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INNOVATIONS IN POROUS SPHALT QUALITY CONTROL FOR COLD REGIONS ON THE AYABE-MIYAZU ROAD IN JAPAN

H. Ishikawa[1], S Takahashi[3], T. Nakai[2] and A. Moriyoshi[1]
[1]Department of Civil Engineering Hokkaido University, Japan
[2] Kyoto Road Public Bureau, Japan
[3]Civil Engineering Materials Unit, Leeds University UK

ABSTRACT

Large proportions of recently constructed Japanese highways have been surfaced with porous asphalt wearing courses to improve skid resistance and reduce aquaplaning at high traffic speeds on wet conditions.As part of the drive towards improving the quality and hence durability of porous asphalts laid on Japanese highways, the 12.6km Ayabe-Miyazu road between Ayabe Junction and Miyazu-Ohe Interchange, which forms part of Kyoto longitudinal highway has been selected for construction new porous asphalt specifications.The new specifications have been introduced for quality control of the constituent materials, asphalt plant production, and field laying and compaction procedures.The new specifications for the Ayebe-Miyazu road are distinctly different from the conventional specifications, and include the following main innovations:Introduction of several testing methods for the acceptance of the materials, especially the binder type to be used in porous asphalt mixes based on pre-set limits to the properties at very low temperatures.a) Improvement of the heating system in the asphalt plant dryer resulting in greater control of the residual moisture content of the hot aggregates emerging from the dryer, b) Enhancement of the ability of the paver to maintain the temperature of the hot bituminous mix during laying operations by employing a special protective covering. or c) Employment of an infrared camera to monitor the variations in surface temperatures of the newly laid surfaces during construction thus ensuring uniformity of the surfacing being constructed.

1 INTRODUCTION

Asphalt pavements have been widely used in Japan due to their advantage of being economical and easy to maintain. Recent environmental conservation issues regarding Japanese roads have become increasingly important in addition to the traffic safety requirements on wet road surfaces. As a result, porous asphalt wearing courses have been progressively introduced in the last 10 years on high-speed lanes initially on motorways but recently this has been further extended to urban areas.

However, the service lives of porous asphalt drainage surfaces are much shorter than those of conventional dense mixes, this has been reported by many investigators around the world. Additionally, local damage has been reported on porous asphalt surfaces, that has been attributed to lack of homogeneity of the laid material. Paving operations of porous asphalts demand extra attention to ensure uniformity of the materials being laid.

Current Japanese specifications require inspection of the thickness, evenness and density as quality control parameters. It is being increasingly felt that this procedure is not adequate and provides no indication of the durability of the laid bituminous composite. In this investigation, new quality control specifications have been proposed to enhance the composite's durability and prolong their service lives.

The Ayabe-Miyazu road is located in the cold, snowy regions of Japan, (see Figure 1), and when it was decided to lay this road with porous asphalt, this demanded extra care in addition to the guidelines set in the Japanese specifications for porous asphalts, at all stages from material selection to material transport and finally laying and compaction of the layer on site.

2 MATERIALS SELECTION

2.1 AGGREGATE PROPERTY REQUIREMENTS

Porous asphalt mixes are composed of mainly coarse aggregate fractions which are required to provide the necessary interlock to withstand the traffic stresses and adequate porosity so the drainage function is adequately maintained. The aggregates used in porous asphalts should therefore possess higher qualities, including grain shape and hardness. Additional aggregate requirements include; excellent adhesion to the binder, resistance to freeze-thaw cycles, and chemical stability against de-icing agents used for drainage pavement layers in cold, snowy areas. Even tighter requirements for the Elongated and Flat Particles Content Test are required for the construction of roads under such freezing conditions than normally required of porous asphalts in moderate climates.

2.2 BINDER PROPERTY REQUIREMENTS

The binder used in porous asphalts should have adequate cohesion to bond the aggregate skeleton tightly against traffic stresses and retard ageing in the field. In this investigation SBS modified binders were employed. Cold climates, such as on the Ayabe-Miyazu road, require that the binders to be used have good resistance to freezing and hence not becoming brittle. Two new binder tests; a breaking point test and a bending test at low temperatures have been added to help in selecting binders that would provide long term durability under cold conditions. The tests are described briefly below.

