Department of Transport and Main Roads

Guideline

Western Queensland Best Practice Guidelines WQ35 Paving Materials and Type Cross Sections for Roads on Expansive Soils in Western Queensland

September 2014

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1 Introduction

This guideline is one of a series developed for pavements in the expansive soils of Western Queensland, typically found in Cloncurry, Barcaldine and Roma district areas. Guidance is provided for the selection of paving materials and type cross sections for roads on expansive soils (locally known as "black soils" or "cracking clays") in a dry environment. Details of these soils are given in WQ32.

The guidelines, and parts thereof, may also apply to adjacent district areas with similar soils and conditions. They do not apply to floodways, perched water table locations or other situations where water ponds or flows within five metres of the pavement edge for extended periods.

Adequate performance of a road constructed in accordance with all the guidelines depends on keeping the water out of, and away from, the pavement. If this does not occur (e.g. a road inundated/ flooded), then the pavement will likely fail quickly afterwards.

The guidelines were developed from reviewing pavement performance under low volume traffic and normal variations in seasonal environmental conditions as detailed in Section 2, and can be applied to similar roads in the western areas.

In some situations, it may not be possible to comply with all the guidelines. Alternative treatments may be possible, but performance may be less than optimal unless compensating measures are taken. Consideration should be given to the future maintenance needs, performance requirements and the whole-of-life costs of the project before a final design is adopted.

2 Background

This guidance is based on analysis of design, construction and performance records, and follow-up structural analysis of many road sections on the Warrego, Mitchell, Landsborough and Flinders highways, which receive average annual rainfall in the range 300 mm to 650 mm. The analysis identified a range in performance:

a) Good sections have roughness progression (increase) rates of 1-2 counts/year, with little rutting and no pavement failures or longitudinal edge cracking.

b) Many sections have roughness progression (increase) rates of 3-6 counts/year, sometimes with pavement rutting and failures and edge cracking.

c) Poor sections have roughness progression (increase) rates of 7-15 counts/year, usually with severe pavement rutting and failures and edge cracking. Variable performance can be found at times on adjacent construction jobs in the same environment carrying the same traffic.

Poor performance has a significant impact on present maintenance, future rehabilitation, whole-of-life costs and road user costs and perceptions.

More background information is provided by Kapitzke (2000).

3 Key principles

The guidelines were developed in the context of:

- typically low average rainfall and short rainfall durations
- relatively low traffic volumes and axle loads and configurations current at the mid-1990s.

Design, construction and maintenance activities should give priority to keeping moisture out of the roadway rather than assuming it will enter and providing measures to remove it (this principle may be different to the approach adopted for wet areas and it is important to distinguish the difference). While some moisture will enter the roadway, the amount and its effect can be minimised and kept clear of the wheel path locations. This is achieved by a combination of:

- moisture control
- pavement material properties
- the drainage system
- type cross section.

To achieve value, quality during design and construction is critical to avoiding re-work with escalated transport costs and negative impact on routing. For example, in “getting it right the first time”, material variability and water sensitivity risks of many non-standard pavement materials are best managed through project oversight by personnel technically experienced in locating, assessing and winning pavement materials, and their design and construction.

4 Moisture control

4.1 General

A detailed discussion of moisture movements in the pavement and subgrade is given by Wallace (1998).

A limited amount of moisture will be sealed into the roadway at construction and some will enter afterwards. Periods of significant rainfall before or during construction may be expected to create excess moisture conditions. High intensity rainfall from storms will usually have less effect on subgrade moisture content than the same rainfall at low intensity. A pavement close to being sealed may also be adversely affected by a smaller single rainfall event. The requirements of the QTMR standard specifications suite apply to sealing.

4.2 Guidelines

For good performance, the moisture content must be kept within the limits of Table 1.

Table 1 – Typical permissable moisture contents

Zone	Typical 1 Moisture Content Range – % of Optimum Moisture Content (OMC) based on Standard Compaction	
	Before covering/sealing	**Equilibrium (post-construction)**
Base	< 70	35-50
Subbase	< 70	35-65
Embankment (top 300 mm above top of subgrade)	total layer: 60-85 upper 150 mm < 70	70-95
Embankment (> 300 mm below top of subgrade)		70-95

Notes:
1. Tighter limits may be required for moisture-sensitive material
2. Repeat Load Triaxial (RLT) testing to Q137 may also used to validate the permissible upper moisture content range for moisture-sensitive materials (as reported for the material’s Degree of Saturation (DOS) or moisture content). Its use is recommended to inform insitu performance for a material.

