INTERNATIONAL HEAVY VEHICLE SIMULATOR WORKSHOP
7 & 8 OCTOBER 2002
INTUNDLA GAME LODGE

MONDAY, 7TH OCTOBER 2002

Welcome and Introduction – Phil Hendricks (PH)			
Name	**Comment/Question**	**Name**	**Answer/Comment**
Vincent Janoo	• Where are you in terms of labour intensive construction? • Machine vs labour-intensive – is there a separate system?	Elzbieta Sadzik Hechter Theyse	• Job creation high priority in SA. • Focus on management. • 15% goes to labour-intensive construction. • Requires better quality control. • Some manuals available. • Early 90's – how do you manage the process. • Mid 90's – construction processes and quality. • HVS used to assess the quality for labour-intensive construction.
Frank Netterberg	• Is there buy-in from the community with respect to labour-intensive programmes?	Les Sampson Simon Oloo	• Two issues – poverty alleviation and creating an asset through labour-intensive methods. • Limpopo – have to run a sustainable development process and programme to involve and train the communities. • Have a sustainable labour-based programme in KZN. • Intend to expand the programme – all communities are involved.

Background to Workshop – Chris Rust (CR), Nick Coetzee (NC) & Joe Mahoney (JM)			
Name	**Comment/Question**	**Name**	**Answer/Comment**
Nick Coetzee	• *Refer to PowerPoint Presentation.*	Fred Hugo	• Subtle difference between the two – focused on full scale.
	• *Refer to PowerPoint Presentation.*	Joe	• *Refer to PowerPoint Presentation.*

Overview: California Pavement Research Centre – Carl Monismith (CM) – Nick Coetzee (NC)			
Name	**Comment/Question**	**Name**	**Answer/Comment**
Arthur Taute	• What is the % of air voids in the drainage layer?	NC	• Over 20%.
Vince Janoo	• 2.4% - did that lead to excessive rutting?	NC Fenella Fred	• No. • Void content in the bottom lift. • High void content in bottom lift give substantial gains.
Nick Coetzee	• n/a	Fenella	• Bottom layer – higher binder content – on construction – binder will last.
Fred Hugo	• The problem with LTPP – not willing to communicate.	NC	• Overcoming some of these issues.
Elzbieta Sadzik	• What is the maintenance budget in Caltrans, to put it in context	NC JM	• Maintenance on asphalt materials - US$280 million/year. • Total maintenance US$2 billion.
Reed Freeman	• Did the operational costs for the HVS include construction cost?	NC	• No, only HVS running costs, excludes traffic control. • The HVS costs shown includes operating personnel, HVS maintenance, data acquisition, etc.
Elzbieta	• Lab costs involved	NC	• No.

Name	Comment/Question	Name	Answer/Comment
Joe Mahoney	• California one of the biggest economies worldwide. Have many issues. Caltrans was very progressive in the 40's and 50's. Due to political impacts, the agency's technical capability eroded during the 70's to 90's. Agency is now moving in a more technical direction. Efforts from this HVS programme is helping to make this happen.	Fred Hugo NC	• This is a strong lesson for SA. • Don't lose the competence. • The HVS programme changed Caltrans thinking.

Overview: VTT/VTI – Leif Wiman (LW) & Niclas Odermatt (NO)			
Name	**Comment/Question**	**Name**	**Answer/Comment**
Vince Janoo	• Please explain what is meant by the term "angle of slope"?	LW	• The influence of the angle of the slope to prevent rutting.
Emile	• Does that include report writing, etc	LW	• Includes operational and construction costs
Fred	• Does the other country get involved	LW	• Each country does own analysis but shares a common database
Frank	• Collaboration with Norway?	LW	• Not yet.
Elzbieta	• With respect to low-volume roads – what traffic count are you talking about?	LW	• Between 50 and 100 heavy vehicles/day.
Simon Oloo Vince Janoo	• What would be a typical cross-section on that type of road? • Trying to correct for lack of ? • Significant, if talking about a granular layer. • Depends on the quality of the sub-base	LW Simon Arthur	• 40mm Asphalt wearing course. Granular, base course of about 100mm, depending on climate, how much sub-base you need. • Rutting on type of structures • The effect of the sub-grade too. • Becomes a bearing capacity problem • Tend to have 2m shoulders
Vince Janoo	• Cost is surprising – construction itself should be more than 40 000. Very cheap	n/a	• n/a
Fenella Long	• How long do the test sections last?	LW	• Does not last long.
LW	• LW discussed recent HVS testing in Poland on A3 Motorway. Observe that for US$.5 million, resulted in US$10 million savings (20:1 return) Reducing stabilised layer thickness from 400mm to 250mm.	n/a	• n/a
Renaldo Lorio	• What was the original design for the A2?	LW	• 6 Million repetitions of a 11.5 tonne axle. • Rutting low, and no cracks
Fred Hugo	• What type of response measurements?	LW	• Primarily strain, plus falling weight before and after

Name	Comment/Question	Name	Answer/Comment
Reed Freeman	• On the Swedish work – increases rutting – did you do a comparison?	LW Fred H LW Fred H	• No comparison done – gut feel • Shoving and deformation taking place. • Material moving back again • The shoving takes place when the wheel comes back
Renaldo Lorio	• Time lapse between construction and test? • Stabilised layer cracked with shrinkage – stabilized well?	LW	• Almost 28 days • No shrinkage cracking
Phil Hendricks	• Seen changes – DOT contracts – change the way we think about financing and risk around % and savings. Must be aware.	Arthur Taute	• Concessionaire more sensitive to saving. Like to have the saving up front – consequences down the line not his concern. Comes down to performance. Meeting the spec.

