A Study on Cold Mixtures for Pothole Repair in Tokyo

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ABSTRACT: In the arterial highways in Tokyo, low-noise pavement is widely used. With the widespread use of this pavement, however, the occurrence of potholes has become a problem. Cold mixtures have been used for pothole repair, but durability still remains as a problem for solution. In recent years, not a few high-performance cold mixtures referred to as the all-weather high-durability type have been developed and have found increasing application in heavy traffic roads. This paper presents the actual state of damages in Tokyo and investigates the performance requirements for repairing them and a method of evaluating each performance properly. For this investigation, we conducted a laboratory test on typical repair materials and confirmed the validity of the laboratory test method through the evaluation by field engineers. Based on the obtained results, we have established Tokyo metropolitan standards.

KEYWORDS: pothole, low-noise pavement, porous asphalt pavement, cold mixture, emergency repair

1 INTRODUCTION

In Tokyo, porous asphalt pavement has been widely adopted under the name “low-noise pavement” with priority given to the arterial highways and in expectation of its noise reducing effect. Its total length now covers 630 km, about 30% of the pavement length (about 2,200 km) under the control of the Metropolitan Government. With increasing construction of this type of pavement, damages specific to the low-noise pavement such as potholes and raveling of aggregate have become obvious. Leaving potholes intact results in serious accidents, so the Road Administrator is required to take immediate emergency measures. Hitherto, cold mixtures have been used for emergency measures, but durability remains as a problem because damages have been caused again in a short time after repair. Under such circumstances, high-performance materials oriented toward application as a medium/high durability and all-weather type have been developed and brought to the market.

This paper presents the actual state of damages to porous asphalt pavement in Tokyo and shows the performance requirements for repair materials, particularly cold mixtures for pothole repair. In order to evaluate them properly, we investigated a performance evaluation method with consideration to how to use them on the worksite and conducted a laboratory test on typical field-proven cold mixtures for repair in Tokyo. Moreover, we confirmed the validity of the performance evaluation method through the evaluation by field engineers. Based on the obtained results, we have established standards for high-durability all-weather type cold mixtures in Tokyo.

2 ACTUAL STATE OF AND MEASURES AGAINST DAMAGES TO LOW-NOISE PAVEMENTS

Figure 1 shows the investigation results on the actual state of damages in one each 10 km section of Ring Roads No. 6 and 8 that are heavy traffic roads in Tokyo. Of the damages peculiar to the low-noise pavement, potholes cover 18% of the total number of damages. As for emergency measures against potholes, cold mixtures have been used so far. However, pothole occurrence being concentrated in the hot and rainy summer season, high-quality materials capable of withstanding such adverse conditions have been called for.

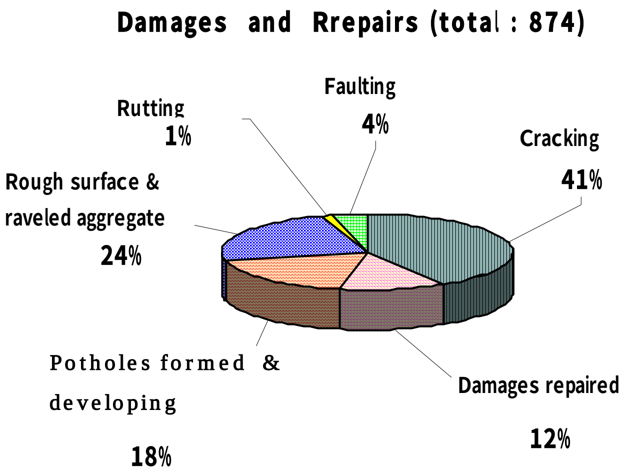

Figure 1: Actual State of Damages to Low-noise Pavement (fiscal 2006)

3 PERFORMANCE REQUIREMENTS

Cold mixtures for use in heavy traffic roads are required to have the following properties:

(1) Initial stability
In the case of emergency repair, sufficient curing time cannot be provided, so opening to traffic before strength development is often unavoidable. As damages are apt to occur in the initial stages of repair work, mixtures must be as high as possible in initial stability.

(2) In-service durability

Heavy traffic roads should desirably be freed from traffic regulation as far as possible. Mixtures must be excellent in durability to reduce the frequency of repairs.

(3) Durability during rainy weather

As potholes are apt to occur during rainy weather, measures have to be taken immediately for pothole repair. Therefore, water resistance is the most important performance requirement, so mixtures must be excellent in durability during rainy weather.

