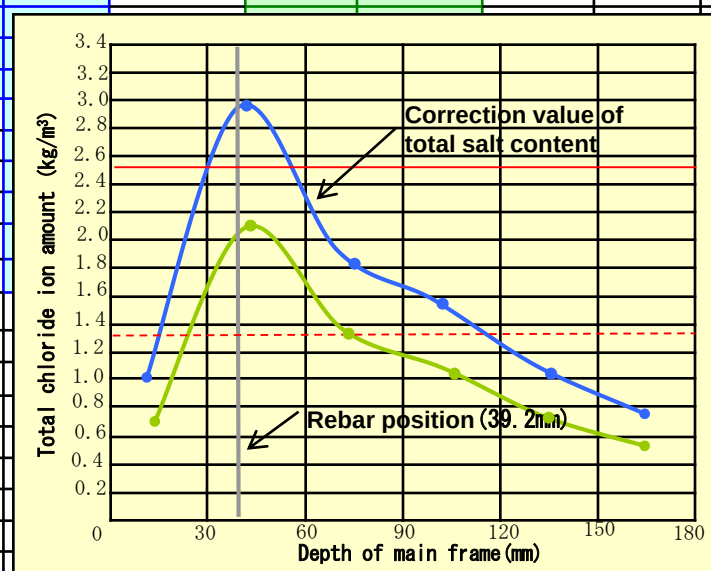
⑥ Conversion table of SLAG LEAD #100 (lithium nitrite)

 Troweling range
(Within 5 mm of coating thickness)
(Mortar ironing· FRP sticking)

 Grout injection
(Coating thickness above 20 mm)
(GF protect)

※Conversion table of Mortar paint thickness was diverted by Cantab (standard item)

Indicated value	Chlorine ion				Desalination Mortar(coating thickness: mm)											
Cantab Display	Cl ⁻	Cl ⁻	NaCl ⁻	NaCl ⁻	LiNO 25% Aqueous solution (kg/m ²)	Concrete covering 5cm					LiNO 25% Aqueous solution (kg/m ²)	Concrete covering 10cm				
	(%)	(kg/m ³)	(%)	(kg/m ³)		Versus cement ratio						Versus cement ratio				
						1%	3%	5%	8%	10%		1%	3%	5%	8%	10%
Standard	0.010	0.23	0.015	0.34	0.114	3.49	1.16	0.70	0.44	0.35	0.229					0.70
2.6	0.059	1.36	0.088	2.03	0.675	20.62	6.87	4.12	2.58	2.06	1.351	4				4.12
2.7	0.064	1.47	0.096	2.20	0.733	22.36	7.45	4.47	2.80	2.24	1.465	4				4.47
2.8	0.069	1.59	0.103	2.37	0.790	24.11	8.04	4.82	3.01	2.41	1.580	4				4.82
2.9	0.073	1.68	0.109	2.51	0.836	25.51	8.50	5.10	3.19	2.55	1.671	5				5.10
3.0	0.078	1.79	0.116	2.68	0.893	27.25	9.08	5.45	3.41	2.73	1.786	5				5.45
3.1	0.083	1.91	0.124	2.85	0.950	29.00	9.67	5.80	3.63	2.90	1.900	5				5.80
3.2	0.088	2.02	0.131	3.02	1.007	30.75	10.25	6.15	3.84	3.07	2.015	6				6.15
3.3	0.093	2.14	0.139	3.19	1.065	32.50	10.83	6.50	4.06	3.25	2.129	6				6.50
3.4	0.097	2.23	0.145	3.33	1.110	33.89	11.30	6.78	4.24	3.39	2.221	6				6.78
3.5	0.102	2.35	0.152	3.50	1.168	35.64	11.88	7.13	4.45			6				7.13
3.6	0.107	2.46	0.160	3.67	1.225	37.39	12.46	7.48	4.67			6				7.48
3.7	0.112	2.58	0.167	3.85	1.282	39.13	13.04	7.83	4.89			6				7.83
3.8	0.117	2.69	0.175	4.02	1.339	40.88	13.63	8.18	5.11			6				8.18
3.9	0.122	2.81	0.182	4.19	1.396	42.63	14.21	8.53	5.33			6				8.53
4.0	0.126	2.90	0.188	4.33	1.442	44.03	14.68	8.81	5.50			6				8.81
4.1	0.131	3.01	0.196	4.50	1.500	45.77	15.26	9.15	5.72			6				9.15
4.2	0.136	3.13	0.203	4.67	1.557	47.52	15.84	9.50	5.94			6				9.50
4.3	0.141	3.24	0.211	4.84	1.614	49.27	16.42	9.85	6.16			6				9.85
4.4	0.146	3.36	0.218	5.01	1.671	51.01	17.00	10.20	6.38			6				10.20
4.5	0.150	3.45	0.224	5.15	1.717	52.41	17.47	10.48	6.55			6				10.48
4.6	0.160	3.68	0.239	5.49	1.831	55.91	18.64	11.18	6.99			6				11.18
4.7	0.170	3.91	0.254	5.84	1.946	59.40	19.80	11.88	7.42			6				11.88
4.8	0.179	4.12	0.267	6.15	2.049	62.54	20.85	12.51	7.82			6				12.51
4.9	0.189	4.35	0.282	6.49	2.163	66.04	22.01	13.21	8.25			6				13.21
5.0	0.199	4.58	0.297	6.83	2.278	69.53	23.18	13.91	8.69			6				13.91
5.1	0.208	4.78	0.311	7.14	2.381	72.68	24.23	14.54	9.08			6				14.54
5.2	0.218	5.01	0.325	7.49	2.495	76.17	25.39	15.23	9.52			6				15.23
5.3	0.228	5.24	0.340	7.83	2.610	79.67	26.56	15.93	9.96	7.97	5.220	159.33	53.11	31.87	19.92	15.93



