[Short Communications]

Evaluation methods for porous asphalt pavement in service for fourteen years

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2 Tables, 1 Photo and 5 Figures

1. Introduction

Recently, the high resolution type for micro focus CT scanner (CT) has been developed in the world. It was applied to asphalt mixtures to examine the air void distribution, hydraulic conductivity, segregation in mixtures [1,2,3, and 4]. Porous asphalt in Kyoto Jukan Expressway has been maintenance free for fourteen years, but the causes of long life were not yet clarified [5].

This paper describes the results of evaluation methods using crack distribution, movement of aggregate on surface using 35 mm camera and water permeability test for long life of porous asphalt in Kyoto Jukan Expressway (Kyoto).

We suppose that most important things for long life of porous asphalt were the movement of aggregate in porous asphalt, and were selected those methods for evaluation of long life of porous asphalt.

Photography by 35 mm camera was conducted to check the movement of aggregate due to moving load on the pavement surface in Section A in Kyoto. Water permeability test at fields was also performed to examine the clogging of porous asphalt due to the movement of aggregate, because it was not caused by clogging of dirt, but also the movement (densification) of aggregate. The last one is the measurement of distribution and thickness of crack in porous asphalt using three dimensional crack analyses, because the cracks spread in surface layer, binder course and asphalt treated base course. Those results were examined, comparing with conventional porous asphalt.

The movement of aggregate porous asphalt was measured by tensile strain or deformation of aggregate during wheel tracking test in laboratory, using two types of methods, namely photo of 35 mm camera and ARAMIS system (described later). Two types of wheel tracking test

(Conventional type and Hokkaido University type) were selected in order to measure the strain and/or distribution of crack in porous asphalt.

From the those test results, it was found that the three dimensional crack analyses, the movement of aggregate on surface by photo, and water permeability test were useful for evaluation methods for long life of porous asphalt in pavement.

2. Material and methods

2.1 Materials

2.1.1 Asphalt

Table 1. shows the properties of modified bituminous binder for porous asphalt and gap type coarse mixture. Binder Type A was satisfied with Kyoto specifications as described later, but other Types of binder do not satisfy those specifications.

The main properties of binder specified in Kyoto Jukan Expressway used in Section A and F are as follows.

Fraass breaking point (FBP: 1 C) after Thin Film Oven Test (TFOT: 5 hours, 163 C): Lower than lowest daily average ambient temperature (-4 C) in February in Kyoto [6].

Fracture temperature due to Moriyoshi Breaking Point（MBP test: described later) test after High Temperature Long Time Durability test (HTLTD:1 C): Lower than lowest ambient temperature (-10 C) in Kyoto for ten years. High Temperature Long Time Durability test (HTLTD, 163 C, 72 hours) was performed and was measured the fracture temperature (HTLTD) due to thermal stress and the test method is the same as Moriyoshi Breaking Point (MBP) test [7, 8].

FBP test with high accuracy type (1 C) was developed in Hokkaido University. Conventional FBP machine was modified with no movement of both ends of steel plate, no permanent deformation of steel (thickness: 0.1 mm) and methanol bath (0.1 C).

Moriyoshi Breaking Point (MBP:1 C) test is as follows. Binder (50 g) was put into the special vessel (diameter 10 cm, depth 10 mm) and was immersed into low temperature bath in methanol for one minute and was measured the fracture temperature (MBP) due to thermal stress.

Those specifications were specified in order to prevent low temperature cracking and aging of binder in porous asphalt in Kyoto Jukan Expressway [9].

Strength (0.01 MPa) of binder at FBP and at FBP-10 C after TFOT (5 hours, 163 C) was larger than 5 MPa and Fracture strain (100 x 10^{-6}) at FBP-10 C after TFOT (5 hours, 163 C) was larger than 3,000 x 10^{-6}. Both specifications were specified in Kyoto Jukan Expressway in order to keep good adhesion to aggregate and to prevent the stripping of aggregate. Strength and fracture strain were calculated using load deformation curve of modified FBP test and this test method was calibrated by gauge.

