vicroads

Pavement Investigation

Guide to Field Inspection and Testing

VicRoads Technical Bulletin
No 40
December 1995

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Foreword

The purpose of this bulletin is to provide guidance for the conduct of pavement investigation and how to record field observations for use in pavement design. Its main aim is to ensure that investigations are carried out in a uniform manner so that relevant design parameters are accurately and consistently obtained.

The document has been structured to reflect the current trends of pavement design and the parameters necessary for this purpose. It also includes new equipment used in measuring the condition of pavements.

Future modifications to this Bulletin may be necessary from time to time due to:-

- new developments in measuring the condition of pavements
- new test procedures for measuring the quality of pavement materials
- changes in parameters used for design.

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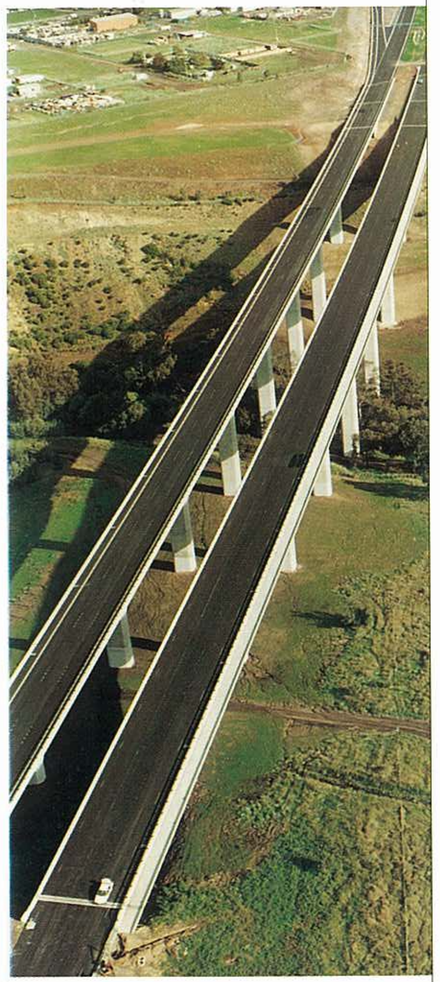

About VicRoads

VicRoads is the Victorian State Road Authority responsible for the management of the road network, which includes planning, designing, constructing and maintaining roads, managing road use through registering vehicles, licensing drivers and traffic management, and providing information and road user services.

Materials Technology Department is responsible for developing technical expertise and training for road making materials, geotechnical work and pavement technology. In addition, the Department provides an investigation, testing, design and information service in these areas of expertise, including a supply service for bituminous materials.

Acknowledgements

This Bulletin is based on an original document prepared by Kelvin York in the early 1980s and has since been brought up to date, modified and formatted to bring it into line with other Technical Bulletins produced by Materials Technology Department of VicRoads.

This updating work was predominantly carried out by Ken Mitchell with the assistance and advice of the following:

Graham Foley, Lance Midgley, Andrew Papacostas, Ross Paul and Gerry Turner.

Pavement Investigation

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Front Cover:

- Fully equipped van for performing dippings, sampling and measuring subgrade strengths using the Static Cone Penetrometer.
- Pavement Strength Evaluator (PaSE) for measuring surface deflections and curvatures of pavements.
- Laboratory Soaked CBR in the process of being tested in a compressor testing machine.

ISBN 0 7306 4912 1

Aim of field inspection and testing

A pavement investigation determines in a systematic manner all conditions relevant to the design, construction and performance of the pavement. The individuals who carry out the investigation not only require a knowledge of testing procedures, but must also be trained to observe and systematically record all conditions at a test site which are relevant to the future performance of the pavement. This generally calls for an accurate description of the pavement surface condition, an assessment of the surface and sub-surface drainage conditions, and an assessment of topographical and environmental features.

Pavement design is determined using Technical Bulletin No 37 – "VicRoads Guide to Pavement Design" in conjunction with "AUSTROADS Pavement Design, A Guide to the Structural Design of Road Pavements."

Overlay and resheet design is achieved using Technical Bulletin No 33 – "Pavement Strength Evaluation and Rehabilitation." Other useful information is contained in VicRoads Technical Notes, and Technical Notes from the Cement and Concrete Association of Australia and Australian Asphalt Paving Association. Further information may be obtained from the Manager – Pavement Technology or staff at 60 Denmark Street, Kew, 3101, tel (03) 9854 2318 or fax (03) 9853 3002.

Field inspection of a road.

Pavement investigation procedures

The flow chart in Appendix 1 shows the steps to be taken in preparation and execution for field testing. Once all the plans have been obtained and the proposals determined, it is then necessary to go on site and locate test sites to enable the necessary design information to be obtained.

It is important, where possible, to involve construction or maintenance personnel as they are able to highlight any problems which may be encountered and more than likely have a knowledge of local conditions and a history of the existing road.

At each site it is necessary to know the pavement material types, depths and quality. The subgrade type, depth, moisture content and CBR also need to be known.

It is of great assistance to know beforehand, the proposed source of fill materials, pavement materials and filter materials as laboratory test information may already be available for these materials.

In some cases considerable time in testing may be saved if a check through the files reveals that the job has previously been tested or had some testing over a relevant length. Information from any nearby pavement testing or deflection testing should be examined beforehand, as this may assist in assessing the conditions of the job under consideration.

Before embarking upon a pavement investigation it is essential to ascertain the exact nature of the proposed construction as this can have a profound bearing upon the nature of the testing to be performed. Alignment plans and longitudinal sections, when available, should be obtained to facilitate the selection and location of test sites. Knowledge of proposed changes in grade or alignment is essential both for the location of test sites and the design of the new pavement. It will also be necessary to obtain information on rutting and roughness from the Road Assets System (RAS) and traffic data from Road Information Services.

When working in a built-up area where underground services such as sewers, water mains or high pressure gas mains are likely to be of concern, it is necessary to check with the appropriate authority regarding their exact location. Surface evidence of their presence such as manholes and covers and sometimes pavement deformation and signs of old trenches, often assists with defining their location. In the case of underground electrical and telephone cables it is imperative to check their location, for surface indications are not so evident and interference with them could lead to serious disruption of services and in the case of electricity cables, serious injury to the testing officer may result. VicRoads Materials Technology Department has a "pipe detector" which can be used to help locate underground metallic services.

Underground Services Information Dial '1100' (refer to "Dial Before You Dig" Booklet prepared by the Local Government Department, 480 Collins Street, Melbourne. Phone (03) 9617 1225)

General Information

All enquiries should be directed through the new 'One Call' system now provided as a Telstra Service. Just Dial '1100' and ask for the appropriate Authority. The following information will be required to be supplied:

- Your name and address
- Contact Telephone Number
- Who will be on site, if anyone

- Detailed address and nearest intersection of the proposed activity, including if possible, a Melways or VicRoads Country Directory map reference
- Commencement Date of Work
- Proposed activity

Electricity Supply Authorities

Some municipalities and other authorities such as the Public Transport Corporation have control of the electricity supply in their own areas.

Gas Distribution Areas

No digging is to be carried out in the vicinity of High Pressure gas pipelines without an authority member being in attendance or having advised you that it is safe to proceed.

Telstra/Optus/Voda Telephone Districts

If these services are disrupted by damage to underground cables, there is likelihood of very expensive repairs, not to mention the total inconvenience and huge loss of revenue due to the service being down.

Sewerage Authorities

Like some other services, these may be controlled by a local authority.

Water Supply Authorities

Like some other services, these may be controlled by a local authority.

Drainage Authorities

Like some other services, these may be controlled by a local authority.

Traffic Management Procedures

All personnel required to assist with traffic management, in any pavement investigation work, must be VicRoads accredited.

Pavement Investigation

3

Reason for types of pavement investigation

It is first necessary to know just what treatment(s) are intended to be carried out as they will impact on the type of investigation performed. The following is a guide to the type of treatment(s) proposed but at times may include combinations of some or all of them. This effects the sampling techniques to be adopted, the location of test sites and the depth to which testing should extend. Tests, other than those listed, may be required in special investigations to determine the cause(s) of severe distress in pavements. These tests may be devised as needs dictate. (eg dye tests to endeavour to determine depth and extent of cracking).

Though representative samples are collected, the main field tests performed as part of routine pavement investigations are:

- Static and/or dynamic cone penetrometer, and/or field CBR tests to determine bearing values of the subgrade.
- PaSE, Benkelman Beam or Falling Weight Deflectometer (FWD) tests to measure pavement strength and stiffness, which is required to determine the need or suitability for a granular resheet or asphalt overlay.
- Ground Penetrating Radar may also be of assistance in determining changes in pavement material type and/or layer thickness but is best used in conjunction with pavement sites to minimise the number needed.

The various types of construction work are listed below together with the testing usually required for pavement investigations.

3.1 New Construction

A new road will traverse an area where no previous road formation has existed. For this work, possession of horizontal and vertical alignment plans and cross sections are essential, to enable correct location of the test sites. Testing of these areas involves dippings combined with insitu strength tests taken at suitable intervals (dependent on length of job, uniformity of subgrade soils and topography). Due cognisance should always be given to variation in topography, drainage and soil type to ensure that, as far as possible, strength tests and samples taken are representative of the majority of soil types present. Additional strength tests may also be required where differences in drainage of the same soil type can be discerned.

Where cuts and fills are involved in undulating or hilly country it is important to sample and test material from the cuts if this material is to be used for filling (this should be discussed with an engineering geologist before commencing). Field tests may give a clue as to whether the material is in fact, suitable for use.

Frequently when dipping proposed cuts, hard rock or a hard soil layer will be encountered long before the proposed grade line is reached. In this case, unless the hard material is believed to be only a "floater", the dipping should generally be abandoned and only the material already obtained from the dipping should be sampled and noted on the field worksheet accordingly. Another hole should be attempted in the near vicinity if it is believed that a "floater" has been struck. Often seismic traverses are performed along the line of major cuts for the purpose of determining the depth to hard rock and the rippability of the cut material. Dippings and strength tests should also be undertaken at points where the new grade line intersects the existing surface.

Generally, testing of subgrade soils is not required where the depth of proposed fill exceeds about 0.5 m. However, insitu tests to determine the depth and strength where fill is to be placed on soft boggy country, such as occurs in watercourses, etc. must be undertaken.

3.1.1 Sampling for CBR Evaluation

❒ If construction is to be at grade or in cutting.

