PINE RIVERS SHIRE COUNCIL

PLANNING SCHEME POLICY 28

CIVIL INFRASTRUCTURE DESIGN

DESIGN GUIDELINES

DG 01	Roundabouts
DG 02	Engineering Drawings
DG 03	As Constructed Information
DG 04	Local Area Traffic Management
DG 05	**Pavement Design**
DG 06	Recreational Trails – Planning, Construction and Maintenance
DG T10	Landscape Construction on Road Reserves, Parks and Drainage Reserves
DG T11	On-Site Carparking and Service Vehicle Facilities

PINE RIVERS SHIRE COUNCIL

DESIGN GUIDELINES

DG 05

PAVEMENT DESIGN

DG 05
PAVEMENT DESIGN

1.0.0 INTRODUCTION 1
- 1.1.0 Purpose 1
- 1.2.0 Scope 1
- 1.3.0 Reference Documents 1
- 1.4.0 Interpretation 1

2.0.0 SUBGRADE EVALUATION 2
- 2.1.0 General 2
- 2.2.0 Field Testing and Sampling 2
- 2.3.0 Laboratory Testing 3
- 2.4.0 Subgrade CBR at Equilibrium Moisture Content 4

3.0.0 DESIGN CBR DETERMINATIONS FOR DELINEATED AREAS 5

4.0.0 MINOR STREET PAVEMENT DESIGN 6
- 4.1.0 General 6
- 4.2.0 Traffic Loadings 6
- 4.3.0 Flexible Pavement Design 7
- 4.4.0 Rigid Pavement Design 9

5.0.0 MAJOR ROAD PAVEMENT DESIGN 10
- 5.1.0 General 10
- 5.2.0 Traffic Loadings 10
- 5.3.0 Flexible Pavement Design 13
- 5.4.0 Alternative Pavement Designs 14

6.0.0 SUBSURFACE DRAINAGE 15

7.0.0 SUBGRADE INSPECTIONS 15

APPENDIX A 16
- Subgrade Evaluation Report Sheets 16
- FIGURES 1, 2 and 3 16

APPENDIX B 20
- Flexible Pavement Design Charts 20
- Figures 4, 5 and 6 20

APPENDIX C 24
- Estimation of Laboratory CBR 24

APPENDIX D 32
- Summary of Unbound Pavement Materials 32

1.0.0 INTRODUCTION

1.1.0 PURPOSE

To outline the minimum requirements for subgrade evaluation and structural design of street and road pavements within Pine Rivers Shire.

To accumulate a database of test results which will lead to a more efficient determination of subgrade material properties.

1.2.0 SCOPE

This guideline sets out recommended procedures for:-

(a) the sampling and testing of pavement subgrade materials
(b) adoption of design CBR for pavement subgrade materials
(c) design methods for determining flexible pavement thickness
(d) design methods for rigid pavements (i.e. reinforced concrete)

1.3.0 REFERENCE DOCUMENTS

This Guideline is based on the following reference documents:-

(a) Australian Road Research Board (ARRB) Special Report No. 41 "Into A New Age of Pavement Design" which was prepared for and on behalf of Australian Local Government Authorities. ARRB Special Report No. 41, except as noted otherwise in this guideline, is to be adopted in the structural design of minor urban and non-urban street and road pavements. Reference should be made to the report for explanation of terms used in this guideline and for background information and examples of the method for determining pavement thicknesses for minor streets and roads.

(b) Queensland Department of Main Roads (D.M.R.) Design Manual, which is appropriate for the design of major road pavements. The D.M.R. Pavement Design Manual, except as noted otherwise in this guideline, is to be adopted in the structural design of major urban and non-urban road pavements.

Reference should be made to the D.M.R. Pavement Design Manual for explanation of the terms used in this guideline and for background information and examples of determining traffic loadings and appropriate pavement thickness for major roads.

1.4.0 INTERPRETATION

In the event of any discrepancies between this guideline and the reference documents a final determination shall be made by a Pine Rivers Shire Council engineer.

2.0.0 SUBGRADE EVALUATION

2.1.0 GENERAL

In designing a new pavement, it is essential that the strength and stiffness of the supporting subgrade be logically assessed and that variations in properties of the subgrade be accurately predicted. The long term performance of the new pavement will depend not so much on the strength of the subgrade achieved at construction, but more on the strength of the subgrade at equilibrium moisture conditions after pavement construction.

The Country Roads Board of Victoria formulated a method for estimating the laboratory CBR from soil classification tests (for fine grained soils). This method has been incorporated in this manual on a trial basis to determine if estimated laboratory CBRs based on soil classification tests can be related to laboratory soaked CBRs for subgrade soils encountered within the Pine Rivers Shire. It is envisaged that a database of laboratory classification tests, estimated laboratory CBRs and soaked CBRs will eventually be produced, and this may lead to a reduction in the number of soaked CBRs required in evaluating subgrade materials. The soil classification tests required are Particle Size Distribution, Liquid Limit, Plastic Limit and Linear Shrinkage.

2.2.0 FIELD TESTING AND SAMPLING

Subgrade investigation should be carried out prior to completion of subgrade preparation along the alignment of new pavement construction. The purpose of the field testing and sampling is to identify the extent and properties of the various subgrade materials likely to be encountered. Particular attention needs to be paid to the soils at anticipated subgrade level and those immediately underlying it.

The investigation should be based principally on a series of bores or test pits from which soil samples are obtained and (if relevant) *in situ* testing carried out. The frequency of test locations will vary depending on the following:-

(a) topography of the pavement route
(b) variation in depths of excavation along the pavement route
(c) anticipated variation in subgrade materials

The frequency of test locations for any specific site shall be to the satisfaction of a Pine Rivers Shire Council engineer.

The minimum sampling frequencies are given in Table 2.0 below: -

Table 2.0

PAVEMENT LENGTH	MINIMUM SAMPLING/TESTING FREQUENCY
Less than 100m	1 per change in material (1 locations min)
100m to 200m	1 per change in material (2 locations min)
200m to 500m	1 per change in material (3 locations minimum)
Greater than 500m	1 per change in material or 1 per 250m or part thereof (3 locations min)

Sampling and testing frequencies for pavement widening should be the same as for new pavement construction.

Additional testing may be required where in the opinion of a Pine Rivers Shire Council engineer variation *in situ* material properties may exist.

Bores/test pits should be extended at least 500mm below the anticipated subgrade level and samples collected of strata penetrated. Sufficient bulk samples of representative subgrade materials should be collected to enable samples to be classified in the laboratory by field moisture, Atterberg limits, linear shrinkage and soaked CBR testing. Soils encountered in the bores/pits at depths other than at anticipated subgrade level and which are different to those at anticipated subgrade level should be visually classified and recorded, and samples taken for moisture content determinations or confirmatory classification testing, as required.

Static or dynamic cone penetration tests may also be carried out (or nominated by a Pine Rivers Shire Council engineers to be carried out) if the subgrade moisture conditions are considered to be representative of equilibrium moisture conditions.