Overview: CRREL – Vince Janoo (VJ)			
Name	**Comment/Question**	**Name**	**Answer/Comment**
Elzbieta Sadzik	• Are the moisture sensors effective	VJ	• Yes. Monitor changes in moisture content. • Calibrate for specific soils.
Frank Netterberg	• Suction measurements?	VJ	• Tried suction under moving wheel load. Break very quickly. Fragile gauge – not used very often.
Joe Mahoney	• How successful in horizontal stresses?	VJ	• Obtained measurements. Tried to use steel pressure chambers using normal pressure. Not good correlation of what was applied and what was measured.
Elzbieta Sadzik	• Do you use MDD's?	VJ	• MDD's need good lateral support. Major concern – did not think had lateral support.
VJ	• Issue against pressure cells results related to MDD and use in granular material.	Morris de Beer	• South African experience – not good. • Still rely on MDD in granular material.
Louw du Plessis	• If you can plot the position of the wheel – the peak (slide) may not be the position of the wheel • All the readings are relative – may not be absolute zero load at that time. In some state of stress – initial reading may lead to misinterpretation of peak.	Morris de Beer	• Only works with compression.
Per Ullidtz	• Definition of failure?	VJ	• 12.5mm surface rut.
Kim Jenkins	• Density measurements?	VJ	• On each lift take 48 density measurements for statistical analysis. Unstabilised layers compacted to 95% of standard Proctor (AASHTO T-99).
Arthur Taute Fred Hugo	• How wide/deep is the trench? • Vertical heave? • Installation of gauges – construction phase?	VJ VJ VJ	• 5 Foot wide for a standard trench & 4 foot deep. • ? • Placed during construction of all systems.
Louw du Plessis	• Static strain, or dynamic strain?	VJ	• Vertical, moving strain, (ie: dynamic)
Reed Freeman	• What is the makeup of the base?	VJ	• 100% crushed stone base.
Fred Hugo	• Does that have something to do with the scale?	VJ	• Yes.
Vince	• How results are disseminated	VJ	• The study on weakening condition – manual
Vince	• Subgrade study	VJ	• Steering Committee AASHTO 2002

Name	Comment/Question	Name	Answer/Comment
Vince	• Utility cuts	VJ	• Prediction programme
Vince	• Significant programmes and issues	VJ	•
Vince Elzbieta Fenella	• Costs	VJ	• US$250 000 – 300 000/year maintenance and operation • Test section – US$250 000/ big test section • Annual cost. Run about 2 to 3 test sections/year.
Vince	• Collaboration		• Always looking to work with others
Renaldo Lorio	• Concern with shallow pavement structure	VJ	• Typical of in-service conditions
Fred Hugo	• Was the data generated from the same pavement structure?	VJ	• Different loads giving different strain levels

Overview: WES – Al Bush (AB) & Reed Freeman (RF)			
Name	**Comment/Question**	**Name**	**Answer/Comment**
Vince Janoo	• Are you going to try to validate the stresses	RF	• Validation is promising. Like to do validations Vince has.
Vince Janoo	• How do you get the strength?	RF	• Mohr's circle or CBR
Fred Hugo	• Have you used PSPA for checking density?	RF	• No.
Fred Hugo	• Management endorsement for standard documentation?	RF	• Yes. • Use "Engineering Technical Letter" must be carefully reviewed before distribution. • Not based on field data – could be a test section.
Nick Coetzee	• Is the HVS operated continuously for 22 hours?	RF	• Have done, but rarely. • Generally 5 days per week.
Nick Coetzee	• How do you do your data acquisition? • Might consider protocols developed for Finland and Sweden.	RF	• Walkie-talkie for instruments. • RF is very interested in these protocols.
Phil Hendricks	• What % of your costs were recovered?	RF	• 15 – 20% reimbursable.
Arthur Taute	• Heavy loads. Lots of airfield pavement work.	RF	• FAA used to fund a lot of test section work – now given to FAA R&D facility located in New Jersey. • Boeing has paid part of the bill for facility. • Valuable source of information.

Overview: Florida DoT – Nick Coetzee (NC)			
Name	**Comment/Question**	**Name**	**Answer/Comment**
Nick Coetzee	• US$1.2 million - full time operator and 6 assistant operators – 7 days/week • Will give further cost information.	n/a	• n/a
Arthur Taute	• Want cost per repetition, then have meaningful information.	JM	• Agreed to attempt that type of summary.
Fred Hugo	• Have costs per axle load.	NC	• Will give costs for understanding.
Arthur Taute	• Rutting in the asphalt, not the sub-grade.	NC	• Correct.
Fenella Long	• What's the surface temperature	NC	• About 50 degrees at depth of 50mm.

Name	Comment/Question	Name	Answer/Comment
Fred Hugo	• If you have temperature, you have lateral shoving. • Steve Brown has done some work. • Very detailed study on heat transfer being undertaken at Sellenbosch. • Important – more rutting in uni-direction.	n/a	• Tread pattern dependent on type of tyre. • Dual tyre vs single tyre – get different configuration. • Neither had any wander for data shown. • Section that rutted more had lower temperature by about 3°C.
Vince Janoo	• Same pattern identified by CRREL	n/a	• n/a
Renaldo Lorio	• Thickness of layer	NC	• 50mm wearing course; 100mm total AC. • Controlling outbreaks on surface. Don't go over 60mm
Fred Hugo	• The second layer is less susceptible to rutting • Ambient Temperature? • Very significant finding.		• Don't know.
?	• Total cost?	NC	• Don't know. Any queries should be e-mailed to Nick.
Phil Hendricks	• For additional information, e-mail Nick for clarification		• Nick concurred.

