NOTES TO SPECIFICATION FOR OPEN GRADED POROUS ASPHALT

(These notes are intended for the guidance of supervising officers and are not to be included in the contract documents.)

1. GENERAL DESCRIPTION

The major change in this 2007 edition of the OGPA specification is the introduction of mixes with better acoustic performance and the changes include:

1. *Higher air void content mixes with air voids greater than 25%*
2. *A wider range of maximum aggregate sizes*
3. *The ability to specify twin layer systems*
4. *Measurement of the abrasion resistance with the cantabro test*
5. *A measure of durability through an accelerated aging test.*

Over the last 10 years there have been a number of trials and developments in New Zealand into the performance of OGPA. These include the design of higher air void content mixes, trials of twin layer mixes and the monitoring of their performance both in terms of drainage and noise reduction. Further background into the latest developments in this specification can be found in the following references.

J Patrick, G Arnold P Herrington, Development of Transit New Zealand P11 OGPA Specification, Proceeding NZIHT conference Auckland 2006

P Herrington, S Reilly, S Cook, 2005 Porous Asphalt Durability Test, Transfund NZ Research report No 265 Transfund NZ

N.J. Jamieson and J.E. Patrick. 2001. Increased effective life of porous asphalt. Transfund New Zealand Research Report No 204

J Vercoe, J Jackson 2003 A Low Noise Surface, Proceeding 6th Annual NZIHT/TransitNZ/Local government NZ Symposium October 2003 Wellington

J Patrick, 1995 Maintaining the Porous Nature of Friction Course Transit NZ Research Report No 46

V Dravitzki, C W B Wood 1999 Comparison of 20mm and 14mm Friction Courses Transfund New Zealand Report 120

The specification TNZ P/11 for open graded porous asphalt material 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

1. *allow water to drain through the material and then percolate along the cross fall of the underlying material to the pavement edges,*
2. *to maintain sufficient macrotexture to meet the requirements of TNZ T10*
3. *to obtain a low noise surface*
4. *to minimise splash and spray and rolling resistance*

Open graded porous asphalt material is produced in a static or mobile 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.

Laying of a mat of compacted thickness less than twice the nominal maximum stone size should not be attempted, even for isolated areas such as over the high spots of the existing road.

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. <u>ITEMS NOT INCLUDED IN SPECIFICATION</u>

Specification TNZ P/11 does not cover a variety of items likely to be related to open graded porous asphalt construction. These include chemical control of vegetation on areas to be paved, construction of levelling courses prior to open graded porous asphalt paving, traffic control, and requirements for provision of standby plant and contingency plans in case of plant breakdown.

3. 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 have some influence on the final open graded porous asphalt surface shape achieved. Typically a 25 mm thick open graded porous asphalt mat after paving will reduce by 2.5 mm 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 have an impermeable surfacing applied prior to open graded porous asphalt construction.

A layer of open graded porous asphalt does have the ability to significantly 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.

4. MATERIALS

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 the TNZ M/6 sealing chip shape requirements. Although it is recognised that a coating on the aggregate can affect aggregate /binder bond it is considered that a poor bond would show up in the retained tensile strength test.

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.

The roading binder should generally be 80/100 penetration bitumen, but 60/70 bitumen should be considered where:

(a) traffic density exceeds 5000 vehicles per lane per day; and

(b) peak shade air temperature exceeding 25°C are common in the summer but winter temperatures are rarely below 0°C.

60/70 penetration bitumen may also be considered where (a) applies but where colder temperatures apply providing the base structure is proven to be very sound.

Polymer Modification
Polymer modification can be used to increase the strength – but care needs to be taken to ensure that full compaction is still achieved especially on the longitudinal joints. Polymer modification has also been advocated as a means of increasing the mix durability and also to aid in decreasing detritus sticking to the binder.

The effectiveness of the use of polymer modified binders (PMB) can be inferred from the cantabro test results. Although this test may not duplicate the abrasive nature of vehicle traffic it does appear to correctly rank mixes. For the mixes with >25% voids the use of binder modification is specified. The polymer content of the binder will need to be such as to meet the cantabro maximum loss of 20%.
The long term effectiveness is controlled by the ratio of cantabro loss before and after ageing.

5. MIX TYPES

Three mix types are specified:

PA15HS This mix has air voids of approximately 15% and has proven in NZ to be able to withstand higher shear stress than the PA type mixes. The higher fine aggregate content has the ability to resist these stresses, but will not retain its free draining characteristics to the same extent.
The inclusion of this mix allows the Engineer to change the mix in a contract from the open material (PA), where traffic is free flowing, to the 10HS mix at intersections without introducing a significant change in surface properties.

PA 20 This mix has a minimum air void content of 20% and is the traditional mix used on the motorway system since the late 1980s.

PA 25HV This mix has a minimum air void content of 25% although mixes with 30% air voids have been used in trials and performed well. This mix would be used in areas where enhanced noise reduction properties are required.

The use of High Strength mixes needs to be considered with caution on some sites. The High Strength mix is not suitable for all areas and in some areas it should not be used, especially on roundabouts.

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.

