

NZTA M01-A NOTES: 2022

NOTES TO THE SPECIFICATION FOR PERFORMANCE-GRADED ASPHALT BINDERS

1 BACKGROUND

For many years New Zealand bitumen was based on an empirical Penetration based specification. However, changes to the crude oil feedstock used to manufacture bitumen, plus the importation of bitumens into New Zealand from other refiners who use other crude oil feedstock has meant that the empirical Penetration test could no longer be used to infer performance. This has led to the adoption of a performance-based specification for asphalt binders.

This performance-based binder specification is aimed at lowering the risk to Waka Kotahi, other road controlling authorities and the contractor by specifying fundamental material properties that predict performance with respect to traffic and within the New Zealand climate temperature range. It is closely based on AASHTO M332 which was developed from research linking binder properties to asphalt deformation.

2 PROPERTIES OF PERFORMANCE GRADES

2.1 General

The testing regime examines the three critical stages of a binder's life:

- (a) Storage and handling prior to mixing with aggregate (original binder)
- (b) Asphalt mix production and construction (RTFOT residue)
- (c) Binder ageing on the road (PAV residue).

A brief description of the properties used to characterise the binder during these stages is outlined below.

2.2 Flash point and Viscosity at 135°C

A minimum flash point is included as a safety measure and is set at a value above the temperatures that would be expected during binder and asphalt manufacture and storage.

A maximum viscosity at 135°C on the un-aged binder has been included to permit binders to be pumped and evenly mixed with aggregate during asphalt production.

2.3 $G^*/\sin\delta$

The $G^*/\sin\delta$ criterion was originally an output from the SHRP program in the USA as a predictor of rutting. However, research and experience has shown that $G^*/\sin\delta$ is not well correlated with the performance of nonlinear viscoelastic systems or conditions that are seen with modified and aged binders. Nonetheless it is retained in the specification as an index criterion providing a link to earlier data and binder specifications.

2.4 Creep Compliance - $J_{nr3.2}$

A strong correlation between rut-resistance and J_{nr} has been developed using typical traffic spectra and a range of unmodified and modified binders. If the binder meets the appropriate J_{nr} specification, then it is expected that the binder will have a minimal contribution to rutting. The binder testing is done at the highest expected pavement temperature and if heavy traffic is expected the requirement J_{nr} is changed to reflect the increased loading the pavement will experience.

2.5 Significance of $J_{nr-diff}$

The J_{nr} is considered independent of stress level for most types of binders, up to 3.2 kPa stress. However, some modified binders exhibit stress dependency when tested at 3.2 kPa as indicated by a $J_{nr-diff}$ greater than 75%. These types of binders behave differently depending on the traffic stress applied to it.

If the $J_{nr-diff}$ exceeds 75%, it does not necessarily mean that the binder will fail to improve deformation resistance. It does mean however, that the correlation between J_{nr} and rut resistance may, or may not hold for that binder, especially if subjected to higher than normal traffic stress. The suitability of a particular binder for use can be independently verified by performing a wheel tracking test during the asphalt mix design process.

2.6 Creep Stiffness (S), m Value, Failure Strain

When pavement temperatures decrease asphalt shrinks. Since friction against the lower pavement layers prevents movement, tensile stresses build-up in the pavement leading to cracking. To prevent this cracking, creep stiffness as measured with the bending beam rheometer (BBR) has a maximum limit of 300 MPa.

Studies have also shown that if the binder can stretch to more than 1% of its original length, cracks are less likely to occur. A uniaxial tension test at constant elongation rate called the direct tension test (DT) measures this ability. The constant elongation rate simulates the loading during thermal cooling of the pavement. The amount of strain that occurs before the sample breaks is recorded and compared to the 1.0% minimum. It is only applied to binders that have a creep stiffness between 300 and 600 MPa. If the creep stiffness is below 300 MPa, the direct tension test is not performed.

In this grading system a minimum temperature is required as security to minimise low temperature cracking. The -16°C as stated is based on real bitumens that have been shown to work successfully when tested for these properties. This gives extra security for ensuring the best crack resistance at lower temperatures - no matter what the mechanism or type.

In AASHTO M 332 Table 1 the low temperature properties Creep Stiffness and Direct Tension (i.e. S at -6°C, m – value at -6°C and Failure strain at -6°C) are only required when the binders will be used in mixes that will experience consistently cold temperatures (such as in Central Otago, Inland Canterbury, Southern Alps and higher elevations in the Central North Island). In these tests, only single event thermal cracking is considered; load induced and thermal cycling fatigue cracking are not.

