NZ TRANSPORT AGENCY
WAKA KOTAHI
New Zealand Government

Significant benefits flow from measuring moisture levels in pavements

Deficiencies in the current means of measuring moisture at high speed in New Zealand road pavements was the impetus for research to develop a more objective and effective approach.

The current way of detecting damage to roads due to water, as a result of insufficient or ineffective drainage, is through visual condition indicators of surface distress. Flushing, cracks with pumping fines, and other types of pavement deterioration are all often lag indicators of inadequate drainage in the pavement.

Such measures are neither definitive, nor objective. A study by research partners Road Science, Downer and Roadscanners explored and developed a moisture measurement approach, suitable for use on New Zealand roads. The technology can identify potential sites that may benefit from drainage investment and can help quantify the effectiveness of road drainage.

Dr Greg Arnold of Road Science says, 'The NZ Transport Agency commissioned the research project to address the current lack of knowledge of moisture content in New Zealand pavements, and improve the understanding of the effectiveness of road drainage. The main purpose of the research was to determine how can we practicably measure, at highway speed, the moisture content in a pavement; and determine what its optimum level is before drainage intervention is needed. Further, there is a need for a moisture measurement survey method that can be used to determine the effectiveness of pavement moisture control techniques over a roading network.'

The research

Previous research at the Transport Agency's long-term pavement performance sites had found poor drainage was the number one factor affecting the rate of rutting and roughness deterioration in pavements. A comparison between sites with adequate drainage and those without, showed that those with inadequate drainage deteriorated at approximately 2.5 times the rate of adequately drained sites. This indicates there could be significant benefits from reliably and accurately identifying sites with inadequate drainage, so drainage improvements can be made.

The research team's initial task was to survey existing pavement moisture measuring techniques and identify those that showed the most promise for use in New Zealand.

A system from Roadscanners in Finland was chosen, which uses moisture detection equipment capable of surveying the whole road network at speeds of 60km/h to 80km/h. The system uses air and ground coupled ground penetration radar (GPR) at low and high frequencies (500MHz and 2.2GHz), with high definition video and 2D light detection and ranging (LIDAR) scans. This equipment was coupled with Road Doctor software to enable the results to be viewed and output to other databases, such as the Road Assessment and Maintenance Management (RAMM) database, Juno Viewer or a geographic information system (GIS).

The next step was to use the Roadscanners moisture detection equipment to survey a selection of roads in the lower North Island of New Zealand.

The full results are documented in the research report, which compares the moisture detected within the pavement layers and subgrade as a result of the trial, with evidence of surface defects due to moisture on the surveyed roads. The data was also verified against the results from test pits. The test pit data confirmed the results of the moisture survey data 80% of the time.

Using the data from the moisture survey

The raw data from the moisture survey provided a moisture damage index (MDI) value at three depths in the pavement (top 200mm, 200 to 400mm, and greater than 400mm):

$$\boldsymbol{MDI_{TOTAL} = 0.5MDI_{TOP} + 0.3MDI_{MIDDLE} + 0.2MDI_{BOTTOM}}$$

The method used to calculate the MDI was based on the roads surveyed in New Zealand to give a relative measure of moisture, with this data correlated to laboratory tests, test pit results and visual indicators of moisture.

The moisture survey data was collated together with the LIDAR rut depths, roughness and pavement depths at two-metre increments to give a complete picture of the pavement. Priority was given to improving drainage on sites showing both pavement rutting and high MDI values.

The MDI relies on an underlying model for correlating raw GPR data into the MDI calculation. The actual calculation of underlying top/middle/bottom layer MDIs from raw GPR data was not part of this research and will require further modelling, calibration and validation to enhance the reliability of the technique and to derive an openly available index for the New Zealand roading industry.

