HIGHWAYS DEPARTMENT

GUIDANCE NOTES
ON
ROAD SURFACE REQUIREMENTS FOR EXPRESSWAYS AND HIGH SPEED ROADS

Research & Development Division

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ROAD SURFACE REQUIREMENTS FOR EXPRESSWAYS AND HIGH SPEED ROADS

1. Purpose

1.1 These guidance notes supersede Road Note 5 which was issued in 1983. Road Note 5 stipulated the road surface requirements for high speed roads and recommended the use of friction course for enhancing road safety on all trunk roads and primary distributors when vehicle speeds exceeding 80 km/hr were anticipated.

2. Background Information

2.1 Since the issue of Road Note 5, friction course material, which is also known as porous asphalt, has been used in Hong Kong as the standard surfacing material on expressways and high speed roads to provide fast drainage of surface water and high skid resistance. The Transport, Planning and Design Manual recommends the use of friction course material as the standard surfacing material in expressways.

2.2 An asphalt binder of penetration grade 60-70 was recommended in Road Note 5 for the friction course material, which has been widely used in expressways or high speed roads. As the friction course material is porous in nature, its oxidation rate and deterioration rate are faster than conventional continuous or gap graded bituminous materials and therefore it is relatively less durable than these materials. Overseas experience and practice indicates that the use of suitable polymer modified binders should enhance the durability of the porous asphalt. In this regard, Highways Department (HyD) Guidance Notes No. RD/GN/011B recommend the use of polymer modified friction course material as a low noise road surfacing material in local roads, because slow moving traffic imposes greater damage on the material than fast moving traffic.

2.3 In 2004 the Research and Development (R&D) Division of HyD began a research study "Testing on Polymer Modified Binders and Friction Course (Porous Asphalt)" in collaboration with the Hong Kong Polytechnic University. The study aims at reviewing the use of the porous asphalt in overseas countries, studying the performance of three types of asphalt binders and their porous asphalt mixes, and conducting a cost-effectiveness analysis. The study report recommends the use of a new type of friction course material with a pre-blended polymer modified binder which is more cost-effective. HyD Technical Report No. RD/TR/048 was issued in 2006 summarizing the testing data and major findings in the research study.

2.4 These Guidance Notes:

(i) review and set out the road surface requirements for expressways and high speed roads;

(ii) promulgate the use of polymer modified friction course with a pre-blended polymer modified binder; and

(iii) provide a standard specification for the supply and construction of the polymer modified friction course with a pre-blended polymer modified binder.

3. Road Surface Requirements

3.1 Road safety on high speed roads is of prime concern and is affected by a number of factors or their combinations, including the vehicle and tyre condition, driver's behaviour, traffic condition, weather condition, road geometry and road surface condition. The skid resistance of the road surface is part of the road surface condition that contributes to safety. As skid resistance increases, the likelihood of skidding on the road surface will be reduced.

3.2 The skid resistance of a road surface is a complex matter. At low traffic speed, this is predominantly controlled by the "microtexture" of the aggregate used, and its resistance to polishing. The skid resistance tester in use in Hong Kong simulates the effect of a braking tyre travelling at 50 km/h, and thus provides a guide to the skid resistance of the road surface for a vehicle travelling at that speed. However, as speed increases beyond 50 km/h, the effect of the "macrotexture" of the road surface (i.e. the surface texture of the pavement) becomes increasingly important, particularly in permitting the escape of the water film between the tyre and a wet pavement. Surface texture is thus an important requirement for expressways and high speed roads in enhancing the road safety. The texture depth is an important factor influencing skidding in wet conditions on high speed roads.

3.3 A minimum average texture depth of 0.7 mm is recommended for concrete carriageway surfaces in the General Specification for Civil Engineering Works. However, research has shown that the texture depth required for no reduction in skid resistance at high speeds on bituminous surfacings is almost double the texture depth required for concrete roads. As the typical texture depth of bituminous wearing course material is only between 0.3 mm to 0.5 mm, it is necessary to adopt the porous friction course material which provides a texture depth of about 1.5 mm measured by the sand patch method at the time of new construction.

3.4 Friction course material is a very permeable asphalt layer with continuous voids. Water can percolate through the material to the pavement edges and discharge into appropriate drainage systems. The material has the following properties compared with continuously graded materials:-

(i) Improved skid resistance at high speeds;

(ii) Reduced water spray from the rear of vehicles during wet weather;

(iii) Greatly increased texture depth;

(iv) Reduced possibility of aquaplaning;

(v) Reduced tyre/road noise; and

(vi) Enhanced resistance to wheel path rutting.