Overview: Gauteng DoT/CSIR – Elzbieta Sadzik (ES) & Morris de Beer MdB)			
Name	**Comment/Question**	**Name**	**Answer/Comment**
Renaldo Lorio	• Sustainable road network	MdB	• Through technical guidelines – able to build good, well-balanced pavements.

TUESDAY, 8TH OCTOBER 2002

WORKING SESSIONS

Session A: HVS Tests vs Field Performance (Fenella Long - chair, Niclas Odermatt, Elzbieta Sadzik & Reed Freeman)	
Name	**Comment/Statement/Question**
Nick	• Australians were only ones who reported strong set of data at 2002 TRB session on APT/LTPP comparisons.
Reed	• Do not have strong data.
Elzbieta	2 examples of comparisons in South Africa: • P10057/1 road to Jhb international – HVS testing done in 1980 with actual road performance assessed in 1996 to compare pavement behaviour – deflections, DCPs, moisture and tracking. Stone pavement, 200 mm crushed stone, 150mm lighly cemented, natural gravel – performs well. No maintenance done, only 13mm reseal. Compared well with HVS predictions. Rutting 3-5mm. surface still in tact without cracks – no moisture ingress into the pavement. Excellent comparison with HVS predictions. The wheel load during 70kN increased to 100kN. Real service (16 years) pavement performed in same way. • Pavement in Natal – national route 16/24. type of pavement 35mm graded asphalt, bituminous base. Sub-base cemented, weathered granite. Wet climate. HVS tests in 1984 – used 100kN wheel load – dry test to 1mm rut, then water added. The section was reevaluated in 1996 (12 years after HVS testing). The structural behaviour – elastic defections, MDDs, rutting, failure, cracking and pumping. Only similarity – in failure. Rutting 3x higher in real life than HVS. Thin asphalt deflections – justified as asphalt was very new. 12 year already aged. Difference in elastic – 2x as weak. • Comparisons (author) from the environment – moisture. In HVS testing, the water should be added from the beginning. Environmental influence on the pavement not important – no ageing – surfacing intact. • Was temperature taken into consideration? • 2 cases, 2 different answers
Hechter	• Workshop at TRB – info provided by Elzbieta. View the HVS not as a simulation tool. Simulation tool simulates exact conditions. Road pavement – very complex due to traffic changing in time and environment and maintenance of the pavement which also has an influence. APT/HVS is a modeling tool (similar to performance test in laboratory), control the conditions under which testing is done, then develop a model which allows simulation. Calibration of the model. Mechanisms were the same under the HVS as to real life- manifested in three variables. Simulation path should be in separate instrument – software, analytical tool. • Advantage of HVS vs lab test. HVS provides with full-scale, real life boundary conditions which cannot be simulated in the lab. Gives added dimension of testing full-life pavement. • Learned from HVS testing and real life - water will always affect. Agree that it is not worth predicting straight from the test. Advise that you test all pavements to destruction. See the mechanism of failure. • Ties into what Elzbieta and Hechter are saying. If you don't have distress, you have nothing to compare. • Not fundamental difference. Be careful of the way it is marketed. Examples of discretionary monitoring of microclimate at specific site, water input. Must look at conditions during the test. May have to adapt some testing methods to simulate. Must look at pavement management systems – build up case history. • Concrete road in the Cape – section chosen to be built, predicted 3 year life – turned out to be 19 year life.
Arthur	• Australians monitoring and building up a history. Use LTPP prudently on APT sections. • Fred and Hechter saying the same thing. There will be no argument.
Fenella	• Same opinion to Fred. Marketing very important. Concentrate efforts to make HVS results as close to physical results.
Fred	• Marketing and publishing – French and Australian approach. There are many complexities. Should show the relevance.

Name	Comment/Statement/Question
Frank	• Damage component 4.2 doesn't work. Work shown by HVS – varies between 2 and 8, depending on pavement. Major findings. HVS site, set up adjacent section for long-term monitoring. No comparisons to offer. Consider some points. Block cracking, erosion, etc., not the same as accelerated trafficking. Drainage is the most important pavement factor – clay and drainage. The following factors should be taken into account when testing is done: bitumen ages, untreated materials deteriorate in service, rocks containing sulphides, self-stabilisation, mechanical ageing (clays and gravels), cement and lime-treated materials, heave of the pavements, interfaces, carbon dioxide levels, moisture, daily temperature induced moisture fluctuations in the base-course (thin surfacings).
Elzbieta	• No initial information on examples given. Since 1985, adjacent sections established. Need protocol for future use.
Morris	• The example given by Elzbieta which showed the failure between HVS test and real life, found that the authors at that time made an error. Recalculated and found that the test was actually very close for the APT performance. Differences in deflections needed to be interpreted correctly. • The test was done on a slip crack – this was a special case that was mentioned. • Van Reenens Pass test section. Found that carbonation in the sub-base was weak. The pavement cracked up badly. Predicted between 10 and 15% cracking. After 3 years 12% was measured. An overlay was put on and the saving was great. • Interpretation is the greatest issue.
Fred	• Agree that the discussion is taking the course which should be followed. Apply the climate and interpret correctly. Accumulate climatic conditions and apply. Keep temperature at critical zones. • Fresh materials critical to the testing. May have to go back to the HVS site and build up history of performance.
Fenella	• Will not get a 1 to 1 correlation. Must take into account climate
Nick	• Distress/failure mechanism under HVS different. • Establishment of LTPP sections and tying with APT.
Fred	• French have historical data
Vince	• Environment has a significant influence on the pavement. APT helps to bring all together and bracket the performance.
Frank	• Pavement goes bad, Moisture accelerates distress.
Nick	• Tied together with mechanistic empirical systems
Vince	• APT on test site could take a very long time
Nick	• Not APT test, moisture measurement, DCP etc
Fred	• Must look at the whole system to understanding the mechanism better. With respect to protocols, need to look at ageing and ingress of moisture and when it is done.
Vince	• Intermittent is ok, but need somewhere in between
Fred	• Changes that occur in the material over time. Include different APT tests on the same section.
Renaldo	• All these factors are important. Need a protocol to do the test.
Vince	• Great support to develop a protocol specifically for the HVS. Need to decide who will be involved, how and when.
Joe/ Agreed by all	• Vince, Fred, Fenella and Reed Freeman will draft the HVS-related protocols. Do a test protocol to be used to evaluated pavements in real life using APT.
Fred	• Real-life/LTPP is the link.
Vince	• Done by 5th December. Linked to evaluation of the effect of the differences between real pavement performance and "Predicting in-service pavement performance from APT".
Fred	• Multiple studies are required.
Nick	• Data protocols which were to be completed for APT generally. • Electronic circular.
Morris	• Know what we have to do, how are we going to do it.
Agreed by all	• The first draft from Vince will be submitted to the team by 8 November.
Vince	• The protocol is a fair level of detail, is this the right way to go at this stage? Very ambitious. Try just to highlight what needs to be looked at and addressed.