To ensure pavement and subgrade strength is maintained and reduce the risk of subgrade swelling and shrinkage:

a) Supplementary specifications should be used to control moisture contents of the top 300 mm below subgrade at the time it is covered by pavement. After construction of the pavement, the total moisture content of this zone should be in the equilibrium range provided in Table 1. Prior to placing the pavement, the total moisture content of the top 300 mm below subgrade should be less than equilibrium to allow for the moisture that will enter the subgrade during pavement construction.

b) Moisture content above equilibrium can be tolerated in both the pavement and the material > 300 mm below the top of the subgrade when covered, provided the top 300 mm of the subgrade is sufficiently dry. Excess moisture will be distributed by soil suction to the top 300 mm of the subgrade. However, if this zone has excess moisture, the pavement edges can also be expected to reach high moisture levels following significant rainfall, and performance problems may be encountered.

c) Moisture content higher than those recommended in Table 1 may be required to achieve compaction during construction. For example, fine-grained materials in hot weather may require up to twice the normal volume of water during construction.

d) It is considered adequate to measure pavement construction moistures for Type 4 materials relative to OMC rather than degree of saturation due to the difficulty sometimes experienced in determining the apparent particle density for these materials.

e) Time for drying back may be necessary before the layer is covered where:

   i. If drying is not fully achieved before sealing, a low permeability pavement of adequate strength will provide better performance than a permeable material (refer Section 5).

   ii. Proof rolling of the subgrade and pavement should also be undertaken before construction of the next layer.

   iii. In extreme cases, staged construction of the pavement could be considered.

f) If the rainfall events described in Section 4.1 or equivalent conditions occur, the pavement and subgrade moisture contents should be checked. When warranted, one or more of the following remedial treatments may be adopted:

   i. Allow time for drying.

   ii. Use mechanical methods to assist drying.

   iii. Treat the subgrade with quicklime (or hydrated lime, noting that 25% additional hydrated lime is often required) to assist drying or if further rain is expected.

g) Soil drying with small amounts of lime will lead to rapid decrease in soil moisture content due to the chemical reaction between water and lime. However, addition of small amounts of lime will significantly increase the permeability of the subgrade, leading to leaching of the added lime and reduction of the expected pavement life. If lime is chosen for soil drying, additional lime should be considered to achieve lime stabilisation with long-term strength gains (refer Technical Note 39 and Technical Note 74 respectively).

4.3 Moisture effects after sealing

The following moisture effects should be considered:

a) If the seal is applied before pavement “dry-back” and excess moisture is trapped in the pavement and subgrade, damage is likely for moisture sensitive base courses and on more heavily trafficked roads. The damage may occur through embedment of seal aggregates and seal bleeding in the wheel paths. In the worst cases, failure of the base may occur.

b) Over time, the surrounding environment typically undergoes continuous wetting and drying cycles. It is vital that the road is insulated from these extremes to prevent premature pavement failure occurring through, e.g. as the result of the swelling and shrinkage of expansive materials, deformation of the pavement surface due to rutting of the pavement and/or subgrade can occur.

c) Deformation resulting from the swelling of expansive material or rutting of the pavement has potential to pond water on the pavement, which may be an aquaplaning hazard. If deformation occurs in, or near wheel paths, high roughness progression rates can occur. Materials which swell excessively are also likely to shrink during dry times. This can produce longitudinal edge cracks, which provide an easy path for water entry. If water enters, premature failure is likely. The impact of swell and shrinkage can be mitigated by the use of appropriate low permeability pavement materials and type cross sections.

5 Pavement materials

5.1 Untreated materials

a) Assuming a sound seal, the main path for moisture entry is through all exposed pavement surfaces. This moisture is, in turn, absorbed by any expansive material present. Increasing amounts of moisture absorbed will result in progressively poorer pavement performance.

b) High permeability pavement materials allow more moisture entry and create edge effects up to 2.5 m under the seal. Such paving materials should be avoided. Low permeability paving materials produce best performance.

c) The use of laboratory tests to measure permeability of fine-grained materials may be less preferable than adopting minimum gradings and Linear Shrinkage (LS).