3.5 In view of the high texture depth and high porosity of porous asphalt, friction course material is recommended to be used on expressways and high speed roads connecting to these expressways where a major portion of vehicles are expected to travel at speeds exceeding 80 km/hr. Based on the findings and recommendation in Technical Report No. RD/TR/048, polymer modified friction course material with a pre-blended polymer modified binder should be used as the standard surfacing material in the above roads.

3.6 A Particular Specification for polymer modified friction course, with a pre-blended polymer modified binder, is attached in Appendix A. A Particular Specification for the determination of the polymer modified binder content and particle size distribution of the polymer modified friction course material is attached at Appendix B.

4. Enquiries

4.1 Any enquiries on this Guidance Notes should be directed to E/1, R&D Division, HyD (Tel. No. 2762 3483).

REFERENCES

1. Highways Department (2001) *Noise Reducing Road Surfacing,* Guidance Notes No. RD/GN/011B, Hong Kong.

2. Highways Department (2006) *Development of a More Durable Porous Asphalt Material,* Technical Report No. RD/TR/048, Hong Kong.

3. Highways Agency (2006) *Design Manual For Roads and Bridges,* Volume 7, UK.

4. Hong Kong Government (2006) *General Specification for Civil Engineering Works - Volume 1*, Hong Kong.

5. Highways Department (1995) *Glossary of Terms Commonly Used in Flexible Pavement Construction,* Guidance Notes No. RD/GN/010A, Hong Kong.

6. Highways Department (1983) *Road Surface Requirements for High Speed Roads*, Road Note 5, Hong Kong.

Appendix A

Particular Specification for Pre-blended Type
Polymer Modified Friction Course Material

SECTION 9 CARRIAGEWAYS : SUB-BASE MATERIAL AND BITUMINOUS MATERIALS

PS 9.xx POLYMER MODIFIED FRICTION COURSE MATERIAL

(a) AGGREGATES

For the purpose of mix design, the combined grading of aggregates for polymer modified friction course material shall be such that the particle size distribution lies within the limits stated in Table 1.

Table 1 : Design limits for particle size distribution and bitumen content

Properties		Polymer Modified Friction Course
Nominal maximum aggregate size (mm)		10
Particle size distribution	BS test sieve	Percentage by mass passing
	14 mm	100
	10 mm	85 – 100
	5 mm	20 – 40
	2.36 mm	5 – 15
	75 µm	2 – 6
Polymer modified binder content as % of total mass of material	min.	5.5
	max.	6.5

(b) DESIGN

(1) The material shall consist of coarse and fine aggregates complying with GS Clause 9.04, filler complying with GS Clause 9.05, and polymer modified bitumen complying with sub-clause (2) below. The material shall have particle size distribution and polymer modified binder content within the limits stated in Table 1.

(2) The polymer modified bitumen shall be a pre-blended type bitumen manufactured by the wet mix method unless otherwise approved by the Engineer. Dry mix method for mixing the bitumen and polymer in the batching plant shall not be allowed. The polymer modified bitumen shall have a performance grade not lower than PG 76 of the Performance Grade Asphalt Binder Specification specified by the AASHTO T315.

(3) Binder drainage tests shall be carried out on the proposed aggregate/modified binder combination in accordance with BS DD 232 to determine the maximum target binder content (Tmax) of the mix. The proposed mix will be acceptable if the maximum target binder content (Tmax) is equal or greater than the proposed binder content.

(4) Specimens shall be prepared for tests using Marshall Method of Mix Design stated in The Asphalt Institute Handbook 'MS-2 Mix Design Methods for Asphalt Concrete and other Hot-mix Types, Sixth Edition (1997)', with modifications only if agreed by the Engineer. The compaction standard shall be 50 blows per side unless otherwise agreed by the Engineer. The mixing and compaction temperatures for the mix shall follow the recommendations of the manufacturer of polymer modified bitumen. The air void in mix as a percentage of total bulk volume shall not be less than 20%.

(c) PARTICULARS OF FILLER AND POLYMER MODIFIED BITUMEN

(1) The following particulars of the proposed filler and polymer modified bitumen shall be submitted to the Engineer :

(i) a certificate from the manufacturer for filler showing the manufacturer's name, the date and place of manufacture and showing that the filler complies with the requirements stated in the Contract and including the result of test for particle size distribution, and

(ii) a certificate from the manufacturer for polymer modified bitumen showing the manufacturer's name, the date and place of manufacture and showing that the polymer modified bitumen complies with the requirements in PS Clause 9.xx(b)(2).

(2) The particulars, including certificates, shall be submitted to the Engineer at the time stated in GS Clause 9.12(3).