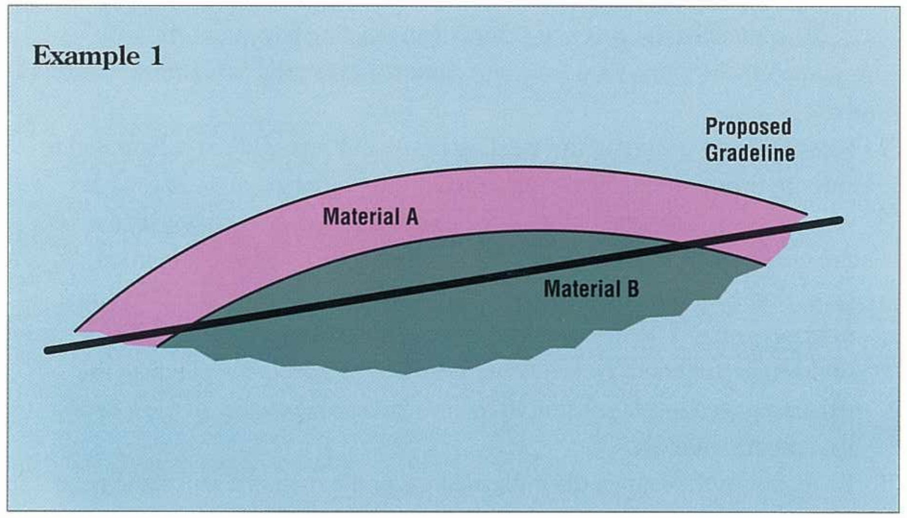
Take samples at frequent intervals along the new alignment at the proposed gradeline level and carry out soil classification tests on all samples. From these results an assessment of the likely variability of the subgrade can be made.

4-day soaked CBRs should then preferably be carried out on the strongest and the weakest soils, although their distribution may also affect the decision on which materials to test, e.g. if the weakest soil represents 80%-90% of the subgrade, testing of the strongest soil would not be warranted.

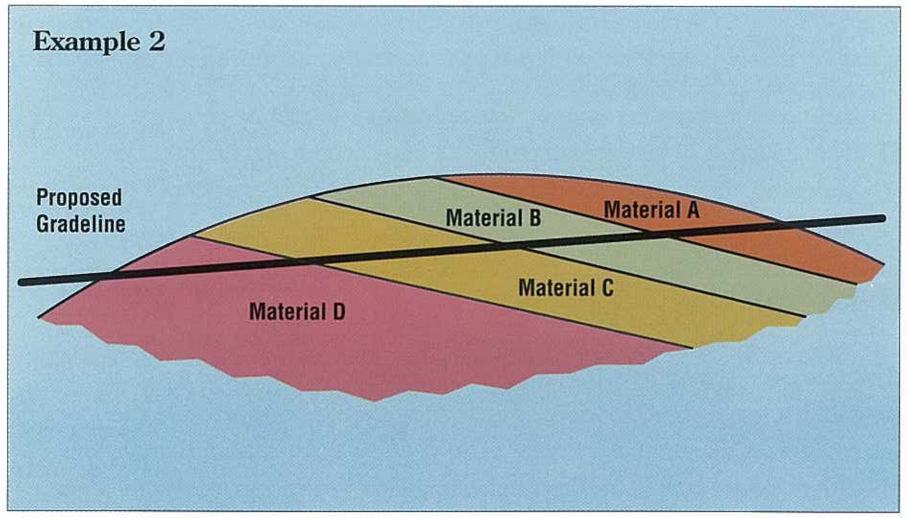
❒ If construction is to be on fill.

4-day soaked CBRs should be performed on samples of the fill material. Variability of material within a cutting from which fill is to be won should be determined in consultation with an engineering geologist.

An estimation of whether or not the various materials can be won separately during construction should be made in consultation with construction personnel as this may affect the extent of CBR testing. Refer to the following examples.

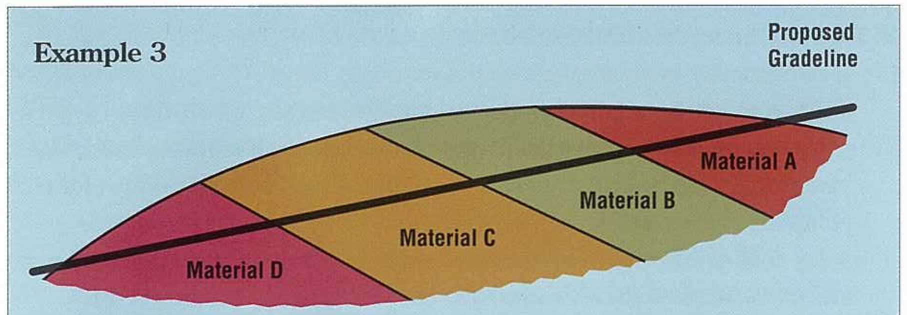


Perform 4-day soaked CBR tests on each material as they can probably be excavated separately from the cutting.



Perform 4-day soaked CBR tests on each material if the cut is to be worked parallel to material layers or CBR tests on a mixture of materials if the cut is to be worked parallel to the gradeline.

Example 3



Perform 4-day soaked CBR tests on weakest material or possibly a mixture of materials if the cutting is to be worked parallel to the gradeline. Possibly CBR tests on each material if the cutting is to be worked on a face.

In the case of shallow fills (say less than 0.5 m) the process described under (a) above should also be followed.

If fills are being constructed well in advance of pavement works, soaked CBRs can be performed on cores taken direct from the fill after a period sufficient to establish equilibrium conditions. This would generally give the most accurate information for selection of a design CBR. See Note on left.

NOTE: Where sealed roads nearby traverse country of similar topography and have similar subgrade soils to those of the new construction, it is of value to sample and test the subgrade materials for strength and moisture content under the seal. The results of these tests will indicate likely equilibrium strength and moisture values of the subgrade and give some information on how existing pavements have performed.

3.2 Reconstruction

This involves the reconstruction of an existing pavement to approximately the same final level and alignment. Testing for reconstruction involves:

- Sampling and testing of the existing pavement material if it is intended to salvage this material for use as subbase and/or basecourse in the new pavement, or if the condition of the existing pavement is inconsistent with the condition of the subgrade. For example a thin pavement in good condition on a soft subgrade or a thick pavement in poor condition on a firm subgrade. The test results for these materials will assist in the design of the new pavement by providing evidence of the performance of the existing pavement in relation to the thickness and quality of the existing pavement materials.
- Insitu strength tests on the subgrade using the dynamic and static cone penetrometers. Ideally, one test of each type should be carried out in diagonally opposite corners of a 0.5 m square test hole in the existing pavement.
- Dippings of the subgrade from which samples for laboratory testing and samples for moisture content determinations should be obtained.
- The selection of test sites should take into account any previous widening/major patching and a suitable number of tests should be taken in these areas.

3.3 Widening and Duplication

If reconstruction involves **widening** of the pavement, additional dynamic cone strength tests should be carried out in the shoulder on the side on which it is proposed to widen. These sites should be adjacent to the pavement test sites and will enable a check of the insitu strength under the shoulders where lack of traffic compaction and exposure to excess moisture may have led to much lower insitu strength than under the pavement. (Where no seal exists, these insitu strength tests are of benefit only when they reveal bearing values lower than those determined in the laboratory.) They are also useful in showing up soft areas requiring either removal during construction or additional pavement thickness.

Existing pavement materials must also be carefully sampled to allow testing for the determination of their qualities. For **duplications** it is necessary to sample the subgrade materials for type and moisture content along the new alignment, to compare with those beneath the existing pavement. If there is no marked variation between the new and existing subgrades and drainage conditions, then it can be assumed that equilibrium moisture contents for the duplication would be the same as that beneath the existing. If materials do vary considerably, soaked CBRs may be necessary to determine a design CBR. If possible this testing should be carried out during spring so that subgrade conditions are at or close to their weakest.

For major highway duplication works the method described for new construction may be more appropriate.

3.4 Realignment

Realignment involves the improvement of longitudinal grade and horizontal alignment of an existing road and will therefore combine some new construction with reconstruction and/or resheeting. The comments under each of these headings are appropriate for jobs involving realignment.

3.5 Pavement Strengthening

3.5.1 Resheeting (Granular)

For the determination of resheet thickness, the preferred method to assess the condition of the existing pavement is to undertake deflection testing using PaSE. However, Benkelman Beam or Falling Weight Deflectometer (FWD) equipment may also be used as an alternative. For completeness, it is desirable to dip the pavement layers and test all dissimilar materials. The insitu strength may be determined for the subgrade beneath the existing sealed pavement (usually by use of the static and dynamic cone).

3.5.2 Overlaying (Asphalt)

Overlaying of existing pavements with asphalt has become increasingly more common and it is necessary to determine the suitability of the existing pavement for overlaying with asphalt, especially the thickness of the existing bound material. Pavement deflection tests **must** be performed to determine existing condition. The deflections under an 8.2 tonne axle load are measured at appropriate intervals with a PaSE or Benkelman Beam apparatus. The magnitude of the deflections as well as the shape of the deflection bowls (curvatures) are used to determine the required overlay thickness.

3.6 Investigation of Pavement Distress Insitu

In these investigations, other tests such as insitu CBRs and insitu densities on pavement materials may be required to ascertain the cause of pavement distress. A transverse trench, carefully excavated across the width of a lane or of the full width of pavement down to the subgrade, may enable the determination as to whether any pavement shape loss has occurred in the pavement materials, or in the subgrade, or in both.

Location and depth of test sites (dippings)

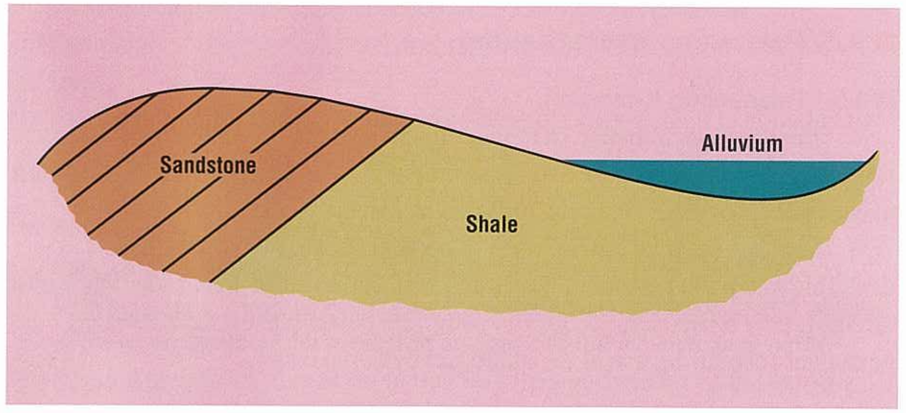
Features such as these should be able to be identified from cut areas. Locate sites so that such features may be verified. This will often save much time in detailed searching to define soil types.

4.1 Longitudinal Location of Sites

4.1.1 Geological Variations

Test sites are located so that representative samples may be obtained of most soils and pavement materials present. Geological maps may be of assistance in planning pavement sampling and testing. These may be helpful in ensuring that all soil horizons present are located and sampled. For example, prior knowledge that the investigation traverses Basaltic, Silurian or Tertiary country may be of assistance in planning the sites to ensure that most materials present are located and sampled. In the case of major works it is desirable to consult an engineering geologist before commencing work.

Extra sites may be required in the region of cut to fill lines as at these points the material is likely to have variable weathering and relatively unstable moisture regimes. In the field, changes in soils often correspond to changes in vegetation, drainage or topography. A worthwhile preliminary check is the inspection of soil exposure in cuts on existing roads in the area. This will often give an overall indication of the variability of the soils of the district. Land-form is an extremely valuable guide as differences often reflect differences in both parent material and the soil profile developed thereon. Changes in slope are a good guide to differences in character and hardness of the parent rock and thus soil differences. *See note in left column.*



4.1.2 Pavement Conditions

Where pavement materials are being sampled, sites should be located with due regard to pavement condition and structure. Care should be taken to locate sites so that pavement samples are obtained to give a coverage of all surface conditions present. Sites should be selected so as to provide information on sound and failed sections of the existing pavement.