⑦ Development implementation method

(A) Surface coating method



Mortar application

(B) Special FRP plate sticking method



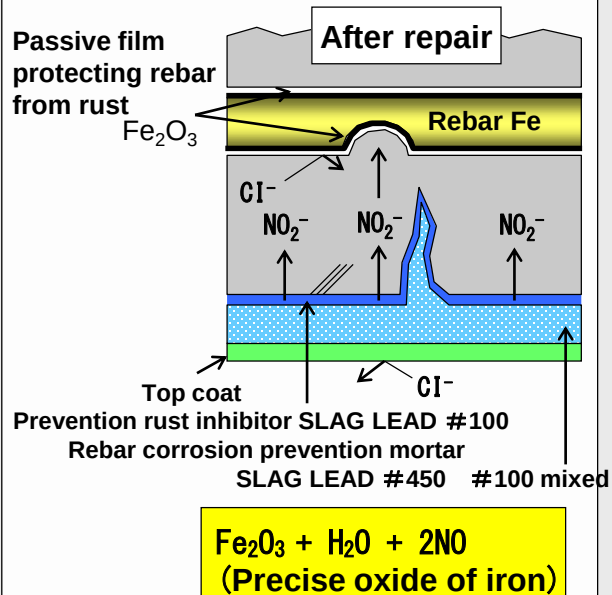
FRP Sticking repair

(C) G F protect

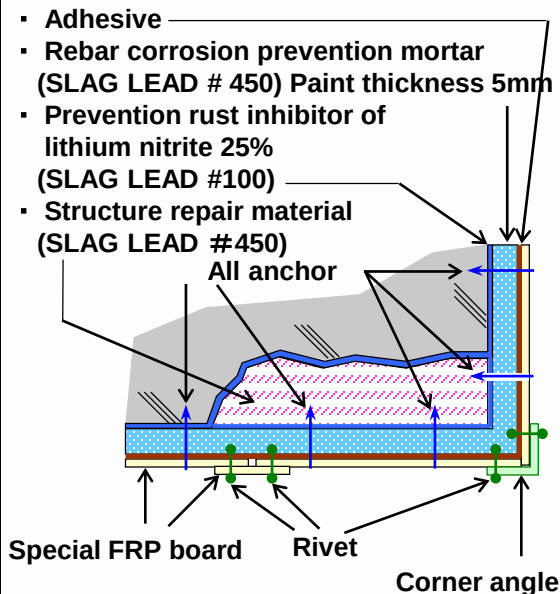


Grout injection by injector

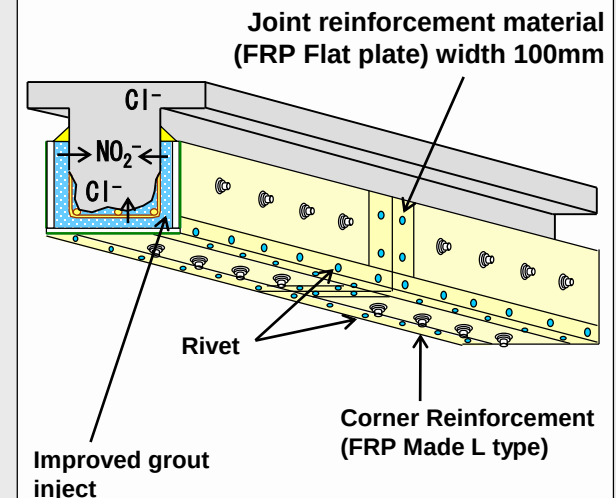
(Figure of pattern)