(4) Workability

For emergency measures for arterial highways, the traffic regulation time should desirably be shortened as far as possible. Therefore, mixtures must be excellent in workability as far as possible to enable opening to traffic in a short time.

4 LABORATORY EVALUATION TEST

In order to evaluate the performance requirements, we selected the test method shown in Table 1 and established a specimen fabrication method and test conditions, assuming the damage patterns in the actual roads. The evaluation test was performed on 7 types (A-G) of cold mixtures for repair, used in a relatively wide range in Tokyo, and one dense-graded cut-back asphalt type (H) of cold mixture as a general-use cold mixture for comparison, 8 types in total.

Table 1: Performance Requirements and Laboratory Test

Performance requirements	Evaluation item	Curing temperature (℃)	Curing time (days)	Test temperature (℃)
Initial stability	①Wheel tracking test at normal temperature	20	Just after fabrication	20
	②Marshall stability test at normal temperature	20	Just after fabrication, after 1,3,7,14days	20
	③Tensile test of cylindric specimen	20	1	20
	④Cantabro test	5,20	1	5,20
In-service durability	⑤Wheel tracking test at normal temperature	60	7	20
	⑥Marshall stability test at normal temperature	60	7	20
	⑦Uncofined compression test	60	7	20
Durability during rainy weather	⑧Simplified wheel tracking test	20	Just after fabrication	20
	⑨Marshall stability (immersed in water)	First in the air at 20℃→ 2days in water immersed at 60℃		20
Workability	⑩Workability examination	5	Just after fabrication	5

4.1 Wheel tracking test at normal temperature (initial stability)

From the viewpoint of evaluating initial stability, we decided to start the test immediately after fabrication of specimens.

Wheel tracking test at normal temperature is performed to evaluate rutting resistance just after work. Specimens are fabricated at normal temperature and wheel tracking test is started at once at the test temperature of 20℃. Deformation may occur to a great degree in the initial stages, depending on the type of material. Therefore, we determined the evaluation value as the number of passes at 20 mm subsidence.

The test results are given in Figure 2. Of the cold mixtures for repair, material A was the largest in the number of passes at 20 mm subsidence.

Though the materials were different in initial stability, any of them was inferior to the dense-graded mixture. However, most of them were superior to the dense-graded mixture in the dynamic stability after 7-day curing at 60℃, checked for evaluation of in-service durability.

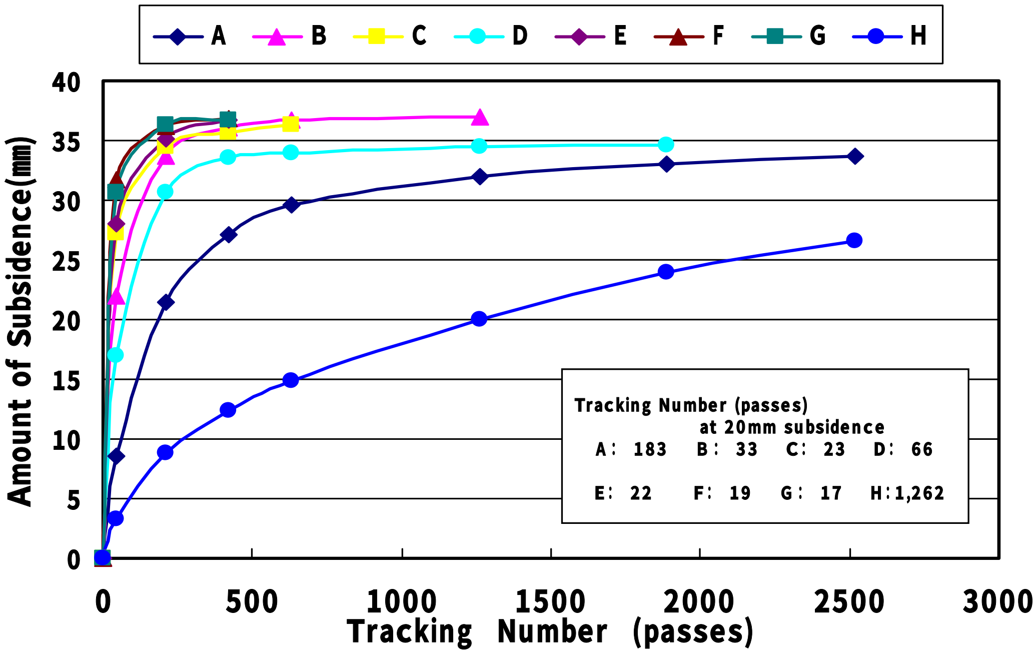

Figure 2: Wheel Tracking Test at Normal Temperature (20℃, just after specimen fabrication)

4.2 Unconfined compression test (in-service durability)

From the viewpoint of evaluating in-service durability, we decided to set the curing temperature of specimens at 60℃, assuming that they are cured at high temperatures in summer, and to perform the test 7 days after specimen fabrication.

