Guideline

Pavement Investigation and Analysis

July 2024

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Contents

1 Introduction

The purpose of this Guideline is to outline a broad approach for the investigation, sampling, testing and analysis of existing pavement and subgrade materials for the purpose of determining suitable pavement rehabilitation treatments.

This Guideline attempts to bring together pavement investigation best-practice techniques into a simple and practical guide for pavement investigators and designers.

This Guideline is to be read in conjunction with the Department of Transport and Main Roads *Pavement Rehabilitation Manual*, *Pavement Design Supplement*, *Materials Testing Manual* and other pavement related technical publications (for example, Austroads *Guide to Pavement Technology*).

> This Guideline is primarily for the investigation of flexible pavements.
>
> For rigid pavements (that is, concrete), refer to TN143 *Rehabilitation Technique and Treatment Prioritisation Method of Plain Concrete Pavements (PCP)*.
>
> For bridge deck wearing surfaces, refer to Guideline *Asphalt Deck Wearing Surface (DWS) Rehabilitation*.
>
> For further information regarding this Guideline or pavement rehabilitation, please email Technical Publications.

2 Purpose of pavement investigation

A good pavement rehabilitation design should investigate and analyse the existing pavement structure and materials to identify the key failure mechanisms and associated root causes. From there, suitable rehabilitation treatment options can be determined to adequately address the failure mechanisms (refer to Chapter 2 of the department's *Pavement Rehabilitation Manual*).

To do this, the pavement designer must utilise different pavement investigation techniques to identify the representative pavement profiles, determine the properties of the existing pavement structure and materials, and understand the pavement's performance.

> As an example of a poor pavement rehabilitation design, it would be unwise to invest funds into a thin asphalt overlay if the existing underlying pavement was likely to continue to fail and therefore distress the new asphalt overlay. A thin asphalt overlay may be considered as a suitable pavement rehabilitation treatment if the existing pavement is found to be in a sound condition and/or any underlying pavement weaknesses are rectified.

The sampled material from the pavement investigation can also be used to assess the suitability of different pavement rehabilitation treatments. For example, laboratory testing can be undertaken to determine if insitu stabilisation is a viable treatment.

> Pavement investigations and materials laboratory testing are critical for a pavement designer to accurately assess the existing pavement profile, structure, and material properties. In doing so, it

will allow the pavement designer to identify the failure mechanisms and develop suitable pavement rehabilitation treatment options.

Pavement investigation and associated materials laboratory testing is very important for insitu stabilisation works. Typically, the department is responsible for the existing pavement materials which will be insitu stabilised. Therefore, the department is responsible for nominating a suitable mix design (or 'recipe') which will achieve the pavement design intent. To achieve this, adequate upfront pavement investigation and materials laboratory testing must be undertaken by the department (or Design Consultant) to determine a suitable insitu stabilisation mix design which is then nominated in the appropriate MRTS Annexure.

Exceptions to this process may include the following situations:

- A *TIC Design and Construct (TIC-DC) Contract*, where the Contractor (and thereby its nominated Designer) is responsible for the pavement design. In this situation, the Designer is responsible for nominating a suitable insitu stabilisation mix design in accordance with departmental technical documents.
- An insitu stabilisation project where ≥ 50% of the material to be stabilised is imported quarried granular (for example, carriageway duplication, pavement widening and/or thick overlay). In this situation, the Contractor may be responsible for nominating a suitable insitu stabilisation mix design based on their preferred quarry supplier. The Contractor's responsibilities and mix design requirements must be clearly detailed in the relevant MRTS Annexure Supplementary Specification.

For plant-mixed stabilised materials, the Contractor is responsible for all materials. Therefore, the Contractor is responsible for nominating a suitable mix design in accordance with departmental technical documents. This is reflected in MRTS08 *Plant-Mixed Heavily Bound (Cemented) Pavement*s, MRTS09 *Plant-Mixed Foamed Bitumen Stabilised Pavements* and MRTS10 *Plant-Mixed Lightly Bound Pavements* and Technical Note 204 *Mix design registration of plant-mixed cementitiously stabilised pavement material* which detail the mix design approval process.

3 Project scope

To help define the pavement investigation and design intent, the pavement designer must consider the project scope. Relevant project scope information may include the following:

- proposed works (for example pavement rehabilitation, widening, realignment, duplication, shape correction and so on)
- project location
- extent of start and finish chainages or features
- delivery timeframe
- available funding
- pavement design parameters (for example, design life, project reliability, Annual Average Daily Traffic (AADT), expected heavy vehicle growth rate and so on)
- available pavement construction and condition data in existing information management systems

- topography, nature of adjacent land use, soil types and geology
- climate (for example, temperature, rainfall, and flooding history)
- road geometry and cross section information
- project constraints (for example, urban or residential surroundings, environmental sensitivity, traffic management, underground services, availability of quarried materials, hydraulic considerations (for example, afflux), structures and so on)
- types, condition and location of drainage systems and other structures, and potential for pavement inundation or saturation of subgrades, and
- types and locations of utilities and services.

Throughout the pavement investigation and analysis process, the pavement designer should refer to the project scope to ensure that the pavement design is appropriately aligned.

As detailed design processes can often extend over long time periods, it is recommended to undertake periodic reviews of the proposed pavement design to check the compatibility with the project scope and other design elements (for example, road geometry, longitudinal grade, widening and typical cross sections).

4 Pavement investigation data

Information regarding the pavement profiles and materials can be gathered from various sources as outlined in the following sections.

4.1 Desktop review

Prior to undertaking onsite investigation works, the pavement designer should collect, correlate, and review all available desktop data. Sources of relevant desktop data may include the following:

- **A Road Management Information System (ARMIS)**

  The department's Chartview database (or Tableau Pavement Dashboard) is an excellent tool to obtain job / pavement history, pavement configuration, traffic details, roughness, rutting, cracking and deflection. While this data is often extremely useful, errors do exist. Accordingly, it is recommended that the data be verified through onsite investigations.

- **Digital Video Road (DVR)**

  Video history of a road over several years is particularly useful if recent resurfacing treatments have masked the underlying pavement condition. Areas of distress can be identified by reviewing the department's DVR records. Google Earth and Google Street View are also useful tools to review road sections.

- **Historical and As Constructed drawings**

  The department's Geospatial Information Management System (GIMS) database is a repository of existing drawings that are a valuable information source.

- **Geotechnical information**

  The department's iMaps' Geotechnical Map contains useful information such as soil types, clay minerology, geotechnical reports, quarries and flooding and inundation data.

- **Maintenance records, local knowledge from District, Council and/or Maintenance Contractor, and historical pavement condition and investigation data.**

  Through the department's District representative (for example, Project Manager),check with the local Transport and Main Roads Materials Laboratory, RoadTek, maintenance staff, Program Managers and recordkeeping for any previous pavement works, typical repairs and/or investigations on nearby sections of the road network.

4.2 Visual inspection

A detailed and documented visual inspection of the pavement is a key element in the pavement investigation process (refer to Chapter 2 of the department's *Pavement Rehabilitation Manual*). If the pavement condition has been masked by recent resurfacing works, DVR records can be reviewed (as detailed in Section 4.1).

It is often beneficial to undertake the visual assessment after surface deflections (for example, Falling Weight Deflectometer) and Ground Penetrating Radar (GPR) analysis has been completed. This allows the pavement designer to visually assess the areas with differing structural response and/or cross sections. If no project level deflection has been undertaken, the pavement designer should review the most recent network level Traffic Speed Deflectometer TSD data from ARMIS (as detailed in Section 4.1).

A visual inspection should be undertaken to:

- Record pavement features such as surface type, condition (good, fair, or poor), edge condition, lane and shoulders widths, cuts and embankment fills.
- Record the general location, type, severity and extent of pavement distresses and defects (for example, rutting, cracking, patches, potholes and so on). Refer to the department's *Pavement Rehabilitation Manual* and *Guide to the Visual Assessment of Pavements*.
- Record the general site details such as topography, soil types, geology, drainage, water table, site constraints, services, road geometry and formation details, and land use.
- Identify any project constraints that may impact the type and extent of proposed pavement treatments or investigation works (for example, kerb, channel, drainage inlets and property accesses may inhibit the ability to overlay the existing pavement).

4.3 Non-destructive pavement investigation

The pavement designer can obtain some important information regarding the pavement strength, profiles, and materials through non-destructive testing activities detailed below.

