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Commentaries

Toward Establishing Guidelines on Silicate-based Surface Impregnation Method for Concrete Structures

Koji TAKEWAKA[*1]

Keywords: surface protection method, silicate-based penetrants, lithium silicate, sodium silicate, potassium silicate, solidifying type, reactive type

In December 2009, the Concrete Committee of the Japan Society of Civil Engineers set up a subcommittee with 47 members under a chairman, Professor Koji Takewaka of Kagoshima University, to study on silicate-based surface impregnation method for concrete structures. Among several surface protection methods, the subcommittee focused its activity on silicate-based penetrants that are expected to improve properties of concrete surface layer, to heal cracks and to prevent deteriorations of concrete structures.

In the subcommittee, the following four working groups were set up to pursue the work for establishing guidelines not only on design and implementation method of the surface silicate-based impregnation method of concrete structures, but also test methods to evaluate performance of the penetrants;

1) Working group 1 (Coordinator: Toshiki Ayano (Okayama University), Sub-coordinators: Toshiya Maeda (Shimizu Corporation) and Hisashi Ando (Aston Corporation)): / To work on idea of the composition and contents of the guideline. / To prepare the draft guideline based on information provided by the other working groups.

2) Working group 2 (Coordinator: Shin-ichi Igarashi (Kanazawa University), Sub-coordinators: Shin-ichi Miyazato (Kanazawa Institute of Technology) and Tetsuya Kudo (Radcon Japan Corporation)): / To clarify the impregnation process and the reaction mechanism of silicate-based surface penetrants in concrete. / To quantify their ability to protect from various deteriorations. / To formulate drafts of testing methods for evaluating performance of penetrants.

3) Working group 3 (Coordinator: Susumu Moriya (Public Works Research Institute), Sub-coordinators: Kazuhiro Kasai (Tobishima Corporation) and Tatsuyuki Takashima (Ever Protect Corporation)): / To develop the most effective implementation method of silicate-based surface penetrants onto concrete surfaces. /To clarify the effectiveness of its use with other repair methods as well as its applicable scope.

4) Working group 4 (Coordinator: Hidenori Hamada (Kyushu University), Sub-coordinators: Toshinobu Yamaguchi (Kagoshima University) and Hideya Nishino (Fuji Kagaku Corporation)): / To develop quality inspection methods on concrete after applying surface penetrant. /To establish verification systems to confirm continuity of surface treatment ability on concrete applied by the penetrants.

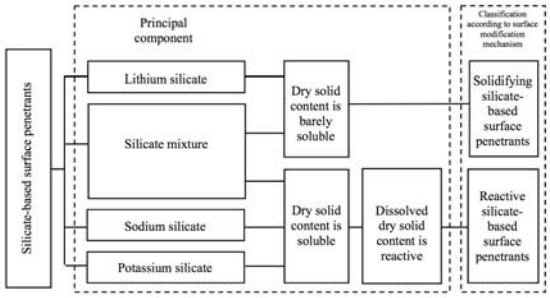

Fig. 1 Relationship between principal components and surface modification mechanism

The main components of silicate-based surface penetrants react with calcium hydroxide, which is formed during the process of cement hydration, and form a C-S-H gel in the concrete. The main component used in commercialized penetrants is lithium silicate, sodium silicate, potassium silicate or their mixture. In the actual products, however, it is unusual to find just one of these ingredients; most of the penetrants contain various additives and minor ingredients that aim to stabilize reactivity of main components and to improve their physical properties. However, from an engineering point of view, it is little meaning to categorize silicate-based surface penetrants according to these additives and minor components. The subcommittee, therefore, proposed a classification of surface penetrants into two types, that are “Solidifying type” and “Reactive type”, according to improvement mechanisms of the main components on concrete surface.

The draft recommendation discussed by the subcommittee includes a test method for distinguishing the type of the silicate-based surface penetrant, as an important part of the test methods.