Binders for Type B, C, D and E satisfied with conventional specifications such as penetration, softening point.

2.1.2 Crushed stone

The low water content of aggregate (crushed stone) for Section A (0.45 %) and Section F (0.98 %) were used, but that of aggregate for Section B was 2.5 %. The aggregate in Section F was used the conventional crushed stone, but crushed stone in

Section A was re-crushed by centrifugal force again with a Barmac sizing device (Barmac) as the aggregate, which was near to a cube which cut off the corner of aggregate. The crushed stone in Section A has a good engagement between aggregate, because of cubic size.

2.1.3 Mixture

The mixtures of Type B, C, D, and E satisfied with the conventional specification, but binders in Section A and Section F satisfied with the specifications of Kyoto.

Specifications of mixture for Section A and F in Kyoto are as follows.

The water content for hot mixture: 0.1 % or lower.

The cored samples (diameter: 10 cm) were taken from the fields and were divided into two parts, upper part (diameter: 10 cm, thickness: 2 cm) and lower part (diameter: 10 cm, thickness: 2 cm). Those specifications were specified to keep the uniformness and prevent the stripping of aggregate in porous asphalt (4 cm) in construction.

The strength of split tensile test for cored sample (whole cored specimen (4 cm), and upper part and lower part) at -25 C and speed of deformation of 60 m/minute: 2 MPa or larger.

Temperature control for hot mixture of porous asphalt was strictly controlled by Kyoto specifications (temperature difference just after finisher spread the porous asphalt: 15 C or smaller). As a result, shipment temperature of hot mixture (objective: 175+-7 C) was obtained as follows.

Number: 343, Max.182 C, Min.174 C, Average 178 C

The mixture for Section B did not satisfy above specifications (conventional specification).

Type E mixture (Gap type coarse) was used to examine the comparison between tensile strain (between aggregate) and width of crack using micro focus CT scanner and ARAMIS system [10] (it was described later) after wheel tracking test. It has small void, comparing to conventional porous asphalt, but it was also called same type of porous asphalt in Japan and used for surface course in Tokyo.

The specimens (30 x 30 x 5 cm) of Type C, Type D, and Type E mixtures were compacted by roller compactor of Transportation Road Research Laboratory type (TRRL in UK) to use the wheel tracking test of Hokkaido University type and conventional wheel tracking test in laboratory.

Same two specimens (Type D mixture: 30 x 30 x 5 cm) were prepared to compare the cracks before and after conventional wheel tracking test (TRRL type). One specimen (before tracking) was made to use the specimen (2.5 x 5 x 8 cm) for CT. Other specimen (after tracking) was performed wheel tracking test at 45 C for on hour. Thereafter, the specimens for CT scanner were cut from center of those specimens in shown Fig. 1..

2.1.4 Composition

Table 2. shows the composition, binder content, void ratio, rate of deformation (Dynamic deformation) and maximum rutting depth of surface course (porous asphalt mixture and gap type coarse) under the wheel tracking test.

Type C mixture was used to measure the movement of aggregate using 35 mm camera during wheel tracking test and Type D mixture were used to examine the results of three dimensional crack analyses for specimen before and after wheel tracking test using micro focus CT scanner. Type E mixture was used to measure the relation between tensile strain （movement between aggregate）and width of crack under wheel tracking test of Hokkaido University Type (described later).

Porous asphalt (surface), binder course (max. size of aggregate: 20 mm, straight asphalt 80/100), asphalt treated base course (max. size of aggregate: 40 mm, straight asphalt 80/100) in Section A, Section F and Section B were also selected to examine the difference between pavement using conventional specification and pavement using Kyoto Specifications.

2.1.5 Pavement structure

Section A (seven years), Section F (seven years) and Section B (five years) were selected to compare the both performance of porous asphalt in service.

Sections A, F and B are Express Highway in Japan. Section A and F was located in Kyoto, while Section B was located in Hokkaido. Those structures in three sections of porous asphalt were all the same. The thickness of surface course (surface), binder course (binder) and asphalt treated base course (base) are 4 cm, 6 cm and 8 cm, respectively and the properties of only binder in surface were different (Table 1.).