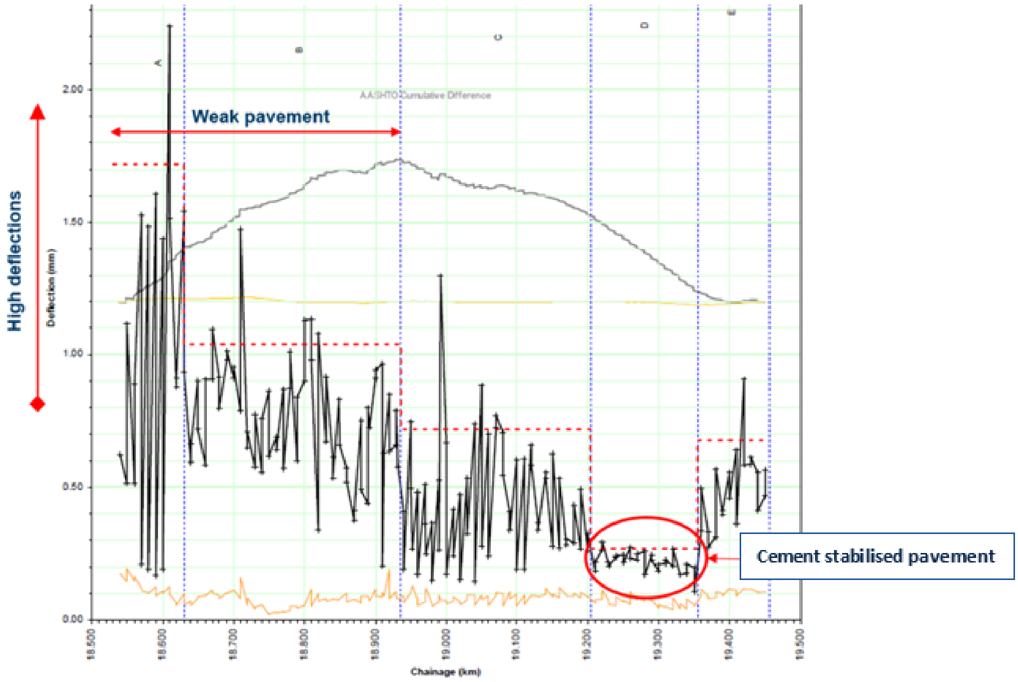
4.3.1 Falling Weight Deflectometer (FWD)

Surface deflections define the pavement's structural response to load. They can be used to determine homogeneous pavement sections which can allow a more targeted destructive pavement investigation. It is common to undertake FWD testing prior to destructive pavement testing as this can help define homogeneous pavement sections with differing structural responses, which could be an indicator of pavement condition or depth. FWD data can also be back-analysed to help define appropriate pavement layer moduli for mechanistic pavement design (that is, CIRCLY). TSD data (refer to Section 4.1) can also be used to define homogeneous pavement sections but is not considered suitable for back-analysis. Refer to Section 2.13.10 of the *Pavement Rehabilitation Manual* for more information about surface deflections.

Figure 4.3.1(a) – Example of FWD equipment

Source: Australian Road Research Board.

Figure 4.3.1(b) – Example of FWD maximum deflection (*D_0*) analysis showing homogenous sectioning

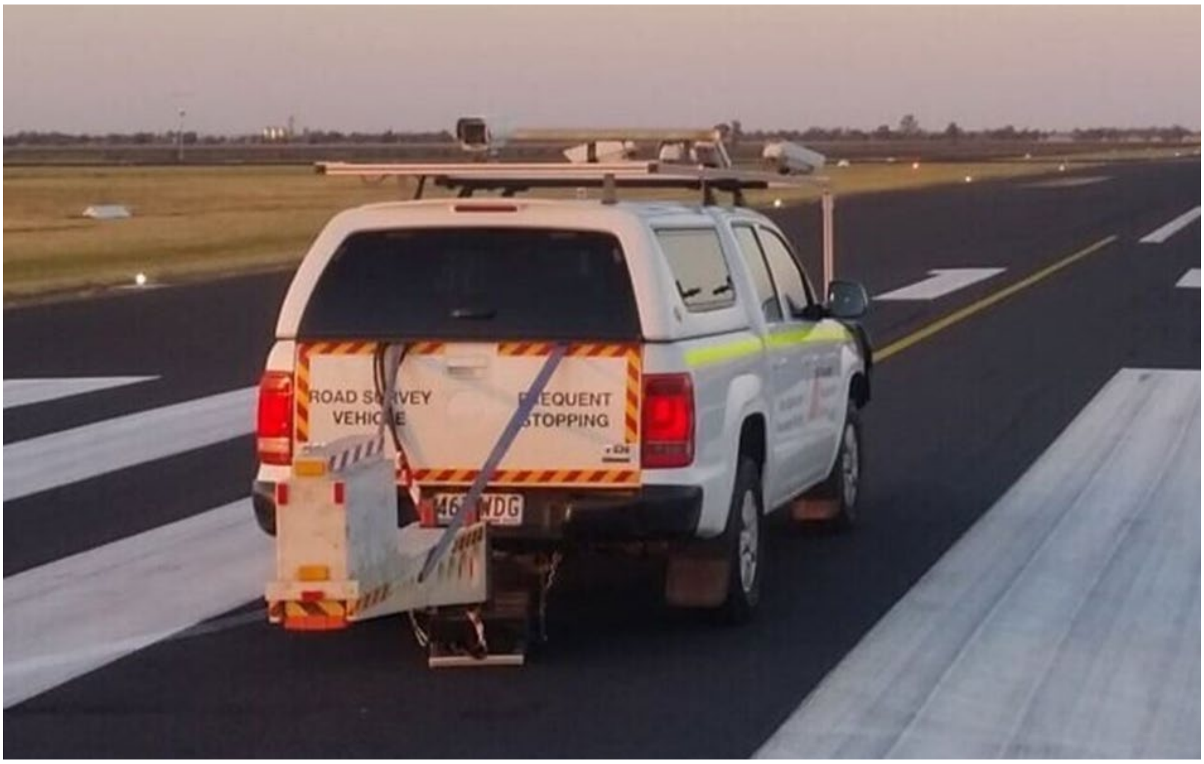


Source: Transport and Main Roads Mt Lindesay Highway

4.3.2 Ground Penetrating Radar (GPR)

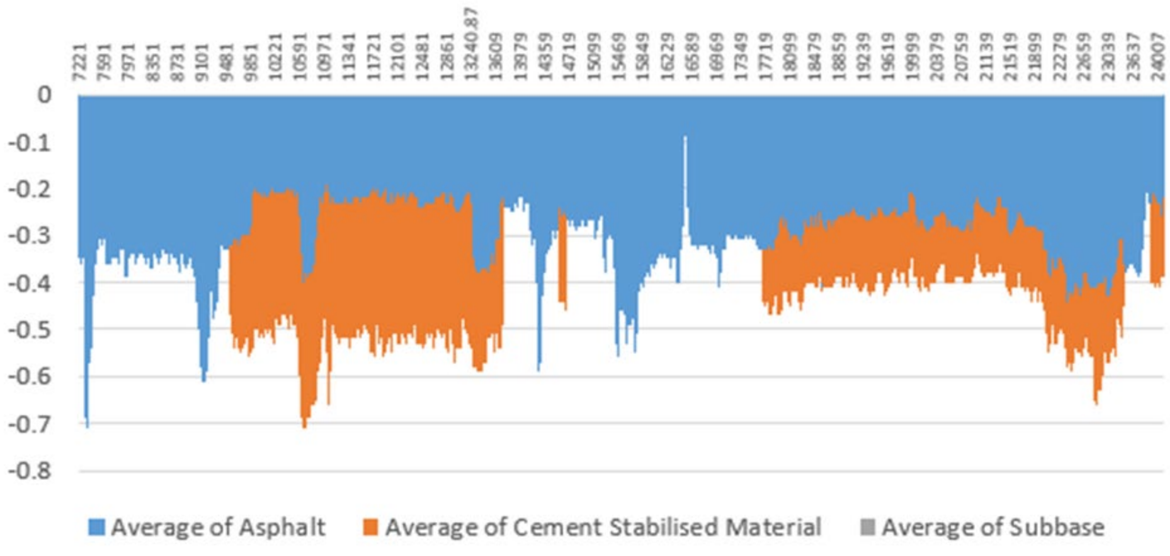
This technology is useful to identify underground obstructions such as service utilities, culverts, pipes and so on. When calibrated with accurate coring, augering and trenching pavement profiles, it can be used to define different pavement layers, materials, extents, and depths. Refer to Section 2.8 of the *Pavement Rehabilitation Manual* for more information about GPR.

