



**HIGHWAYS DEPARTMENT**

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**GUIDANCE NOTES**

**APPLICATION OF POLYMER MODIFIED  
STONE MASTIC ASPHALT**

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**Research & Development Division**

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## **1. Introduction**

- 1.1 This set of Guidance Notes updates the application of polymer modified stone mastic asphalt with 10mm nominal maximum aggregate size (PMSMA10) on bituminous carriageways.

## **2. Background**

- 2.1 Guidance Notes RD/GN/030 was issued in December 2001 introducing the use of stone mastic asphalt (SMA) as a surface course for heavily trafficked roads. Since then SMA has been extensively used as the surfacing layer on heavily trafficked bituminous carriageways in Hong Kong. Approaching 2010, more frequent occurrence of rutting and shoving on SMA has been noted and these defects sometimes appeared shortly after construction, in particular during hot season.
- 2.2 The Research and Development Division launched an investigation study in 2009 with a view to identifying the causes of such premature failures, which concluded that the major cause of such problem was attributed to instability of SMA under high local temperature. A number of measures were subsequently recommended for incorporation into an improved mix design of SMA (namely PMSMA10) which contains polymer modified bitumen with Styrene-Butadiene-Styrene polymer having performance grade not less than PG76 of the Performance Grade Asphalt Binder Specification under AASHTO M320. When compared with conventional penetration grade 60-70 bitumen, the polymer modified bitumen has a higher dynamic shear modulus against permanent deformation and this PMSMA10 shows significant improvement on the stability against rutting and shoving. Such improvement was substantiated by laboratory study and site trials. In view of the significant improvement against rutting and shoving, it was recommended that the conventional SMA should be replaced with this PMSMA10 as anti-rut surface course on road sections that were heavily trafficked.
- 2.3 Since the promulgation of RD/GN/038 in April 2012, PMSMA10 has been more extensively used in our road network. Except on some road sections with extremely heavy traffic loading, it is observed that PMSMA10, together with intact base course layer, can effectively prevent carriageway pavements from early deformation and rutting.
- 2.4 This guidance notes updates the practices on the use of PMSMA10 and incorporate some general revisions. Meanwhile, R&D is conducting a study to review the recommended type of surface course on local roads. Upon completion of the study, Table 2 of this guidance notes will be updated.

## **3. Mix Design of PMSMA10**

- 3.1 The mix design for PMSMA10 is shown in Table 1 for reference. Owing to the use of high binder content, fibres are added to reduce the binder drain. The mix design and specification for the PMSMA10 may be subject to change when required. The most up-to-date specification for the PMSMA10 in the latest edition of Highways Department term contract should always be referred to.

Table 1: Mix Design for PMSMA10

Properties		
Nominal maximum aggregate size		10 mm
Particle size distribution	BS test sieve	Percentage by mass passing
	14 mm	100
	10 mm	93 – 100
	5 mm	26 – 48
	2.36 mm	21 – 35
	75 µm	9 – 14
Bitumen type		Pre-blended type polymer modified bitumen having performance grade not lower than PG76 of the Performance Grade Asphalt Binder Specification
Bitumen content as percentage of total mass		6.0 % min.
Fibre content as percentage of total mass		0.3 % min
Draindown percentage as determined from binder draindown test		0.3 % max
No. of blows per side at Marshall compaction		75
Marshall stability		6 kN min
Air voids in mix (VIM) as percentage of total bulk volume		3.5 % - 4.5 %
Voids in mineral aggregate (VMA) as percentage of total bulk volume		17.0 % min

#### **4. Areas of Application**

- 4.1 Compared with conventional wearing course (WC) material using Pen 60/70 binder, the capital cost of PMSMA10 is higher owing to the high binder content and the use of a superior bitumen (i.e. polymer modified bitumen), cellulose fibre and hydrated lime. Considering its better high-temperature stability, PMSMA10 is recommended for use as surface course for local roads that are subject to moderate to heavy traffic flow as shown in Table 2 below. Polymer modified friction course material should continue to be used on high speed roads to improve skid resistance and reduce the risk of aquaplaning when vehicles are travelling at high speeds.
- 4.2 Table 2 provides general guidance on selection of surfacing material for road sections with different traffic levels. To minimize premature rutting on new roads, the guidance shall be followed in pavement design in new road projects. For existing roads, maintenance offices can refer to the guidance in rectification of rutted road sections. In this connection, an existing road section falling into a particular group does not imply that the surface course recommended for that group must be used.

Local experiences and other engineering considerations shall be taken into account in selecting the most suitable resurfacing option. For example, the rate of deformation for road section with steep gradient (e.g. gradient exceeding desirable maximum percentage stipulated in TPDM) or sharp turning (e.g. horizontal radius smaller than normal minimum radius stipulated in TPDM) will not be the same as that on gentle, straight road section with same traffic level. Engineers shall, therefore, exercise their professional judgement in selecting appropriate surfacing material. Reference should also be made to RD/GN/039 in formulating the maintenance and rehabilitation schemes.

