CONCRETE RENOVATION

CS-21™

Material Properties Viewed in Photos

Version 2.0

Aston®

Preface

CS-21, concrete renovation, should be applied to or sprayed on concrete structures. It does not aim at creation of a film over the surface nor shows the effect by drying and hardening water repelling material.

It aims at making the surface denser and closer by permeating it hardened concrete to cause reaction with unhydrated cement or calcium in concrete, forming stable CHS-based crystal to fill minute pores and cracks.

CS-21 was developed as injecting water sealant for water leak repair work and is currently used for waterproofing of the body, surface protection, repair of cracks, restoration of sections, treatment of joints and imprinted hole of separator ends of concrete structures.

To achieve the intended effect, it is important to understand the reaction properties of the material and to select and perform the method suitable for the condition of concrete and environment on the spot. Since CS-21 does not show its performance unless the condition necessary for reaction is not satisfied, Aston Incorporated which developed, produce and sell CS-21, and domestic special agents established Aston Association to improve the technology including training of engineers and settle the system that the work is performed under the responsibility and technical instruction of Aston Association members.

Aston Association offers high quality and technique of Aston Engineers and Technicians who understand the reaction properties of the material completely and have learned the skill of utilizing them.

This document introduces the properties of CS-21 with photos.

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1. PACKAGES AND PHYSICAL PROPERTIES

Packages of CS-21: 5 kg plastic bag

Physical properties of CS-21

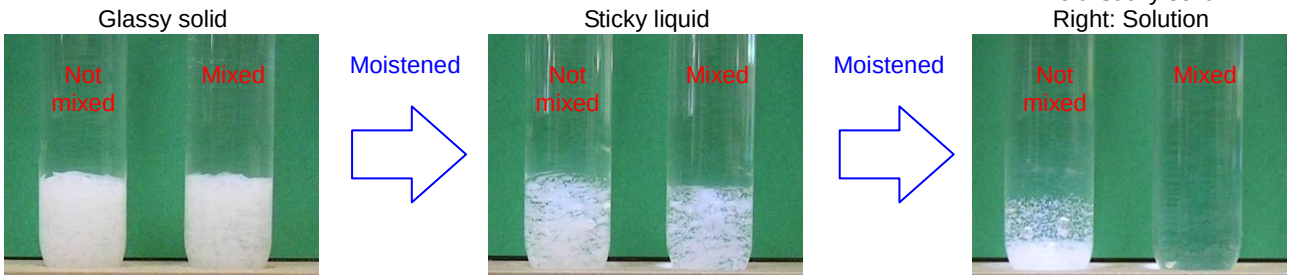
Main component	Sodium silicate
Aspects	Colorless, transparent solution
Odor	None
pH	11.3 or more
Dynamic viscosity	5.70 mm^2/s or less
Specific gravity	1.240 or more
Evaporation residue	390,000 mg/L or more
Steam pressure	Not applicable
Flash point	No ignition
Inflammability limit	Not applicable
Spontaneous ignition temperature	Not applicable
Explosiveness	None

2. CHANGE IN PHYSICAL PROPERTIES BY DRY/WET CONDITION

CS-21 is dried and deprived of moisture to become sticky liquid and becomes glassy if dried further. When the glassy solid soaks in water, it absorbs water to become sticky liquid and melting starts at a part contacting water gradually. The sticky liquid returns to be solution if mixed and the melting speed is slow unless it is mixed.
Some of CS-21 which has permeated the surface part of concrete and remains unhydrated exists in a state of glassy solid or sticky liquid and forms a reactant if provided with water due to rain or morning dew and with calcium due to occurrence of cracks.

Solution → Dried → Sticky liquid → Dried → Glassy solid

Glassy solid → Moistened → Sticky liquid → Moistened → Left: Sticky solid, Right: Solution



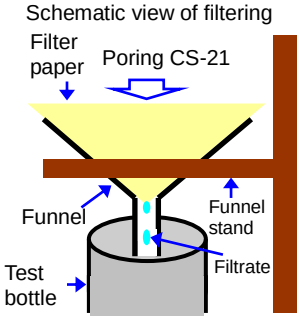
Just after dipped in water | 1 hour later | 7 days later

3. SIZE OF PERMEATING PORES AND CRACKS

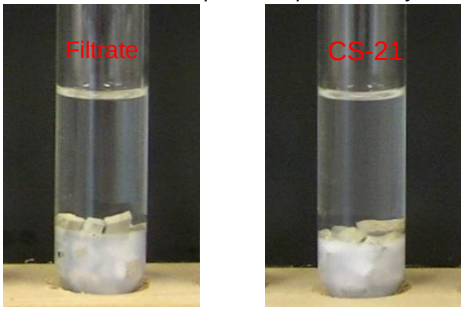
To confirm that CS-21 permeates minute pores and cracks in concrete, perform reaction test by filtering CS-21 through filter paper (JIS P3801, Type 5C: Particle retention of 1 μm, manufactured by Advantec, round quantitative filter paper No.5C) and mixing it in a test tube.
As a result of the test, there was no difference between the filtered liquid and CS-21. Thus it was verified that CS-21 permeated minute pores and cracks of 1 μm.

Filtering

Schematic view of filtering



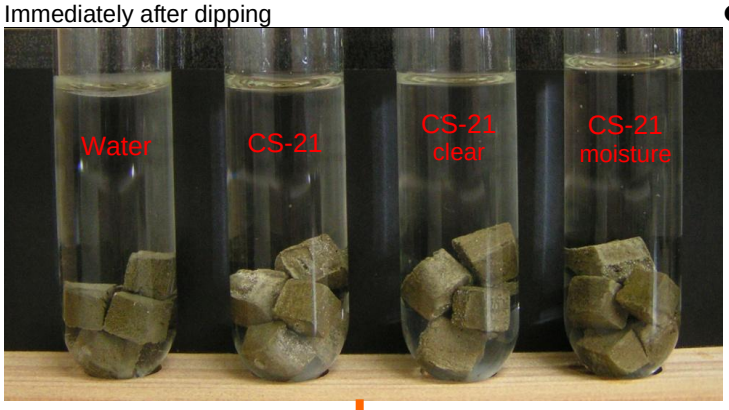
Reaction with cement paste test piece: 14 days later



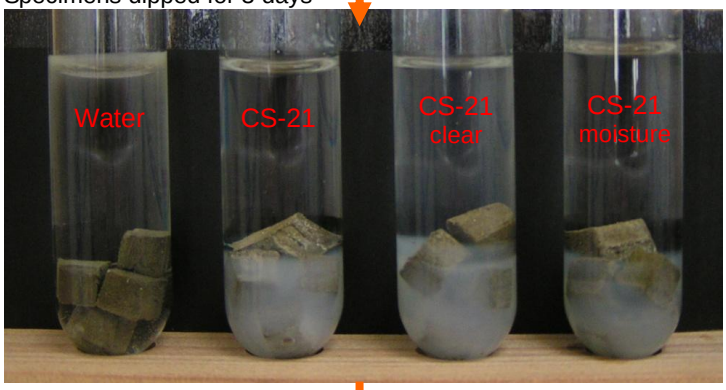
4. REACTION TEST [1] PROGRESS OF REACTION DUE TO CONCENTRATION CHANGE

To reproduce the state that CS-21 permeates inside of concrete to fill minute pores and cracks with reactants, we created specimens of cement paste and observed the progress of reaction after they were dipped in CS-21.

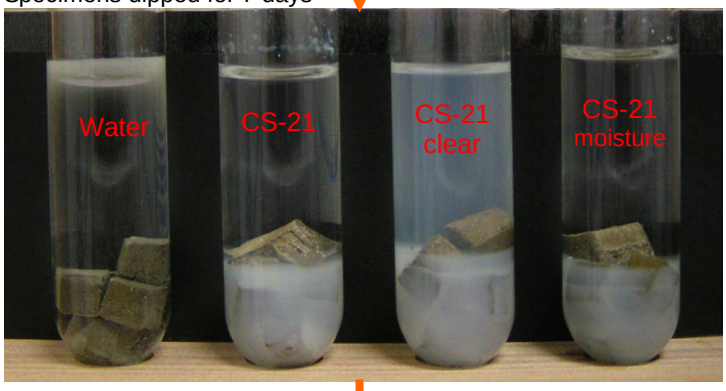
Immediately after dipping



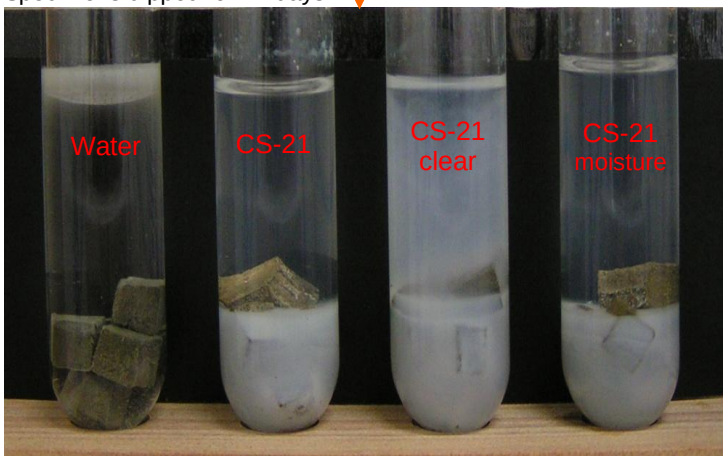
Specimens dipped for 3 days



Specimens dipped for 7 days



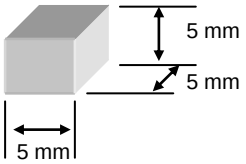
Specimens dipped for 14 days



● Specifications of cement specimen of cement paste

Type of cement	Ordinary Portland cement
Water-Cement ratio W/C	50%
Form	5 × 5 × 5 (mm)
Number in test tube	5
Age till dipping	7 days
Cure till dipping	After form removal in age of 1 day, cured in water