(d) PARTICULARS OF MIX

(1) The following particulars of polymer modified friction course material shall be submitted to the Engineer :

(i) polymer modified binder content % by weight of total mass,

(ii) source and type of aggregates,

(iii) certified copies of work sheets for mix designs, which shall include the relative density of the mixed aggregates,

(iv) mixing temperature during production,

(v) grading details in tabular and graphical form,

(vi) source of polymer modified bitumen,

(vii) details of each mixing plant proposed, and

(viii) if requested by the Engineer, past test records of the same mix produced in the same plant.

(2) The above particulars shall be submitted to the Engineer at least 14 days before :

(i) trial areas are constructed, or

(ii) the mix is placed in the permanent work if trial areas are not required.

(e) SAMPLES : TRIAL AREAS

If instructed by the Engineer, a trial area of polymer modified friction course shall be constructed to demonstrate that the proposed material, mix, methods of production and construction are capable of producing a carriageway which complies with the specified requirements. Unless otherwise stated in the Contract, the trial area shall be constructed as part of the permanent carriageway at locations agreed by the Engineer. The width of each trial area shall be at least one lane of carriageway, and the length shall be at least 60 m. One sample of polymer modified friction course material shall be provided from the trial area. The method of sampling shall be as stated in Table 2.

Table 2 : Sampling and testing

Type of material	Properties	Methods of sampling	Method of testing
Polymer modified friction course	Particle size distribution	PS Clause 9.xx(p)	PS Clause 9.xx(q)
	Polymer modified binder content		
	Texture depth and permeability		PS Clause 9.xx(s)

(f) TESTING : TRIAL AREAS

Each sample of polymer modified friction course material taken as stated in PS Clause 9.xx(e), shall be tested to determine the properties stated in Table 2. The method of testing shall be as stated in Table 2.

(g) APPROVED MIX

(1) The approved gradation envelope for polymer modified friction course material shall be the gradation envelope found by applying the tolerances stated in GS Table 9.7 to the particle size distribution of the approved mix.

(2) The approved polymer modified binder content range for polymer modified friction course material shall be the range formed by applying a tolerance of ± 0.5% to the total polymer modified binder content of the approved mix.

(h) HANDLING, STORAGE AND TRANSPORT OF MATERIAL

Unless otherwise permitted by the Engineer, polymer modified friction course material shall not be stored in heated surge bins for more than 12 hours and shall not be stored in transport vehicles for more than 3 hours.

(i) MIXING

(1) Aggregates and filler for the material shall be measured to an accuracy of ± 3.0 % by mass. The aggregate moisture content after drying shall not exceed 0.4 % by mass.

(2) The material shall comply with the temperature requirements as recommended by the supplier of bituminous materials during and after mixing.

(3) The particulars of temperature requirements for polymer modified friction course material shall be submitted to the Engineer at the time stated in GS Clause 9.12(3).

(4) If instructed by the Engineer, the Contractor shall measure in the presence of Engineer's Representative the following temperatures :

(i) temperature after mixing;

(ii) temperature at laying; and

(iii) temperature at start of compaction.

(j) LAYING AND COMPACTION

(1) Laying and compaction of the material shall follow the procedure and requirements as stated in GS Clauses 9.33, 9.34, 9.35 and 9.36.

(2) The material shall comply with the temperature requirements as recommended by the supplier of bituminous materials during and after mixing.

(3) Pneumatic-tyred roller shall not be used to ensure continuity of voids in the mix.

(k) JOINTS

No transverse joint is allowed at location closer than 3 m from any transverse joint of the carriageway or otherwise agreed by the Engineer.

(l) PROTECTION OF SURFACE

Where traffic conditions and other constraints permit, 6 hours shall be allowed before Constructional Plant or other vehicles use the newly laid and compacted bituminous course. Where traffic conditions and other constraints do not permit, the Contractor shall so programme his works so as to allow sufficient time for the bituminous course to be sufficiently cured to withstand traffic loading. In any event, the newly compacted bituminous course shall not be opened to traffic unless the surface temperatures of the bituminous course fall below 50^0C. The surface temperatures shall be measured by the infrared type thermometer according to the manufacturer's recommendation or other type of thermometer approved by the Engineer. The use of mercury type thermometer is not allowed.

(m) TOLERANCES : LEVEL OF CARRIAGEWAYS

Requirements on level shall be as stated in GS Clause 9.40.

(n) BATCH : BITUMINOUS MATERIAL

A batch of polymer modified friction course is a quantity not exceeding 100 t of the materials of the same type and same mix produced at the same mixing plant in one day.