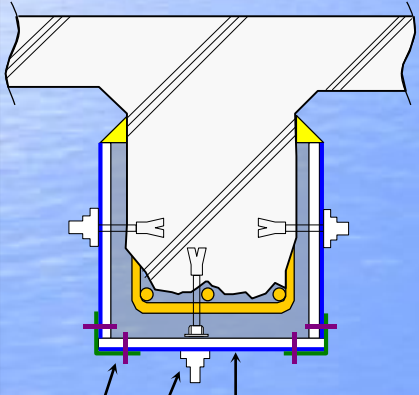
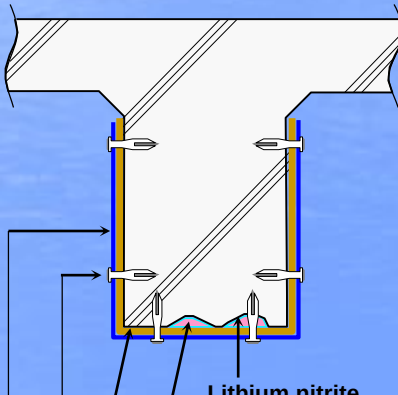
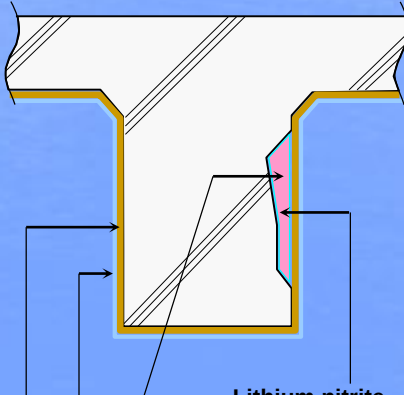
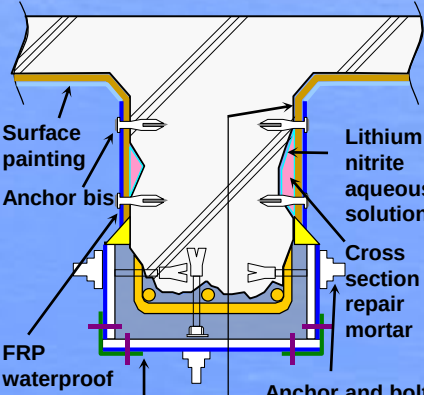
(Figure of pattern)



(Figure of pattern)



⑧ Concrete structure rebar corrosion prevention method (combination according to damage situation)

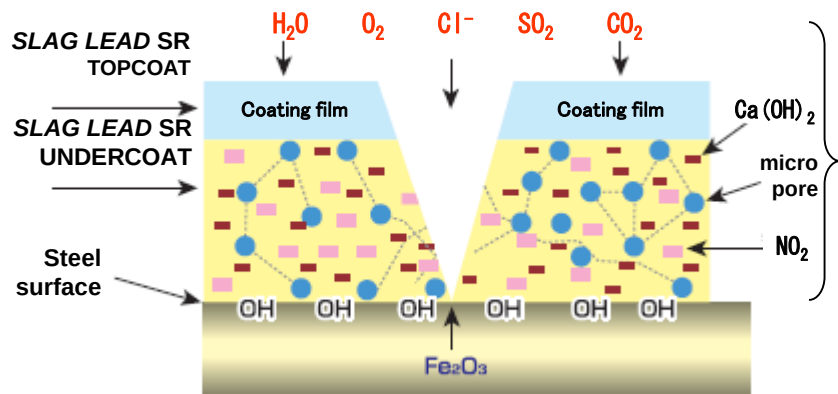
	GF Protect method (thickness 35 mm)	Surface FRP plate joining method	Surface treatment (surface coating) method	GF Protect method complex
Construction method Overview	For the purpose to prolong the life of degraded concrete structure, cross-section restoration using and embedded mold etc which environmentally friendly methods to repair/reinforcement, call concrete structure reinforcing steel corrosion prevention method.	By the simplicity of GF protect, attachment the FRP board directly and it brings close effects to GF Protect. Easy GF Protect	On the concrete surface of the entire target part, painting by lithium nitrite aqueous solution was mixed with mortar and infiltrate the rebar. Construction method which bring out rust prevention over a long term	As an example, in the left figure construction method, - GF protect method 20% - Surface FRP plate attachment method 20% - Surface coating method 60% Combined in area ratio
Schematic	 Chloride countermeasure grout Anchor and bolt cap Embedded mold	 Lithium nitrite aqueous solution Cross section repair mortar Chloride countermeasure mortar Anchor bis FRP waterproof layer	 Lithium nitrite aqueous solution Cross section repair mortar Surface painting Chloride countermeasure mortar	 Surface painting Anchor bis FRP waterproof layer Lithium nitrite aqueous solution Cross section repair mortar Anchor and bolt cap Chloride countermeasure mortar Embedded mould

