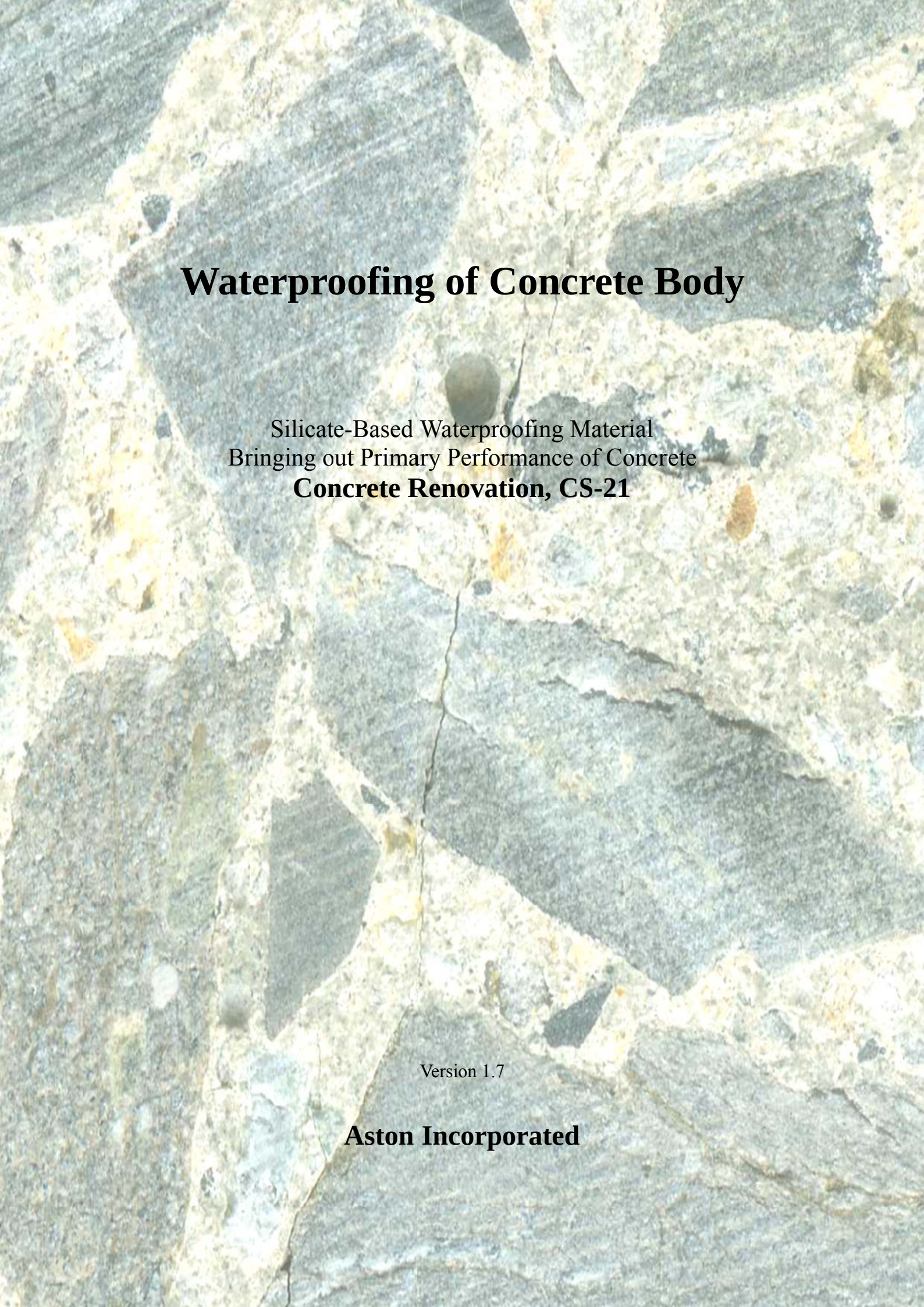

Waterproofing of Concrete Body

Silicate-Based Waterproofing Material
Bringing out Primary Performance of Concrete
Concrete Renovation, CS-21

Version 1.7

Aston Incorporated

Introduction

Some people say that cement has been used since Neolithic Age, about 9,000 years ago. In addition, Pyramids in Egypt for which plaster and caustic lime have been used 5,000 years ago can be said that those are structural objects using cement in a broad sense. Ancient Rome, 3,000 years ago, has constructed a lot of highly durable concrete buildings still remaining now. The buildings have been made by using cement in which caustic lime carried on the tradition of Etruscan conquered mixed with volcano ash soil, Pozzolana, containing silicon oxide.

The manufacturing process of Portland-Cement generally used now has been developed in England in 1842. Japanese cement manufacturing has started at the Finance Ministry's plant in Fukagawa, Tokyo, in 1872.

Cement-Concrete is excellent construction material indispensable to social infrastructure development now since it has high molding freedom degree, extremely high rigidity, high durability and low cost.

Among structural objects made of concrete, waterproof construction work is applied to roof, underground structure, water tank, etc., where water leaking may cause trouble. The waterproofing work is not only preventing water leak but also undertaking an important role of protecting concrete body to maintain the structural object for long time.

The waterproof method for concrete structural object is roughly divided into two. One of them is a covering method to pave concrete surface with low permeability coefficient material (asphalt, sheet, coating film, FRP, metal sheet, etc.). Another one is waterproofing of concrete body method enhancing water-tightness of concrete itself by filling gaps in the concrete.

The covering method has the advantage of easy to follow that the performance of paving material itself directly becomes waterproof performance. For the reason, product development of covering method has promoted in advance and has occupied the most of market so far.

Meanwhile, the waterproofing of concrete body method which enhances the water-tightness of body concrete was said that it is ideal. But the method stays only for limited use due to the reason that effect is not confirmed only by material but is depending largely on the quality of target concrete body. However, this comes under review recently.

What became the factor is the asset management of structural object. The durability of structural object becomes extremely important when considering lifecycle cost of structural object. Accordingly, the waterproofing of concrete body method is started to be reviewed, which enhances concrete durability in addition to waterproof effect.

Currently, silicate-based surface penetrant in engineering field and silicic system waterproofing material in architecture field are attracting attention as material used for waterproofing of concrete body method. The fundamental way of thinking on those materials, material scope of application, caution items at material/ method selection, standard specifications, etc., are described in this leaflet.

We are yearning for the waterproofing of contribution to the asset management of concrete structural object. We expect your positive utilization.

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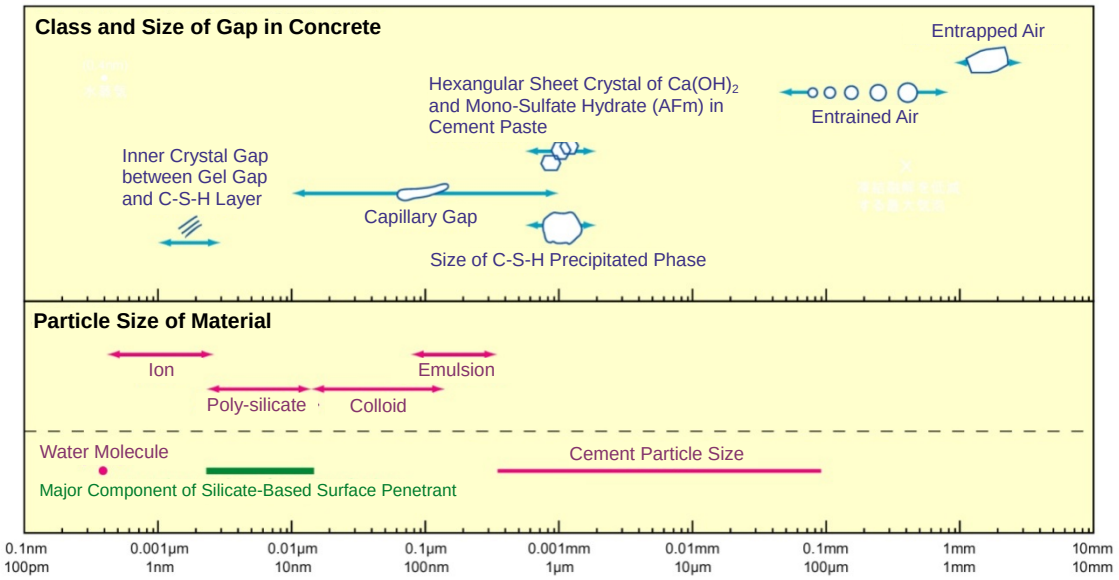
1. Target Material

The intended silicate-based surface penetrant and silicate-based waterproofing material are clear watery solution of silicate as main component and is the material to enhance water-tightness by impregnating into concrete to fill concrete fine gaps with C-S-H crystal.

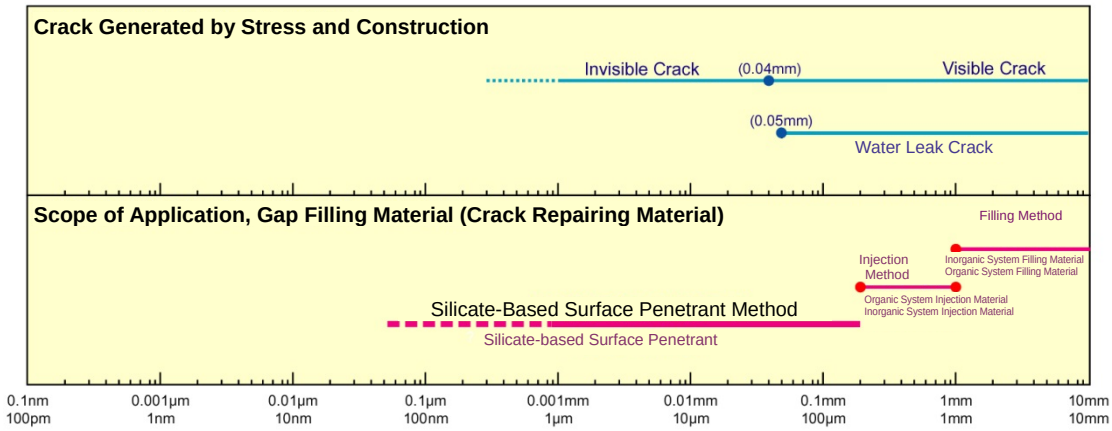
The main component, silicate, exists as poly-silicate having a structure where continuing chain molecule of Si(OH)n close around alkali metal atom under water solution status. The diameter of poly-silicate is larger than that of ion but smaller than colloid as shown on Fig.-1 and the diameter of major component in silicate-based surface penetrant falls in the almost same range.

Fig.-1: Gap Size in Concrete and Particle Diameter of Silicate-Based Surface Penetrant



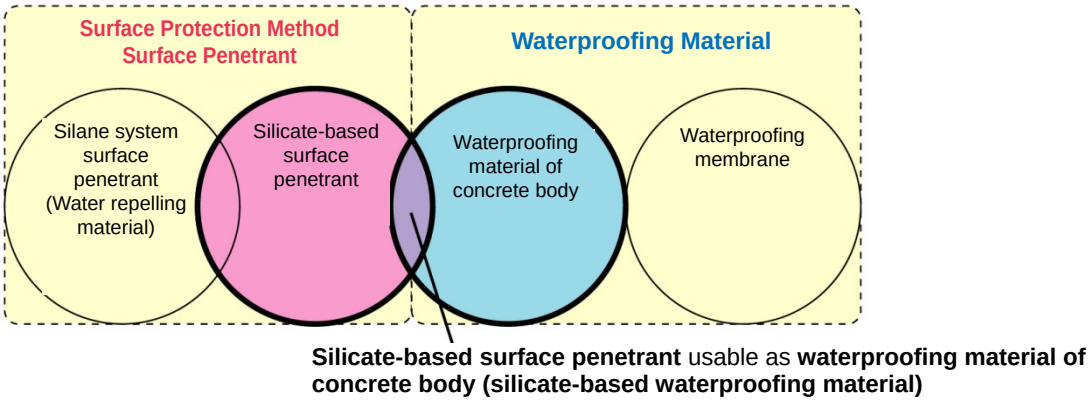
This is the material suitable to fill fine gaps from the particle size, application range is as shown on Fig.-2 and is the effective material for fine cracks or water leaking crack which are hard to correspond with filler and injectable material.

Fig.-2: Crack Width Generated on Concrete Structural Object and Application Range against Crack Width for Silicate-Based Surface Penetrant Method



Silicate-based surface Impregnation method at Japan Society of Civil Engineer is classified into solidified type which elaborates air gaps due to solidification of material itself and reaction type which elaborates air gaps by repeating reaction with calcium in the concrete but reaction type silicate-based surface penetrant which is usable as waterproofing of concrete body for concrete is described here as comparison. (Refer to Fig.-3)

Fig.-3: Surface Penetrant and Waterproofing Material of Concrete Body



Material is phrased as [Silicate-Based Waterproofing Material] and concrete performance for waterproofing of concrete body is phrased as [Water-Tightness] in the description below;

2. Water-Tightness of Concrete

Concrete is the material with rich water-tightness and preventing water penetration but is dealt with various factors when making a structural object and water-tightness is deteriorated due to partial generation of crack; and those become the cause of water leakage. It is tend to be thought that crack is easily be confirmed visually but fine cracks and gaps which are hard to be confirmed visually are generated on the concrete thought to be sound. Those become the cause of water-tightness deterioration.

2.1 Factors for Water-Tightness Deterioration

① Impact by Concrete Material

Concrete contains small unit water amount and water-tightness becomes higher as water-concrete ratio becomes smaller but workability is important when building structural object and material balance is important for the water-tightness of structural object. There is the tendency of water-tightness deterioration due to the lack of good quality aggregate recently.