d) Although low permeability is important, so too is adequate pavement strength. Structural back-analysis of existing roads showed that a base modulus of about 300 MPa (possibly lower) is required in service to prevent rutting of the base for low volume roads in a dry environment. This strength can be achieved at the equilibrium moisture content given in Table 1, and CBR testing may be removed. However, paving materials with an excess of plastic fines will attract more moisture, creating wider pavement edge effects, and will not achieve sufficient strength. A measure of this effect is given by the fines ratio (% $<$ 0.075 mm divided by % $<$ 0.425 mm). Placing a maximum limit on these criteria provides limits on plastic fines. For these materials, it was demonstrated that measuring CBR at moisture contents below OMC or at modified compaction can be misleading and does not provide an adequate measure of insitu strength for materials with excess plastic fines. It must not be used as an alternative.

e) Pavement materials with too low a fines ratio will often also produce poor performance. They will have higher permeability as less voids are wholly or partly filled and tend to be difficult to compact. They also do not stand up well under traffic and back watering, and will be unstable in service and shear easily under traffic loads. Limiting the minimum fines ratios and linear shrinkage is required to control these deficiencies.

f) Table 2 provides guidance for property limits for base and sub-base that have been shown to achieve a balance between low permeability and insitu strength for the locations outlined in Section 1. Where the material is largely produced by crushing, better overall particle interlock results and a higher maximum fines ratio may be allowable. Note that some performing pavements have been constructed from sandstones which have an upper Linear Shrinkage of 6%.

Table 2 – Preferred limits for selected properties for pavements based on the guidelines

Properties		**Base**		**Sub base**
		Alternative 1	**Alternative 2**	
Per cent passing 53 mm sieve (% < 53 mm)		100	100	100
Per cent passing 9.5 mm sieve (% < 9.5 mm)		65-100	65-100	65-100
Per cent passing 2.36 mm sieve (% < 2.36 mm)		40-70	40-100	40-100
Per cent passing 0.425 mm sieve (% < 0.425 mm)		24-40	24-80	24-100
Per cent passing 0.075 mm sieve (% < 0.075 mm)		12-22	12-30	12-40
Linear shrinkage (LS)%		1.5 4.5	1.5-5.5	1.5-7.0
LS x per cent passing 0.425 mm sieve		75-120	75-275	75-350
$\frac{\% < 0.075mm}{\% < 0.425mm}$	Mainly uncrushed material	0.32-0.50		0.32-0.55
	Mainly crushed material	0.32-0.55		0.32-0.60
$\frac{\% < 0.075mm}{\% < 2.36mm}$	(if less than 50% < 0.425 mm)	0.15-0.45		0.15-0.45
$\frac{\% < 0.075mm}{\% < 0.300mm}$	(if greater than 95% < 0.425 mm)	Not applicable		Minimum 45

g) The following applies to Table 2 when selecting the Base material:

i. Alternative 1 "high standard" base material requirements are encouraged as the preferred base material when feasible and economic, and are required for more adverse or special conditions, including:

- Construction under traffic
- Higher traffic volumes (for example, greater than 40 heavy vehicles per day per lane)
- Placing with a paver
- Construction when wetter conditions more likely
- To enhance primer penetration or adherence of a primerseal

- Where there is poor longitudinal drainage and/or low formation height (that is, where increased wet strength is required)

ii. While many sound materials satisfy the Alternative 2 base material requirements, there have been examples of non-performing materials also satisfying Alternative 2 base material requirements. For example, QTMR District experience includes that where the grading curve crosses the outer thirds of the Alternative 2 envelope (for example to be high enough on the 2.36 mm sieve), the resultant material can be sandy. This may result in an unstable, moisture sensitive material that will not perform well in service and will be difficult to compact.

iii. QTMR District experience includes an increased risk for manufactured or blended materials.

iv. When Alternative 1 materials are not feasible or economic, Alternative 2 materials may be considered.

h) The following applies to use of the materials in QTMR projects:

i. Materials with properties not conforming to Table 2 may be successfully used provided they are of low permeability and have proven performance. However, additional measures (e.g. a greater width of shoulder protection) to those outlined in this Technical Note may be required and specialist advice should be obtained. General information on a range of materials that have been used is given in Technical Note WQ33.

ii. Figure 1 details key milestones in Western Queensland Best Practice (WQBP) materials selection. Where local experience has demonstrated performance, Table 2 may be used as a basis for developing suitable project-specific supplementary specification or annexure requirements for Type 4 materials in MRTS05 Unbound Pavements. This may include requirements for:

- material requirements within the ranges of Table 2
- sourcing – for example, identify location
- “pit rules” – for example, for winning and mixing
- stockpiling and transporting
- construction, including grading and compaction
- special testing procedures, if any, required for sample preparation.
- Type 1 materials will not meet the requirements of Table 2.

iii. With supplementary requirements, some MRTS05 Type 2 materials and MRTS05 Type 3 materials may meet the requirements of Table 2.

iv. The use of a low permeability untreated sub-base beneath a permeable base does not satisfy the key principles and does not overcome problems of excess moisture entry. A low permeability treated sub-base beneath a permeable base is not recommended.

v. Experience has shown that examples of suitable non-standard materials may include:

- sandstone pavements – e.g. Muttaburra sandstones, e.g. Longreach and Winton districts

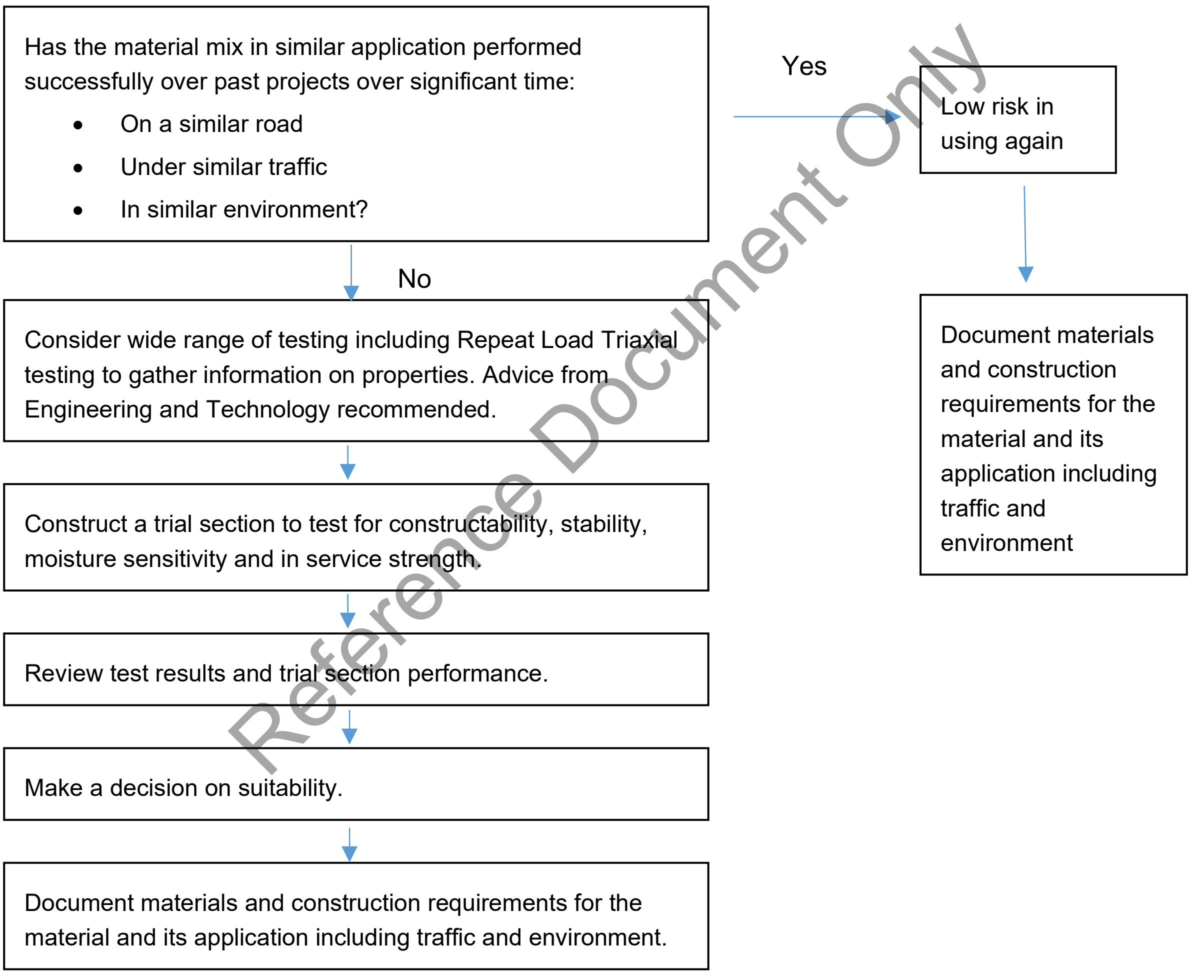
- white rock pavements – e.g. Tara and Waggamba districts
- "gob" – e.g. Banana district
- mudrock – e.g. Diamantina Shire
- "armchair" graded material – e.g. Barcaldine district
- best locally available material, excavated from cuttings – e.g. Taroom district.

vi. Where a material complying with the limits of Table 2 cannot be readily found, the option is either to cart further from conforming pits, or find alternative material sources.

