Newsletter on the Latest Technologies Developed by RTRI

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# Railway Technology Newsletter

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GENERAL INFORMATION



ARTICLES



## Japan's International Standardization Efforts

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Director, Railway International Standards Center

With the advent of market globalization trends in recent years, international standardization has increasingly become a matter of critical importance in the railway field. Since the establishment of the World Trade Organization (WTO) in 1995, maintaining accordance with international standards has become a key to success in marketing and is a basic requirement in the distribution of products and services in the railway industry. It is increasingly important for a railway operator to have a good understanding of international standards, and to aggressively take actions for observing and sustaining them when appropriate.

To facilitate these efforts, the Railway International Standards Center was established within the premises of the Railway Technical Research Institute in 2010 under the guidance of the Ministry of Land, Infrastructure, Transport and Tourism, in order to centralize and facilitate the implementation efforts for international standardization in the railway field. The Railway International Standards Center has organized and is conducting efforts to assist a total of 131 domestic railway related associations and enterprises in their international standardization activities.

That said, the first step in international standardization activities has just been taken by Japan. Europe already has a long history of experience with standardization. On top of that, Europe has worked extensively on promoting International standards. In the years ahead, Japan should endeavor to create an environment where Japan's important technologies will be incorporated into existing international standards.  Japan should also promote activities to help develop international standards in those technical fields where Japan can play a substantial role. Moreover, in the railway field, although product standards have occupied a predominant position, generic standards prescribing the linkage and management across different systems are presumed to emerge for international standard. Thus railway operators will have to take leadership positions in formulating these generic standards.

Standards setting organizations exist, including the IEC/TC9 (Electrical equipment and systems for railways) that has been active since 1924, and the ISO/TC269 (Railway applications) that was established in 2012. Thus the basis mechanisms now exist for effectively conducting the development of international standards for a wide range of technological sectors in the railway field. Japan should embrace these international standardization activities without delay and contribute to the sustainable development of the railway in the world and to the enhancement of reliability and safety.

## Participating in the “9th UIC World Congress on High Speed Rail”

RTRI personnel attended the “9th UIC World Congress on High Speed Rail” that was held at the Tokyo International Forum between July 7 and July 10, 2015. Including the keynote speech by Norimichi KUMAGAI (President, RTRI) in the opening session, six presentations were delivered by RTRI. President KUMAGAI’s speech was titled “Creating New Values of Railway by Shinkansen Technology.” He reviewed the contribution of Japanese Shinkansen to the creation of new values of railways from the aspects of safety, reliability, environmental adaptability, and high-speed operation. These innovations have positively impacted society and the economics of Japan. He also commented on other technical improvements required for further speed-up and added-value of Shinkansen operations in the future. In Executive Director OKUMURA’s speech, “Vehicle Running Safety on Railway Structure during Earthquake”, he introduced a fundamental design and its concept to specifically ensure the safety of railways during earthquakes through analyses on causes and mechanisms of actual derailments. RTRI also opened an exhibition booth at the Congress for the participants to showcase its efforts to develop Shinkansen technologies in the past, present, and future.

Dr. KUMAGAI (President, RTRI) during speech

## Superconducting Flywheel Power Storage Demonstration System

RTRI has been developing a superconducting flywheel power storage system, as a next-generation large power storage system. The flywheel power storage system is capable of storing electricity in the form of kinetic energy by rotating a large disk (flywheel) and converting the rotating power again to electricity as required. Typically, in combination with less reliable power-generation systems such as solar photovoltaic or wind-power generation, it can help stabilize power supplies. It is also applicable to electrical railways in order to prevent regenerative cancellation.

Since the superconducting flywheel power storage system developed by RTRI is levitated without contact by a “superconducting magnetic bearing” composed of a high-temperature superconducting coil and high-temperature superconducting bulk, the power loss is minimal even though a large flywheel is used. It is a very practical system that permits stable power generation over a long period. The completed demonstration unit has 300-kW output capability and 100-kWh storage capacity. It is equipped with a built-in carbon fiber reinforced plastics (CFRP) flywheel (2 m in diameter and weighing 4 tons), which is levitated with a superconducting magnetic bearing (SMB) at a maximum speed of 6,000 rpm. The SMB that consisted of a superconducting material bulk and a superconducting magnet is the world’s first. Dispite small in size, the SMB is capable of supporting a heavy weight.