② Impact by Construction Work after Concrete Placing into Formwork and before Solidification

Defective part from construction work such as honeycomb as a matter of course, construction joint, cold joint and penetrating member (including separator) get impact such as breathing and water-tightness largely deteriorated if proper action is not taken.

③ Impact by Hydration Heat and Cure before Strength Generation

Crack tends to take place due to temperature difference went with hydration heat at mass concrete and hydration heat rise becomes the cause of passing-through crack went with shrink after solidification at the case other than mass concrete. In addition, drying due to the lack of initial cure largely deteriorates surface layer quality and water-tightness is deteriorated.

④ Impact by Environment after Starting Performance

The water-tightness also gets impact by material thickness, thin material structural object gets passing-through crack easily by the repetition of dry-wet and temperature variation after starting performance specifically and water-tightness is deteriorated.

Stress variation repetition such as deflection by self-weight and load may cause passing-through crack easily and water-tightness is deteriorated.

2.2 Hydration Reaction and Water-Tightness of Concrete

The cement used for concrete has the performance of filling cracks and gaps by hydration reaction and the water-tightness is enhanced by performing wet curing. It is said that concrete becomes elaborate and strength is enhanced for long time if the concrete is cured by this performance. However, still-water becomes curing water but moving water transfers the component of cement under hydration reaction. In addition, since hydration reaction is slow in reaction, it is required to keep wet status for long time and water-tightness enhancement performance is not brought out sufficiently at structural object in actual situation.

2.3 Silicate-Based Waterproofing Material and Water-Tightness of Concrete

Silicate-based waterproofing material is the waterproofing material of concrete body to enhance water-tightness of concrete.

There is the concrete water-tightness enhancement effect by keeping water retention (cure) effect through impregnation into fine crack and air gap as well as supplying silica component required for cement hydration reaction to enhance reaction rate. The reaction continues by water supply after starting performance and there is the water-tightness recovery effect for newly generated air gap up to healthy situation.

3. Structural Object Requirements and Scope of Application of Silicate-Based Waterproofing Material

Waterproof refers to prevent water impregnation but the requirement difference corresponding to intended purpose and the scope application for silicate-based waterproofing material are shown as follows;

① Requirements for the no notice case of small amount water leakage such as channel, etc.; for no notice case of bleeding and small amount of water leakage by taking installation action for double walls and drainage system such as basement parking lot:

[Partial Application]

The requirements are secured by building concrete with high water-tightness and total usage of silicate-based waterproofing material is not required as water proofing.

Silicate-based waterproofing material is able to improve water-tightness and durability by processing construction joint location, plastic cone location and cold joint where predisposing to repair or faulty places.

In addition, water-tightness is able to be secured used as water shutoff material at water leaking location but prior process is economical since water stop construction work requires a lot of labor cost.

② Requirements for the Cases of not Allowing Water Leakage for Direct Outer Wall Use of Water Tank, Roof and Basement:

[Scope of Application]

If a structural object becomes larger, the securing of requirements becomes difficult only by concrete but this becomes applicable by using high performance silicate-based waterproofing material.

This comes into effect as waterproofing of concrete body including the process on construction joint, plastic cone and penetrating members.

Requirements are able to be secured by performing partial repair on construction faulty location and structural crack.

③ Requirements for the Case of Having the Custody of Precision Equipment to Prevent Water Leaking as a Matter of Course and Moisture:

[Out of Application]

It is required to pave water contact location with low water/air permeability resin and metal, and is the out of application range for silicate-based waterproofing material.

4. Confirmation Items for Selecting Silicate-Based Waterproofing Material and Method

It is required to confirm and select usable material as waterproofing material and method by the standardized test method since performance of silicate-based waterproofing material largely differs depending on material and method. Refer to Attached Data, (1) Simulation on Micro Void Filling Effect by silicate-based waterproofing material for details.

① Should Secure Sufficient Solid Amount
It is important to confirm solid amount per unit area for filling gaps and the amount is obtained from dilution ratio and design application amount, and dry solid content ratio. It is necessary to confirm the dry solid content ratio by test.

② Should Have Re-Reactivity
Selection of re-reactivity material is important in order to fill newly generated gaps after construction work continuously and it is necessary to confirm by re-extraction test and re-reaction test after dried and solidified.

③ Performance to React Neutralized Concrete should be Equipped
Calcium hydroxide in concrete is neutralized quickly when contacting with air.
It is important to select material which reacts with neutralized concrete since inner surface of gaps and cracks is neutralized and is necessary to confirm by reaction test between neutralized cement paste and material.

④ Should Secure Water-Tightness of Fine Crack
Silicate-based waterproofing material is intended to secure the primary water-tightness of concrete by filling fine crack.
It is necessary to confirm performance by using crack water permeability suppressing test using specimen which generates passing-through crack less than 0.2mm.

⑤ Construction Work System by Engineers Who Totally Know about Material Property should be Put into Place
In order to secure waterproof quality, concrete-related knowledge and knowledge and skill to arrange reaction suitable conditions by impregnate solid amount into concrete gap are required.
It is necessary to confirm work system, work planning document and accomplishment by the worker in charge, etc.

CS-21 Checking Result against Confirmation Items, ① ~ ⑤

Confirmation Item	Result of CS-21
① Dry Solid Amount	Dry Solid Amount: Greater than 390g/L (JIS K0102-14.2) Dry Solid Amount in Design Application Amount, 200g/m^2: 63g/m^2 Dry Solid Amount in Design Application Amount, 300g/m^2: 95g/m^2
② Yes/No of Re-Reactivity	Dried and solidified CS-21 indicates solubility and deliquescent property, and has re-reactivity.
③ Reaction to Neutralized Concrete	Reactivity to neutralized concrete is confirmed, which is slighter than that to concrete that is not neutralized.
④ Effect on Minute Cracks	Water sealing effect at crack part and air penetration reduction effect at crack part has been confirmed by the test on specimen having 0.1mm width penetrating crack.
⑤ Work System / Training of Managing Engineer	An association has been organized to be responsible for work and the system of training engineers has been established. Much work has been successively performed and management engineers have much experience.

5. Silicate-Based Waterproofing Material CS-21 Applied Waterproof

Applicable structure and concrete quality have limitation for waterproofing of concrete body.
It is important to plan to meet each waterproof method.
It is possible corresponding to cracks due to dried shrink and temperature stress but additional process is required against structural cracks.

5.1 Application Conditions for Waterproofing of Roof

Waterproofing of roof by CS-21 is the waterproofing of concrete body to enhance water-tightness of concrete body. The structural quality confirmation is necessary by referring to the Table-1 below at the application. This is the method requiring cooperation for constructing concrete with high water-tightness by designer, main contractor, concrete body construction contractor and waterproof construction contractor.

Table-1: Application Conditions for Waterproofing of Roof by CS-21

Class	Assumed Problems	Necessary Conditions for CS-21 Waterproofing of Concrete Body
Material	Crack generation due to lack of initial strength and shrink	The concrete to be used shall be normal concrete (site placing).
	Much breathing and crack due to material separation and gap under reinforcing bar generated	If fluidizer is not used, slump should be less than 16cm, water ratio should be less than 55% and unit water volume should be less than 175Kg/m^3.
Structure	Generation of structural crack	Structural object should be RC/ SRC structure and has sufficient bearing force.
	Crack generation due to structure	Minimum cover thickness should be 30mm from slab upper surface. (40mm of maximum cover thickness is desirable)
	Rusting generation on reinforcing bar due to corrosion current and crack generation due to partial loss of area	Electrical wiring should be cured by protecting duct, multiple batch piping is prohibited and position should be the center of slab cross-section in principle.
Treatment (Placing)	Crack generation went with defective quality of post filling material and peel-off generation	Water disposal drain should be direct placing into concrete.
	Puddle generation due to poor drainage	Set drainage slope greater than 1/100.
	Generation of crack at construction joint section and concrete strength shortage	Clean construction joint section completely and perform concrete placing after spraying CS-21.
	Generation of crack and shortage of concrete surface strength	Concrete surface should be finished with metal trowel (brushing at same time is acceptable) and crack-inducing joint is not laid on.
Treatment (Curing)	Alligator crack generation due to abnormal setting/ shrink	Keep concrete surface in wet status for 2 days after concrete placing and prevent rapid drying (film curing agent is not used).
	Incidence of delayed waterproof effect	Perform accelerated curing such as water spraying in order to bring out quick waterproof effect.

* The waterproofing of roof using CS-21 is the method complying with Housing Warranty Insurance.
* The waterproofing of concrete body is in conjunction with processing construction joint and penetrating member, and whole surface application.

5.2 Application Conditions for Waterproofing of Parking Lot

Waterproofing of parking lot by CS-21 is the waterproofing of concrete body to enhance water-tightness of concrete body. This is the method having a lot of merits such as load relief and substantial shortening of construction period because protecting layer and waterproof layer are not required, superior in durability, structural defect may be corresponded by partial repair, etc.
It is necessary to confirm the quality of structural object by referring to Table-2 below at the application. This is the method requiring cooperation for constructing concrete with high water-tightness by designer, main contractor, concrete body construction contractor and waterproof construction contractor.

Table-2: Application Conditions for Waterproofing of Parking Lot by CS-21

Class	Assumed Problems	Necessary Conditions for CS-21 Waterproofing of Concrete Body
Material	Crack generation due to lack of initial strength and shrink	The concrete to be used shall be normal concrete (site placing) and use expansive additive if area is large (greater than 30m of long arm).
	Much breathing and crack due to material separation and gap under reinforcing bar generated	If fluidizer is not used, slump should be less than 16cm, water ratio should be less than 55% and unit water volume should be less than 175Kg/m^3.
Structure	Generation of crack	Slab structural object should sufficiently bear live load (dynamic load included).
	Crack progress and generation of vibration trouble	Deflection of beam should be less than 1/400 to suppress deck slab deflection. (Less than 1/300 of deck slab deflection is desirable)
	Generation of crack due to bond and deflection, and strength shortage of concrete and reinforcing bar	Arrangement of bar should be greater than D10@200 single bar arrangement and arrange additional reinforcement around girder and pillar. Minimum cover thickness should be 30mm from slab upper surface. (40mm degree of maximum cover thickness is desirable)
	Crack generation due to concrete cross-section shortage	Concrete thickness should be greater than 80mm (100mm for light-weight aggregate concrete) at minimum cross-section.
	Rusting generation on reinforcing bar due to corrosion current and crack generation due to loss of cross-section area	Electrical wiring should be cured by protecting duct, multiple batch piping is prohibited and position should be the center of slab cross-section in principle.
	Generation of crack due to breathing water and mortar flown out and strength shortage of porous section and concrete	The construction joint gap of deck plate is held by waterproof tape (butyl rubber tape greater than 2.0mm thickness and 20mm width).
Treatment (Placing)	Crack generation went with defective quality of post filling material and peel-off generation	Water disposal drain should be direct placing into concrete.
	Corrosion generation at end portion hardware due to poor drainage	Set drainage slope greater than 1/100. Lift up concrete finished surface at floor edge with the degree of 15 ~ 20mm.
	Foster crack at construction joint section and corrosion generation	Secure the predetermined shape of construction joint location and be sure to remove the lath net fixed by concrete.
	Generation of crack at construction joint section and concrete strength shortage	Clean construction joint section completely and perform concrete placing after spraying CS-21.
	Generation of crack and shortage of concrete surface strength	Concrete surface should be finished with metal trowel (brushing at same time is acceptable) and crack-inducing joint is not laid on. In addition, slope section, upon vacuum concrete method, is finished with a brush after holding with a metal trowel.
Treatment (Curing)	Alligator crack generation due to abnormal setting/ shrink	Keep concrete surface in wet status for 2 days after concrete placing and prevent rapid drying (film curing agent is not used).
	Crack generation due to impact displacement	Do not apply load until predetermined strength is realized. Use concrete product for bumping post, adhere with chemical anchor and epoxy resin, and fix.
	Incidence of delayed waterproof effect	Perform accelerated curing such as water spraying in order to bring out quick waterproof effect.

* The waterproofing of concrete body is in conjunction with processing construction joint and penetrating member, and whole surface application.

5.3 Application Conditions for Waterproofing of Underground Structure/ Waterproofing of Water Tank

Underground structure and water tank waterproofing by CS-21 is the waterproofing of concrete body to enhance water-tightness of concrete body. It is necessary to confirm the quality of structural object by referring to Table-3 below at the application.

This is the method requiring cooperation for constructing concrete with high water-tightness by designer, main contractor, concrete body construction contractor and waterproof construction contractor.

Table-3: Application Conditions for Underground Structure / Water Tank Waterproofing by CS-21

Class	Assumed Problems	Necessary Conditions for CS-21 Waterproofing of Concrete Body
Material	Much breathing and crack due to material separation and gap under reinforcing bar generated	If fluidizer is not used, slump should be less than 16cm, water ratio should be less than 55% and unit water volume should be less than 175Kg/m^3.
Structure	Generation of structural crack	Structural object should be RC/ SRC structure and has sufficient bearing force.
Treatment (Placing)	Generation of crack at construction joint and penetration sections, and strength shortage of concrete	Clean periphery of construction joint and penetration sections completely, and perform concrete placing after spraying CS-21. Be sure to remove the lath net frame, etc.
	Gap generation on the lower surface of separator	Avoid separation location at placing on fresh concrete and make sufficient compaction. Clean plastic cone section completely after form removal and fill mortar, etc., after spraying CS-21. Injection combined method is recommended for inside waterproofing.
Treatment (Curing)	Alligator crack generation due to abnormal setting/ shrink	Keep concrete surface in wet status for 2 days after concrete placing and prevent rapid drying (film curing agent is not used).
	Incidence of delayed waterproof effect	Curing period is required in order to surely bring out waterproof effect. Provide more than 2 weeks in case of underground structure outer wall before backfill, and in case of water tank before water storage.