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Technical reports

The influence of crushed limestone aggregate on the properties of concrete

—fine particle contents, drying shrinkage, ASR, sulfate attack, compressive strength—

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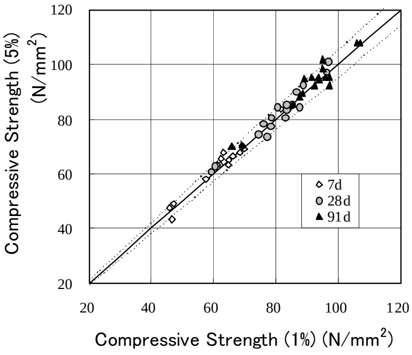
Keywords: crushed limestone aggregate, fine particle contents, drying shrinkage, ASR, sulfate attack, compressive strength

Since crushed limestone aggregate tends to easily increase its fine particles for several percentages during transportation, it is necessary to know the influence of fine particles on properties of concrete. Recently, with respect to Concrete using crushed limestone aggregate, it has been found that drying shrinkage tends to be small, no ASR will be expected, inhibitory effect on sulfate attack, and strength development effect is high. "Limestone Aggregate and Concrete - Addendum (2012)" was published by Limestone Association Japan summarizing these aspects as follows.

Compressive strength: For general-strength concrete, fine particles enhance strength slightly. However, no effect was detected for high strength concrete. This is the case of Portland cement containing minor amount of limestone addition.

Drying shrinkage: Drying shrinkage strain of concrete using crushed limestone aggregate is relatively small compared with other aggregate types because of its higher Young's modulus.



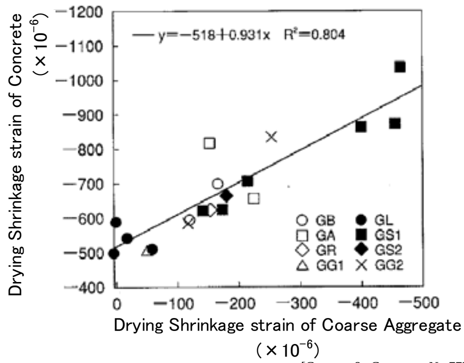
[Concrete Journal, Vol.49, No.12, pp.31-38]

Fig.1 Relationship of Compressive Strength for the Cases of 1 & 5% of Fine Particle Contents

ASR: Limestone aggregate in Japan is non-reactive because of its high purity more than 90% with limited amount of silica minerals. This is complete different situation from worldwide average of impure limestone. It is important to recognize that there is a risk of ASR for many foreign limestone aggregates containing significant amount of impurities.

Sulfate attack: Thaumasite sulfate attack attracted great attention in the United Kingdom. Although in Japan this deterioration type has not been reported because sulfate-rich soil is limited, it is necessary to consider this mechanism under specific conditions.

Alumina content: Limestone aggregate reacts with aluminate phase ($3CaO \cdot Al_2O_3$) to generate hydrates called as hemi-carbonate or mono-carbonate and this reaction contributes to the increase in strength by decreasing porosity. This effect is eminent especially for cement containing a large amount of reactive alumina.



[Cement & Concrete, No.777, pp.21-29]

Fig.2 Relationship between Drying Shrinkage Strain of Coarse Aggregate and Drying Shrinkage Strain of Concrete

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Construction records

Reinforcement of RC apartment house Considering Living Environment

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Keywords: seismic reinforcement, execution plan, low noise/low vibration, dismantling/cutting the body, mortar removal, concrete chipping, post-installed anchors

1. Introduction

Various seismic reinforcement methods have been developed, but the execution of many conventional methods is accompanied by noise, vibration, and dust. They also restrict the use of the interior of buildings during execution. These factors severely limit the performance of seismic reinforcement.

This paper reports on a case of seismic reinforcement of an apartment building where it was necessary to perform the execution entirely from outside while the building remained in use. It introduces an execution plan permitting "Execution during Occupancy"‒upgrading work on the building while its residents continued to occupy the building—and special execution methods which do not interfere with the daily lives of the residents and preserve their living environment.

2. Outline of the building

Photo 1 shows the exterior of the building before and after the reinforcement work.