● Form of specimen of cement paste



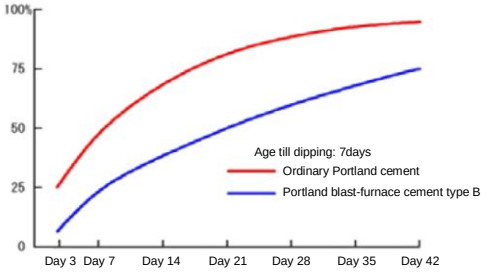
● Test result

In case of dipping the specimen in water, a layer of calcium carbonate was found around the surface of water formed by reaction of dissolved calcium hydroxide with carbon dioxide.
In case of dipping the specimen in CS-21, the lower the concentration was, the wider the reactant diffused; and the higher it was, the reactant gathered around cement.

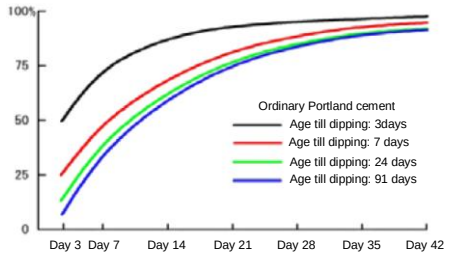
Low CS-21 clear < CS-21 < CS-21 moisture High

● Properties by the type of cement and age

Reaction properties by the type of cement



Reaction properties by the type of cement

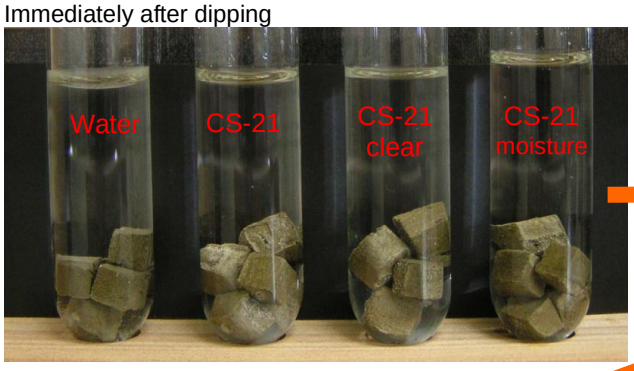


Note: Comparison was performed assuming the reaction of ordinary Portland cement paste at age of 7 days dipped in CS-21 for 91 days.

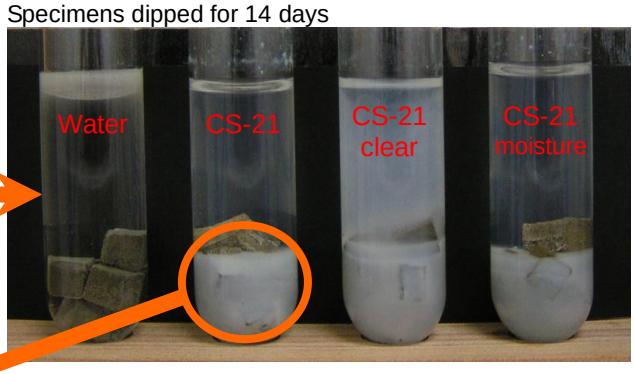
4. REACTION TEST [2] ELECTRON MICROSCOPE PICTURE OF REACTANT

When specimens were dipped in CS-21 for 28 days, we took them out of the test tubes, removed lysates by dipping them in fresh water for 3 days, and dried them in natural air indoors. Then we requested a test organization to take electron microscope pictures of the reactant. (Photo: Insoluble crystal)

Immediately after dipping

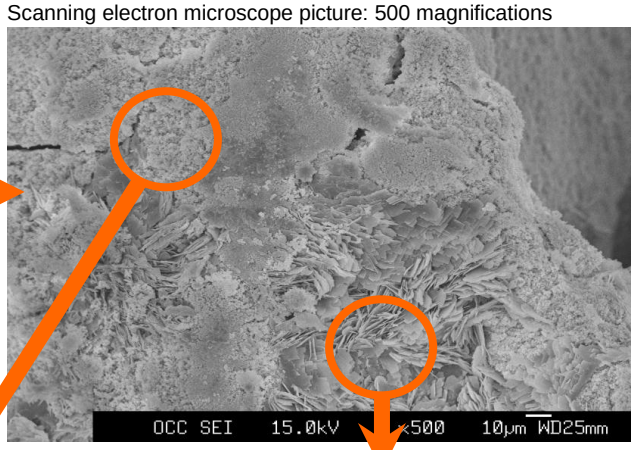


Specimens dipped for 14 days

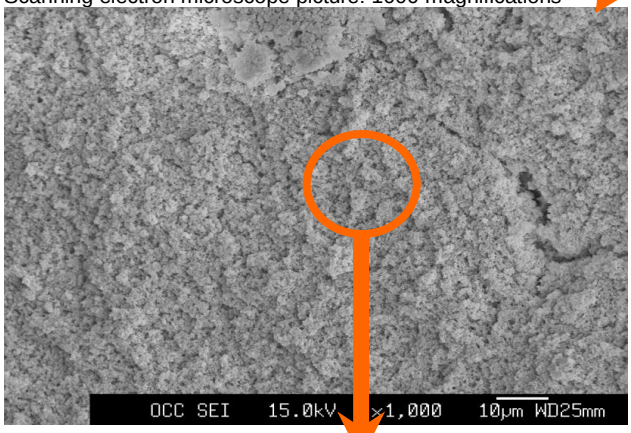


Insoluble crystal

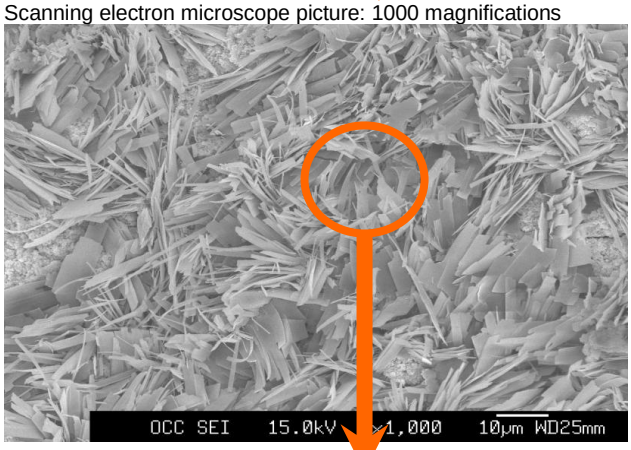
Scanning electron microscope picture: 500 magnifications



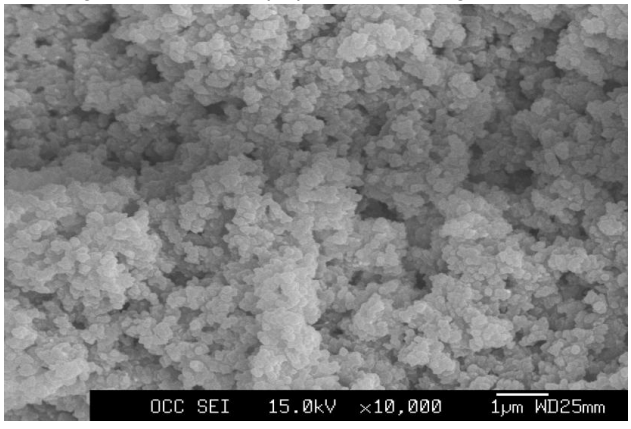
Scanning electron microscope picture: 1000 magnifications



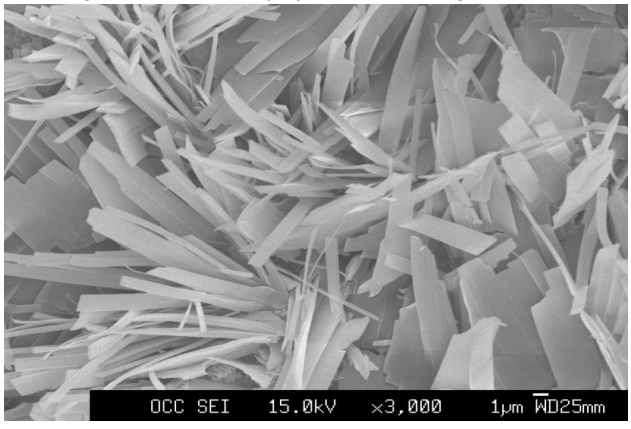
Scanning electron microscope picture: 1000 magnifications



Scanning electron microscope picture: 3000 magnifications



Scanning electron microscope picture: 3000 magnifications



5. REACTION WITH NEUTRALIZED CONCRETE

CS-21 shows its effect on concrete at any age if some hydration activating component is added. To reproduce the reaction of CS-21 with neutralized concrete in a test tube, we dipped calcium carbonate in CS-21 and observed the progress of reaction to confirm the reactant.
As a result of the test, it was confirmed that CS-21 reacted with calcium carbonate (limestone) though it progressed quite slowly.