Name	Comment/Statement/Question
Fred	• Should be guidelines towards drafting of the protocol.
Simon	• LTPP – formalized long-term monitoring and informal monitoring – performance cycle – rut depth a good measurement. In a committee such as COTO, ways of picking out specific pavement configurations and annual monitoring and input into a database.
Fred	• Need to know how many wet axles, hot axles, to give clarity.
Frank	• Have document to go through formal permission to use.
Jeremy Lea	• Be careful not to put too much data in. Modeling can't be done effectively if too much data is put in, to be effectively analysed and sustained. Info needs to be immediately applicable. Don't put in too many variables, otherwise you can't analyse it.
Fenella	**Summary:** • Should not expect a 1 to 1 relationship between HVS and field performance; • Test the sections to failure for comparison; • LTPP is essential to compare test section to real-life performance; • Vince is going to give some guidelines towards development of the protocol.
Elzbieta	• Rutting, up to 20mm or cracking will be seen as the "destruction" level to which the testing should be done.

Session B: Analytical & Performance Issues (Hechter Theyse - chair, Carl Monismith & Reed Freeman)	
Name	**Comment/Statement/Question**
Measured vs calculated response parameters	
Vince/ Hechter	• Under all conditions
Reed	• In terms of predictions, based on back-calculations – comparing with load test. Difference mad predictions very unconservative. Worked on correction factor. • Comparing predictions to measured responses – account for variability. More effective.
Fred/ Hechter	• Interpret predictions – actual strains are higher than predicted. • Specific way it is done. Extract the strains of the layer. Other is average calculation, which is lower. • Higher actual values than theoretically - Australia
Per	• Amadeus project (advanced model for analytical Europe pavement system): spin-off from EU project. Had a workshop. 3 phases. 1: run through different pavement analysis programmes and good comparisons came out. 2: took data to measure strains and deflections (from Europe). See if you could come up with measured predictions. Generally, predicted half of the actual value. 3: create performance. Report – National Laboratory website: www.lnec.pt.
Hechter	• What is the solution to some of the problems?
Kim/ Morris	• Unbound material used different load levels of FWD to get stress dependency.
Per	• With FWD, non-linearity is partly due to the impact load. Pick up on tail of deflection base.
Hechter	• How well can some of the parameters be calculated? Measured data, instruments to collect data and difference in accuracy – strain and stress?
Morris	• Understand the assumptions of the linear elastic models.
Hechter	• Each analysis tool has its associated assumptions. Is that good enough? What are the gains by going in that direction? - calculated vs measured parameters.
Arthur	• Identify areas – uniform layers. To what extent do you need to accommodate the materials.
Vince	• To chose the models – know the material conditions
Morris	• On what do you focus and how do you measure the response of the soil. Accurate measuring will dictate what model to use.
Simon	• Should assume the method of measurement in the field is correct. How well can you calculate the measurement?
Hechter	• Issues around material characteristics and specifics.
Vince	• Depends on how you characterize
Hechter	• Purely linear elastic theory. Is there a difference – model strains and stresses?
Vince	• Trying to predict the strain using linear elasticity. Differences – procedure to minimize
Simon	• Back calculation assuming strength and elastic model – then calculate the model. Analysis – lab measure linear elastic. What comes out is prediction. Back-calculation – closed loop system
Hechter	• How close can you get to the answer?
Simon	• Stresses – dependent on behaviour. What models can you use? Stiff layers – linear elastic is good.
Per	• Elastic layer theory – the assumptions we make are incorrect.
Arthur	• The whole system is incorrect.
Hechter	• Measured vs calculated response. Get the basics and assumptions right. Get the model to simulate the real physical problem. Make sure you have the correct input to the model and then will get the correct assumption.
Per	• Take very simple model with reasonably correct assumption for routine testing
Nick	• There are a number of elastic models, not only linear.
Hechter	• Look at material models. The analysis tool is build around the material models. Linear elastic model. What are the options and the non-linearity models. Layer-type approach. Linear elastic programmes – finite packages with non-linear elastic – discrete element.
Vince	• Whether linear- or non-linear elastic – may be more dependent on pavement structure.
Hechter	• Could also be geometric elastic
Reed	• Information guides the complexity warranted. Level of detailed input and accuracy.