Section A and F (length:12.6 km) was constructed in 1998 according to Kyoto Specifications, regarding bitumen, aggregate, asphalt mixture, mixing plant, construction equipment, construction method. Ambient temperature of the site (Section A and F) always exceeds 30 C in summer. On the other hand, it sometimes becomes -10 C and snows in winter. Traffic volume per day/one direction was two thousand vehicles after in service.

Section B was constructed in 1999 according to conventional methods, specifications and materials. Pavement structure and traffic volume in Section B is the same as Section A [11]. It becomes -30 C or lower in winter and sometimes exceeds 30 C in summer. It snows a lot in winter. Damages of pavement surface like rutting and cracks in those sections (Section A, Section F) after seven years and (Section B) after five years were not observed.

2.2 Methods

2.2.1 Wheel tracking test

Two types of wheel tracking test for measurement of tensile strain and distribution of crack were used in this study. Both machines are the same machine as wheel tracking test in Transportation Road Research Laboratory (Conventional Type:

TRRL type), but the front frame of specimen is made of transparent glass (Hokkaido University Type).

The test conditions of two types of wheel tracking test (Conventional Type and Hokkaido University Type) are as follows [12].

One type is the method using 35 mm camera, other is the method using ARAMIS system (described later). The former was selected to examine the movement of aggregate and strain between aggregate in mixture (Type C and Type D). The latter was mainly used to examine the relationship between tensile strain and width of crack in mixture (Type E).

The width of wheel with solid rubber tire: 5 cm,

Contact pressure of tire: 0.54 MPa,

Temperature: 45 C,

Moving speed of wheel: 42 passes/minute,

The rate of deformation (mm/minute) due to wheel tracking test was calculated from the deformation between 45 minutes and 30 minutes. Dynamic stability (pass/mm) was transformed from the rate of deformation in Japan.

Wheel tracking test of Hokkaido University Type was performed to measure the movement of aggregate and strain distribution on the end of specimen (5 x 30 cm) at 45 C for one hour (Photo 1.).

The test conditions of this apparatus are follows.

The center of wheel in this test was shifted to glass side 5 cm and the nearest wheel of path was 5 mm apart from the glass. One side of specimen in this test consists of transparent glass and the movement of aggregate and asphalt mortar can be measured through the glass by 35 mm camera (Fig.1). The movement (0.01 mm) and rotation (0.01 degree) of aggregate (2 mm or lager) [13] in mixtures were measured for the end of specimen (5 x 30 cm) facing glass by 35 mm camera.

The analytical method for movement and rotation of aggregate in mixture using 35 mm camera were described below. The images of film taken from 35 mm camera were transformed to digital images using film scanner. The straight line (it is the fundamental line to determine the rotation angle for each aggregate) draws to every aggregate with larger axis of 2 mm or longer and coordinate of intersections of both straight line and perimeter of aggregate were determined. The strain (100 x 10^{-6}) between aggregate and rotation (0.01 degree) of each aggregate were calculated by personal computer and software (Hanako2001, Just Systems Corporation) using the change of coordinate.

The method of measurement for tensile strain using ARAMIS system under wheel tracking test of Hokkaido University Type is as follows.

The tensile strain is measured by two CCD cameras and accuracy for tensile strain is 100 x 10^{-6}. The photographs, images, of the end of the specimens (5 x 30 cm) were divided into about 2,400 facets (one facet : 25 x 25 pixels, 6 mm^2/facet. The measured area in this case was 50 x 300 mm^2, the camera resolution was 5M pixels = 2448 x 2050 pixels) and with the positions of the four corners of the facets and the centers of the facets, a value for the changes in each facet between photographs (taken after different pass numbers) was obtained. From those datum, tensile strain of the facet was obtained using the difference from the initial position (initial coordinate) and the deformation gradient tensor using ARAMIS system.