3 BINDER GRADE SELECTION

3.1 Climate Zones

This specification matches the binder properties to the temperatures experienced at the site. New Zealand has been divided into three climate zones: cool, moderate and warm. The first step in selecting a binder grade is to identify the climate zone appropriate for the site from the climate zone map.

The map outlines broad climate zones. Binders should be selected and specified based on the site climate zone, but engineering judgement should be used if localised microclimates within climate zones subject the binder to higher or lower maximum temperatures. In this case the climate zone and consequently the binder grade should be adjusted appropriately to match the binder grade to the site conditions.

Table 1: New Zealand Climate Zones

| Climate Zone | Binder Grade |
|--------------|--------------|
| Cool | PG 52 -16 |
| Moderate | PG 58 -16 |
| Warm | PG 64 -16 |

The grade temperature, 52°, 58° or 64°, as defined by the site becomes the temperature at which the binder performance testing is carried out in the laboratory.

The intention is to provide for the use of binders that are sufficiently stiff at site maximum temperatures to resist permanent deformation of the asphalt (rutting and shoving) but not so stiff as to create workability and compaction issues, and also not to become brittle at site minimum temperatures.

3.2 Traffic Category

The specification sets out four performance levels, “S”, “H”, “V” and “E” based on traffic loading measured in equivalent standard axles (ESA) over the design period and traffic speed. ESA can be calculated from AADT and commercial vehicle data. For new pavements or rehabilitation works this information will be in the pavement design report.

Binder grade traffic categories are separated between surface mixes and sub-surface mixes. A sub-surface mix is defined as a layer deeper than nominally 80mm in the pavement structure.

Grades can be produced through a process of blending different bitumen grades or by the addition of modifiers to the bitumen. The specification does not discriminate between these methods. However, for the Very high (V) and Extremely high (E) grades, the use of a modified binder is more likely. This may require some modification to the asphalt laying process in terms of minimum compaction and pavement temperatures which should be reflected in the contractor’s quality plan.

4 ASPHALT GRADES

The performance-graded binders are appropriate for dense graded asphaltic as specified by M10 specification.

The performance graded binders may also be used for Stone Mastic Asphalt (SMA). However, experience in New Zealand has related loss of texture and flushing in SMA with the use of softer or unmodified binder grades. Refer to NZTA M27 specification for guidance on binder grade selection.

The performance-graded binders may also be used for Open-Graded Porous Asphalt (OGPA) complying with NZTA P11 specification. OGPA generally fails by binder hardening due to oxidation, so the intention is to use the least stiff (highest J_{nr}) binder, appropriate to the climate zone that allows compliance with the Cantabro abrasion resistance criterion of P11. It is expected that such binders will maximise the life of the OGPA, while the Cantabro test will prevent the use of inappropriately soft binders.

5 OTHER PERFORMANCE CONSIDERATIONS

The binder properties in this specification relate to controlling rutting and fatigue. There are times where a type of binder is desirable in surfacing mixes to improve other aspects of performance that are not related to traffic. For example, using a polymer modified binder in open graded asphalt can allow thicker binder films in the mix without the risk of binder drain down and so increase the life of the surfacing.

In these cases, a binder grade different to that indicated by the traffic category in Table 1 may be needed. It is recommended to consult with the asphalt supplier on an appropriate binder for these situations. Advice on binder selection is also available from the Waka Kotahi Principal Surfacing Engineer. Contact pavements@nzta.govt.nz.

6 QUALITY ASSURANCE REQUIREMENTS

The NZTA Q05 specification requirements will need to be met for all bitumens imported into New Zealand.

As performance grades can be produced through different means (blending or modification), the supplier will need to include in their quality plan how they will achieve specification compliant properties. General requirements that should be addressed in a quality assurance plan are specified by NZTA Q05.

For Polymer Modified Binders (PMBs), compatibility of the base bitumen and the polymers needs to be considered by the supplier to minimise the risk of segregation (bitumen and polymer separation) and degradation (properties of binder fall below specification values). PMBs can be prone to degradation when stored at elevated temperatures for long periods. Therefore, the binder supplier may place requirements around storage times and temperature. For unmodified binders, segregation will not be an issue.