Figure 1 – Decision tree

WQBP Material selection

WQBP Material Selection



5.2 Mixed materials

Pavement materials meeting the requirements of Table 2 are occasionally found naturally, while at other times mixing of different materials is required. Because of historic QTMR District experiences with underperforming Alternative 2 materials (see Section 5.1 above), it is preferred that manufactured or blended materials comply with the Alternative 1 requirements of Table 2, where:

a) All natural deposits will be variable in quality and thorough mixing will provide benefits in producing a more uniform material by removing the extremes. Where different materials are mixed, this is best carried out dry using equipment specifically designed for mixing. It is important to ensure that any lumps remaining after mixing will not prevent the preferred properties being met.

b) Homogeneity is critical as inadequately mixed materials may perform worse than if the individual components were used alone. A small amount of permeable material poorly mixed with a clayey material would be expected to increase moisture entry and decrease strength. A small amount of clayey fines poorly mixed with a permeable material will not fill the voids as intended.

c) When mixed on the road or on a separate pad, accuracy in proportioning the materials can be improved by first placing them in adjacent uniform rills before combining. Care is needed to ensure that material from the underlying surface is not incorporated during mixing.

There are reports that, when blending materials with significant differences in relative densities, there are benefits to supplementing mass-based grading with volume-based grading.

5.3 Treated materials

When pavement materials cannot be economically obtained naturally or by mixing, then treatment with binders, such as cement, lime, fly ash (in combination with other binders, e.g. lime) and bitumen (with lime) can be considered (sometimes in combination). Cement, lime and fly ash would normally be added to clayey materials, i.e. with linear shrinkage and/or fines ratio above the limits in Table 2. Bitumen and cement are used on materials with linear shrinkage and/or fines ratio below the limits of Table 2. Information on selecting suitable stabilising agents is given in Table 2.3 of the *Guide to Stabilisation in Roads Works Austroads* (1998). Detailed experience is given by Lansbury (1999).

For treated materials to perform successfully, a low permeability material of adequate strength, as required for untreated material, is required. The adopted additive content should be sufficient to produce a clearly reduced rate of capillary rise than lower contents (measurements commencing at one hour). A UCS of 1.0-2.0 MPa, with a target of 1.5 MPa, after seven days curing for cement additives and after 28 days for lime and lime blends is considered appropriate.

6 Type cross sections

Figure 1b (Appendix A) illustrates the suggested desirable type cross section features outlined in the following sections.

6.1 Shoulder protection

Even with the best low permeability/adequate strength paving materials, moisture will still enter the roadway and produce edge effects of pavement and subgrade weakening to about one metre in width. Best performance will be achieved by providing at least one metre of sealed pavement outside the edge of the wheelpath. The wheelpath position should be determined from observations taken of at least 100 heavy vehicles on roads of similar traffic volume and composition, type cross section and alignment. Consideration of any different edge and centre line marking is required. Additional lane width may be required on crests and curves to allow for different wheelpath positions due to visibility restrictions and vehicle tracking characteristics.

The *Road Planning and Design Manual* (QTMR, 2013) requirements apply.

6.2 Encased pavements

When the traffic lanes and shoulders are fully sealed, moisture can still be absorbed by pavement material exposed on the batters. Large exposed areas will create problems even with low permeability materials. Situations to avoid include excess pavement width beyond the seal (e.g. unsealed shoulders), loose pavement spilled or graded down the batters and very flat pavement batters (as opposed to embankment batters). These can be overcome by cutting the pavement batter to 1 on 2 at the seal edge, removing excess pavement material and encasing the pavement with embankment at a 1 on 4 slope. Good compaction at the pavement edge and of any material encasing it is important to minimise moisture entry.

Even more positive encasement can be provided by adding 300 to 500 mm of embankment on both sides of the formation. Spraying bitumen (without cover aggregate) on the top 300 mm of the pavement batter before encasing would further improve performance, particularly in the first few years.