Width of seal coat or changes of seal coat, can indicate different construction times and therefore a variation. This possibility should be checked by locating some sites in proximity to the seal coat changes.

4.1.3 Drainage

Where it is noted that there are changes in surface (or sub-surface) drainage conditions, then extra sites should be located to better determine those variations.

4.1.4 Spacing

The spacing between sites is dependent on the length of the job, uniformity and whether construction has level constraints or not. Spacing should be closer for more important or major jobs. On roads of lesser importance the interval between sites may be increased, particularly where conditions are more uniform.

The length of road to be tested will frequently govern the site spacing as it is essential to test sufficient sites so that the possible range of variation in material properties can be deduced. Samples should be taken at each site, leaving the culling of samples to be done on return to the laboratory when all the materials can be inspected closely.

4.2 Lateral Location of Sites

When testing for new construction, sites should be located on the proposed carriageway centre line. When reconstruction or resheeting is involved, sites should be located on the outer wheelpath of the seal. This is usually discernible as a slight deformation in the seal or as a black or smoother track on the surface of the seal. If the outer wheelpath is not discernible the site should be placed about 0.5m in from the edge of the seal. Sites should be alternated left and right of the centre line along the length of the job, depending on the treatment proposed. Additional sites should be located at the centre of the existing pavement where moisture conditions are more likely to be at equilibrium. Shoulder sites should be included where there is to be widening on either or both sides.

Where widening strips are present, especially where resheeting is proposed, it is important to sample the pavement materials from both the original pavement and the widening.

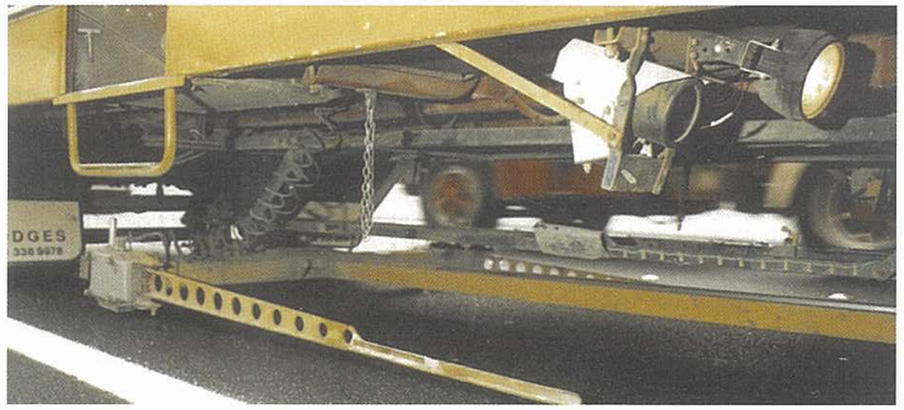
4.3 Depth of Test Site

It is normal to test to a depth of 1m below the proposed or present pavement surface. With the dynamic cone the maximum depth of penetration is usually in the vicinity of 0.6 – 0.7m. Dippings and static cone penetrations should be carried to a depth of 1m. Deep dippings through proposed cuts should if possible, be continued to a depth of 1m below the proposed finished pavement level. However, for safety reasons, this would generally not be > 1.2m; use geotechnical sampling for deep holes etc. In areas where extremely soft material is encountered it is important to penetrate until a firm layer of substantial thickness is found. Firm material in this context may be defined as having an insitu CBR of greater than 5%. Where extremely soft materials are encountered it is essential that sufficient sites are tested to try to delineate its extent in the horizontal as well as the vertical direction.

Non-destructive testing

Wherever possible, forms of non-destructive testing should be used to assess the condition of an existing pavement and to assist in locating sites for dippings.

5.1 Pavement Strength Evaluator



The Pavement Strength Evaluator (PaSE) is a purpose built vehicle with a standard rear axle load of 8.2 tonne to accurately measure the downward movement of the pavement under the rear wheels by a sophisticated electro-mechanical system. PaSE also measures the shape of the deflected pavement surface called the "deflection bowl". The vehicle travels at a test speed of 2-4 km/hr and takes readings at intervals of 4-7 metres in both wheel paths, giving a continuous strength profile of the pavement. It tests about 30 kilometres of traffic lane per day. Electronic sensors attached to the measuring beams measure deflections to the nearest 0.01 mm.

The results are processed and displayed on a computer, in the cabin which also records this information on computer for further processing and analysis by the pavement designer.

To evaluate the strength of an existing pavement, PaSE measures:

Deflection: – the measured maximum vertical movement of the pavement beneath the dual wheels of the 8.2 tonne axle load as an indication of overall pavement strength. High deflections indicate insufficient pavement depth over the subgrade, poor quality or saturated pavement materials which may lead to deformation of the subgrade with rutting and cracking of the pavement.

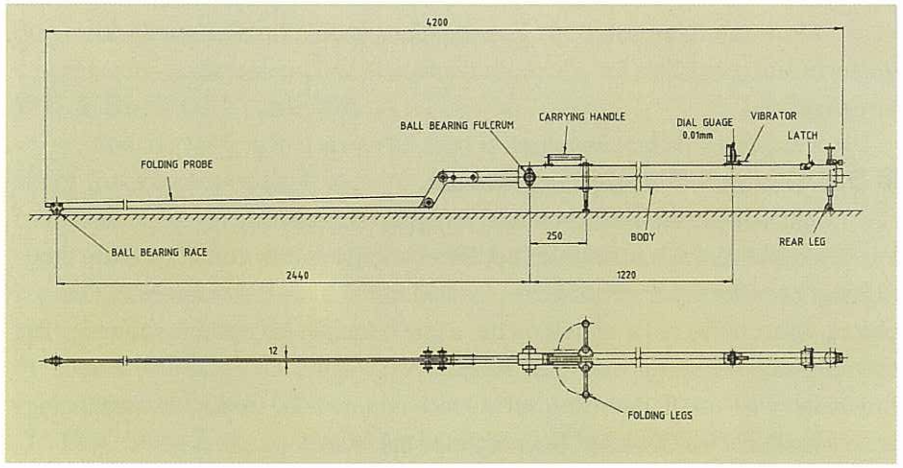
Curvature: – a shape of the deflected pavement surface (deflection bowl) which is determined by calculating the difference between the maximum deflection and the measured deflection at a point 200mm away. Curvature is a measure of pavement stiffness and the level of tensile strain

within the pavement layers. High curvature indicates a lack of pavement stiffness which is likely to result in premature fatigue cracking of any bound pavement layers such as asphalt or cemented materials.

PaSE testing is VicRoads principal form of pavement strength testing.

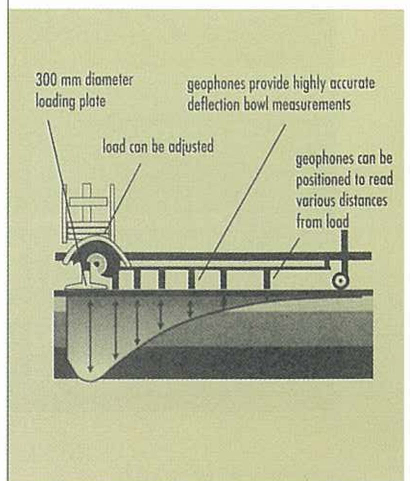
Typical charts of deflection, curvature and rehabilitation are shown in Appendix 5.

5.2 Benkelman Beam



An automated recording (computer system) may be attached to the beam in order to measure deflection bowls and maximum deflections (refer to TB33 for the use and operation of Benkelman Beams).

5.3 Falling Weight Deflectometer (FWD)



The FWD simulates a dynamic wheel loading to the pavement and is used to measure the shape of the deflection bowl. A dynamic load, which can be varied between 25 and 120 kN, is generated by dropping a known mass from a predetermined height onto a 300 mm diameter plate. The magnitude of the load and the pavement response are measured by a load cell and seven geophones. One geophone is located directly under the load and the others are located at various distances from the centre of the load plate, dependent on the anticipated bowl size and shape.

Plots of maximum deflection, curvature and various offset deflections can be obtained for each location.

The information obtained from the above three parameters in conjunction with knowledge of pavement layer materials and thicknesses determined by this form of testing, are used to derive the following:

- maximum subgrade compressive strain (an indicator of surface rutting),
- maximum horizontal tensile strain (an indicator of fatigue of bound materials),
- subgrade modulus/subgrade CBR.

The FWD is also suitable for assessing rigid pavements.

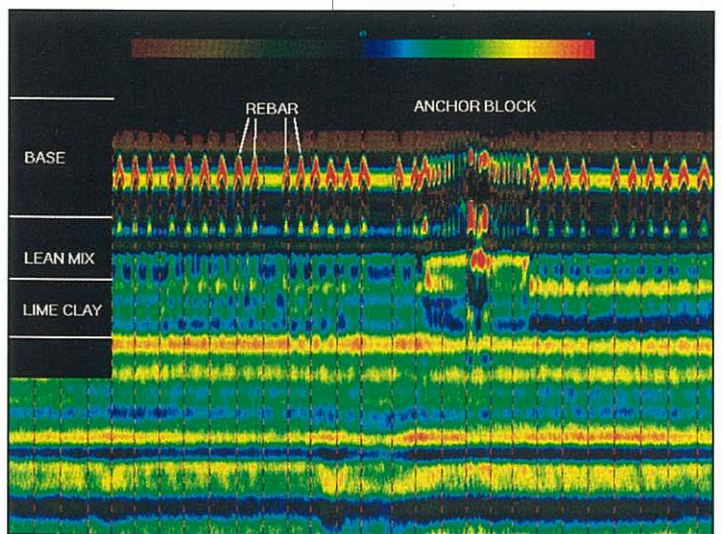
All of the above testing services are commercially available.

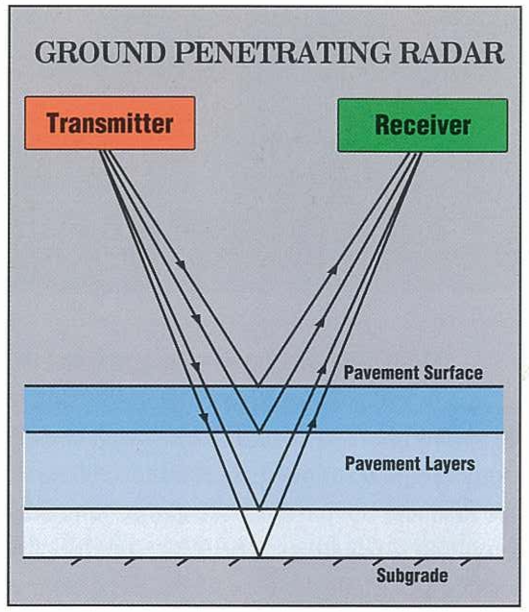
More extensive subgrade investigations should be discussed with geotechnical specialists for advice on geological and geotechnical subsurface investigations.

