Development of Liquid-applied Type Asphalt Water-proofing Material and Adhesives for Deck Water-proofing

M. Okada
Technology Management Office, Metropolitan Expressway Co.,Ltd., Chiyoda-ku, Tokyo, Japan

A. Hanyu
Engineering department, Nichireki Co., Ltd., Chiyoda-ku, Tokyo, Japan

H. Ohki
Tokyo branch, Nichireki Co., Ltd., Koshigaya, Saitama, Japan

M. Kobayashi
Technical Research Laboratory, Nichireki Co., Ltd., Shimotuke, Tochigi, Japan

ABSTRACT: In Japan, the bridge-pavement on concrete decks is generally composed of the water-proofing layer, the leveling course and the surface course. The water-proofing layer consists of adhesive and water-proofing materials. Most of the water-proofing layers field-proven in our country are asphalt sheet type and hot asphalt-based membrane type. Asphalt sheet type water-proofing materials find wide application for newly built bridges and hot asphalt-based membrane type do for repair of bridge deck pavements. In either case, adhesives mainly used are solvent type materials.

As the adhesive property cannot be secured if the adhesive spread on the deck is not dry, we cannot move to the next process. In the repair work of the bridge-pavement done at the nighttime in winter when the temperature is low in particular, it has been a problem that it takes a long time to get dry. We developed materials of the speed dryness to shorten time for repair construction.

Water-proofing material of hot asphalt-based membrane type may adhere to the tires of working vehicles and peel off. In this case the repair of the points that peel off is necessary.To prevent such damages to the water-proofing layers, the less adhesion to the tires was controlled by the improvement of materials.

We applied to the repair construction of the Metropolitan Expressway experimentally after having confirmed the performance of these materials by an indoor examination. As a result, the construction time was able to be shorten and of the water-proofing layer to prevent peeling off.

KEY WORDS: Tokyo Metropolitan Expressway, water-proofing, bridge pavement, adhesive, the liquid applied type asphalt water-proofing

INTRODUCTION

In Japan, the bridge-pavement on concrete deck is generally composed of the water-proofing layer, the leveling course and the surface course[1)]. The water-proofing layer consists of adhesive and water-proofing materials. Most of the water-proofing layers field-proven in our country are asphalt sheet type and hot asphalt-based membrane type. Asphalt sheet type water-proofing materials find wide application for newly built bridges and hot asphalt-based membrane type do for repair of bridge deck pavements. In either case, adhesives mainly used are solvent type materials.

As the adhesive property cannot be secured if the adhesive spread on the deck is not dry, we cannot move to the next process. In the repair work of the bridge-pavement done at the nighttime in winter when the temperature is low in particular, it has been a problem that it takes a long time to get dry. We developed materials of the speed dryness to shorten time for repair construction.

Water-proofing material of hot asphalt-based membrane type (hereinafter referred to as the water-proofing material) is a material such that hot melt asphalt is applied over the deck surface and then cooled down to form a water-proofing membrane. However, the adhesiveness increases when vehicles for construction are put in high temperature more than 50 ℃ for a long time, this water-proofing material may adhere to the wheels of working vehicles and peel off. In this case the repair of the points that were peeled off is necessary and it is needed more time. To prevent such damages to the water-proofing layers, the less adhesion to the tires was controlled by the improvement of materials.

We applied to the repair construction of the Metropolitan Expressway experimentally after having confirmed the performance of these materials by an indoor examination. As a result, the construction time was able to be shorten and of the water-proofing layer to prevent peeling off.

This paper presents the process for developing these materials.

