National AustStab Guidelines

Pavement design guide for a cement stabilised base layer for light traffic

[Version B – 31 July 2012]

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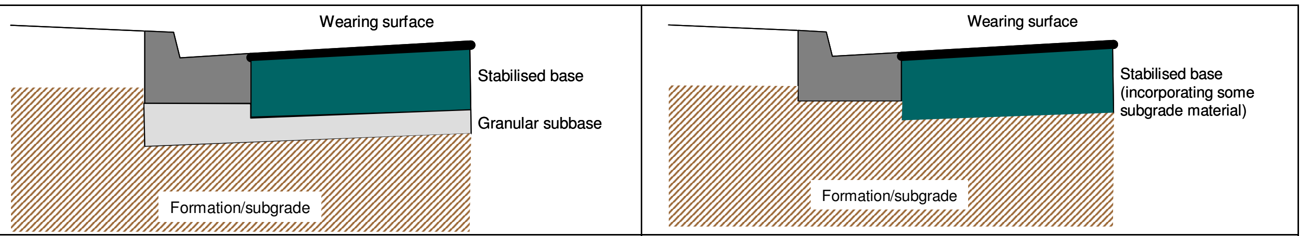
1 Introduction

The purpose of this guideline is to provide the design thickness of stabilised local roads using an empirical approach. The thickness of the stabilised layer is based on experience from a range of local government practices in Australia and includes the material mix design procedure.

All cementitious binders may be used with these design tables. For more information about Australian cementitious binders refer to the AustStab guideline titled *Australian binders used for road stabilisation* (AustStab, 2006).

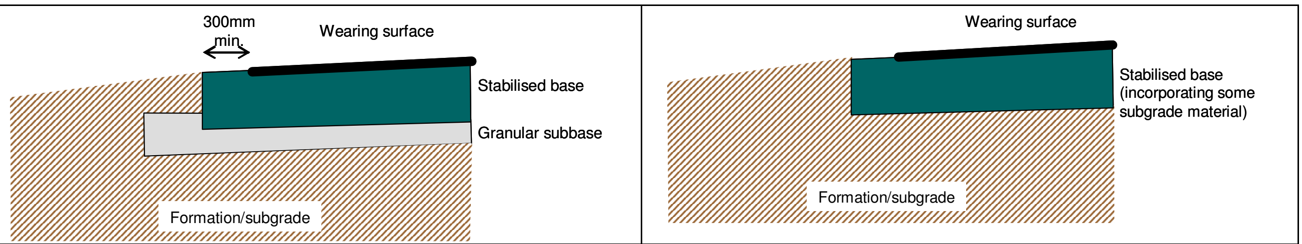
Figures 1 and 2 show the typical configurations of insitu stabilised base layers of local roads. When the existing road has less than the required pavement material, up to 30% of the subgrade material has been used in projects to get sufficient mixing depth and strength.



(a) Both base and subbase materials are used to stabilise the road.

(b) Up to 30% of the subgrade could be used to stabilise a thin existing road.

Figure 1 Typical configurations in urban streets with kerb and gutter.



(a) Both base and subbase materials are used to stabilise the road.

(b) Up to 30% of the subgrade could be used to stabilise a thin existing road.

Figure 2 Typical configurations in rural roads without kerb and gutter.

This guideline does not apply to roads where the design traffic exceeds 10^6 DESAs or when the stabilised layer becomes a subbase.

Refer to the AustStab guideline on common stabilisation definitions (AustStab, 1996).

2 Design procedure

The design procedure described in this guideline is summarised in the flowchart below (see Figure 3).