2.3 NEW BINDER TESTS

2.3.1 MORIYOSHI BREAKING POINT (M.B.P) TEST

The temperature at which the binder changes behaviour from ductile to brittle/elastic is very important for binder selection in cold regions. Moriyoshi et al. developed the M.B.P. test to determine the brittle point temperature more easily and accurately than the conventional Frass Breaking Point test [1]. In this test, 50g (3 mm thickness) of binder is poured in a special stainless steel plate with internal diameter 140 mm and 10 mm depth. The sample is subsequently immersed in a cold methanol bath at constant temperature. After 1-minute immersion, the sample is taken out of the bath and visually inspected for any signs of surface cracks. If no cracks are detected on the surface of the binder, the sample is reimmersed in the bath and the temperature is decreased by 1°C. Visual inspection is carried out again and the whole procedure is repeated until a crack emerges on the surface of the binder. The temperature at which a crack is detected is termed the M.B.P. The equipment is shown in Figure 2.

2.3.2 BENDING TEST

The test is performed using a modified Frass Breaking Point (F.B.P.) test apparatus, which can measure both the strength, and fracture strain of bitumens in a constant temperature controlled methanol bath [2].

2.4 REQUIRED VALUES

For the binder to be used on the Ayabe-Miyazu road, it was required that the F.B.P. after Thin Film Oven Test (TFOT) is equal to or below -4°C which is the average daily ambient temperature at Ayabe city during January. The M.B.P. after the TFOT (163°C for 72 hours) should be equal to or less than -10°C which is the minimum ambient temperature expected at the job site. The values recommended for the bending test have been extracted from a previous investigation [2]. Bending Test at both the F.B.P. and (F.B.P.-10°C) should be equal to or over 5 MPa. Strain at failure in the Bending Test should be equal to or over 3000×10^{-6}. Finally it is recommended that the binder should not include any waxy components.

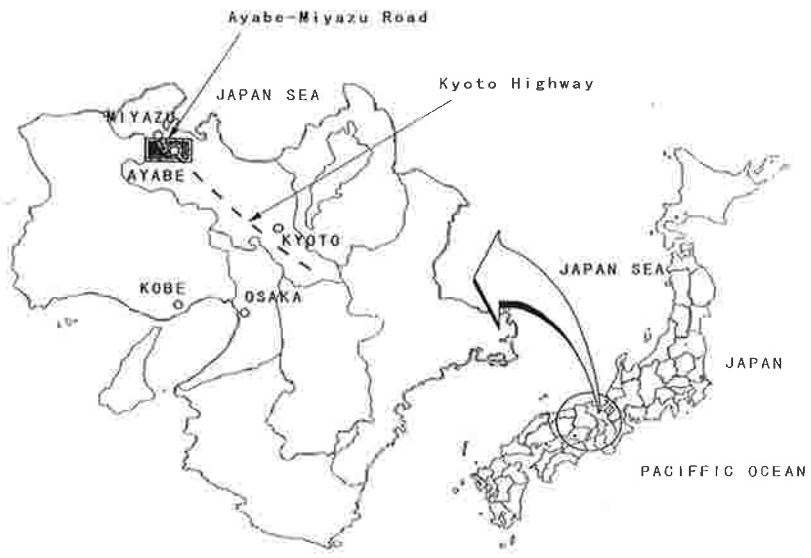

Figure 1: Map of Ayabe-Miyazu Road

Figure 2: M.B.P. Test

3 MIXTURE PROPERTY REQUIREMENTS

3.1 GENERAL

Additional specifications for the porous asphalt mixes used in this investigation are described below. These tests are considered to be effective in creating more durable mixtures, especially in cold climates.