This system has been developed by RTRI jointly with Kubotek Corporation, Furukawa Electric Co., Ltd., Mirapro Co., Ltd., and the Public Enterprise Bureau of Yamanashi Prefecture, in a project known as “the Technical Development for Safe, Low-Cost, Large-Capacity Power Storage System - the Development of the Next-Generation Flywheel Power Storage System” sponsored by the New Energy and Industrial Technology Development Organization (NEDO).

The Flywheel Power Storage Demonstration System

## Research Workshop on Railway Operations at RTRI

On July 31, a research workshop on railway operations modelling, analysis and simulation was held at RTRI with a total of 40 participants.

The workshop began with a welcome by Dr. Ikuo Watanabe, Executive Director. In addition to six lectures on simulation, timetable stability, rescheduling and some other subjects, a 40 minute plenary session was held to discuss topics including evaluation of timetable and rescheduling from the viewpoint of passengers with accumulated data. The six lecturers were Ms. Yoko Takeuchi (RTRI), Mr. Hajime Ochiai (JR-West), Dr. Yung-Cheng Lai (National Taiwan University), Mr. Hideyuki Yabuki (Tokyo Metro), Dr. Francesco Corman (Delft University of Technology) and Mr. Keisuke Sato (RTRI), listed in the order of presentation .

After closing the discussion, the participants were guided through the research facilities on the premises of RTRI, and invited to a welcome reception to become better acquainted with one another.

Taking the advantage of the opportunity of the workshop this time, we look forward to further extend the areas of research activities of the Transport Operation Systems Research Group, which is responsible for the railway operations research at RTRI.

Discussion at the research workshop

# Characteristics of Under-Floor Flow of Shinkansen Train

**Makoto IWASAKI**
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## 1. Introduction

To reduce aerodynamic noise and aerodynamic drag of a Shinkansen train, the flow field under the vehicle floor must be understood. The under-floor flow velocity in the longitudinal direction (X direction in Fig.1) induced by the passage of the train has so far been measured at the central position between the rails. However, since the flow velocity is likely to have a distribution laterally across the track (in the sleeper direction), multiple hot wire anemometers were installed across the track as shown in Fig.1 to measure the under-floor flow velocity. These instruments provided measurements of the under-floor flow velocity distributions in the longitudinal direction and the sleeper direction for the passage of the Shinkansen train.

## 2. Outline of the Measurement

In a slab track of Shinkansen, a total of seven one-dimensional hot wire anemometers were installed, each positioned at one of the seven measurement points across the track, starting from the center of the track to the outside of rails as shown in Fig. 1. This instrumentation arrangement allowed under-floor flow velocities to be measured during the passage of the Shinkansen train.

## 3. Measured Results

In this study, we took the mean of time series data of velocity and the mean flow velocity was transformed into a non-dimensional form by the train speed. The flow velocity distribution in the longitudinal direction of a 10-car Shinkansen train is shown in Fig.2. The flow velocity is almost constant throughout the train except for the leading and trailing vehicles. From Fig.2, we can see that the flow velocity was highest at the center of the track (at R1) compared to the other measurement points across the track. And we can see a trend where the flow velocity is highest at the inter-vehicle gaps, and drops off steadily as the front bogie, the between front and rear bogies, and the rear bogie for car No.3 and the other cars behind it. Although there is some variation in the flow velocity under the influence of local locations of vehicles such as bogies and inter-vehicle gaps, the flow velocity at each measurement point was found to be almost constant as car No.2 and the following cars passed the measurement location. There was one exception in that measurements at R7, located outside of the vehicle side surface, tend to show an increase in flow velocity from front to back of the train.

Figure 3 presents the flow velocity distribution across the track for car No.5. We can see that the flow velocity is highest at R1 (center of track) and decreases gradually towards the R7, although variations are observed between measurement points.

The flow velocity distribution obtained by the actual cars as described above was reproduced for a wind tunnel test. This has led us to develop a methodology for estimating the aerodynamic noise and aerodynamic drag generated from bogies with high precision.