⑨ SLAG LEAD SR method

■ Characteristics of SLAG LEAD SR method

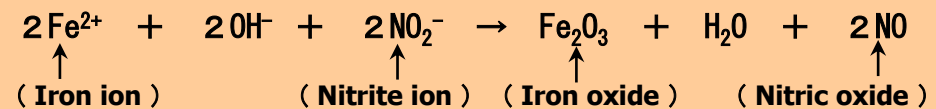
Including cement, inorganic powder and nitrite in the coating film, alkali corrosion prevention and self-repairing corrosion inhibiting action simultaneously proceed, improvement of corrosion prevention dramatically.

Complex type (self-repair) corrosion prevention method



Complex type
(Self-repair)
Corrosion
prevention
method

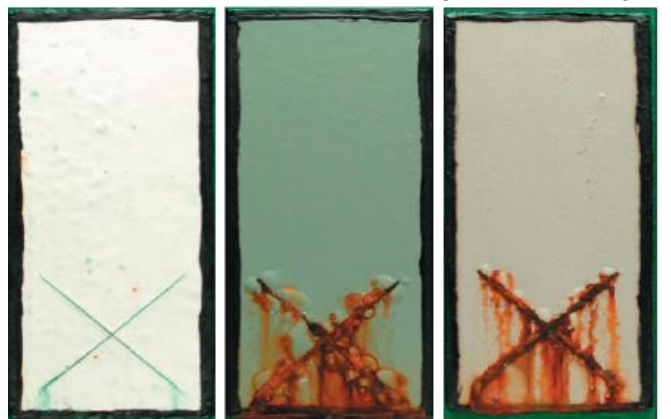
Even if the coating
film is scratched,
it does not rust



■ CASS test (200 times x 8 hours = 1600 hours)

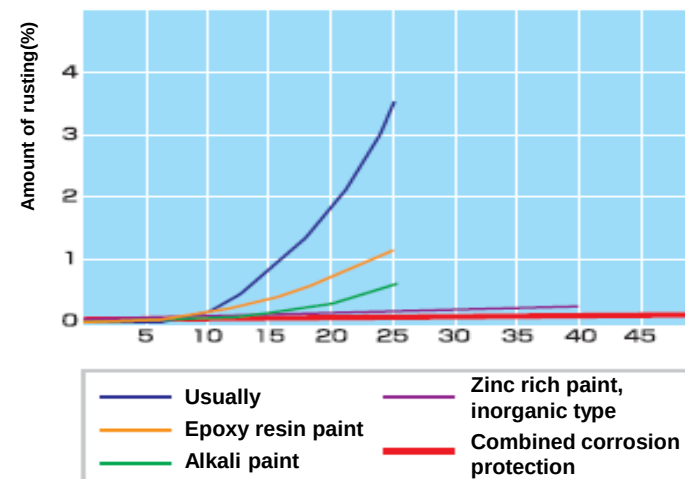
※CASS solution spray 4 hr, drying (60 °C , humidity 50%) 2 Hr

Moisture resistance test (50 °C, humidity 95%) 2Hr



Composite Alkali paint Epoxy resin paint
corrosion protection

● Comparison of corrosion protection performance (salt spray test)

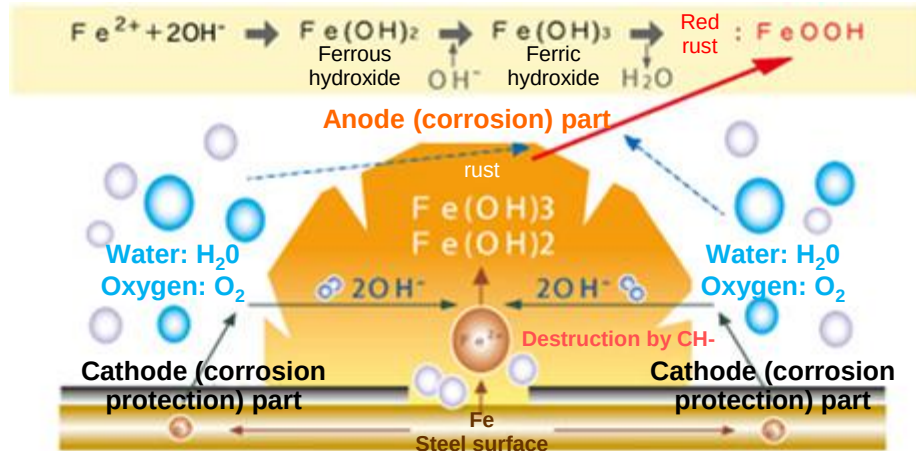


※ This test result is based on internal test data and does not guarantee quality.

