NZTA P11 Notes: 2023

Notes to the Specification for Open-Graded Porous Asphalt

Waka Kotahi NZ Transport Agency

Te Kāwanatanga o Aotearoa
New Zealand Government

1 General

The 2023 update to NZTA P11 Specification for Open-Graded Porous Asphalt incorporates several changes and upgrades to the previous edition that was issued in 2007. These changes include:

(a) Additional requirements for aggregate quality to ensure long-term durability.
(b) A requirement to use binders as specified by NZTA M01-A.
(c) Deletion of the “high voids” (HV) mixes. These were added to the specification in 2007 with a view to improving acoustic performance, but recent research and experience has shown that deeper lifts of finer mixes give the best noise attenuation.
(d) The addition of a PA 7 HS mix.
(e) Deletion of the Marshall method of mix design and specifying the “Superpave” gyratory compaction apparatus for laboratory specimen preparation.
(f) A reduction in the compaction effort used to prepare laboratory specimens for mix design purposes to 50 gyratory cycles. This is consistent with practice in the United States. See AASHTO PP 77 and ASTM D7064.
(g) An increased emphasis on maximising binder content, while maintaining compliance with drain off, volumetric and abrasion resistance requirements.
(h) Adding all binders to the accelerated aging and durability requirements.

The objective of the review is to improve the durability of porous asphalt wearing course mixes, use modern methods of design and optimisation and rationalise the number of mix grades in the specification.

P11 specification lays much emphasis on the properties of the manufactured product. The purpose of open-graded porous asphalt material is to produce a very permeable asphalt with a sufficiently high proportion of continuous voids to:

(i) allow water to drain through the material and then percolate along the cross fall of the underlying material to the pavement edges,
(j) to maintain sufficient macrotexture to meet the requirements of NZTA T10
(k) to obtain a low noise surface
(l) to minimise splash and spray and rolling resistance

Open graded porous asphalt material is produced in a static or mobile asphalt plant, laid with a paving machine and compacted while it is hot.

Sufficient stability is needed in the compacted layer so that the material does not squeeze sideways under traffic. Durability or resistance to weathering and aging of asphaltic mixes is important and is primarily a function of connected voids and the binder film thickness. Though open-graded porous asphalt material is designed to have a high proportion of inter-connected voids, it also has a low total aggregate surface area, and hence a substantial binder film thickness is possible as an aid to promoting reasonable durability.

The tolerances for the accuracy of the surface on which the paving is to be laid, and for the accuracy of the open graded porous asphalt surface itself, should limit the compacted thickness to a depth such that the non-structural nature of the material will not cause deformations.

It is essential that the roadway underlying the open graded porous asphalt is structurally sound, and that the surfacing of the underlying roadway is impermeable. Laying of open graded porous asphalt over permeable, unsound or high deflection pavements can lead to early failure of the open graded porous asphalt. This failure may occur rapidly after signs of distress are first visible on the surface of the open graded porous asphalt.

2 Levelling Treatment

Open graded porous asphalt material is not a structural material and care should be taken to see that the layer thickness does not have to be too great to take up irregularities in the underlying layer.

In addition, although open graded porous asphalt does not compact much under rolling, the shape of the underlying road surface will influence the final open graded porous asphalt surface shape achieved. A 25mm thick open graded porous asphalt mat after paving will typically reduce by 2.5mm after compaction.

A levelling treatment will be necessary if any area of the existing surface on which the open graded porous asphalt is to be laid ponds water.

If a levelling treatment is constructed, it should be impermeable or have an impermeable surfacing applied prior to open-graded porous asphalt construction.

A layer of open-graded porous asphalt does have the ability to improve the ride quality of the pavement if the paver is equipped with an appropriate levelling device.

Consideration should be given to controlling the finished shape rather than the nominal layer thickness to maximise the benefits of the treatment. It is recognised that if only a minimum thickness is specified it can be difficult to estimate the total quantity of mix that will used.

3 Materials

3.1 Aggregate

The aggregates, by their grading, shape and surface texture, provide the greater part of the mechanical stability of open graded porous asphalt material. The binder cements and waterproofs the aggregate and acts as a lubricant during laying and compaction.

The function of the coarse aggregate is to provide stability by the interlocking of the aggregate particles and by their frictional resistance to displacement. Both the shape and surface texture therefore contribute to stability, and the ideal aggregate is a hard angular stone with a rough surface texture. This limits the use of flaky aggregate. To meet these requirements the coarse aggregate is specified in terms of NZTA M06 sealing chip shape requirements.