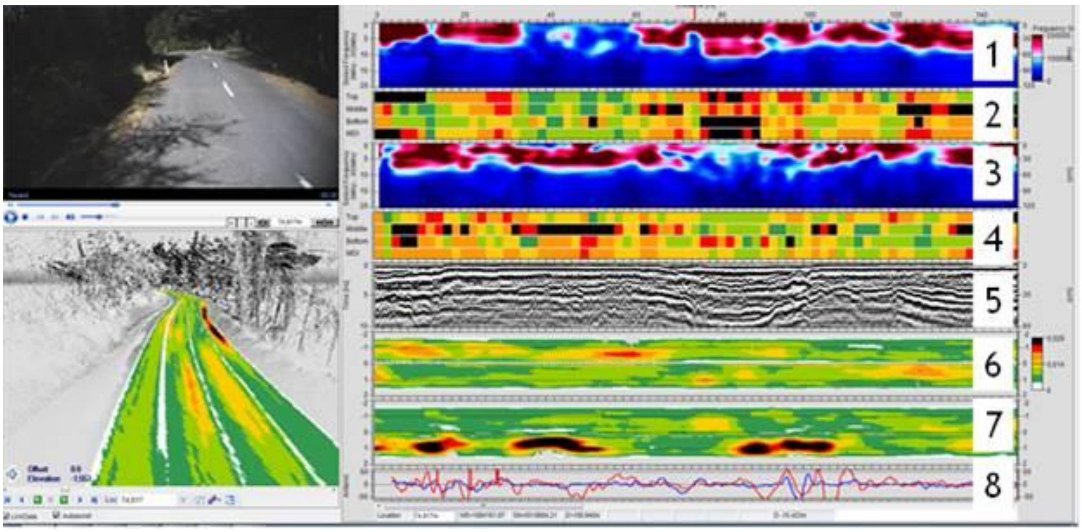
The outputs of the MDI have the potential to offer roading authorities a viable approach for surveying moisture content across their networks, in order to identify areas of moisture-based risk to pavement life, and enable more focused and informed investment decision making.

The MDI outputs could assist asset managers identify investment opportunities for planning forward works programmes on their networks. The MDI data can be output to GIS or Google maps, and colour coded as per the Road Doctor viewer software. Black areas are those with the highest moisture values and indicate to asset managers the areas that need looking at more closely with the Road Doctor viewer software to determine whether drainage improvements or surface waterproofing are required. The type of drainage improvement to be used at each location will depend on where the viewer software shows the water is being retained in the pavement. (Deep mitigation treatment will be required to remove moisture from the subgrade and shallow treatment to remove it from the basecourse.)

A cross-section view also enables the software to determine whether the depth of the drainage ditch adjacent to the pavement is adequate and whether there is a high shoulder lip trapping the water.

The figure below shows an example of moisture detection survey results.

In the figure, fields 1 and 3 present 400 MHz GPR moisture profiles (left and right lanes), while fields 2 and 4 present MDI data for top (0 to 200mm), middle (200 to 400mm) and bottom (400 to 600mm) depths. The highest and wettest areas are the black shaded areas in the MDI data. Field 5 presents layer thickness data from the GPR. Fields 6 and 7 present rut depth maps from left and right lanes on both sides of the road as measured with the laser LIDAR travelling in both directions.



Because the Road Doctor software also displays the LIDAR rut depth information, it enables the identification of small localised areas with depressions or other problems with moisture. These smaller areas are those that are commonly patched, and the software can be used by asset managers, when scheduling patch repairs, to determine if any drainage improvements are also required alongside the patched areas.

John MacDonald of the Transport Agency summarises the potential future relevance of the research, ‘As an industry, we have always known that moisture in unbound granular pavements reduces their durability and increases their susceptibility to damage under high loads. This research has shown that technological advances have now reached the point where systematic measurement of indicative pavement moisture content can be contemplated, once we develop the measurement techniques for routine deployment.

‘It is expected that this will help assess the permeability of road surfaces as they age, guide their repair or replacement, and identify areas of road that will benefit from improved surface water or subsoil drainage in order to increase the durability of road pavements.’