A renewed look at bitumen performance

A recently completed research project supports the development of a New Zealand performance-based specification for bitumens when used in chipseals.

Undertaken in 2015 by Opus Research, Opus International Consultants, the project investigated three specific aspects of bitumen performance in chipseals:

- compatibility with kerosene
- adhesion to aggregate in the presence of water
- chip retention in relation to binder cohesive energy.

The Transport Agency is currently developing a performance-based bitumen specification, which will ultimately replace the current M/1:2011 bitumen specification for chipseal binders. A performance-based specification is one where the bitumen properties specified are directly related to the key performance properties required from road surfaces. So, for example, a future specification might specify bitumen properties relating to chip retention or surface failure modes (such as water-induced adhesion failure).

Compatibility with kerosene

Kerosene is added to bitumen to temporarily lower its viscosity to assist with chip wetting and allow sealing chips to reorient during and following construction.

In the existing M/1 specification there is a requirement that bitumen is 'compatible' with kerosene. The concept of compatibility means that the addition of kerosene to a bitumen results in consistent changes in its viscosity.

The research found that, in fact, differences in the base (unmodified) viscosity of the bitumen have a far greater impact than those produced by small differences in kerosene compatibility. Anecdotally, there is no evidence that kerosene compatibility differences have any practical impacts.

This conclusion was reached following an analysis of data from the past decade. The data demonstrated there would be no need for a kerosene compatibility requirement to be included in a new performance-based specification. If it was to be retained, then the overall effect of slope and base viscosity of the bitumen on its response to kerosene should be included in the assessment.

The research report notes, however, that the new performance specification for chipseal bitumens must make allowance for the fact that kerosene will be added during seal construction. This will affect the properties of bitumen, especially in the early life of the seal.

Adhesion to aggregate

Good chipseal performance depends on there being adequate levels of bitumen adhesion to the sealing aggregate and of bitumen resistance to water-induced stripping.

Any test to assess potential adhesion problems with chipseal binders needs to take into account chemical affinity (between the bitumen and the chip), potential degradation of adhesion agents at high temperatures (during handling) and the physical wetting of the aggregate at ambient temperatures. At present, contractors use Vialit plate adhesion tests to test particular bitumen-chip-adhesion combinations. The research found no better, practical test that warranted replacement of this test, but was able to suggest some changes to the test methods that may potentially improve its precision.

Inclusion of the Vialit test in a new bitumen specification would not be practical. Instead an acid number screening test and a rheological measurement related to the ability of the binder to adhere to wet chip were recommended for inclusion in the new performance-based specification.

Such tests would provide protection against bitumens likely to perform poorly, and would help ensure batch-to-batch consistency. The existing Vialit plate adhesion tests by contractors would continue to be required when new chip sources or adhesion agents were used.

Chip retention in relation to binder cohesive energy

One of the main functions of the sealing binder is to retain chip under traffic loadings. In the current M/1 bitumen specification, chip retention under traffic stress is only controlled for indirectly.

In the field, chip loss due to the cohesive failure of the bitumen film that is holding the chip tends to occur at either very low or very high road temperatures. As a result, the research recommended the new performance-based specification should include tests for bitumen properties at both low (-10ºC to 0ºC) and high (50ºC to 60ºC) temperatures.

The research also looked at the possibility of including binder cohesive energy in the new performance-based specification, and the methods available to measure this. Cohesive energy is defined as the energy expended to create two new bitumen surfaces.

At present, the only standardised method for measuring bitumen cohesive energy in relation to chip retention in chipseals is the Vialit pendulum test, used in the UK and Europe. The test has fundamental problems, however, that affect its accuracy.

The research also concluded that cohesive energy alone may not be the most suitable parameter for assessing the ability of a bitumen to resist chip loss. This was because the measured cohesive energy of a binder is strongly affected by its viscoelastic properties. Highly ductile materials can have high cohesive energies but also have yield strains that would in practice (in a chipseal), be unsatisfactory.

Alternative tests, for use at high and low temperatures were suggested, along with a recommendation that the new specification should include parameters for using these tests.

At low temperatures, a simple tensile test to measure and control the bitumen yield stress and strain was cited as a better alternative. Minimum yield (rupture), stress and strain values would be specified.

At high temperatures, tensile tests on bitumen become impractical. In addition, at high temperatures large non-recoverable deformations of the binder below the yield strain must also be controlled for. The research suggested that the multiple stress creep recovery (MSCR) test could be used at high temperatures instead, with a maximum value for the creep compliance and a minimum value for the percent recovery specified.

The research report sounds a note of caution, however, stating that additional research is needed before either the tensile or MSCR test approaches are adopted.