

Canterbury Accelerated Pavement Testing Indoor Facility



A world-leading pavement testing facility



OUR PURPOSE

CREATING TRANSPORT SOLUTIONS FOR A THRIVING NEW ZEALAND



NZ TRANSPORT AGENCY
WAKA KOTAHI



NZ Transport Agency (NZTA)

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CONTENTS

1

What is
CAPTIF?

2

Accelerated
pavement
testing in
New Zealand

3

Simulated
loading &
vehicle
emulator
(SLAVE)

4

Pavement
construction &
testing

5

The benefits
of accelerated
pavement
testing

6

Previous
projects

8

A selection of
recent CAPTIF
projects &
papers

What is CAPTIF?

Canterbury Accelerated Pavement Testing Indoor Facility (CAPTIF) carries out accelerated pavement testing for both public and private organisations.

Clients can specify the pavement design, vehicle configuration, and data to be collected. CAPTIF staff can advise on these matters.

Examples of testing that can be undertaken include:

- pavement materials and construction techniques
- comparative testing of different heavy vehicle suspensions, loads and tyres
- pavement/vehicle interaction.

Pavement testing is carried out indoors, in a controlled environment that eliminates weather factors that can otherwise cloud the results obtained.

CAPTIF was successfully utilised in DIVINE (dynamic interaction of vehicle and

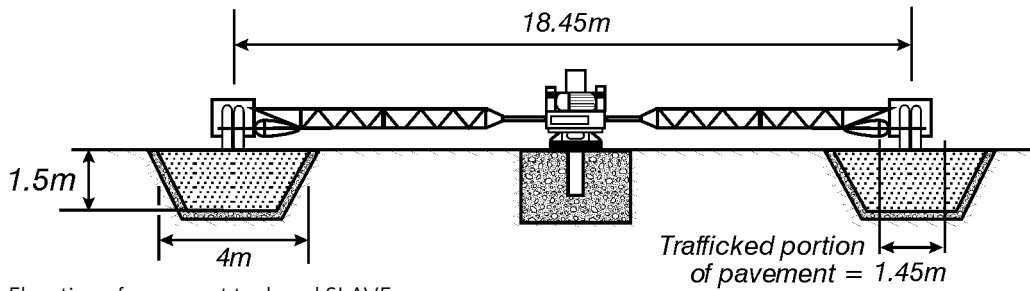
infrastructure experiment) to determine vehicle suspension effects on pavement condition and performance.

Fully computerised data acquisition systems, both in the pavement and on the vehicles, ensure complete data sets for the duration of the tests.

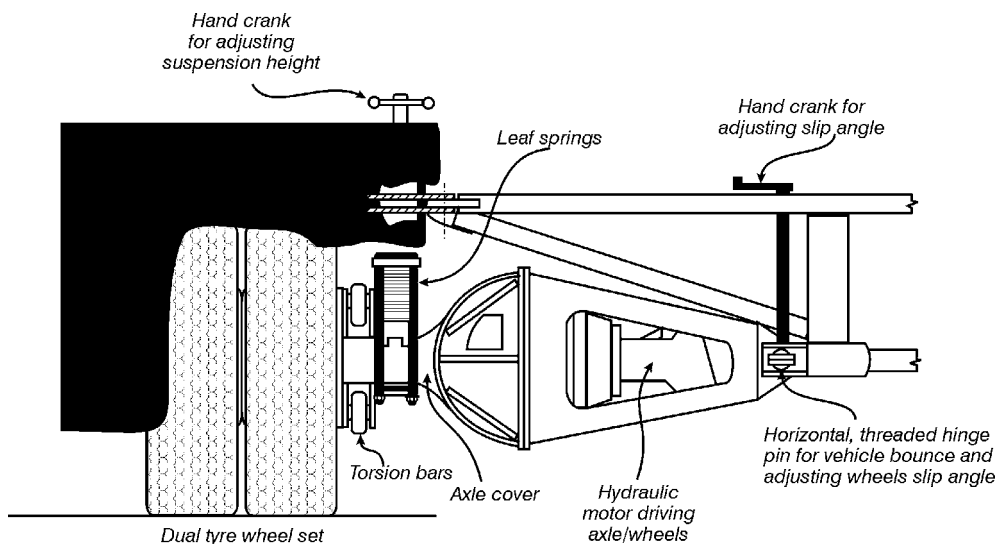
Data can be transmitted worldwide overnight for complete project control.

A full data analysis and reporting service is available, or the data can be compiled and forwarded to the client in raw form.

CAPTIF presents a unique opportunity in which pavement and vehicle engineers are able to work together, thereby aiding in the interpretation of the results.