Road sections constructed initially or through subsequent maintenance with encased pavements have been found to have substantially less edge heave and roughness increase rates. This is attributed to reduced moisture infiltration and evaporation and the greater uniformity obtained.

6.3 Pavement depth

Thin unbound granular pavements have been shown through computer simulation and monitoring of instrumented pavement sites to absorb less moisture than thicker unbound granular pavements. With the resultant stronger subgrade and more appropriate traffic loading distribution assessments, these pavements may carry more traffic than predicted in pavement design procedures (Baran 1999).

Pavements as thin as 100 mm have been used in the past, but are not recommended because of construction tolerances, compaction difficulties and the risk from severe damage from heavily overloaded vehicles. However, many pavements of 250 mm and even 150 and 200 mm have performed well.

In addition to the above advantages, a single pavement course (or at most two courses) will conserve material resources, save costs, reduce longitudinal crack widths and shorten construction time. The latter will provide other benefits in decreasing exposure to excess rainfall.

6.4 Sealed pavement batters

Sealed pavement batters have been used on a number of jobs in conjunction with very permeable base materials. They reduce the severity of moisture entry in the short-term, but will not eliminate it where the more uniform conditions created will reduce roughness progression rates and extend pavement life. Disadvantages include increased construction and reseal costs, and damage from traffic and maintenance operations. Their use as a long-term measure is not recommended universally, but they have a possible use as a corrective treatment on existing permeable pavements.

6.5 Batter slope and formation height

Flat embankment batters and low formation heights should be used whenever possible as these will minimise moisture changes below the pavement.

Batter slopes of 1 on 4 or flatter should be used on all fills up to 2 m.

Providing flat embankment batters using low permeability materials (1 on 4 or flatter) and low formation height will reduce the risk of shoulder and pavement edge cracking and deformation, which are more prone to occur as fill height increases and where batters are steeper.

Wherever possible, maintain positive formation height above the surrounding terrain (say 300-500 mm at the top of pavement at formation edge, with subgrade level being at least 100 mm above the surrounding terrain).

6.6 Longitudinal drainage

In flat country, table drains should never be constructed as they will hold water for extended periods and adversely affect road performance. Existing table drains in flat country should be filled with embankment. In addition, flatter batters can be used to keep any ponded water further away from the pavement. Diversion drains to nearby borrow pits can also help.

On grades where there is positive drainage, table drains may be used provided erosion is not an issue. If used in cuttings, long shallow cuttings should be avoided particularly where grades are nearly flat. It is recommended that the invert of the table drain be at least 300 mm below the top of subgrade. Flat bottomed drains are an option if excessive siltation is expected, or if required to provide adequate capacity.

6.7 Zonal use of expansive materials

The zonal use of expansive materials to place them in the embankment beyond the influence of seasonal effects has application in higher rainfall.

The requirements of MRTS04 apply.

6.8 Use of existing formation

Construction on the line of an existing formation can be an advantage, provided sufficient formation height is achieved as it is liable to provide moisture conditions close to equilibrium. However, good performance has also been achieved on sections of new alignment. The other issues discussed in this Technical Note are considered to have the greater influence on performance.

Construction costs and all other relevant factors should also be considered when deciding whether to construct on the existing alignment.

7 Maintenance warning

The undesirable features which increase moisture entry are shown in Figure 1a (Appendix A).

One possible disadvantage of some untreated paving materials conforming to Table 2 is that they can produce very stiff bases when (very) dry, and treated materials may have even higher stiffnesses. Shrinkage and other cracking may occur as such bases dry out. Cracks 1-2 mm wide or wider may result and these may reflect through a seal. It is important that cracks are sealed before moisture entry occurs. Once water entry occurs, the trafficked pavement may fail prematurely (e.g. pumping out fines, deformation, increased roughness and decreased pavement life).

Provision of a wide seal that is kept in good condition is vital for good pavement performance. Sealed shoulders, where provided, must be maintained (e.g. resealed, cracks sealed). Reseals must always be applied to the full original width and at the appropriate time before the seal becomes permeable.

Maintenance operations must ensure that material placed to encase pavements allows surface drainage but is retained in position, since there materials are prone to erosion.

8 Further research

The desirable properties of paving materials are not comprehensively measured by existing testing methods.