5.4 Ground Penetrating Radar

RADAR (RAdio Detection And Ranging) has historically been used to locate storms, aircraft and ships. A pulse of energy is transmitted and the time delay of its reflection from an object is used to calculate the distance to that object. Short pulse radar works on the same principle except that the range of the reflecting object (or pavement layer) is very short. Originally developed by the military for use in detecting subsurface non-metallic mines, this technology is now available for "looking" beneath road surfaces.

The radar equipment is vehicle mounted and the data is generally collected at about 100-250 mm intervals (depending on the vehicle speed), but analysed only over selected intervals. These can be given as uniform sections, at 100 m intervals (usually satisfactory) or at any interval as may be required. The data can be collected at speeds up to 70 km/hr and thickness can be determined up to depths of approximately 800mm. The number of layers can be identified only if the relative dielectric constant of the adjacent layers is significantly different, such as asphalt compared to crushed rock. Also where materials have substantially different moisture contents, or air gaps are present.





Assessment of existing pavement condition

Comparison of the performance of existing pavement materials and pavement depths, under the past traffic, with the known existing subgrade strengths, will assist in the design of a new pavement. To facilitate and systematise the assessment of an existing pavement, a table listing elements of pavement condition is provided on the pavement investigation worksheet (see Appendix 4). Under general headings of surface condition, faults and shape, are listed the detailed condition elements. The appropriate items which describe the pavement condition near the test site should be ticked. In most cases this will provide an adequate description but on occasions further description may be required.

6.1 Surface Condition

The following notes are to be read in conjunction with the FIELD WORK SHEET (refer to Appendix 4) and are given to further describe the pavement condition.

This applies to the general overall condition of the surface without regard to the detailed nature of the faults, if any. Five surface condition ratings are given as follows:

- **Good.** This rating is applied to a surface that is completely sound and has no apparent flaws.
- **Fair.** Some faults such as minor cracking and minor loss of shape are apparent but the seal or asphalt remains intact and shows no signs of breaking up.
- **Poor.** Extensive flaws, such as loss of shape, and extensive cracking are apparent. Some, but not extensive seal or asphalt break up is evident and may be associated with minor patching.
- **Very bad.** Seal or asphalt is extensively broken up, potholes have developed and numerous patches are evident.
- **Complete failure.** The pavement is in such a state that it cannot properly perform its intended function, that is the safe carriage of vehicles. This condition is very rare, for it is seldom that a road is allowed to reach this state prior to evaluation or testing.

6.2 Faults

The faults listed on the pavement sub-surface investigation field worksheet are described below with brief notes on possible causes of failure. The symptoms exhibited by a weak pavement are often the result of the interaction of many faults in the composition of the pavement and surfacing with factors such as pavement thickness and environmental features.

6.2.1 Transverse and Longitudinal Cracking

The cause of these types of cracking is often difficult to determine and their presence cannot always be ascribed to pavement or subgrade deficiencies. These cracks may be due to:

- The presence of pavement materials with excessive plasticity which shrink and form cracks on drying out.
- Swelling and shrinkage of the subgrade after construction - usually as a result of allowing an expansive clay subgrade to become overdry during construction.
- Reflection cracking of bituminous surfaced cemented base materials. Cracks in base are associated with shrinkage due to hydration of cement and other environmental factors.

6.2.2 Crocodile Cracking

This is usually due to:

- Plastic deformation or shear failure, of the subgrade or the pavement materials under traffic loading. It is often associated with deformation, the extent of which may be an indication of whether subgrade or pavement failure is involved. Large areas of deformation may indicate subgrade failure, small areas may indicate pavement material failure.
- The use of unduly hard or brittle bitumen or it has oxidised through age and when due to this alone, no deformation is usually involved.
- Fatigue failure of bound pavement materials. This type of failure is common where cement treated materials have been used in the base layer and is usually depicted by an irregular pattern of cracking, associated with loss of shape usually due to loss of pavement strength.
- Insufficient asphalt thickness to carry the traffic loads, resulting in fatigue of the asphalt surfaced base.

6.2.3 Potholes

These occur in the pavement primarily when the seal coat or surfacing has broken, and erosion of the underlying base, has been caused by traffic and water.

6.2.4 Edge Failures

These are of two types:

- Breaking away of the extreme edges of the pavement due to lack of support from the shoulders. These failures are not associated with cracking of the pavement and indicate lack of maintenance or lack of seal width rather than deficiency of the pavement.
- Breaking up of the pavement edges associated with cracking and deformation. These indicate poor pavement materials or inadequate pavement thickness. This condition is often found in poorly constructed pavement widening.

6.2.5 Patching

Patching reveals to some extent the maintenance history of a pavement.

- Edge Patching. This is self evident and where present indicates that one of the above types of edge failure has occurred.

- Minor Patching. This consists of a few scattered relatively small patches. These are often repairs made to potholes or developing potholes and their presence would normally indicate faults in the seal coat or surfacing.
- Major Patching. This consists of either numerous small patches or single large patches. Usually indicates insufficient pavement thickness, inferior pavement materials or localised poor drainage.
- Patching over Services. These usually appear in the form of trenches transversely across the full width of the pavement or longitudinally along or close to the edge of a pavement.

6.2.6 Sinking

Sinking comprises longitudinal and/or transverse deformation of the pavement. The position of the deformation should be noted and space is provided for this on the field worksheets. Sinking can be due to the following:

- Traffic compaction of pavement materials and subgrade. This is generally due to poor construction practice. The chief feature is rutting along the wheel paths, (wheel tracking) and is common on widening strips.
- Shear failure of subgrade or pavement materials.
  The feature of this type of failure is the lateral and upward movement of the failed material to produce bulges either side of the deformation. Traffic compaction does not produce this type of deformation.

Cross-sectional views of pavement surface.

- Fill settlement or consolidation can produce sinking. Depressions along a fill are common, the greatest deformation occurring over the deepest part of the fill; eg. at bridge abutments. This is also troublesome on steep side slopes where differential settlement across the width of the pavement is common.
- In built-up areas sinking is often found where the pavement has been disturbed in the repair of services and drainage lines or where leaking water mains under the pavement lead to saturated conditions and loss of strength of the subgrade.
- Trees or other environmental factors causing drying out and shrinking of the subgrade creating localised depressions.

6.2.7 Rutting

Depressions in wheelpaths caused by deformation of subgrade due to inadequate pavement depth (high deflections) or deformation due to poor quality pavement materials, or both.

6.3 Shape

The field worksheets allow for assessments of both transverse and longitudinal shape. Transverse shape refers to the cross sectional profile of the pavement surface and longitudinal to the lengthwise profile of the pavement surface. Loss of shape is due to one or more of the causes listed under sinking. Major loss of shape is often involved on major fills where consolidation and compaction may act independently or together to produce deformation.

Corrugations are a special type of loss of longitudinal shape. Short amplitude corrugations are generally caused by instability of the surfacing material or to the slippage of the surfacing on the underlying pavement materials under high traction or braking forces. Longer amplitude corrugations generally indicate deficiencies in the pavement materials or deeper rather than in the seal.

Loss of shape, in many cases, leads to faults in the pavement surface and impairs riding qualities, but may actually improve the strength of the subgrade and/or pavement. In the long term, all roads generally show some loss of shape.

6.4 Rigid Pavements

A rigid pavement needs to be assessed in a similar manner to a flexible pavement, but, surface conditions and faults would need to be expressed in relevant terms as shown in reference 4.

6.5 Other Faults

For typical photographic examples of the above conditions and possible causes, refer to “A Guide to the Visual Assessment of Pavement Condition” (ref 4).

Topography

The following notes are to be read in conjunction with the FIELD WORK SHEET (refer to Appendix 4) and are given to further describe the pavement condition.

Topography can nearly always be described by reference to the classes of topography listed on the field worksheets with ticks being placed alongside the appropriate item. There are two sets:

- General topography which applies to the district as a whole, and
- Local topography which applies to the area in the near vicinity of the test site.

Most of the definitions given are self explanatory but the following notes are given under the general topography headings to clarify a few of the points that should be noted.

7.1 Flat

The term flat in the topographic sense does not imply a completely level surface. Minor "ups and downs" will exist in the form of very broad shallow stream valleys and subdued dips. Moderate longitudinal slopes may be developed on valley sites.

The term low flat is used to describe a depressed flat area with rising ground around it.

Dip is used to describe a depression without an appreciable flat floor.

On occasions a generally flat area may be cut by a deeply incised river valley with quite steeply sloping valley sides. Under these circumstances the topographic classes given on the field worksheets will not fully describe the conditions and further description should be included.

7.2 Undulating

Undulating or Rolling country is dissected by broad relatively shallow valleys with moderate longitudinal slopes developed on the valley sides. Generally no steep grades are encountered. Terms used for local topography here include high flat and crest.

High flat is used to describe an elevated flat area from which the surrounding ground slopes away.

A crest is formed by the intersection of two opposing slopes without the development of an appreciable flat area.

7.3 Hilly

Dissection of the landscape is more pronounced, valleys are steeper sided and narrower than in undulating country and steep grades are common. The local topographic terms of low flat and dip are hence dropped and the term valley used instead.

A further classification of mountainous could be used under appropriate circumstances.

Frequently it may be found necessary to divide an area into sections to simplify description where a job extends over different classes of topography.

8

Drainage

The following notes are to be read in conjunction with the field work sheet (refer to Appendix 4) and are given to further describe the pavement conditions.

8.1 General

A description of drainage condition in the context of pavement design refers to the evaluation of all factors which have an influence on the strength of the subgrade and the stability of the pavement materials. It must extend beyond the simple ideas of surface drainage, i.e. slopes, relative levels and adequacy of outlets for water (all factors which are still very relevant), to questions such as the nature of the soil, the topography and the structure of the pavement.

Every endeavour should be made to include an assessment of sub-surface drainage including any reversal of permeability between layers, or the original pavement and any widening.

8.2 Soil Drainage

Soil drainage refers to the dissipation of water from the surface of a soil by surface run-off and internally from a soil by flow through the soil to underground channels, by evaporation and by transpiration from vegetation. Climatic conditions of an area are an important consideration. Areas having similar internal drainage will have different drainage characteristics under different climatic conditions. For example, a flat area having neither run-off nor percolation to the deep soil substrata, can be well drained from the agricultural point of view under low rainfall conditions, because the water from precipitation can distribute itself within the upper layers of the soil and dry out again by transpiration and evaporation without saturation of the soil for any protracted period. In any area of high rainfall, an area with similar internal drainage characteristics would be poorly drained because saturation of a soil for even relatively short periods, may lead to instability of the subgrade under traffic.

The frequency and duration of periods when the soil is unsaturated is a measure of the soil drainage. This can be accurately measured in the laboratory, but for pavement condition purposes it has to be estimated.

Accurate appraisal of the drainage of a soil is important in road construction and is far more complicated than it may at first appear. Obviously, the assessment of drainage in mid-summer after a prolonged dry period is more difficult than in mid-winter after heavy and protracted rain when evidenced by free water and saturated topsoil. Variations in soil drainage may often be inferred from differences in soil coloration or colour patterns. Mottlings, grey coloration and the presence of significant organic material in engineering soil (ie not topsoil) may often indicate poor drainage.