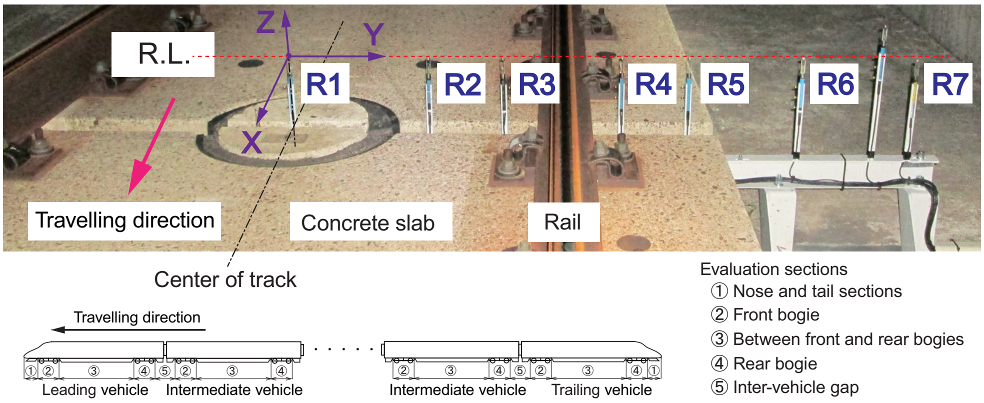


Fig.1 Layout of hot wire anemometers and evaluation sections

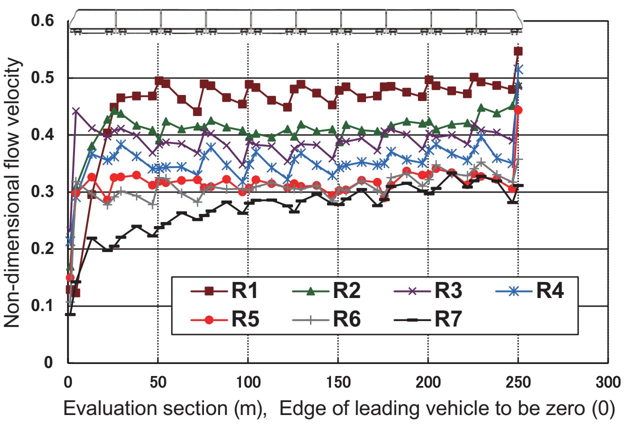


Fig.2 Flow velocity distribution in the longitudinal direction

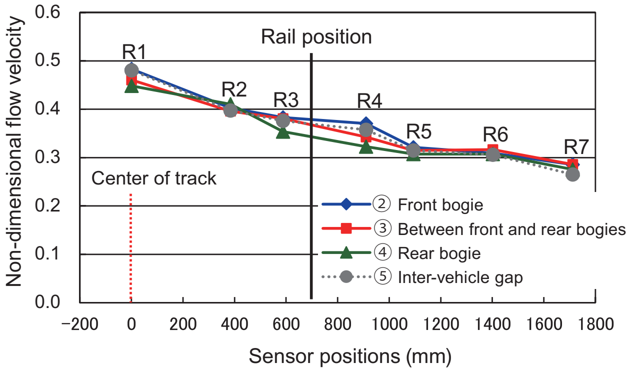


Fig.3 Flow velocity distribution in the sleeper direction of every measurement point for car No.5

# Development of an Efficient Vehicle Structure through Optimization Methodology

**Masakazu TAKAGAKI**
Senior Chief Researcher,Laboratory Head, Computational Mechanics, Railway Dynamics Division

## 1. Introduction

In response to the recent demands for improved safety and comfort of railway vehicle structures, collision safety designs have been introduced. These have caused the weight of these structures to increase and the additional installation of peripheral units is giving rise to further weight increases. Since conflicting requirements such as increased vehicle speed and energy-saving are emerging, the design of vehicle structures that are well balanced between strength improvement and weight saving is increasingly demanded. To meet these challenges, we have developed a methodology that efficiently facilitates the optimization of strength improvement and weight saving in the design of railway vehicles by using a single vehicle model.

## 2. Formulating a Structure Optimization Methodology

The present optimization methodology performs the stress analysis of a structure by means of finite-element analysis with a single vehicle model (Fig.1) to determine high stress regions. For such a highly stressed region as a spot-welded area, a further high-precision finite element analysis model is created. The shape of this model is optimized to define the structural configuration that will result in the reduction of stress and weight. Thus the defined structure is re-formulated as a single vehicle model to reevaluate the stress distribution in the entire model of the improved structure. Since there are trade-offs between strength improvement and weight saving, repeating the calculation until these conditions satisfy the requirements will give an optimum solution.