* This is compatible to the evaluation criterion of ministerial ordinance, Ministry of Health and Welfare, defining technical standard of water supply facility.
* The waterproofing of concrete body is in conjunction with processing construction joint, plastic cone and penetrating member, and whole surface application.
* In case of underground structure outer waterproofing, CS-21 + Filler Method is recommended, which reduces curing and enhances waterproof performance.

5.4 Water Sealing Method

The water sealing refers to stop water flow and the water sealing method is required when water leak from concrete becomes problematic. Water leak incidence from concrete structural object requires conditions, water, gap, and moving force of water, the leak is able to be prevented by eliminating one of those. Water leak does not occur in the environment where concrete does not contact with water. In case of underground structure, water tank, roof, etc., where water exists, water leak prevention is possible by covering with waterproofing membrane not to contact concrete with water but if water invaded by the cause of braking waterproofing membrane and recovery of waterproofing membrane is difficult, water sealing construction is required.

Water sealing prevents water leak by filling gap of concrete where water goes through.

The water sealing method should include the review to reduce water moving force by taking water gradient, lowering water level, pressure-reduction by raw water conveyance, etc., in addition to forced stop.

5.4.1 Necessary Conditions for Water sealing Material and Silicate-Based Waterproofing Material

As for material to fill gaps, the material such as capable one of filling fine gaps, no volume reduction at hardening, and slightly expandable and durable is desirable if possible.

In case of water sealing cement, volume reduction is small and durable but since it is difficult to fill fine gaps, gaps are filled while widely expanded by chipping. Grout such as urethane foam is able to fill fine gaps and expanded but durability is poor.

Silicate-based waterproofing material meets the condition of water sealing material.

The silicate-based waterproofing material contains a lot of dry solid amount with high reactivity is able to fill fine gaps and volume is reduced by drying but compensate volume reduction, and has the same durability as cement hydrate. If gaps are greater than 0.2mm, water sealing becomes capable by combining with cement system grout.

The water sealing by the silicate-based waterproofing material fills gaps by injection and penetration from surface. Generally used injection tool is usable and combined use with other method is also possible.

There is the standard water sealing method but it is important to establish a work plan after investigation and diagnosis on the current status of structural object and collection of opinion from technicians who actually work is most important.

5.4.2 Standard Method for Water Sealing

① Injection Method

Injection method refers to inject material into fine gaps by using mounting tool and injection device, and pressure-injection, low pressure continuous injection, etc., are common.

Silicate-based waterproofing material is the material suitable to fill fine gaps.

Air and water which exist in gaps are required to be escaped, and sound escape is the secret to the construction work.

If drill a hole and inject from inside, do not seal surface cracks, inject after escaping air and water, seal after flow out silicate-based waterproofing material, and apply pressure.

If gaps are greater than 0.2mm, inject cement system grout and resin system grout after injection of silicate-based waterproofing material to stop water.

② Filling Method

If gaps are large and wider in range at concrete honeycomb section and cold joint, if break off weakened part and repair cross-section with cement material, those might be the cause of water leak at bond interface.

Improvement of adhesive force and enhancement of water-tightness are capable by coating with silicate-based waterproofing material CS-21 to bond interface.

Taking action to escape water temporarily with raw water conveyance pipe, water not coming around to water pressure and boundary face until strength of cross-section repair agent is the secret.

Stop water by injection or filling water stop cement at water supply position after filler strength is generated.

③ Application Method

If applied surface is able to be dried temporarily in the case of bleeding degree of water leak from concrete surface, water sealing becomes possible by coating with silicate-based waterproofing material CS-21 for densification.

If water is stopped by injection and filling method, water pressure goes higher and water is further stopped by coating with CS-21 from surface on water sealing location where water is escaped to fine gaps.

④ Water Transmission Method

This is the method not to apply load onto building frame by reducing water pressure through water processing and guide water to trouble free location, even though usable location is limited to the location where water discharge facility is equipped, etc.

Chasing one another for water sealing not only spends a lot of money but also hurts concrete body also.

Water sealing plan, such as guiding water in advance to location where water processing is easy and stop water at other locations, is important.

6. Follow-up Investigation and Decision Criteria for Waterproofing of Concrete Body by CS-21

The waterproofing of concrete body by CS-21 is intending waterproofing and cracks on concrete surface is not direct problem but is an important factor to control waterproof performance.
Self-motivating follow-up investigation has been performed on constructed properties by the construction contractors so far but no consistency exists on investigation and decision criteria, and there were some problems for comprehensive evaluation on the investigation results.
So, we have tried to set follow-up investigation and decision criteria tentatively as material to review method, concrete body conditions, etc.

6.1 Purposes and Investigation Items of Crack Investigation Intending Investigation/ Diagnosis Work

Crack investigation is intending to secure the durability of structural object by performing a diagnosis on occurrence cause, selecting proper repair method and by construction.
Normally, the crack occurrence cause is easily estimated by the assumption on the cause of crack [Japan Concrete Institute; Concrete Crack Investigation, Repair/ Reinforcement Guideline, 2009; Chapter-3: Assumption on the Cause of Crack], from the result of standard investigation regarding crack occurrence or discovered timing and crack pattern.
However, if the cause is not understandable only by standard investigation, implementation of detailed investigation is required. Measurement by using nondestructive test equipment may be implemented for special case.

6.1.1 Standard Investigation Items Related to Crack Occurrence Cause

① Present Investigation
Pattern, Surface Opening Width, Length, Yes/ No of Foreign Matter Filling, Wet-Dry, Dirt …
② Trouble Investigation
Water Leak, Efflorescence, Corrosion on Reinforcing Bar, Member Deflection, Disfigurement …
③ Age-Based Crack Investigation
Time of Occurrence or Discovery, Growth Progress …
④ Investigation on Design Document Group
Design Drawing, Structural Calculation Sheets …
⑤ Investigation on Construction Record
Used Material, Composition, Placing, Curing, Process, Control Test Data, Class of Ground Status and Frame, Environmental Condition …

6.1.2 Detailed Investigation Items Related to Crack Occurring Cause

① Present Investigation
② Investigation on Concrete Strength by Core
③ Collation Investigation of Cross-Section Dimensions with Design Drawing
④ Investigation on Load Condition
⑤ Investigation on Ground
⑥ Investigation on Reinforcing Bar
⑦ Investigation on Neutralization
⑧ Investigation on Water Leak Route
⑨ Detailed Investigation on Crack
⑩ Analysis Investigation on Concrete
⑪ Load Test Investigation on Structural Object
⑫ Vibration Test Investigation on Structural Object

6.1.3 Items of Investigation for which Nondestructive Test Equipment is used

Nondestructive Test Technology contains various methods by items, such as hammering test/ impact wave method/ supersonic wave method by using elastic wave, electromagnetic wave method/ electromagnetic induction method by using electromagnetic wave, test hammer by using rebound degree, self-potential method to measure electric characteristics, etc. There are many test equipment which replace other measured value to intended value from technical characteristic reason, those values should be corrected depending on aged phenomenon in order to inspect structural objects. In addition, measuring condition has limitation and there is the problem of unstable accuracy depending on environment.

6.2 Tentatively Set Follow-up Investigation on Waterproofing of Concrete Body

Follow-up investigation performed by the construction contractors is a simple investigation intending waterproof function keeping and discussion with a manager is required if detailed investigation related to structure is needed.

6.2.1 Timing of Investigation

The investigation will be implemented at annual periodical inspection defined by the construction schedule or at failure occurrence.

6.2.2 Investigation Contents of Waterproofing of Concrete Body

The investigation method is standardized on visual inspection, confirmation on entire status and detailed follow-up investigation are performed at selected locations.

① Investigation on Entire Area

As for the entire area, prepare rough development diagram for cracks greater than 0.2mm and perceive the trend of crack, length variation and yes/ no of self-healed effect. In addition, water leak, efflorescence, corrosion on reinforcing bar, member deflection and disfigurement should be recorded.

② Investigation on Selected Location

Select some typical locations with $10m^2$ degree and perform detailed investigation. If any deformation and defect are occurred, locations for those should be included in the selected locations. Take photographs of selected locations corresponding to the development diagram and confirm crack width variation and self-healed effect.

6.2.3 Measurement Equipment Used Investigation

Confirmation on bar arrangement status by Reinforcing Bar Detector is effective to determine whether non-convergent crack is able to be corresponded by waterproofing of concrete body or not. Air permeability test, surface water absorption test, etc., are there as the confirmation method for concrete surface layer quality.

① Investigation by Using Reinforcing Bar Detector

The Reinforcing Bar Detector is the equipment for nondestructive search to look into the inside of concrete and is mainly used for the reinforcing bar arrangement status in concrete. This is the test method with high accuracy.

② Investigation by Using Air Permeability Test Equipment

The Air Permeability Test Equipment (Torrent Method) uses a vacuum pump and measures concrete surface quality at site with 2 chamber cells under nondestructive status.

The air permeability is the property of gas penetration in a substance and the air permeability of concrete is one of the properties to govern durability, and has the close relationship especially neutralization progression speed.

③ Investigation by Using Surface Water Absorption Test Equipment

The Surface Water Absorption Test Equipment is the equipment which measures the property of water penetration from substance surface along with time quantitatively under nondestructive status. The concrete water absorbability is one of the properties to govern durability and has the close relationship especially composite degradation progression speed.

6.3 Temporary Set Criteria

The self-motivating investigation and determination performed by waterproof construction contractor also presumes the cause of crack occurrence and predicts future but maintaining of waterproofing of concrete body is the consistent purpose.

Presence of sufficient effect, necessity of additional processing and other method are determined based on the crack status.

6.3.1 Determination Based on Investigation Result by Entire Area

Gain an understanding of entire crack tendency. Add the crack progress variation spot to special locations as needed for careful investigation.

6.3.2 Determination Based on Investigation Result on Special Location

If crack progress trend is in convergence within 3 years, confirm the presence of self-healed effect and review additional processing. If crack is not in convergence more than 3 years, bar arrangement investigation is required. Determine the necessity of additional processing based on the presence of self-healed effect.

6.3.3 Determination Based on Investigation Result by Reinforcing Bar Detector

The root for the scope of application of waterproofing of concrete body is the concrete bound by reinforcing bar, etc.

As for the location where crack progress is not in convergence more than 3 years and water leak accident occurred due to large crack movement, it is required to measure bar arrangement by using Reinforcing Bar Detector.

If bar arrangement has not been confirmed at concrete placing such as modification work, etc., careful confirmation is required specifically.

For example, if reinforcing bar locates extremely deeper than designed position, binding force against tensile stress becomes weak which becomes out of application range of waterproofing of concrete body and review on other methods are required.

6.4 Way of Thinking Regarding Partial Repair

Concrete crack not only becomes the cause of water leak but also becomes the status in which cover concrete to protect reinforcing bar partially reduced and this is the major cause, reducing the durability of structural object.

In addition, the concrete crack repeats shrink by natural environment such as repeating temperature, dry-wet, etc.

The method of filling from crack inside with reactant gradually is recommended at waterproofing of concrete body by CS-21. We believe that the temporary method of covering crack surface does not resolve the issue.

If it was determined that reprocessing is required from site investigation, additional processing depending on crack status is performed.

6.5 Examples of Filling Investigation Report and Determination of Self-Healed Effect

Refer to [Attached Data (3); Validation Results of Waterproofing of Concrete Body Effect of Concrete, Filling Example of Follow-up Investigation Slip].

6.6 Future Issues

Since the root of investigation is visual contact, difference may arise depending on investigation. In addition, determination may have individual difference based on experience and knowledge.

It is necessary to hold study meeting periodically and to check against reasonable investigation method and criteria for judgment.

7. Relevant Matters of Waterproofing of Concrete Body by CS-21

Matters requiring future modification and review in which other functions are added to waterproofing of concrete body by CS-21 are described here.

7.1 Items Related to Skid Resistance and Surface Quality

Skid risk on floor and its cause are studied in various circles but there is no unified value of [Skid Risk] (skid resistance value/ friction resistance coefficient) based on scientific reason. This is because of divided opinions throughout the world.

In Japan, appropriate skid resistance value (BPN) as floor material was set on Facility Improvement Manual 2009, Tokyo Citizen Based Town Planning Promotion Bylaw and written clearly as [BPN Value greater than 40 is desirable] but standard value and unified unit are not existed on the law such as Building Standards Act, etc., and restrictions neither. Actually, only [Floor material with rough surface or skid resistance should be used] is written even on bylaw and Building Access Law and values are not defined but it is considered that the matter will be controlled in future.

Even at metal trowel finished parking lot where CS-21 was used, it becomes slippery when wet.

In case of concrete, skid resistance largely differs depending on surface finish but surface layer quality is reduced by coarse surface finishing. The waterproofing of concrete body by CS-21 improves surface layer quality of deteriorated concrete by coarse surface finishing.

The Aston Incorporated validates skid resistance and surface layer quality went with concrete finishing.

Please contact Aston Engineering Department for required data.

7.2 Matters Related to Paint Attachment, etc., after Waterproofing of Concrete Body Construction Work

After waterproofing of concrete body construction work with CS-21, the necessity of coat application is brought up in order to satisfy requirements such as lining to add function of esthetic purpose coating, reinforcing purpose or chemical resistance, lines to intend parking space and guide.

Basically, CS-21 is the material to fill gaps of crack by repeating reaction and re-reaction under the environment where water is existed, and total coating is not recommended in order to bring out the performance of waterproofing of concrete body.