Name	Comment/Statement/Question
Kim	• How much detail in applicability in material. Don't have the material co-efficients. Need the understanding. Should choose simplistic model.
Hechter	• Non-linear vs linear elastic models.
Per	• Reasonable answers can be used for a number of purposes.
Morris	• Non-linearity is not the answer to everything. In favour of simplistic model. How do you use this model? Study the behaviour of pavements over time and at different stages of the life of the pavement. Using different input values and calibrated with HVS programme.
Nick	• California project: set up so that analytical changes in time can be adapted accordingly.
Fenella	• Be careful in the development and use of transfer functions. What you use for prediction and calibrated for model used to develop it. The transfer function may then not be applicable the two are different.
Hechter/ Fenella/ Morris	• Develop transfer function in isolated environment – controlled. More constitutive model. • Need to understand and quantify the difference. • How lab tests complement HVS results.
Simon	• Development of material model is in the lab under representative conditions. Dynamic axle models – can put this in the analysis. The amount of lab testing should be much more extensive than is being done.
Hechter	• Discuss this later in the programme. • Compare measured and predicted response. May not need direct measurement. May not always need direct measured result.
Vince	• Lab info more important than APT test.
Hechter	• Measure stress and strain under the HVS – to simulate in lab is very difficult. Transfer function means: the function used in the transition of elastic response parameter conversion to predicted distress.
Vince	• Must have a link to APT.
How do laboratory results complement the HVS?	
Reed	• When doing APT, tests on granular layer – what tests should be done to make the test section as useful as possible to all. • Not only calibrate models, but testing the pavement with DCP etc.
Arthur	• Be careful that don't get trapped in a certain direction. Perhaps missing something. Don't need another model.
Fenella	• The transfer function is essential to working it out.
Hechter	• Go back and mine the information.
Arthur	• Need Monte Carlo method.
Jeremy	• Must distinguish between research, APT analysis and design. Thicknesses will give good enough in the sub-grade. Must understand the pavement – research. Can't do Monte Carlo simulation with full-blown – will have to analyse a lot more in the HVS testing. Linear elastic – critical in layer thickness.
Arthur	• Overlay feels the deflection. How much absorb the deflection.
Simon	• Materials and pavement behaviour model. Perhaps confusing the two. Must understand both.
Morris	• Surface deflection is a function of the pavement system. 50 – 75% deflections come from the sub-grade. Is dependant on the sub-grade. Systems thinking is part and parcel. The short cut could be a semi-empirical.
Vince	• APT results may be applicable some of the time, but not all the time.
Arthur	• APT give both environments by simulation. Wet pavements fail, dry pavements don't fail. There are easier ways to do this in practice, than to try and model the environment exactly.
Hechter	• Discussion is going into pavement design issues. How does lab supplement APT?
Reed	• Environment keeps on coming out of discussions. • Test some materials – soaking or dry. Missing something in between? Come up with lab lest in this regard.
Frank	• Need to characterize the site very well. In addition, the CBR should be done at OMC and saturation at minimum. Characterize geologically. Like performance limits to the tests (may not be clear at this stage, but future warning). Variability: material much more variable than one thinks, particularly with materials, moisture content and suction aspects in the pavement important.
Morris	• Endorse what Frank says. Do we understand stress regime during the lab test and the real stress regime during normal traffic. Perhaps need further studies in this regard.

Name	Comment/Statement/Question
Hechter	• In some cases in the lab, not knowing stress pavement – model over a wide range of conditions to capture. May not always be true. Same applies to APT. Applying stresses far more than normal traffic.
Vince	• Must link lab and APT.
Fred	• Must compare same with same. There is a concern that this is not being done.
Joe	• Two different levels of analysis – variability associated with construction (water tables). 90% of lack of performance due to construction. Research important to move ahead.
Frank	• On variability, take into account, the following: material as such; repeatability; reproducibility; significant differences in standard test procedures.
Vince	• The construction variability could be incorporated into … simulation.
Arthur	• Pre- and post-expiry of the life of testing. What testing should be done to complement the results. Assessment of the material.
Hechter	• Complex problem which we are aware of.
Morris	• Do use simple models to crush.
Nick	• Using 4 levels in California design process; 0: Current empirical Californian Design; 1: Every day engineer; 2: Pavement engineer; 3: research.
Successes in predicting successes in performance and current performance predictions needs	
Reed	• Able to predict performance where pavement is ideally built. • Need more consideration in environment, predict changes with wetting and drying. Perhaps more important than predicting stress levels. • Consideration for discontinuities.
Fred	• Performance now occurring can be predicted when using a power function. Removed variables and looked at surface mixing – critical- and non-critical zones. For specific types of distress, can predict performance. Frequency and temperature – performance prediction in closed environment, using critical temperature.
Morris	• In APT environment, in the HVS users group – define and have a standard for terminologies.
Hechter	• Is there a need for a group to do this?
Nick	• Will volunteer to take this international and delegate accordingly.
Hechter	• If you work in a controlled environment, possible to get a good prediction in HVS. Tend to work in perfect sections, but will you still be able to do a good prediction?
Kim	• Re lab testing: 10 scale tests down to 1 HVS test. Agree, must have right lab testing. Strong need for feedback from the APT testing, the lab tests, the tests used in practice. Do not understand very well the stresses. Take the technology in accelerated testing and improve the simple tests.
Hechter	• Feedback is needed. Often difficult to get that.
Arthur	• Concern of concept of structural capacity (pavement at the end of its life). Predict the life beyond the life of pavements.
Fred/Per/ Morris/ Fred	• What is the residual life? Understand where the stress in the system is, then will have the tools to do this. Could core from untrafficked section and trafficked section and do a comparison. • The life of the pavement is not necessarily lost at this point. • Rather than residual life and performance functions, look at damage functions (% of distress)
Morris	• HVS helps you define the damage ~~of the~~ relationship.
Hechter	• Lab work – calibrate for all the way. Have different levels of deformation. From plastic strain of 1% to as high as you want.
Frank	• Under the HVS, dealing with 8m length, on the road, more length to redo, if required.
Innovative new directions	
Simon	• Been a move from moisture content and soils being saturated or not saturated. In pavement engineering, defining stress. Presents advantages – defining whole system as a stress. Can put in a representative stress condition. If you know what the stress state is, you can carry out the lab and HVS testing. • If you combine moisture/soil interaction, can calculate.
Hechter	• Not at a position to implement yet, but innovative idea.
Frank	• Study done by Dave Ventura which could be used.
Morris	• Future HVS testing: controlled dynamic loading for greater spread on the loads
Fred	• Prediction of how many pavements are sub-grade moisture and surface moisture