Corrosion concept

Fe²⁺ of the anode reaction product and OH⁻ of the cathode reaction product combine to become Fe(OH)₂, oxidized and change to rust such as Fe(OH)₃ · FeOOH.

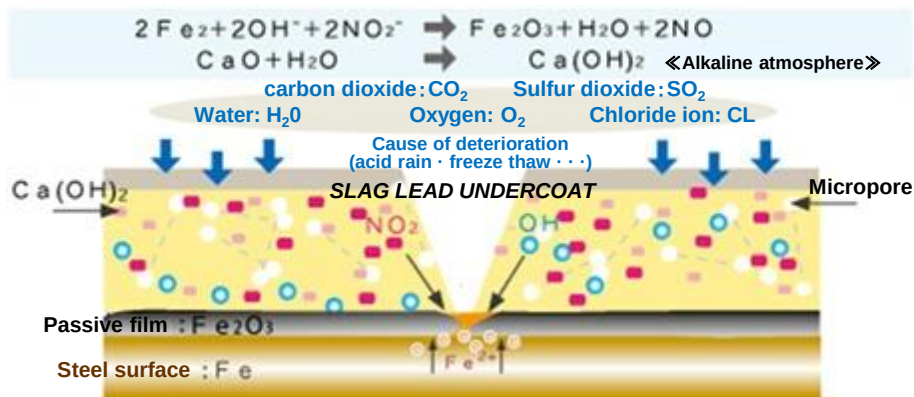
Overall, it is a reaction in which iron is combined with water and oxygen to form hydrated oxides.



Technical overview

◆ SLAG LEAD UNDERCOAT

Iron ions combine with nitrite ions and rebuild the passive film by becoming an oxide of iron.



◆ SLAG LEAD TOP COAT

It is a blended design that combines hydrophobicity and hydrophilicity. By having such performance, it contributes to adhesion and corrosion protection in the undercoat material.



Hydrophobicity: Moisture present on the surface of the undercoating film is pushed away and it is easy to come into direct contact with the object to be coated.
 Hydrophilicity: Absorbs moisture which can not be excluded by hydrophobicity, making it more wet easily.

■ Fukuoka Kitakyushu Expressway Corporation

Kitakyushu Road Balustrade repair work

Rebar rust preventive agent
SLUG LEAD # 100 Application



Chipping situation



SLUG LEAD # 100 # 450
The filling situation



cross section Repair completed



SLUG LEAD # 100 # 450
Salinity countermeasure
mortar is done



Surface protective coating B
specification complete



Implementation report

Before construction
(Overall picture)



Immediately after completion



Seven years after completion



Before construction
(representative place)