- Test method

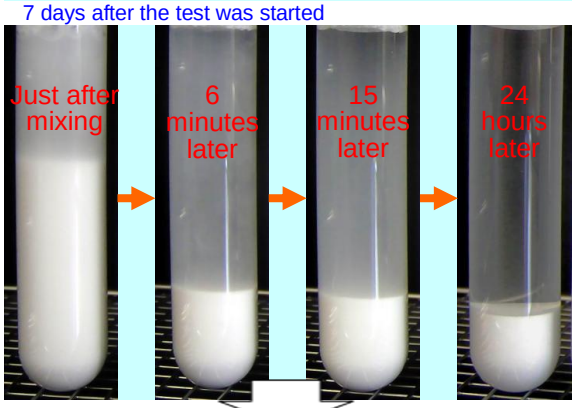
  We created each specimen of calcium carbonate (3 g) mixed with water (10 ml) and of calcium carbonate (3 g) mixed with CS-21 (10 ml). Mixing the test tubes once a week, we examined the state of deposition. When the specimens were dipped for 90 days, we took calcium carbonate out of the test tubes, removed lysates by dipping them in fresh water for 3 days, and request a test organization to take electron microscope picture of them.

- Test result

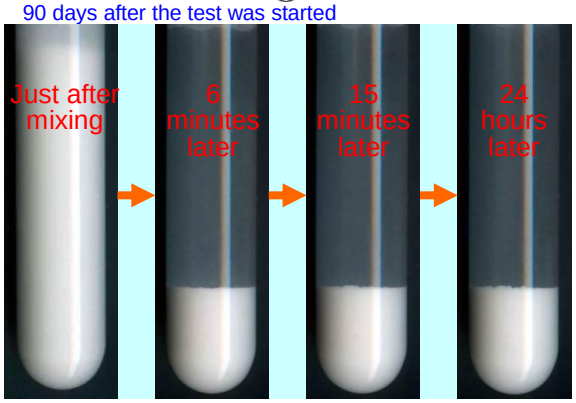
  There was no change in the calcium carbonate dipped in water. But as the other one dipped in CS-21, cloudiness in the upper portion became thinner gradually after the test was started. 90 days later, the cloudiness was almost cleared and the speed of deposition became slower than the condition of 7 days after the test was started. The state of deposition 24 hours after mixing indicated increase in dummy volume and distinct difference.
  As a result of taking pictures of them by electron microscope, there was no reactant found though adhesion of minute powder of calcium carbonate was found after dipping in water but formation of reactants on the surface was found after dipping in CS-21.

Water + Calcium carbonate

7 days after the test was started

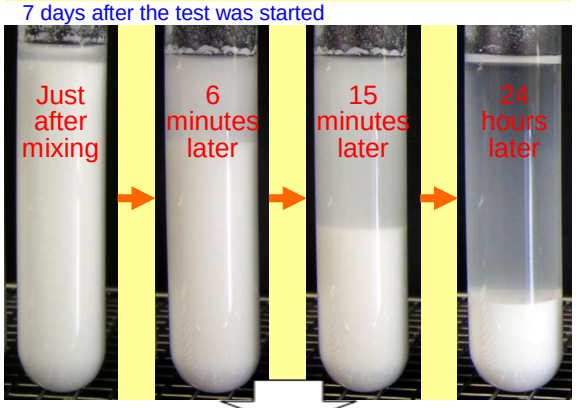


90 days after the test was started

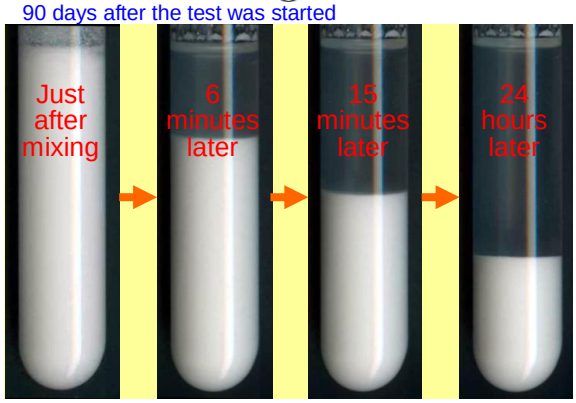


CS-21 + Calcium carbonate

7 days after the test was started

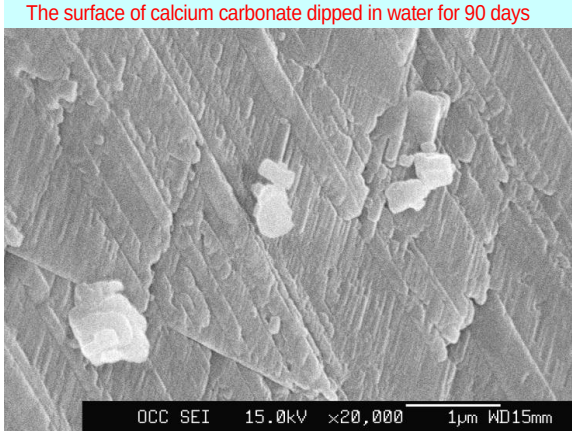


90 days after the test was started

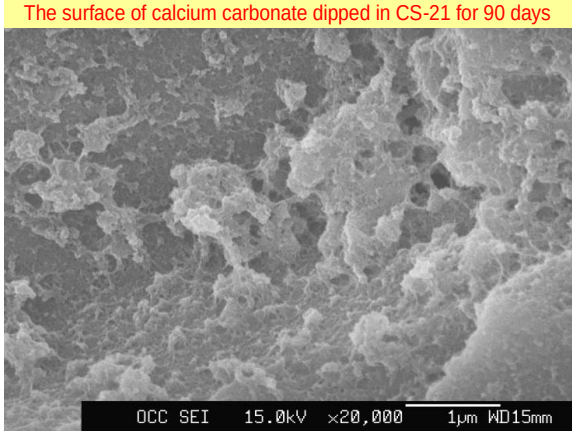


- Electron microscope picture of calcium carbonate dipped for 90 days (20000 magnifications)

The surface of calcium carbonate dipped in water for 90 days



The surface of calcium carbonate dipped in CS-21 for 90 days



6. CHANGE IN REACTION SPEED BY NEUTRALIZATION OF CONCRETE

We performed a test to confirm the difference in reaction speed of application of CS-21 between newly established structures and existing structures.
To reproduce reaction in concrete in different state of neutralization, we created 2 types of specimens and dipped each of them in CS-21 to confirm the progress of reaction.

As a result of the test, both Specimen A, which is assumed to be a newly established structure, and Specimen B, which is assumed to be an existing structure, began to react when the test was started and white cloudiness caused by the product of reaction was found around each specimen of cement paste.
Thus it was confirmed that CS-21 reacted with concrete in any age.

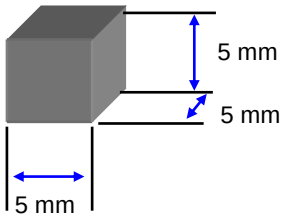
The period when it was thought that the reaction finished since there was no change in the test tube was 14 days regarding Specimen A and 63 days regarding Specimen B.

Outline of the test

- Specifications of specimen of cement paste

Type of cement	Ordinary Portland cement
Water-cement ratio W/C	50%
Form	5 × 5 × 5 (mm)
Number in test tube	5

- Form of specimen of cement paste

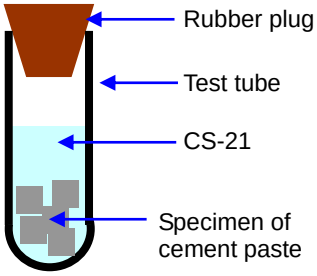


- Curing method of specimen of cement paste

Specimen A: 1) Form was removed the next day after placement → 2) After form removal, it was cured in water for 5 days → 3) It was cured in air for 1 day

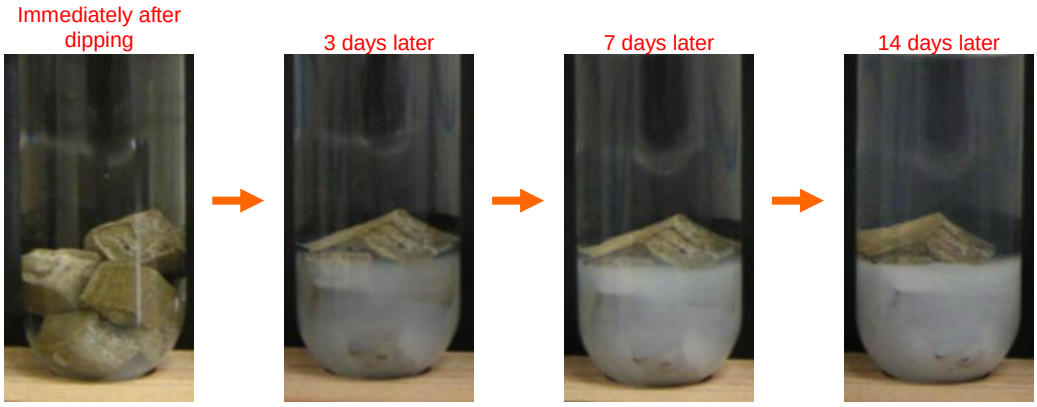
Specimen B: 1) Form was removed the next day after placement → 2) After form removal, it was cured in air for 1 day → 3) Neutralization was accelerated for 7 days (concentration of carbon dioxide → 4) It was cured in air for 5 days

