iPAVe saves billions by redefining live deflection measurement

The Hawkeye 2000 Series survey vehicle

Traffic speed deflectometer device (TSDD) technology has become the global benchmark for road asset management (RAMS) condition surveys. In South Africa, ARRB Systems leads with its proprietary iPAVe TSDD with onboard processing systems, which is saving billions of rand to the fiscus and promoting a safer road environment.

The origins of pavement deflection measurements can be traced back to Francis Hveem (1938) and subsequently the Benkelman beam developed in 1952. This measures sur face deflection via the axle load of the test vehicle on an instrumented beam. The practice is still in existence to this day in some countries.

The next breakthrough in deflection testing was the introduction of the first falling weight deflectometer (FWD) around 1968 in Denmark. In South Africa, subsequent evolutions of the FWD have been employed since the late 1980s for project and network level assessments.

Then, during the late 1990s, the traffic speed deflectometer device (TSDD) was piloted in Denmark. This proved to be a highly viable alternative to the long-established FWD method of measuring road pavement response to loading.

The introduction of the ARRB Systems iPAVe TSDD solution is now gaining increasing traction as the benefits of TSDD technology are becoming better understood by road pavement design engineers and RAMS managers.

In expert hands, FWD surveys provide an accurate view of the structural health of a road. However, it is a discrete test and not comparable to modern-day TSDD renditions, such as the iPAVe, which record deflections and other condition data simultaneously at a far higher resolution, thanks to advanced intelligent onboard systems. The best way to illustrate this is through a side-by-side comparison.

Stationary concerns

During FWD operations, the measurement device attempts to simulate a moving wheel by dropping a short impulse load on to the road surface. The response of the pavement to the load creates a deflection bowl, which is measured by a series of geophones. These are positioned at various distances from the load centre, typically starting at 300 mm and stepping out with the last geophone being at 1 800 mm from the load. The shape of the deflection bowl provides an indication of where a potential problem exists within the pavement structure.

However, a key requirement for FWD measurement is that the test vehicle remain stationary while testing, which raises traffic accommodation and serious safety concerns for both persons using the road and the technicians undertaking the measurements. The stop-start nature of the technique also makes it a time-consuming process. For example, tests are usually performed at 50 m to 100 m intervals for project level assessments, and at a 200 m or more spacing for network level surveys. At 300 test points per day, this equates to 15 to 30 lane kilometres at project level and a maximum of 60 lane kilometres for network level surveys.

Full mobility

In contrast, TSDD systems are highly mobile and efficient. Everything, including the two test personnel, is housed within a special, purpose-built vehicle. This is equipped with high-resolution doppler laser and advanced imaging technology that, together with ARRB Systems' Hawkeye software, make it possible to accurately capture and subsequently analyse high-definition integrated data sets continuously and seamlessly. Analysis is aided by ARRB Systems' Hawkeye Insight platform – a web-based viewing and analysis tool that enables the interrogation and evaluation of the collected data in a user-friendly format.

"TSDD testing enables us to calculate pavement deflections using measured horizontal travelling velocity and vertical surface displacement velocity. This provides a far more realistic measurement of the visco-elastic pavement response imposed by rolling tyre motion on the road surface. This cannot be achieved with FWD, which creates a purely elastic response. A significantly higher measurement frequency also means that TSDD technologies provide a far more precise road life estimation," explains Yeshveer Balaram, GM: South Africa, ARRB Systems. He adds that in terms of South Africa's Provincial Roads Maintenance Grant, up-to-date deflection measurements are a minimum grant compliance requirement.

As an early adopter of TSDD, ARRB Systems has led the way with the development of its iPAVe intelligent pavement assessment survey vehicle. This is believed to be the world's first fully integrated road surface and subsurface condition assessment system, providing integrated functional and structural data recording in one pass at speeds up to 80 km/h.

Currently, iPAVe vehicles are operating

"At project level, the cost per test/metre is almost 10 x more for FWD at a 50 m test spacing than the iPAVe at a 5 m test frequency."

across the world in diverse regions that include Australia, the UK, USA, China, and several European countries. ARRB Systems has two iPAVe vehicles deployed in South Africa and has surveyed more than 76 000 km of the country's paved road network since 2016. The iPAVe regularly undertakes surveys for provincial, metropolitan and national road authorities and consulting engineers under taking project level design work.

Meanwhile, ARRB Systems' global teams have collectively surveyed over 750 000 km to date. In the USA, the TSDD technology has surveyed roads in 30 states, with New Mexico being the latest state to award a multiyear routine TSDD testing contract for pavement management and rehabilitation purposes.

"ARRB Systems is also a member of the DaRTS (Deflection at Road Traffic Speed) focus group, which is a global forum of TSDD operators and users that meets on a bi-annual basis to share knowledge, discuss projects and give feedback on technological developments. Members include numerous state and federal road authorities in the USA, Europe and Australasia, as well as operators including the Australian Road Research Board, BASt (Germany), TRRL (UK), IBDiM (Poland) and the FHWA (USA)," says Balaram.

In South Africa and across the world, there's been a strong uptake in demand for iPAVe from design engineers and transportation specialists

iPAVE COST BENEFITS

The iPAVe is a powerful tool that uses advanced technologies to collect and analysefull-spectrum structural, surface and functional road condition data that is critical for the efficient life-cycle management of road networks, saving billions towards the fiscus by enabling optimal proactive, rather than reactive, maintenance strategies to be identified.