Immediately after completion



Seven years after completion

■ Karatsu Port pier ■

Before construction



Under construction

Before construction



Under construction

Under construction



completion

Construction example

Before construction



completion

Before construction



completion

Before construction



completion

Construction example

Under construction

Before construction

Under construction



completion

completion

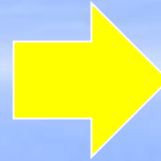
completion

Construction result

Yahata Steel mill - Stacker Crane



Before construction



After construction

Construction in China / Dalian



Application status of
undercoat material



Application status of
topcoat material



Transport
situation

Construction result

**NYB Outdoor Exhaust Facility
Before construction**



**Cement silos
Before construction**



**Chemical factory
Before construction**



**NYB Outdoor Exhaust Facility
3 years after construction**



**Cement silos
After construction**



**Chemical factory
After construction**



Construction result

Monorail - movable bearing

Before construction



After undercoat application

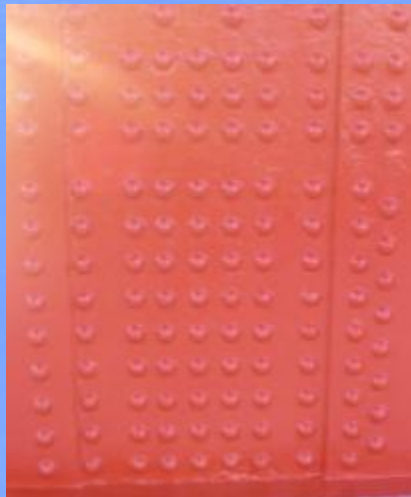


Wakatooohashi - The flank of the pier

Before construction



After construction



Kitakyushu Airport Tent Square

Before construction



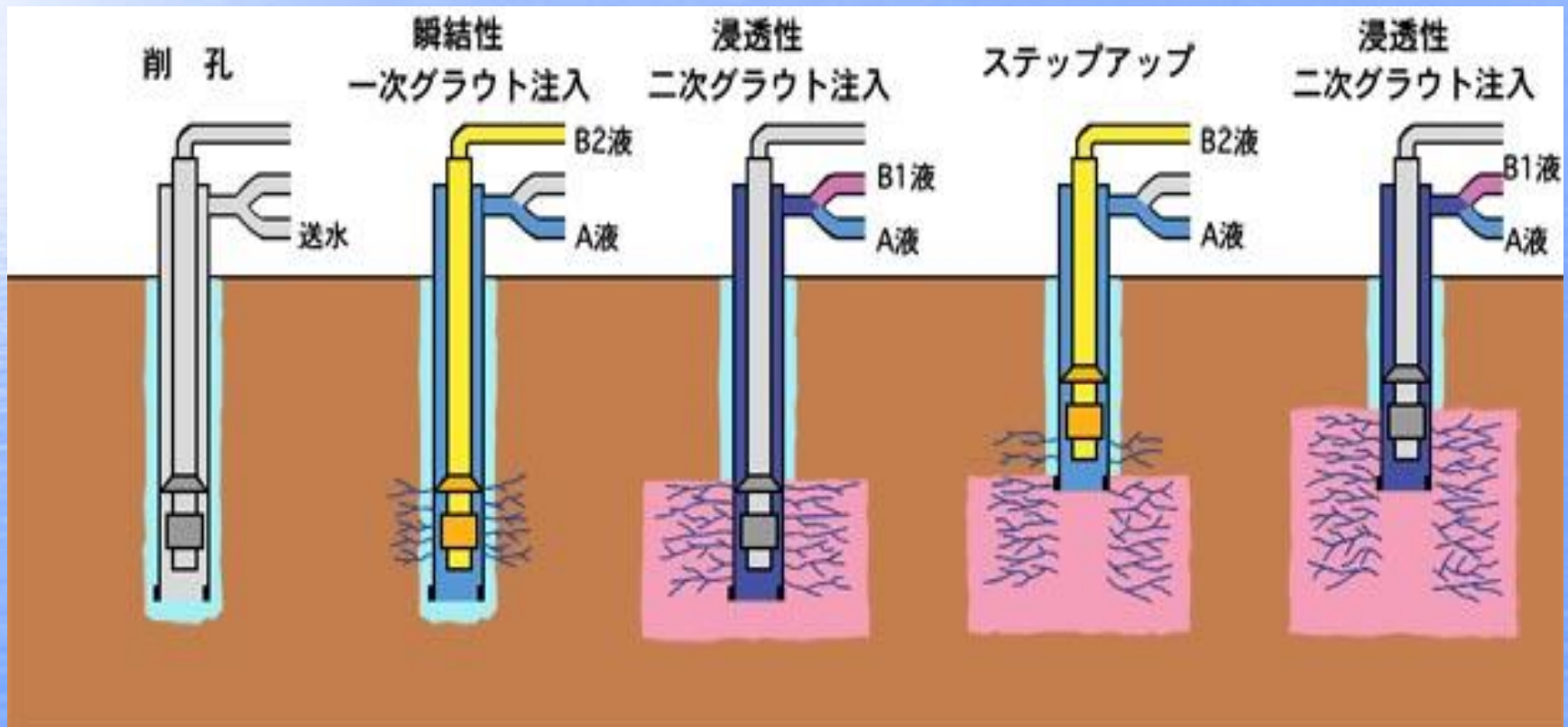
Two years after construction



Two major construction methods in soil improvement

○Method1:

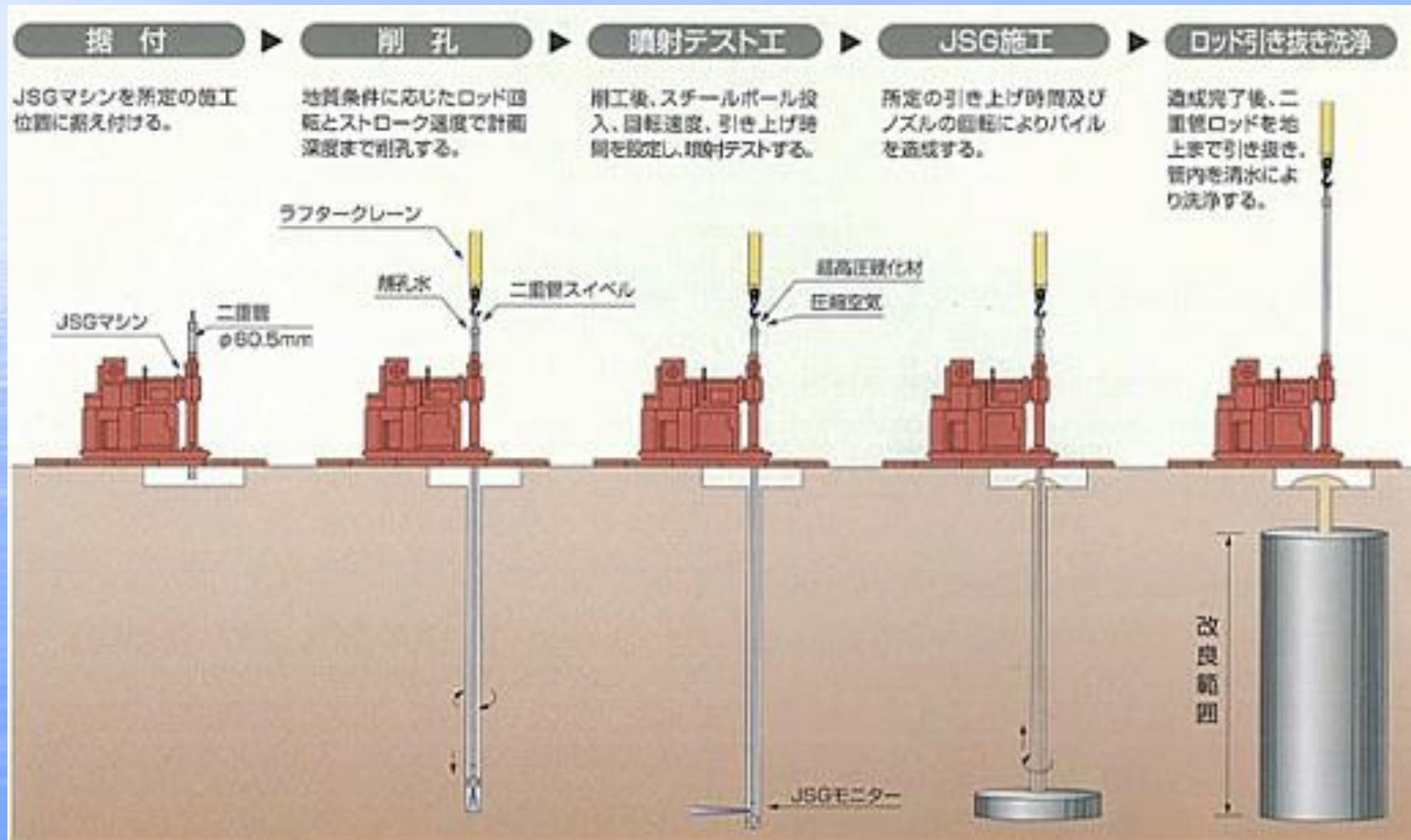
Chemical grouting (materials: sodium silicate and harder)