- Schematic diagram of the test

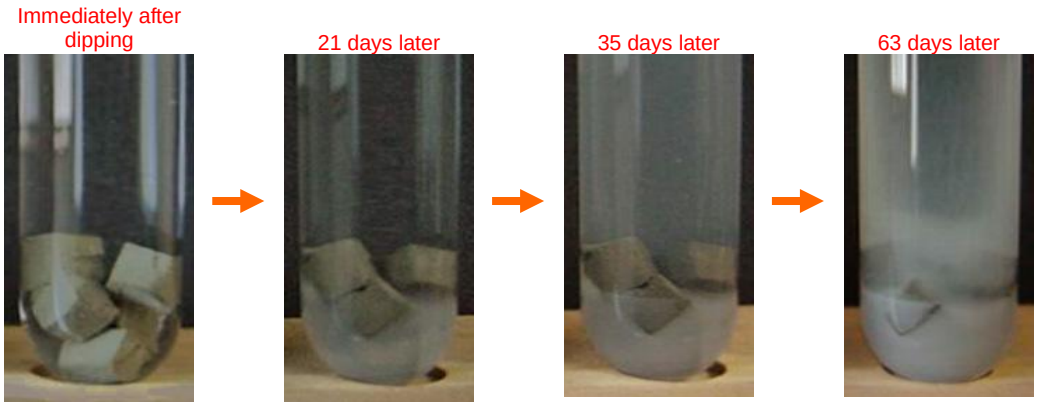


Photos of the specimens

Specimen A (without neutralization)

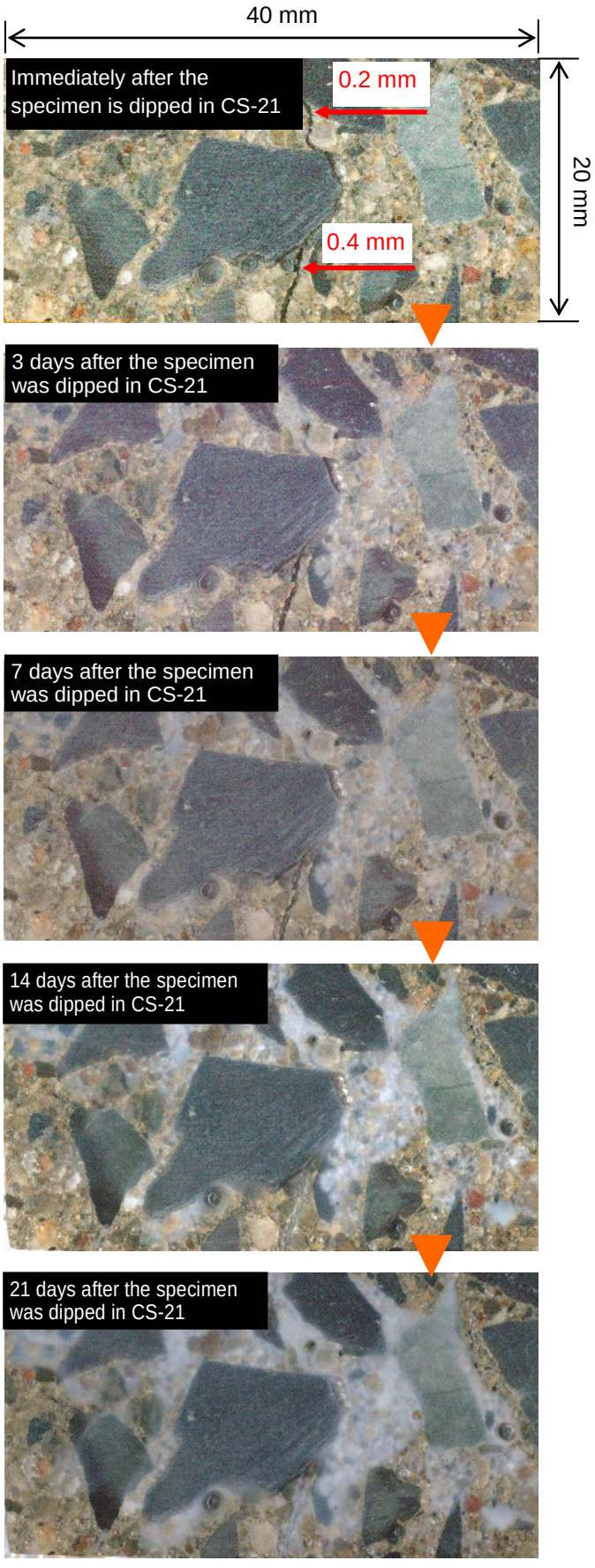


Specimen B (with neutralization)



7. CRACK WIDTH AND AUTOMATIC CLOSING FUNCTION OF CONCRETE

CS-21 has an effect of closing minute pores and cracks with reaction products formed by reaction with unhydrated cement and calcium in hardened concrete. The speed of reaction and the amount of reaction product depend on the age of concrete and proportioning. An example of the process of reaction is shown as follows.

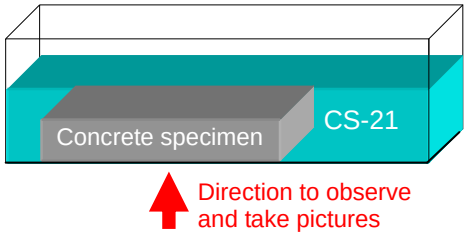


- Outline of concrete specimen

Proportioning strength	28 N/mm^2
Type of cement	Ordinary Portland cement
Maximum size of coarse aggregate	20 mm
Slump	15 cm
Air volume	5%
Size of specimen	100 × 30 × 10 (mm)
Age till dipping	7 days

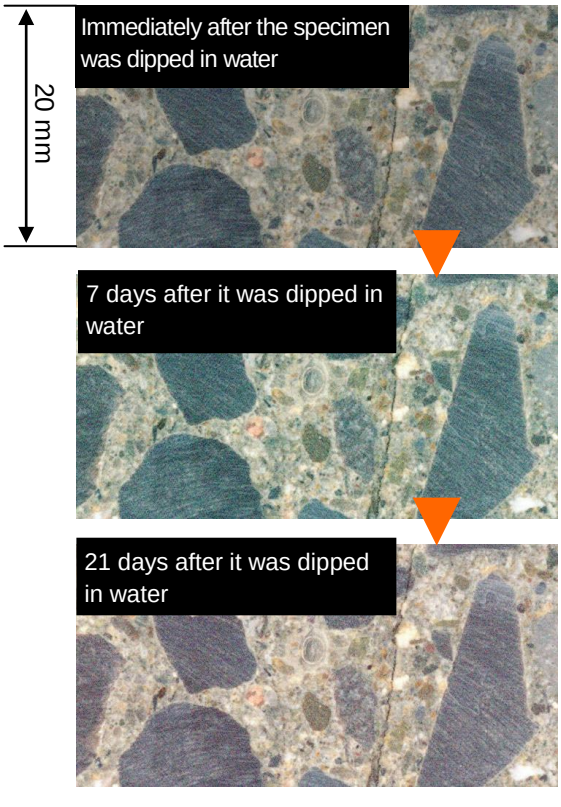
- Test method
  After creating cracks around the center of concrete specimen, we dipped it in CS-21 poured in a plastic vessel and took pictures and observed from the bottom.

- Schematic drawing of the test



- Result of observation
  Since the specimen was dipped in CS-21 for 3 days, a gelatinized product was sighted and the process that crystal grew up after that was observed.
  There was no change in the specimen dipped in water.

- Progress of the specimen dipped in water under the same condition



8. CONFIRMATION TEST OF DEPTH OF PERMEATION THROUGH MINUTE CRACKS

To confirm the depth of permeation of CS-21 applied to a concrete structure through the cracking part, we performed a test to confirm the depth of permeation using a specimen with a neutralized surface having a thorough crack of 0.1 mm wide.

CS-21 is alkaline solution with pH 11.3 or more. Neutralized part through which CS-21 penetrates shows alkaline properties.
Utilizing these characteristics, the depth of permeation can be examined by applying CS-21 to the neutralized surface of a specimen and then measuring the range of alkaline part in the crack adhering to JIS A 1152 (Method for measuring neutralization depth of concrete).

As a result of the test, it was confirmed that CS-21 permeated 13.5 cm deep into the specimen when it was applied to the surface sideways and 7.5 cm deep when applied upwards.