The conventional wheel tracking test (TRRL type) was performed to examine the degree of cracks in mixture (Type C mixture) before and after wheel tracking test at 45 C for one hour using micro focus CT scanner (Shimazu Corporation, inspeXio SMX-22CT) and software (ExFact Analysis 2.0 for Porous/Particles, NVS LtD.)[14]. The same two specimens (30 x 30 x 5 cm) for micro focus CT scanner were prepared to examine the degree of cracking in mixtures. The specimens B for micro focus CT scanner in Figure 1. (2.5 x 5 x 8 cm) for micro focus CT scanner were cut from the center of the both specimens (30 x 30 x 5 cm), including the width of the wheel track (5 cm) after wheel tracking test and before wheel tracking test.

But the specimen A for micro focus CT scanner in Figure 1. was prepared and it was used using ARAMIS system to obtain the relation of tensile strain and width of crack in Type E mixture.

2.2.2 CT scanner and three dimensional crack analyses

The methods of CT scanner and three dimensional crack analyses were as follows. The core specimens (diameter: 10 cm) were taken from three fields (Section A, Section F and Section B). The specimen of each layer for CT scanner (2.5 x 2.5 x 8 cm) was cut by diamond cutter. The resulting image (3D image) obtained by the CT scanner (Shimazu Corporation, inspeXio SMX-22CT, 16 bit grey scales, 512 x 512 pixels, 1,440 sheets, size of pixel: 0.06 x 0.06 x 0.06 mm) was analyzed by software (ExFact Analysis 2.0 for Porous/Particles, NVS LtD., minimum crack width: 0.24 mm). The crack width was divided into five colors such as red, orange, yellow, green, and blue. The precision of three dimensional analyses was confirmed with the artificial crack of 0.60 mm by researchers.

Three dimensional crack analyses were applied to samples (2.5 x 2.5 x 8 cm) of each layer in those Sections (Section A, Section F and Section B) to evaluate using figures (damage) of cracks in asphalt pavement.

2.2.3 Photography of pavement surface

Photography of pavement surface was suggested to examine the movement of aggregate on surface of pavement. This method was very simple, but it can not correctly measure the movement of aggregate in porous asphalt. The movement (0.1 mm) of aggregate on pavement surface at Section A was measured by 35 mm camera, including with the embedded nail of four points (51 x 40 cm) in Fig.2.. Those points were located under the wheel path and it was 20 cm apart from the outer white line and photo was taken at area of 51 cm x 40 cm. Thereafter, the analyses (0.1 mm) of those images were conducted using the images used film scanner. The four points of nails were used to fit the images.

2.2.4 Water permeability test in the field

The water permeability test in the field was conducted to examine the degree damage (densification) by the content of water permeability in the field. It was measured outflow time of water of 400 cc from the outlet of diameter 13 cm in the field and they are averaged by three times. This method was specified in JHS 230 in Japan and regulated 10 seconds or smaller for porous asphalt in Japan. The perimeter of water permeability test was covered by clay. It was conducted in Section A, Section F and Section B under wheel path.

3. Results and discussion

We suppose that long life in porous asphalt depends upon the degree of movement of aggregate and the relation between movement of aggregate in porous asphalt and tensile strain exists, and performed wheel tracking test of Hokkaido University Type.

Wheel tracking test of Hokkaido University Type was performed by Kondo for Type C mixture (porous asphalt, void ratio: 19.9 %, maximum rutting depth: 1 mm) at 45 C [15]. From this test, he found that all aggregate (2 mm or larger) of the end of specimen (5 x 30 cm) remarkably moved (1 mm or more) and rotated (5 degrees or more) under wheel tracking test at high temperature (45 C) and the large strains (500 % or more) occurred at asphalt mortar between aggregate and aggregate in porous mixture of Type C at 600 passes of wheel under wheel tracking test (45 C) using 35 mm camera, in spite of small rutting (1 mm). But it was not reported crack was occurred or not at large strain.