Benefits and uses include:

- Significant cost saving per test/metre over traditional structural testing methods
- The measured data is vigorously analysed and used towards the provision of safer road infrastructure
- Collects all pavement surface and structural parameters with high accuracy inone pass
- Ability to operate at traffic speeds, improving production, safety and efficiency
- Continuous measurements at significantly higher resolution than traditional techniques such as FWD
- Provides comprehensive data with which to make better informed decisions forfinancially and technically appropriate rehabilitation and surfacing treatments
- Better QA/QC for road agencies, consultants and contractorspromotes accountability

Removing the guesswork

The high accuracy and resolution of the iPAVe data enables engineers to pinpoint precise locations (down to 1 m) and areas where the capacity of the pavement structure is of concern. iPAVe provides additional and essential input to network level assessment and evaluation, which is crucial for deterioration modelling and future maintenance budgeting based on accurate determination of the expected serviceable lifespan. This information also influences the selection of optimal maintenance and rehabilitation strategies.

"Engineers design roads based on their structure. In many parts of the world, though, road asset managers still maintain roads based on their sur face characteristics. However, to reliably determine the remaining life of the pavement, both the structural and functional condition must be factored into the equation. This can only be truly

ARRB Systems' iPAVe intelligent pavement assessment vehicle is the first and only comprehensive pavement measurement system in the world, providing seamlessly integrated structural and surface condition data at highway speeds

ARRB Systems' Hawkeye Insight is a web-based viewing tool that enables the visual assessment of collected data, in a simple, user-friendly format

iPAVE COLLECTS ALL THE FOLLOWING INFORMATION:

- Pavement surface condition, including:
  - o Cracking
  - o Roughness (IRI)
  - o Texture (MPD and SMTD)
  - o Rutting
- Continuous pavement deflection
- Geometry (slope, crossfall, gradients)
- Spatial location (GLONASS GPS)
- Asset inventory imaging

determined through full-spectrum integrated techniques such as the iPAVe," says Simon Tetley, director, ARRB Systems.

"As technology solutions practitioners, our responsibility is to ensure that road authorities understand the limitations of FWD and the reasons why TSDD is regarded as the global best practice," he explains.

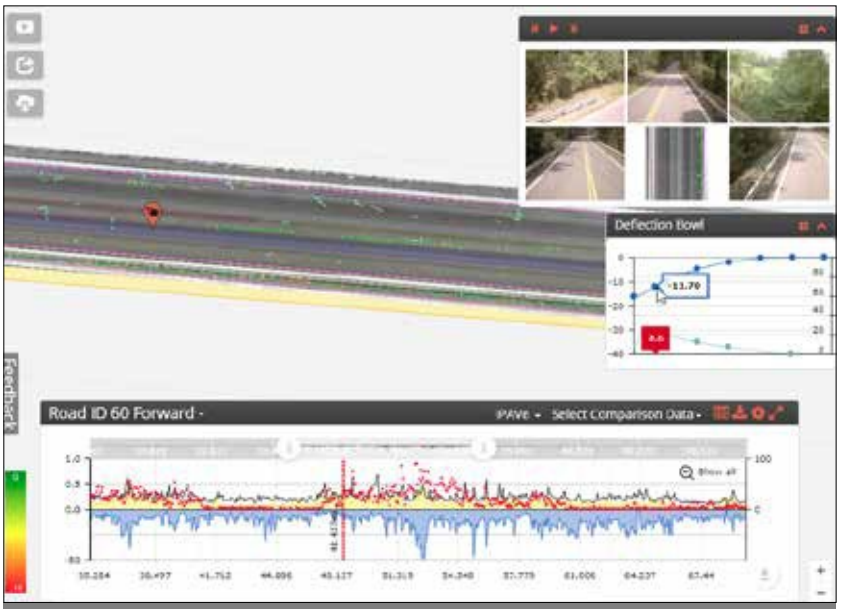
"With conventional methods, project level deflection measurements are typically done at spacings of 50 m and upwards, meaning that there are large gaps in the data. If it is assumed that each deflection point covers 5 m, at a 50 m spacing, a mere 10% of the project will have structural test data with which to undertake an appropriate pavement design – obviously not an ideal situation. Using technologies like iPAVe removes the guesswork, as there are no gaps, resulting in 100% of the project having structural test data," Tetley continues.

Financial implications

Getting a pavement design wrong because assumptions have to be made regarding the structural integrity of the pavement between test points has huge financial implications for road authorities and road users. For example, the problem might only be skin deep – i.e. a poor road surface condition is not necessarily an indication of overall pavement failure, negating the need for an over-engineered and overpriced remedial intervention. Conversely, under-design will lead to premature failure with resulting excess vehicle operating costs for road users, and additional needless expenditure incurred on road authorities and the national fiscus.

"In addition to better accuracy, iPAVe is also more cost-competitive. It has been calculated that, for project level, the cost per test/metre is almost 10 x more for FWD at a 50 m test spacing than the iPAVe at a 5 m test frequency. This does not include establishment and disbursement costs or the added benefit of synchronised riding quality, rut depth and road texture measurements provided by the iPAVe," Tetley explains.

"iPAVe is the perfect all-rounder when it comes to the rapid and efficient surveying of road networks and individual design projects at operating speeds of between 20 km/h and 80 km/h. This means that an iPAVe truck can potentially collect around 90 000 km of continuous data in a year or approximately 350 km a day, subject to road configuration and traffic congestion. If the TSDD data were to be processed at 10 m intervals, it would take an FWD 117 years to provide the same information," Tetley concludes. 35



iPAVe doppler laser beam measurements determine the pavement deflection bowl readings, which are seamlessly integrated with other pavement characteristics such as Cracking, IRI, Rutting, Texture and more

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