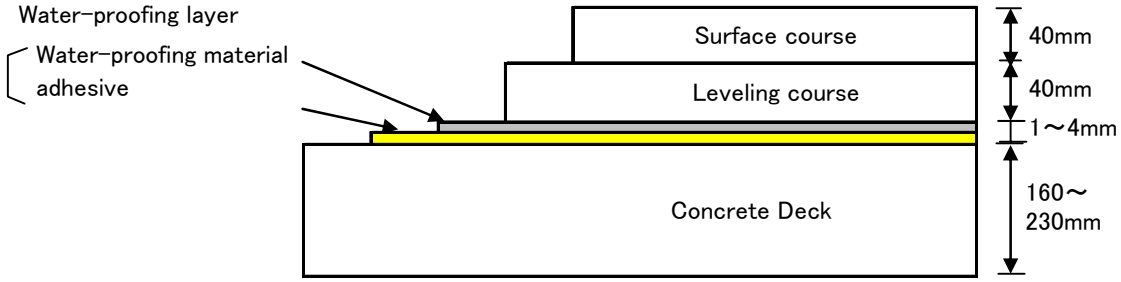


Figure1: Pavement structure on concrete deck

1 MEASURES BY IMPROVEMENT OF ADHESIVE AND WATER-PROOFING MATERIAL

(1) Shortening of drying time of adhesive

Adhesives serve to bond the deck and the water-proofing layer. Among others, the solvent type adhesive that is easy to apply by roller brushes on the deck, etc. at normal temperature is widely used [2].

The adhesives have the property of taking a longer time to get dry, the lower the air temperature is. Particularly at the temperature to 0-10℃, in the winter nighttime, it has often taken 60-80 minutes to get dry.

Therefore, we have made improvements to the adhesive to shorten the drying time [3]. The features of this material (hereinafter referred to as the improved adhesive) are as follows:

a. It can get dry in 30 minutes or less even in winter when the deck temperature becomes 10℃ or less.
b. It can be ensured the adhesion to the deck and water-proofing material which is equivalent to or higher than that in the case of the conventional one.

(2) Improvement of the adhesion resistance of water-proofing material

Water-proofing material is intended to form a water-proofing layer by melting materials made of asphalt added with thermoplastic elastomers and applying it by brushes on the site.

In the water-proofing work, in order to prevent the water-proofing material adhering to the tires of working dump trucks, we have made improvements to the water-proofing material (hereinafter referred to as the improved water-proofing material) to enhance the adhesion resistance to tires. The features of this material are as follows:

a. It does not adhere to the tires of asphalt finishers, dump trucks, even if the temperature of the water-proofing materials surface is 60℃.
b. It has higher adhesion of the improved adhesive than that of the conventional water-proofing material.
c. It can be ensured the adhesion of the deck and water-proofing material to the leveling course is equivalent to or higher than that of the conventional one.

2 ADHESIVE

2.1 Description

The conventional adhesive consists of nonvolatile content and organic solvent. The nonvolatile content is asphalt, thermoplastic elastomer, tackifier. Generally, in the case of dissolving the nonvolatile contents in an organic solvent, the volatilization performance of the solvents decreases.

Therefore we chose the organic solvent in ability for volatilization. In addition, we chose the nonvolatile contents which do not disturb the volatilization performance. It was in particular effective to exclude petroleum asphalt from the components.

The basic properties of the improved adhesive are shown in Table 1.

Table1: Basic Properties of Improved Adhesive

Test item	Improved adhesive	Conventional adhesive	Test method
Non-volatile content (%)	31.7	41	ASTM D1353
Viscosity(20℃) (mPa·s)	72.3	70.5	ISO 2555
Color	Light yellow	Black	Visual

2.2 Evaluation of drying property
(1) Test method

The drying property evaluated by the set-to-the-touch time on a concrete plate. The set-to-the-touch time was length of time from the time of applying adhesive to the time when the adhesive discontinues adhering to the finger when pressed strongly against it. The test was done at test temperatures of -5℃ and +10℃.

(2) Test results

The set-to-the-touch times of the improved adhesive and the conventional adhesive are as shown in Figure 2. The set-to-touch time of the former is 20 minutes or less, about 1/2 that of the latter, at both -5℃ and +10℃.