The similar test was performed for Type E using wheel tracking test of Hokkaido University Type and we found maximum tensile strain at 45 C for one hour reached to 3.69 % using ARAMIS system and this value corresponds to the width of crack of 0.555 mm using ARAMIS system and micro focus CT scanner [16]. The crack may be occurred at smaller tensile strain, because the minimum width of crack in Type E was 0.185 mm using micro focus CT scanner.

Therefore, it was concluded that the movement of aggregate was caused to a large tensile strain and caused to a crack in porous asphalt.

The relation between maximum deformation due to rutting at high temperature and crack in porous asphalt was also important, because small rutting for porous asphalt was recommended in the world.

Conventional wheel tracking test at 45 C was conducted to obtain the distribution of cracks before and after wheel tracking test using Type D mixture with small rutting depth (Table 2.). The mixture of Type D satisfied with the specification of dynamic deformation (1,500 pass/mm or larger at 60 C: JHS 230-1992 in Japan) and maximum rutting depth was 2 mm at 45 C for one hour. The mixtures for Section A, Section B and Section F also satisfied with the specification (Table 2.).

Fig. 3. shows the three dimensional cracks for Type D mixture before (Fig. 3a.) and after (Fig. 3b.) conventional wheel tracking test in laboratory. The width of cracks spread over the specimen from 0.24 mm (minimum: red) to 1.2 mm (maximum: blue). It suggests that the most new crack was a red line (0.24 mm), because the width of crack increased with the increase of passes of wheel under moving load in this study. Many small cracks with red color and yellow color were observed in specimen (2.5 x 5 x 8 cm) after wheel tracking test [17]. Cracks were observed not only under the wheel (green in Fig. 2b.), but also the outside of wheel in specimen. Those results were all the same in various other mixtures, even if the deformation under wheel tracking test was 5 mm or smaller. It was concluded that cracks were caused by moving load at 45 C for one hour, even if the rutting depth at 45 C for one hour was 2 mm and satisfied the specification of dynamic stability in Japan.

Section A (seven years, Kyoto specification) and Section B (five years, conventional specification) were selected to compare the performance of porous asphalt in the fields. Both sections were not observed rutting and cracking.

Fig. 4. shows the results of three dimensional crack analyses which were conducted to examine the crack of each layer (surface, binder, and asphalt treated base) for the Section A and Section B. Maximum crack width (mm) and void ratio (%)

were also shown in Fig. 3. It shows that the maximum crack width for each layer in Section A was 1.2 mm and the values were constant in spite of layer. While, the maximum crack width for each layer in Section B were changed from 0.96 mm to 2.4 mm and many small cracks of red line (0.24 mm) were observed at every layer. Especially, longitudinal cracks were observed [18] in binder course (1) and fatigue crack in asphalt treated base course (1) were also observed in Section B. The width of crack of porous asphalt (surface course) in Section B was very fine (red) and those cracks have small continuity, comparing with that of Section A.

The void ratio and maximum crack width in Section A did not change from initial conditions (void ratio: 20 %), because the small crack of red type was fewer. The three dimensional crack distribution of pavement in Section A just after completed was the same as that of pavement after seven years in Section A. But the void ratio of porous asphalt in Section B decreased from 17 % (initial value) to 7.21 %. The small crack of red type was also in surface course and void ratio also decreased. It suggests that the aggregate in porous asphalt moved under moving load and the densification of surface course occurred in Section B.

Densification of porous asphalt in Section B affected to occurrence of crack in lower layers. The many cracks in binder course and asphalt treated base course were vertical and it seems that vertical cracks may be caused by the movement of aggregate from side to side. Those cracks may be connected to longitudinal cracks in porous asphalt.

Section A and F was constructed in 1998 according to Kyoto Specifications, but the conventional crushed stone (composition is the same) was used in Section F. Section F was selected to examine the difference of type of crushed stone.

The void ratio in surface course in Section F decreased from 20 % (initial value) to 14.7 % for 7 years. It supposed that the densification of surface course due to moving load occurred. Many cracks of each layer in the pavement were also observed and cracks were especially remarkable in asphalt treated base.

It was concluded that densification of porous asphalt due to moving vehicle were caused to cracks to lower layers in asphalt pavement.