A Pine Rivers Shire Council engineer may relax the requirement for sampling/testing for subgrade assessment in areas of new pavement where in excess of 500mm of filling is yet to be placed to achieve subgrade formation level. Sampling/testing should, however, be carried out on materials to be won from site which are to be used as filling in pavement areas, as the properties of this filling will dictate the overlying pavement thickness.

An estimate of likely subgrade drainage conditions (i.e. good, fair or poor) and observations whether springs are evident in the near vicinity of the test location should also be made. This estimate is applicable to the determination of an appropriate 'F' factor (refer to Section 2.4.0).

Strata encountered at each test location should be recorded and presented in the format of the attached Test Bore / Test Pit Report sheet - refer Appendix A - Figure 1.

2.3.0 LABORATORY TESTING

Laboratory testing should be carried out on samples collected at anticipated subgrade level from each bore/test pit location to collect the results required in Table 2.1. All tests should be carried out in a NATA registered laboratory and in accordance with relevant test methods detailed in AS1289 "Methods of Testing Soils for Engineering Purposes" (or its updated equivalent).

Table 2.1

TESTED	RESULT PROVIDED AS
Field moisture content	%
Sieve grading analysis	% passing 2.36 mm % passing 425 μm % passing 75 μm
Liquid limit	%
Plastic limit	%
Plasticity index	%
Linear shrinkage	%
Laboratory soaked CBR	%

Laboratory soaked CBRs should be carried out on samples compacted to a dry density ratio of 100% standard compaction, at standard optimum moisture content and with the appropriate surcharge.

If samples from adjoining bores/test pits are visually classified as being of the same soil type, and their similarity is confirmed by grading and plasticity index results, then laboratory soaked CBRs need only be carried out on one sample from either of the two adjoining bores/test pits.

Where subgrade materials contain significant quantities of rock fragments or comprise low strength or highly weathered rock, pre-treatment of samples to be used in the soaked CBR test and the standard dry density/moisture content relation test (carried out prior to the soaked CBR test) is required. These types of subgrade materials typically occur in the central and western parts of the Pine Rivers Shire where phyllite, argillite or greywacke rock is commonly encountered. Pre-treatment is required to simulate the breakdown of rock fragments which will occur under construction plant during subgrade preparation and also traffic loads during the life of the pavement.

The specified method of pre-treatment is as follows:-

- sieve the sample through the 19mm sieve as detailed in AS1289
- compact at field moisture content in the CBR mould with modified compactive effort (i.e. 5 layers with 53 blows per layer)
- remove the compacted material from the mould and then resieve through the 19mm sieve
- use the resieved material to carry out moisture/density test and the soaked CBR test
- the CBR test shall be carried out on the sample recompacted to a dry density ratio of 100% standard compaction and at standard optimum moisture content.

Results of laboratory testing carried out on each subgrade sample shall be presented either in the format of the attached Laboratory Testing Report Sheet - refer Appendix A - Figure 2 (or a similar approved format). Results shall be listed in order of running chainage.

Results of laboratory classification tests shall be used to calculate values of estimated laboratory CBR using the method detailed in Appendix C. Calculated values of estimated laboratory CBR shall be included on Figure 2, although the values shall only be used for comparative purposes in assessing similarity of subgrade materials.

2.4.0 SUBGRADE CBR AT EQUILIBRIUM MOISTURE CONTENT

The most vital step to be taken in the pavement design procedure is to accurately predict the subgrade strength achieved under equilibrium moisture conditions. Common practice in the past has been to assume that the constructed subgrade will, over a period of several years, reach an equilibrium state approximating that of a soil sample undergoing four days soaking in a laboratory mould. Pavement design has therefore been based on the laboratory soaked CBR of the subgrade material. (ARRB Special Report 41)

Recent research (by Mulholland 1986) shows that the CBR adopted for design should take into account subgrade soil type, climate and drainage. Common practice to determine the CBR at equilibrium moisture conditions is to multiply the laboratory soaked CBR (as determined in Section 2.3 of this Guideline) by a factor "F". “F" factors for various subgrade types within the Pine Rivers Shire and for various drainage conditions are currently being assessed. Until this assessment has been completed, an "F" factor of 1.0 should generally be adopted. A Pine Rivers Shire Council engineer may determine an alternative "F" factor for specific site conditions.

The estimated *in situ* CBR value at equilibrium moisture content is referred to as the Equilibrium CBR. Computed values of the Equilibrium CBR shall then be included on Figure 2.

3.0.0 DESIGN CBR DETERMINATIONS FOR DELINEATED AREAS

Results of field and laboratory testing carried out (as detailed in Sections 2.3 to 2.4 of this Guideline) shall be analysed in conjunction with topographical considerations and knowledge of proposed earthworks cut/fill requirements. The length of new pavement construction may then be delineated into sections of similar subgrade type and drainage conditions. Sections must be of sufficient length to conform to practical and economical construction practice.

The design CBR appropriate for each delineated subgrade area (with similar subgrade conditions) can then be computed using one of the following formulae:-

- When four or less values of CBR are being considered for one delineated subgrade area:-

Design CBR = least of the calculated Equilibrium CBRs

- When five or more values are being considered for one delineated subgrade area:-

Design CBR = 10th percentile (Note 1 below) of all calculated Equilibrium CBRs (for five or more results)

= C - 1.3 S

where C is the mean of all calculated Equilibrium CBRs, and
S is the standard deviation of all values.

Design CBRs should then be reported as detailed in the Table 3.0.

Table 3.0

CBR RANGE	VALUE REPORTED TO NEAREST
Less than 5	**0.5**
5 - 20	**1**
Greater than 20	**5**

Results of design CBR values to be adopted for delineated areas should then be reported on plans/drawings of proposed pavement areas and in tabular form similar to that displayed in Figure 3 (Appendix A).

Note 1:- The 10th percentile method can be very misleading if delineation of subgrade areas with similar subgrade conditions is not carried out. Particular care must be taken to exclude any single high or low CBR result, a so-called "outlier". For example, if CBR results on a clay were 5, 4, 7, 8 and 15:-

- C - 1.3 S = 2.5 if CBR 15 is included, or
- C - 1.3 S = 4.0 if CBR 15 is excluded.

The latter should apply, illustrating the need to exclude an outlier from any subgrade strength assessment. If an outlier result occurs, then checks should be made to ensure that subgrade materials are similar or a mistake has not been made in calculating the CBR value.

4.0.0 MINOR STREET PAVEMENT DESIGN

4.1.0 GENERAL

This section of the Guideline is applicable to the determination of appropriate pavement thickness for lightly trafficked urban and non-urban streets and roads whose primary function is to provide access to residential properties. The design traffic loadings are limited to between 10^3 and 10^6 ESA's.