If attaching coating material is required, water-tightness of concrete surface layer is enhanced by minimum of 2 week curing after CS-21 construction work and has the same water-tightness as concrete with high surface density after accelerated curing. The work is able to be performed pursuant to the construction specifications of coating material.

Please contact Aston Engineering Department at construction plan establishment.

7.3 Matters Related Concrete Surface to be Constructed

Parting agent for form attached to concrete before construction work is easy to remove but material compatibility is required to be confirmed since concrete initial curing agent and penetrant used for treatment of construction joint are hard to be removed.

There may be the case of processing unable if water repellent agent is impregnated.

Please contact Aston Engineering Department at construction plan establishment.

Attached Data

Attached Data (1): Referenced Data Related to Work and Quality

I. Simulation on Micro Void Filling Rate Accompanied by Material

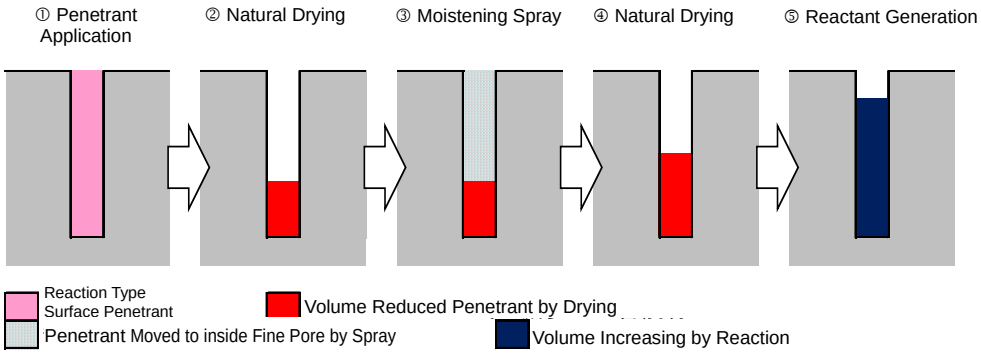
In order to perform waterproofing of concrete body and water sealing, material to fill gaps sufficiently and method are becoming important.
The simulation on material solid content ratio, presence of reactivity and filing rate by the number of application times was performed.

(* Comparison to the product by our company)

1. Material Setting to be Simulated
   Penetrant: Alkaline Metal Silicate/ Molar Ratio 3.2
   Dry Solid Amount in Penetrant: 390g/L (Dry Solid Density: 1.84g/cm^3)
   C-S-H Gel (C1.7SH4) Molar Weight: 227.4g/Molar/Density: 2.12g/cm^3
   Total of 3 materials were compared; 1 reactive type, undiluted solution and 2-time diluted solution of solid type.
   * Reaction type reacts 100% and solid type not reacted.

2. Reaction Type Silicate-Based Surface Penetrant
   2.1 Conditions Associated with Work Schedule
   ① Penetrant Application: Inside of micro void is filled with penetrant by application
   ② Natural Drying: Make micro void volume at next process to be 2/3 of last penetrant (volume at dry to touch)
   ③ Moistening Spray: Penetrant on surface moves to inside of micro void by water spray (75% concentration)
   ④ Natural Drying: Make micro void gap volume at next process to be 2/3 of last penetrant (volume at dry to touch)
   * Repeat ① ~ ④ for every time of application

   2.2 Filling Status in Micro Void (Image)



   * Silicate-based surface penetrant proceeds reaction gradually and enhances filling rate after application work is finished.

   2.3 Calculation Result

# of Times		Volume, Micro Void Gap (%)	Dry Solid Amount Filling Rate (%)		Reactant Filling Rate (%)
			By Process	Total Sum	
1	Application	100.0	21.2	31.8	81.2
	Water Spray	66.7	10.6		
2	Application	44.4	9.4	45.9	117.3
	Water Spray	29.6	4.7		
3	Application	19.8	4.2	52.2	133.3
	Water Spray	13.2	2.1		
4	Application	8.8	1.9	55.0	140.5
	Water Spray	5.9	0.9		
5	Application	3.9	0.8	56.2	143.6
	Water Spray	2.6	0.4		

3. Solidified Type Silicate-Based Surface Penetrant

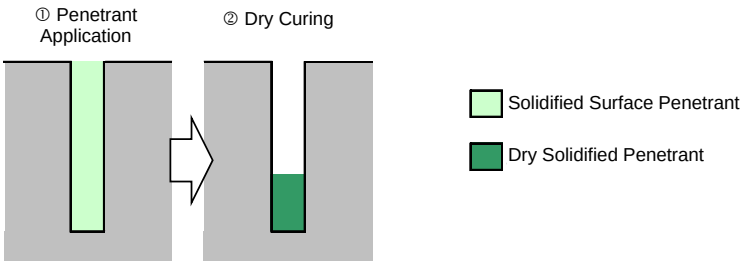
3.1 Conditions Associated with Work Schedule

① Penetrant Application: Inside of micro void is filled with penetrant by application

② Dry Curing: Penetrant in micro void solidified by dry curing after application

Repeat ① and ② for every time of application

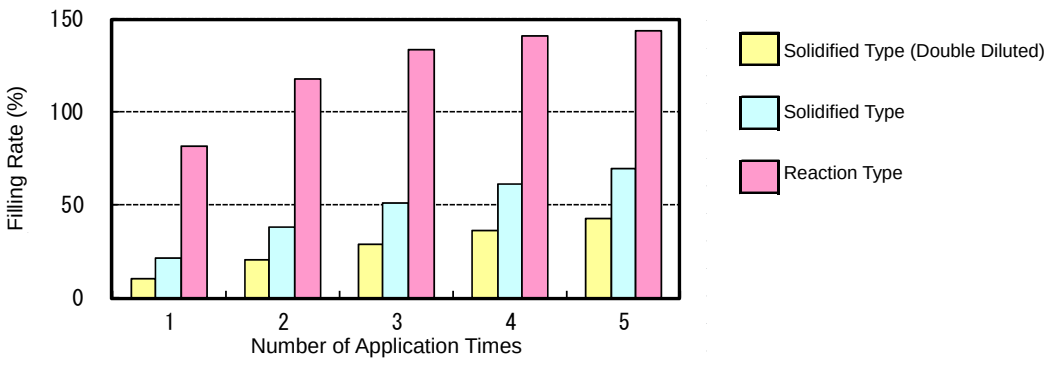
3.2 Filling Status in Micro Void (Image)



3.3 Calculation Result

# of Times	Neat Liquid			Double Diluted Solution		
	Pore Gap Volume (%)	Dry Solid Content Filling Rate (%)		Pore Gap Volume (%)	Dry Solid Content Filling Rate (%)	
		By Process	Cumulative Total		By Process	Cumulative Total
1	100.0	21.2	21.2	100.0	10.6	10.6
2	78.8	16.7	37.9	89.4	9.5	20.1
3	62.1	13.2	51.1	79.9	8.5	28.5
4	48.9	10.4	61.4	71.5	7.6	36.1
5	38.6	8.2	69.6	63.9	6.8	42.9

4. Result Comparison



Discussion

This simulation sets the maximum status but the following items are confirmed from the results;

- Gap filling rate is enhanced by increasing solidified amount and the number of application times.
- The reaction type is able to fill gaps greater than 100% by filling solidified component greater than 40% and gradual reaction after construction work.
- In order to fill concrete gaps at construction work and to fill gaps generated later, it is necessary to confirm solidified amount of used material, reactivity (including neutralized concrete), application process and number of application times.

II. Difference of Micro Void Filling Rate Associated with the Construction Work of Silicate-Based Waterproofing Material

Silicate-based waterproofing material is clear and is wet color just after application on concrete but it looks same as concrete after 2 ~ 3 months. It is said that this is the material hard to determine and control quality visually.
However, quality differs depending on method as the result of test and follow-up investigation on actual construction.
The standard construction work procedures are set by the Aston Incorporated based on accomplishment and experience so far but the meaning of procedures and secret to enhance quality are described here.

1. Adjustment of Moisture at Concrete Surface Layer

There are many gaps in concrete and air exists in the gap. When immerse concrete into water, air bubbles come out. This means that water gets through concrete and existed air is expelled and comes out as bubbles. It will take degree of 30 minutes to 1 hour before water replaces air in micro void at concrete surface layer.
Since viscosity of silicate-based waterproofing material is higher than water, the agent is hard to be replaced by air and as viscosity gets higher associated with drying, impregnation gets harder. For the reason, it is required to replace air in micro void on concrete surface layer with water before agent application. In doing so, silicate-based waterproofing material to be applied is impregnated in deep part of micro void without early dry solidification of agent by water absorption into concrete body.
In addition, if bleeding exists on concrete surface, securing dry solid component amount required to fill micro void gaps becomes difficult since material to be applied with the water becomes thin.

[Important One Point]
Perform high-pressure washing before application of silicate-based waterproofing material and the status of concrete surface gets almost dry (status of wet not touch on finger) is the most appropriate status for agent application. If concrete surface layer is dry, it is necessary to perform construction work after misting water with a spray, etc.

① Bleeding Status
Application: Unsuitable

② Drying Status
Application: Suitable

③ Close to Dried
Application: Suitable

④ Close to Dried
Application: Suitable

⑤ Dried Status
Application: Unsuitable
(Water Spray Required)

2. Necessity of Water Spray after Application

When silicate-based waterproofing material is applied, its viscosity gradually increases associated with drying and the agent is solidified finally. Since volume is decreased (shrinking) when solidified, new gaps are generated in micro void where agent was filled. Then, it is required to feed (move) dried and solidified agent on concrete surface, decreasing viscosity with water, into the micro void gaps. Refer to ③ and ④, 2.2, Section I, [Filling Status in Micro Void]. (Image)

[Important One Point]
After application of silicate-based waterproofing material, it is important to spray water with the degree of not to flow out applied agent and agent on surface to be impregnated. If water is not sprayed, there may be the risk of agent abounding portion on concrete surface gets bleached.

3. How to Use Brush and Spray, etc.

At the standard construction work procedures, as the method of coating with silicate-based waterproofing material, roller brush or trowel brush is defined. However, for the location such as construction joint section where brush is hard to be used, spray is an effective means.
For application method by roller brush or trowel brush, and spray method, followings are considered as advantage and disadvantage respectively;

3.1 Method by Brush, etc.

[Advantage]

- Performance to fill agent into concrete micro void is high. (by the reason of air escape by brush friction pressure on concrete surface)
- Agent fly almost nothing

[Disadvantage]

- Concrete component attached to brush gets into agent container and reaction starts if leave it.
  (As the countermeasure, make consumable amount in small quantity and do not return residual to the container)

3.2 Method by Spray, etc.

[Advantage]

- Effective for the location not suitable to brush use such as location with markedly uneven on concrete surface at construction joint section, inaccessible location by worker for reinforcing bar, etc.
- No risk of entering concrete component into agent container.

[Disadvantage]

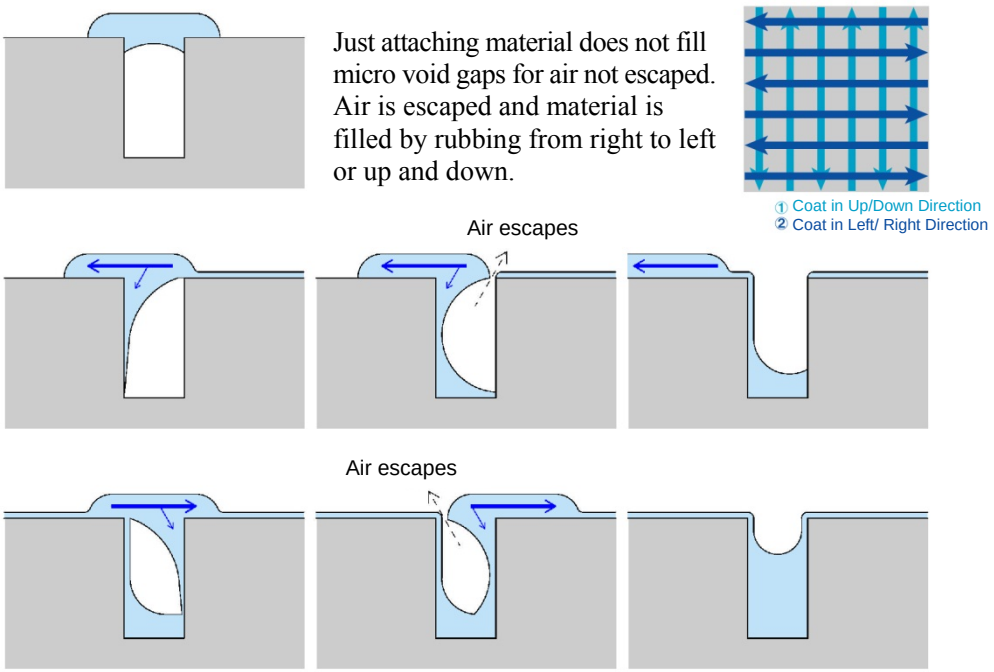
- Performance to fill agent into concrete fine gaps is low. (Combination use of brush is desirable to compensate this)
- Agent may fry apart when wind is strong.

[Important One Point]

In case of using brush, in order to impregnate agent sufficiently into micro void gaps, it is important to move brush not only in one direction but also move the brush from right to left or up and down. (Imaging of rubbing agent into micro void gaps)

In case of wall surface, move the brush from downside to upward to coat by rubbing.

Image Drawing for Coating Method and Micro Void Gap Filling



4. Relationship between Dry Solid Content, Number of Coating Times and Coating Amount

The agent with high dry solid content has high filling rate on micro void gaps since it is the agent with less volume reduction rate (by drying shrinkage rate) but it is said that impregnation is hard because of high viscosity. Accordingly, if material with high dry solid content is applied, it is important to adjust wet adjustment for concrete surface layer before coating and to adjust viscosity of silicate-based waterproofing material by water spray after coating.