Figure 4.3.2(a) – Example of GPR equipment



Source: Pavement Management Systems

Figure 4.3.2(b) – Example of GPR output for a full depth asphalt pavement



Source: Transport and Main Roads Bruce Highway

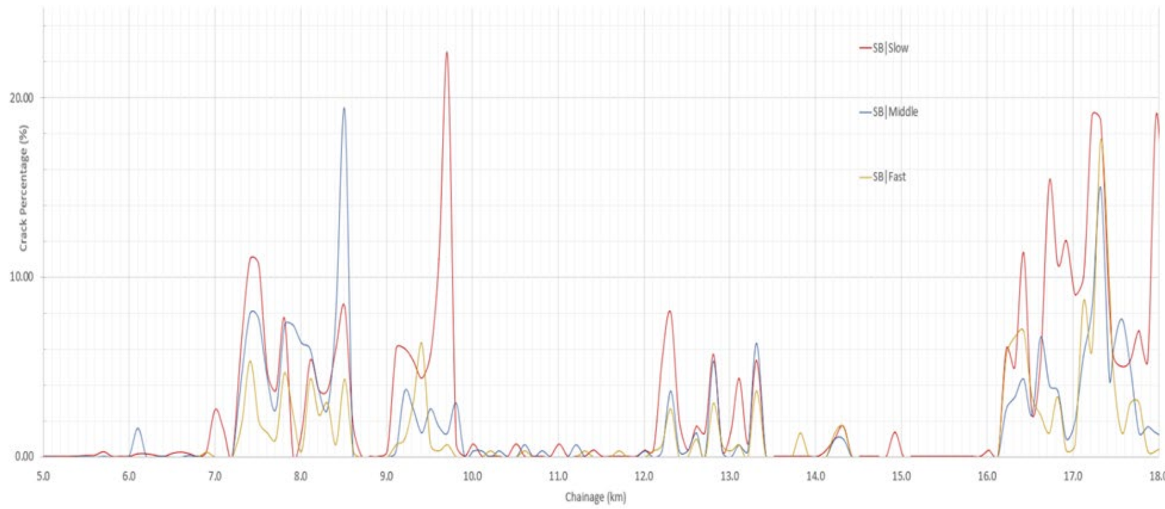
4.3.3 Automated pavement condition and cracking survey

The primary purpose of the survey is to collect pavement condition data (video, high-definition photos, roughness, rutting and texture), and locate, identify, and detail surface cracks / visual defects in the existing pavement surface. Automated mobile collection of the pavement condition and crack survey is typically undertaken at posted road speeds.

Figure 4.3.3(a) – Example of automated pavement condition and cracking survey equipment

Source: Pavement Management Services

Figure 4.3.3(b) – Example of automated pavement cracking survey output



Source: Transport and Main Roads Bruce Highway

4.4 Destructive pavement investigation

Before commencing the destructive pavement investigation, the pavement designer should undertake a holistic review of the project scope (refer to Section 3) and available pavement investigation data (refer to Sections 4.1, 4.2 and 4.3).

The pavement designer should use any existing pavement data to help determine the most suitable investigation locations and laboratory materials testing regime within the project scope. Further to this, the holistic review can be used to define areas of existing pavement that may be grouped into typical or homogeneous sections.

Collecting pavement samples and undertaking laboratory testing is typically the most expensive part of the pavement investigation process. It is, therefore, recommended that the pavement designer aims to optimise the testing locations by reviewing all available information prior to commencing the destructive pavement investigation. Where possible, the sampling and testing plan should also be optimised to allow one visit to site (that is, one site establishment). This will help reduce costs and minimise the impact to road users.

> For some large projects, it may be more optimal to undertake a multi-staged pavement investigation approach requiring more than one site visit. For example:
>
> 1. FWD and GPR investigation.
> 2. Auger investigation to determine the pavement profile and basic materials characteristics (intensive sampling with basic materials testing).
> 3. Targeted trench investigation to sample additional materials for further laboratory testing (targeted sampling with detailed materials testing).
>
> Appendix C provides an example of a multi-staged pavement investigation approach.

Extra sampling of the existing materials is recommended to obtain sufficient sample to allow for stabilisation mix design laboratory testing, such as Unconfined Compressive Strength (UCS) or foamed bitumen. Even if the pavement rehabilitation treatment option(s) have been initially determined, sampling extra materials upfront will be significantly cheaper than returning to site for additional rounds of sampling if stabilisation is later identified as a viable rehabilitation treatment. However, in some circumstances the pavement investigation reveals previously unknown issues that may trigger additional investigations later.

Key questions the pavement designer should consider when preparing the destructive pavement investigation scope may include:

- Are there areas of existing pavement which would be considered as 'outliers'? For example, turning lanes that were recently constructed by a Developer.
- Are there areas that exhibit more severe or frequent defects / failures that require additional investigation or closer inspection? For example, cement treated block cracking, deep rutting and shoves, and/or asphalt fatigue cracking.
- Will the investigation be able to identify the existing pavement profiles and material properties for use in pavement design? For example, granular strength, design subgrade California Bearing Ratio (CBR), and/or expansive soils.

- Will the investigation be able to identify (or confirm) the pavement failure mechanisms and associated root causes?
- Where applicable, will areas of existing pavement that have varying profiles be investigated along with the existing road formation (overtaking lanes, pavement realignments and/or widenings)? For example, situating trenches through the Inner Wheel Path (IWP) / Outer Wheel Path (OWP) / shoulder to determine a suitable cut-back point for the proposed pavement widening; and/or locating trenches to encompass areas that may have different pavement profiles.
- Will the proposed pavement investigation operations provide sufficient and suitable materials samples to progress with the pavement design? As noted above, extra sampling of materials is recommended.
- Will the nominated laboratory materials testing regime align with the intended pavement scope? Typically, the laboratory testing regime might include particle size distribution (gradings), Atterbergs, CBR (soaked or unsoaked), moisture content, Moisture Density Relationship (MDR), Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) for each pavement and subgrade layer.
- Will the nominated laboratory materials testing regime support the likely treatment option(s) and pavement design? For example, if a treatment option nominates stabilisation of existing materials, ensure that sufficient sampling will be undertaken to complete an UCS or foamed bitumen mix design. By doing this, it will minimise costs by reducing the likelihood of requiring additional site visits to obtain more samples.
- If any bridges or structures are present within the project extents, is a rehabilitation of the asphalt deck wearing surface (DWS) within scope? DWS investigations are a specialist activity. Refer to *Guideline Asphalt Deck Wearing Surface (DWS) Rehabilitation* for more guidance.
- Will underground services and/or cover over existing structures (major and minor culverts) limit pavement rehabilitation treatment options in certain locations?
- Will the pavement rehabilitation design need a multi-faceted approach? For example, low lying areas, flood ways, overlays, realignment, and widenings may all need different rehabilitation treatments.

4.4.1 Pavement investigation brief

Once the pavement investigation scope is defined, the pavement designer should prepare a detailed Pavement Investigation Brief. This brief defines the pavement investigation requirements and is provided to the relevant pavement investigation Contractor and/or laboratory.

Information that is included in a Pavement Investigation Brief may include the following:

- Site details (for example, Transport and Main Roads District, road name, road number, start and finish chainages and so on).
- Pavement investigation work activities and estimated quantities (for example, number of cores, trenches, augers and insitu tests).
- Accurate pavement investigation locations (GPS coordinates).

- Indicative pavement profiles (typically based on ARMIS Chartview data and/or historical drawings).
- Details of pavement investigation services (for example, safety management, environmental management, public notifications, traffic management, service locating, project management, and so on).
- Details of pavement investigation work activities (for example, FWD, GPR, coring, augering, trenching, insitu testing, material sampling, reinstatement, and so on).
- Material laboratory testing requirements and estimated quantities.
- Reporting requirements.
- Contractual requirements (for example, tendering dates, offer details, variation requests and so on).