Name	Comment/Statement/Question
Per	• Finite and particulate media – only when computers are much faster.
Reed	**Summary:** • Model must be appropriate for materials, load level, complexity • Must understand assumptions • APT link with real world – making transfer function; developing models • Lab testing must include minimum to characterize materials in test section; parameters for model development • Testing should better address environmental and geologic effects on mechanical properties • Performance very dependent on construction variability • Important part of APT is expanding few cases/simple conditions to many cases of full pavement life predictions • Need consistent APT terminology • Should account for soil/moisture interaction • HVS testing with dynamic loading • Using lab tests to determine level of distress: compare distressed and undistressed pavements.

Session C: Equipment/Instrumentation/Data Collection Issues (Louw du Plessis - chair, Per Ullidtz & Vince Janoo)	
Name	**Comment/Statement/Question**
Variability of deflection techniques	
Arthur Chris	• Variability of various deflection techniques • Some differences in instrumentation
Hechter	• The practice of staggering of MDDs only used between 1990 and 1995. Not recommended.
Frank	• If it is too variable, should not be doing an HVS test.
Morris	• Need for smart measurements on the fly – perhaps to replace the MDD.
Louw	• Other instruments also need attention. Current project at Transportek looking at wireless MDD technology.
Kim	• MDD hold on response of the pavement. Any further information?
Louw	• Not conducted a complete study to look at that.
Hechter	• Some discontinuity being created. Not determined if it influences the results.
Louw	• Sometimes the instrument moves and the measuring may not be right.
Louw	• MDDs – anchor point must be checked for movement.
Arthur	• What is the depth?
Morris	• 3 meters
Fenella	• Where is the CTL anchored?
Reed	• 6 meters
Frank	• On expansive clay, it should be at least that depth.
Louw	• Using automated or computerized instruments – should be placed within linear operating range.
Vince	• Must calibrate the range
Nick	• How do you deal with effect of the metal of the carriage, on the induction coil?
Vince	• Take the wheel off and run it and get response. Near the surface, the effects are small compared to the movement. Easy to install.
Louw	• Make sure the initial reading is within range of the operating range.
Morris	• Must be reset at an appropriate time when modules have moved.
Jeremy	• Strain gauge is difficult to keep track of permanent strain when recalibrating.
Louw	• Under the HVS, it is a micro model. In the field, may be different interpretations of measurement of rut depth.
Arthur	• What rut depth do you report?
Louw	• Whole array of definitions
Morris	• Made a distinction of definitions.
Jeremy	• 4 different minimums and maximums for dual channelised traffic. Maximum of these 4 readings.
Frank	• With respect to long-term pavement performance: Important to consider whole cross-section. During construction, controlled technique. Rut dept and device used for measuring rut depth.
Louw	• Profiler had a wheel with ADT on top. Reported as rut. Now using laser technology. Such precise technology could give warped information.
Morris/ Frank	• Giving additional data and texture depth. May not have algorithms to calculate.
Jeremy	• In California data, get an initial reading which gives surface texture. Takes out peak values before doing the measurement.
Frank	• Important in rural pavements in South Africa.
Arthur	• On the HVS, this is important.
Morris	• Opportunity to study texture issues.
Louw	• Developed equipment at CSIR – reads very high density. Gets full texture. Would take time on an HVS test.
Frank	• Stick to straight edge on long-term pavements.
Simon	• Comparison of full width - total rut with localized rut?
Louw	• To do a direct comparison may be difficult. Do manual checks. The rut profile is always referenced to some baseline reading. Repeat the measurement at exactly the same spot.