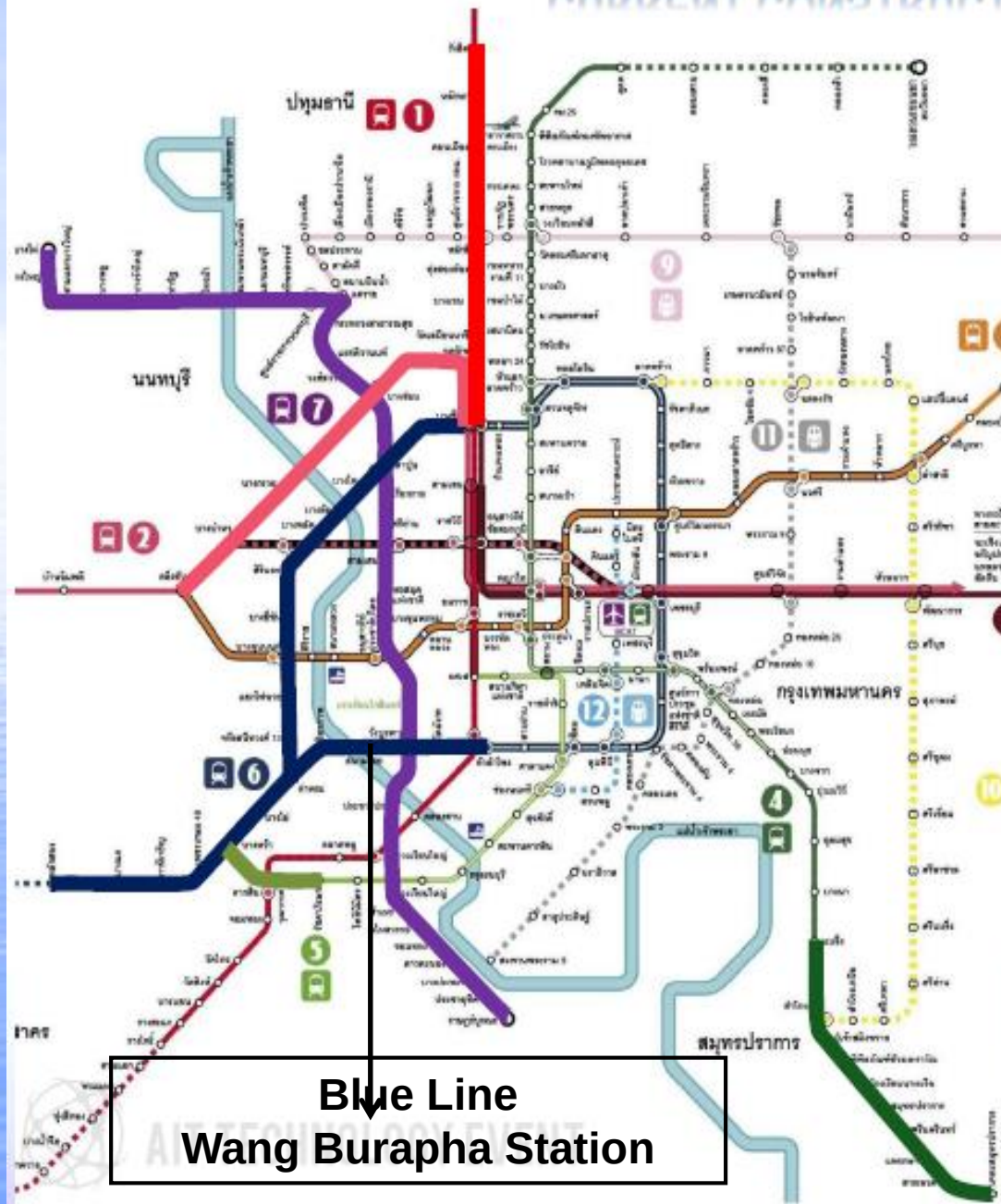
Two major construction methods in soil improvement

○Method2:

JET grouting (materials: cement and additives)



CURRENT CONSTRUCTION ROUTES



Agency	Name of Route	Length of Route
SRT	Red Line Bang Sue - Rangsit	26 km 6 stations
SRT	Light Red Line Bang Sue - Taling Chan	15 km 4 stations
MRTA	Purple Line	25.6 km 16 stations
MRTA	Blue Line Ext.	26.9 km 19 stations
MRTA	Green Line Ext. Bearing - Kheha Samut Prakan	13 km 9 stations
BTS	Light Green Line Talat Phlu - Bangwa	~2.7km 2 stations



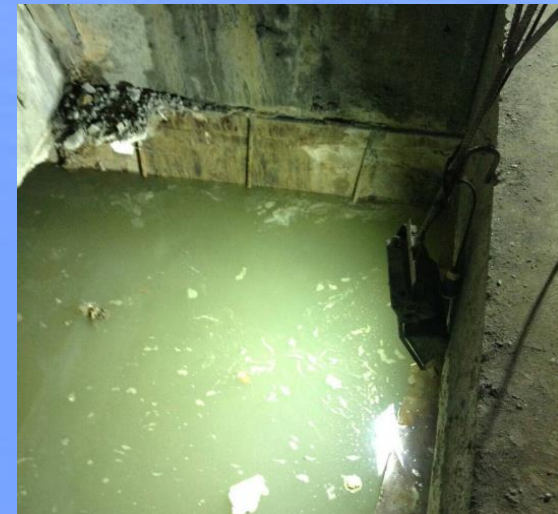
**Blue Line
Wang Burapha Station**

Pictures: Job site of chemical grouting at Wang Burapha Station in MRT Project

○Injecting materials for stopping underground water



**Around 50 meter
depth in underground**



Contact Us

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