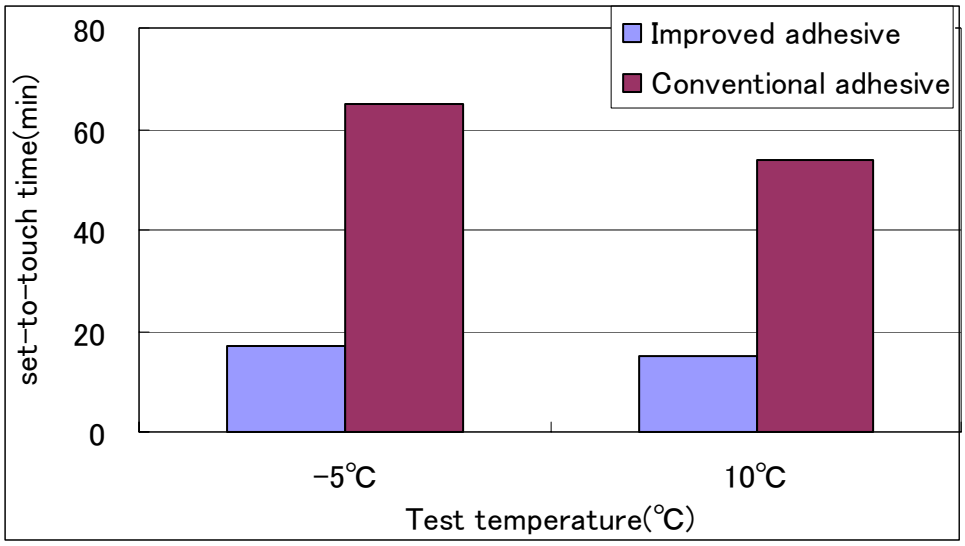


Figure2: Set-to-touch Time

3 WATER-PROOFING MATERIAL

3.1 Description

In temperature regions more than 110℃ that are placing temperature of the asphalt mixture, viscosity of water-proofing materials decreases. By the heat of asphalt mixture, the water-proofing materials glue itself to an asphalt mixture. In other words the adhesion mechanism is similar to general the Hot- melt type adhesive.

In ordinary water-proofing materials, a tackifier is added to achieve stable dispersion of thermoplastic elastomer and ensure specified adhesion. Conventional tackifiers have posed an essential problem of becoming tacky to tires at high temperatures of 50℃. As to tackifier to prescribe for improvement water-proofing materials, we chose the material which presents the adhesiveness in more than 60℃ and does not present the adhesiveness in less than 60℃. Therefore, this material prevents adhesion to tires during pavement construction.

The general properties of the improved water-proofing material are as shown in Table 2. As compared with the conventional one, the material is about 20℃ higher in softening point and greater in tensile strength.

Table2: General Properties of Improved Water-proofing Material

Test item		Improved Water-proofing Material	Conventional Water-proofing material	Test method
Penetration(25℃ conical needle)	mm	2.5	2.7	ASTM D5329
Softening point	℃	103.0	84.0	ASTM D36
Tensile strength(23℃)	N/mm^2	0.51	0.40	ASTM D412
Elongation at break	%	400	340	ASTM D412

3.2 Evaluation of adhesion resistance

(1) Test method

The test was performed to evaluate the adhesion resistance of the water-proofing material to the tires of working vehicles. The test condition is as shown in Figure3.
The test method was as follows[2)].

a. A specimen was water-proofing layer on a concrete plate. The temperature of a steel loading plate (200 x 200 mm), a synthetic rubber plate (200 x 200 x 10 mm), and the specimen adjusted to the examination temperature in the oven. The test was done at test temperatures of 50℃, 60℃ and 70℃.

b. The synthetic rubber plate was placed on the water-proofing layer. The steel loading plate was placed on the rubber plate. The loading plate forced a load of 20 kN upon the water-proofing layer for one minute (Figure 3), then removed the load.

c. After removing the rubber plate, the examiner visually checked for peeling-off of the water-proofing layer and adhesion to the rubber plate. The adhesion resistance was evaluated by Table 3.