From above results, conventional porous asphalt occurred densification at short years, because of movement of aggregate in porous asphalt. Then, we suggested a very simple evaluation method in the field for the movement of aggregate on porous asphalt.

The analyses of photo images using 35 mm camera for pavement surface (Section A) were conducted to measure the movement of aggregate on surface of pavement at just after completed of pavement and three years later. It showed that all aggregate in those images did not move (0.1 mm) for three years. But all aggregate on the pavement surface in another conventional porous asphalt at same area (51 x 40 cm) moved 1 mm or larger from original position for only one year (Fig. 2.). It is a very easy tool to measure the movement of aggregate, but it can not correctly measure the movement of aggregate in porous asphalt.

If the clogging of porous asphalt due to moving load occurred and densification also occurred in porous asphalt, we suppose that the value of water permeability test changed.

Fig. 5. shows that results of permeability tests for three sections (Section A, Section B, and Section F). It was shown the maximum value of 100 seconds was reached for two years in Section B, but the values of Section A and Section F were almost constant in spite of lapse of year. They may cause to densification and/or clogging in porous asphalt. It was demonstrated the line of cracks were short and blue color of cracks (wider cracks) were very few in porous asphalt in Section B in Figure 4..

The ageing of binder for long life of porous asphalt was also important. Binders in Section A and Section F satisfied with Kyoto specifications, but that in Section B did not satisfy with those specifications.

The color of surface in porous asphalt between Section A, Section F and Section B were remarkably different. The former (Section A and Section F) are real black and binder did not stripped on the surface of crushed stone, but the color of surface in porous asphalt in Section B, was grey and/or white and all binders covered on crushed stone were already stripped off and many aggregate on surface were come out from the surface of porous asphalt. It means that the aging properties of porous asphalt in Section A and Section F were superior to that of porous asphalt in Section B and it may be caused by the difference of specification of binder.

From above results, it suggests that porous asphalt made of conventional specifications was densificated and caused to clogging due to moving vehicles, and it may connect to longitudinal crack. But longitudinal cracks did not occur in porous asphalt made of Kyoto specifications. The cause may be connected to the wider distribution of tensile strain due to moving vehicle in each layer, because the movement of aggregate in porous asphalt was very complex.

It was concluded that three dimensional crack analyses, photography of surface and water permeability test are useful to evaluate for long life in Kyoto Jukan Expressway. Especially, longitudinal crack in porous asphalt may be evaluated by three dimensional crack analyses, considering with the figure of crack patterns.

4. Conclusions

The following conclusions were obtained in this study.

(1) Three dimensional crack analyses, photography measured by camera and water permeability test are useful methods to evaluate the degree of damage for porous asphalt.

(2) The tensile strain of porous asphalt under wheel tracking test was caused by the movement of aggregate and it was caused to a crack in porous asphalt.

(3) Kyoto specification for binder is useful to prevent the stripping of aggregate and aging of binder in porous asphalt.

(4) Longitudinal cracks may be caused in porous asphalt according to conventional specifications, but they were not observed in porous asphalt according to Kyoto specifications.

(5) Longitudinal cracks initially occurred at binder and/or asphalt treated base course. They may be progressed toward the surface course.

(6) Even if the rutting depth at 45 C for one hour was 2 mm, many cracks occurred in porous mixture (Type C and Type D) under wheel tracking test at 45 C for one hour.

(7) The long life in porous asphalt may depend upon the mixture composition and properties of binder. Especially, re-crushed stone was useful to keep the long life of porous asphalt.

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Figure captions.

Fig. 1. Outline of wheel tracking test and specimen for micro focus CT scanner

Fig. 2. The photo of pavement surface including four points of nail

Fig. 3. Distribution of three dimensional cracks for before and after wheel tracking test using Type D mixture

Fig. 4. Comparison of distribution of three dimensional crack between Section A and Section B

Fig. 5. Comparison of water permeability test in the field between Section A, Section F and Section B

Photo 1. Overview of wheel tracking test of Hokkaido University type

Table captions.