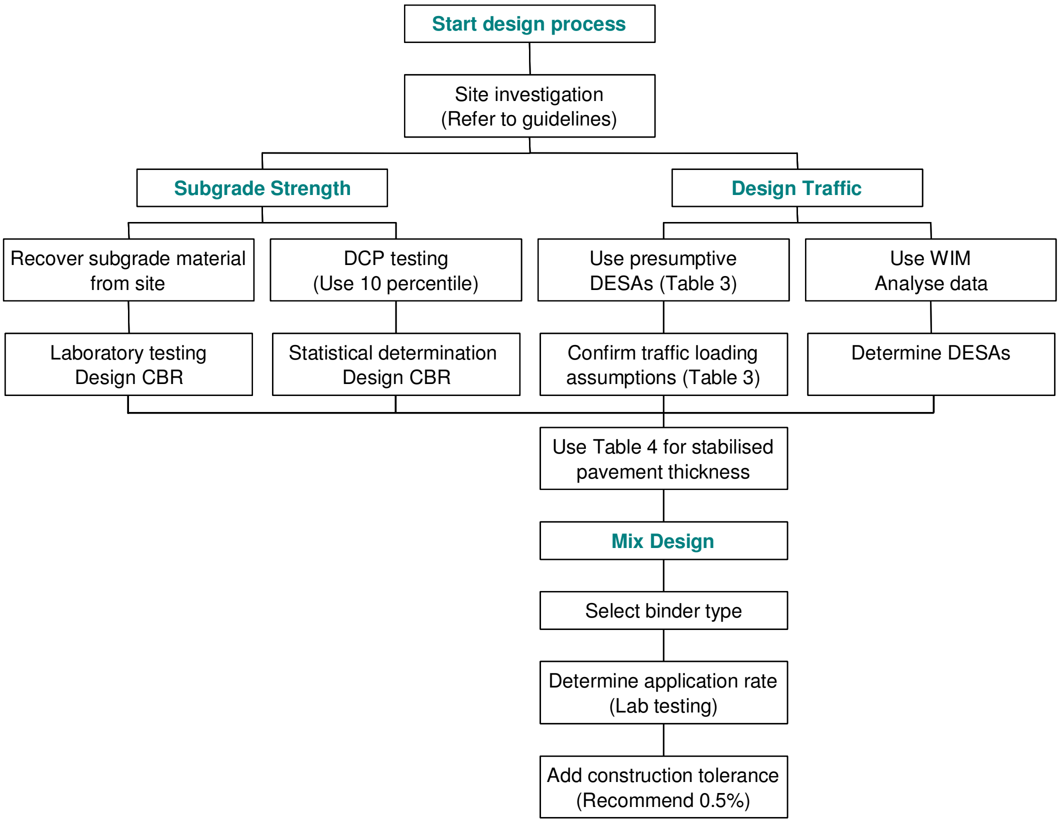


Figure 3 Design procedure for stabilised base for local roads.
(Refer to site investigation guideline (AustStab, 1999a))

3 Material mix design

Material mix design procedures are detailed in Part 4d of the Austroads Pavement Technology series (Austroads, 2006). As a starting point, material properties including particle size distribution and Atterberg limits are minimum requirements to understand the pavement material. Table 1 can be used as a guide to assist practitioners with the preliminary binder selection.

The thickness of the stabilised layer is based on a cemented material tested in the laboratory to meet the unconfined compressive strength range (UCS) of 1 to 2 MPa, prepared and tested to the following conditions:

- Sample size - 115.5 x 105 mm diameter cylinder
- Compaction at 100% standard or 98% modified
- 7-day curing at a 90% or more humidity and 23°C and precondition sample prior to testing with 4-hour soak (applicable for GP & GB cements)
- 7-day curing at 65°C and precondition sample prior to testing with 4-hour soak (applicable for slow setting cementitious binders, for example lime/slag and lime/fly ash blends)
- UCS testing to AS1141.51

If there is no experience with using cementitious binders in your region, the following starting application rates (by mass[1]) may be used for the laboratory test program:

- 1 to 3% for reasonably graded crushed rock
- 2 to 4% for reasonably graded sandy, clayey gravels
- 3 to 5% for poorly graded sandy, clayey gravels

[1] It is common to use the dry mass of the pavement material. Do not specify application rates by volume of material.

Table 1 A simple guide to selecting a binder for road stabilisation.

Particle Size	MORE THAN 25% PASSING 0.425mm			LESS THAN 25% PASSING 0.425mm		
Plasticity Index	PI ≤ 10	10 < PI <20	PI ≥ 20	PI ≤ 6 WPI ≤ 60	PI ≤ 10	PI > 10
Binder Type						
Cement and Cementitious Blends*	Usually suitable	Doubtful or Supplementary binder required	Usually not Suitable	Usually suitable	Usually suitable	Usually suitable
Lime	Doubtful or Supplementary binder required	Usually suitable	Usually suitable	Usually not Suitable	Doubtful or Supplementary binder required	Usually suitable
Bitumen	Doubtful or Supplementary binder required	Doubtful or Supplementary binder required	Usually not Suitable	Usually suitable	Usually suitable	Usually not Suitable
Bitumen/ Cement Blends	Usually suitable	Doubtful or Supplementary binder required	Usually not Suitable	Usually suitable	Usually suitable	Doubtful or Supplementary binder required
Granular	Usually suitable	Usually not Suitable	Usually not Suitable	Usually suitable	Usually suitable	Doubtful or Supplementary binder required
Polymers	Usually suitable	Usually suitable	Usually not Suitable	Usually suitable	Usually suitable	Usually not Suitable
Miscellaneous Chemicals**	Usually not Suitable	Usually suitable	Usually suitable	Usually not Suitable	Doubtful or Supplementary binder required	Usually suitable