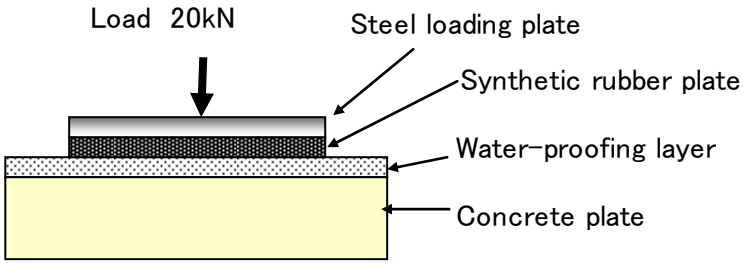
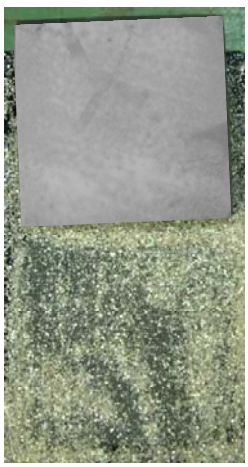
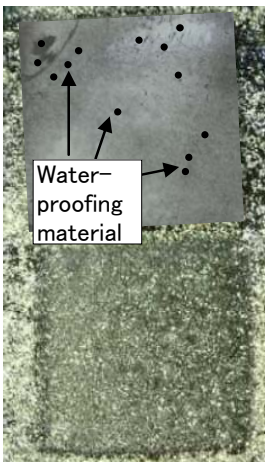


Figure3: Test for Adhesion Resistance

Table3: Evaluation Standards

Rating	○	△	×
State after test			
State of water-proofing layer	No damage	No damage	Peeling-off
State of rubber	No adhesion of water-proofing material	Slight adhesion of water-proofing material	Significant adhesion of water-proofing material

(2) Test results

The results of the test for the adhesion resistance are as shown in Table 4. The improved water-proofing material did not exhibit adhesion even at 70℃.

Table4: Adhesion Resistance

Water-proofing material	50℃	60℃	70℃
Improved Water-proofing Material	○	○	○
Conventional Water-proofing material	○	△	×

4 ADHESION OF WATER-PROOFING LAYER
4.1 Description

We examined the adhesion to evaluate the tripartite adhesion of the concrete course, the water-proofing layer and the asphalt pavement.

4.2 Evaluation of the adhesive property
(1) Test method

The adhesion of the water-proofing layer composed of a combination of the improved adhesive and improved water-proofing material was evaluated by the test for tensile adhesion strength[2)]. The test condition is as shown in Figure 4. The test was done at test temperatures of -10℃ and +23℃.

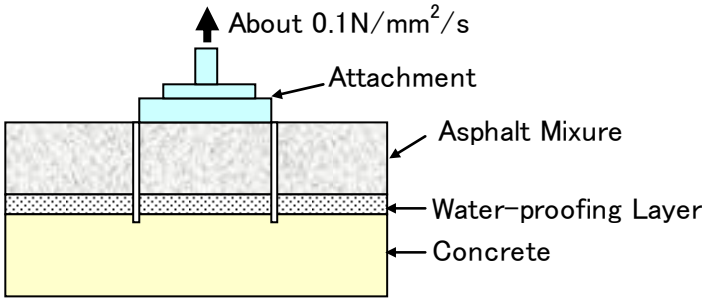


Figure4: Test for Tensile Adhesion Strength

(2) Test results

The results of the test for tensile adhesion strength are as shown in Figure 5. The tensile adhesion strength was confirmed to satisfy the specification[2)]. In the case of the porous asphalt mixture, the tensile adhesion strength of the improved water-proofing layer satisfied the specification.