(o) SAMPLES : BITUMINOUS MATERIAL

(1) One sample of the bituminous material shall be provided from each batch of material unless otherwise required by the Engineer.

(2) The size of each sample shall be at least 15 kg.

(3) Samples shall be taken from at the mixing plant from the delivery vehicle immediately after loading from the plant, roadway prior to compaction where the bituminous material will be laid, or from other location as instructed by the Engineer.

(4) Unless otherwise agreed by the Engineer, the method of sampling shall be in accordance with ASTM D 979.

(p) TESTING : BITUMINOUS MATERIAL

(1) Each sample of bituminous material taken as stated in PS Clause 9.xx(o) shall be tested to determine the particle size distribution and polymer modified binder content.

(2) The method of testing shall be in accordance with the following : -

Particular size distribution	: ASTM C136 and ASTM C117
Polymer modified binder content	: Appendix B

(q) COMPLIANCE CRITERIA : BITUMINOUS MATERIAL

The results of tests on polymer modified friction course material shall comply with the following requirements:

(1) The particle size distribution shall be within the approved gradation envelopes as determined in PS Clause 9.xx(g)(1).

(2) The polymer modified binder content shall be within the approved range as stated in PS Clause 9.xx(g)(2).

(r) TESTING : TEXTURE DEPTH AND PERMEABILITY

(1) Unless otherwise specified, testing to determine the texture depth shall be carried out by the Engineer. The method of testing shall be by the sand patch test in accordance with GS Appendix 10.1.

(2) Unless otherwise specified, testing to determine the permeability shall be carried out by the Engineer. The method of testing shall be in accordance with GS Appendix 9.1.

(3) Unless otherwise specified, rate of tests for texture depth and permeability shall be as specified in GS Table 9.15. Tests for texture depth and permeability shall be carried out on each sub-area at positions which in the opinion of the Engineer are representative of the sub-area of friction course as a whole. No measurement shall be taken within 300 mm of the longitudinal edge of the carriageway.

(s) COMPLIANCE CRITERIA : TEXTURE DEPTH AND PERMEABILITY

The results of tests for texture depth and permeability shall comply with the requirements stated in GS Clause 9.67 and 9.68 respectively.

DETERMINATION OF THE POLYMER MODIFIED BINDER CONTENT AND PARTICLE SIZE DISTRIBUTION OF POLYMER MODIFIED FRICTION COURSE MATERIAL

1 SCOPE

This method covers the determination of the polymer modified binder content (i.e. the total binder and polymer content) and particle size distribution of polymer modified friction course by making use of a combination of two tests in accordance with ASTM D2172, Method A and ASTM D6307.

2 CALIBRATION PROCEDURE

Testing on laboratory mix to determine the calibration factor shall be required. The procedure shall be as follows:

(a) For a particular mix, prepare a laboratory mix of known particle size distribution and bitumen content (A).

(b) Test the trial samples of the laboratory mix in accordance with ASTM D2172, Method A (Centrifuge Method) to determine the polymer modified binder content (B) of the trial samples.

(c) Test the residual of the trial samples that have been tested by ASTM D2172, Method A in accordance with ASTM D6307 (Ignition Method) to determine the polymer modified binder content (C) of the residual.

(d) Calculate the calibration factor for that particular mix by the following formula:

$$\text{Calibration Factor (for a particular mix), } Z = C - (A - B)$$

3 TESTING

The procedure for testing polymer modified friction course material shall be as follows:

I. Test by the Centrifuge Method

(a) Test the test samples in accordance with ASTM D2172, Method A to obtain the polymer modified binder content (X) of the test samples.

(b) Keep the residual (Residual 1) of the test samples that have been tested in 3 (a).

II. Test by the Ignition Method

(c) With the value of the calibration factor, Z entered into the NCAT Tester for correction purpose, test Residual 1 obtained from 9.2.3 (b) in accordance with ASTM D6307 to obtain the residual polymer modified binder content (Y) of Residual 1.

(d) Keep the residual (Residual 2) of Residual 1 that have been tested in 3 (c).

III. Determination of Particle Size Distribution

(e) Determine the particle size distribution of Residual 2 in accordance with ASTM C136 and ASTM C117.

4 CALCUATIONS

The polymer modified binder content of the test samples is calculated as follows:

$$\text{Polymer modified binder content} = X + Y$$

5 PARTICLE SIZE DISTRIBUTION

The particle size distribution of Residual 2 is taken to be the particle size distribution of the test samples.

6 REPORTING OF RESULTS

The followings shall be reported:

(a) Polymer modified binder content (X);

(b) Polymer modified binder content (Y); and

(c) Polymer modified binder content (total binder and polymer content)