

Technical Note 213

Registration of nonstandard dense graded asphalt mixes containing bitumen adhesion agents instead of hydrated lime

May 2025



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1 Background – the role of lime in reducing stripping in asphalt

Moisture induced damage due to the stripping of the bituminous binder from aggregates is a concern for asphalt pavements that are exposed to moisture during their in-service life. In severe cases this damage can lead to cracking, loss of shape (rutting) and the formation of potholes in the pavement, and ultimately lead to premature failure of the pavement. Increased maintenance and costs may also result.

During the 2000s severe moisture damage was observed in several asphalt pavements in Queensland on the state-controlled road network (e.g. Figure 1). Investigation of some of these moisture damaged asphalt pavements found that the insitu asphalt had poor cohesion, low strength and uncoated aggregate particles in the mixture. In many cases, asphalt layers were also found to be saturated with moisture (e.g. Figure 1).

Figure 1 – Example of a stripped asphalt pavement and of a stripped asphalt layer



To help combat this issue, the Department of Transport and Main Roads implemented a number of significant changes to its asphalt specifications to reduce the moisture sensitivity of asphalt pavement layers. One of these changes was the mandatory inclusion of at least 1% hydrated lime in all dense graded asphalt mixes. Hydrated lime has a strong affinity for bitumen and its inclusion in asphalt mixes helps to reduce the moisture sensitivity of these mixes. Since these changes were introduced, the number of projects exhibiting moisture induced damage (on the state-controlled road network) has reduced significantly.

2 Innovations in asphalt through nonstandard mix designs

The department's asphalt specifications and mix design registration process currently include provision for the registration of nonstandard asphalt mix designs. This provides the department (and contractors) with a mechanism to trial the use of innovative nonstandard constituent materials and/or asphalt mixes provided:

- their use aligns with the strategic objectives of the department (such as increasing the use of recycled materials or supporting decarbonisation of transport infrastructure), and
- information / test data that is satisfactory to the department is submitted and the department is satisfied it supports the potential use of the nonstandard mix design on Transport and Main Roads projects.

In addition:

- the department may require the completion of additional testing or assessments prior to registration being granted, and
- 'Conditions of use' associated with the implementation and use of these mix designs on Transport and Main Roads projects may also be applied (e.g. to enable trials while managing risk).

Depending on the particular case, to provide a more holistic picture, the additional testing or assessments may include work / testing to assess engineering, safety and/or environmental impacts related to use of the nonstandard mix design (e.g. by benchmarking the proposed nonstandard mix to the nearest 'conventional' standard mix). Reference should be made to the department's Technical Specification MRTS30 *Asphalt Pavements* and Technical Note 148 *Asphalt Mix Design Registration* for more details about nonstandard (and nonconforming) mixes.

The use of bitumen adhesion agents (BAAs) in lieu of hydrated lime (to reduce the moisture susceptibility of asphalt) for example has the potential to help decarbonise transport infrastructure which aligns with the department's vision of 'Connected communities in a sustainable, thriving and inclusive Queensland' and supports the 'Sustainable' aspect of the department's strategic plan.

3 Bitumen adhesions agents as a potential alternative to hydrated lime

Austrroads recently undertook a project that investigated the potential of using BAAs (i.e. anti-stripping additives) as an alternative to hydrated lime for reducing the moisture susceptibility of asphalt layers in-service. The project primarily comprised a literature review and found that in addition to improving the moisture resistance of asphalt mixes, hydrated lime also acts as a mineral filler that can assist with:

- achieving the desired aggregate particle size distribution
- reducing the plasticity of any clayey particles present in the mix, and
- improving the deformation resistance and oxidation properties of the binder mastic.

The literature review also identified several studies that indicated a range of BAAs can also be used, as an alternative to hydrated lime, to reduce moisture sensitivity of asphalt layers.

Some of the tangible benefits of using BAAs over hydrated lime in asphalt include:

- lower costs, and
- a smaller carbon footprint.

Additionally, some BAAs can also function as a warm mix asphalt additive and so be used to lower asphalt production and paving temperatures (as well as to reduce moisture susceptibility).

The outcomes of the Austroads project are documented in report AP-R708-24 *Feasibility of Using Anti-stripping Additives as an Alternative to Hydrated Lime*.

4 Transport and Main Roads' approach to moisture sensitivity assessment and recent developments

Like many state transport jurisdictions in Australia, the Department of Transport and Main Roads currently uses the ATM 232 *Stripping Potential of Asphalt – Tensile Strength Ratio* test to assess the moisture sensitivity of asphalt mixes. Although this is a commonly used test (both in Australia and overseas), the department has not found it to be a wholly reliable indicator of the moisture sensitivity of asphalt mixes. For example, the department has found on several occasions that mixes complying with specification requirements for moisture sensitivity using ATM 232 have exhibited severe moisture induced damage in the field.