- Mix porosity of the whole layer thickness and of both the upper and lower halves of a porous asphalt layer should be approximately equal to 20%.
- Indirect Tensile strength test results (-25°C, 50 mm/min.) of cores obtained from the porous asphalt layer (40 mm) should be equal to or greater than 2 MPa. The same values apply for the upper and lower halves of cores sawn in half (20 mm thick).
- Specimens must pass the freeze and thaw test (-18 to 4°C, 300 cycles).

3.2 MIX POROSITY

Previous investigations [3] show that even in a 40 mm thick porous asphalt layer, the porosity of the upper half of the layer can be different from the lower half. This indicates that conventional pavers and compactors may not provide equal compactive effort for the entire depth of a bituminous layer. When the porosity varies considerably with depth, the hydraulic conductivity of the layer may be reduced, it is thus recommended that cores obtained from porous asphalt surfaces be sliced in half and the porosity of each of the upper and lower halves be checked individually.

3.3 INDIRECT TENSILE STRENGTH

The indirect tensile strength test result give an indication of the tensile strength of the mix, but the results are very dependent on the test temperature and loading rate. In order to assess the property of the mix in the brittle temperature range, the test is conducted at -25°C at a loading rate of 50mm/min.

4 MANUFACTURE OF MIXES

4.1 INFLUENCE OF THE AGGREGATE MOISTURE CONTENT

Moisture that remains locked in the aggregates after drying in an asphalt plant, may result in stripping of the bitumen film off the aggregate surfaces. Previous research [4] indicated that it is more difficult to evaporate the residual moisture from coarse aggregates than it is to do so from finer aggregates. Porous asphalts, typically composed of 80% by weight coarse aggregates require greater control at the asphalt plant during the aggregate drying stage prior to coating with bitumen. It has been observed using thermal imaging of surfaces of porous asphalts during laying operations in the field that this residual moisture significantly affects the temperature of the porous asphalt layer during construction. Larger aggregate residual moisture contents, cause lower mix temperatures of the porous asphalt layer, and result in inadequate compaction of the wearing course. Inadequate compaction results in surface deterioration quite rapidly after opening the road to traffic.

4.2 IMPROVEMENT IN THE ASPHALT PLANT

4.2.1 CONTROL OF AGGREGATE MOISTURE CONTENT

As discussed earlier, to create durable mixes, drying the aggregates as much as possible is a necessity. To control the residual moisture contents of dried coarse aggregates below 0.1%, ensures good adhesion of the bitumen to the aggregate surfaces. To attain this level of control, the following improvements had to be carried out on the asphalt plant:

- Covering / Roofing the aggregate stockpiles
- Improving the drying process by prolonging the period that the aggregates are retained in the drum burner.
- Constructing additional ventilation ducts on the hot bins to facilitate smooth moisture evaporation.
- Determination of moisture content of aggregate samples taken from the hot bins, using a microwave on a daily basis.

Figures 3 and 4 illustrate the improved stockpiling facility and the dryer unit modification respectively.

4.2.2 BITUMEN STORAGE

Bitumens, in particular SBS modified bitumens have the potential for segregation/separation of the various bitumen/polymer constituents in storage tanks at high temperatures. Circulation equipment was installed in the bitumen tanks to maintain binder uniformity.

5 CONSTRUCTION

5.1 TRANSPORTATION AND LAYING

To maintain uniform temperatures and minimise the temperature differences in the porous asphalt during mix transportation from plant to site, improvements on the delivery vehicles have been carried out as follows:

- Covering the container of the trucks with wooden boards to prevent local drop in temperature.