Table 2: Recommended type of surface course on local roads

Area Definition (Bituminous Carriageways)	Traffic Levels (Commercial vehicles per lane per day)			
	Up to 1500	1501 – 2500	2501 – 4000	Over 4000
Single and dual carriageways (straight sections and minor junctions)	WC			PMSMA10
Gradient 5% to 10%, longer than 50m Bend radius 100m – 250m	WC		PMSMA10	
Approaches to roundabouts, traffic signals, pedestrian crossings and railway crossings, and similar Gradient steeper than 10%, longer than 50m Roundabout and bend radius <100m	WC	PMSMA10		

Notes:

1. WC and PMSMA10 denote wearing course and 10mm nominal size stone mastic asphalt containing polymer modified bitumen respectively.
2. Commercial vehicles include all medium/heavy goods vehicles and buses classified in the Annual Traffic Census issued by the Transport Department.
3. Annual average daily traffic and percentage of commercial vehicles at appropriate stations listed in the Annual Traffic Census shall be referred to in determining the no. of commercial vehicles per lane per day of a road section. For the procedure of calculating the traffic level, reference can be made to the Guidance Notes No. RD/GN/042, Pavement Design for Carriageway Construction. If there are no core or counting stations in the road section, the relevant data of adjacent roads in the areas shall be referred to. Manual traffic counting may be required if necessary.

- 4.3 On roads with normal to high traffic volume, the skid resistance of PMSMA10 attributable to its micro texture would be shortly reduced to that similar to WC due to the repeated tyre/road surface interaction. Application of anti-skid surface dressing will be necessary if higher skid resistance is demanded. On the other hand, the skid resistance of PMSMA10 on roads of extremely low traffic can maintain at a high value for a reasonably long period of time after construction. Therefore, for road sections with low daily traffic flow of less than 300 vehicles per lane, PMSMA10 alone could be used as anti-skid surface. Application of extra anti-skid surface dressing material using aggregates of high polished stone value such as calcined bauxite on top of PMSMA10 is not necessary in this situation.

- 4.4 For WC road surfacing, when epoxy based anti-skid dressing is necessary, the existing wearing course has to be replaced with PMSMA10 first due to the incompatibility between the low elastic modulus of wearing course and the high elastic modulus of the epoxy based anti-skid dressing. In the circumstances the anti-skid dressing shall be overlaid about 4 weeks after replacement of the wearing course.
- 4.5 The rate of PMSMA10 has been included in the schedule of rates (SoR) of Highways Department term contracts commenced in April 2012 and afterwards. For existing term contracts or existing capital works contracts without SoR or BoQ items for the supply and laying of PMSMA10, the Engineer may, depending on the severity of defects observed and sensitivity of the roads in question, select either WC or issue variation order to use PMSMA10.

## **5. Quality Control on PMSMA10 during Construction**

- 5.1 Bituminous materials using polymer modified bitumen shall comply with the temperature range as recommended by the respective asphalt suppliers during mixing and compaction. The recommended temperature range varies from one supplier to another. It is essential for the site supervisory staff to record the temperature of PMSMA10 when it is compacted and check against the specified temperature range. The higher viscosity of polymer modified binder makes the bituminous mixture stiffer at the same temperature but harder to compact. Particular attention should be paid while planning and supervising paving work of PMSMA10 in cold winter to ensure compliance to the temperature requirements and work quality.
- 5.2 Bulk samples of PMSMA10 shall be collected on site to determine the particle size distribution of aggregates and bitumen content. A combination of two tests in accordance with ASTM D2172 and ASTM D6307C shall be carried out to determine the bitumen content of PMSMA10 since the bitumen contains polymer. The bitumen content range of the bulk samples is targeted at +0.3% to -0.7% during the site trial. Core samples are to be taken on site to check the compacted layer thickness and air void content, which is set between 3% and 8% during the site trial. Tests for texture depth shall also be carried out on site.
- 5.3 Similar to any other bituminous materials, good practice during construction is a pre-requisite on maintaining the quality and durability of PMSMA10. Attention should be paid to the following when construction works using PMSMA10 are carried out:
- (i) The underlying bituminous material should be structurally sound. Otherwise deformation of this layer may cause the top PMSMA10 to deform as well.
  - (ii) Good bonding between pavement layers should be attained. Tack coat should be properly applied and construction on rainy days should be avoided.
  - (iii) The compacted PMSMA10 should be adequately cooled down (surface temperature below 50°C) before opened to traffic. This is essential to avoid excessive early pavement deformation.
- 5.4 Despite the improved durability of PMSMA10, it must be emphasized that there is still a limit on this new mix against heavy traffic loading. Permanent deformation in the

form of shoving or rutting may still occur when PMSMA10 is subject to very heavy and slow or “stop and go” traffic, especially under hot summer season. Consideration should be given to replace the carriageway with more stiff material, such as concrete pavement, at such locations.

- 5.5 To enhance the monitoring on the use of correct type of bitumen in a works contract, the project proponent should make necessary contract provisions to require the contractor and asphalt supplier to:
- (i) advise on a monthly basis the quantity of polymer modified bitumen consumed and the quantity of polymer modified bituminous materials supplied under a contract;
  - (ii) keep all procurement and delivery records as well as any testing proof on the polymer modified bitumen purchased. All records of tonnage of each polymer modified bituminous material produced and supplied, together with the bitumen type and content used in the production shall also be kept. For the avoidance of doubt, the aforesaid records shall cover all production and bitumen procurement/consumption since the commencement date of contract, but shall not be limited to those materials supplied to the contract. From time to time and at any time in the contract period, such records shall be submitted to the Engineer of the contract for checking within 7 days upon the Engineer’s request; and
  - (iii) grant access to the Engineer of the contract, from time to time and at any time when the production plants of the asphalt supplier are in operation, to the production plants to check records and process of production.
- 5.6 The guidelines on quality control on PMSMA10 during construction may be subject to change. The most up-to-date requirements in the latest edition of Highways Department term contract should always be referred to.