These streets or roads comprise the following classifications:-

Urban	-	Access Place
	-	Access Street
	-	Collector Street
	-	Bus Collector Street
	-	Service Roads
Park Residential	-	Access Place
	-	Access Street
	-	Collector Street
Rural Residential	-	Access Place
	-	Access Street
	-	Collector Street
Rural	-	Access Road
	-	Collector Road

4.2.0 TRAFFIC LOADINGS

Traffic loadings for minor streets and roads are determinable from the relevant number of allotments being serviced by the particular street or road and therefore can be adopted from the relevant street or road classification.

The traffic loadings to be adopted for the various minor streets and road classifications are detailed in the Table 4.0

Table 4.0

ROAD STANDARD	DESIGN E.S.A.
Urban Residential Streets	
- Access Way (Driveway)	2.3×10^3 (for each allotment)
- Access Place	4.0×10^4
- Access Street	9.2×10^4
- Collector Street	5.3×10^5
- Bus Collector Street	6.5×10^5
Park Residential Streets	
- Access Way (Driveway)	2.3×10^3 (for each allotment)
- Access Place	9.2×10^4
- Access Street	2.0×10^5
- Collector Street	4.9×10^5
Rural Residential Streets	
- Access Way (Driveway)	2.3×10^3 (for each allotment)
- Access Place	9.2×10^4
- Access Street	2.0×10^5
- Collector Street	4.9×10^5
Rural Roads	
- Access Way (Driveway)	2.3×10^3 (for each allotment)
- Access Road	9.7×10^4
- Collector Road	1.6×10^5
Roundabouts	
- Access Streets/Roads	allow additional 0.5×10^4
- Collector Streets/Roads	allow additional 1.0×10^4

4.3.0 FLEXIBLE PAVEMENT DESIGN

The design procedures for determining minor street and road pavement design are derived from A.R.R.B. Special Report No. 41 and accordingly limited to design traffic loadings not exceeding 10^6 ESA's

The depth of the flexible pavement (excluding AC thickness) shall be determined using the design chart given in Appendix B - Figure 4 for urban and non-urban residential street pavements (with kerb and channel) and Appendix B Figure 5 for minor rural roads (without kerb and channel).

Where kerb and channel is introduced on a minor rural road for the purposes of limiting earthworks, drainage or scour protection, the above Figure 4 shall be used.

The relevant design charts for the various street / road classifications are detailed in the Table 4.1

Table 4.1

ROAD STANDARD	DESIGN CHARTS
Urban Residential Streets	
- Access Way (Driveway)	Figure 4
- Access Place	Figure 4
- Access Street	Figure 4
- Collector Street	Figure 4
- Bus Collector Street	Figure 4
Park Residential Streets	
- Access Way (Driveway)	Figure 4
- Access Place	Figure 4
- Access Street	Figure 4
- Collector Street	Figure 4
Rural Residential Streets	
- Access Way (Driveway)	Figure 4
- Access Place	Figure 4
- Access Street	Figure 4
- Collector Street	Figure 4
Rural Roads	
- Access Way (Driveway)	Figure 5
- Access Road	Figure 5
- Collector Road	Figure 5

The configuration of the pavement layers, material type and compaction requirements are detailed in Table 4.2

Table 4.2

PAVEMENT LAYERING			
Pavement Layer	Minimum CBR	Minimum Thickness	Compaction Requirements
Base Course	80%	100mm	98% Modified
Sub-Base Course	40%	100mm	95% Modified
Selected Fill (Rest of Pavement)	15%	100mm	95% Modified
Blanket Course (where required)	15%	300mm	95% Modified
Subgrade			
Top 0.15m	-	-	100% Standard
Below 0.15m	-	-	95% Standard

Where subgrade materials have a design CBR of less than three, these materials may be stabilised *in situ* to the satisfaction of a Pine Rivers Shire Council engineer (using lime, cement or a lime/cement combination) or replaced using a blanket course material with a minimum CBR of 15. The depth of the blanket course layer shall be not less than 300mm, although significantly thicker bridging layers may be required where very low strength subgrades exist. The specified compaction standard shall be achieved at the top of the layer.

The top of the blanket layer shall be deemed to be the subgrade for inspection purposes. **The pavement above the blanket course layer shall be designed using a subgrade CBR of 3%.**

4.4.0 RIGID PAVEMENT DESIGN

Rigid pavements are to be designed and constructed in accordance with the Cement and Concrete Association of Australia Technical Notes. These include:-

- Technical Note 43 - Introduction to concrete road pavements
- Technical Note 44 - Concrete for road pavements
- Technical Note 45 - Subgrades and subbases for concrete road pavements
- Technical Note 46 - Thickness design for concrete road pavements
- Technical Note 47 - Joints in concrete road pavements
- Technical Note 48 - Joint sealants for concrete road pavements
- Technical Note 49 - Steel reinforcement for concrete road pavements
- Technical Note 50 - Outline guide for the construction of concrete road pavements

The rigid pavement design procedure shall be limited to either jointed reinforced concrete pavements or continuously reinforced concrete pavements

The extent and location of rigid pavement within any development shall be subjected to the approval of a Pine Rivers Shire Council engineer.

Unless otherwise approved by a Pine Rivers Shire Council engineer, the minimum thickness of the reinforced concrete pavement shall be 175mm. Where stencilled on patterned surface treatments are proposed, an additional 5mm shall be added to the design thickness of the concrete pavement.

Colouring of stencilled or patterned concrete shall be subject to the approval of a Pine Rivers Shire Council engineer. Particular attention is to be given to the selection of surface treatments which ensure that appropriate skid resistance is maintained. Where colouring of the rigid pavement is proposed, the complete pavement mix is to be coloured. Preferably one oxide colour used shall used throughout the mix; however two colours may be used with the darker colour on top. The selection of colours shall be provided to a Pine Rivers Shire Council's engineer for approval. Surface colouring shall only be accepted upon written approval from a Pine Rivers Shire Council engineer. Light colours are to be avoided and all works are to be carried out by approved contractors.

Where the rigid pavement section being designed is less than 25m in length and is abutted by a flexible pavement, the combined thickness of the rigid pavement and its supporting subbase shall be equivalent to the combined thickness of the abutting flexible pavement base and subbase courses.

5.0.0 MAJOR ROAD PAVEMENT DESIGN

5.1.0 GENERAL

This section of the guideline is applicable to the determination of appropriate pavement thicknesses for highly trafficked urban and non-urban roads which act as "traffic routes" whose primary function is to convey traffic between centres of population or which act as major links within an area.

In industrial or commercial areas these roads will carry a high proportion of commercial vehicles.

The design traffic loadings should ideally be assessed for each case but are typically in excess of 10^6 ESAs.