Specimens were fabricated in the shape shown in Figure 3 and cured at 60℃ for 7 days without being removed from the mold form. After curing at 20℃ for about two hours, a compressive load was applied to the parallel surfaces of the specimen at the loading speed of 1 mm/min (Figure 3). Used as the evaluation value was the residual strain rate determined by the analysis method shown in Figure 4.

The test results are given in Figure 5. Material A exhibited the highest residual strain rate, not less than twice as compared with the dense-graded material H. Other materials were also higher than the dense-graded mixture in residual strain rate.

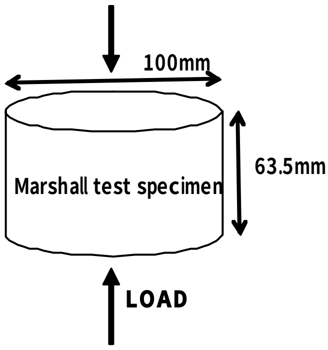

Figure 3: Specimen for Unconfined Compression Test

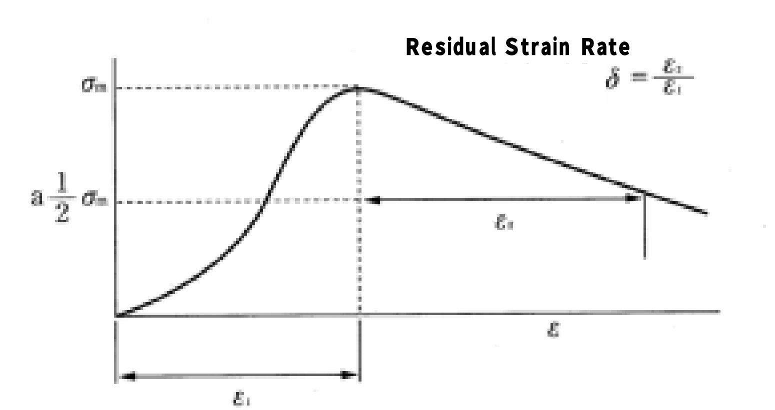

Figure 4: Analysis Method for Unconfined Compression Test (Residual Strain Rate)

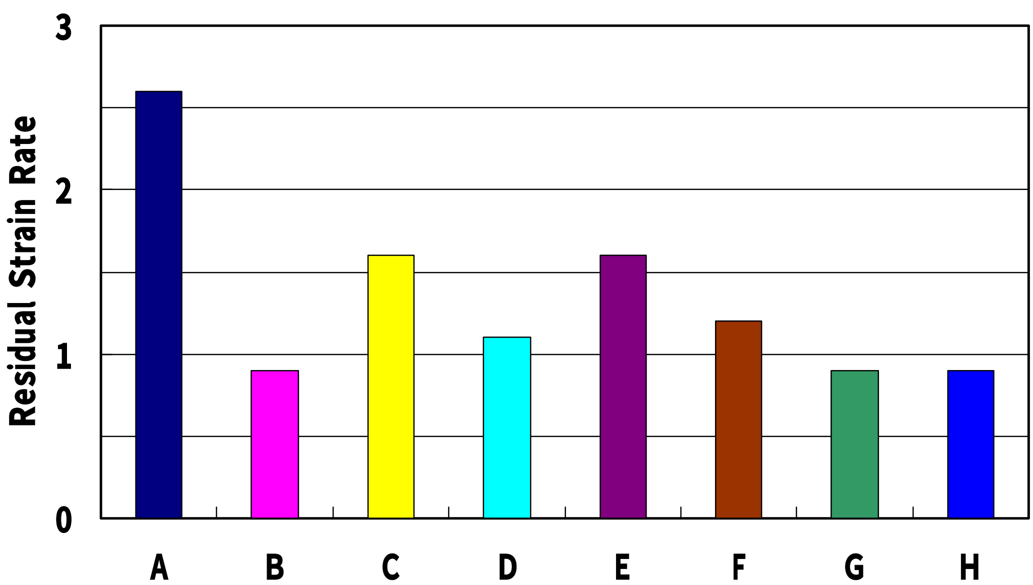

Figure 5: Unconfined Compression Test (20℃, curing time: 7 days at 60℃)

4.3 Simplified wheel tracking test (durability during rainy weather)

This test imagines the damages during rainy weather.