To address this issue, the Department of Transport and Main Roads and the National Transport Research Organisation (NTRO) has undertaken a preliminary investigation, through the National Asset Centre of Excellence (NACoE) research program, to assess the suitability of using the department's Test Method Q325 *Stability of asphalt – Hamburg wheel tracker (HWT)* test as an alternative to ATM 232. Although the department's Test Method Q325 test has shown promise of being able to more accurately predict the moisture sensitivity of asphalt mixes, further research is required before it can be formally introduced into the department's standard specifications for asphalt.

5 Protocol for assessing the suitability of dense graded asphalt mixes that contain a BAA instead of hydrated lime

The protocol described below, which is based on the interim laboratory assessment protocol outlined in Austroads report AP-R708-24, provides the department's Prequalified Asphalt Contractors (PACs) with guidance about how they can demonstrate to the department that they have developed a (nonstandard) mix design that contains a BAA (instead of hydrated lime) and has a low risk of stripping when placed in a well designed and constructed pavement.

The protocol consists of 4 phases:

1. Desktop assessment
2. Constituent materials testing
3. Binder – aggregate adhesion testing, and
4. Asphalt mix performance testing.

5.1 Desktop assessment

The PAC must provide to the department's Asphalt Mix Design Registrar:

- a sample of the BAA proposed for use. The sample may be subject to Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) spectroscopy testing for future reference
- the following information about the BAA proposed for use:
 - details of the quality management systems that are used to ensure that a consistent product will be supplied
 - details from the manufacturer regarding the product such as a product description, the type of technology (i.e. amine, silane, etc.), recommended dosage rates, storage and handling requirements (including storage and temperature stability details) and any secondary benefits
 - the safety data sheet for the product
 - proposed method of dosage and details about how the dosage rate will be monitored for quality control purposes, and
 - evidence of proven performance elsewhere (either in Australia or overseas) in a similar application / usage.

The nominated BAA content must be within the range of 0.3-1.0% by mass of binder and be consistent with the additive manufacturer's recommendations.

5.2 Constituent materials testing

The PAC must undertake the following testing on the constituent materials of the proposed nonstandard mix:

- test the bituminous binder(s) to be used with and without addition of the BAA to demonstrate conformance to specification requirements in both cases, and
- for the combined filler (excluding hydrated lime), demonstrate compliance with the department's asphalt specifications and the following requirements:
 - methylene blue value ≤ 10 , and
 - voids in dry compacted filler $\geq 40\%$

The methylene blue value requirement for the combined filler also applies to each individual component that make up at least 20% of material passing the 0.075 mm sieve in the mix (e.g. crusher dust, manufactured sand, rock flour and baghouse dust).

Mixes that contain materials that do not conform with these requirements will not be considered for registration as a nonstandard mix design at this time. However, once satisfactory performance has been demonstrated with a variety of mixes that have a methylene blue value ≤ 10 , the nonstandard mix design registration process may be expanded to include mixes that have a methylene blue value > 10 and ≤ 18 .

5.3 Binder – aggregate adhesion testing

The PAC should undertake the following testing as a qualitative assessment of the adhesion between the bituminous binder and aggregate:

- resistance to stripping of cover aggregates from binders (in accordance with AS 1141.50 *Methods for sampling and testing aggregates, Method 50: Resistance to stripping of cover aggregates from binders*):
 - conduct the testing (with and without addition of the proposed BAA at the nominated percentage) using 14 mm aggregate in an “as received” condition state for each aggregate source (including coarse aggregate, crusher dust and manufactured sand sources) and the bituminous binder(s) to be used in the mix, and
 - report the results obtained.

5.4 Asphalt mix performance testing

The Contractor must prepare 3 mix designs with similar gradings and binder contents to test the following combinations:

- hydrated lime and no BAA (i.e. a conforming mix design containing 1.0-1.5% hydrated lime)
- no hydrated lime and no BAA, and
- no hydrated lime and BAA (dosed at the nominated adhesion agent content).

Mix designs used for this testing would not typically contain reclaimed asphalt pavement (RAP) material or recycled glass aggregate.

The PAC must then conduct the following tests on each of the 3 mix designs to compare their performance:

- Test Method Q305 *Stability, flow and stiffness of asphalt – Marshall* (or AS/NZS 2891.2.2 *Methods of sampling and testing asphalt, Method 2.2: Sample preparation – Compaction of asphalt test specimens using a gyratory compactor*)
- ATM 232, and
- Test Method Q325 in accordance with Section 5.4.1.