Reducing coating amount per one time and increasing the number of coating times lead to even impregnation of agent easier and is the effective means to enhance micro void filling rate.

The following specifications are set as the standard method by Aston;

- CS-I Method: 0.2Kg/m^2 for Agent Total Use Amount; 1 Time of Coating; Surface Protection as Main Intended Purpose
- CS-II Method: 0.3Kg/m^2 for Agent Total Use Amount; 2 Times of Coating; Waterproofing of Concrete Body, Surface Protection as Main Intended Purpose

[Option]

- CS-III Method: 0.2Kg/m^2 for Agent Total Use Amount; 3 Times of Coating; Waterproofing of Concrete Body as Main Intended Purpose

5. Accelerated Curing and Curing Period

Keeping concrete surface layer after agent coating in wet status is effective to enhance micro void filling rate earlier. However, since gaps in concrete structural object occur by agent as aged, water-tightness enhancing action for long time is necessary when performing waterproofing of concrete body. Silicate-based waterproofing material makes micro void gaps dense with gradual reaction by supplying water through dew condensation, rainfall, etc.

If concrete surface provided with silicate-based waterproofing material touches directly to water such as water tank, underground structure, more than 2 week curing period is required before water filling in water tank or backfill of underground structure.

If sufficient curing period is unable to secure, CS-21 + CS Filler Coating Method is effective as Aston recommended method. Since this method prevents diffusion of coated CS-21 into contacted water and calcium is supplied from CS filler, reaction effect with CS-21 is accelerated.

Attached Data (2): Construction Control Example of Waterproofing of Concrete Body by CS-21

If silicate-based waterproofing material is applied to concrete, there are acceptance inspection at agent acceptance, construction inspection during construction and completion inspection at construction finishing as construction control method.

As the acceptance inspection method, there are density inspection, pH value inspection, etc., in addition to acceptance quantity inspection and appearance inspection generally performed.
Construction inspection is generally controlled by construction photographs. As the inspection method against subjected concrete, the example of coating confirmation inspection using coating confirmation sheet (patch method) is shown here because the appearance of agent is water-clear liquid and hard to confirm visually after coating on and impregnating into concrete.
As the completion inspection method, this is controlled by the acceptance inspection on the quantity of empty used cans generally.

In addition, construction effect in case of applying silicate-based waterproofing material onto concrete is able to be confirmed by the presence of water leak since waterproof is the object. Examples of water leak confirmation test, surface air permeability test and surface water absorption test are shown here as construction effect confirmation method which is able to be perform by nondestructive test.

Item, Inspection, etc.	Inspection/ Confirmation Method
I. Acceptance Inspection (Material Inspection)	1. Density Inspection
	2. pH Value Inspection
II. Work Inspection	1. Application Confirmation Inspection
III. Work Effect Confirmation Method	1. Water Leak Confirmation Test
	2. Surface Layer Air Permeability Test
	3. Surface Water Absorption Test

I. Acceptance Inspection

1. Density Inspection

As the density test, there are methods using volumeter such as measuring cylinder and gauge, and using specific gravity meter. The method by using volumeter and gauge which is easy to apply at site is shown here.

1.1 Equipment Used
a) Volumeter: Use the volumeter using measuring cylinder.
b) Gauge: The gauge with digital display and with tare subtraction function is desirable.

1.2 Inspection Method
a) As the measurement preparation, place a volumeter on a gauge and set the value to 0Kg with tare subtraction function.
b) Read the gauge measured value by injecting material on the volumeter.
c) Calculate density from measured result and confirm the value satisfies standard value.
* Density = Mass/ Volume
* Specific Gravity is the density ratio with water and is considered to be the same since water density is about 1g/cm^2 but please be careful that specific gravity has no unit.

Photo-1: Tare Weight Subtracted

Phote-2: Measurement Setting

[Important One Point]
Since test equipment (measuring cylinder/ gauge) may have doubtful accuracy even if display of regular standardized article is labeled or causing error, etc., it is desirable to confirm in advance.

2. pH Value Inspection

As for the pH value inspection method, there are the methods to use pH test strip and pH meter. Since pH meter is required to maintain temperature at constant and frequent calibration is required, the method by using pH test strip which is easy to use at site is shown here.

2.1 Equipment Used
a) pH test strip: Phenolphthalein test strip or utility test strip (wide range test strip) is used.
b) Dropper: Versatile dropper is used.

2.2 Inspection Method
a) As measurement preparation, compare the color of pH test strip before inspection with color samples and read pH value. Confirm current pH value of pH test strip is almost neutral.
b) Drop appropriate amount of agent on pH test strip by using a dropper.
c) Read pH value by comparing the area of discoloration, pH test strip, with color samples. Confirm the measured result satisfies the standard value.

Photo-3: pH6, before Inspection

Photo-4: pH12, after Inspection

[Important One Point]
Since test device (pH test strip) may cause error due to passing expiration date or long time passed after unpacking even if it is a regular standardized article, it is desirable to confirm in advance.

II. Construction Work Inspection

1. Coating Confirmation Inspection

As for the coating confirmation inspection method, there are patch method, mat method, seal method, etc. The patch method using coating confirmation sheet is introduced here. The patch method is able to confirm coating at arbitrary point such as the point designated by inspector and not subjected to the restriction of coating method such as coating by roller, misting by spray, etc. However, since concrete surface before construction is required to be neutralized, caution is required.

1.1 Equipment Used

a) Coating Confirmation Sheet
b) Dropper: General dropper is used.

1.2 Inspection Method

a) As the measurement preparation, confirm no color reaction on target concrete before construction with coating confirmation sheet in advance.
   ① Drop appropriate amount of water on test strip portion on rear side of coating confirmation sheet by using a dropper.
   ② Paste with double-faced tape, etc. by which the rear side of coating confirmation sheet contacts on concrete surface.
   ③ Confirm the presence of color reaction at test strip portion of frame window.
b) After agent coating, confirm the coating confirmation sheet is presenting pink color on subjected concrete surface same as before construction.

Photo-5: No Color Reaction before Coating

Photo-6: Color Reaction after Coating

III. Construction Work Confirmation Method

1. Water Leak Confirmation Test

At the construction for which silicate-based waterproofing material is applied, this test confirms water leak status at water leaking location from crack on concrete body object and confirms waterproof performance (water stop performance) after construction work.

1.1 Equipment, Device to be Used

a) Square Log: Use square log such as crosspiece.
b) Sealing Material: Use material with high water sealing performance and sealing agent which is easy to peel off after test.

1.2 Test Method

a) Select a location where local defect (crack, etc.) is able to be confirmed on concrete surface and confirm water leak presence before and after construction at the same location. The confirmation after coating should be performed after curing period of 28 days.
b) The measuring spots shall be 1 location and greater.
c) Confirm the presence of water leak at concrete body by water filling. The confirmation method is shown below; (Refer to Photograph 1-1 and 1-2)

① Confirm the surface is under finger-touch dry status, surround marked area of confirmation with square log, mount securely with sealing agent, etc. and pay attention not to cause water leak from mounting position.
② Observe direct beneath portion of water filling location from down stairs visually after filling water and a certain time later, and confirm the presence of water leak before coating.
③ Remove square log and sealing agent, and perform construction work.
④ After coat curing, confirm the surface is under finger-touch dry status, surround marked area with square log, and mount with sealing agent same as before coating.
⑤ Observe direct beneath portion of water filling location from down stairs visually after filling water and a certain time later, and confirm the presence of water leak after coating.
⑥ Remove square log and sealing material.

Photo 1-1:
Water Filling Status; Before Construction Work

Photo 1-2:
Water Filling Status; After Construction Work

Photo 1-3:
Water Filling Directly below;
Before Construction Work, 20 Hours Later

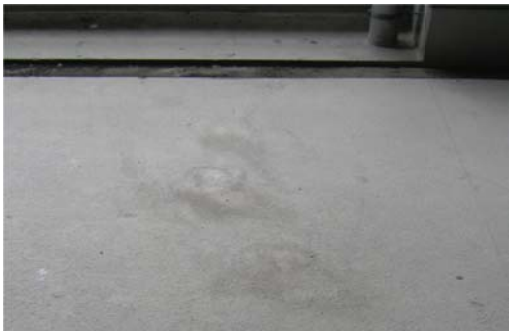


Photo 1-4:
Water Filling Directly below;
After Construction Work, 48 Hours Later

1.3 Remarks

This test method is effective to the case, confirming repair or waterproof effect of water leaking cracks. If it is fine gaps, there may be the case of no water leak occurrence within short time and confirmation in 24 hour unit is required.

1.4 Example of Test Result

When performing water filling before silicate-based waterproofing material coating, water leak was observed at direct beneath portion after 20 hours. When performing water filling again after construction work, water leak was not observed at direct beneath portion after 48 hours. Thus, waterproof effect of silicate-based waterproofing material was confirmed by performing water leak confirmation test.

2. Surface Layer Air Permeability Tester

This test is intending to confirm the variation of air permeability coefficient (mass transfer resistance) by the densification of concrete surface layer with Air Permeability Tester and measurement is performed at the same place before and after construction on silicate-based waterproofing material.

2.1 Equipment, Device to be Used

Air Permeability Tester (Use the tester with double structured chamber as shown on Fig. 2-1, and inner chamber has the scheme of measuring air permeability in depth direction only by eliminating impact of air intake in lateral direction by the outer chamber. As one example of the tester, Torrent, Permea-TORR is corresponded)

2.2 Test Method

a) Select surface without local defect (crack, pit, aggregate extrusion, etc.) and measure air permeability coefficient at the same place before and after construction work. The measurement after coating shall be performed after 28 day curing period.

b) Number of measurement should be greater than 3 locations.

c) Measure air permeability coefficient of concrete surface layer by the air permeability tester. Measuring method is shown below;

(Refer to Photo 2-1)

① Surface Preparation: Adjust and smooth the unevenness of measuring surface by using disk sander, etc. Remove dirt or attached matters on concrete surface by using sand paper, etc. Do not leave concrete powder, etc., by water washing, etc.

② Confirm the surface is under finger-touch dried status, mount air permeability tester at marked location to be measured and measure air permeability coefficient before coating.

③ Confirm the surface is under finger-touch dried status after coating cure, mount air permeability tester at the same location as marked location before coating and measure air permeability coefficient after coating.

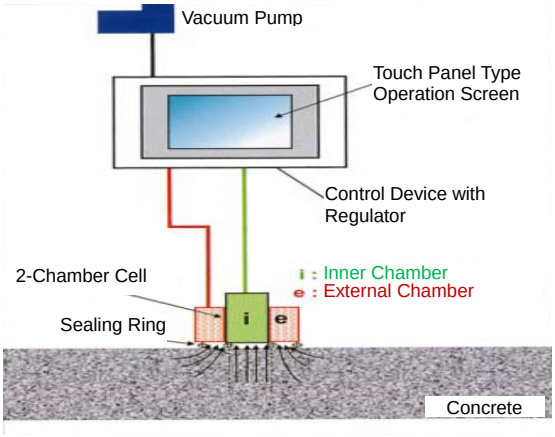


Fig. 2-1: Scheme of 2-Chamber Cells

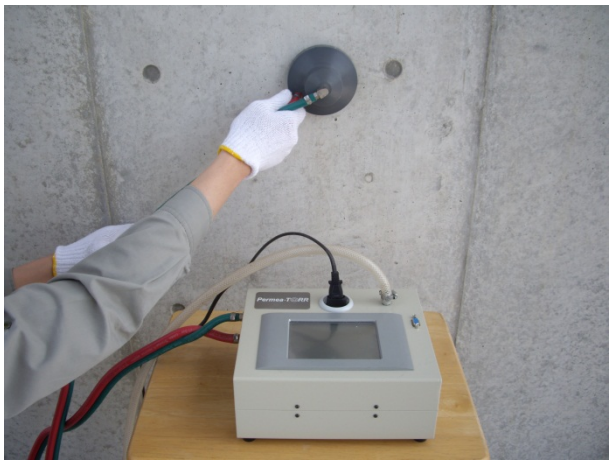


Photo-2-1: Testing Status

2.3 Remarks

If quality of target concrete is high, air permeability coefficient difference between unprocessed location and construction completed location may not appear prominently. Performing at location where quality is poor for cold joint or construction joint section is effective.

Since concrete quality differs when measurement position is moved a little, be sure to measure at the same position for before/ after construction works.

In addition, since this test easily gets impact of concrete surface water rate, it is required to perform test after confirming surface dry status.

2.4 Example of Test Result

Air Permeability Coefficient was measured before coating silicate-based waterproofing material and found that Air Permeability Coefficient KT is 0.36 ($\times 10^{-16}m^2$).

Air Permeability Coefficient was measured again after coating cure and found that Air Permeability Coefficient KT is 0.028 ($\times 10^{-16}m^2$).

Waterproof effect of silicate-based waterproofing material (mass transfer resistivity) was confirmed by the implementation of surface layer air permeability test.

3. Surface Water Absorption Test

This test is intended to confirm the variation of water absorption amount by waterproofing effect (water absorption inhibition capability) due to the densification of concrete surface layer with Surface Water Absorption Test Equipment and perform measurement at the same place before and after constructing silicate-based waterproofing material.