Date completed : March 1972
Use : apartment building
Structure : 11th stories

3. Execution plan considering living environment

Execution plans and work methods were proposed and actual execution carried out by estimating the impact of the execution of this work on the residents' environment in advance, to select measures to counter its impacts.

3.1 Study of limits on execution hours

For weekends, when a large percentage of the residents would remain at home, noisy work was not performed on Saturdays and no work was carried out on Sundays.

3.2 Reducing noise, vibration, and dust caused by dismantling existing walls

The screen walls were dismantled by cutting and removing the walls applying the wall saw AWA method. The side walls and the spandrel wall, etc. were dismantled applying a dismantling method using a crusher.

3.3 Reducing dust produced by removal of finishing mortar

Mortar on the existing body was removed using a mortar splitter.

3.4 Reducing vibration, noise, and dust produced by concrete chipping work

Concrete chipping with an electrically powered pick produces noise, vibration, and dust. The vacuum blast method was adopted to execute concrete chipping to a depth of about 3mm.

3.5 Reducing noise and vibration produced by post-installed anchor work

This work was done partly by the method using the post installed anchors—injection type anchor cartridges equipped with wet core drills—in order to minimize the production of noise and vibration.

4. Conclusions

This report introduced special work methods to execute seismic reinforcement of a building while it remains occupied. This special work method was a method which considers the residents' environment on the premise of "Execution during Occupancy."

Photo 1. View of the building after reinforcement

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Construction records

Construction Technology of the World's Largest Pneumatic Caisson

— Main Pump Construction of the Higashi Ogu Sewage Treatment Plant —

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Keywords: pneumatic caisson, world's largest, large-scale, underground, IT construction, mechanically stabilized ash

1. Construction Summary

The Higashi Ogu Sewage Treatment Plant, located in Arakawa Ward, Tokyo Japan, is a facility designed for the water quality improvement of the Sumida River and the prevention of eutrophication of the Tokyo Bay.

The core Nishi-Nippori District main pump building has three (3) stories with a steel-reinforced concrete structure above ground and six (6) below with a reinforced concrete structure. The underground structure was completed through the design and construction of the Pneumatic Caisson Method and has the world's largest plane area (A＝4,837 sq.m, equivalent to 8 tennis courts).

A carefully thought-out plan carried out using advanced technical know-how at each of the design and construction stages, successfully realized, in terms of both economic efficiency and high-accuracy, a first-of-its-kind supersize pneumatic caisson. As a result of central controlling sinking position by centralizing the on-time information gathered by sensor, high accuracy of only 4mm to 9.6m (diagonal line) is realized at the completion of the sinking.

2. Structure of Large-scale Caisson

2.1 Structure of Large-scale Suspended Girder

Generally suspended girder structure is adopted to tolerate torsion and bending generated during settlement. For this caisson suspended girder structure with 15.9 m high (equivalent to the six basement level to the fourth basement level) reinforcing wall is adopted and built before its settlement.

2.2 Adoption of Steel Plate for Edge of Caisson and Ceiling Slab

Pneumatic caisson with world's largest plane area needs the structure of large-scale suspended girder and high-density rebar. Therefore steel plates (double as a formwork) are adopted especially for the surface of edge of caisson and ceiling slab. Also, hybrid structure of steel plate and stud welded to steel plate reduced reinforcement volume.

3. Construction of Large-scale Caisson

3.1 Action of Air Pressure from the initial stage of settlement

This caisson weighs 1.1×10^3 KN and is much heavier than general one. Soil improvement was implemented previously to secure soil bearing capacity of heavy caisson placed on soft ground. But only soil improvement was not enough to bear the weight of this caisson. So Excavation work with 4.7m below the ground level carried out and hefty caisson is constructed below the underground water level. As a result, seeming weight of caisson are reduced by activating working pressure 0.03Mpa (3-m water head) upward from the beginning of excavation. This technique enabled to bear the world-largest caisson and reduce cross-sectional force generated by the weight of ceiling slab. As a result this construction technology brought economic structure.

Finally, the knowledge obtained by this project will contribute greatly to future large-scale underground structures.

Fig.1 Settling Higashi Ogu Sewage Treatment Plant

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