Elevation of pavement tank and SLAVE



Elevation of a SLAVE vehicle

Accelerated pavement testing in New Zealand

Accelerated pavement testing has been conducted in New Zealand since the late 1960s.

The key milestones are:

- The first New Zealand accelerated pavement testing machine built in 1969–70 WDO Paterson's PhD project.
- Used until 1983 – research results justified significant upgrade.
- CAPTIF facility built 1984–86.
- Major refurbishment 1997–98.

Clients have included:

- Austroads.
- BP Oil International Ltd.
- National Roads Board.
- Organisation for Economic Cooperation and Development (OECD).
- Transfund New Zealand.
- Transit New Zealand.
- NZ Transport Agency (NZTA).
- Ministry of Transport.
- Cement and Concrete Association of New Zealand.
- Opus International Consultants.

CAPTIF has been used by a number of roading agencies for a diverse range of projects. Among the projects undertaken to date, the OECD's dynamic interaction of vehicle and infrastructure experiment (DIVINE) project perhaps provides the most outstanding compliment to CAPTIF's unique abilities.

Accelerated loading facilities throughout OECD member countries were evaluated in terms of their potential to serve the research objective. CAPTIF was selected primarily because, alone among accelerated loading facilities, it was designed to generate realistic dynamic wheel loads. And because the facility has dual arms, so that the effects of two different suspensions can be compared simultaneously. The CAPTIF 'vehicles' which apply the loads are fitted with suspensions based on actual heavy vehicle components.



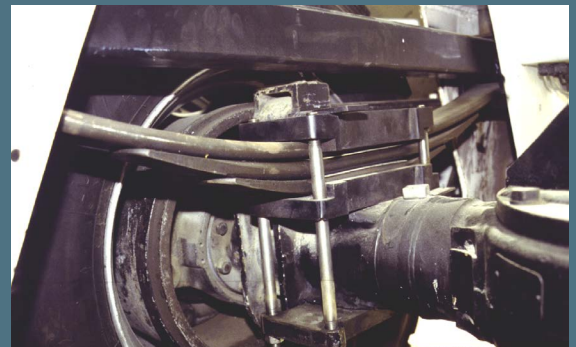
The original test machine (1969–83)



The current test machine (1986–present)

Simulated loading and vehicle emulator (SLAVE)

- Operates continuously for long periods unattended. Safety features automatically stop the rig in case of pavement or machine failure.
- Runs at speeds from 5-50km/h, programmable in 1km/h increments.
- Applies realistic dynamic loads and tractive forces to a test pavement at a high rate (up to 18,000 revolutions in 24 hours).
- The geometry of each vehicle can be adjusted in terms of wheel camber and toe-in.
- Distributes the loads over the test pavement to any user-defined pattern, programmable in 1cm increments over 1m of transverse travel. The trafficking distribution can be configured so that each unit travels in a separate wheelpath.
- Employs trapezoidal leaf, parabolic leaf or air bag suspensions in each of the two vehicles. Either dual or single wheels can be fitted.
- Able to carry a wide range of data acquisition equipment and can transmit data, such as dynamic vehicle loads and axle movements, while in motion.
- Carries static loads from 21kN to 60kN, in 2.75kN increments, on each vehicle.
- A 50kW electric motor drives a hydraulic pump which powers a hydraulic motor in each SLAVE unit. The electricity for the electric motor is transferred to the central pedestal through slip rigs at the base of the pedestal.
- The rig is controlled by an industrial programmable logic control (PLC) unit mounted in the central of the rig. The PLC unit is controlled by a computer in the control room. The computer and PLC communicate with each other using a wireless modem.



Pavement construction and testing

Pavement tank

The pavement is built in an annular concrete tank 4m wide by 1.5m deep. The tank has a mean radius of 9.2m and a volume of 400m³. The tank means that the moisture content of the pavement can be controlled, regardless of the level of the water table at the site.

Subgrade construction

The subgrade material is placed by a loader, compacted with a small sheepfoot trench roller then trimmed to shape. The subgrade is typically 1.2-1.3m deep and has a California bearing ratio (CBR) of 3-14%.

Basecourse construction

The basecourse material is either placed by a paver or levelled using a laser controlled blade mounted on a tractor. It is then compacted with a large plate compactor and combination roller.

Construction testing

In addition to laboratory materials testing, extensive use is made of nuclear density measurement and falling weight deflectometer (FWD) equipment to monitor the quality of the pavement during construction.

In situ instrumentation

3D inductive soil strain coils, asphalt H bar strain gauges, soil pressure cells, time domain reflectometry moisture gauges and soil suction gauges are available to be installed in the pavement during construction.