3.1 Equipment, Device to be Used

a) Case of Using Test Equipment: Surface Water Absorption Test Equipment (Use equipment to fix plastic test tube pressed on concrete surface by reaction force plate absorbed by a vacuum pump. Refer to Fig. 3-1)

b) Case of Using Funnel: Measuring pipette, Funnel, Rubber Tube or Vinyl Tube, Sealing Agent

3.2 Test Method

a) Select surface without local defect (crack, pit, aggregate extrusion, etc.) and measure water absorption amount at the same place before and after construction work. The measurement after coating shall be performed after 14 day curing period.

b) Number of measurement should be greater than 3 locations.

c) Measure water absorption amount on concrete surface with Surface Water Absorption Test Equipment. Measuring method is shown below; (Refer to Fig. 3-1)

① Surface Preparation: Adjust and smooth the unevenness of measuring surface by using disk sander, etc. Remove dirt or attached matters on concrete surface by using sand paper, etc. Do not leave concrete powder, etc., by water washing, etc.

② Confirm the surface is under finger-touch dried status, surely mount Surface Water Absorption Test Equipment not to cause water leak and measure water absorption amount before coating. Perform marking at measuring point at measurement.

③ Confirm the surface is under finger-touch dried status after coating cure, mount surface water absorption tester and measure water absorption amount after coating. In addition, if a funnel is used for the test, mount the funnel securely with sealing agent, etc., and pay attention not to cause water leak from mounting position.

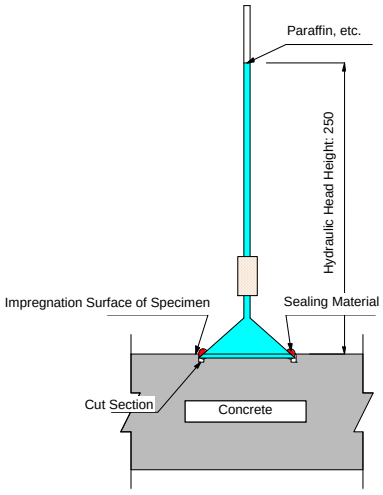


Fig. 3-1: Test Equipment and Test Image

Photo 3-1: Test Situation Using Test Equipment

3.3 Remarks

If cracks, etc., are existed at ground contact part of concrete surface and test equipment, accurate measurement of water absorption amount is unable.

In addition, same story applies if sealing is imperfect. If water absorption amount does not decrease with time, possibility of water leak is high and retest is necessary.

Be sure to measure concrete quality at the same place before and after construction work since the quality differs if measurement position moves even a little bit.

3.4 Example of Test Result

Water absorption amount was measured before coating silicate-based waterproofing material at new placing concrete with 55% of water-cement ratio and the result was 2.43ml/ day. The amount was 0.44ml/ day when measured after coating cure. In this way, the waterproof effect (water absorption inhibition capability) of silicate-based waterproofing material was confirmed by the implementation of surface water absorption test.

Attached Data (3): Follow-up Investigation on Waterproofing of Concrete Body by CS-21 and Validation of Effect

Aston and Aston Association have constructed waterproofing of concrete body on concrete structural objects by using concrete renovation, CS-21, since 1995.
The production of concrete renovation, CS-21, started in 1993 as subsidiary agent of water sealing and was initially used as the agent to stop water discharged from fine cracks. By the modification and establishment of construction work method afterward, the usage as waterproofing of concrete body has started and is continued until now.

1. Accomplishment of Ordering Work Reported by Appointed Stores by September 2013
   Adding up by Method/ Application

Method/ Purpose	Number of Construction Cases	Construction Work QTY
Waterproof (Parking Lot/ Roof/ Floor Slab)	360 Cases	About 813 Km^2
Waterproof (Others)	210 Cases (62 cases for underground structure, 48 cases for water tank)	About 194Km^2
Surface Protection	333 Cases	About 298Km^2
Modification/ Cross-Section Repair	178 Cases (Water Channel: 131 Cases)	About 33Km^2
Repair of Crack/ Water Leak	210 Cases	About 43Km
Treatment of Construction Joint/ Plastic cone Section	63 Cases	
Total	1,354 Cases	

Adding up by Promoter

Promoter	Number of Construction Work	Breakdown
Ministry of Land, Infrastructure, Transport and Tourism	206 Cases	99 Cases of New/ 107 Cases of Existing
Local Government	410 Cases	186 Cases of Prefecture Level, 224 Cases of City Level
Civil & Others	738 Cases	
Total	1,354 Cases	

2. Properties of Investigation Target
   For the above construction accomplishment, follow-up investigation after construction work has been performed for each property but the follow-up investigation on the same item was implemented by selecting properties with the same method in tending the validation of effect this time.
   Generally speaking, investigation becomes difficult once structural object started performance. Drive-in type parking lot on roof for which confirmation is relatively easy was selected for follow-up investigation this time and the investigation was implemented against 4 properties of 10 year old and 6 properties greater than 10,000m^2.

2.1 Waterproof Property of Drive-in Type Parking Lot, 10 Years after Construction

Name of Property	Construction Area	Date Constructed
① Roof Parking Lot, Electronics Retail Shop	2,100m^2	February 1998
② Roof Parking Lot, Pachinko Parlors	1,920m^2	July 1999
③ Waterproofing of Multilevel Parking Lot, Large Store	15,270m^2	April 2002
④ Waterproofing of Parking Lot, Food Factory	1,575m^2	May 2002

2.2 Waterproof Property of Drive-in Type Parking Lot with Construction Area Greater than 10,000m^2

Name of Property	Construction Area	Date Constructed
⑤ Waterproofing of Roof Parking Lot, Large Store	20.528m^2	December 2007
⑥ Waterproofing of Multilevel Parking Lot, Distribution Depot	13,233m^2	March 2008
⑦ Waterproofing of Roof Parking Lot, Large Store	24,134m^2	February 2010
⑧ Waterproofing of Roof Parking Lot, Large Store	10,267m^2	March 2011
⑨ Waterproofing of Roof Parking Lot, Large Store	16,198m^2	September 2011
⑩ Waterproofing of Roof Parking Lot, Large Store	15,126m^2	September 2011

3. Investigation and Enrollment Methods

Site investigation was performed and follow-up investigation slip on the following items was prepared.

- Overview of Structural Object/ Investigation
- Waterproof Performance and Progression
- Investigation Result on Cracks

4. Investigation Result

Name of Property	Crack Length per Area (m/m^2)	Self-Healed Rate
① Roof Parking Lot, Electronics Retail Shop	$0.475m/m^2$	100%
② Roof Parking Lot, Pachinko Parlors	$0.002m/m^2$	100%
③ Waterproofing of Multilevel Parking Lot, Large Store	$0.240m/m^2$	100%
④ Waterproofing of Multilevel Parking Lot, Food Factory	$0.110m/m^2$	100%
⑤ Waterproofing of Roof Parking Lot, Large Store	$0.043m/m^2$	86%
⑥ Waterproofing of Multilevel Parking Lot, Distribution Depot	$0.039m/m^2$	95%
⑦ Waterproofing of Roof Parking Lot, Large Store	$0.013m/m^2$	93%
⑧ Waterproofing of Roof Parking Lot, Large Store	$0.004m/m^2$	100%
⑨ Waterproofing of Roof Parking Lot, Large Store	$0.005m/m^2$	88%
⑩ Waterproofing of Roof Parking Lot, Large Store	$0.006m/m^2$	100%

5. Discussion

5.1 Property which Passed over more than 10 Years after Completion

Waterproofing of concrete body of drive-in parking lot has been used since initial development stage of waterproofing of concrete body method because of direct merits such as shortening work period, weight saving, etc.

Since concrete body application conditions have not been established at that time in 1998, large difference was cause on the degree of quality depending on structural object. Mark of crack was rarely confirmed on structurally rigid properties.

While on the other hand, cracks are self-healed in case of structural object with small amount of reinforcing bar (large deflection) and water leak is not occurred but many crack marks are confirmable.

The followings are confirmable from investigation results.

- Fine dry shrink and crack associated with temperature change are self-healed, unified and becomes hard to be confirmed visually.
- At the position not sprayed by water, there are positions where cracks are not filled up to surface and water feed is essential for self-healed action.
- Tendency of quick filling is seen at downstream side of water gradient. It is assumed that coated agent attached to surface moves down to downstream side with water though it is small amount.
- Concrete surface gets impact of acid rain, etc., and sand surface is exposed but sand grain is not peeled off.
- Dirt is attached on surface but is easily removed by water washing

5.2 Property with Construction Work Area greater than $10,000m^2$

Application to large size property increased by piling up construction accomplishment, advanced concrete quality standard from progress observation and seeing great amount of modification expense associated with deterioration of coating waterproof as a problem since 2005. Initially, heat expansion impact by sunlight was worried about since structural object is large but it was confirmed that cracks are almost not moved if cracks are integrated and stress is evenly broken up.

The followings are confirmable from investigation results.

- As for the properties after 2008, the quality of body concrete approaches to waterproof standard and visible cracks become extremely low.
- There are distinct places by cracks and missing surface part at stress change location such as elevator hall, staircase and twist generating location of hook shape structure but just limiting to CS-21 recoat until inside is filled and not blocking surface early make surface blemish not being wide.
- Problem has not occurred at construction joint by securing cross-section, CS-21 processing after cleaning and placing.
- Follow-up investigation is necessary since there are properties less than 1 year after construction and the possibility of crack growing exists.

Listed Example of Follow-up Investigation Slip

Overview of Structural Object

Name of Facility/ Structural Object	General Name	Type of Structural Object	Bar Arrangement Shape such as Steel Framed Structure, Composite QL Deck Slab, etc.
Location	Address:	Construction Area	Waterproof Construction Work Area (m^2)
Date Constructed	YYMMDD	Mixing of Concrete	Such as N 21-12-20
Name of Waterproof Contractor	Aston Association Special Agent	Specification of Applied Method	CS-21: Agent and Method such as CS II Method

Overview of Investigation

Date Investigated	YYMMDD	Investigation Person in Charge	Name of Investigation Person in Charge
Organization Investigated	Name of Affiliated Company, etc.	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progress

Performance as Waterproof such as NO WATER LEAK Progression of Inspection/ Repair after Waterproof Construction Work

Crack Investigation, Result

	Measured Length (m)	Target Area	Crack Length per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total Length, Cracks (m)	Measured Value, m	Measured Value, m^2	Calculated Value (Measured QTY + Object Area)	———
B) Crack Length Self-Healed among Cracks (m)	Measured Value, m	Measured Value, m^2	———	Calculated Value (%)

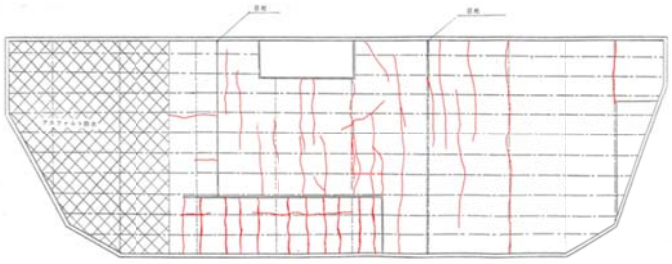
Cover Shot, Crack Developed Figure, Fill Noticed Points as Remarks

Crack Measurement

A) Total quantity of cracks (m) should include self-healed cracks, prepare development figures for all visually confirmed cracks and perform measurement.

Photo of Cracks not Self-Healed

Example of Crack Development Figure

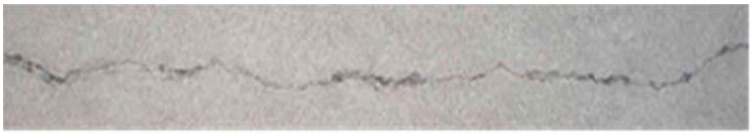


Decision Criteria for Self-Healed Crack (Unification of Inspector's subjective view)

B) Among cracks, measure self-healed crack quantity (m) which have the evidence of crack but are filled up to surface at the time of investigation.
If a crack with cross-section shortage burst by surface compression is filled up to surface, this is deemed as a self-healed crack and record the quantity (m).

Photo of Self-Healed Crack

Inside Self-Healed Crack, Cross-Section Shortage Burst by Surface Compression



Follow-up Investigation Slip

№ 001

Overview of Structural Object

Name of Facility/ Structural Object	Electronics Retail Shop Roof Parking Lot	Structural Type	Steel Structure, Composite QL Deck Slab 8mm, 100 × 100 Mesh Arrangement
Address	Hiroshima City, Hiroshima Pref.	Construction Area	2,100m^2
Date Constructed	Feb. 1998	Concrete Composition	N 21-15-20
Name of Waterproof Work Contractor	Aston Inc.	Spec. of Applied Const. Method	CS-21 CS II Method

Overview of Investigation

Date Investigated	Mar. 17, 2012	Investigation Person in Charge	Masahiro Yamamoto
Investigation Organization	Eng. Dep., Aston Inc.	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progression

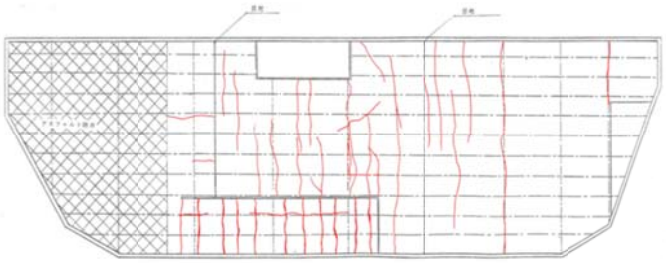
No Water Leak Accident
Recoating on crack at annual inspection, 100mm width

Crack Investigation, Results

	Measuring QTY (m)	Target Area	Crack QTY per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total QTY, Cracks (m)	998m	2,100m^2	0.475m/m^2	———
B) QTY of Self-Healed Cracks among Cracks (m)	998m	2,100m^2	———	100%

Cover Shot

Crack Developed Figure



Photo, Crack Status

Photo, Crack Status

Photo, Crack Status

Remarks

There are buried cracks looked white and cracks looked black where water retention characteristics are high around the crack. There are many crack marks since there is no reinforcing bars on beam, single mesh bar, but all of cracks self-healed up to surface.