Name	Comment/Statement/Question
Morris	• Very important point for LTPP sections.
Absolute vs relative	
Frank	• Must be anchored below the level of seasonal movement
Strains	
Jeremy	• How much does a crack open and how much does it close.
Arthur	• Rigid vs flexible.
Position of strain in relation to the wheel	
Vince	• Create a beam – know when the beam is broken.
Jeremy	• Triggered off the HVS proximity sensor. Measures where the carriage is.
Frank	• The wheel section in relation to the rut depth – is it the same? Large deflection surfaces. If you shift the wheel over, it will make a difference to the structural capacity.
Bruce	• Testing in outer wheel path. Limited to what you can do.
Frank	• Record the position
Louw	• Realigning horizontal alignment on the road. Calculated structural capacity.
Frank	• Measure moisture edge effects on the road
PCC Deflections	
Fred	• What is the impact of the support system under the slab? Measuring relative or actual values? With joint transfer, could be restricting movement.
Louw	• Always had 8m section free.
Jeremy	• Do 24 hour test without the machine on the section and measure movement of the slabs on instrumentation. Then, put machine on without traffic; then with trafficking.
Louw	• Have temperature control on the sections, but couldn't get good correlation. Plotting deflection vs temperature – then correlations. Rule established.
Morris	• Important point for test protocol in rigid pavements
Frank	• Could refer to warped slab in Namibia
Louw	• Ratio of concrete and support moduli tremendously different – models do not take care of good support. Then would predict a very different life. US definition of cracks are different to SA. Interpretation and quantification of cracks is important.
Fred	• Make a decision of what the size a crack is
Louw	• Big foot may see the same. Rubber deposits mask the cracking that takes place underneath.
Nick	• Presentation on tracking with tyre – also had rubber deposit. 1 inch shift – the rubber deposit stopped.
Morris/ Louw	• Could be shear force.
Nick	• This paper could be presented at TRB
Niclas	• Hard to measure width of crack
Fred	• Wouldn't differentiate too finely. Monitor crack in a specific segment. Differential in cracks.
Louw	• California, Texas – differentiates in cracks.
Frank	• Techniques in full-scale pavements – broad categories of pavement description.
Louw	• Some concrete test sections close to Krugersdorp – send out people who are good in visual surveys.
Nick	• Any way of standardizing checkers
Louw	• They are calibrated
Frank	• Have calibration sections. Approved visual road raters for inspections.
Per	• Decrease in stiffness before you see any cracking. Essential to capture that before you see the cracks.
Fred	• Important – significant amount of stiffness lost before you get to the crack. Must have a system for checking for stiffness as well as the crack. FWD can't to it.
Nick/Per	• Don't agree.
Fred	• % of stiffness?
Per	• 1500 and end value 200.
Fred	• With FWD can differentiate stiffness – primarily in the asphalt – then there is a problem.
Nick	• 4 inch asphalt – lost before any cracks showed.
Fred	• Agree.

Name	Comment/Statement/Question
Frank	• When doing Benkelman Beam deflections, what are you measuring?
Louw	• 1st level report – summary of HVS results, conditions and what you have seen and limited analysis. 2nd level report – deflection bowl parameters, stiffness reduction. This gives a vast amount more info. Not only for the RDD, but also for the MDD
Frank	• Radius of curvature
Louw	• TRH12 – gives info on
Frank	• ARRB took curvature meter and fastened on the Benkelman Beam which did both tests at the same time.
Jeremy	• In SA, only get 150 useful points in the bowl. In California, get about 400 points. Far more information obtained.
Emile	• Talking apples and pears. Benkelman Beam rebound, RSD not.
Vince	• Are crack depths measured? Depth all the way through?
Louw	• In California – crack depths and widths measured. Cracks were random.
Vince	• Must you know crack depths in the analysis?
Louw	• Very important – during testing.
Fenella	• Must also know where the crack starts.
Fred	• Seismically, can consider depth of crack. Not studied to any great extent.
Per	• Any instrumentation must be reliable. • Instruments must be durable.
Renaldo	• In general, the reliability issue with FWD instruments?
Per	• FWD very reliable.
Nick	• For repeatability, Sharp developed instrumentation.
Per	• 3 drops doesn't change. Identical. No change in moisture content, temperature or structural damage.
Nick	• Repeatability – looked at all devices in late the 80's.
Reed	• Test of pressure cells at higher angles? Different, depending on orientation of the gauge?
Per	• 45 degrees. Function out of the gauge – should be as close to zero and put them in vertically.
Fred	• The results showed consolidation with all directions.
Reed	• Deep gauge effective in any orientation.
Simon	• In theory, should the horizontal stress be zero? Not rigid.
Frank	• Durability of instrumentation – moisture instrument – look carefully if it will last out the test. • Repeatability – information is available. • If the FWD is not available – the light/heavy Clegg could be used.
Fred	• Durability – on measuring long-term pavement deformation with MDD – is it monitored or is long-term durability a problem.
Louw	• Do capture and get post construction compaction. Open up process. Difficult to go back.
Fred	• Worth considering down the line.
Louw	• Perhaps more available and viable soon. At limited costs, could tap data once per month.
Frank	• Probably give indication of interlayer. Lower tech – drag a chain across the pavement and listen to it. Works well on thin layer pavements.
Reed	• Pressure cells – is any work being done? Calibrated air pressure chamber if pressured for time.
Vince	• Had experience with Danish pressure cell – used pressure chamber. Found calibrations provided by manufacturer could use them for both. When compacted, the difference became small. In the process of using the same calibration chamber. Took pressure response and integrated. If you calibrate in chamber, it gives a nice straight line.
Arthur	• Why does it not give the same in soil?
Per	• Different pressures. This info is in a TRB paper some years ago.
Vince	• Peak valves – still possible.
Renaldo	• FWD – results reported in road authorities database correct?
Per	• Force measurement is correct.
Nick	• LTPP database in the US. Operator inputs sensor location. This could cause error. There is a programme that will check incorrect input.
Frank	• Put paint where measurement are done. Road agency do have paint marks.
Nick	• Routinely change sensors. Operator has to measure where the sensors are an type it into the computer.

Name	Comment/Statement/Question
Jeremy	• California data – a lot of wrong operator inputs. That information cannot be easily checked. Critical to data obtained – RSDs and MDDs.
Bruce	• FWS – use paint marking to line up
Nick	• New system – can put DPS in as an option.