Table 1. Properties of the high viscosity modified bituminous binder in Section A, B, F and mixture Type C, D and E

Table 2. Compositions, binder content, maximum rutting depth, void ratio of surface course (porous asphalt mixture), dynamic stability

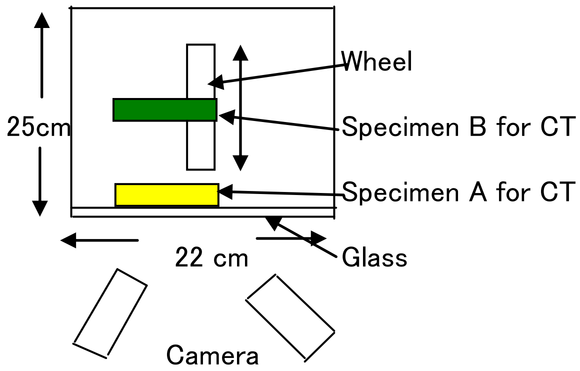

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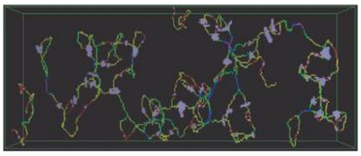
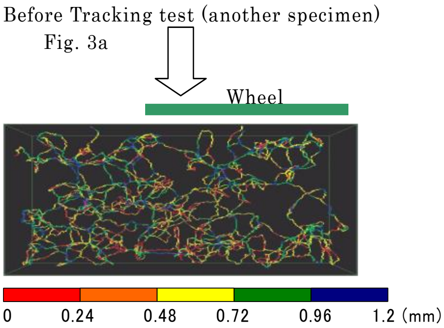
Fig. 2 . The photo of pavement surface including four points of nail

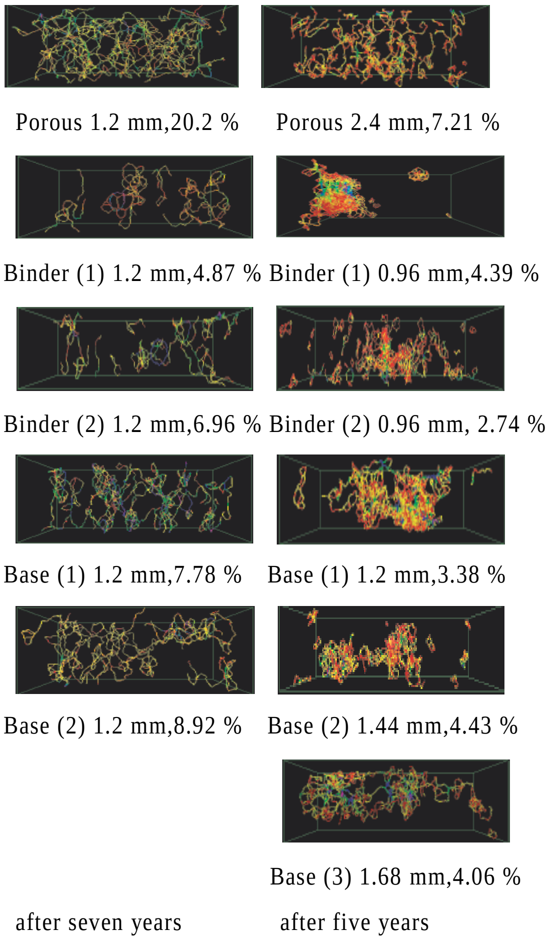


Before Tracking test (another specimen)
Fig. 3a



After Tracking test (One hour, 45 C)
width of crack: 0.24 mm-1.2 mm
Fig. 3b

Fig. 3. Distribution of three dimensional cracks for before and after wheel tracking test using Type D mixture



(Source:RMPD,10(3), Tomoto, T.,)

Fig. 4. Comparison of distribution of three dimensional crack between Section A and Section B