Follow-up Investigation Slip

№ 002

Overview of Structural Object

Name of Facility/ Structural Object	Pachinko Parlors Roof Parking Lot	Structural Type	Steel Structure, F-Deck Continuously Succeeded Slab D13 @200 Double Bar Arrangement
Address	Hiroshima Pref.	Construction Area	1,920m^2
Date Constructed	July, 1999	Concrete Composition	N 21-12-20
Name of Waterproof Work Contractor	Aston Inc.	Spec. of Applied Const. Method	CS-21 CS II METHOD

Overview of Investigation

Date Investigated	Mar. 17, 2012	Investigation Person in Charge	Masahiro Yamamoto
Investigation Organization	Eng. Dep., Aston Inc.	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progression

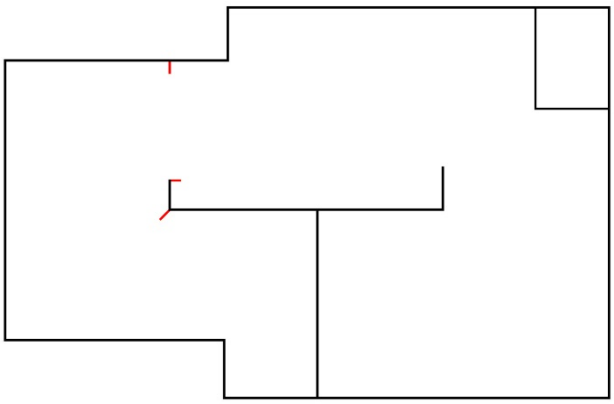
No Water Leak Accident No Repair History

Crack Investigation, Results

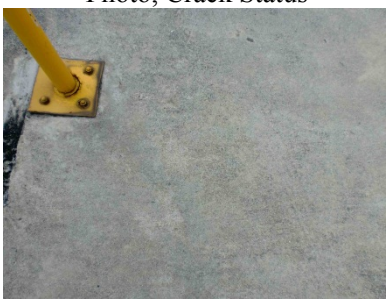
	Measuring QTY (m)	Target Area	Crack QTY per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total QTY, Cracks (m)	3m	1,920m^2	0.002 m/m^2	———
B) QTY of Self-Healed Cracks among Cracks (m)	3m	1,920m^2	———	100%

Cover Shot

Crack Developed Figure

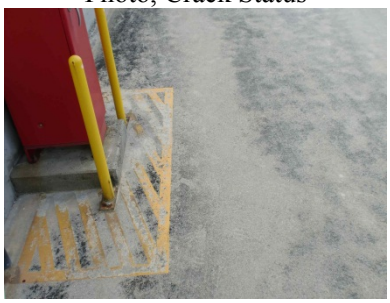


Photo, Crack Status



Photo, Crack Status

Photo, Crack Status



Remarks

When cleaned, the location looked crack disappears and searching crack mark becomes difficult.
Flat Deck, Double Bar Arrangement, D13 @200 which have a lot of reinforcing bar and is rigid structure.
Crack associated with dry shrink is thought to be occurred, off course, but all of them are self-healed and visible crack is seldom.

Follow-up Investigation Slip

№ 003

Overview of Structural Object

Name of Facility/ Structural Object	Large Store Waterproofing of Multilevel Parking Lot	Structural Type	Steel Structure, F-Deck Slab 6mm, 150 × 150 Mesh Double Bar Arrangement
Address	Sapporo City, Hokkaido	Construction Area	15,270m^2
Date Constructed	April, 2002	Concrete Composition	N21-15-20
Name of Waterproof Work Contractor	Sapporo Peck Co., Ltd	Spec. of Applied Const. Method	CS-21 CS II METHOD

Overview of Investigation

Date Investigated	March 16, 2012	Investigation Person in Charge	Masatoshi Matsuzawa
Investigation Organization	Sapporo Peck Co., Ltd.	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progression

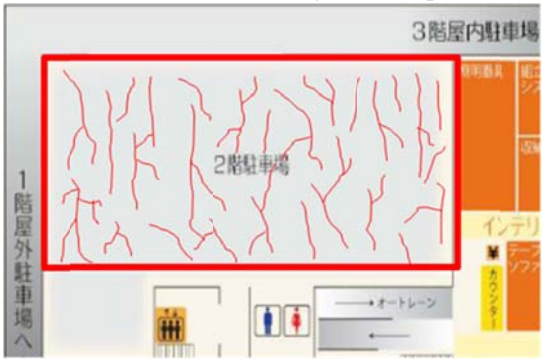
No Water Leak Accident No Repair Record

Crack Investigation, Results

	Measuring QTY (m)	Target Area	Crack QTY per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total QTY, Cracks (m)	3,665m	15,270m^2	0.240m/m^2	———
B) QTY of Self-Healed Cracks among Cracks (m)	3,665m	15,270m^2	———	100%

Cover Shot

Crack Investigation Map



Crack Status Photo

Crack Status Photo

Remarks

Roof parking lot is constructed by asphalt waterproof and protecting concrete for snow removal and the construction place by this method locates indoor but vehicles bring rain water, especially snow in winter season, drenched in water by which crack self-healed effect is geared up. There are crack marks looked white and cracks looked black where water retention characteristics are high.

Follow-up Investigation Slip

№ 004

Overview of Structural Object

Name of Facility/ Structural Object	Food Factory Waterproofing of Multilevel Parking Lot	Structural Type	Steel Structure, QZ-Deck Slab D10 @200 Single Bar Arrangement
Address	Yamato-Koriyama City, Nara Pref.	Construction Area	1574.8m^2
Date Constructed	May, 2002	Concrete Composition	N21-18-20
Name of Waterproof Work Contractor	Masuda Koumuten Inc.	Spec. of Applied Const. Method	CS-21 CS II METHOD

Overview of Investigation

Date Investigated	March 19, 2012	Investigation Person in Charge	Teppei Kuze
Investigation Organization	Masuda Koumuten Inc.	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progression

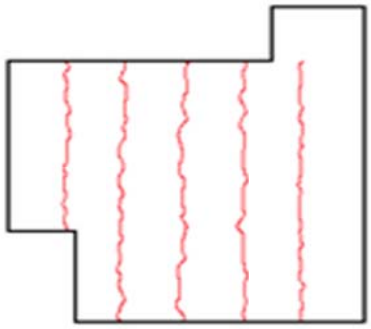
No Water Leak Accident No Repair Record

Crack Investigation, Results

	Measuring QTY (m)	Target Area	Crack QTY per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total QTY, Cracks (m)	174m	1,575m^2	0.11m/m^2	———
B) QTY of Self-Healed Cracks among Cracks (m)	174m	1,575m^2	———	100%

Cover Shot

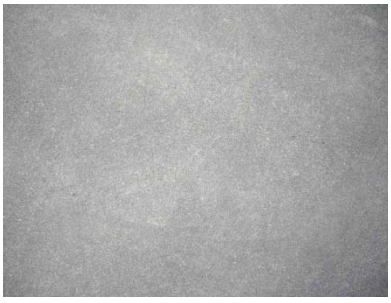
Crack Investigation Map



Crack Detailed Photo

Crack Detailed Photo

Crack Detailed Photo



Remarks

Not written on the type of above structural object but is the robust structure with large column and beam member to the sight.

Unable to confirm without careful investigation since crack width is self-healed less than 0.2mm.

Follow-up Investigation Slip

№ 005

Overview of Structural Object

Name of Facility/ Structural Object	Large Store Waterproofing of Roof Parking Lot	Structural Type	Steel Structure, Composite QL Deck Slab D13 @200 Double Bar Arrangement
Address	Hiroshima City, Hiroshima Pref.	Construction Area	20,528m^2
Date Constructed	Dec., 2007	Concrete Composition	N 21-15-20
Name of Waterproof Work Contractor	TOM WORKS	Spec. of Applied Const. Method	CS-21 CS II METHOD

Overview of Investigation

Date Investigated	March 26, 2012	Investigation Person in Charge	Naomichi Minami
Investigation Organization	TOM WORKS	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progression

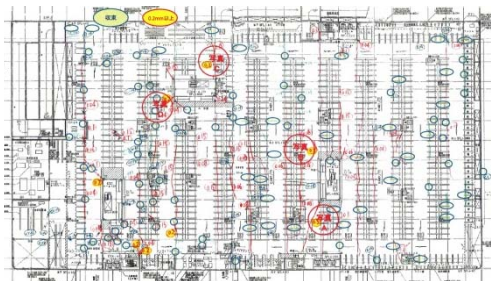
No Water Leak Accident
Repair History: Crack recoated at periodical inspection, 1, 2 and 3 years. Coating Width = 50mm

Crack Investigation, Results

	Measuring QTY (m)	Target Area	Crack QTY per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total QTY, Cracks (m)	890m	20,528m^2	0.043m/m^2	———
B) QTY of Self-Healed Cracks among Cracks (m)	765m	20,528m^2	———	86%

Cover Shot

Crack Investigation Map



Crack Detailed Photo

Surface Deficient Crack

Remarks

The movement of structural object concentrates on crack between staircases at center section and surface deficient crack is there but inside is filled up.
The crack not filled up to surface was 125m at this investigation but additional processing was made for all of portion deeper than 2 ~ 3mm from surface.

Follow-up Investigation Slip

№ 006

Overview of Structural Object

Name of Facility/ Structural Object	Distribution Depot Waterproofing of Multilevel Parking Lot	Structural Type	Steel Structure, FABB Deck Composite Slab Partly D10 @150 Double Bar Arrangement
Address	Kobe City, Hyogo Pref.	Construction Area	13,233m^2
Date Constructed	March 2008	Concrete Composition	N30-12-20
Name of Waterproof Work Contractor	Masuda Koumuten Inc.	Spec. of Applied Const. Method	CS-21 CS II METHOD

Overview of Investigation

Date Investigated	April 10, 2012	Investigation Person in Charge	Teppei Kuze
Investigation Organization	Masuda Koumuten Inc.	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progression

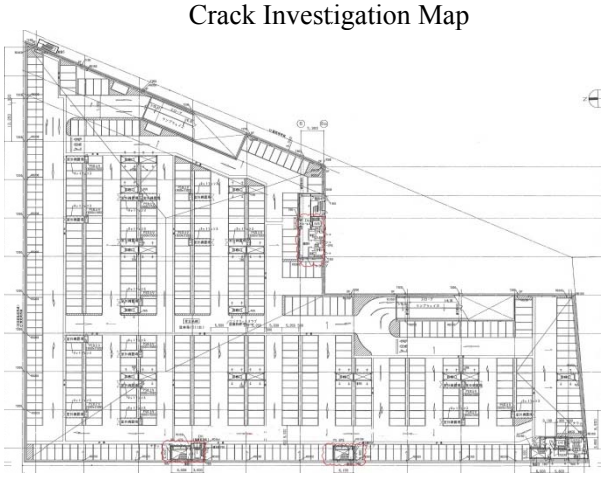
No Water Leak Accident
Repair History: Crack recoated at periodical inspection, 1 and 2 years.

Crack Investigation, Results

	Measuring QTY (m)	Target Area	Crack QTY per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total QTY, Cracks (m)	515m	13,233m^2	0.039m/m^2	———
B) QTY of Self-Healed Cracks among Cracks (m)	489m	13,233m^2	———	95%

Cover Shot

Crack Investigation Map



Crack Detailed Photo

Crack Detailed Photo

Crack Detailed Photo

Remarks

Concrete self-healed action looks progressing early since cement amount of concrete is a lot.
Visually confirmable cracks are extremely less compared with periodical inspection at 1 and 2 years.
Locations where confirmable as crack are almost filled up to surface, too.

Follow-up Investigation Slip

№ 007

Overview of Structural Object

Name of Facility/ Structural Object	Large Store Waterproofing of Roof Parking Lot	Structural Type	Steel Structure, Composite QL Deck Slab 6mm; 100 × 100 Mesh Arrangement
Address	Nagoya City, Aich Pref.	Construction Area	24,134m^2
Date Constructed	Feb, 2010	Concrete Composition	N24-15-20
Name of Waterproof Work Contractor	Masuda Koumuten Inc.	Spec. of Applied Const. Method	CS-21 CS II METHOD

Overview of Investigation

Date Investigated	April 9, 2012	Investigation Person in Charge	Teppei Kuze
Investigation Organization	Masuda Koumuten Inc.	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progression

No Water Leak Accident No Repair Record

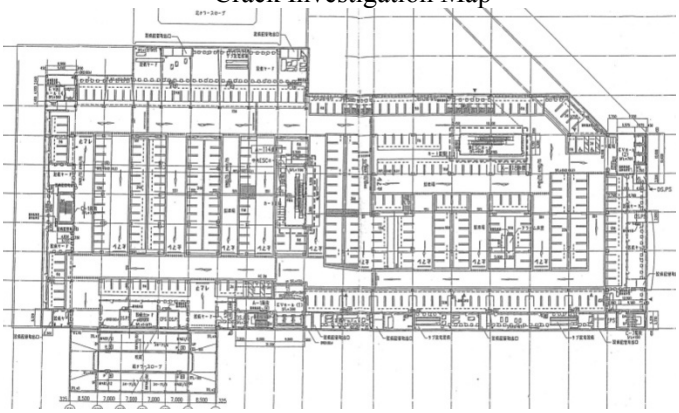
Crack Investigation, Results

	Measuring QTY (m)	Target Area	Crack QTY per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total QTY, Cracks (m)	320m	24,134m^2	0.013m/m^2	———
B) QTY of Self-Healed Cracks among Cracks (m)	300m	24134m^2	———	93%

Cover Shot, Roof Parking Lot

Parking Lot, 5F

Crack Investigation Map



Crack Detailed Photo

Remarks

The penthouse is not used as parking lot but cracks are practically not confirmed visually.
Unfilled cracks are remarkable at location where rain not falling indoor part of 5F parking lot but are self-healed up to surface at rain directly falling location.