An example Pavement Investigation Brief issued under Transport and Main Roads current Standing Offer Arrangement (SOA) TMRPR1481 for Provision of Pavement Investigation & Material Testing Services is provided in Appendix A.

Two example pavement investigation and testing regimes are also provided in Appendix B and C which attempts to illustrate the required engineering assessment processes to arrive at a suitable pavement investigation and testing scope.

For further information regarding preparing a Pavement Investigation Brief, please email Technical Publications.

4.4.2 Coring of bound materials (asphalt, concrete, and stabilised layers)

150 mm diameter cores can be used to define layers, depths, and condition (for example, presence of moisture and binder stripping of asphalt).

Laboratory UCS can be undertaken on cement treated cores to determine strength parameters. Laboratory indirect tensile strength testing can be undertaken on asphalt and foamed bitumen cores to obtain resilient moduli.

In the field, further augering through lower pavement layers may be required to obtain a Dynamic Cone Penetrometer (DCP) test of the subgrade.

Figure 4.4.2 – Example of 150 mm diameter core of asphalt (left) and stabilised pavement layers (right)

4.4.3 Augering (within and outside the existing road formation)

Augering can be used to define the pavement / subgrade profile and collect limited materials samples for laboratory testing.

Extreme care must be taken to minimise contamination (or mixing) of the pavement and subgrade materials.

The auger size is typically a minimum 350 mm diameter. Larger diameter augers (for example, 600 mm) can allow for greater sampling volumes and easier definition of pavement sub layers.

At the subgrade or fill level, an insitu DCP test to determine insitu subgrade CBR should be undertaken.

Augers are typically undertaken to a depth of 1.5 to 2.0 m below surface level to ensure the entire subgrade profile is sampled.

Figure 4.4.3(a) – Example of augering (left) and auger profile (right)

4.4.4 Trenching (within the existing road formation)

Trenching is often undertaken where there is a high chance of a variable pavement profile cross section and where larger amounts of sample are required.

Trenching allows cracking and rutting to be examined at all layers in the pavement profile. Trenching also allows a greater sample of pavement and subgrade materials to be collected for laboratory testing, especially where significant sample size may be required for testing such as for stabilisation mix designs. Often a milling (or profiler) attachment is used to sample the upper bound pavement layers to better represent the pulverisation of a stabiliser.

Trenches are typically undertaken to a depth of 1.5 to 2.0 m below surface level to ensure the entire subgrade profile is sampled.

Figure 4.4.4(a) – Example of trenching using excavator with a bobcat milling attachment

Figure 4.4.4(b) – Example of trenching showing the high level of pavement profile detail

4.4.5 Test pits (outside the existing road formation)

Test pits are typically undertaken to define the natural subgrade profile and properties for widenings and/or new alignments.

Test pits can also be undertaken to investigate potential embankment material for use on the project.

Test pits are typically undertaken to a depth of 1.5 m below surface level to ensure the entire subgrade profile is sampled.

Figure 4.4.5(a) – Example of excavating test pit (left) and test pit profile (right)

4.4.6 Sampling methods

Table 4.4.6 below details the relevant sampling test methods for pavement materials.

Table 4.4.6 – Sampling test methods

Sampling method	Material type	Method No.
Dry coring of bound materials	Stabilised (bound and lightly bound)	Q070
Dry coring of asphalt	Asphalt	AS 2891.1.2
Disturbed samples – machine excavated pit or trench	Granular	AS 1289.1.2.1 *Methods of testing soils for engineering purposes*
	Fill and subgrade	
Disturbed samples – power auger drilling	Granular	
	Fill and subgrade	

4.4.7 Reporting

These destructive pavement investigation work operations must record and photograph the type, properties, and thickness of each material layer. A clear site description and photographs should be included that records the site location, road formation details, embankment / cut height, and relevant site details in the vicinity, such as pavement and drainage condition. Clearly traceable material samples should be collected during the work operations for further laboratory testing. DCP testing of the insitu subgrade and/or fill material should also be undertaken at each testing location.

Gathering of additional data for classification of materials may be required during sampling operations. For example, when classifying soils using AS 1726 *Geotechnical site investigations*, Clause 6.1 *Soil description and classification*, the recording of colour, moisture condition, consistency is performed in the field. The determination of dry strength, dilatancy and toughness may also be required for fine-grained soils where field assessment is used.

5 Review pavement profiles

Once all the data from the pavement investigation has been collated and reviewed, the pavement designer must nominate a suitable material laboratory testing schedule.

The pavement designer should review the pavement profiles and determine any pavement profiles and materials which would be considered as alike. Where possible, inspection of the material samples will help in assessing and categorising pavement, fill and subgrade materials.

Table 5 and Figure 5 provide examples of how pavement profile data may be collated and presented.

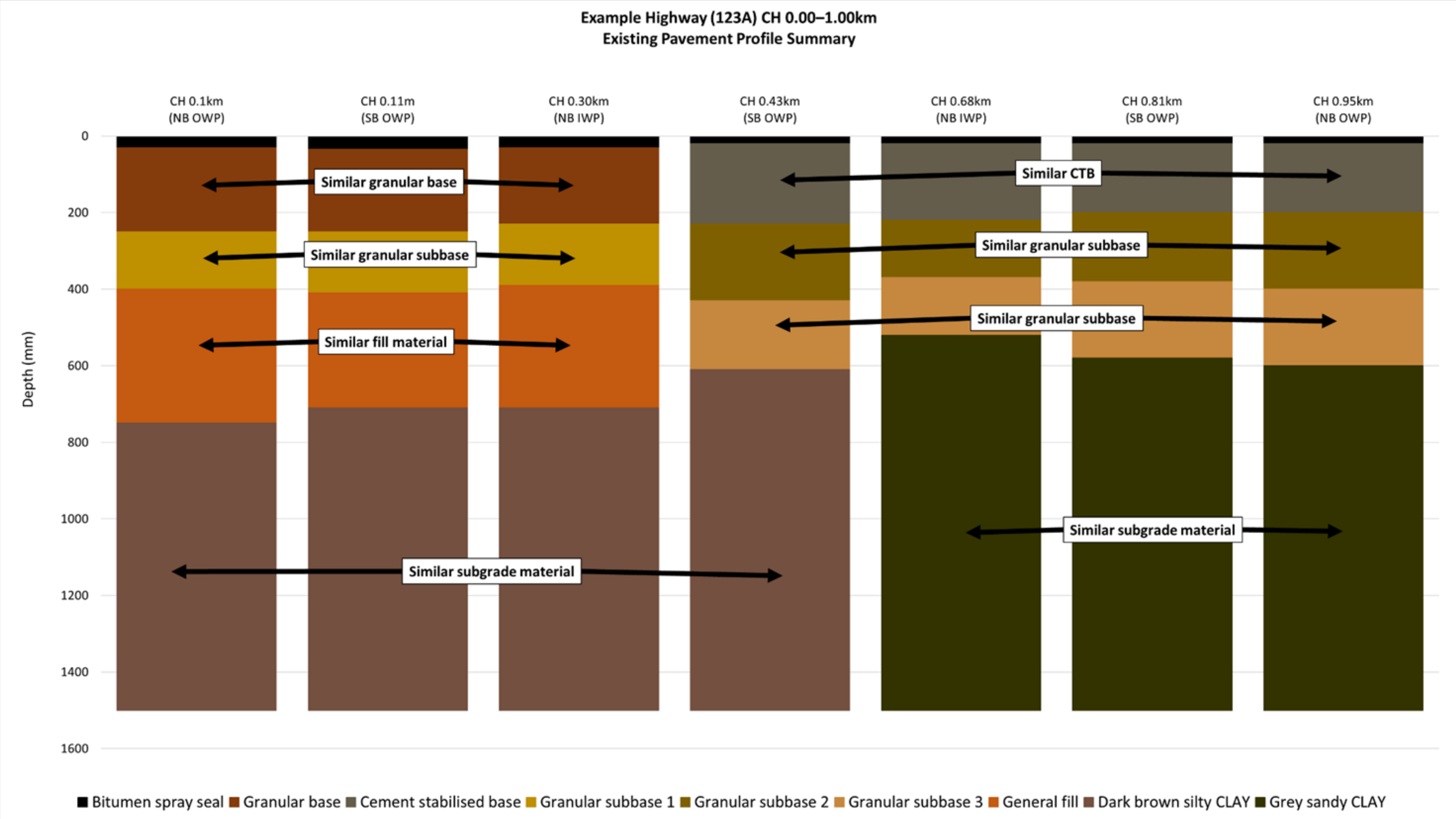
Table 5 – Example of tabulated presentation of pavement profiles