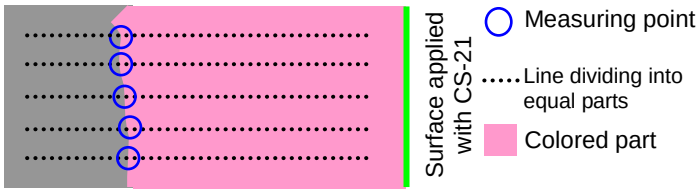
- Outline of concrete specimen

Type of cement	Ordinary Portland cement
Nominal strength	21 N/mm^2
Slump	8 cm
Maximum size of coarse aggregate	20 mm
Water-cement ratio W/C	58%
Air volume	4.5%
Form	Vinyl chloride pipe VU75
Size of form	ϕ83 × h250 mm
Size of specimen	ϕ83 × h200 mm

- Test method

1) After placing concrete in the form, we cured it in air.
2) We cut both top and bottom ends to reduce the height to 200 mm.
3) We created a through crack of 0.1 mm wide.
4) We neutralized the cracked surface by accelerated neutralization for 14 days (with a carbon dioxide concentration of 5%).
5) We applied CS-21 sideways and upwards.
6) Removing the form, we cleaved the specimen at the cracking surface.
7) Spraying 1% solution of phenolphthalein to the cracking surface, we measured the depth of permeation from the surface.

- Schematic diagram of measurement of permeation depth



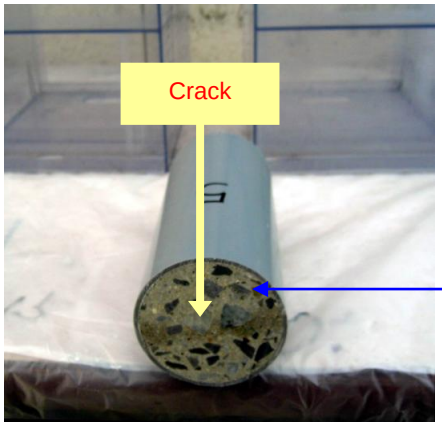
- Method of applying CS-21 (CSI Method)

1) Apply water (0.15 kg/m^2)
2) Apply CS-21 (0.2 kg/m^2)
3) Apply water (0.15 kg/m^2)

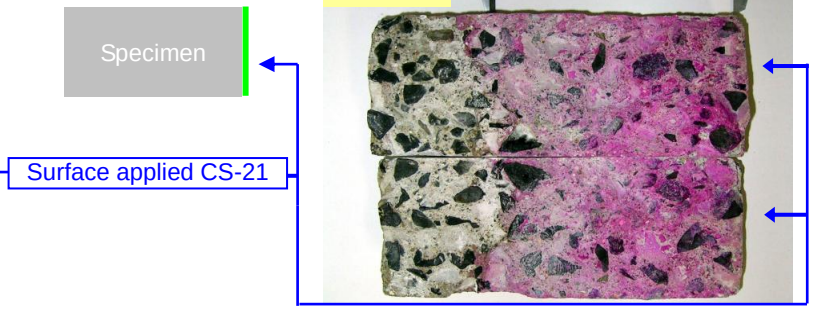
Note: Apply both water and CS-21 with a brush

The photos of the test

Application sideways: Application was finished

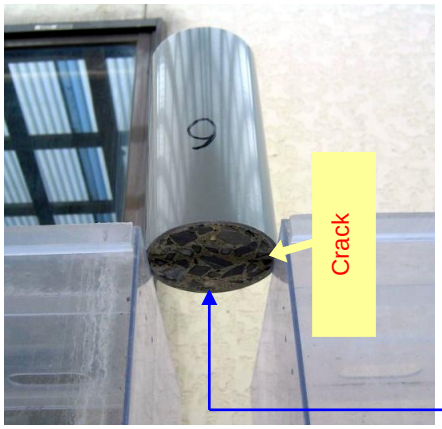


Schematic diagram of application sideways

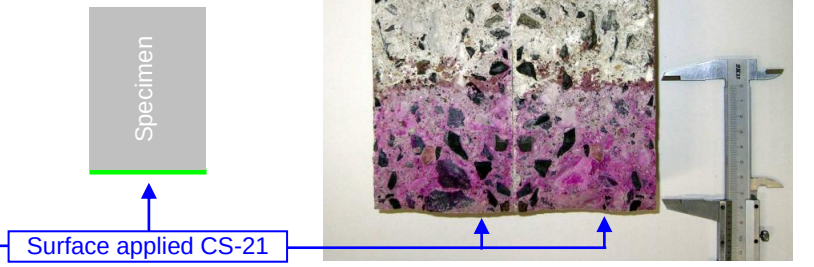


Application sideways: The depth of permeation was measured.

Application upwards: Application was finished.



Schematic diagram of application upwards



Application upwards: The depth of permeation was measured

9. PERMEABILITY TEST OF MINUTE CRACK

To confirm the effect of repairing cracks by application of CS-21, we performed a pressurized permeability test using specimens with a through crack of 0.1 mm wide of which surfaces were neutralized. As a result of the test, it was found that water leakage was not stopped without CS-21 treatment and was stopped with the treatment, with bleeding on the surface disappeared and dried.
Besides, as a result of observation of the section of the specimen after the test, it was found that the crack penetrated completely through the specimen without treatment and that pores and cracks of the specimen with treatment were filled with reactants so closely they could not be found.

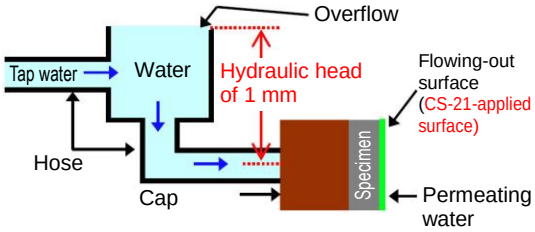
- Outline of concrete specimen

Type of cement	Ordinary Portland cement
Nominal strength	21 N/mm^2
Slump	8 cm
Maximum size of coarse aggregate	20 mm
Water-cement ratio W/C	58%
Air volume	4.5%
Form	Vinyl chloride pipe VU75
Size of form	ϕ83 x h250 mm
Size of specimen	ϕ83 x h50 mm

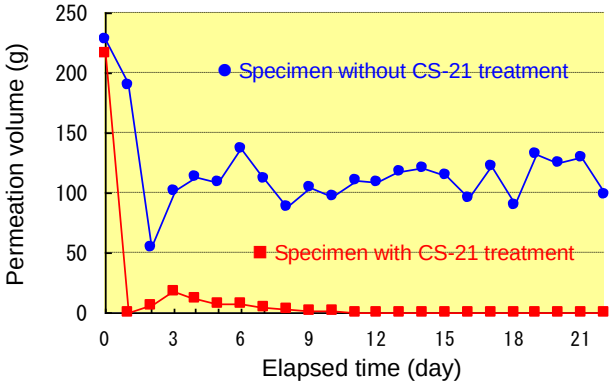
- Outline of test method

1) After placing concrete in the form and curing it, we cut the top and bottom ends to reduce the height to 50 mm.
2) Creating a through crack of 0.1 mm wide, we performed an accelerated neutralization test.
3) Setting the specimen on the permeability test equipment, we applied a water pressure at 1 mm of hydraulic head on it from pressure-applied surface and measured the volume of water flowing out of the flowing-out surface for 60 minutes (that is, initial permeation volume).
4) Selecting 3) specimens having close results of permeation volume measurement, we applied CS-21 (0.3 kg/m^2) on the surface of one specimen and did not apply it to the surface of the other.
5) We applied pressure in the method of 3) on each specimen and measured permeation volume one a day.

- Schematic diagram of permeability test

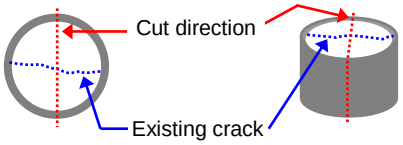


- Graph of permeability test result

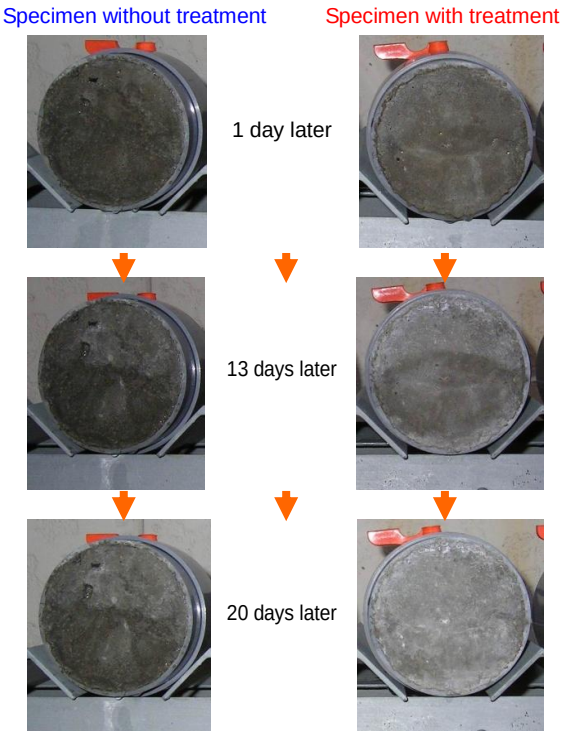


Note: “0” value of Elapsed time (day) means the initial permeation volume

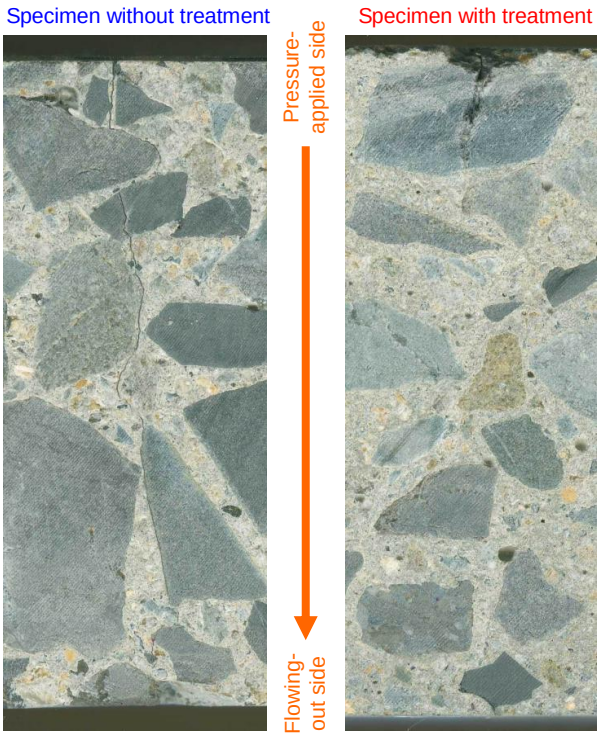
- Schematic diagram of section of specimen