Follow-up Investigation Slip

№ 008

Overview of Structural Object

Name of Facility/ Structural Object	Large Store Waterproofing of Roof Parking Lot	Structural Type	Steel Structure, Composite QL Deck Slab 6mm,100 × 100, Special Mesh Bar Arrangement
Address	Asahi-Cho, Mie Pref.	Construction Area	10,267m^2
Date Constructed	March 2008	Concrete Composition	N30-15-20 Expansive Additive is used.
Name of Waterproof Work Contractor	Masuda Koumuten Inc.	Spec. of Applied Const. Method	CS-21 CS II METHOD

Overview of Investigation

Date Investigated	April 10, 2012	Investigation Person in Charge	Teppei Kuze
Investigation Organization	Masuda Koumuten Inc.	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progression

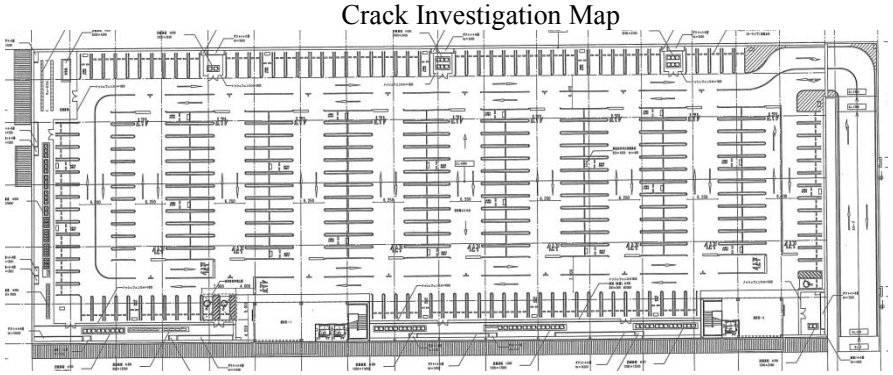
No Water Leak Accident No Repair Record

Crack Investigation, Results

	Measuring QTY (m)	Target Area	Crack QTY per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total QTY, Cracks (m)	60m	13,233m^2	0.004m/m^2	———
B) QTY of Self-Healed Cracks among Cracks (m)	60m	13,233m^2	———	100%

Cover Shot of Roof Parking Lot; 2F Store

Crack Investigation Map



Detailed Photo, Joint Section

Remarks

Agent anchorage with brush finishing after pressing with metallic trowel is excellent and high quality is maintained. Crack is confirmed at around the column of staircase but self-healed up to surface less than 0.2mm. The joint section is processed linearly and self-healed up to surface.

Follow-up Investigation Slip

№ 009

Overview of Structural Object

Name of Facility/ Structural Object	Large Store Waterproofing of Roof Parking Lot	Structural Type	Steel Structure, Composite QL Deck Slab 6mm, 100 × 100 Mesh Bar Arrangement
Address	Hashimoto City, Wakayama Pref.	Construction Area	16,198m^2
Date Constructed	September, 2011	Concrete Composition	N24-18-20 Expansive Additive is used.
Name of Waterproof Work Contractor	Masuda Koumuten Inc.	Spec. of Applied Const. Method	CS-21 CS II METHOD

Overview of Investigation

Date Investigated	April 13, 2012	Investigation Person in Charge	Teppei Kuze
Investigation Organization	Masuda Koumuten Inc.	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progression

No Water Leak Accident No Repair Record

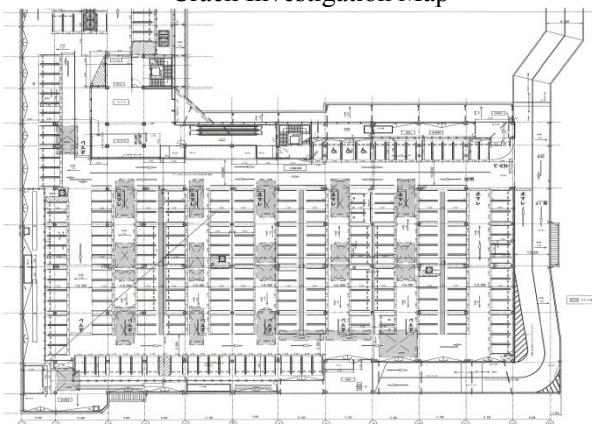
Crack Investigation, Results

	Measuring QTY (m)	Target Area	Crack QTY per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total QTY, Cracks (m)	85m	16,198m^2	0.005m/m^2	———
B) QTY of Self-Healed Cracks among Cracks (m)	75m	16,198m^2	———	88%

Cover Shot

Cover Shot

Crack Investigation Map



Crack Detailed Photo

Remarks

Crack which is not self-healed up to surface is confirmed at location where rain water is not dropped directly. Crack which is not filled up to surface is not confirmed at location where rain water is dropped directly. However, continuation of follow-up investigation is required in future because it is less than 1 year and has the possibility of crack growing.

Follow-up Investigation Slip

№ 010

Overview of Structural Object

Name of Facility/ Structural Object	Large Store Waterproofing of Roof Parking Lot	Structural Type	Steel Structure, Composite QL Deck Slab 6mm, 100 × 100 Mesh Bar Arrangement
Address	Hashimoto City, Wakayama Pref.	Construction Area	15,126m^2
Date Constructed	September 2011	Concrete Composition	N24-18-20 Expansive Additive is used.
Name of Waterproof Work Contractor	Masuda Koumuten Inc.	Spec. of Applied Const. Method	CS-21 CS II METHOD

Overview of Investigation

Date Investigated	April 17, 2012	Investigation Person in Charge	Teppei Kuze
Investigation Organization	Masuda Koumuten Inc.	Investigation Item	Crack Investigation (Visual, Drawing Figure)

Waterproof Performance and Progression

No Water Leak Accident No Repair Record

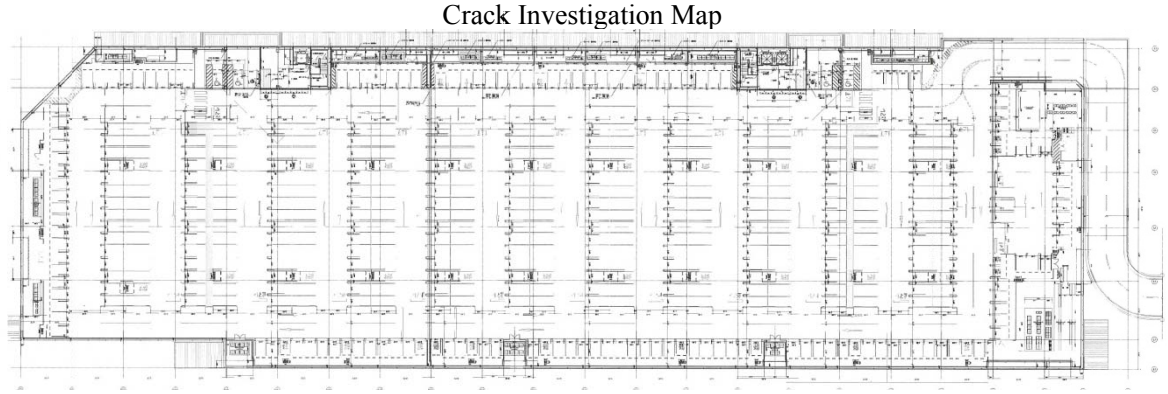
Crack Investigation Results

	Measuring QTY (m)	Target Area	Crack QTY per Area (m/m^2)	Self-Healed Rate (B/A)
A) Total QTY, Cracks (m)	95m	15,126m^2	0.006m/m^2	———
B) QTY of Self-Healed Cracks among Cracks (m)	95m	15,126m^2	———	100%

Cover Shot

Cover Shot

Crack Investigation Map



Remarks

Agent anchorage with brush finishing after pressing with metallic trowel is excellent and high quality is maintained. However, continuation of follow-up investigation is required because it is less than 1 year and has the possibility of crack growing in future.

Consider Life Cycle Cost of Concrete

Concrete has been created. I want to make it last well…

Mr. Aston

Without treatment

Cracks are caused.

Neutralization progresses (much).

Degradation progresses (much). Reinforcing gets rusty (much).

Degradation progresses (much). Reinforcing bar gets rusty (much) Burst

I should have repaired it…

Cracks become apparent.

I think I must repair only cracks.

Repair cracks

Degradation is progressing (moderately).

Degradation is progressing. Reinforcing gets rusty.

Repair of minute cracks is difficult…

Film coating method

Cracks are caused.

Neutralization progresses (a little) without damage to coating film.

Degradation progresses (moderately). Damage to coating film.

Degradation progresses (much). Reinforcing bar gets rusty (much).

It was fine at first.

It might be good since the appearance is good.

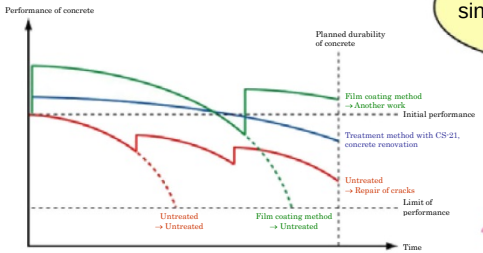
The surface is a little degraded.

I wonder I had better apply once more for safety.

Another treatment

Degradation progressed (a little).

Periodical treatment costs so much…



Treatment method with CS-21, concrete renovation

Cracks are caused.

Neutralization progresses (moderately) with cracks self-healed.

Neutralization progresses (moderately) with cracks self-healed.

Neutralization progresses (moderately) with cracks self-healed.

It is the most economical!!

I wonder if the condition is good.

I think the condition may be good.

Aston association

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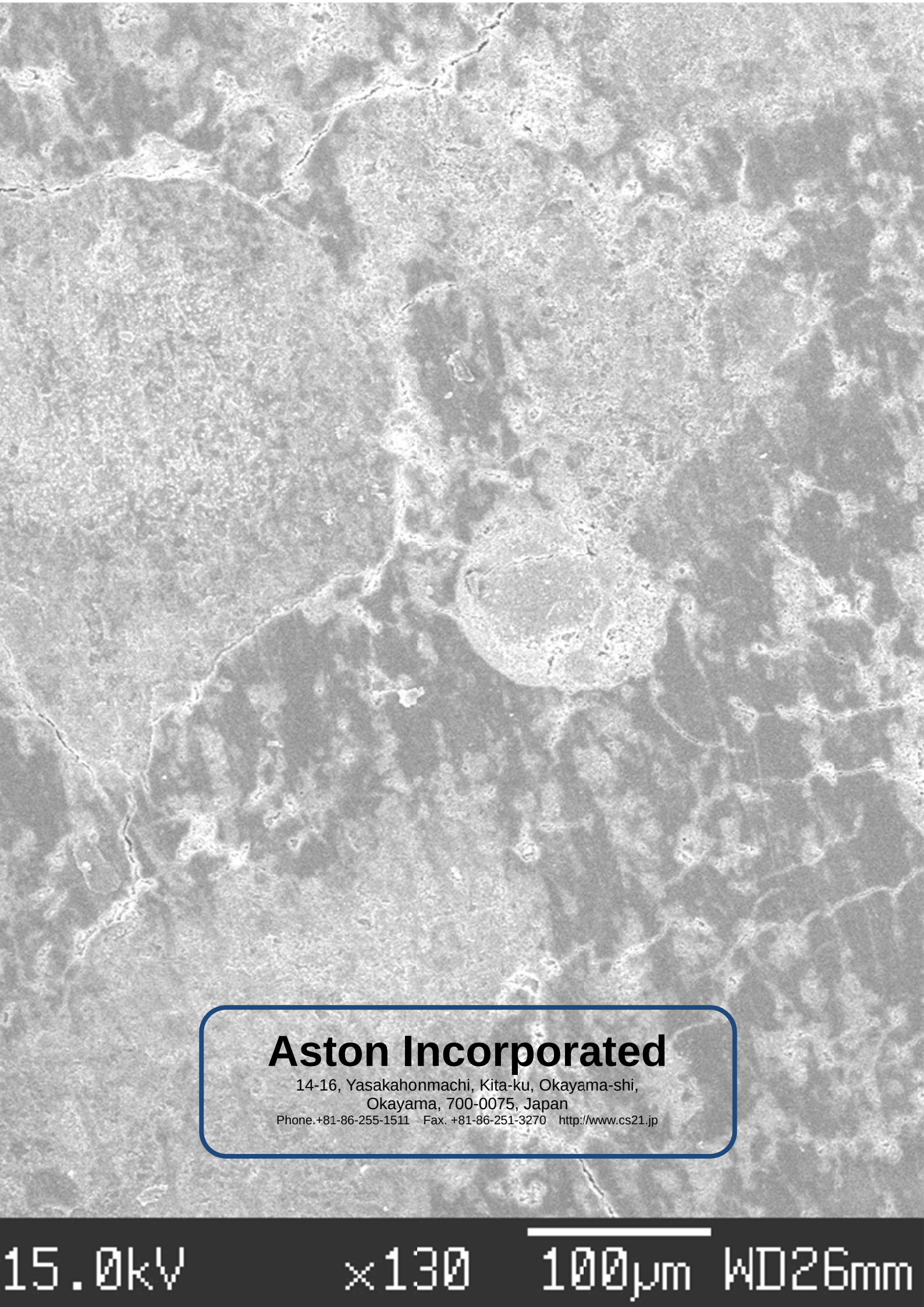
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15.0kV
×130
100μm
WD26mm