These streets or roads comprise the following classifications:-

Urban	-	Trunk Collector
	-	Sub Arterial
	-	Arterial
Industrial	-	Access
	-	Collector
	-	Sub Arterial
	-	Arterial
Commercial	-	Access
	-	Collector
	-	Sub Arterial
	-	Arterial
Park Residential	-	Sub Arterial
	-	Arterial
Rural Residential	-	Sub Arterial
	-	Arterial
Rural	-	Sub Arterial
	-	Arterial

5.2.0 TRAFFIC LOADINGS

The appropriate assessment of the design traffic loading for major roads is essential in the production of an acceptable pavement design which will not only cater for the existing traffic loading but will remain serviceable under projected increases in traffic loading throughout the design life of the pavement.

The methods of assessment of "Design Traffic" are detailed in the D.M.R. Pavement Design Manual.

It should be noted that the method used to calculate design traffic depends on the type of traffic data available. The selection of the appropriate level of traffic data which is to be obtained should be based on a combination of factors such as:-

- the availability of historical data
- the accuracy required
- the resources available
- the cost of obtaining the data
- the presence in the traffic spectrum of specialised loadings
- a typical axle group or loading distribution

When historical data is limited, the designer will need to give consideration to the following design variables:-

- present traffic volumes (if available)
- percentage of commercial vehicles
- road functional class
- number of ESAs per commercial vehicles
- growth rate
- design period

The recommended values for the above design variables are detailed in Table 5.0

NOTE:- Final determination of an appropriate "design traffic" loading for major roads is subject to the approval of a Pine Rivers Shire Council engineer

Table 5.0

ROAD STANDARD	TRAFFIC VOLUME	PERCENTAGE OF COMMERCIAL VEHICLES		No. ESA'S PER COMMERCIAL VEHICLE	GROWTH RATE %	DESIGN PERIOD (Years)
		RANGE	DEEMED TO COMPLY			
URBAN						
- Trunk Collector	From Counts	3 - 7	5	0.5	4	25
- Sub Arterial		3 - 10	7	0.75	4	25
- Arterial		3 - 10	7	1.0	4	25
INDUSTRIAL						
- Access	From Counts	10 - 25	20	1.0	4	25
- Collector		10 - 25	20	1.0	4	25
- Sub Arterial		10 - 25	20	1.0	4	25
- Arterial		10 - 20	15	1.0	4	25
COMMERCIAL						
- Access	From Counts	8 -20	15	1.0	4	25
- Collector		8 -20	15	1.0	4	25
- Sub Arterial		8 -20	15	1.0	4	25
- Arterial		8 -15	12	1.0	4	25
PARK RESIDENTIAL						
- Sub Arterial	From Counts	3 - 10	7	1.0	5	20
- Arterial		3 - 10	7	1.1	5	20
RURAL RESIDENTIAL						
- Sub Arterial	From Counts	3 - 10	7	1.0	5	20
- Arterial		3 - 10	7	1.1	5	20
RURAL	From Counts					
- Sub Arterial		3 - 10	7	1.0	5	20
- Arterial		3 - 10	7	1.1	5	20

In new development works, or other areas where historical traffic counts are not available, design traffic loadings to be adopted for the various major road classifications are detailed in Table 5.1

Table 5.1

ROAD STANDARD	DESIGN E.S.A.
Urban	
- Trunk Collector	1.2 x 106
- Sub Arterial	2.9 x 106
- Arterial	9.6 x 106
Industrial	
- Access	2.9 x 106
- Collector	1.1 x 107
- Sub Arterial	1.1 x 107
- Arterial	2.0 x 107
Commercial	
- Access	2.2 x 106
- Collector	8.2 x 106
- Sub Arterial	8.2 x 106
- Arterial	1.6 x 107
Park Residential	
- Sub Arterial	3.1×10^6
- Arterial	8.4×10^6
Rural Residential	
- Sub Arterial	3.1×10^6
- Arterial	8.4×10^6
Rural	
- Sub Arterial	3.1×10^6
- Arterial	8.4×10^6

5.3.0 FLEXIBLE PAVEMENT DESIGN

The design procedures for determining major road pavements are derived from D.M.R. Pavement Design Manual.

Flexible pavements shall be designed as full depth (excluding AC thickness) granular material of standard specification using the design chart given in Appendix B - Figure 6 for urban and non-urban major roads.

Where the proposed pavement is to be surfaced with asphaltic concrete surfacing which is 50mm or greater in thickness, the depth of granular pavement material may be reduced by the thickness of the surfacing.

When subgrade materials have a design CBR of less than three, these materials may be stabilised *in situ* to the satisfaction of a Pine Rivers Shire Council engineer (using lime, cement or a lime / cement combination) or replaced using a blanket course material not less than a minimum CBR of 15. The depth of the blanket course layer shall be not less than 300mm, although significantly thicker bridging layers may be required where very low strength subgrades exist. The specified compaction standard shall be achieved at the top of the layer.

The top of the blanket layer shall be deemed to be the subgrade, for inspection purposes. **The pavement above the blanket course layer shall be designed using a subgrade CBR of 3%.**

The configuration of the flexible pavement layers are detailed in the Table 5.2

Table 5.2

PAVEMENT LAYERING		
PAVEMENT LAYER	**MINIMUM CBR**	**MINIMUM THICKNESS**
Base Course	80%	125mm
Sub-Base Course	40%	125mm
Select Fill (Rest of Course)	15%	100mm
Blanket Course (Where Required)	15%	300mm
Subgrade Top 0.15m Below 0.15m	 - -	 - -

Pavement compaction requirements and material type shall be in accordance with Appendix D.

Compaction of the subgrade shall be 100% (standard) for the top 150mm and 95% (standard) below 150mm.

5.4.0 ALTERNATIVE PAVEMENT DESIGNS

Alternative designs for pavements constructed from other than full depth granular materials (flexible pavements) may be considered subject to prior approval from a Pine Rivers Shire Council engineer. Such designs shall be in accordance with the procedures outlined in the D.M.R. Pavement Design Manual.

In requesting approval for pavement design using alternative materials other than full depth granular, the consulting engineer shall submit full details of the circumstances leading to the selection of the particular alternative pavement design, together with a design for a full depth granular (flexible pavement) for the section of road being considered.

6.0.0 SUBSURFACE DRAINAGE

Longitudinal and transverse subsurface drains shall be provided to all streets and roads where kerb and channel is being constructed, as directed by a Pine Rivers Shire Council engineer.

Subsurface drainage may be required under other roads where considered necessary to adequately drain the pavement and subgrade areas to the satisfaction of a Pine Rivers Shire Council engineer.

The construction of longitudinal and transverse subsurface drains shall be in accordance with the Pine Rivers Shire Council standard drawings.

Additional subsurface drainage may be required at traffic islands, medians, roundabouts and landscaped areas as directed by a Pine Rivers Shire Council engineer.

7.0.0 SUBGRADE INSPECTIONS

Inspections of subgrade areas should be carried out when bulk earthworks are nearing completion. Such inspections are required to confirm that subgrade conditions inferred from the bore/test pit investigation are appropriate to the subgrade conditions exposed, and to delineate between areas of differing subgrade conditions. Subgrade inspections should be carried out by experienced engineering personnel and the results of the inspections should be presented to a Pine Rivers Shire Council engineer as a plan/drawing of subgrade areas, with areas of various subgrade conditions (and design CBRs adopted for those areas) delineated.