Unmottled and red coloured soils on the other hand often indicate good drainage. The assessment of soil drainage is therefore partly a matter of inference and partly direct observation. In order to appreciate and assess soil drainage conditions it is necessary to understand the three broad concepts of surface run-off, soil permeability and internal soil drainage as follows:

8.3 Surface Run-off

This is the rate at which water is removed by flow over the soil surface. It includes water falling as rain as well as water flowing onto the soil from higher ground. Three major classes of run-off are recognised on the basis of the relative flow of water from the soil surface as determined by the characteristics of the nature of the soil, soil slope, climate and vegetation. These are:

8.3.1 Slow

Surface water flows away so slowly that free water lies at the surface for long periods or quickly soaks into the soil. Most of the water either passes through the soil or evaporates into the air. Soils with very slow surface run-offs are commonly in flat terrain or are very porous.

8.3.2 Medium

Surface water flows away at a rate whereby some water enters the soil profile and free water lies on the surface for short periods. Part of the precipitation is absorbed by the soil and is used by plant growth, part is lost by evaporation or part flows away through the soil into underground channels.

8.3.3 Rapid

Most surface water runs off soil, with only a small proportion moving through the soil profile. Surface water runs off nearly as quickly as it is added by precipitation. Areas with rapid run-off are usually moderately steep to steep and/or have low infiltration capacities.

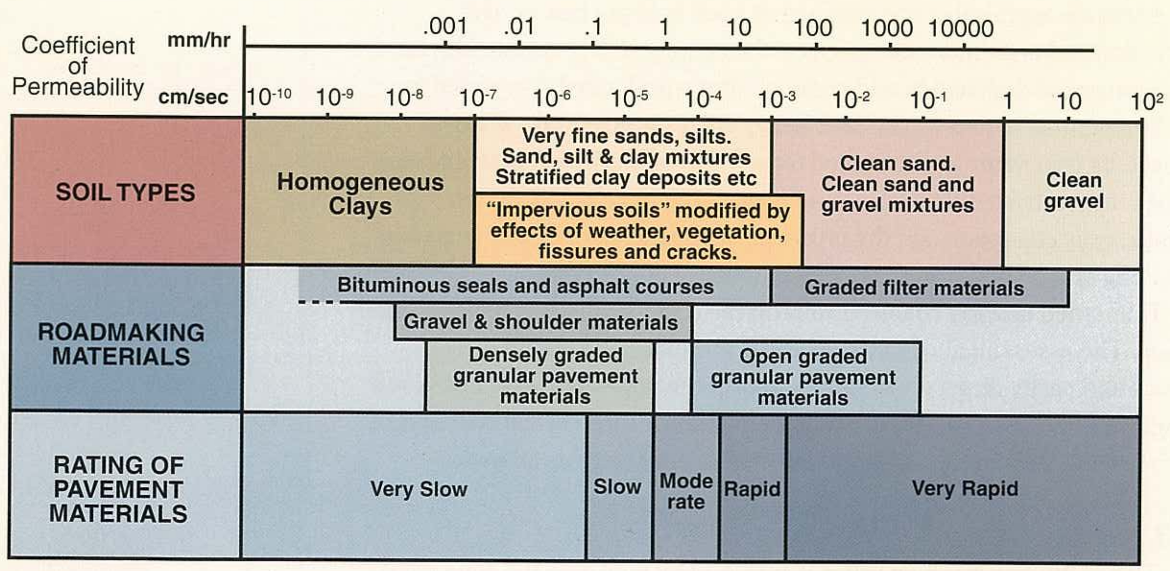
8.4 Soil Permeability

Soil permeability may be defined as the ability of a soil to transmit water or air. It can be measured in terms of the rate of flow of water through a unit cross section (cm/sec) of saturated soil in unit time under specified temperature and hydraulic conditions.

In the absence of such measurements, it is necessary to place soils into relative permeability classes through study of structure, texture, porosity, etc.

Ranges of soil permeability are as shown in Table 1.

Table 1 – Permeability Ranges



If the investigating officer is in some doubt as to a soil's permeability, some opinion may be expressed. Inspection in areas away from the pavement (cuttings, pits, drains, etc.) can often provide useful information.

8.5 Internal Soil Drainage

Internal soil drainage is the ability of a soil to permit downward flow of excess water through it and is reflected by the frequency and duration of periods of saturation. The internal soil drainage is determined by the texture and structure of the soil profile and by the height of the water table either permanent or perched, relative to the soil. Thus, soils of similar permeability have different internal drainage under different climatic conditions or under conditions relative to the water table. It is evident therefore that even a free gravel or sand may have virtually no internal drainage if it is in a position where the water table is at or near the surface for most of the year, or may be poorly drained if it is underlain by an impermeable horizon.

The infiltration rate or entry of water into surface horizons may be rapid yet overall the permeability may be low because of an impermeable layer near the surface which restricts water movement.

8.6 Soil Drainage Classes

On the basis of the observations and inferences used to obtain an estimate of run-off, soil permeability, and internal soil drainage, general relative soil drainage classes may be described as follows:

8.6.1 Poor

Water drains so slowly that the soil remains wet for long periods. The water table is commonly at or near the surface during a considerable part of the year. Poorly drained conditions are due to a high water table, to a layer of low permeability within the soil profile, to seepage or to some combination of these. Free water commonly lies on the surface for protracted periods, and soils of this drainage class usually occupy level or depressed sites. The soils often have dark grey or black, surface layers and are often light grey - sometimes mottled - in the deeper parts of the profile. Also in this class are those soils that have free internal drainage but are subject to saturation by flow of water through them for relatively long periods. Such conditions arise on the lower slopes of hillsides where water continues to drain through the soil from the higher slopes for long periods after rain due to the retarded effects of the water flow.

8.6.2 Fair

Water drains from the soil slowly enough to keep it wet for significant periods but not all of the time. Imperfectly drained soils commonly have a layer of low permeability within the profile, a high water table, additions through seepage or a combination of these. Free water may lie at the surface after rain for a considerable period. Soils of this drainage class are often uniformly coloured in the upper layers but commonly have mottlings in the lower horizons.

8.6.3 Good

Water drains from the soil and free water rapidly disappears after rain. Soils of this drainage class are commonly sandy and very permeable, although fine grained soils may be well drained if the soil structure is such that fissures and pore spaces between soil aggregations permit high permeability. Generally well drained soils are often of uniform colour over depths of about 1 metre.

It should be noted that in road works, provision of kerbs, channels, and stormwater drains alone, in no way constitutes good drainage. These are merely intended to carry away the surface run-off water. Leakage of an underground stormwater drainage system could lead to saturation of the subgrade and pavement materials, thereby worsening the drainage conditions. Any improvement of drainage in low lying urban areas with kerbs and channels but with the chance of having saturated subgrade conditions, could only be effected by the installation of properly designed and maintained sub-surface drains installed at the appropriate levels. Refer Technical Bulletin No. 32 "Drainage of Sub Surface Water from Roads" (ref 6).

8.7 Ground Water Table

The upper surface of a permanently saturated zone having appreciable thickness and areal distribution is referred to as the ground water table. There are three classes of water table, deep, shallow and perched, the characteristics of which are as follows:

8.7.1 Deep Water Table

Depth of a deep water table is so great that it is seldom if ever involved in road drainage problems. The saturated surface elevation is relatively constant and the zone of saturation may not be encountered until depths > 10 m. The surface of the free water is practically horizontal.

8.7.2 Shallow Water Table

The depth of a shallow water table varies widely but it is sometimes intersected by deep cuttings in road works. Its presence in a newly opened cutting is reflected by saturated zones along the face of the cutting. If encountered at the grade line, soft, saturated subgrade conditions will be found.

The surface of the shallow water table is seldom level except in broad stream valleys or extensive areas of relatively flat terrain. Under undulating terrain the surface of the water table will reflect the ground surface contours.

8.7.3 Perched Water Table

Perched water tables are frequently present in certain soil profiles well above the elevation of the underlying water table. They are formed by the retardation of downward movement of water and may occur whenever permeable soils are underlain by impermeable soil layers having a level or slightly concave surface.

Unlike the shallow and deep water tables, perched water tables, are discontinuous and of limited areal extent.

8.8 Topographic Features

Where water is encountered in auger holes during dippings, it is important to measure the depth from the ground surface to the top of the water and record the date. If flow of the water is observed, the direction of the flow should be noted.

Examples of drainage conditions related to topographic and other factors that may be encountered in field investigations are:

8.8.1 Crests

Drainage is generally good although poor drainage will very occasionally be found if there is either a perched water table or a flat or basin shaped impermeable layer close to the surface.

8.8.2 Steep Slopes

Drainage is usually good but it is not uncommon to find areas of fair to poor drainage where springs or seepage associated with rock or an impermeable layer of soil in the soil profile intersect the upper soil layers.

8.8.3 Bottom of Steep Slopes

It is common to find poorly drained regions where water percolating through the soil from upper slopes causes saturation (for considerable periods) of the soil towards the base of the slopes.

8.8.4 Moderate Slopes

Drainage is usually fair to good but perched water tables and seepage can again lead to areas of poor drainage.

8.8.5 Dips

Drainage tends to be poor and the same conditions often apply here as at the bottom of steep slopes. If there is free egress of water and the soil has good internal drainage it may have relatively good drainage.

Frequently, with high water tables, the surface of the water table will be close to the ground surface. Dips are often abandoned water courses and it is not uncommon to find saturated fine sands or silts in them.

8.8.6 Cuts

Cuts, especially through fissured rock, seasonal springs and seepage, often related to a high water table, can develop and quickly lead to saturation of the subgrade and pavement materials with consequent failures.

8.8.7 Cuts in Sidling Country

Surface run-off from the hillside above, together with seepage, can create troublesome drainage conditions, particularly on the inside of curves which are towards the hillside. The presence of any surface cracks or slips should be noted. Provision of catch drains to intercept water on the high side of the cut and careful attention to longitudinal profile and the roadside drains through the cut can do much to alleviate this problem.

8.8.8 Irrigation Areas

Considered as areas of poor drainage, unless tests show that the soil is dry under the worst possible conditions at the end of the irrigation season. Care should always be taken to identify irrigation areas for this is not always obvious.

8.9 Conditions Associated with the Pavement

Due to economic and other constraints, a pavement is quite often constructed between late autumn and early spring when conditions are more than likely unstable. These seasonal conditions may produce distress in a pavement if high traffic loadings occur during this period. Some of these conditions are as follows:

- If open graded material is present in a pavement which lacks adequate subgrade drains or outlets through the shoulders, a critical subgrade condition may be created by ponding of water in the "boxed-in" pavement.
- The combination of materials of different permeability such as a moisture sensitive fine-grained material (such as sandstone) in a widening trench placed alongside an original pavement of macadam, may lead to the saturation of the fine material and subsequent distress. A free draining material such as macadam can retain stability while completely water logged, but this may not be true of moisture sensitive fine-grained materials.
- For expansive clay subgrades, shrinkage cracks may develop during dry periods and lead to very rapid and complete saturation of materials which might be normally considered as impermeable.
- Contrary to popular belief, thin layers of asphalt are relatively permeable unless placed upon a bituminous seal. Bituminous seal coats are generally more waterproof than thin asphalt overlays.