Twin Layer Systems

In order to further reduce noise and also to maintain the open nature longer than the traditional OGPA twin layer systems have been trialled in NZ. In this system a layer of mix with a maximum particle size of 14 or 20mm is laid 30-50mm thick. On top of this layer a 20-30mm thick layer of a mix with a smaller top size is laid. The intention of the system is to:

1. *Increase the void content of the surfacing to absorb noise*
2. *Use a small sized aggregate in the surfacing to reduce noise*
3. *Use the smaller voids on the top layer to trap detritus and use the large voids in the bottom mix to allow water to flush the detritus – thus maintaining the drainage and noise properties of the system.*

Although this system is performing well in NZ there is insufficient data to determine the optimum ratio of the mix sizes and thickness.
The European experience is to use a 16mm mix in the bottom layer and a 7 or 5mm mix in the top layer. The mixes can all have a void content of greater than 25%.
Typical gradings of these mixes are given in Table 5.1.
At this stage in the development of low noise surfaces the minimum maximum aggregate size specified in P11 is 7mm. These is no experience in NZ of a 5mm mix.

The use of High Void mixes is encouraged, but not enough about their performance in New Zealand is known. To encourage contractors to trial these mixes some joint risk is being considered between the contractor and client (Transit NZ). Until experience is gained the use and layer thickness of twin layer systems must be discussed with the Engineering Policy Section of TNZ before specifying in any contract.

6. DESIGN OF MIX

The determination of the design bitumen content shall be made in accordance with the principles given in Section 4.12 of APRG report No 18 (AP-T20). This comprises the manufacture of tests mixes over a range of binder contents and then measuring the quantity of binder drainage that occurs when the mix is held at the mixing temperature *for a period of time that models the expected time from manufacture to laying. The maximum binder content obtained is then used to manufacture blocks to test for air voids content, permeability, retained tensile strength abrasion loss and durability.*

If the requirements of the specification are meet this then becomes the design binder content. The objective is to have the highest binder content possible to obtain durability but still to meet the other requirements. In order to obtain high binder contents the mixing temperature of OGPA is significantly lower than the used for dense graded mixes. The mixing viscosities were originally taken from USA specifications in the 1970s and have become the norm in NZ.

The use of hydrated lime is not specified; instead the retained tensile test is included to determine the risk of stripping. The test specified gives the ratio of retained tensile strength when Marshall specimens are soaked in water at 60°C for 24 hours. If the minimum specified retained strength (75%) is not obtained with the aggregate, then the use of an additive such as an adhesion agent or hydrated lime would be required.

Shear strength of OGPA is obtained through the aggregate properties and grading and ensuring that the ratio of maximum stone size to layer thickness is not great. Most OGPA fails through fretting and the cantabro test has been introduced to model this failure mechanism. The cantabro test consists of subjecting blocks of the mix to an abrasion action and measuring the weight loss. The blocks are tumbled in a Los Angeles Abrasion Testing drum (without the steel balls) at 25 C for300 revolutions.

In order to obtain a measure of the durability of the mix a durability test has been introduced. This essentially subjects a compacted sample of the mix to accelerated ageing in a pressure vessel at 80C for 72 hours. After the ageing the cantabro test is performed the ratio of the initial loss to the aged specimen is determined. Although this test may in the future be specified for use on all binder types it is currently specified for use only with polymer modified binders. The objective is to ensure that the properties of the PMB are such that enhanced life is obtained.
Although PMB has the potential to allow higher binder contents than straight bitumen it depends on the properties of the PMB and the use of an appropriate mixing temperature. There is at present no accepted method of determining the appropriate mixing temperature for PMBs and thus the same criteria that was used in the previous edition of this specification has been retained. This requires that the binder drainage test is performed using 80/100 bitumen to obtain the maximum binder content that meets the void requirements and drainage criteria. This binder content is then used with the PMB.

7. TACK COAT

The roadway surfacing underlying the open graded porous asphalt should 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/m^2 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 membrane will be
required where OGPA will be laid on a granular basecourse, refer to the NZ supplement to the Austroads Pavement Design Guide.
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.

8. MIXING TEMPERATURES

The mixing temperature is based on the viscosity versus temperature relationship of the bitumen. Penetration grade bitumen mixing and compaction temperatures shall be modified to attain binder viscosities of 1 Pa.s ± 0.1 Pa.s and 2 Pa.s ± 0.2 Pa.s respectively.

For typical New Zealand bitumen mixing temperatures of 115°C and 120°C for 80/100 and 60/70 grades are appropriate.

9. TRANSPORTATION, SPREADING, TRIMMING AND COMPACTION

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 diesel is. When a soap or detergent and water solution is used, the truck tray 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 open graded porous asphalt extends more than 0.5 m 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.

When twin layer systems are used the height of the seal may be up to 70 – 100mm proud. Care needs to be taken to ensure that this does not become a safety hazard. Details of measures taken to prevent safety hazards need to be clearly defined in the contract documents.

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 rolls, as an over-supply 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.

Where polymer modified materials are used the manufacturers recommendations with regard to compaction temperatures should be followed. OGPA mixes are difficult to hand lay and the addition of polymer exacerbates the problem.

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 preset layer thickness for the open graded 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.