APPENDIX A

SUBGRADE EVALUATION REPORT SHEETS

FIGURES 1, 2 AND 3

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FIGURE 1

TEST BORE/TEST PIT RESULTS

Client:	**Date:**	**Test Location:**
Project:	**Project No:**	**Chainage:**
Location:		**Surface Level:**

Depth (m)	Description of Strata	Sampling and Testing		
		Type	Depth (m)	Results

Rig:

Logged:

Groundwater Observations:

Remarks:

Drainage Conditions:

Testing Laboratory

This Laboratory is registered by the National Association of Testing Authorities Australia. The tests reported herein have been performed in accordance with the Pine Rivers Shire Council requirements.

CERTIFIED BY:

SAMPLING AND TESTING

D disturbed sample

B bulk sample

pp pocket penetrometer (kPa)

U_x x mm dia. tube

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FIGURE 2

LABORATORY TESTING REPORT SHEET

PINE RIVERS

Road No. or Test Location				
Chainage				
Finished Pavement Level				
Surface Level at Test Location				
Sample Depth				
Sample Description				
Unified Soil Classification Symbol				
Field Moisture Content %				
Plasticity:- Liquid Limit % Plastic Limit % Plasticity Index %				
Linear Shrinkage %				
Estimated Laboratory CBR* %				
Compaction:- OMC (Standard) % MDD (Standard) t/m3				
Soaked CBR** % Swell on Soaking %				
Drainage Condition				
'F' Factor				
Equilibrium CBR %				

Testing Laboratory	This Laboratory is registered by the National Association of Testing Authorities Australia. The tests reported herein have been performed in accordance with the Pine Rivers Shire Council requirements. **CERTIFIED BY:**

- Determined using the method detailed in Appendix C and based on the results of laboratory classification tests.
- Compacted to 100% Standard Compaction at optimum moisture content and tested after four days soaking with an appropriate surcharge (4.5 kg minimum). Result given is for 2.5mm penetration.

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FIGURE 3

SUBGRADE DELINEATION AND DESIGN CBR REPORT SHEET

PINE RIVERS

ROAD NAME	PAVEMENT CHAINAGE	EARTHWORKS REQUIRED		ANTICIPATED SUBGRADE	LABORATORY SOAKED CBR (%) (RANGE)	EQUILIBRIUM CBR (%) (RANGE)	DESIGN CBR (%)
		Excavation Depth	Fill Depth				

Testing Laboratory	This Laboratory is registered by the National Association of Testing Authorities Australia. The tests reported herein have been performed in accordance with the Pine Rivers Shire Council requirements. **CERTIFIED BY:**

APPENDIX B

FLEXIBLE PAVEMENT DESIGN CHARTS

FIGURES 4, 5 AND 6

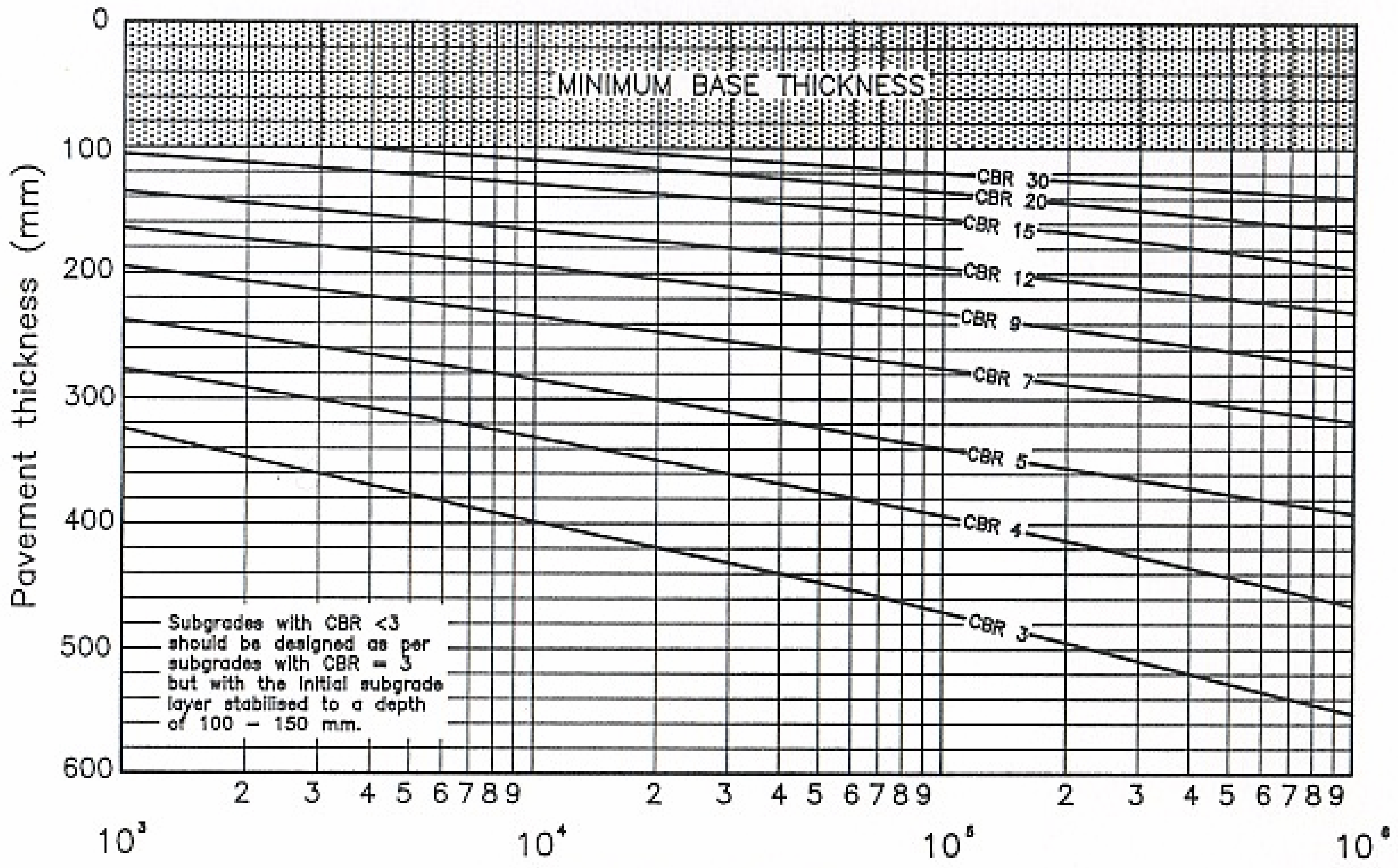

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FIGURE 4

PAVEMENT THICKNESS DESIGN CURVES FOR URBAN AND NON URBAN RESIDENTIAL STREETS

Pine Rivers Shire Council
Road Pavement Design
Derived from ARRB Special Report No. 41