Pavement surfacing

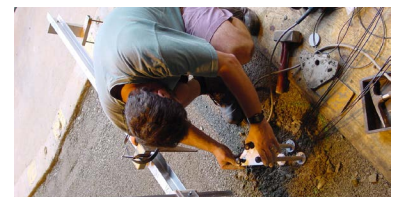
Either a chipseal or an asphaltic concrete surfacing is used. The chipseal binder is sprayed with a custombuilt spray bar and the asphaltic concrete surfacing is laid with a standard paving machine.

Accelerated pavement testing

The SLAVE units can rotate at 18,000 revolutions in a 24-hour period, meaning that the equivalent of 15-20 years worth of traffic can be applied in 6-9 months. Insitu instruments are regularly recorded and performance of the test monitored for rutting, roughness, texture and dynamic load changes.

Pavement postmortem

At the completion of the accelerated loading phase of a project, the pavement is trenched and tested to help understand mechanisms and the extent of any failures and/or types of distress present.



The benefits of accelerated pavement testing

The New Zealand experience

The benefits to New Zealand of the research programme conducted at CAPTIF since 1987 can be split into tangible and intangible benefits.

The tangible benefits include:

- Research into subgrade strain criteria that paved the way for the adoption of the Austroads 1992 *Pavement design guide*. The Austroads guide has led to more economic designs than the previous pavement design guide.
- The DIVINE research for the OECD proved that the 4th power law could not be used in vehicle dynamics research, spatial repeatability does occur and road friendly suspensions must be in good operational condition to provide any benefit.
- Another key finding has been in the use of the repeat load triaxial test to examine the unbound materials that make up the bulk of New Zealand's pavements. The test was validated and calibrated at CAPTIF and finally allows engineers to compare the performance of one basecourse with another in the laboratory. A massive leap forward from our current empirical recipe based specifications.
- The benefits of stabilising pavements have been captured in recent research. These benefits were not captured by the existing NZTA *Pavement design guide*. This work provides a good understanding of the intermediate steps between relatively weak but cheap unbound pavements and strong but expensive structural asphaltic concrete pavements.
- Epoxy open graded porous asphalt (OGPA) has been demonstrated as a viable product at CAPTIF. The testing showed that it was viable to produce and lay, and it performed very well under accelerated loading. Additional laboratory testing suggests that we will end up with a surfacing product that could increase the life of OGPA

surfacing from an average of seven years to 40 plus years. An initial five-year old field trial is producing promising results and ongoing laboratory tests suggest that the mix can be optimised to make it far more economically attractive than conventional OGPA.

The intangible benefits include:

- During the past 10 years, closer cooperation between researchers in the fields of pavements, transport, vehicle manufacturing, and between researchers and practitioners has resulted from the CAPTIF research programme.
- International bodies, such as the OECD and the Transportation Research Board (USA), have invited New Zealand researchers to serve on specialist expert committees and peer review international papers, which is directly attributable to their research involving CAPTIF.
- Improvements in technology and knowledge gained from research at CAPTIF have been transferred directly to university civil engineering students (through lectures and post graduate involvement) and practitioners (through formal presentations at seminars, conferences and meetings, and through informal discussions), thereby significantly increasing the dissemination and implementation of research.
- Over the past 10 years, four PhD students have completed their doctorates using data from the test track – two from Canterbury University, one from Auckland University and one from Nottingham University. One post doctoral fellow has studied at CAPTIF from the University of Dresden. This benefited both Germany and New Zealand with significant advances in modelling and testing made.

Previous projects

(Refer to our website for a full list www.nzta.govt.nz/CAPTIF.)

Projects have been undertaken at CAPTIF for a variety of clients. These clients have included the National Roads Board, BP Oil International, Transit New Zealand, OECD Road Transport Research programme, Transfund New Zealand, Opus International Consultants, the Ministry of Transport, the Cement and Concrete Association of New Zealand and ARRB TR Ltd on behalf of Austroads.

The dynamic interaction of vehicle and infrastructure experiment (DIVINE)

The OECD Scientific Expert Group IR/6 has completed a coordinated international research programme investigating the effect of vehicle dynamic loading on pavement deterioration. The experiment consisted of six interlinked research elements undertaken by researchers from more than 10 countries. Element 1 of the DIVINE programme was an accelerated pavement testing project undertaken at CAPTIF to investigate the relationship between the dynamic loading produced by different suspensions and the resultant pavement performance.