The use of microphotography procedures to examine compacted materials in thin section should provide a better understanding of the structure of pavement materials on a microscopic scale. This should provide information regarding particle interlock, void size and arrangement, an assessment of strength, permeability, thoroughness of mixing and the effect of additives can then be made.

Impermeable membranes used in the past under the pavement and beneath the batter were not successful as they did not extend under the seal further than the pavement moisture edge effects. Further trials of different designs may be worth consideration.

9 Checklist

Table 1 in Appendix A provides a checklist of issues derived from this Technical Note.

10 Author

This Technical Note was originally written by F J Kapitzke, then Special Projects Engineer (Mackay).

This Technical Note was reviewed for consistency by Pavement Research and Innovation and Pavement Rehabilitation Units, Engineering and Technology.

11 References

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Appendix A

The following are attached:

Figure 1a, Figure 1b, Table 1.

Figure 1a – Undesirable features (Expansive soil)

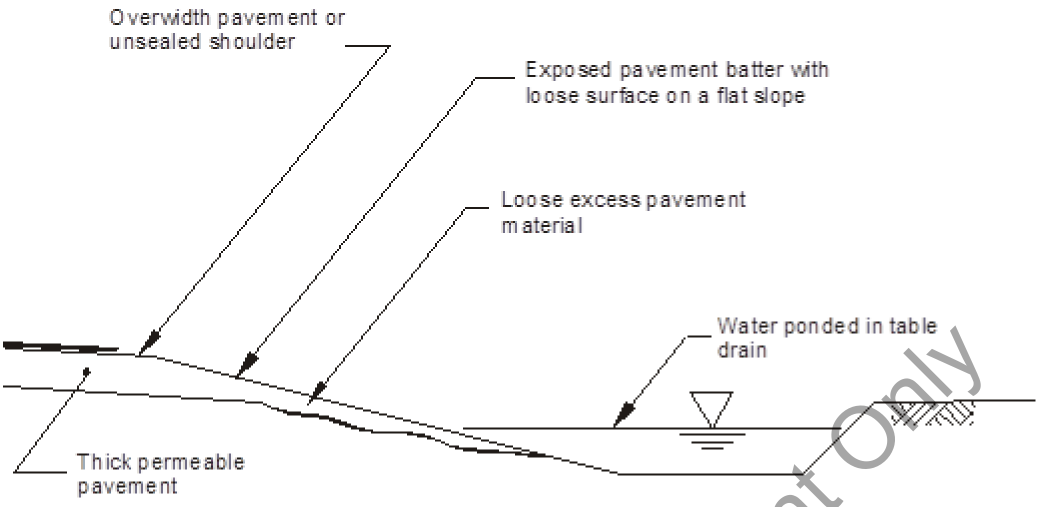
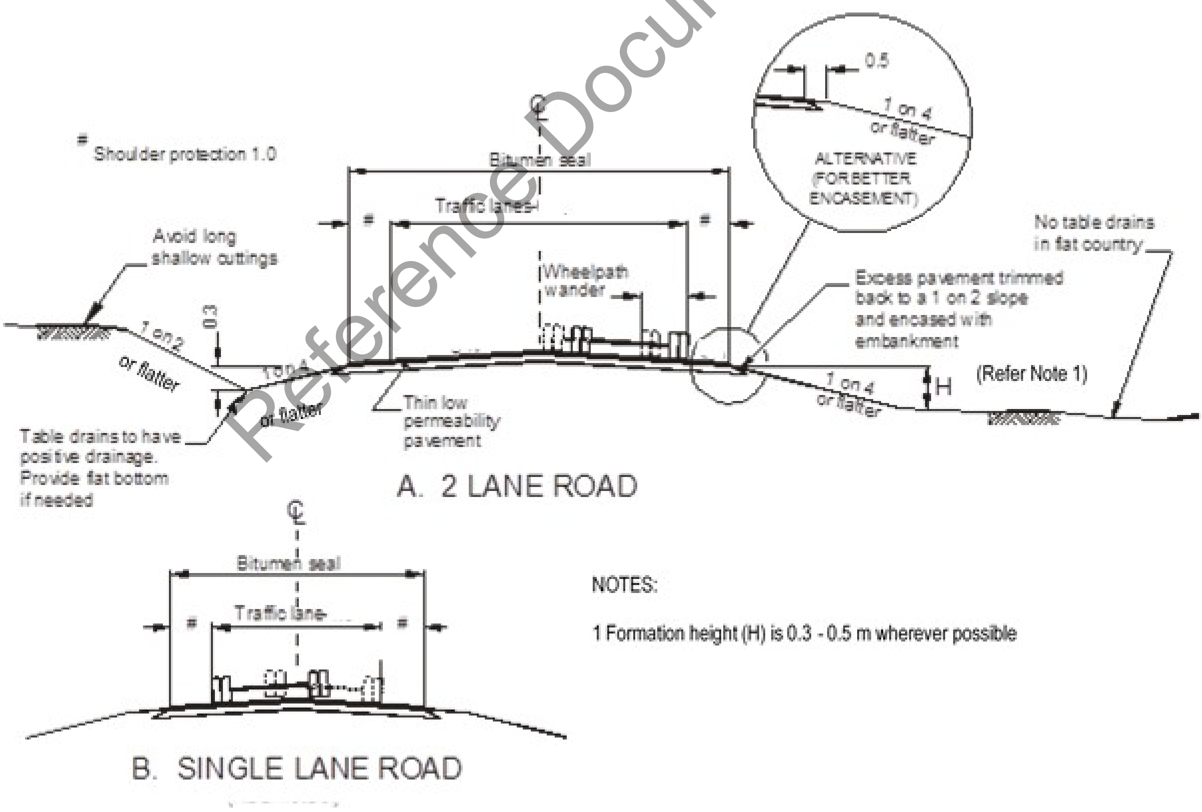