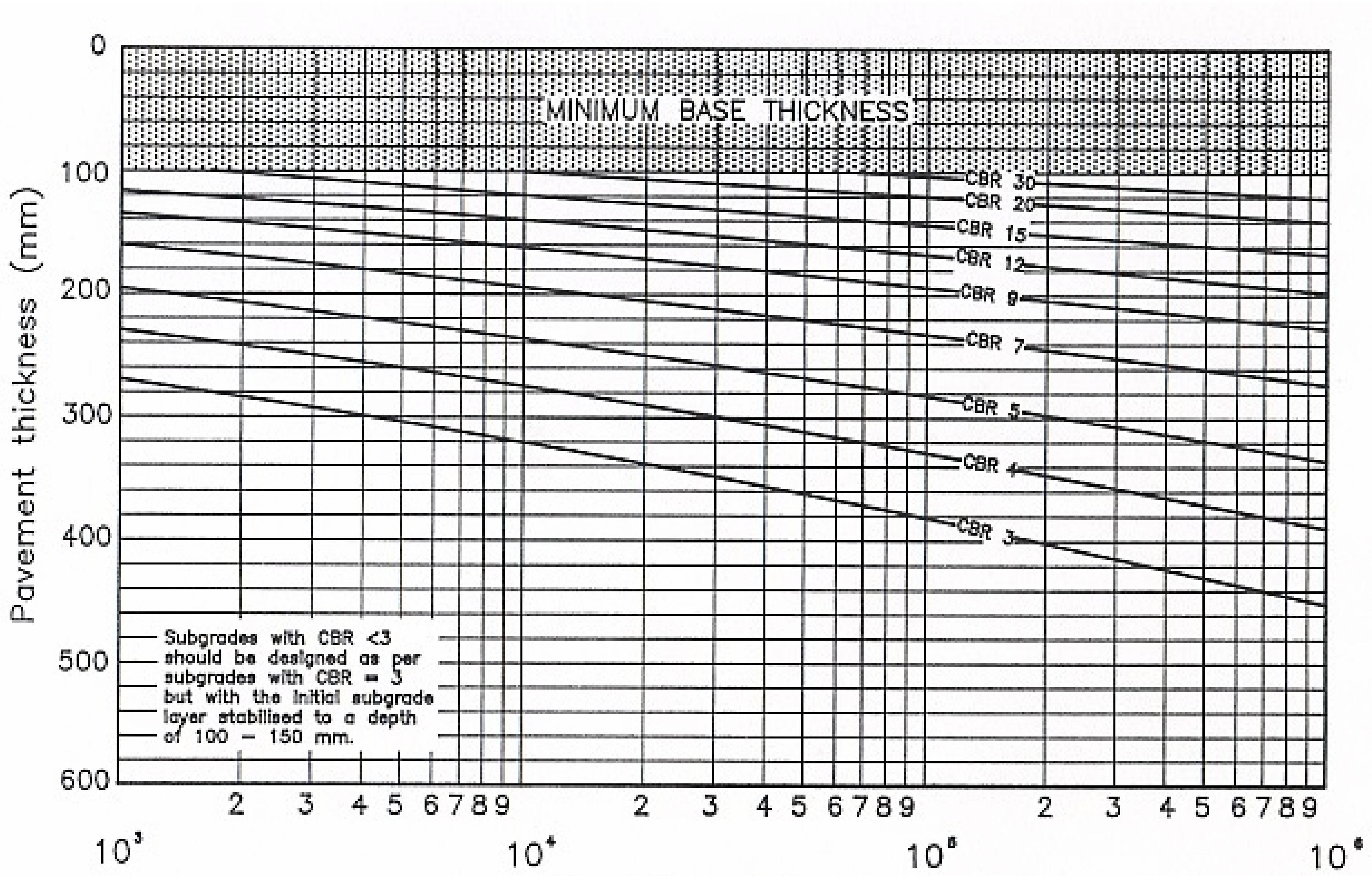

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FIGURE 5

PAVEMENT THICKNESS DESIGN CURVES FOR MINOR RURAL ROADS

Pine Rivers Shire Council
Road Pavement Design
Derived from ARRB Special Report No. 41