As an example, an optimization trial was conducted on the skeleton structure of an existing electric train on a conventional line, It was found that, if a constant mass condition is desired, a reduction in stress of 40% (Fig.2) in the stress-concentrated region is achievable. Alternatively, to maintain a constant stress condition, a reduction in weight for one vehicle coach of 7% (Fig.3) is possible.

## 3. Application to Vehicle Structure Design

Since thus formulated structure optimization methodology employs the finite element analysis, it facilitates not only evaluations of vehicle structures with the objectives of strength improvement and weight saving, but also it assists the study of high-rigidity and light-weight vehicle coach structures with improved riding comfort through suppression of high-frequency vibration. Further, the methodology can be used with such structural materials as stainless steel and aluminum. Above all, this methodology can be applied to a wide variety of tasks including improvement of existing structural configurations and design of novel structural configurations.

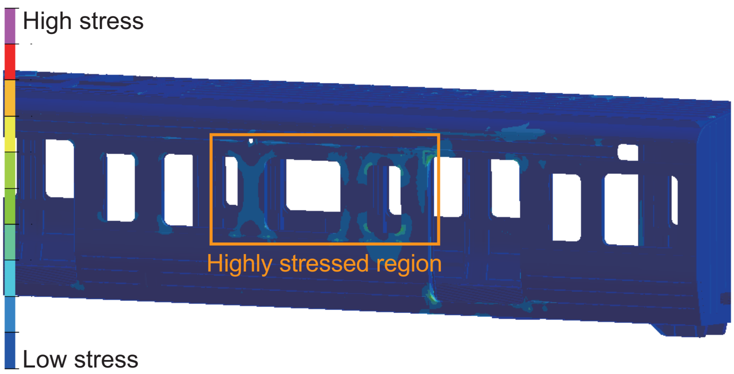


Fig.1 Stress analysis on a single vehicle model

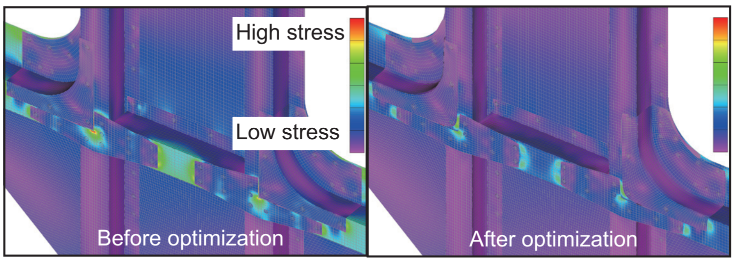


Fig.2 Optimization of shape in a highly stressed region

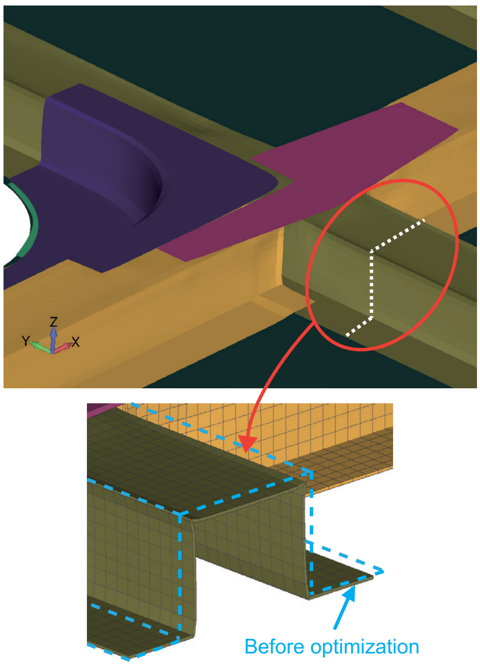


Fig.3 Cross-section of the skeleton structure after optimization
(Skeleton structure of a window corner)

# Summertime Thermal Comfort Predictive Method for Commuter Train Coaches

**Hiroharu ENDOH**
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## 1. Introduction

Although almost every commuter train in urban areas of Japan is equipped with an air-conditioning system, particularly in the hot and humid summer season quite a few comments about comfort dissatisfaction, such as feeling “hot” or “cold” are raised by passengers. To make the air-conditioned ambience in train coaches comfortable, it is essential to properly predict the thermal comfort of passengers to determine the thermally uncomfortable situations. The PMV/PPD method employed in ISO 7730 Standard for the thermal comfort prediction method (PMV: Predicted Mean Vote, PPD: Predicted Percentage of Dissatisfied) was originally developed for application to the interior ambience in buildings. The PMV is an index that predicts the mean value of the votes of a large group of persons on a thermal sensation scale varying from +3 (hot) to -3 (cold) with zero indicating a neutral vote. But individual votes are scattered around the mean values and the PPD establishes a quantitative prediction of the number of thermally dissatisfied people.