The PAC must repeat the testing for each bituminous binder to be used.

The following test parameters must be used for Test Method Q325 testing:

- duplicate test specimens (i.e. 4 pats per test)
- specimens shall be compacted to $7.0 \pm 1.0\%$ air voids, and
- 50°C test temperature.

Further, the Test Method Q325 testing is to be terminated once a 12.5 mm rut depth or 30,000 passes is achieved and the rut depth reported after every 5,000 passes and when the test is terminated.

Unless otherwise determined by the department's Asphalt Mix Design Registrar, for the nonstandard mix to be registered the Test Method Q325 testing must demonstrate the mix containing the BAA:

- provides similar (or better) performance to the equivalent conforming (standard) mix design, and
- conforms to the following requirements:
 - ≤ 12.5 mm rut depth at:
 - 20,000 passes for polymer modified binder (PMB) and M1000 mixes
 - 15,000 passes for C600 mixes, and
 - 10,000 passes for C320 mixes.

Note: 15,000 and 10,000 passes may be reduced to 10,000 and 5,000 passes respectively if deemed appropriate by the department's Asphalt Mix Design Registrar.

5.5 Acceptance criteria

Unless otherwise determined by the department's Asphalt Mix Design Registrar, the requirements of the department's Technical Specification MRTS30 *Asphalt Pavements* and the criteria outlined in this document will be used to assess the suitability of dense graded asphalt mixes that contain a BAA instead of hydrated lime to be registered as nonstandard mix designs.

Mix designs that comply with the class 320 bitumen mix requirement for Test Method Q325 testing, will be deemed to comply with class 600 bitumen and PMB mix requirements for Test Method Q325 testing. Mix designs containing M1000 bitumen must be assessed separately to those containing bitumen and PMBs due to the different chemistry involved with multigrade bitumen binders.

Where the Contractor submits additional mix designs that use the same constituent materials, the Asphalt Mix Design Registrar may reduce the testing requirements for registration of the additional mix designs provided satisfactory performance is demonstrated by the first mix design.

6 Usage of nonstandard mix designs with BAA instead of hydrated lime on Transport and Main Roads projects

Usage of nonstandard mix designs on departmental projects requires Administrator acceptance prior to use (refer Hold Point 3 in MRTS30 *Asphalt Pavements*). Further guidance about the potential use of nonstandard mix designs on departmental projects is outlined in MRTS30 *Asphalt Pavements*.

Until more experience is gained with the use of nonstandard mix designs that include BAA instead of hydrated lime, the department's Engineering & Technology Branch will generally recommend their use be limited to projects involving not more than 2,000 tonnes of a particular nominal size mix. It is anticipated that the Engineering & Technology Branch will increase the recommended tonnage limit once a proven track record of satisfactory performance has been established for these mix designs.

The recommended tonnage limit that applies to a specific design will be listed on the department's Asphalt Mix Design Register. In addition to the mix conformance requirements outlined in MRTS30 *Asphalt Pavements*, nonstandard asphalt mix designs that contain a BAA instead of hydrated lime must be tested on each project to conform compliance with the Test Method Q325 requirements outlined in Section 5.4.1 of this document. However, testing is not required on small scale projects (i.e. projects that include <500 tonnes of asphalt).

Undertaking this testing at a project level will provide the department's Project Managers with additional confidence that the mix being supplied to their projects will provide satisfactory performance in the longer term. The results from this testing will also be used to help inform future specification development.

7 References

- Austroads, *Feasibility of Using Anti-stripping Additives as an Alternative to Hydrated Lime*, AP-R708-24
- Austroads, *Stripping Potential of Asphalt – Tensile Strength Ratio*, ATM 232
- Standards Australia, *Methods for sampling and testing aggregates, Method 50: Resistance to stripping of cover aggregates from binders*, AS 1141.50
- Standards Australia, *Methods of sampling and testing asphalt, Method 2.2: Sample preparation – Compaction of asphalt test specimens using a gyratory compactor*, AS/NZS 2891.2.2
- Transport and Main Roads, *Asphalt Pavements*, MRTS30
- Transport and Main Roads, *Asphalt Mix Design Registration*, TN148
- Transport and Main Roads, *Stability, flow and stiffness of asphalt – Marshall*, Test Method Q305
- Transport and Main Roads, *Stability of asphalt – Hamburg wheel tracker (HWT)*, Test Method Q325