Example Highway (123A) CH 0.00–1.00 km – Summary of Pavement Profiles – Layer Thicknesses (mm)									
No.	**Location**	**Bitumen spray seal**	**Granular base**	**Cement stabilised base**	**Granular subbase 1**	**Granular subbase 2**	**Granular subbase 3**	**General fill**	**Subgrade**
T_1	CH 0.10 km (NB OWP)	30	220		150			350	750
T_2	CH 0.11 km (SB OWP)	35	215		160			300	790
T_3	CH 0.30 km (NB IWP)	30	200		160			320	790
T_4	CH 0.43 km (SB OWP)	20		210		200	180		890
T_5	CH 0.68 km (NB IWP)	20		200		150	150		980
T_6	CH 0.81 km (SB OWP)	20		180		180	200		920
T_7	CH 0.95 km (NB OWP)	20		180		200	200		900

OWP = Outer Wheel Path

IWP = Inner Wheel Path

Figure 5 – Example of graphical presentation of pavement profiles which helps to identify 'similar' materials



6 Material laboratory testing

The pavement designer should ensure that the laboratory testing regime provides data which is relevant for the proposed pavement design approach. The laboratory testing should allow the pavement designer to determine the properties of the existing pavement materials and the pavement's support conditions (for example, subgrade CBR strength and expansiveness). A laboratory testing schedule should be prepared that optimises the number and type of tests to reflect the project scope, design approach and budget.

All materials sampling and testing shall be undertaken by laboratories accredited by the National Association of Testing Authorities (NATA) and registered under Transport and Main Roads *Construction Materials Testing Supplier Registration System (CMTSRS)*.

The pavement designer should factor into their design program the time allocation required to complete the laboratory materials testing regime. For example:

- some highly plastic clays will require additional curing time before undertaking CBR testing, and
- the laboratory testing required to successfully complete a stabilisation mix design with working time (for example, cementitious UCS or foamed bitumen modulus), is typically two to three months.

6.1 Test methods

In most cases, materials characterisation testing is undertaken to determine the properties and strength of the existing materials. As a guide, Table 6.1 nominates the typical material characterisation testing.

Table 6.1 – Material laboratory testing for existing pavement materials

Laboratory test	Material type	Property to be Tested	Test Method No.
Classification of soils	All	Description and classification	AS 1726 Clause 6.1
Insitu moisture contents	All	Moisture content at the time of sampling	AS 1289.2.1.1
Atterberg limits and Plasticity Index (PI)	Granular	Liquid limit	Q104A
		Plastic limit and plasticity index	Q105
		Linear shrinkage	Q106
	Fill and subgrade	Liquid limit	AS 1289.3.1.1 or AS 1289.3.9.1 [1]
		Plastic limit	AS 1289.3.2.1
		Plasticity index	AS 1289.3.3.1 or AS 1289.3.3.2 [2]
		Linear shrinkage	AS 1289.3.4.1
		Weighted plasticity index	Q252
Particle size distribution (PSD)	Granular	Grading curve	Q103A
	Fill and subgrade		AS 1289.3.6.1
Dry density moisture relationship	Granular	MDD and OMC	Q142A
	Fill and subgrade		AS 1289.5.1.1
CBR (1 or 4 points) @ 100% std compaction @ 100% OMC [3]	Granular	Strength	Q113A or C [4,5]
CBR (1 point), including swell @ 97% std compaction @ 100% OMC [3]	Fill and subgrade		AS 1289.6.1.1

Note [1]: Where Liquid Limit cannot be determined using AS 1289.3.1.1.

Note [2]: Where Plasticity Index cannot be determined using AS 1289.3.3.1.

Note [3]: The soaked conditions (dry, 4 day or 10 day) should be appropriately selected by the pavement designer. Refer to *Pavement Design Supplement* Section 5.6.2.

Note [4]: Q113A is a 4-point CBR test. This test is preferred as it will provide an indication of the moisture sensitivity of the granular materials. However, a large sample size is required to undertake Q113A.

Note [5]: Q113C is a single point CBR test.

Materials testing to assist with the classification of soils using AS 1726 *Geotechnical Site Investigations*, Clause 6.1 – *Soil description and classification*:

- Sufficient sieves, for test methods AS 1289.3.6.1 or Q103A, must be specified to allow for the classification of soils and comparison to relevant Transport and Main Roads technical specifications. As a minimum, 75.0 mm, 53.0 mm, 37.5 mm, 19.0 mm, 9.50 mm, 6.70 mm, 4.75 mm, 2.36 mm, 0.600 mm, 0.425 mm, 0.210 mm, and 0.075 mm sieves are required, and

- When classifying granular materials, Q test methods may be used in place of AS test methods for determination of particle size distribution, liquid limit, and plasticity index.

Note that different results may be obtained when using equivalent Q test methods and AS test methods on the same material.

Classification of each material using AS 1726 *Geotechnical Site Investigations*, Clause 6.1 *Soil description and classification* should include:

- a systematic description including composition and condition (excluding relative density of coarse-grained soils) for each material shall be included, and
- for visual classifications the USC symbols enclosed in brackets.

Materials testing that may be considered depending on site conditions and pavement treatment options:

- Q101E pre-treatment of road construction materials by subjecting the material to repeated artificial weathering by cyclic wetting and drying and/or compaction. This test can be considered for soft or brittle materials used in earthworks or pavement construction, which are liable to breakdown during winning, compaction and trafficking (for example, shales, siltstones, highly weathered materials, soft laminated rock, jointed rock or Winton sandstone). Refer to Section 5.6 of the *Pavement Design Supplement* for further guidance.
- *AS 1289.3.8.1 Methods of testing soils for engineering purposes, Method 3.8.1: Soil classification tests – Dispersion – Determination of Emerson class number of a soil*.
- AS 2891.13.1 *Methods of sampling and testing asphalt, Method 13.1: Determination of the resilient modulus of asphalt – Indirect tensile method.*
- More specialised testing for problematic subgrade soils, for example:
  - contaminated soils
  - expansive soils
  - dispersive soils
  - sodic or saline soils, and/or
  - acid sulfate soils.

These soil types typically require specialist geotechnical advice.

Subgrade materials testing to determine the insitu strength of the existing materials:

- Q114B *Insitu California Bearing Ratio - dynamic cone penetrometer* to be undertaken during the pavement investigation site works.

For determining the CBR of the sampled materials, the following conditions shall apply to Test Method AS 1289.6.1.1:

- soaking period of four days (refer to Table 6.1, Note 3)
- for materials within the subgrade zone – target laboratory density ratio of 97.0%
- for materials outside the subgrade zone – target laboratory density ratio of 95.0%

> Refer to MRTS04 *General Earthworks* for typical cross sections which details the 1.5 m subgrade zone in areas of embankment and cut.

- target laboratory moisture ratio of 100%
- standard compactive effort
- surcharge mass during soaking of 4500 g
- surcharge mass during penetration of 4500 g