In this study, human subjects were invited to participate in series of tests to determine the precision of the prediction when the PMV/PPD method is applied to commuter train coaches. Further, the error causes were examined to develop a new, novel approach with higher precision.

## 2. Subjective Experiment on a Commuter Train Coach

The tests were conducted in a coach of a commuter train standing still during a summer season. A total of about 100 examinees participated and performed a subjective evaluation on the thermal comfort in an ambience simulating the thermal environment inside an operating train coach. Fig.1 indicates the relationship between PMV/PPD and also shows the measured percentage of dissatisfaction from our examinee evaluations. Comparison of the PPD with measured values showed mainly two types of errors:

(1) While the PPD is specifed one value for a PMV, the measured values of dissatisfaction during a temperature rise period differ from those during a temperature fall period.

(2) While the minimum value of PPD occurs when PMV = 0 (corresponding to “thermal neutral”), the minimum value of our measured values occurs around PMV = - 1 (corresponding to “slightly cool”) or thereabouts.

Error type (1) is considered to have occurred because the effect of the variation characteristic of thermal comfort was not taken into consideration in the PMV/PPD method, while error (2) is considered to have occurred because the effect of seasonal characteristics (“slightly cool” is preferred in summer) was not taken into consideration in the method.

## 3. Development of Thermal Comfort Prediction Method

In this study, a prediction method taking into consideration the above-mentioned two influential characteristic has been developed. As shown in Fig.2, this new method consists of a physiological response calculating section based on a human body thermal model having body temperature regulating functions and a psychological response calculating section based on a regression model obtained from examinee evaluations. As demonstrated in Fig.3, the two trends of errors observed in the PMV/PPD method were substantially improved by the new method. The new method can be utilized in developing more appropriate air-conditioning designs to provide improved passenger comfort. Further, it is expected to be utilized in other countries with hot and humid climates.

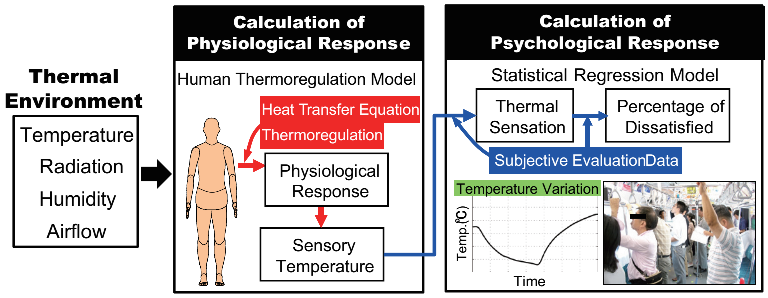


Fig. 2 The schematic representation of the proposed prediction method

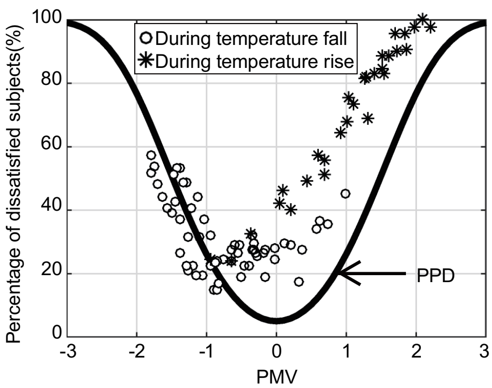


Fig.1 Comparison between results of subjective evaluation and PMV/PPD method

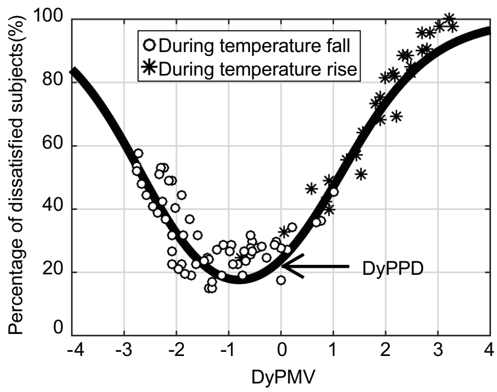


Fig.3 Comparison between results of subjective evaluation and the new (proposed) method