Assessment of subgrade bearing strength

(refer also to "VicRoads Guide to Pavement Design" Technical Bulletin No. 37)

9.1 CBR Test

The Californian Bearing Ratio (CBR) test is the method most commonly used to rate the bearing capacity of materials. The CBR method of pavement design was devised in California in the 1930s by O.J. Porter of California State Highways Department, and has since undergone development and modification by many other authorities.

In brief the test consists of forcing a flat cylindrical plunger of 1936 mm^2 (50 mm ø) into a soil at a rate of 1 mm per minute and measuring the load required to maintain this rate of penetration at 2.5 and 5.0 mm. This load is expressed as a percentage of a standard load, ie. the load required to force the plunger into a standard sample of crushed Californian Limestone (CBR=100%).

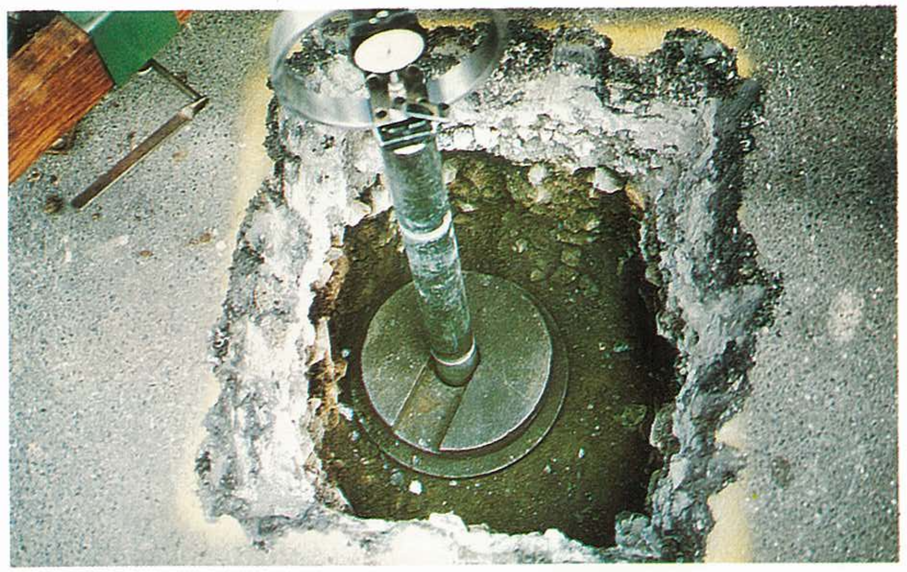
The development of the pavement design method involved the testing of many thousands of widely different Californian subgrades. The subgrade CBR values determined were then correlated with the observed pavement thickness and performance. These studies led to the conclusion that a material of a certain CBR required a certain minimum thickness of pavement above it. Design curves for thickness estimation were developed and in various modified forms are now widely used throughout the world.

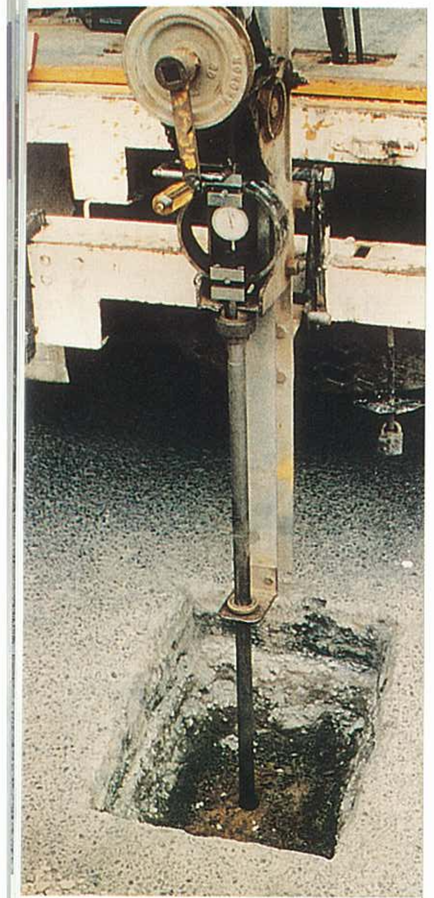
9.2 Methods of CBR Determination

9.2.1 General

The insitu CBR can be determined from a Field CBR test or from an estimated CBR by cone penetration tests. The cone penetration tests (Static and Dynamic Cone) employed by VicRoads were developed and correlated with insitu CBRs, by A.J. Scala in the early 1960's. They give a quick and continuous record of the bearing strength of the subgrade being tested. The dynamic cone test is less reliable than the static cone test and should only be used as the sole test when a static cone is not available, when materials are too stiff (CBR greater than 10) for the static cone to penetrate or when vehicular access to the test site is not possible. Dynamic cone results should be compared with static cone results if both are available. Any dynamic cone results not paired with static cone results should be adjusted, if paired results for the same material, show a regular difference.

9.2.2 The Field CBR Test (AS1289.F1.3 1977 Method F1.3)





The test is performed in the same manner as the laboratory CBR test. A flat cylindrical plunger having a cross sectional area of 1936 mm^2 (50 mm diameter) is forced into the soil at a uniform rate of 1 mm per minute. The resistance to penetration is measured at frequent intervals and a graph of penetration resistance versus depth of penetration is drawn. After correcting for surface irregularities the penetration resistance in kN at 2.5 and 5.0mm is determined. These loads are divided by the standard loads of 13.2 kN for 2.5 mm and 19.8 kN for 5.0 mm penetration and the answer expressed as a percentage. The test method requires that the higher value of the two (at 2.5 or 5.0mm) is taken as the CBR of the material.

During the testing, annular surcharge weights are used around the test plunger to represent the pavement load on the subgrade. A load of 9 kg is generally used to represent each 150 mm depth of pavement.

This method is accurate, but slow and cumbersome. Considerable time is spent in excavating and levelling the test site and the resultant answer is applicable only to the layer actually penetrated during the test. To delineate the weak or controlling layer for design purposes using this test alone would be overwhelmingly time consuming.

9.2.3 The Static Cone Penetrometer (AS1289.F5.1 Method F5.1)

In this test a cone with a point angle of 60° and a cross sectional area of 1000 mm^2 (diameter 36 mm) is forced into the soil by means of a rack and pinion type loading apparatus. The penetration resistance is measured by a load ring. The rods to which the cone is attached are standard "XRT" drill rods which have a diameter of 28 mm. (if unavailable, adapt a rod of 28 mm diameter or less). This leaves a clearance of approximately 4 mm between the wall of the hole and the rod to minimise skin friction. Readings are normally taken at each 30 mm penetration down to 1 m or until a sufficiently high CBR value is obtained compared with the layers above. The cone is forced into the soil at a convenient speed, but when a reading is being taken the penetration rate should be 1 mm per minute.

The CBR is calculated from

$$CBR = \frac{4.5 \times Pa}{10^6}$$

where "P" is the penetration resistance in kN and "a" is the cross-sectional area of the cone in mm^2. The CBR is usually determined from a chart prepared from the calculated CBR against load.

9.2.4 The Dynamic Cone Penetrometer (AS1289.F3.2 Method F3.2)

The dynamic cone consists of a 9 kg drop hammer sliding on a 16 mm steel rod. The hammer falls through a distance of 510 mm and strikes an anvil at the lower end of the rod. A further 1 m length of 16 mm diameter steel rod is threaded at one end to attach to the lower side of the anvil and has a case hardened steel cone attached to the other end. This cone has a point angle of 30° and a cross sectional area of 320 mm^2 (20 mm diameter). The gross mass of the apparatus is 12.7 kg and the overall length is approximately 1.8 m.

In use, the penetrometer is driven in by blows from the drop hammer to a depth of approximately 760 mm below the surface or further if using a longer lower rod. The penetration for each blow or series of blows is measured with a 1 m rule and a record of blows versus penetration is kept. A calibration curve for a dynamic cone and calibration chart of blows/mm penetration versus CBR is shown in Appendix 2. The dynamic cone is used in place of the static cone for circumstances as indicated in 9.2.1. It is quick to operate and very portable but tends to give less reliable results than the static cone.

The CBR is calculated from

$$CBR = \frac{4.5 \times Pa}{10^6}$$

where "P" is the penetration resistance in kN and "a" is the cross-sectional area of the cone in mm^2. The CBR is usually determined from a chart prepared from the calculated CBR against penetration per blow. (Refer Appendix 2).

9.2.5 Reliability of Results.

It should be noted that there is only one insitu test which gives the actual CBR, viz. the field CBR test. The other tests described give estimates of the CBR. Of these the static cone gives the most reliable results, while the dynamic cone gives variable values. It is advisable to make a few correlation checks between the dynamic and static cone values during the course of an investigation so that dynamic cone results obtained in areas inaccessible to the static cone or field CBR apparatus, may be adjusted for the particular soil.

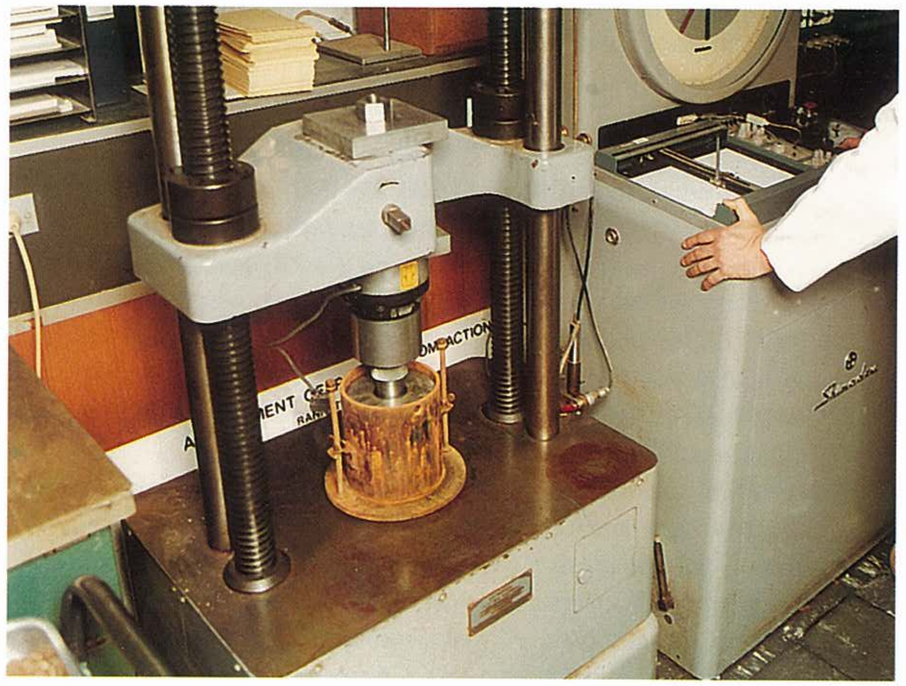
In general, results obtained by all methods in fine-grained cohesive soils have fair agreement. In non cohesive soils wide variations in values are often found and less reliance can be placed on the insitu tests. Values from all 3 types of insitu tests must be related to moisture conditions at the time of test. (CBR does vary considerably, depending on the density and moisture conditions of the soil under test).