- Photos of permeability test (photos of the flowing-out surface)



- Magnified photos of the section of specimens



10.MINUTE CRACK PERMEABILITY TEST

To confirm the repair effect of CS-21 application on cracks, we performed an air permeability test using specimens having a through crack of 0.1 mm wide. As a result of the test, there was little change in the specimen applied only water compared to the specimen without application (first time) and on the other hand, the crack was reduced by half by application of CS-21 once and reduced to 1/5 by application twice. In addition, the crack was reduced to 4% compared to the specimen without treatment by repeating water sprinkling after application of CS-21.

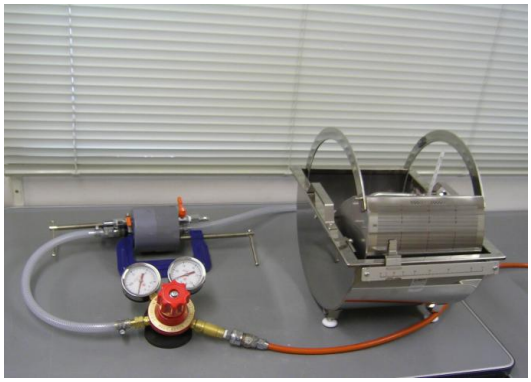
● Outline of concrete specimen

Type of cement	Ordinary Portland cement
Nominal strength	21 N/mm^2
Slump	8 cm
Maximum size of coarse aggregate	20 mm
Water-cement ratio W/C	58%
Air volume	4.5%
Form	Vinyl chloride pipe VU75
Size of form	ϕ83 x h250 mm
Size of specimen	ϕ83 x h50 mm

● Outline of test method

1) After placing concrete in the form and curing it, we cut the top and bottom ends to reduce the height to 50 mm.
2) Creating a through crack of 0.1 mm wide.
3) Setting the specimen on the air permeability test equipment, we applied a pressure of 0.05 MPa on it from the pressure-applied side and perform the first measurement of the volume of air flowing out of the flowing-out side (first time).
4) Selecting 3) specimens having close results of the air permeation volume measurement, we applied CS-21 on the flowing-out surface of each specimen.
5) After performing treatment, we perform the second measurement in the method of 3).
6) After repeating water sprinkling on Group B only, we performed third measurement.

● Air permeability test equipment



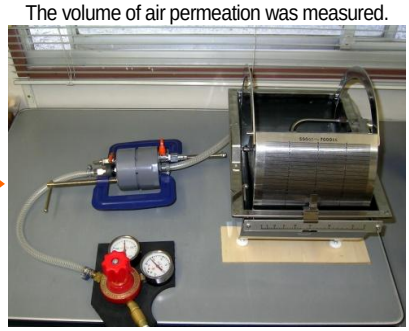
● Method of treating the flowing-out surface

Group A: Apply water	1. Apply water (0.15 kg/m^2) 2. Apply water (0.2 kg/m^2) 3. Apply water (0.15 kg/m^2) → 2nd time
Group B: Apply CS-21 once	1. Apply water (0.15 kg/m^2) 2. Apply CS-21 (0.2 kg/m^2) 3. Apply water (0.15 kg/m^2) → 2nd time Twice a day (morning and afternoon) for 12 days Apply water (0.15 kg/m^2) → 3rd time
Group C: Apply CS-21 twice	1. Apply water (0.15 kg/m^2) 2. Apply CS-21 (0.15 kgm^2) 3. Apply water (0.15 kg/m^2) 4. Apply CS-21 (0.15 kgm^2) 5. Apply water (0.15 kg/m^2) → 2nd time

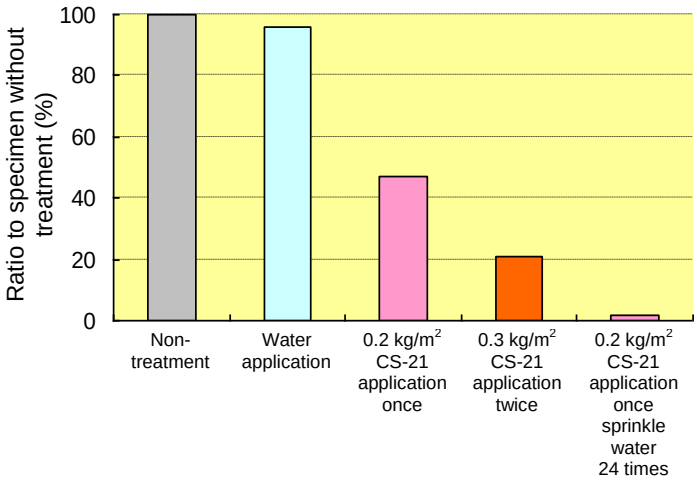
The specimen was being set.

The specimen had been set.

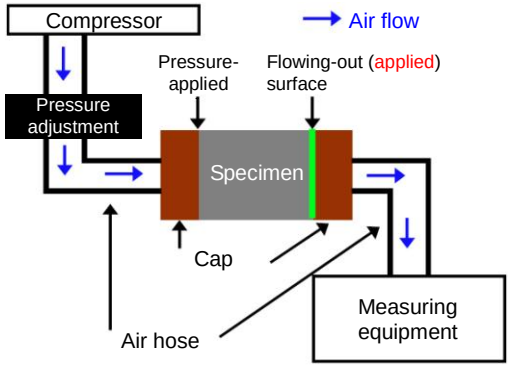
The volume of air permeation was measured.



● Graph of air permeation test result



● Schematic diagram of air permeability test



11. EFFECT AS JOINT TREATMENT MATERIAL

We performed a test to confirm the effect of CS-21 as joint treatment material. As a result, it was found that influence on a jointed surface was reduced by application of appropriate amount of CS-21 to make the base concrete denser and closer which caused jointed concrete to show its adhesion efficiently to accelerate unification.

- Photos of the test

1) Placing concrete half in the forms

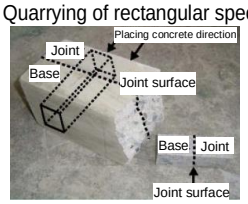
2) Laitance treatment

3) Application of CS-21

4) Placing concrete on hardened concrete

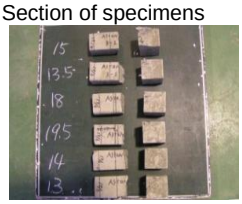
5) Bending strength test (horizontal)

6) Quarrying of rectangular specimen



7) Bending strength test (vertical)

8) Section of specimens



- Photos of the section of specimen having vertical joint surface applied appropriate amount of CS-21

State of damage on other than joint surface

- Outline of the test

1) We placed concrete to half of then height of the form for rectangular specimens (150 × 150 × 530 mm).

2) 24 hours after placing concrete, we performed laitance removal and chipping by high-pressure wash.

3) We create [1] Unified specimen without joint, [2] Specimens with CS-21 treatment (0.2 kg/m^2, 0.4 kg/m^2) joint surface, and [3] Specimen without CS-21 treatment.

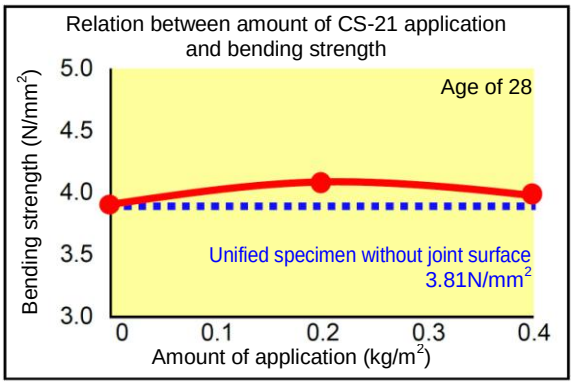
4) 7 days after placing base concrete, we placed concrete on the hardened concrete to create specimen having horizontal joint surface.

5) We performed a bending strength test using specimen having horizontal joint surface.

6) By quarrying a rectangular specimen (50 × 50 × 150 mm) from specimen having horizontal joint surface in conformity to JIS A1114: 2002, we created specimen having vertical joint surface.