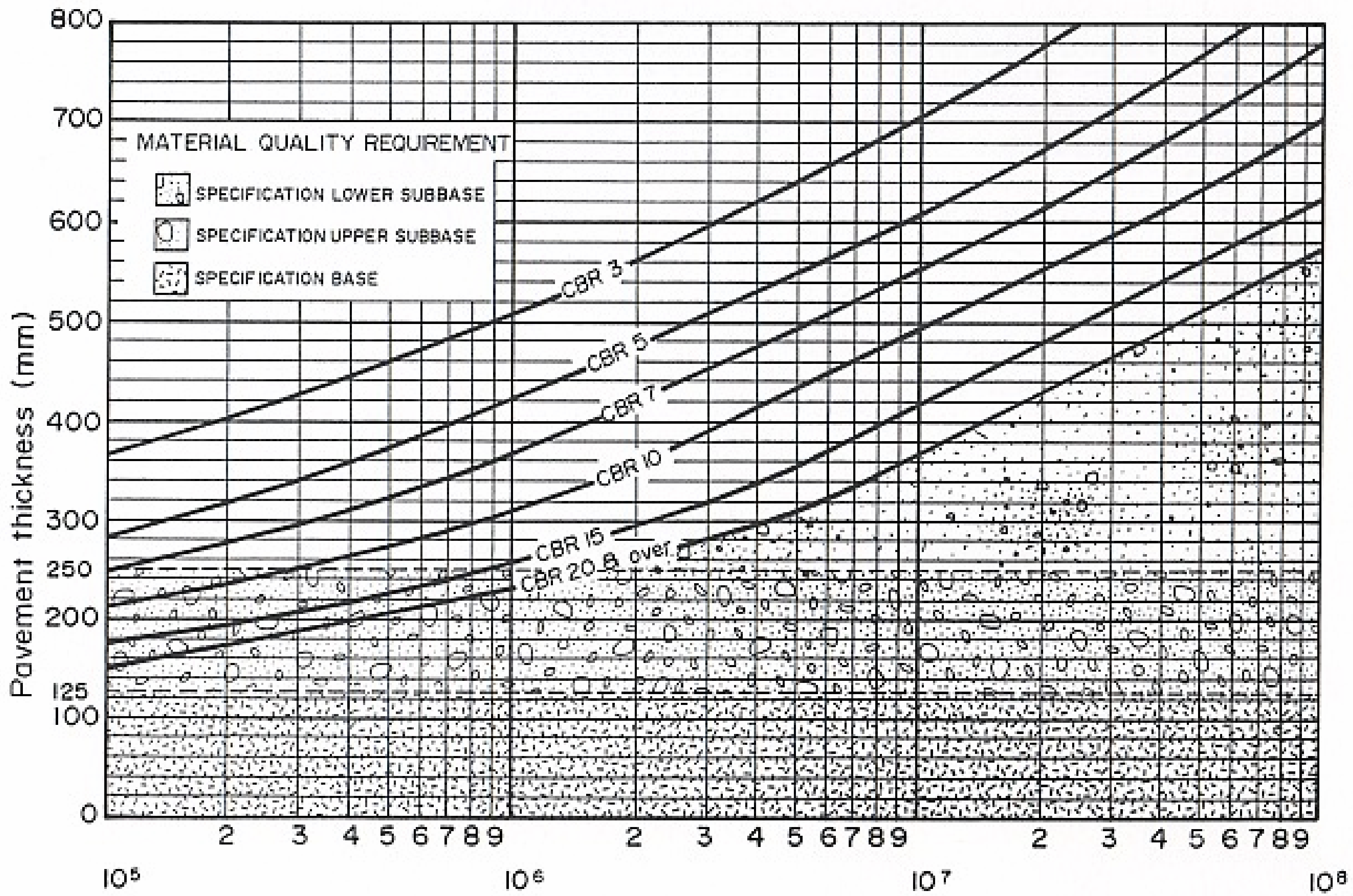

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FIGURE 6

PAVEMENT THICKNESS DESIGN CURVES FOR URBAN AND NON URBAN MAJOR ROADS

Pine Rivers Shire Council
Road Pavement Design
Derived from ARRB Special Report No. 41

APPENDIX C

ESTIMATION OF LABORATORY CBR

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ESTIMATION OF LABORATORY CBR FROM SOIL CLASSIFICATION TESTS

The Country Roads Board of Victoria formulated a method for estimating the laboratory CBR from soil classification tests (for fine grained soils). This method has been incorporated in this manual on a trial basis to determine if estimated laboratory CBRs based on soil classification tests can be related to laboratory soaked CBRs for subgrade soils encountered within the Pine Rivers Shire. It is envisaged that a data base of laboratory classification tests, estimated laboratory CBRs and soaked CBRs will eventually be produced, and this may lead to a reduction in the number of soaked CBRs required in evaluating subgrade materials. The soil classification tests required are Particle Size Distribution, Liquid Limit, Plastic Limit and Linear Shrinkage.

Having performed the soil classification tests, the lab-estimated CBR is calculated from the following equation:-

(i) Obtain a first estimate of CBR using the expression:-

Log_{10} CBR	=	0.51765	-	(0.005056	x	% passing 425 µm)	+ Table C1
				(0.001855	x	% passing 75 µm)	+ Table C2
		0.35	-	(0.01676	x	Linear Shrinkage %)	+ Table C3
		0.80	-	(0.000385	x	Linear Shrinkage % x % passing 75µm)	+ TableC4

Tables C1 to C5 may be used to solve this equation. The values from Tables C1, C2, C3 and C4 are added and the sum is used to obtain the CBR from Table C5.

(ii) Obtain a second estimate of CBR using the expression:-

Log_{10} CBR	=	0.486	-	(0.003717	x	% passing 2.36 mm)	+ Table C6
		0.5	-	(0.004495	x	% passing 425 µm)	+ Table C7
				0.005153	x	$\left[\dfrac{\text{\% passing 75 µm x 100}}{\text{\% passing 425 µm}}\right]^2$	- Table C8
				0.000045	x	$\left[\dfrac{\text{\% passing 75 µm x 100}}{\text{\% passing 425 µm}}\right]$	+
		0.9	-	0.01429	x	(Plasticity Index)	Table C9

Tables C6 to C10 may be used to solve this equation. The values from Tables C6, C7, C8 and C9 are added and the sum is used to obtain the CBR from Table C10

Lab-estimated CBRs greater than 5% are reported to the nearest whole number, lower values are reported to the nearest 0.5.

EXPLANATION OF THE USE OF THE TABLES

These tables have been derived from multiple regression analysis of a large number of test results.

The estimated CBR value used for design purposes is a weighted average of the estimates obtained from the two methods.

SAMPLE - Silty Clay Loam

EXAMPLE 1 (USING LINEAR SHRINKAGE AND GRADING RESULTS)

In Example 1 the logarithm of the California Bearing Ration is derived from the percentages passing the 425mm and 75mm sieves and the linear shrinkage.

* Pass 425µm sieve	= 86%	value from table C1	=	83
* Pass 75µm sieve	= 80%	value from table C2	=	148
* Linear shrinkage	= 6.6%	value from table C3	=	240
* Linear shrinkage x Pass 75µm - (6.6 x 80)	= 528	value from table C4	=	597
		TOTAL		1068
Interpolated value of C.B.R from Table C5			=	12

EXAMPLE 2 (USING PLASTICITY INDEX AND GRADING RESULTS)

In Example 2 the logarithm of the California Bearing Ratio is derived from the percentages passing the 2.38mm, 425mm and 75mm sieves and the plasticity index.

❖ Pass 2.38µm sieve	= 97%	value from table C6	=	125
❖ Pass 425µmm sieve	= 86%	value from table C7	=	113
❖ Pass 75µm sieve	= 80%			
❖ $\frac{80}{86} \times 100$	= 93%	value from table C8	=	85
❖ Plasticity Index	= 17	value from table C9	=	657
		TOTAL		980

Interpolated value of C.B.R from table C10 = 9.6

From the two values one estimate of C.B.R is arrived at giving greater weight (3 times) to the lower value.

Thus :- $\frac{(3 \times 9.6) + (1 \times 12)}{4} = \frac{40.8}{4} = 10.2$

The estimated C.B.R used then is 10

(Values of C.B.R greater than 5 percent are reported to the nearest whole number)

TABLE C 1

Values of (0.51765 - (0.00506 x % Pass. 425 µm)) x 10^3

% Pass. 425 µm	0	1	2	3	4	5	6	7	8	9
0	518	513	508	502	497	492	487	482	477	472
10	467	462	457	452	447	442	437	432	427	422
20	417	411	406	401	396	391	386	381	376	371
30	366	361	356	351	346	341	336	331	326	320
40	315	310	305	300	295	290	285	280	275	270
50	265	260	255	250	245	240	234	229	224	219
60	214	209	204	199	194	189	184	179	174	169
70	164	159	154	149	143	138	133	128	123	118
80	113	108	103	98	93	88	83	78	73	68
90	63	58	52	47	42	37	32	27	22	17

Example 80 + 6 = 86%

Therefore Value = 83

TABLE C 2

Values of (0.00185 x % Pass. 75 µm) x 10^3

% Pass. 75 µm	0	1	2	3	4	5	6	7	8	9
0	0	2	4	6	7	9	11	13	15	17
10	19	20	22	24	26	28	30	32	33	35
20	37	39	41	43	45	46	48	50	52	54
30	56	58	59	61	63	65	67	69	70	72
40	74	76	78	80	82	83	85	87	89	91
50	93	95	96	98	100	102	104	106	108	109
60	111	113	115	117	119	121	122	124	126	128
70	130	132	134	135	137	139	141	143	145	147
80	148	150	152	154	156	158	160	161	163	165
90	167	169	171	173	174	176	178	180	182	184

TABLE C 3

Values of (0.35 - (0.01676 x Linear Shrinkage %)) x 10^3

L.S.	0	1	2	3	4	5	6	7	8	9
0	350	333	316	300	283	266	249	233	216	199
10	182	166	149	132	115	99	82	65	48	32

Difference for half per cent. L.S. = 8 units.