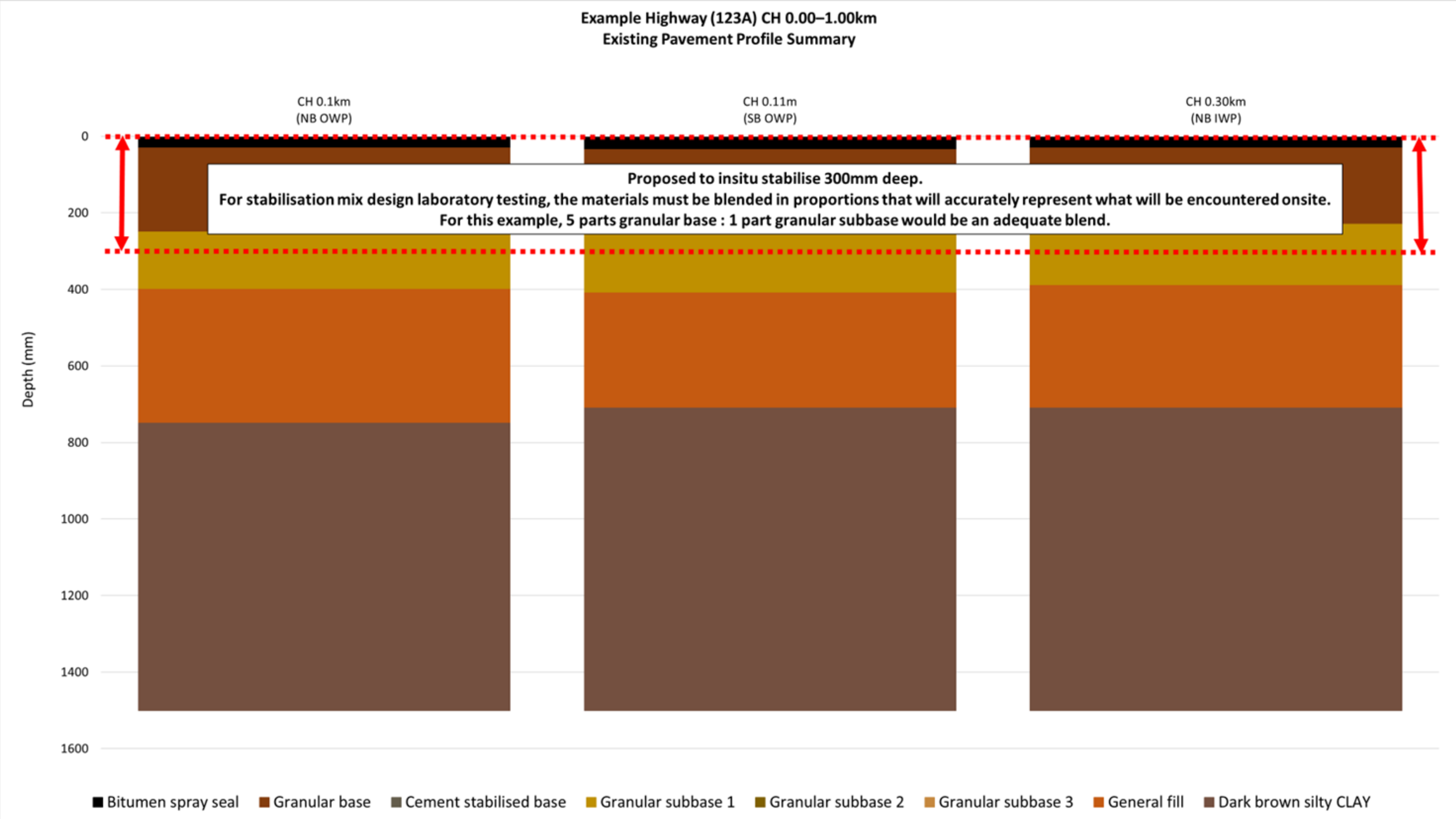
> AS 1289.6.1.1 does allow surcharges to be adjusted to better reflect the insitu conditions.

- minimum curing times in AS 1289.6.1.1 Table 1 shall apply, and
- swell, dry density after soaking and moisture content of the remaining depth of specimen after penetration to be reported.

Materials testing to determine the suitability of existing materials for insitu or plant-mixed stabilisation:

- refer to Transport and Main Roads *Materials Testing Manual* Part 2 – *Application*, and
- the pavement designer must consider the location and depths of the proposed stabilisation so the laboratory testing accurately reflects the situation likely to be encountered onsite (Figure 6.1 is provided as an example).

Figure 6.1 – Example of blending materials for laboratory testing



7 Failure mechanism

Through analysis of the pavement investigation data, the pavement designer should confirm or identify the pavement failure mechanisms and associated root causes. The determination of the pavement failure mechanism is a key element which needs to be addressed in any proposed pavement rehabilitation treatments. More details are provided in the department's *Pavement Rehabilitation Manual*.

8 Pavement rehabilitation treatment options

Using the gathered pavement investigation data, the pavement designer can develop appropriate pavement rehabilitation treatment options using the guidance of the department's *Pavement Rehabilitation Manual*, *Pavement Design Supplement* and other pavement related technical publications.

9 Suitability of rehabilitation treatment options

9.1 General

Once proposed pavement rehabilitation treatment options have been nominated, the pavement designer must review the treatment to determine if the proposed design remains functional and achievable. For example, checking the pavement design assumptions are aligned with the laboratory test results, checking that the pavement rehabilitation treatment options are within the project budget and scope, and checking that any imported pavement materials are readily available in the area. Through this process, the most suitable pavement rehabilitation treatment can be recommended.

9.2 Additional laboratory testing

The pavement designer may also undertake additional laboratory testing to optimise the pavement design solution. For example, this may include stabilisation mix design and working time, refinement of stabilising agents optimising stabilising agent contents, and maximising working time. This follow-up (or secondary) laboratory testing may help reduce the project costs, construction risks or delays without compromising the pavement design.

> As noted in Section 6, the laboratory testing required to successfully complete a stabilisation mix design with working time is typically two to three months.

9.3 Geometrics

Once a proposed pavement rehabilitation design has been nominated, the pavement designer must holistically review the project design and in particular geometrics. For example, checking that the existing formation width can encompass a pavement overlay or whether additional widening is required, and/or checking clearances to underlying drainage structures for insitu stabilisation.

For insitu stabilisation projects, the shape and profile of the existing road and finished design level often affects the composition of the existing pavement materials in the insitu stabilised layer. This is especially relevant for projects that require pavement overlay and/or shape correction, or pavements on expansive soil subgrades that exhibit high roughness, large deformations, and/or movement. Accordingly, it is incumbent on the pavement designer to check that the material laboratory testing encompasses the range of material blends (or mixes) that that are likely to be encountered onsite using the finished design level. Further stabilisation mix design laboratory testing for different material blends may be required to confirm that the insitu stabilisation pavement rehabilitation treatment remains appropriate.

For projects where there is a requirement for the import of overlay / shape corrector prior to insitu stabilisation, the shape and profile of the existing road and finished design level will affect the composition of the existing pavement and new pavement materials in the insitu stabilised layer. Upfront materials laboratory testing (that is, prior to tendering) can be coupled with a targeted testing regime to be undertaken by the Contractor early in the Contract works. This will ensure that the insitu stabilisation design intent is being achieved and avoid nominating potentially ineffective presumptive mix designs. The Contractor's stabilisation mix design testing requirements are often detailed in the relevant Technical Specification Annexure's *Supplementary Specifications* clause.

Appendix A – Example Pavement Investigation Brief

SOA TMRPR1481 for Provision of Pavement Investigation & Material Testing Services

Pavement Investigation Brief No **DD Month YYYY**

Project title: Bruce Highway / Gympie Arterial Road (Strathpine Road to Dohles Rocks Road)

Metropolitan Region – U14 Gympie Arterial: Both Carriageways (from Strathpine Road Interchange to Pine River Bridge)

North Coast Region – 10A Bruce Highway: Both Carriageways (From Pine River Bridge to Dohles Rocks Road)

A1. Pavement Investigation Background

Investigate the existing pavement structure, material type, condition and thickness of existing pavement layers and subgrade in the shoulders for future widening at the specified locations.

Collect material sample of each pavement layer and subgrade for road alignment, widening and rehabilitation design. DCP test at each location to assess insitu strength of subgrade.

Undertake coring of asphalt pavement to evaluate existing layer thickness and condition.

A1.1 Activity and Anticipated Quantities for the Project

Activity	Quantity
Trench in existing pavement – 300 mm minimum x 2.0 m to a depth of 2.0 m (min 1.5 m below subgrade level). • Trench to include verge, shoulder and traffic lane. Refer to location list. • Where trench is not practical due to barriers, lane width restrictions, then do augers, one in the lane, one in shoulder and one in verge as agreed on site by Transport and Main Roads representative.	27
Augers in existing pavement – 350 mm diameter to depth of 2 m (minimum 1.5 m below subgrade level).	24
Test Pit (TP) in medians – 300 mm x 1.6 m to a depth of 2.0 m (min 1.5 m below subgrade level). Pit to include verge, shoulder and traffic lane.	10
DCP – Transport and Main Roads Test Method Q114B – commence at subgrade level and end at 1.5 m below subgrade or refusal.	57
Dry Coring of Asphalt (AS 2891.1.2-2008) – (100 mm or 150 mm diameter cores)	38
Provisional – TP – Median	5
Provisional Augers – Pavement	5

Refer to the attached Test Pit location spreadsheet for details of location and other requirements.