As shown in Figure 6, a pseudo pothole 100 mm in diameter and 20 mm in depth is provided at the center of a wheel tracking test specimen. Specimens are fabricated under non-immersion and immersion conditions. In the case of non-immersion, the mixture is put as it is in the pseudo pothole and compacted 30 times by using a tamper. In the case of immersion, the mixture is put in the pseudo pothole filled with water and compacted in the same way as in the case of non-immersion.

The test is performed at the test temperature of 20℃ immediately after specimen fabrication. In the case of non-immersion, the test is done in the dry state, while in the case of immersion, it is done after the surface has been sprayed with water after compaction.

Used as the evaluation value was the number of passes at 3 mm subsidence because the initial subsidence relates to the subsequent durability.

The test results are given in Figure 7.The number of passes at 3 mm subsidence in the case of non-immersion showed the same trend as that in the results of the wheel tracking test just after specimen fabrication (Figure 2). In the number of passes at 3 mm subsidence, each material was smaller in the case of immersion than in the case of non-immersion. This fact indicates that durability decreases under the influence of water. Material A and dense-graded material H were almost equal and higher than other materials in the number of passes at 3 mm subsidence, but both of them showed a lower value when immersed.

The durability during rainy weather can also be evaluated by the cold Marshall stability test after immersion curing. However, the simplified wheel tracking test under the conditions closer to the on-site service conditions is more effective.