# Maintenance Control of Concrete Structures with Consideration of Water Migration

**Hiroshi UEDA**
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## 1. Introduction

Among many causes of degradation to concrete structures such as corrosion of rebars by carbonation or salt attack, freezing damage, alkali-silica reaction and so on, the presence of "water" has a significant influence on each of them. Accordingly, to conduct satisfactory maintenance control of a concrete structure, knowing the behavior of water in the concrete is extremely important. For example, rebar corrosion due to carbonation is frequently observed where water is splashed (Fig.1). In such a case, when water penetrates into concrete and reaches a rebar, it accelerates the rebar corrosion. Thus preventing water penetration to rebars is essential and knowledge of the depth of water penetration is required.

## 2. Measuring the Depth of Water Penetration

As a result of conducting various experiments by preparing test pieces of concrete each embedded with a water sensor, the variation of water penetration time into concrete (Fig.2) was successfully determined. Experiments were also conducted by varying concrete parameters. From the measured results, it was determined that water penetration resistance varied with changes in mix proportion, although for each mix proportion a high-quality curing process significantly increased the water penetration resistance. Further, for fly ash-mixed concrete specimens, a sufficient degree of curing was found to provide more resistance to water permeation than that of concrete using ordinary Portland cement only.

## 3. Improving the Durability in the Interface of Concrete and Repair Members

In a study to improve the durability of repaired concrete structures, the state of water penetration in the interface between the concrete and the cross-sectional repair member was examined. The results indicated the following: the water penetration resistance of the concrete mass near the interface significantly differs with the substrate treatment method before applying the repair member; the use of a primer enhanced the water penetration resistance; and when the concrete surface was chiseled off by using an electric pick gun, the water migration resistance decreased presumably due to fine cracking in the concrete mass. Thus the repairing performance is critically affected by differences in the substrate treatment method (Fig.3).

Judging from the above-mentioned results, we are confident that we can develop maintenance control technology taking the effect of "water" into consideration. We can predict degradation behavior depending on the condition of subject structures and take necessary measures based on reality.

Fig.1 Exposed rebars where water splashes

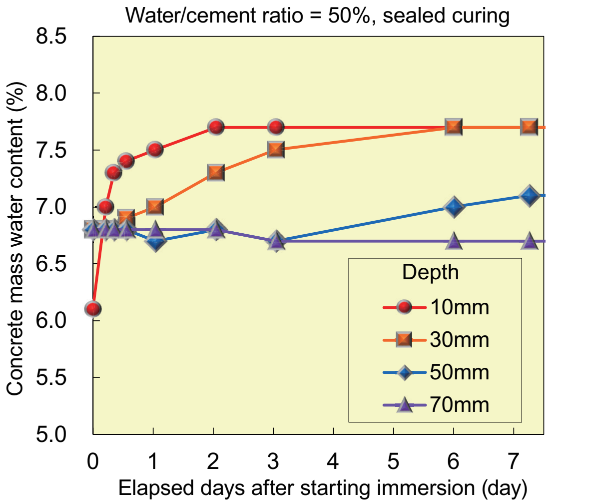


Fig.2 Example results of water permeation test

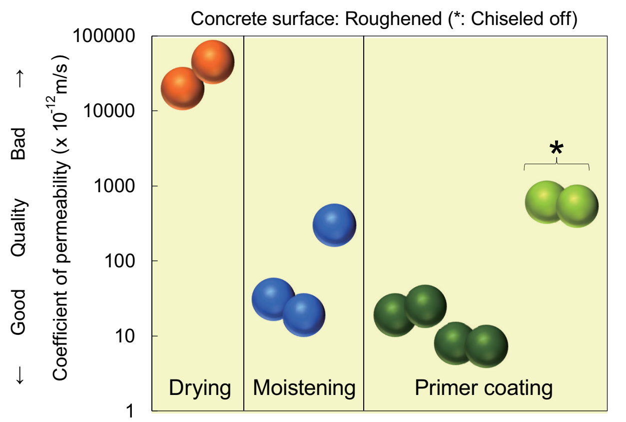


Fig.3 Effect of substrate treatment before repair material application on the suppression of water migration