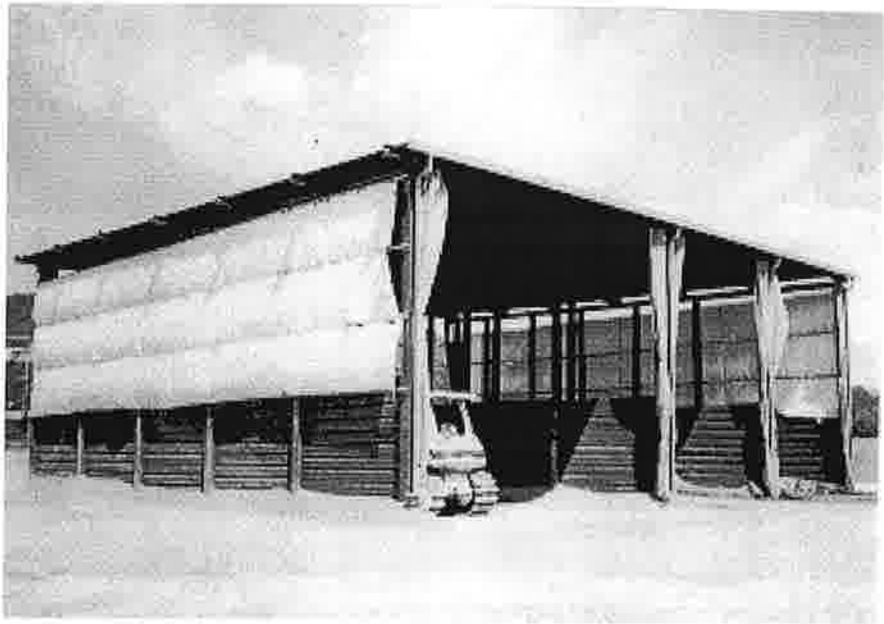

Figure 3: Improved Aggregate Stockyard

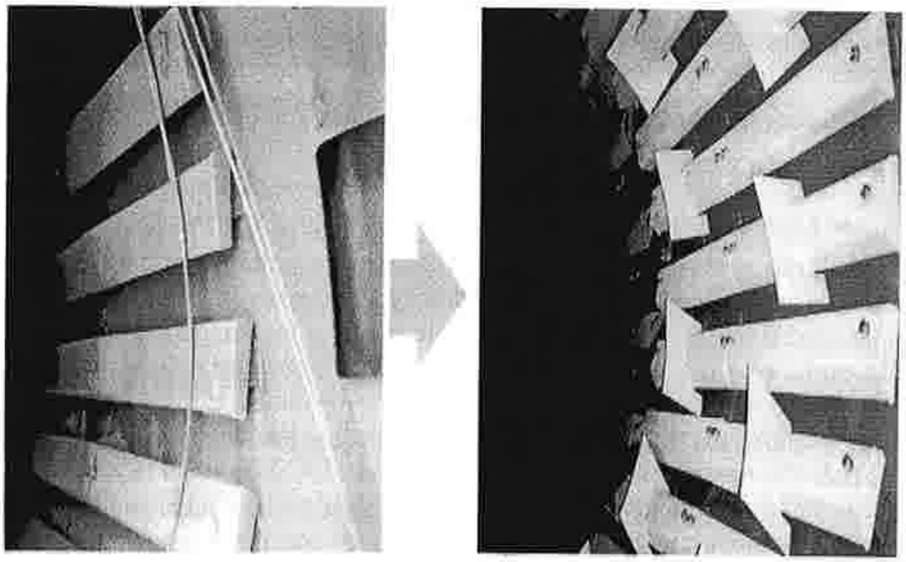

Figure 4: Before and After Improving Dryer

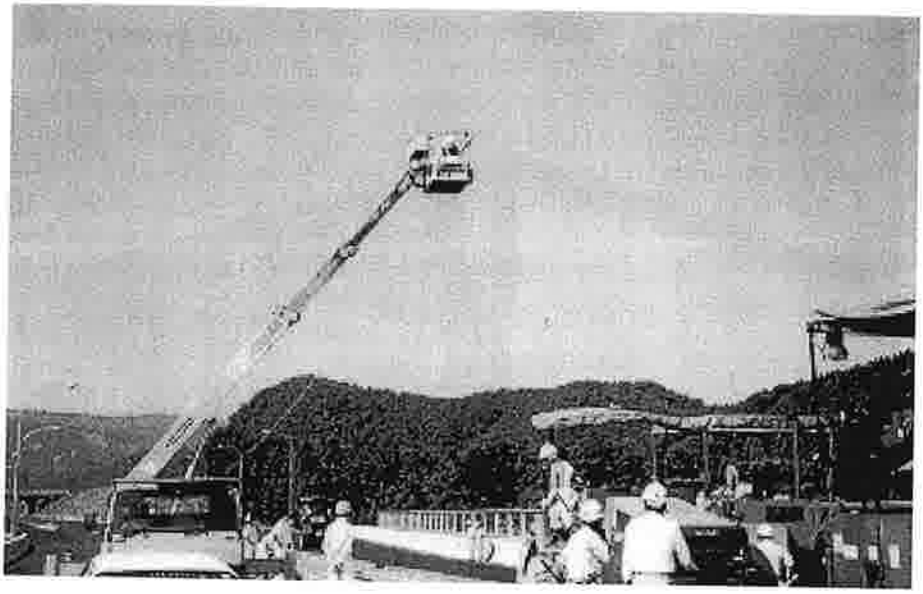

Figure 5: Thermal Inspection by Infrared Camera

- Covering the hot mixes during transportation with two layers of insulation sheets.

Pavers used in the construction of the Ayabe-Miyazu road were modified as follows:

- Attaching heat insulation materials onto the paver hoppers
- Installing a windbreak sheet on the top of the paver screed.

5.2 MEASUREMENT OF SURFACE TEMPERATURE PROFILES

Raab et al. reported on the use of infrared sensing apparatus to detect temperature differences on flexible pavements immediately after laying [5]. Figure 5 shows the attempt carried out at Ayabe-Miyazu road to measure the temperature distribution on the surface of the freshly laid porous asphalt immediately behind the paver using infrared sensors. It was found that the temperature differences from one location to