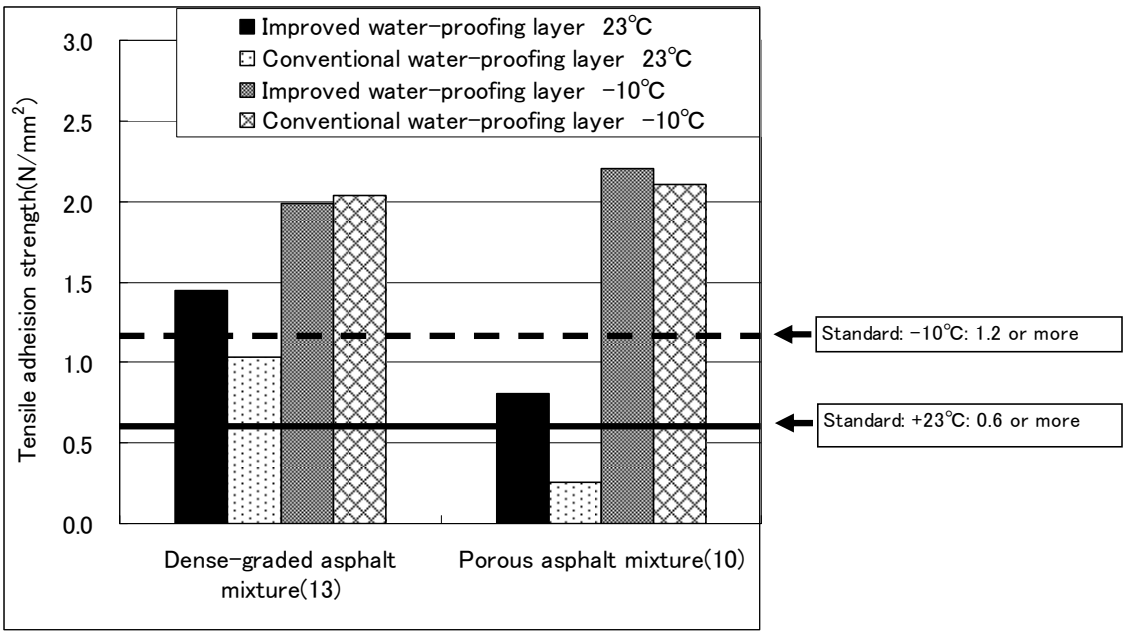


Figure5: Tensile Adhesion Strength

5 SUMMARY OF LABORATORY TEST

The test results are summarized as follows:

a. The set-to-touch time of the improved adhesive was less than 1/2 that of the conventional one.
b. The adhesion resistance of the improved water-proofing material was superior to that of the conventional one.
c. The adhesion of the asphalt mixture to the water-proofing layer composed of these two materials was equivalent to or higher than that of the conventional materials.
d. Particularly when a porous asphalt mixture was applied for paving, the tensile adhesion strength of the improved water-proofing layer satisfied the specifications.

6 TEST WORK

6.1 Description

We decided to tentatively apply these improved materials on the site and verify their effects[3)]. Metropolitan Expressway Co., Ltd. undertakes roadwork to place SFRC (steel fiber–reinforced concrete) on existing concrete deck to reinforce them. In this work, all processes from SFRC placing after removal of the existing pavement to construction of the surface course have to be completed as soon as possible.

The pavement structures are shown in Figure 6.

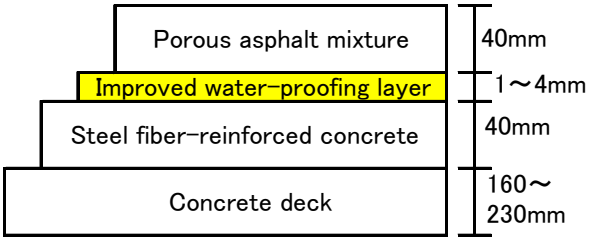


Figure6: Pavement in the Concrete Deck Version（Reinforce Method）

6.2 Results of test work

The set-to-touch time of the improved adhesive could be verified to be about 5-13 minutes at air temperatures of 5 to 10℃ on the site, i.e., shorter as compared with the laboratory test results.

The improved water-proofing material did not adhere to the tires of asphalt finishers and mixture dump trucks, so the paving work could be completed with the water-proofing layer kept in good condition

On this site, the good surface condition is still maintained three years after completion of the work.

7 CONCLUSION

a. The on-site set-to-the-touch time of the improved adhesive was 10-20 minutes even in the low-temperature season, which contributed to shortening the length of time for night repair work.
b. The improved water-proofing material was excellent in adhesion resistance to the tires of working vehicles, which ensured the working efficiency.

REFERENCES

1) Japan Road Association., 2002. *Road Specifications (I. Common edition & III. Edition on concrete bridge) and Explication of Idem*, Japan (in Japanese).
2) Japan Road Association., 2007. *Reference Guide to Road Bridge Deck Water-proofing*, Japan (in Japanese).
3) Musashi, T., 2009. *Case Examples of Construction of Thin-layer Porous Pavement on Steel Fiber Reinforced Concrete in Steel Bridge*, hoso, Vol. 44（Feb.2009）, Japan (in Japanese).