The dynamic cone when used in near saturated sands and silts gives much lower CBRs than the static cone. This is due to the difference in cone size and angle which allows the point of the dynamic cone to reorient the particles by vibration, and penetration occurs more readily. The static cone has a greater resistance to penetration, as the constant load compresses the particles beneath the cone, rather than reorienting them. If sands and silts, whether they are saturated or dry, are properly confined they generally develop quite high CBRs.

9.3 Laboratory Tests

9.3.1 Laboratory Soaked CBR Tests (AS1289.F1.1 Method F1.1)

The laboratory soaked CBR test and the field CBR test procedures are similar except that in the laboratory CBR test the soil is compacted into a 150 mm diameter mould. The CBR is determined after the material has soaked for 4 days. For soils the CBR reported is usually for a sample compacted to 98% of maximum dry density using standard compactive effort and of the corresponding moisture content. It has been found that the degree of saturation achieved in 4 days soaking of the CBR sample is rarely reached in the field in areas where the rainfall is less than 850 mm per annum. In these circumstances an adjustment may be made on the basis of the average annual rainfall, and the laboratory soaked CBR is multiplied by a factor greater than unity. (Refer to Chapter 5 of Technical Bulletin No 37).



Where poor sub-surface conditions prevail or where construction is subject to level constraints, the correction factor should not be applied.

Contours of laboratory soaked CBRs should be carried out for:

- most major projects
- when a design CBR of less than 5% is anticipated.

9.3.2 Laboratory CBR by Core Cutter (AS1289.F1.2 1977 Method F1.2)

This method requires a CBR sized thin walled cylinder with a sharpened cutting edge to be pressed or jacked into the subgrade. The cylinder with sample is carefully excavated and the ends struck off level, sealed in an air tight container and returned to the laboratory where it is attached to a normal CBR mould base plate, surcharged, soaked for 4 days and then tested. The in-place density is determined from the mass and volume of the core and the moisture content is determined from the struck off cuttings. This test is applicable only to fine grained cohesive soils.

The main advantages of this method are as follows:

- accuracy is ensured as the moulding density and moisture content can be determined;
- useful as a check on laboratory soaked CBR;

- useful as a check on CBR when there are slight variations in material;
- most useful when earthworks precede pavement works by some months. This allows time to adjust pavement thickness design, if necessary, however 5-6 days testing time is required to check design CBRs.

9.4 Design CBR

The aim of a site investigation is to select the CBR expected to be achieved in the long term, under equilibrium moisture conditions. (See also VicRoads Technical Bulletin No. 37). A design CBR must be selected so that a pavement thickness can be determined for a given design traffic loading. Its selection must be consistent with the standard of construction, and must allow both for economy of construction and for the pavement performance required.

(Refer also to VicRoads Materials Technology Department Code of Practice for Determination of Design CBR of Filling and Sub-Base Material - RC/MTD/500.20)

Reporting of test results and laboratory testing

Any unusual observations not recorded under the headings of Pavement Condition, Topography and Drainage should also be noted.

The report sheets, as well as serving as part of a formal report, should also enable certain general information to be stored on a computer database for future reference. It is therefore important that all collected information be reported. (Refer to Appendix 4.)

In a report the following parameters are to be reported for each site.

1. Total length of deflection testing by PaSE
   - maximum deflections
   - curvatures
2. Pavement differences
   - Surfacing type
   - Depth of each pavement layer and material type and a description of colour
   - Depth of each subgrade layer and material type and colour and moisture contents at layer or strength changes
   - Strength of subgrade to a depth of at least 1m preferably by static cone
   - Design CBR.
3. Design traffic loadings
   - Determined from either actual traffic counts or from Culway data
   - % commercial vehicles.
4. Road condition data (RAS)
   - roughness
   - rutting
   - texture (if available).
5. Proposed rehabilitation treatment.

The Materials Technology Department LMS Computer System has previously been used for reporting Pavement Investigation details. A Quattro Spreadsheet is also available for recording pavement layer thicknesses and subgrade CBR values as well as laboratory testing results such as PI and Grading. Reporting methods are currently being reviewed.

When the report sheets are completed, they are to be forwarded to a laboratory, before laboratory testing can be carried out on the samples.

On completion of the laboratory testing, the results are written on the test results sheets and the report returned to the relevant supervisor to enable a pavement design to be determined.

For existing pavements, the field information may form part of a Pavement Condition Report which will cover other information about the pavement.

References

1. VicRoads (1993) Technical Bulletin No 37 "A Guide to the Structural Design of Pavements."
2. RCA (1986) Technical Bulletin No 33 "Pavement Strength Evaluation and Rehabilitation."
3. Australian Standard AS1289.0 - 1991 Methods of testing soils for engineering purposes. Part O: General requirements and list of methods.

   3.1 AS1289.2.1.1 1992 Method 2.1.1: Soil moisture content tests – Determination of the moisture content of a soil – Oven drying method (standard method)

   3.2 AS1289.F1.1 1977 Method F1.1: Soil strength and consolidation tests – Determination of the California bearing ratio of a soil – Standard laboratory method for a remoulded specimen.

   3.3 AS1289.F1.2 1977 Method F1.2: Soil strength and consolidation tests – Determination of the California bearing ratio of a soil – Standard laboratory method for an undisturbed specimen.

   3.4 AS1289.F1.3 1977 Method F1.3: Soil strength and consolidation tests – Determination of the California bearing ratio of a soil – Standard field-in-place method.

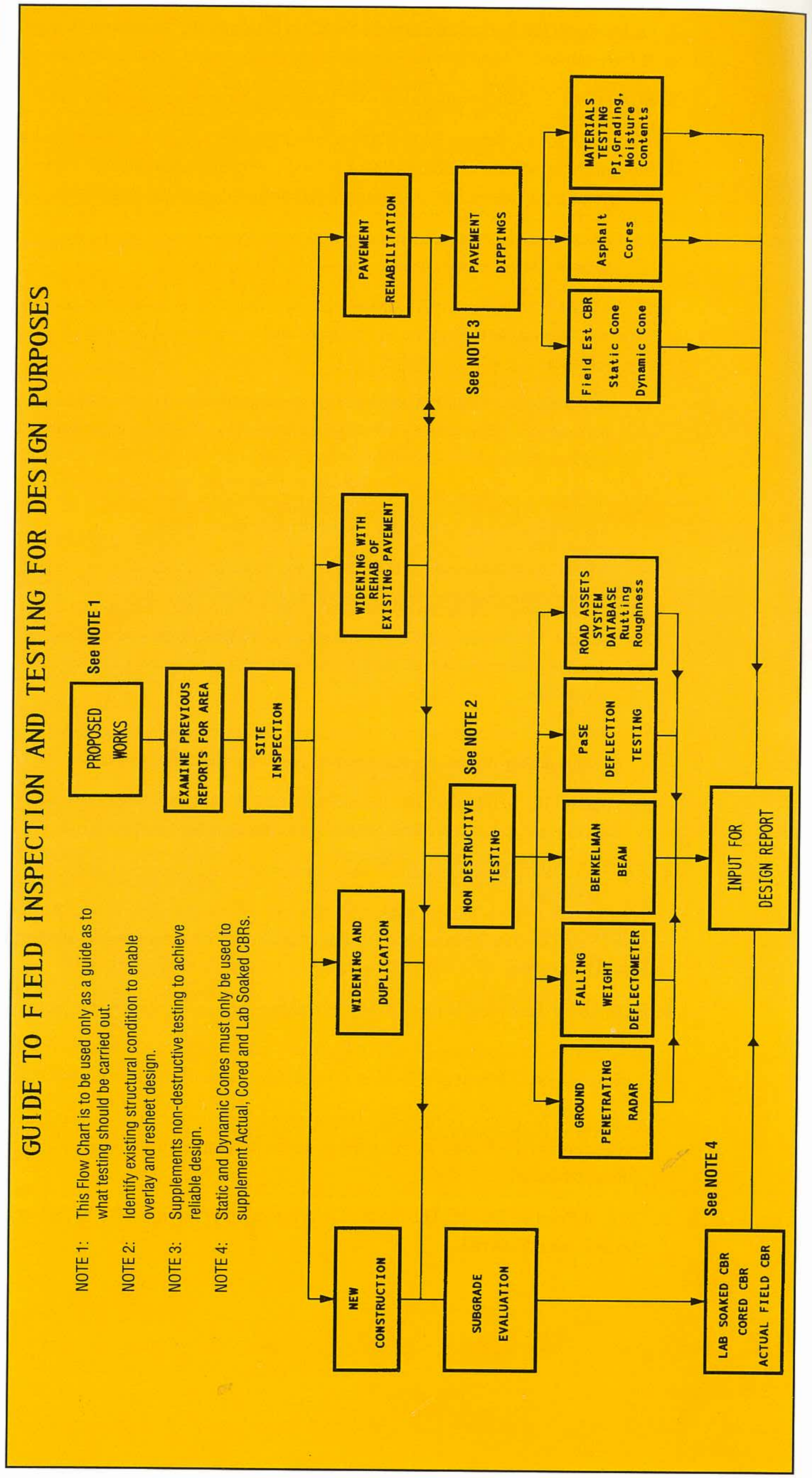
   3.5 AS1289.F3.2 1984 Method F3.2: Soil strength and consolidation tests – Determination of the penetration resistance of a soil using the 9kg dynamic cone penetrometer.

   3.6 AS1289.F5.1 1984 Method F5.1: Soil strength and consolidation tests – Determination of the static cone penetration resistance of a soil – Field test using a cone or a friction cone penetrometer.

   3.7 AS1289.5.1.1 1993 Method 5.1.1: Soil compaction and density tests – Determination of the dry density/moisture content relation of a soil using standard compaction.

   3.8 AS1289.5.2.1 1993 Method 5.2.1: Soil compaction and density tests – Determination of the dry density/moisture content relation of a soil using modified compaction.
4. NAASRA (1987) A Guide to the Visual Assessment of Pavement Condition, 1987, NAASRA.
5. AUSTROADS (1992) Pavement Design; A Guide to the Structural Design of Road Pavements.
6. RCA (1984) Technical Bulletin No 32 "Drainage of Sub-Surface Water from Roads."
7. VicRoads (1994) Manual of Testing Procedures.
8. VicRoads – Materials Technology Department, Pavement Services Section and Pavement Technology Group Procedures (available on VicRoads Lotus Notes Database).
9. Code of Practice RC/MTD 500.20 – Determination of Design CBR of Filling and Sub-base Materials.

Pavement investigation procedures



9 kg dynamic cone penetrometer chart

This Table shows the CBR value determined from the calculation referred to in Section 5 of this document and applied to the dimensions of this particular cone.

