



SUBCOMMITTEE 362

RESEARCH SUBCOMMITTEE ON EVALUATION OF WATER PENETRATION INTO CONCRETE AND ITS APPLICATIONS

Introduction

Standard specifications for concrete structures 2017 (Design) published by the Japan Society of Civil Engineers adopted for the first time a verification method for rebar corrosion using water penetration as an index. In this revision, it was decided to directly incorporate the effect of water into the verification equation, since water has a large effect on rebar corrosion. At the same time, the JSCE-G 582-2018 standard, "Test method for water penetration rate coefficient of concrete subjected to water in short term" was enacted. These are an important step towards the development of concrete engineering.

On the other hand, it is still difficult to say that the mechanism of water penetration and rebar corrosion has been elucidated. Therefore, it was necessary for the committee to theoretically support the validity of the investigation of rebar corrosion caused by water penetration. Moreover, to ensure and improve the durability of concrete structures, it is necessary to clarify the influence of water on concrete structures and to systematize everything from design to maintenance.

Therefore, this committee aims to systematize the effects of water on concrete structures and to secure and improve the durability of concrete structures, a study on mechanisms of water penetration and rebar corrosion, verification and examination of the introduced verification and test methods, and investigation on utilization in maintenance were carried out.

Responsibility for this report

Chairman of subcommittee 362
Prof. Toshiharu Kishi
[The University of Tokyo]



Research Subcommittee on Evaluation of Water Penetration into Concrete and its Applications (362 Committee)

Chairman : Toshiharu KISHI, Vice chairman : Tetsuya ISHIDA, Secretary general : Hiroshi UEDA, 51 members in total

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Corrosion of rebar at water splash point (RRR,68(4),22-25,2011)



<p>Water penetration and rebar corrosion mechanisms</p> <p>Manager : Yuya SAKAI</p> <ul style="list-style-type: none"> ● Elucidation of water penetration mechanism ● Elucidation of rebar corrosion mechanism <p>Diffusion model : analysis example of mean saturation</p>	<p>Method of the verification</p> <p>Manager : Jun-ichi KINO</p> <ul style="list-style-type: none"> ● Compatibility of actual structures and the verification equation ● Reproduce reinforcing bar corrosion by analysis <p>Example of comparative analysis results of corrosion progress between constant humidity (solid line) and dry-wet cycle (dotted line)</p>	<p>Test method for water penetration</p> <p>Manager : Atsushi UENO</p> <ul style="list-style-type: none"> ● Effects of JSCE-G 582-2018 test conditions on measurement results ● Applicability for existing concrete structure at maintenance stage <p>Conversion considering porosity to ASTM method</p>	<p>Utilization in Maintenance</p> <p>Manager : Yasushi KAMIHIGASHI</p> <ul style="list-style-type: none"> ● Summarization of investigation cases in existing concrete structures ● Maintenance management focused on water <p>Example of water treatment at a pier</p>
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Activities of this subcommittee

Water penetration and rebar corrosion mechanisms

To contribute to successful rational design and sophisticated numerical analysis, the committee collected basic information on water penetration into concrete and rebar corrosion caused by water penetration and discussed the future research direction. The main conclusions are as follows.

The main challenges in the study on water penetration are: 1. A model that can estimate the water penetration in concrete driven by capillary force, which is applicable to various types of concrete and environmental conditions is not established yet. 2. An insufficient amount of data on the effect of drying on the moisture distribution in concrete and the generation of micro cracks. 3. The establishment of a testing method to obtain the characteristic values for design.

On rebar corrosion, the quantitative evaluation of rebar corrosion in unsaturated concrete is a major goal. To achieve this, models of the moisture distribution, which is determined by the pore structure and moisture content, and its effect on the location of the anode and cathode and oxygen supply are necessary. In the measurement of rebar in concrete, because the voltage drop due to the cover concrete is large and the current distribution can be non-uniform, the measurement method on rebar needs to be devised based on the characteristics of the measurement method to improve the accuracy.

Method of the verification

The committee investigated the cover thickness of the reinforcing bar, the influence of rain water, the carbonation depth of the concrete and the falling of the cover concrete due to the corrosion of the reinforcing bar in the existing structures. As a result, the following findings were obtained.

- Falling of cover concrete due to the corrosion of reinforcing bar occurs when the cover thickness at that location is smaller than the cover required by the verification formula for reinforcing bar corrosion due to water penetration.
- In the absence of rain water, the rate of falling of cover concrete is low even when the residual carbonation reaches 10 mm, so it is suggested that rain water affects reinforcing bar corrosion.

And the committee examined whether it was possible to reproduce reinforcing bar corrosion by analysis. We analyzed cases in which reinforcing bar corrosion did not progress even when carbonation progressed, and cases in which reinforcing bar corrosion progressed early even though carbonation progressed slowly due to repeated dry-wet cycles. As a result, it was found that it was possible to express the concept of the specification standards that evaluates both carbonation and water permeation by analysis.

Test method for water penetration

JSCE-G 582 was specified in 2018 to measure water penetration rate in concrete specimen. Several factors affect the results of the test. The committee investigated the testing factors, such as applied water head for penetration, direction of water penetration, influence of existing micro cracks. Influence by use of mineral admixture, GGBFS, in high replacement is also investigated by reviewing literatures. From the investigations, JSCE-G 582 is suitable to obtain water penetration rate as the value for durability designing. However, if GGBFS is used in high replacement, shape of water penetrating frontline will be clearly influenced by drying the specimen, and the results of the concrete will be also affected by carbonation clearly.

JSCE-G 582 requires 9 specimens for one test. Therefore, the test might be difficult to apply for existing concrete structure at maintenance stage. ASTM C1585 is introduced for using existing concrete structure. The method is based on mass change of specimen; therefore, it does not require many specimens. However, water penetration depth is calculated as whole cross section of specimen adsorb water. We recommend new calculation method using dry up voids' ratio.

Utilization in maintenance

Summarization of investigation cases in existing concrete structures

According to past surveys, the ratio of concrete pieces falling off due to corrosion of reinforcing bars of railway viaducts is about 5% in spots without rain, and about 45% in spots with rain. Therefore, it is easier to peel and peel off if there is rain.

Maintenance management focused on water

Under normal circumstances, deterioration of concrete structures is limited to locations where

repeated drying and wetting due to the action of water occurs. For this reason, it is possible to carry out rational maintenance and management by conducting visual inspections focusing on areas where water is splashed or where there are traces of water, and depending on the results, implement water-proofing to limit the action of water, conduct water.

As an issue in the maintenance and management of existing structures, tests conforming to the JSCE-G582 standard partially damage structures. In addition, since the water permeation rate coefficient to be obtained is the evaluation near the relatively dry concrete surface areas , the evaluation up to the rebar position (cover) is on the safe side.