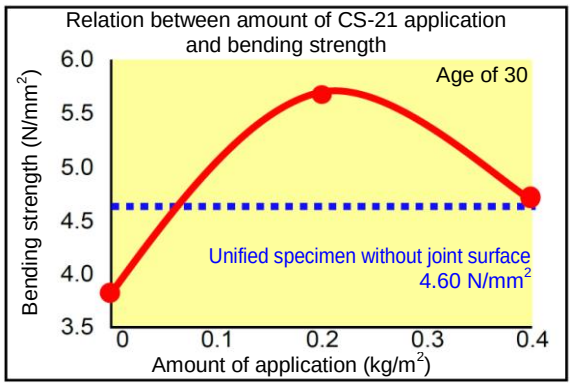
7) We performed a bending strength test using specimen having vertical joint surface.

- Result of bending test using specimen having vertical joint surface (Photo 5)



Application of CS-21 to the horizontal joint surface had a small influence on the bending strength.

- Result of bending strength test using specimen having vertical joint surface (Photo 7) and 8))



Compared to unified specimen without joint surface, specimen without treatment had lower bending strength and specimen with CS-21 treatment (0.2 kg/m^2) had higher bending strength. Specimen with CS-21 treatment (0.4 kg/m^2) had lower bending strength than specimen with 0.2 kg/m^2 of treatment.

Note: This test result does not assure adhesion or adhesive strength.

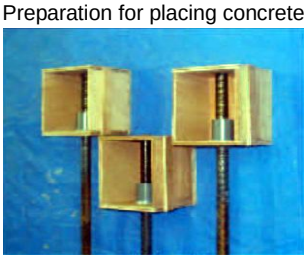
12.INFLUENCE ON ADHESION OF REINFORCING BAR AND CONCRETE

We performed a test to confirm the influence of CS-21 adhering to reinforcing bars on adhesion strength of reinforcing bar and concrete.

As a result of the test, it was confirmed that CS-21 adhering to reinforcing bars in ordinary work did not inhibits adhesion of reinforcing bars and concrete since the adhesion strength was equal between the specimen without treatment and the specimen with CS-21 treatment (0.2 kg/m^2, brush application).

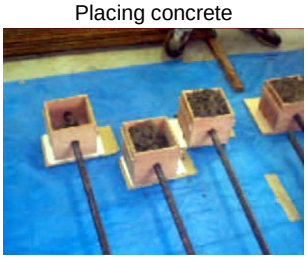
- Photos of the test

Preparation for placing concrete



Application of CS-21

Placing concrete



Pull-out test

State of damage (of specimen without treatment)

State of damage (of specimen with CS-21 treatment)

- Conforming standards

Japan Society of Civil Engineers

"Test method for bond strength of reinforcing bar and concrete by pull-out testing (Proposal) JSCE-G 503-1988"

- Materials and equipment used

Reinforcing bar

Deformed steel bar SD345 D25
(Bar dia.: 25.5 mm)

Displacement meter

CDP-25 by Tokyo Sokki Kenkyujo Co., Ltd.
(Measurement precision: 1/500 mm)

- Test procedures

1) On the previous day of placement, we removed rust and dirt from the reinforcing bar surface and created 3 specimens each with CS-21 treatment (0.2 kg/m^2, brush) and without treatment.

2) After placing concrete in the forms of the specimens and creating a rectangular specimen for compression test, we cured them in air for 28 days.

3) After finishing curing in air, we put specimens on a universal tester to measure slippage of the reinforcing bars with the displacement meter.

- Test result

Result of compression strength test for concrete of column specimen

No.	Maximum load (KN)	Compression strength (N/mm^2)	Correction factor for concrete compression strength α
1	272.5	34.7	
2	285.0	36.3	
3	268.0	34.1	0.86
Mean value	–	35.0	

Note: Properties value of corresponding bond strength is 3.0 (N/mm^2) according to "Standard specifications for concrete structures, Design"

- Formula for calculating adhesive stress

$$\tau = \frac{P}{4\pi D2} \times \alpha$$

τ : Adhesion stress
P : Pull-out load
D : Diameter of reinforcing bar
α : Correction factor for concrete compression strength
α = 30/f'c
f'c : Compression strength at the age of 28 of the column specimen which was created at the same time

Result of bond strength test

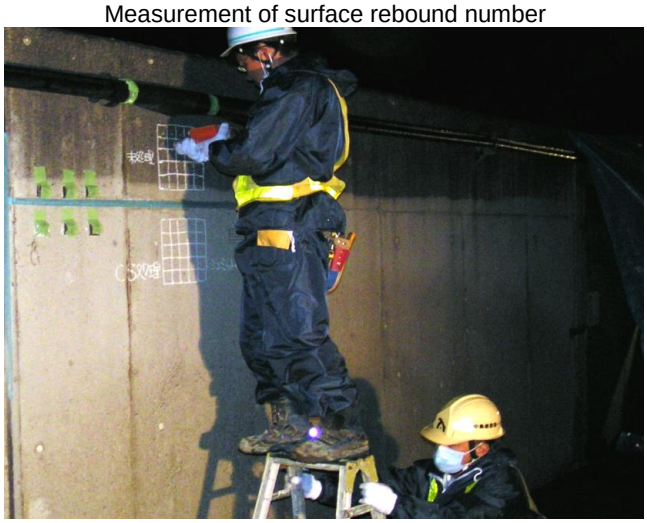
Type of specimen	Load when slippage is 0.002D (KN)	Maximum load (KN)	Adhesion stress (N/mm^2)	Maximum adhesion stress (N/mm^2)	Mean adhesion stress (N/mm^2)	Mean maximum adhesion stress (N/mm^2)
Without treatment	48.0	100.4	5.03	10.53	5.16	9.80
	47.6	97.0	4.99	10.17		
	52.0	83.0	5.45	8.70		
With CS-21 treatment	42.4	102.2	4.45	10.72	5.18	10.02
	48.2	100.4	5.05	10.53		
	57.6	84.2	6.04	8.83		

13. EXAMPLE OF TEST TO CONFIRM EFFECT OF TREATMENT - [1] CHANGE IN HEALTHY PART OF CONCRETE (ONE AND A HALF YEAR AFTER WORK)

We performed a test (Schmidt hammer rebound test, Surface tensile test, and Test with pictures taken by scanning electron microscope) to confirm the effect of CS-21 application on a concrete structure at the age of 10 years or more when one and a half year passed after the work.
As a result of the test, it was found that the part with CS-21 treatment had higher surface rebound number and tensile strength with minute pores and cracks around the aggregates filled with the reactants. Thus CS-21 had an effect of making the surface part denser and closer by reaction in existing concrete structures with neutralized surface, as well.

Treated part (Soundproof wall of an elevated bridge)

Measurement of surface rebound number



Measurement of surface tensile strength

Outline of test to confirm effect of treatment

When one and a half year passed after performing treatment in CSII treatment (application of CS-21 twice), we selected places to measure and sample in the part with CSII treatment and in another near part made of the same component freely and performed a test.

i Schmidt hammer rebound test for surface

ii Tensile test for surface with Kenken method apparatus

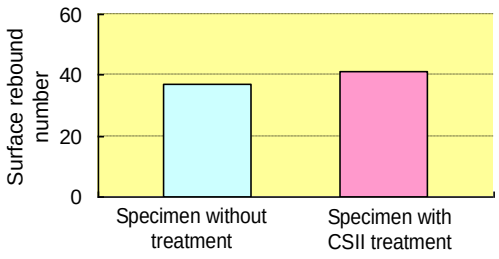
iii Test with pictures of sample of the surface taken by a scanning electron microscope

We confirmed the change after treatment (effect of quality improvement) by comparing the test result between the part with CSII treatment and the part without treatment.

i Schmidt hammer rebound test

Test method
Adhering to JSCE-G504-2007, we measured the surface rebound number in the part with CSII treatment and the part without treatment.

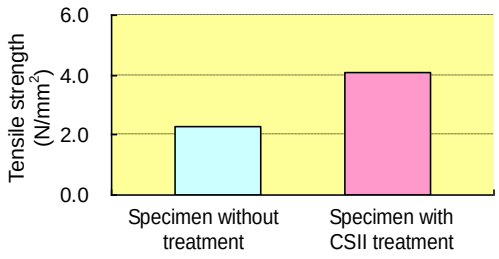
Test result



ii Surface tensile test

Test method
Attaching 40-mm-square washer to the place with CSII treatment and the place without treatment with epoxy-based adhesive and making a cut around the washer deeply to the base, we measured the surface tensile strength with Kenken Method apparatus.

Test result



13. EXAMPLE OF TEST TO CONFIRM EFFECT OF TREATMENT - [2] TAKING PICTURES BY ELECTRON MICROSCOPE

iii Test with pictures taken by scanning electron microscope

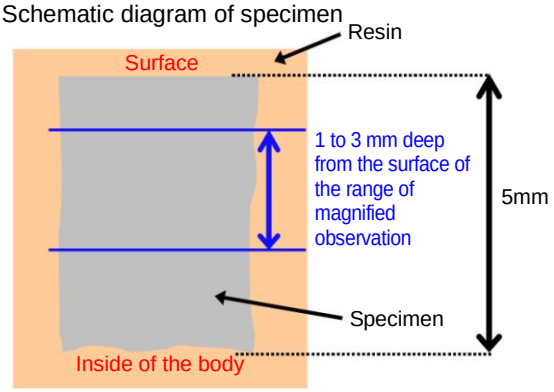
Test method

Extracting a sample (100 × 100 × 50 mm) each in the part with CSII treatment and in the part without treatment, we requested a test organization to take pictures of the samples by a scanning electron microscope after working them into specimens. The target of magnified observation of the place of picture taking was performed at around an aggregate located 1 to 3 mm deep from the surface and at micro cracks which expanded from the aggregate.