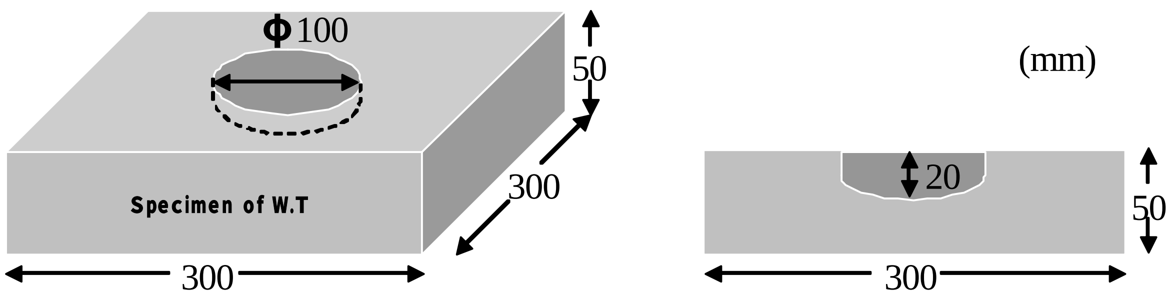

Figure 6: Specimen for Simplified Wheel Tracking

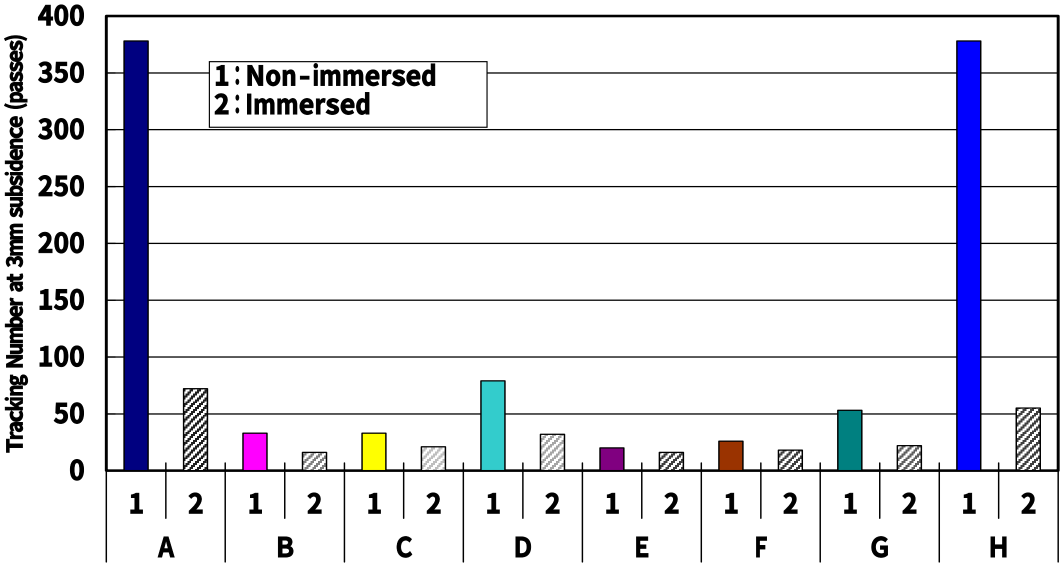

Figure 7: Simplified Wheel Tracking Test (20℃, just after specimen fabrication)

4.4 Summary of laboratory evaluation test

The general evaluation of the laboratory test is given in Table 2. According to this, material A was the most excellent in the laboratory test.

Table 2: Results of General Evaluation of Laboratory Evaluation Test

Performance requirements	A	B	C	D	E	F	G
Initial stability	◎	△	△	△	△	△	△
In-service durability	◎	△	◎	○	○	△	△
Durability during rainy weather	◎	△	○	△	○	△	△
General Evaluation	◎	△	○	○	○	△	△

Legend； ◎：Very excellent ○：Good △：Defective in durability

5 TEST WORK

With materials A-G used in the laboratory evaluation test, i.e., 7 types of cold mixtures, we carried out a test work to make pseudo potholes and carry out emergency repair on Ring Road No. 8, one of the heavy traffic routes in Tokyo. The purpose of this work was to check for workability, initial stability, and condition after opening to traffic and thereby to verify the validity of the laboratory evaluation method.

As shown in Table 3, the test results on materials A, D and E were rated good by the general evaluation before, and 7 weeks after, opening to traffic. These results virtually agreed with those by the laboratory evaluation, so the laboratory evaluation method proved to be valid.

Table 3: Test Work Results

Investigation item / Name of cold mixture		A	B	C	D	E	F	G
Subsidence by 10 passes of 4-ton vehicle (mm)	Immersion	2	2	1	2	2	3	1
	Non-immersion	6	8	5	5	3	2	3
Condition before opening to traffic	Immersion	Good	Unusable	Good	Good	Good	Unusable	Unusable
	Non-immersion	Good	Unusable	Good	Good	Good	Unusable	Unusable
Condition 7 weeks after opening to traffic	Immersion	Good	−	Broken next day	Good	Good	−	−
	Non-immersion	Good	−	Broken next day	Good	Good	−	−
General evaluation of test work		◎	×	△	◎	◎	×	×

Legend ; ◎ : Good, △ : Defective in durability, × : Questionable for adoption

"Unusable": Though small in subsidence, the mixture moved by a slight force (unstable state) and peeled off after opening to traffic, so it was judged unable to be put into service.

6 STANDARDIZATION OF HEAVY TRAFFIC-RESPONSIVE ALL-WEATHER TYPE MIXTURES

As a result of investigating various laboratory tests, we could find a test method considered appropriate for performance evaluation. Based on this result, questionnaire survey of field engineers and results of application in actual roads, the Tokyo Metropolitan Government has standardized heavy traffic-responsive all-weather type mixtures in the Tokyo Metropolitan Specifications for Civil Engineering Materials as shown in Table 4.

Table 4: Quality Standards for Heavy Traffic-responsive All-Weather Type Mixtures

Performance requirements	Laboratory examination	Standard value
Initial stability	Wheel tracking test at normal temperature	50 passes or more of tracking number at 20mm subsidence
In-service durability	Uncofined compression test	Residual Strain rate is 1.0% or more
Durability during rainy weather	Simplified wheel tracking test	30 passes or more of tracking number (in water immersed) at 3mm subsidence

7 CONCLUSION

In this study, we could find an appropriate evaluation method for cold mixtures. The cold mixtures for repair each have specific characteristics and are somewhat different in the test results. We have established standards for them in the Tokyo Metropolitan Specifications, based on the results of repair in actual roads. We intend to make efforts more than ever to achieve satisfactory results and thereby establishing an optimal evaluation method.

REFERENCES

Japan Road Association 2007. *D001T Method of Unconfined Compression Test of Cold Mixture for Repair.* Reference Guide to Pavement Survey and Test Methods.

Tokyo Metropolitan Construction Bureau 2009. *Specifications for Civil Engineering Materials.*