another across the width of the lane behind the paver, immediately after laying were a maximum of 15°C and on average 8°C. The results are shown in Figure 6. These values are considerably smaller than data obtained from other sites where the previous recommendations and precautions were not carried out. On other sites, temperature differences of 30°C have been recorded.

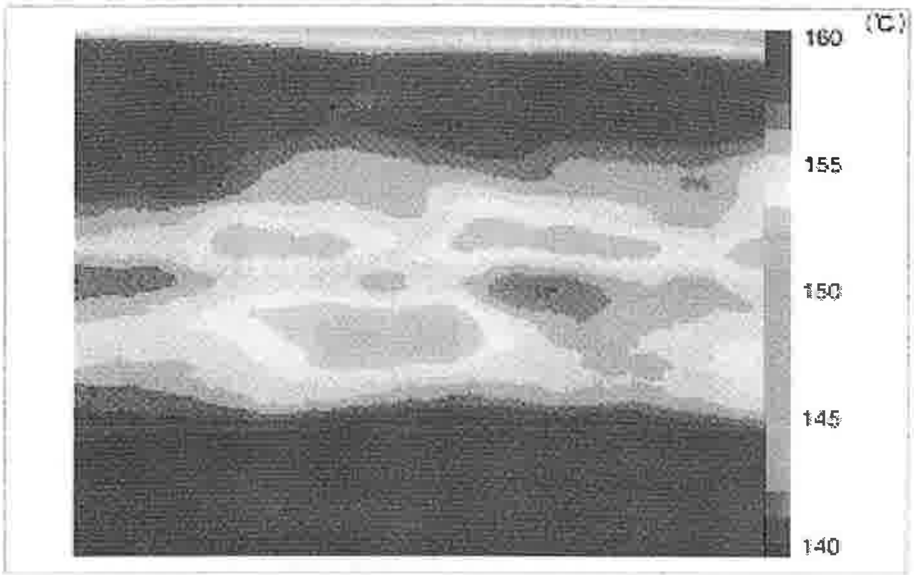

Figure 6: Temperature Distribution on Surface Just After LayingMì

6 FOLLOW UP

To evaluate the effectiveness of this new approach in controlling the construction procedures of porous asphalts, the following future monitoring is to be carried out at 1 and 2 years after opening to traffic:

- Evenness and skid resistance of the surface
- Hydraulic permeability and Noise reduction
- Observation of the Maximum/Minimum surface temperature points at the initial construction by Visual inspection and their possible relation to deterioration.

7 REFERENCES

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