Effect on pavement wear of an increase in mass limits (stages 1 - 4)

Research into potential axle mass limit changes showed that for state highway pavements – the increase to a 8.8 tonne single axle dual tyre for high productivity motor vehicles (HPMV) is unlikely to be significantly damaging to pavement structures or chipseal surfacings. The research also showed that the 4th power law for road user charges is conservative for state highways. Conversely, damage law exponents for low-strength low-volume roads could increase. The most appropriate damage law exponent for use in road user charges should be determined as a function of the pavements strength.

Benchmarking pavement performance between Transit's LTPP and CAPTIF programmes

This programme includes analysis of the NZ long-term pavement performance (LTPP) programme and the CAPTIF accelerated pavement testing programme to develop a rutting model for New Zealand conditions. Previous work highlighted some data limitations in the LTPP programme.

Epoxy-modified porous asphalt

Undertaken as part of a larger collaborative research programme conducted under the auspices of the OECD/ECMT (European Conference of Ministers of Transport) Joint Transport Research Centre, this research focused on the economic evaluation of long-life pavements. The aim of the research was to investigate the potential of epoxy-modified asphalt as a low-maintenance long-life (>30 years) surfacing material. The NZTA's contribution to the research focused on the potential benefits of epoxy-modified open-graded porous asphalt (EMOGPA).

Pavement thickness design charts derived from a rut depth finite element model

The two finite element models, validated with data from CAPTIF, were used to calculate rutting for a range of pavement depths on a number of subgrade soils. This information was used to develop pavement thickness design charts from the rut depth predictions and these were compared to the chart for granular pavements in the Austroads design guide.

The design of stabilised pavements in New Zealand

This research showed that modifying the tested aggregates with 1% cement could reduce rutting and improve the rutting life of the pavement by 200-300% compared to the traditional unbound pavement. Foamed bitumen and cement reduced rutting and created a 500% improvement in life compared to the unbound pavement without any loss of stiffness (fatigue) during the project.

The benefits of modified aggregates can be included in the current Austroads design framework with the empirical procedures developed in the report. The procedures can be used to estimate design life from laboratory mix design data on any proposed material.

Development of tensile fatigue criteria for bound materials

The purpose of this research was to develop a methodology from laboratory beam fatigue tests to obtain the tensile fatigue design criteria of aggregates bound by stabilising agents for use in pavement design to guard against cracking and/or a return to an unbound condition within the design life.

The testing found that stabilised aggregate beams can be successfully compacted in a the laboratory resulting in similar strengths (maximum tensile stress) to saw cut beams at CAPTIF and Australia's accelerated loading facility (ALF).

The analysis method developed calculated conservative fatigue lives for the CAPTIF pavements. The surface of the CAPTIF tests did not crack, but the strain and deflection measurements increased to a typical level for a fully unbound pavement.

Fatigue design criteria for low noise surfaces on New Zealand roads

This research showed that, if pavements are constructed well, then applying low noise surfaces immediately after construction is possible. From analysis of the first test falling weight deflectometer readings, a conservative approach would consider all deflections having curvatures over 0.25mm to be unacceptable and that such results would require additional analysis. Where the criteria was not met – a short period of trafficking of the underlying pavement would generally lead to acceptable surface life.

Fundamental behaviour of unbound granular pavements under various loading conditions

The purpose of this project was to examine specific fundamental loading parameters (load magnitude and number of repetitions, tyre inflation pressure and basic tyre type) that influence the behaviour of thin-surfaced granular pavements. The pavement response and performance measurements included continuous surface deflection basins, longitudinal and transverse profiles, and vertical strains in the granular layers and subgrade.

Effect of binder modification on asphalt pavement performance

The trial involved constructing six test sections of various asphaltic concrete mixes over 200mm of unbound granular basecourse and a silty clay subgrade. The design life of all test sections was 1.0×10^6 ESA, so the depth of the asphaltic concrete varied from 80mm to 125mm, depending on the characteristics of the different mixes.

Dynamic wheel forces and pavement wear

The objective of this research programme (three pavements) was to compare the pavement deterioration caused by dynamic loads generated under different types of suspensions: steel parabolic leaf spring and shock absorber, multi-leaf steel suspension, and air bag suspension with shock absorber.