EXAMPLE ONLY

A1.2 Pavement Investigation Locations

Figure A1.2 – Location of Investigation sites

A1.3 Investigation Test Site Details

Refer to attached spreadsheet (Test Pit Locations – V2) and attached KMZ file for site location details.

GPS coordinates to be used to locate the sites.

Actual Chainage for the test locations to be recorded using the Transport and Main Roads Tripmeter on site.

A1.4 Indicative Pavement Profile for Lanes (from ARMIS Data)

Table A1.4 – Summary of indicative pavement profiles

Chainage From (km)	Chainage To (km)	Existing Pavement
U14		
11.35	13.58	100 – 150 mm Asphalt 300 mm Granular Base Subgrade
13.58	14.18	200 – 300 mm Asphalt 300 mm Granular Base Subgrade
10A		
0.12	1.57	350 mm Asphalt 150 mm Granular Base 500 mm Granular Subbase / Fill Subgrade
1.57	2.45	150 – 250 mm Asphalt 300 mm Granular Base Subgrade

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A2. Pavement Investigation Services

A2.1 Required services

- Project Management of resources to undertake Investigation & reinstatement.
- Traffic management and all relevant permits.
- Dial before you dig and service locating by a DBYD Certified Locator.
- Laboratory to undertake material sampling, logging, DCP and testing.
- (Laboratory shall have current NATA accreditation for the scope of tests and shall also be a Transport and Main Roads Registered Construction Materials Testing Supplier).
- Disposal of excessive excavated material in accordance with environmental regulations.
- Collate pavement investigation and laboratory results into a detailed pavement investigation report.

A2.2 Safety and Environmental Management

The contractor shall maintain and must be able to provide evidence of operational and documented workplace health and safety documentation in conformance with the *Workplace Health and Safety Ac*t, Regulations and Codes of Practice.

Environmental and Safety Management plans including Safe Work Method Statements detailing all activities involved in the investigation works must be submitted to Transport and Main Roads by the Contractor prior to commencement of the investigation.

A2.3 Traffic Management

- The contractor will be responsible for organising all traffic control / management and ensuring all investigations are undertaken with the appropriate traffic management and obtaining all necessary permits.
- Traffic Guidance Scheme (TGS) shall be prepared by a person holding Traffic Management Design (TMD) qualifications and engaged by a Transport and Main Roads registered Traffic Control Company.
- Traffic Control Permit Application and associated traffic guidance scheme shall be submitted through the online application system.

A2.4 Locating of Services

- The investigations contractor shall engage a DBYD Certified Locator to undertake site and services locating and clearing prior to commencement of works to ensure no services lay within test pit excavation sites.
- The investigations contractor shall assume all responsibility to avoid excavation of any underground services.
- The investigations contractor shall be responsible for liaison with all relevant authorities and complying with their rules as required.
- Investigation Contractor to be present at site during site clearing.

EXAMPLE ONLY

A2.5 Supervision

Transport and Main Roads Representatives will:

1. Attend and witness site clearing and marking activities
2. Attend the pavement investigation, and
3. Review pavement investigation report and results.

A3 Site Investigation

A3.1 Project Management

The Contractor shall be responsible for ensuring that all required resources are available on site to undertake the investigation works.

The expected pavement profile provided in this brief is the best information available, however the Contractor shall be responsible for reviewing the existing pavement structure to identify the need of any specialised or heavy-duty equipment.

The Contractor shall ensure availability of suitable plant and equipment to core / excavate through thick or multiple layers of asphalt and possible bound base.

A3.2 Observations, Records and Sampling

- Prior to commencing excavation, a visual observation shall be undertaken of the site and details recorded relating to the site including terrain, cross fall, drainage, the condition of the pavement surface and description of the existing surface condition.
- Site photos shall be taken in direction of travel showing the layout of the site, location of test pit in relation to identifiable features.
- Photographic evidence of each test site excavated to full depth depicting the ground conditions encountered and of the material is required.
- A log is required for each test site with details of GPS coordinates (Latitude and Longitude) and in UTM format (Easting and Northing), offset from edge line or centreline, direction of travel, and wheel path.
- The subsoil conditions of each test site shall be logged in accordance with AS 1726-2017 *Geotechnical Site Investigation*s, including both pavement and natural soils with reference to soil layer structure, moisture condition (including water table depths), consistency, plasticity and USCS classification.
- The various pavement layers and depth at which material samples were recovered shall also be recorded on the logs for future reference.
- Each sample shall be labelled with reference to the test site, soil layer and depth from which it was recovered. The samples shall be stored in sealed container / bags so that the moisture content of the sampled material is not significantly altered.
- All sampling shall be in accordance with Department of Transport and Main Roads test methods and/or Australian Standards.
- Classification of bedrock if encountered including insitu condition, strength and rip ability.
- Note any groundwater observations or seepage within the test holes.

EXAMPLE ONLY

A3.3 Excavation and material sampling

Investigation process shall be as follows:

- Use a saw, profiler / milling head to cut neatly through the bound layer.
- Carefully continue excavating pavement layers, watching for change in material properties. Take care to prevent cross contamination of different materials between layers. Collect samples and log layer details and description (including photos), material classification and thickness of each layer.
- Cease excavation when the subgrade is reached. Remove all loose materials and expose the subgrade surface. Undertake insitu DCP on the subgrade surface to the specified depth (*if not specified, it shall be 1.5 m measured from start of subgrade*), or refusal. Moisture content samples to be taken of subgrade.
- Continue excavation of the subgrade to the specified depth. Record layer description (including photos), material classification and thickness of each layer.
- Base, sub-base / fill and subgrade material to be sampled from each site for laboratory tests. Sufficient quantity (around 60 kg) of each layer to perform the tests indicated in Section 4.

A3.4 Reinstatement

For the existing pavement:

- The excavated pit may be backfilled up to -1 m below existing surface level using only good-quality excavated base, sub-base and imported granular material. The reinstatement shall be machine compacted in 150 mm layers (refer to Technical Specification MRTS04 *General Earthworks*, Clause 15 Compaction.

  Note: Asphalt profiling and any unsuitable excavated material is not to be used and shall be removed from site and disposed.

- Reinstatement from -1 m below existing surface level to – 0.2 m below existing level shall be backfilled with Lean Mix Concrete (no slump, target 5 MPa), placed and compacted in layers of maximum thickness of 150 mm (refer MRTS39 *Lean Mix Concrete Sub-base for Pavements*).
- Reinstatement of surfacing from -0.2 m to finished wearing surface level shall be hot-mix asphalt conforming to AC14 (A15E) asphalt (or similar that is available within proximity).
- Prior to placement of asphalt, the surface shall be brushed clean of any loose material and finished in a manner which shall promote adhesion of the bituminous emulsion to the surface.
- Bitumen emulsion tack coat shall be applied to the bottom and sides of the trench / auger. (refer to MRTS12 *Sprayed Bituminous Emulsion Surfacing*, Clause 10).
- Asphalt shall be placed in accordance with MRTS30 *Asphalt Pavements* and mechanically compacted in 50 mm finished layer thickness.
- Joints between the finished reinstated surface and existing road surface shall be appropriately sealed.

EXAMPLE ONLY

For medians and off-road test pits:

- Reinstate using suitable excavated material and top up as required with imported granular or fill material. Top 0.2 m should be filled with soil material that will support vegetation growth.
- Material to be compacted in layers of 200 mm. Finished surface to be raked even and left tidy.

Compaction of all backfill material shall be carried out mechanically using pneumatic or hydraulic compactor, roller, plate compactor, a ‘Wacker Packer’, or acceptable custom-built compacting equipment / attachment.

A warranty period of 12 months shall apply to the backfilling and compaction works. Any failures in the reinstated test locations shall be rectified by the Contractor immediately (within 24 hours). The contractor will be liable for all rectification costs and any compensation arising from the failures.

A.4 Material testing requirements

On completion of the investigation works, a Transport and Main Roads representative shall be provided with the draft ground logs in order to nominate the required testing.

The testing in the following table is indicative only.