Session D: Open Discussion Including Collaboration Opportunities (Joe Mahoney & Leif Wiman)	
Name	**Comment/Statement/Question**
	HVS Consortium
Phil	• Has the workshop been of benefit? Does it need to be formalized in the form of collaboration?
Joe	• Spoke to Elzbieta and Fred who were enthusiastic about further collaboration.
Vince	• Found the workshop very beneficial. Should definitely continue. Could do with input from people outside the HVS.
Reed	• Found the workshop very beneficial. Made contacts and found people to share information with.
Louw	• Very good exercise. Tend to live in isolation, but talking to others, find out a lot more. Not only the formal setup, but also the social interaction has brought much benefit.
Nicolas	• Beneficial, but would like a two-day working session, not only 1.
Nick Fenella	• Need a theme per session
Per	• Important to use for marketing as well. Only those who are actively involved will benefit. Needs to be more than 2 days. Get more input from the outside and more detail.
Frank	• Essential to collaborate with LTPP and on a network level.
Arthur	• Missed a bit on each group and the owners strategic direction. Seems ad hoc. Need to look at what has been tested and the knowledge there and how to expand.
Chris	• Sharing of knowledge. No-one has time to analyse another's raw data, but of results.
Joe	• Each owner has pavement design and analysis tools. Spend some time helping each other understanding the practices and the design tools and benefit from each other. Have a perspective from the interaction.
Vince	• A lot of times, don't have the choice of developing a programme. Sometimes can, but often have to go with others. If there is sharing, can benefit each other.
Nick	• Big reason for the success is the California APT strategic plan. A lot of options which can be chosen which puts another building block. There is info on the website.
Kim	• The strategy helps define the objectives. A lot of different types of HVS testing that can be carried out. Deciding on the testing programme – the strategy will assist.
Emile	• Caution against a rigid experimental design. The materials engineer moves on and the champion moves on then there is a loss of interest. Topical issues can be tested immediately. With some effort, 80% of the answers can be obtained almost immediately. The HVS and its total management has a huge political attachment to it and it must be well managed.
Nick	• ME design – a lot of management. Recording enough information and additional calibration.
Chris	• Underlying long-term goal and short-term fruits to pluck. It works.
All	The consensus was that it will be taken ahead and some actions need to be taken. **HVS Consortium:** Members: either **must** own or operate HVS Associate members: **chosen by HVS consortium members.**
Phil	• Rotate venues and ask Dynatest to take the lead in conjunction with the agency hosting the next session
Nick	• One of the owners of the agency should take the chair. Think it is inappropriate to be in the management – biased and vested interest. Elzbieta should take the chair.
Phil	• Problem – don't have all the lead agencies.
Joe	• Elzbieta agreed to consider the position. Joe would offer some bylaws
Phil	• It would have more effect in SA if the consortium were driven from outside SA
Nick	• Vote of confidence in SA
Arthur	• Test the waters with Jack
Nick/ Chris	• International rotating chairpersonship
Kim	• 3 years – the chair or the consortium?
Joe	• For either. Give it a try.
Kim	• Consortium for 3 years, chair for 1 year – chair may be too short.
Nick	• If the chair has to count, has to be for a longer term
Joe	• Selection of the chair really matters.
Emile	• Evolutionary develop and champion to pull everything together.

Name	Comment/Statement/Question
Morris	• Exclusion of other APT devices is troubling. Don't want it only HVS. Would be able to do other business by expanding a bit.
Joe	• Example: MMLS (Fred Hugo) – if this used in conjunction with the HVS – Fred would fit into the consortium. To go broader, it will be difficult to focus and get too big.
Morris	• APT consortium too big to handle?
Emile & others	• Yes. The whole understanding of sharing techniques – the HVS just happens to be there.
Joe	• Start this way and later down the road, bring more in if that makes sense. Not restricted to changing the game. Start with what you know.
Nick	• Had previous experience (Four State Group), changes were made as and when required.
Emile	• Create a slip way which sucks people in, when it starts to produce. Gender issue: go back to the mother organization that started the HVS. Someone from Transportek should champion it at this early stage.
Phil	• Transportek would already be involved. Should be an HVS owner. The real purpose is to ensure collaboration. Don't put too many restrictions, as it might kill it.
Joe	• Immediately going to have others who want to join – such as ALF operators.
Phil	• Would require a letter
Vince	• If this is an issue – have 2 chairs. One SA and one other – given the flexibility. Elzbieta will need some help.
Hechter	• Speculating. Elzbieta was nominated and did agree to accept. Offer her the opportunity for first refusal. Should have an alternative.
All	• Consensus reached. Steps – correspondence until acceptance is gained, whereupon she will communicate will all.
Nick	• Send a letter of support to Elzbieta.
Phil	• The minutes of the meeting will suffice.
Arthur	• Must have a letterhead from the owners.
Joe	• Reed, Vince, Leif. Nick and Joe will coordinate the letters, which will be forwarded to Elzbieta for any approvals she may need to go through.
Chris/Joe	• Membership: Owners and operators
Reed	• HVS vs APT – want to learn from the people in this room.
Nick	• Dynatest operates the 2nd HVS for Caltrans.
Jeremy	• Leave to the agencies to invite the operators
Chris	• The operators is where the learning takes place.
Frank	• Agrees
All/Joe	• Consensus that membership includes owners and operators. Members will consider associates who can participate at their discretion.
Arthur	• The name HVS Consortium – entails a legal organization. Perhaps needs something
Fenella/ Arthur	• HVS Owners and Operators (Association)
Nick	• User Group
Frank	• Is AASHTO too clubby?
Nick	• Yes
Chris	• Terminology means different things in different countries.
Arthur	• Joint venture – legal term.
Joe	• Those who draft the arrangement for circulation could suggest an appropriate name. • Sub-information that needs inclusion: o California/CSIR collaboration has shown good results.
Phil	• For closure. Thank those who put this all together
Nick	• The Brazilians felt the gathering was excellent, and had some trouble in understanding and would like to thank the meeting for being part of it. • Exceeded his expectations.
Phil	• Joe will take responsibility for the letter to Elzbieta.

INTERNATIONAL HEAVY VEHICLE SIMULATOR WORKSHOP 7TH & 8TH OCTOBER 2002 INDUNDLA GAME LODGE LIST OF ATTENDEES							
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