A selection of recent CAPTIF projects and papers

DATE	TITLE	REFERENCE
2012	CAPTIF strain monitoring system	4th International Conference on Accelerated Pavement Testing, Davis, California, USA, September 19-21 2012
2012	Ultra long life low noise pavements	Acoustics 2012, Hong Kong
2012	Development of tensile fatigue criteria for bound materials	NZ Transport Agency research report 463. 136 pp.
2012	The design of stabilised pavements in New Zealand	NZ Transport Agency research report (in press)
2011	Investigating the permanent deformation of unbound greywacke road base considering geology, gradation and moisture conditions	Transportation Research Board 90th Annual Meeting
2011	Investigating the performance of surface technologies and pavement materials under wet conditions using accelerated pavement testing	8th International Conference on Managing Pavement Assets, 15-19, November 2011, Santiago, Chile
2009	An experimental study of the deformational and performance characteristics of foamed bitumen stabilised pavements	PhD Thesis, University of Canterbury
2008	Performance Tests for road aggregates and alternative materials	Land Transport New Zealand research report 335, Land Transport New Zealand
2008	Measured tire/road contact stresses characterized by tire type, wheel load, and inflation pressure	Transportation Association of Canada (TAC), 2008 Annual Conference
2007	Benchmarking pavement performance between Transit's LTPP and CAPTIF programmes	Land Transport New Zealand research report 319. 98 pp.
2007	Epoxy modified open-graded porous asphalt. Economic evaluation of long-life pavement: Phase II, design and testing of long-life wearing courses	Land Transport New Zealand research report 321. 27pp
2007	3D finite element elastic analysis of accelerated pavement test results from New Zealand's CAPTIF facility	International Conference on Advanced Characterization of Pavement and Soil Engineering Materials, Athens, June 2007
2007	A practical method to estimate remaining pavement life of low volume roads using falling weight deflectometer results	TRB Low Volume Roads Conference, Texas, June 2007
2007	Prediction of pavement response using accelerated test results of New Zealand's CAPTIF facility	Post Doctoral Fellowship, Deutsche Forschungsgemeinschaft
2006	Investigation of road base shear strains using in-situ instrumentation	Master Thesis, University of Canterbury
2006	The analytical design of an OGPA surfaced granular pavement	4th year project, University of Durham, UK
2006	Shakedown analysis of unbound granular materials using accelerated pavement test results from New Zealand's CAPTIF facility	Pavement Mechanics and Performance - GeoShanghai International Conference, American Society of Civil Engineers
2006	Fatigue design criteria for low noise surfaces on New Zealand roads.	Land Transport NZ research report 307. 90pp

DATE	TITLE	REFERENCE
2005	Effect on pavement wear of increased mass limits for heavy vehicles – concluding report	Land Transport New Zealand research report 281. 80pp.
2005	Effect on pavement wear of increased mass limits for heavy vehicles – stage 4	Land Transport New Zealand research report 280. 30 pp
2005	Effect on pavement wear of increased mass limits for heavy vehicles – stage 3	Land Transport New Zealand research report 279. 118pp.
2005	FWD backcalculation using CAPTIF test results	Master Thesis, Universität Stuttgart
2005	The development and verification of a pavement response and performance model for unbound granular pavements	PhD Thesis, University of Canterbury
2004	Rutting of granular pavements	PhD Thesis, University of Nottingham, Nottingham, UK
2004	The equivalent standard axle approach and flexible thin surfaced pavements	2nd International Conference on Accelerated Pavement Testing, Transportation Research Board Committee A2B09, Minneapolis Minnesota
2004	Do we really know how thin surfaced granular pavements behave under higher axle loads	8th International Symposium on Heavy Vehicle Weights & Dimensions, Gauteng, South Africa
2004	Damage law exponents for thin surfaced granular pavements	6th International Symposium on Pavements Unbound, Nottingham, England, 6 th – 8 th July 2004
2003	Impact of new heavy vehicles on pavement wear and surfacings— summary report on findings from 2002/03	Austrroads publication No. IR-59/03
2002	The effect of mass limit changes on thin-surface pavement performance	7th International Symposium on Heavy Vehicle Weights & Dimensions, Delft, The Netherlands, June 2002
2002	Effect on pavement wear of an increase in mass	9th International Conference on Asphalt Pavements, ISAP 2002, Copenhagen, Denmark, August 2002
2001	Prediciton of pavement performance from repeat load tri-axial tests on granular materials	Transfund New Zealand research report 214
2001	Effect on pavement wear of an increase in mass limits for heavy vehicles	Transfund New Zealand research report 207
2001	Effect on pavement wear of an increase in mass limits for heavy vehicles –stage 2	Transfund New Zealand research report 231. Wellington, New Zealand
2000	Dynamic loading effects on pavements	Proceedings 10th REAAA Conference, Tokyo, Japan. September 4-9th 2000
2000	Comparison of accelerated pavement test facilities in New Zealand and Australia	Transfund New Zealand research report No. 198
1999	The influence of vehicle dynamics on pavement life	Heavy vehicle systems, a series of the Int. J. of Vehicle Design, Vol6 Nos1/4, pp99-114



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