Figure 1b – Desirable type cross sections (expansive soils)



NOTES:

1 Formation height (H) is 0.3 - 0.5 m wherever possible

Table 1 – Checklist for sealed pavements on expansive clays (not for floodways, perched water tables or close to ponded water)

Feature	Section ref.	Details	Degree of compliance			
			Nil	N/A	Part	Full
DESIGN						
Key principle	3	Design to keep moisture out				
Moisture control	4.2	Include supplementary specifications for moisture control in base, subbase and top 300 mm of embankment				
Untreated pavements	5.1	Schedule as Type 4, with supplementary specification in accordance with Table 1 (Appendix A)				
Treated pavements	5.3	Consider option of treated materials, provided they are low permeability and satisfy capillary rise and UCS requirements				
Wheel path positions	6.1	Determine OWP position for similar road, traffic volume and composition, type cross section and alignment				
Shoulder protection	6.1	Provide 1 m min. sealed shoulder protection outside edge of OWP				
Crests and curves	6.1	Adjust widths on crests and curves if appropriate				
Encased pavement	6.2	Provide fully encased pavement with no exposed surfaces				
Pavement depth	6.3	Provide thinnest pavement that will carry the traffic				
Batter slope	6.5	Keep batters 1 on 4 or flatter (up to 2 m high)				
Formation height	6.5	Keep formation edge height 300 to 500 mm at top of pavement wherever possible				
Table drains	6.6	Avoid table drains in flat country				
		Provide 300 mm deep table drains where positive drainage is available				
		Avoid pondage of water within 5 m of the formation for extended periods				
		Provide flat bottom table drain if excessive siltation is a problem				
Permeable embankment	6.7	Don't allow the use of permeable materials				
Existing formation	6.8	Consider alignment options which include reuse of any existing formation				
Alternatives	1	Consider alternative treatments in terms of maintenance needs,				

Feature	Section ref.	Details	Degree of compliance			
			Nil	N/A	Part	Full
		performance requirements and whole of life costs				
		Obtain specialist advice when appropriate				
CONSTRUCTION						
Key principle	3	Construct so as to keep moisture out				
Rainfall	4.1	Monitor rainfall prior to and during construction				
		Schedule construction to avoid excess rainfall				
Moisture control	4.2	Use construction practice that avoids excess wetting or drying of materials				
		Monitor moisture in base, subbase and top 300 mm of embankment.				
		Take action to dry materials if necessary				
Paving materials	5.1 or 5.3	Ensure paving materials meet the specification requirements				
Mixed materials	5.2	Use specifically designed mixing equipment or appropriate mixing techniques				
		Ensure any lumps remaining after mixing will not affect properties				
Encased pavement	6.2	Ensure pavement is fully encased with no exposed surfaces				
		Ensure good compaction at the edges				
Table drains	6.6	Ensure water cannot pond within 5 m of embankment for extended periods				
Permeable embankment	6.7	Don't use permeable embankment materials				