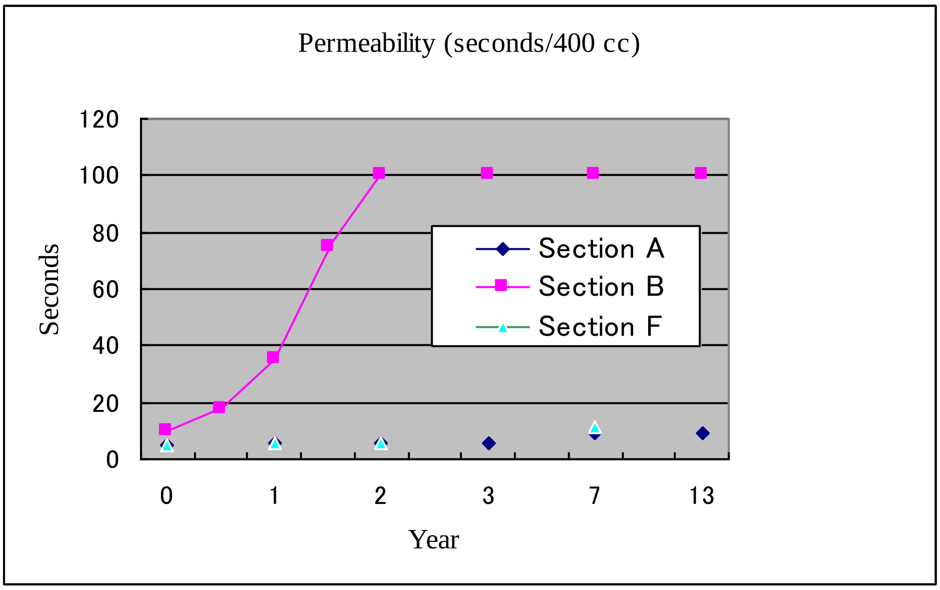


Fig. 5. Comparison of water permeability test in the field between Section A, Section F and Section B

Photo 1. Overview of wheel tracking test of Hokkaido University Type

Table 1. Properties of the high viscosity modified bituminous binder in Section A, B, F and mixture Type C, D and E

	Porous asphalt		Porous asphalt		Gap type coarse
Binder type	Type A	Type B	Type C	Type D	Type E
	Section A	Section B	Laboratory C	Laboratory. D	Laboratory. E
Penetration (25°C, 100gr., 10sec.)	41	79	51.0	63	65
Softening point (°C)	98.0	98.5	96.5	99.5	112.5

Table 2. Compositions, binder content, maximum rutting depth, void ratio of surface course (porous asphalt mixture), dynamic stability

	Porous asphalt		Porous asphalt		Gap type coarse
Sieve opening (mm)	Section A, F	Section B	Laboratory C	Laboratory D	Laboratory E
Binder Type	Type A	Type B	Type C	Type D	Type E
Mixture Type	Type A	Type B	Type C	Type D	Type E
53.0	-	-	-	-	-
37.5	-	-	-	-	-
26.5	-	-	100	100	-
19.0	100	100	98.5	100	100
13.2	95.6	98.5	82.0	99.3	98.5
9.5	65.7	72.5	73.6	69.2	81.7
4.75	17.6	24.6	57.5	24.5	32.6
2.36	15.1	19.0	44.6	19.1	24.4
0.6	9.0	12.7	26.4	12.5	16.2
0.3	6.9	9.5	17.6	7.0	12.3
0.15	5.5	5.7	8.5	7.0	8.6
0. 0 75	4.2	4.3	5.1	4.4	7.3
Binder Content (%)	5.0	5.2	5.0	5.0	5.5
Dynamic stability*, (pass/mm, 1h)	8,114(A) 60 C(A)	11,900 60 C (2.2mm)	3,150 45C(1mm)**	7,534 (45C) 6,010 (60 C) 45C(2mm)** 60C(1.4mm)**	45 C (smaller than 1 mm)**
Void ratio (%)	20	17.1	19.9	18	5.5

Numbers in the table indicate % passing the sieve.
**: Maximum rutting depth
*: Inverse of rate of deformation (mm/minutes) between 45 minutes and 60 minutes (pass/mm) under wheel tracking test at 45 C or 60 C.