Table A4 - Material Testing Requirements

Laboratory Test	Test Layer	Test Method	Estimated Number
Dynamic Cone Penetrometer Test (DCP)	Subgrade	Q114B	57
Moisture Contents (field moisture content is required for each layer sampled).	Pavement & Subgrade	AS 1289.2.1.1	250
Atterberg limits (Atterberg limits & weighted PI shall be reported for each layer / material type).	Pavement	Q104A Q105 Q106	110
	Subgrade	AS 1289.3.1.1 AS 1289.3.2.1 AS 1289.3.3.1 AS 1289.3.4.1 Q252	140
Particle size distribution (PSD)	Pavement	Q103A	110
	Subgrade	AS 1289.3.6.1	140
4 day soaked CBR (4 Point), including swell @ 100% std compaction @ 100% OMC (minimum curing time of sample shall comply with the test method).	Base & Sub-Base	Q113A	110
Dry Density-Moisture Relationship (minimum curing time of sample shall comply with the test method).	Fill & Subgrade	AS 1289.5.1.1	140
4 day soaked CBR (1 Point), including swell @ 97% std compaction @100% OMC (minimum curing time of sample shall comply with the test method).	Fill & Subgrade	AS 1289.6.1.1	140

EXAMPLE ONLY

A.5 Pavement Investigation Report

The pavement investigation report shall include at least the following:

- Summary of the project brief, layout map of site location, and details of test pit.
- Summary of all laboratory material test results in a single spreadsheet.
- Investigation test pit log shall include detailed description, location & position of each test pit including:
  - Transport and Main Roads Chainage, offset from centreline, direction of travel, lane type and wheel path.
  - Multiple photos of the surroundings and excavation for each test site.
  - Hand-held GPS coordinates of site in GDA94 (Latitude, Longitude) and in UTM format (Eastings, Northings).
  - Cross-fall of pavement
  - Pavement visual defects and rutting as observed at each site
  - Observation of surface condition of the investigation site position and surrounding area

- Description, depth from surface and layer thickness of Surfacing, Base, Subbase, Select Fill, Subgrade and Natural Subgrade.
- Dynamic cone penetrometer (DCP) test report.
- Laboratory material test reports.

- Where surface cracks are noted at the start of the investigation, report type and severity of cracks and if cracking appears to be a top-down or bottom-up propagation,
- Record of any evidence of moisture and possible source.
- Any other observation of possible cause of defect / failure of existing pavement.

A6. Variation or extension of pavement investigation scope

The pavement investigation scope may need to be varied or extended based on unforeseen subsurface conditions encountered on site, weather, 3rd party availability and client requirements.

The client may also vary the scope to incorporate additional road sections, test trenches, augers or cores.

Where a variation or extension is required, the conditions and costings shall be agreed by the client's contract manager and the contractor's representative and confirmed in writing.

A.7 Proposal for the pavement investigation works

Proposal for the pavement investigation works shall include at least the following:

- Detailed costing for TGS preparation and roadwork traffic management. The TGS shall allow for appropriate number of traffic controllers and traffic management vehicles in accordance with the *Manual of Uniform Traffic Control Devices* (MUTCD).
- It is anticipated that single lane closures will be allowed as follows:
  - Gympie Arterial Road Northbound between 9pm and 6am
  - Gympie Arterial Road Southbound between 7pm and 5am
  - Bruce Highway Northbound between 7pm and 5am
  - Bruce Highway Southbound between 7pm and 4am
- Where required for taking cores in the middle lane, this should be planned alongside the works on the adjacent slow or fast lane. Two lane closures will be allowed for the duration of the coring works between 10pm and 4am.
- Appropriate and suitable lighting shall be provided around the work area and the location of traffic control flagman for night work.
- Estimated number of days / nights to complete the Investigation works.
- Detailed schedule breakdown of cost for Investigation works including plant and labour, traffic control, materials testing, excess material disposal, reinstatement materials, expenses & allowances, Investigation and Testing Report (Number and unit rate of all resources, personnel, plant, trucks, Traffic Controllers, utes, and so on shall be provided).
- Costing for Laboratory and field testing based on details in Section 4 of this brief.

EXAMPLE ONLY

Note: Quantities shown is for costing purpose. Payment will be based on actual testing quantities ordered.

EXAMPLE ONLY

Appendix B – Example of destructive testing schedule for small to medium size project

The pavement designer should use the information from the project scope, desktop study, surface deflection and site inspection (refer to Section 4) and determine the likely pavement treatment types. This will guide the scope of destructive field investigation required. These likely treatments are still subject to the information and analysis of the pavement investigation data and may be changed upon review.

Table B1 – Summary of project information and proposed destructive field investigation

Section	Chainage	Anticipated existing pavement profile	Proposed pavement treatment	Proposed destructive field investigation
A	21.0 to 22.5 km	150 mm deep granular base 200 mm granular subbase Clay subgrade	Box-out pavement widening LHS (1500 mm nominal). Pulverise, cross-blend and spread existing granular pavement full width. Insitu triple-blend stabilise 300 mm deep. 200 mm overlay with unbound granular.	Trenching in each lane at multiple locations to gather pavement and subgrade data in the IWP, OWP and shoulder.
B	22.5 to 24.75 km	N / A	Realign and raise formation (0.5 to 0.75 m) for flood mitigation purposes. Imported embankment fill requirements: Class A or B1 embankment fill with minimum soaked CBR 10. Design the new pavement based on the test pit subgrade data and imported embankment fill.	No investigation required of the existing pavement. Test pits at multiple locations along the new alignment to gather subgrade and ground condition data.
C	24.75 to 25.6 km	Old 5 m sealed pavement 150 mm granular pavement Clayey sand subgrade	Widen LHS (1500 mm nominal). 300mm overlay with unbound granular.	Trenching in each lane at multiple locations to gather pavement and subgrade data in the IWP, OWP and shoulder.

EXAMPLE ONLY

Table B2 – Sampling for testing schedule for small to medium size project

Layer	Tests required	Reason	Chainage	Lane	Location
Pavement (surfacing, base, and subbases)	• Classify material • Depth • Visual moisture content description (compared to OMC) • Moisture content • MDD / OMC • Grading and Atterbergs • Soaked CBR	To record existing materials and insitu conditions and strength of material.	**Section A**		
			21.1 km	1	IWP, OWP and shoulder
			21.5 km	2	
			21.9 km	2	
			22.25 km	1	
			22.45 km	2	
			Section B (new alignment)		
			22.8 km		Test pits
			23.35 km		
			24.05 km		
			24.6 km		
			Section C		
			24.8 km	1	IWP, OWP and shoulder
			25.2 km	2	
			25.55 km	1	
	UCS	UCS mix designs (including deleterious materials testing). Keep base and subbase samples separate. Blends and mixes to be confirmed once initial review of all pavement investigation results by designer.	**Section A only** All Chainages as above		
Subgrade, earthworks and natural	• DCP • Classify material • Grading and Atterbergs • Depth profile • Visual moisture content description • Soaked CBR	Subgrade support conditions BEFORE DISTURBANCE. Subgrade type, classification, and depths, visual assessment of moisture content based on experience. Test all locations unless a significant proportion are visually similar. Subgrade strength information for existing pavement, widening pavement, and new alignment design.	**Sections A, B and C** All Chainages as above		

EXAMPLE ONL

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Appendix C – Example of initial auger investigation for larger projects

For larger projects, the pavement designer may choose to undertake an initial augering investigation (due to its relative quickness), analyse the auger results, and then undertake a targeted trenching investigation to collect additional samples for laboratory testing.

Table C – Example of initial auger investigation schematic

Chainage	**Northbound**		**Southbound**		**Notes**
	OWP	IWP	IWP	OWP	
0.05	A1		A2		
0.2		A3			Visual inspection identified an area of major potholing and rutting in NB and SB lanes from CH 0.10 to 0.60km.
0.4	T_1		T_2	A4	Targeted trenches 1 and 2
0.55	A5				
0.7		A6			
0.85		A7			
0.95		T_3	A8		Targeted trench 3
1.15	A9				
1.3				A10	ARMIS data showed a change in pavement structure from CH 1.20km onwards.
1.45	A11			T_4	Targeted trench 4
1.75				A12	Visual inspection identified a change of seal at CH 1.40km.
1.9		A13			
2.05			A14		
2.15				A15	
2.45	A16	T_5			
2.6	A17				Targeted trench 5
2.8		A18		T_6	Visual inspection identified an area of minor rutting and crocodile cracking in the NB and SB lanes from CH 2.35 to 2.70km.
2.95		A19			
3.1	A20				Targeted trench 6
3.3	T_7			A21	
3.5			A22		
A: Initial auger T: Targeted trench					

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