NOTE: *This chart is applicable only to the 320 mm2 cone, 9 kg hammer, 510 mm drop, 816 mm penetration rod.*

PENETRATION (cms)	CBR Values No. of BLOWS 1	2	4
0.5	50	50	50
0.7	30	50	50
1.0	22	50	50
1.2	18	40	50
1.5	15	30	50
1.7	12	25	50
2.0	10	22	50
2.2	9	20	45
2.5	8	18	40
2.7	7	15	35
3.0	6	14	30
3.2	6	13	30
3.5	6	12	26
3.7	5	11	24
4.0	5	10	22
4.2	4	9	21
4.5	4	9	20
4.7	4	8	18
5.0-6.5	3	7	
6.6-9.5	2		
9.5+	1		

Glossary of Terms

CBR	Californian Bearing Ratio.
Coned CBRs	Cones are pressed into the subgrade, carefully removed, shook off and returned to laboratory for soaking and testing.
cut to fill lines	this is where the intersection of the gradeline with the topographical line or natural surface, changes from cut to fill or from fill to cut.
deflectograph	A special vehicle for automatically measuring surface deflections (see also PaSE)
design CBR	The CBR value selected for pavement design purposes.
DCP	Dynamic Cone Penetrometer.
dipping	The measurement of layer thickness and/or depth from the surface.
estimated CBR	A CBR value determined in the field using a DCP, SCP or any method other than by laboratory CBR or actual CBR measured insitu.
floater	a large isolated sub-surface rock usually of volcanic origin.
FWD	Falling Weight Deflectometer.
GPR	Ground Penetrating Radar.
insitu	in-place, in a field situation.
laboratory soaked CBR	A laboratory prepared sample for CBR testing, which has been soaked in water for 4 days prior to testing.
overlay	overlaying of an existing pavement with asphalt.
parent rock	naturally occurring rock (not placed), sometimes called "bedrock".
PaSE	VicRoads testing vehicle (Pavement Strength Evaluator) used for automatic measuring of surface deflections (see also Deflectograph). Pavement modification.
permeable material	A material which will allow water to pass through it.
PI	Plasticity Index – difference between liquid limit and plastic limit of a subgrade soil or pavement base or sub-base material, and indicates the "clayiness" of a material.
resheet	placing a layer of granular material over an existing pavement.
reverse permeability	where a lower permeability material overlies one of higher permeability.
SCP	Static Cone Penetrometer.
soaked CBR	laboratory soaked CBR.

Any unusual observations not recorded under the headings of Pavement Condition, Topography and Drainage should be carefully noted.

The information from field work sheets, as well as serving as part of a formal report, should also enable certain general information to be stored on a computer database for future reference. It is therefore important that all collected information be reported.

When the field work sheets are completed, they are to be forwarded to the laboratory with any pavement and subgrade samples for testing.

The Materials Technology Department LMS Computer System has previously been used for reporting Pavement Investigation details. A Quattro or Lotus Spreadsheet could also be used for recording pavement layer thicknesses and subgrade CBR values as well as laboratory testing results such as PI and Grading and laboratory soaked CBRs.

On completion of the laboratory testing, the results are collated and submitted to the designer for his written recommendation report on the final pavement design options.

Example Pavement Investigation Field Worksheet

(see over for field worksheet)

Form 3521

vicroads

MATERIALS TECHNOLOGY DEPARTMENT

PAVEMENT INVESTIGATION FIELD SHEET

TEST METHOD 300.05

Operator ....

Date ....

Highway/Municipality	Section/Road	Site No.
Chainage	Lateral Position	Proposed Change in Level

Site Code	Transverse Deformation Index No.	Degree of Cracking Index No.	Width of Seal m	Width of Formation m

LAYER DESCRIPTION	DEPTH cm	BAG NO.	M C Depth cm	M C Tin No.

STATIC CONE at cm Prov. Ring No.

DEPTH mm	Load Reading	Est. C B R	Layer C B R

DYNAMIC CONE at cm

Blows	Depth mm	Penet-ration mm	Est. C B R	Layer C B R

TOPOGRAPHY

GENERAL : ☐ Flat ☐ Undulating ☐ Hilly

LOCAL

☐ Flat ☐ Dip ☐ Steep slope

☐ Mod. slope ☐ High flat ☐ Valley

☐ Low flat ☐ Crest ☐ Saddle

Side slope

Depth of cut .... L H S .... R H S

Height of fill .... L H S .... R H S

DRAINAGE

General ☐ Good ☐ Fair ☐ Poor

Near site ☐ Good ☐ Fair ☐ Poor

Free water observed ☐ Yes ☐ No

Swampy ☐ Yes ☐ No

Subject to flooding ☐ Yes ☐ No

Irrigated area ☐ Yes ☐ No

Existing drains ....

Vegetation ....

CONDITION OF PAVEMENT

SURFACE IN GENERAL

☐ Good ☐ Fair ☐ Poor

☐ Very bad ☐ Completely failed

SHAPE-TRANSVERSE

☐ Good

☐ Fair

☐ Poor

SHAPE-LONGITUDINAL

☐ Good

☐ Fair

☐ Poor

FAULTS

☐ Nil ☐ Minor patching

☐ Trans. cracking ☐ Major patching

☐ Long. cracking ☐ Sinking

☐ Croc. cracking ☐ Rutting

☐ Potholes ☐ Shoving

☐ Dev. potholes ☐ Ravelling

☐ Edge failures ☐ Slick

☐ Edge patching ☐ Polished aggregate surface

(Tick where applicable)

Remarks ....

....

....

....

LAYER DESCRIPTION	DEPTH cm	BAG No.	M C Depth cm	M C Tin No.

CROSS SECTION

CODES USED IN REPORTING

SITE CODE
MS : Sealed pavement other than ES
ES : Sealed pavement within 0.5 m of edge of pavement
UP : Unsealed pavement
SH : Unsealed shoulder
TS : Sealed shoulder
RS : Road reserve
NA : New alignment

CLASSIFICATION OF SEALED PAVEMENT SURFACE CONDITION AT TEST SITE

D Transverse Deformation Under a 2 Metre Straight Edge		C Degree of Cracking (visible cracks)	
Index No.	Deformation	Index No.	Crack Length/Unit Area
1	< 10 mm	1	Nil
2	10 - 15 "	2	0 - 1 m/m^2
3	15 - 20 "	3	1 - 2 "
4	20 - 25 "	4	2 - 5 "
5	> 25 "	5	> 5 "
			Ravelling and pot-holing imminent, immediate maintenance required.

Pavement Investigation

Appendix 5

Typical Deflection Output Charts

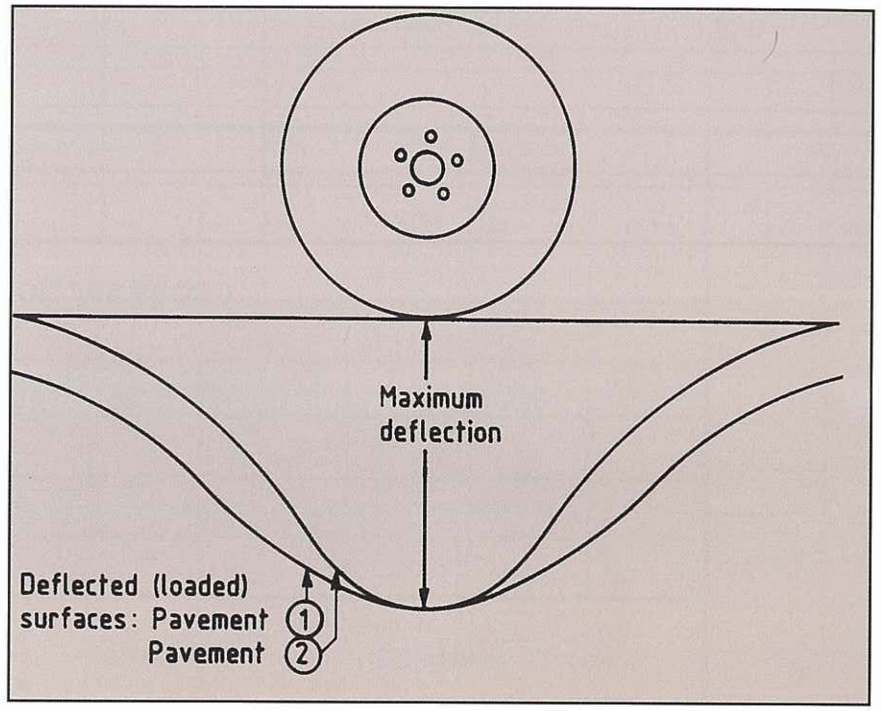


Chart showing how a dual wheel loading effects the deformation of the pavement. Pavement 1 and Pavement 2 have equal strength which is determined by the magnitude of the Maximum Deflection.

Pavement 1 has a greater stiffness than Pavement 2 and this is determined by the slope of the deflected bowl. This means that the larger the bowl diameter, the greater the stiffness of the pavement.

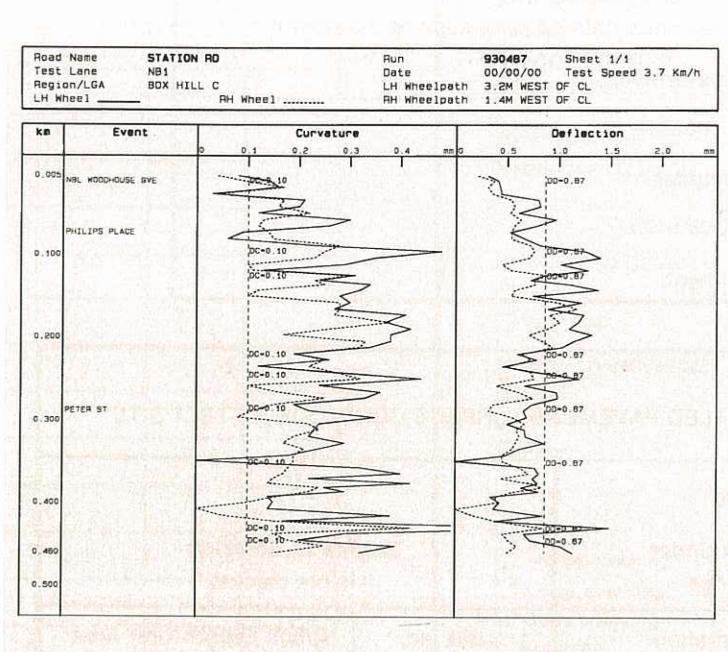


Chart showing maximum deflections and curvatures, design deflection and design curvature for a particular length of road.

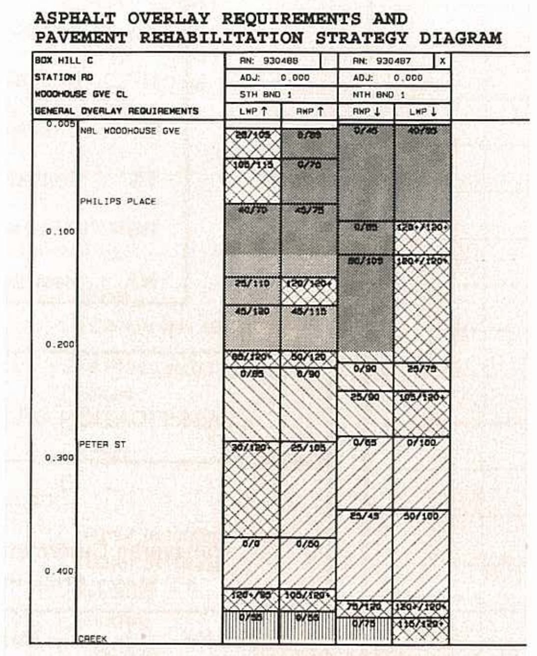


Chart showing proposed rehabilitation treatments for each lane and wheelpaths for a particular section of road.