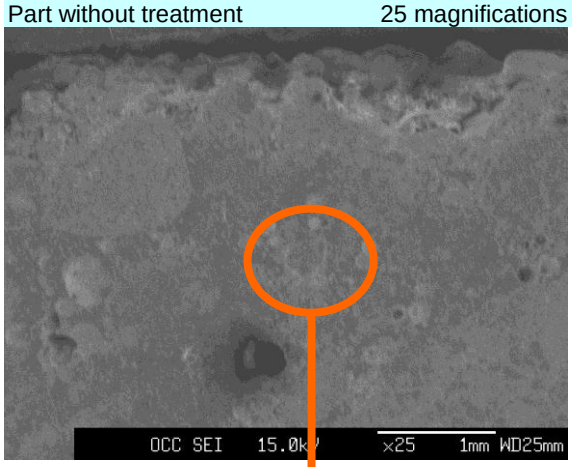
Test result

It was found that minute pores and cracks around the aggregate were filled with reactants at the part with CSII treatment but it was not at the part without treatment.

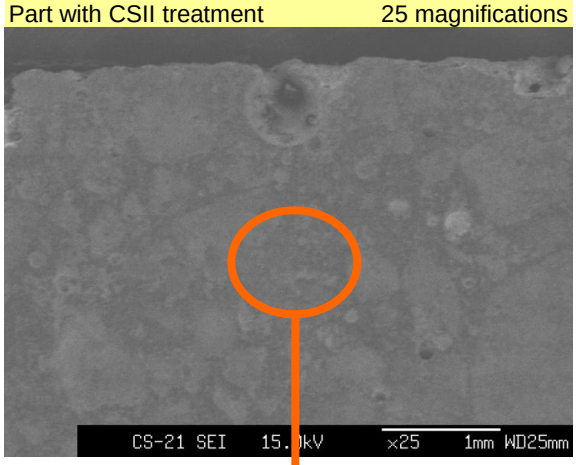
Schematic diagram of specimen



Part without treatment 25 magnifications

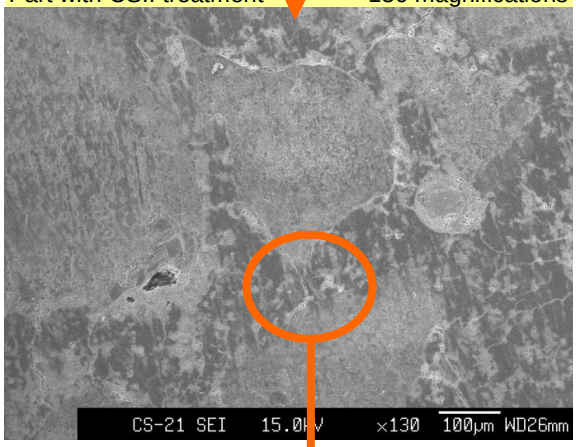


Part with CSII treatment 25 magnifications

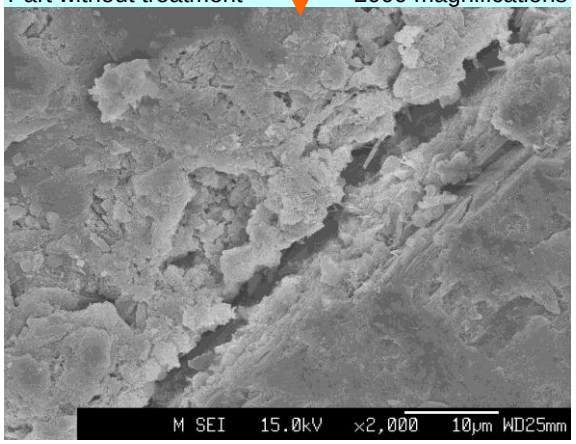


Part without treatment 130 magnifications

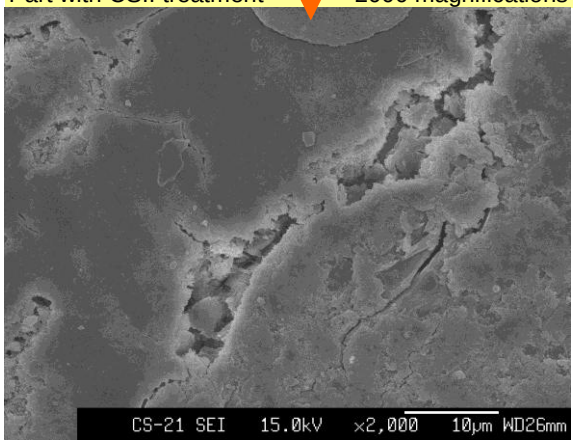
Part with CSII treatment 130 magnifications



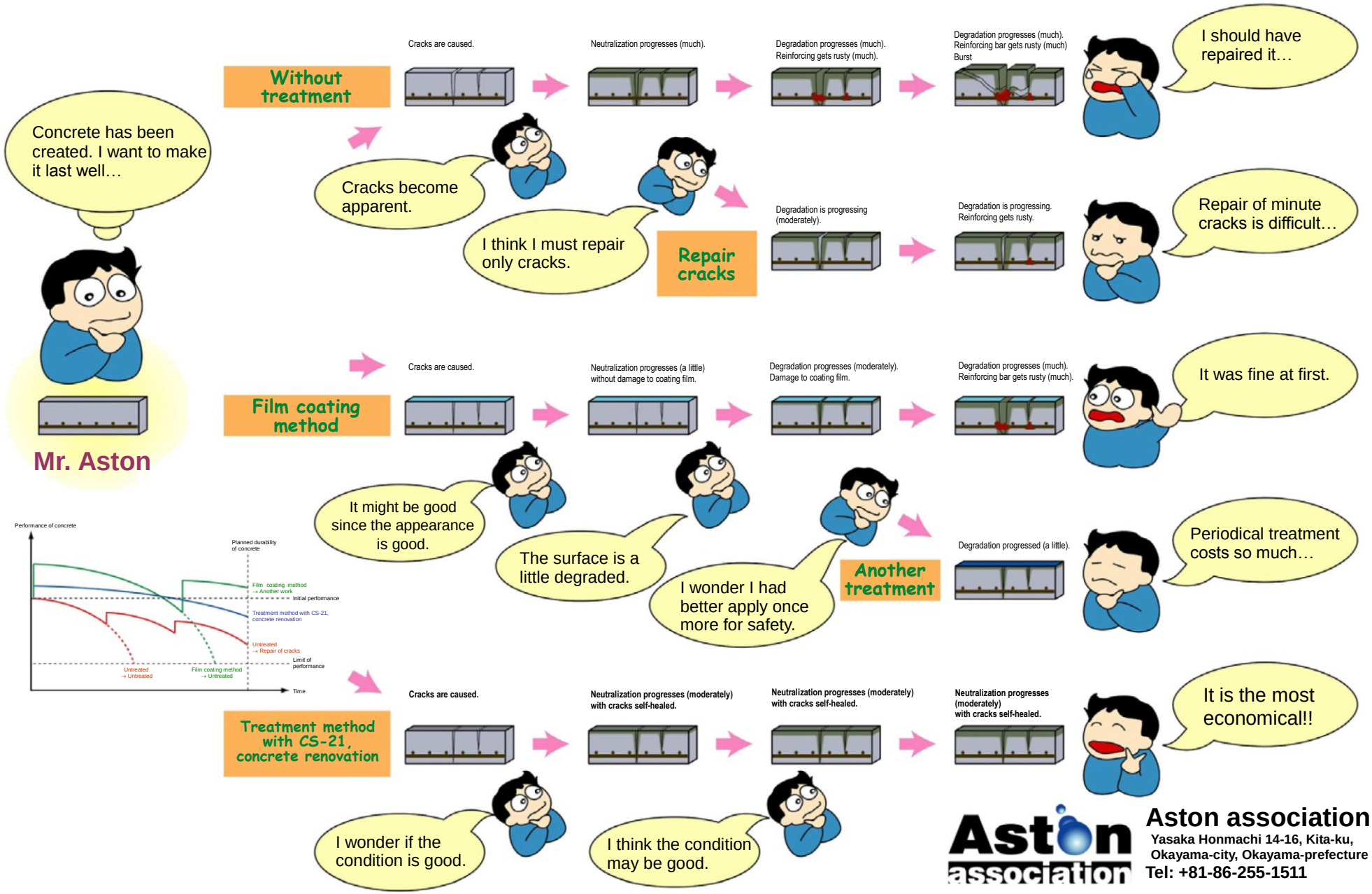
Part without treatment 2000 magnifications



Part with CSII treatment 2000 magnifications



Consider Life Cycle Cost of Concrete



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