TABLE C 4

Values of (0.80 - 0.000385 x (Linear Shrinkage % x % Pass. 75 µm)) x 10^3

L.S. % x % Pass. 75 µm	0	10	20	30	40	50	60	70	80	90
0	800	796	792	788	785	781	777	773	769	765
100	762	758	754	750	746	742	738	735	731	727
200	723	719	715	712	708	704	700	696	692	688
300	685	681	677	673	669	665	661	658	654	650
400	646	642	638	635	631	627	623	619	615	611
500	608	604	600	596	592	588	585	581	577	573
600	569	565	561	558	554	550	546	542	538	535
700	531	527	523	519	515	511	508	504	500	496
800	492	488	484	481	477	473	469	465	461	458
900	454	450	446	442	438	434	431	427	423	419
1000	415	411	408	404	400	396	392	388	384	381
1100	377	373	369	365	361	358	354	350	346	342
1200	338	334	331	327	323	319	315	311	307	304
1300	300	296	292	288	284	281	277	273	269	265
1400	261	257	254	250	246	242	238	234	231	227
1500	223	219	215	211	207	204	200	196	192	188
1600	184	181	177	173	169	165	161	157	154	150
1700	146	142	138	134	131	127	123	119	115	111
1800	107	104	100	96	92	88	84	80	77	73
1900	69	65	61	57	54	50	46	42	38	35

TABLE C 5

Value of CBR equivalent to calculated values of (Log CBR) x 10^3

(Log_{10} CBR) x 10^3	0	100	200	300	400	500	600	700	800	900
0	1	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9
1000	10	13	16	20	25	32	40	50	63	79

For convenience in the Tables C1 - C5, all values have been multiplied by 1,000.

The values from Tables C1 and C4 are added and the sum is used to obtain the CBR from Table C5.

TABLE C 6

Values of (0.486 - (0.003717 x % Pass. 2.36 mm)) x 10^3

% Pass. 2.36 mm	0	1	2	3	4	5	6	7	8	9
0	486	482	479	475	471	467	464	460	456	453
10	449	445	441	438	434	430	427	423	419	415
20	412	408	404	401	397	393	389	386	382	378
30	374	371	367	363	360	356	352	348	345	341
40	337	334	330	326	322	319	315	311	308	304
50	300	296	293	289	285	282	278	274	270	267
60	263	259	256	252	248	244	241	237	233	230
70	226	222	218	215	211	207	204	200	196	192
80	189	185	181	177	174	170	166	163	159	155
90	151	148	144	140	137	133	129	125	122	118

TABLE C 7

Values of (0.5 - (0.004495 x % Pass. 425 µm)) x 10^3

% Pass. 425 µm	0	1	2	3	4	5	6	7	8	9
0	500	496	491	487	482	478	473	469	464	460
10	455	451	446	442	437	433	428	424	419	415
20	410	406	401	397	392	388	383	379	374	370
30	365	361	356	352	347	343	338	334	329	325
40	320	316	311	307	302	298	293	289	284	280
50	275	271	266	262	257	253	248	244	239	235
60	230	226	221	217	212	208	203	199	194	190
70	185	181	176	172	167	163	158	154	149	145
80	140	136	131	127	122	118	113	109	104	100
90	95	91	86	82	77	73	68	64	59	55

TABLE C 8

$$\text{Values of } 0.005133 \times \left[\frac{\text{Pass. 75 µm} \times 100}{\text{\% Pass. 425 µm}}\right] - 0.000045 \times \left[\frac{\text{\% Pass. 75 µm}}{\text{\% Pass. 425 µm}}\right]^2 \times 10^3$$

% Pass 75µm x 100 / % Pass 425µm	0	1	2	3	4	5	6	7	8	9
0	0	5	10	15	20	25	29	34	38	43
10	47	51	55	59	63	67	71	74	78	81
20	85	88	91	94	97	100	103	106	109	111
30	114	116	118	120	122	124	126	128	130	132
40	133	135	136	137	138	139	140	141	142	143
50	144	144	145	145	145	146	146	146	145	145
60	145	145	144	144	143	142	141	140	139	138
70	137	136	135	133	132	130	128	126	124	122
80	120	118	116	113	111	108	106	103	100	97
90	94	91	88	85	81	78	74	71	67	63

TABLE C 9

Values of (0.9 - (0.01429 x Plasticity Index)) x 10^3

Plasticity Index	0	1	2	3	4	5	6	7	8	9
0	900	886	871	857	843	829	814	800	786	771
10	757	743	729	714	700	686	671	657	643	628
20	614	600	586	571	557	543	528	514	500	486
30	471	457	443	428	414	400	386	371	357	343
40	328	314	300	286	271	257	243	228	214	200
50	186	171	157	143	128	114	100	85	71	57

TABLE C 10

Values of CBR equivalent to calculated value of (Log. CBR) x 10^3

(LogCBR) x 10^3	0	100	200	300	400	500	600	700	800	900
0	1	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9
1000	10	13	16	20	25	32	40	50	63	79

For convenience in the Tables C6 - C10, all values have been multiplied by 1,000.

The values from Tables C6 - C10 are added and the sum is used to obtain the CBR from Table C10.

APPENDIX D

SUMMARY OF UNBOUND PAVEMENT MATERIALS

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Testing for compliance shall be carried out in accordance with Department of Main Roads specification MRS 11.05 - Unbound Pavements as follows:-

PAVEMENT TERMINOLOGY

PAVEMENT LAYER	BASE COURSE	SUBBASE COURSE	SELECTED FILL
Material Type	Type 2.1	Type 2.3	Type 2.5
CBR (minimum)	80	45	15
Minimum compaction requirement (Modified)	98	95	95

TEST FREQUENCIES

- 4 day soaked CBR - 1 per 10,000m^3
- Particle size distribution and fine quality (plasticity limits) - 1 per 500m^3

TEST METHODS

- Q101 Sample Preparation
- Q103A Particle Size Distribution
- Q104A Liquid Limit
- Q105 Plastic Limit and Plasticity Index
- Q106 Linear Shrinkage
- Q113A California Bearing Ratio

COMPACTION CONTROL TESTING

Compaction control testing shall be carried out in accordance with the methods set out in the current Australian Standard - AS1289 “Methods of Testing Soils for Engineering Purposes.”