The fine aggregate adds to the stability of the mix through the interlocking of particles, and also provides for greater ease in laying the mix.

3.2 Binder

Bitumen binders are specified in terms of NZTA M01-A specification. The concept is that the least aged (i.e. least stiff or highest J_{nr}) binder that complies with the M01-A climate zone requirements should be used provided the porous asphalt mix design complies with the volumetric and particle loss requirements of the specification. The traffic loading is not used to select the Grade category as it considered that the stone-on-stone coarse aggregate interlock will provide deformation resistance for the porous asphalt mix. This is tested by the asphalt particle loss requirements.

The specified grades, H, V, and E generally reflect the bitumen grades traditionally used in the past for open-graded porous asphalt binders. The stiffer, lower J_{nr} grades, V and E, will likely need to be modified to comply with NZTA M01-A specification.

Consequently, the explicit specification of “PMB” for the binder is strongly discouraged. M01-A provides a technical basis for the binder properties and the specifying of a PMB of ill-defined properties in contract documents should cease. Where a modified binder is required, this will be on the basis of climate zone and compliance with the particle loss requirements of P11.

Epoxy modified binders are specified by NZA T21. The Epoxy modified binder must be on the list of approved binders published on the Waka Kotahi web site.

4 Mix Types

P11: 2023 specification contains two broad mix types: the “standard“ PA grades which have design air voids between 20 – 25%, and a “HS” grade which has lower design air voids but better aggregate interlock and resistance to traffic damage.

The use of the HS grade mixes needs to be considered with caution on some sites. The lower air voids content of the HS grades means that water drainage through the mix is limited.

The previous version of P11 published in 2007 contained criteria for a high air voids, or "HV" grade of porous asphalt mix. These high voids mixes were believed to give better attenuation of surface noise, but at the price of reduced durability. Subsequent research has shown that the finer porous asphalt mixes, such as PA 7, laid deeper than the minimum specified, give the best reduction in tyre noise emissions. Consequently the "HV" mixes have been deleted from this version of P11 specification.

A 14 mm maximum aggregate sized mix has been included to cover those areas where the road geometry is such that a larger reservoir for water runoff is required. This mix would be laid 40 - 50 mm thick. It can be used in areas where water tends to run down the road rather than to the sides. As this mix has a larger maximum aggregate its noise reducing properties are not as great as the smaller sized mixes. This mix does however have benefits where water drainage is the main concern.

5 Mix Design

Open-graded porous asphalt mixes are designed by determining a blend of aggregates by calculation to comply with the limits of Table 4, then preparing samples of mix in the laboratory at various binder contents. Test specimens are prepared by compacting mix in moulds using a gyratory compaction device.

Previous versions of P11 allowed the use of impact compaction, using the Marshall apparatus, for the purposes of mix design but this has been discontinued in this version of P11. Gyratory compaction is preferred because the test specimens better reflect aggregate particle orientation achieved in the field and gyratory compaction causes less aggregate damage during the compaction process. The "Superpave™" compaction apparatus has been specified for the manufacture of laboratory specimens as the Austroads compliant machines are no longer supported or supplied.

The intention of the mix design process for open-graded porous asphalt is to maximise the binder content, while complying with volumetric, drain off and particle loss criteria of the specification, so that mix durability is maximised. This is why a minimum binder drain off criterion is included in Table 7.

The use of additives such as cellulose fibres, or fibres from recycled textiles can be a useful means of elevating binder content while controlling drain off.

6 Tack Coat

The roadway surfacing underlying the open graded porous asphalt must be impermeable. The tack coat therefore is to ensure a good bond between the open graded porous asphalt and the existing surface. A residual binder application rate of some 0.10 - 0.13 L/m² should be adequate in most cases. Slightly heavier application rates than this can be used as the open graded porous asphalt can absorb some excess binder, application rates much lighter than this should generally be avoided. Absorbent surfaces on the existing roadway will require a heavier application rate. A uniform application of tack coat is important. The use of waterproofing seal is required where OGPA will be laid on a granular basecourse.

To preserve continuity of drainage paths, vertical surfaces of open graded porous asphalt material should not be tack coated unless they abut an existing impermeable material.

A cutback bitumen tack coat should only be used in unusual circumstances. Almost always an emulsion tack coat should be specified.

7 Waterproofing Seal

The roadway surfacing underlying the open graded porous asphalt must be impermeable. This can be achieved by constricting waterproofing seal coat layers over water susceptible substrates, such as granular basecourses. The minimum residual binder content should be 3.0L/m², but some practitioners believe that 4.0L/m² should be used.

