Cracking in specialist surfacing systems

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RESEARCH REPORT 598

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Preventing premature failure of specialist surface systems

New research explores the relationship between specialist surfacing systems, and their underlying substrates, to understand whether and why the surface is likely to fail.

Specialist surfacing systems, such as high-friction surfaces (as used in known trouble spots to prevent skidding) and coloured traffic-calming surfaces (as used in bus and bicycle lanes) have gained huge popularity since they were first introduced in New Zealand.

However, they have also been plagued by premature failures, due to cracking, delamination, chip loss and other causes. Many of these failures have been found to originate from, or at least be associated with, the performance of the underlying pavement substrate.

Specialist surfacing systems are very expensive when compared with other surfacing treatments. To be cost-effective, expectations are that the systems need to last seven years or more. Premature failures add to the overall costs of using the systems, as well as undermining their functional effectiveness.

At present, New Zealand has a pilot performance-based specification for calcined bauxite systems (NZTA P25: 2011). In addition, a draft specification for coloured safety surfacing is being developed (NZTA P33).

The purpose of the latest research, undertaken by Opus Research, Opus International Consultants, was to extend the scope of these specifications so they could be used to minimise premature failure in specialist surfacing systems. For example, the current draft of NZTA P33 does not yet deal comprehensively with substrate condition, creating an obvious gap.

To this end, the research project assessed test methods that focused on the performance of the underlying substrate and its interaction with the specialist surfacing systems.

Specialist surfacing systems are multi-layered and can fail cohesively or adhesively. For them to work effectively, the bond strengths between the binder and the aggregate, as well as between the surfacing systems and their underlying substrate, are very important. Being able to predict surface failures, due to one of those bonds breaking, was a vital part of the research.

A number of commercial resin systems, namely epoxy, polyurethane and methyl methacrylate were tested using the standard tensile bond (pull-off) and percentage elongation (tensile) test methods in ASTM C1583-13 and D638-10. Thermal effects were also investigated through thermal cycling experiments.

The outcome was a general guideline for preventing premature failures, and a draft test method, with recommendations for the method's further refinement. The overall intention was to develop a test that could be implemented in the field.

The draft guidelines and test

Based on the findings of the test assessments, the project team developed a general guideline. Provided the three criteria in the guideline are met, the risks of the specialist surfacing system failing prematurely, for either adhesive or cohesive reasons, can be minimised.

- The system must be applied according to best practice. The surface must be clean and dry, and the resin system mixed according to the supplier's notes. Both of these steps will minimise the risks of adhesive or cohesive failure of the resin used in the system.
- The adhesive and cohesive strengths of the resin used on the substrate must be greater than the cohesive strength of the substrate itself. This will ensure loads are transferred from the thin specialist surfacing down to the substrate (to prevent delamination).

- The cohesive strength of the substrate, at various temperatures, must meet or exceed the expected traffic loadings (to prevent cohesive substrate failure).

The next step was to develop a draft test method that could be used to determine the various adhesive and cohesive strengths required by the guidelines.

As a starting point, it was recommended a tensile bond (pull-off) test should be incorporated in the draft specifications for calcined bauxite and coloured surfacing systems (NZTA P25 and NZTA P33, respectively). This would help ensure the adhesive bond strength of the resin used in the surface meets the cohesive strength of the substrate (the second criteria in the guidelines).

The apparatus used for this test should be capable of controlling the loading rate, and the equipment (load cell and loading speed) should be calibrated regularly, to ensure consistency. (The research report makes recommendations about the tensile loading test apparatus, based on models currently available on the market.) In addition, it is important to carry out testing on a representative set of samples.

It was also recommended a pull-off test should be conducted before the specialist surfacing system is applied. This will help ensure the underlying substrate is of sufficient strength to withstand potential traffic loading (the third criteria in the guidelines).

Based on the data from the research, the project team have set a preliminary benchmark that asphalt substrates have to be able to withstand – namely, tensile stresses of at least 750kPa (or approximately 1.5kN on a 50mm diameter test area) when tested at 23°C. This tensile strength could be achieved either by using a binder with a higher cohesive strength, or through allowing the asphalt substrate to age. The latter approach precludes specialist surfacing system being applied on freshly laid substrate; which is not recommended in any event. The research report recommends a way to conduct the testing to accommodate temperature variations in the field.

The test method is still in a draft stage, and one function of the research report is to make it available for further comment and refinement. Recommendations in the report to inform this process include field trials, and work to address gaps and create benchmarks for the testing processes.