The seal coat structure will need to be designed and constructed in several layers so that the bitumen volume is suitably accommodated by the chip aggregate. The first layer of seal (not counting any prime coat) should be a single-coat or racked-in seal so that the membrane thickness is maximised for best waterproofing.

Two-coat seals, as opposed to two seal coat layers, are considered to be less waterproof than single-coat or racked-in seals, so designers of waterproofing seals should carefully consider the design of the waterproofing seal structure, using two-coat seals only if and when necessary. Trafficking of two-coat seals is considered to improve their waterproofness as the compaction action of the traffic reduces the voids in the seal structure.

8 Mixing Temperatures

The mixing temperature is based on the viscosity versus temperature relationship of the bitumen. Binder mixing and compaction temperatures for mixes produced in the laboratory are adjusted to attain binder viscosities of 1 Pa.s ± 0.1 Pa.s and 2 Pa.s ± 0.2 Pa.s respectively.

9 Transportation, Spreading, Trimming and Compaction

Suitable release agents are needed to prevent the open-graded porous asphalt from sticking to truck decks when transported to the job. The use of a soap and water, or detergent and water solution is more effective in preventing open graded porous asphalt sticking to truck beds than is Diesel fuel. When a soap or detergent and water solution is used, the truck deck should be elevated and drained immediately before the open-graded porous asphalt is loaded.

It is important to ensure that the drainage paths within the open graded porous asphalt are not impeded when the material is laid. In the situation where kerbs are absent, the open-graded porous asphalt should be left proud of the shoulders whenever the porous asphalt extends more than 0.5m beyond the lane edge. If the shoulder is not sealed and abuts the lane edge, it is desirable to have open graded shoulder metal to facilitate drainage from the edge of the open graded porous asphalt. If the shoulder is sealed, consideration should be given to extend the open graded porous asphalt to the edge of the seal.

Where kerb and channel is present, the layer on which the open graded porous asphalt is to be laid should be flush with the channel so that the open graded porous asphalt can extend above the lip of the channel and drain into it. All open graded porous asphalt edges should be trimmed and compacted to a neat step.

Somewhat less rolling effort is required for open graded porous asphalt material than for normal asphaltic concrete. Care should be taken that the rollers have a sufficient but not over-generous uniform application of water over the front and rear drums, as an oversupply of water could lie in the material voids with consequent effects on compaction and adhesion. Compaction temperatures can be lower than for normal asphaltic concrete, but care should be exercised in completing the rolling as the thin layer of open graded porous asphalt will lose heat readily. To ensure continuity of voids in the mix, rubber tyred rolling is excluded. Excessive steel wheel rolling leading to aggregate breakdown must not occur. Evidence of sufficient compaction will be visible when all roller marks are obliterated.

Minimum thicknesses of each type of mix have been specified. These are based on 2.5 times the nominal maximum stone size. These thicknesses are the minimum amount of mix laid over any high points.

Because of the relative absence of fines in the open graded porous asphalt material, it is not possible to use it to feather out to an existing surface. When feathered joints are necessary, a dense asphaltic material, which has the necessary fines, should be used. Care should be taken that the tack coat application rate is adjusted so that flushing of the mix used for feathering does not occur.

The thickness of OGPA layers can be determined using the method of ASTM E3209. This entails the use of reflective steel discs placed on pavement substrates and covered with the OGPA wearing course. A magnetic pulse induction device is then used to determine the distance between the disc and the pavement surface. The advantages in this approach are that the accuracy is very good, and the test is non-destructive. However the devices are not readily available at the time of writing these Notes, so the requirement to do this testing should be explicitly specified In the Contract.

10 Surface Tolerances

With good workmanship, a high-quality smooth riding surface can be achieved with open-graded porous asphalt. The achievement of this smooth riding surface is to take precedence over attempting to achieve a defined pre-set layer thickness for the porous asphalt. This needs to be taken fully into account at all stages of the contract, including estimating financial requirements and the actual contract supervision.

It should be very rare for the depth of mix specified in the specific contract requirements to be a defined single number.

The surface tolerance of 5mm maximum deviation under a 3m straight edge is appropriate for highway conditions. On well shaped suburban streets an 8mm maximum deviation would be more appropriate.

11 Low Noise Surfaces

Research has shown that best attenuation of noise generated by vehicle tyre and road surface interactions is from finer mixes laid at thicknesses greater than the specified minimum and improve with increasing layer depth. Hence the specific layer depth requirements for low noise surfacings.