Key: Usually suitable (solid black) | Doubtful or Supplementary binder required (vertical stripes) | Usually not Suitable (white)

NOTES:

* The use of some chemical binders as a supplementary addition can extend the effectiveness of cementitious binders in finer soils and higher plasticities

** Should be taken as a broad guideline only. Refer to trade literature for further information.

The above binders may be used in combinations or as part of staged construction viz:

(a) Bitumen and lime combined is commonly used as a binder for manufacture of bound pavement materials

(b) Lime stabilisation may be adopted to dry out materials and reduce their plasticity prior to applying other binders.

Once the laboratory value has been determined, it is common to add 0.5% to the application rate to allow for construction tolerances and the varying density of the pavement material.

4 Design subgrade strength

The design CBR is determined by using either the Dynamic Cone Penetration (DCP) or laboratory test results of a representative sample of the subgrade. For both approaches the designer should subdivide the project into sections which are deemed to be homogeneous with respect to subgrade type, topography and drainage, and a design subgrade CBR is determined (separately) for each of these sections.

When using the DCP approach to establish the design CBR, the following should be taken into consideration:

- A minimum number of 10 tests are required
- Attempt to have uniform spacing of the test sites
- Determine the Field Moisture Content (FMC) of the subgrade material at the time of testing
- Conduct tests in the outer wheelpath

Alternatively, when using the laboratory approach, the following should be taken into consideration:

- A minimum of three representative samples (and where applicable the average of the three results)
- Testing conditions as detailed in Table 2
- Samples compacted to 100% standard compaction with 4.5kg surcharge loading
- The design CBR is the mean of pairs

Table 2 Typical laboratory moisture conditions for CBR testing (Austroads, 2004a).

Median Annual Rainfall (mm)	Design Moisture Content	Testing Condition	
		Excellent to Good Drainage	Fair to Poor Drainage
<500	OMC	unsoaked to 4 day soak	1 to 4 day soak
500–800	OMC	unsoaked to 4 day soak	4 to 7 day soak
>800	1 to 1.15 x OMC	unsoaked to 4 day soak	4 to 10 day soak

5 Design traffic

The design traffic has been based on the Austroads classification of local roads as shown in Figure 4 and Table 3.

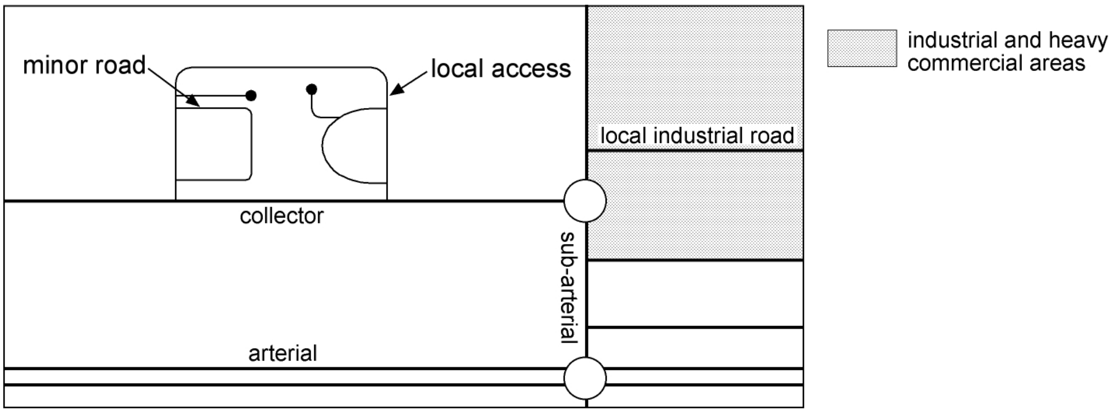


Figure 4 Lightly-trafficked street categories to be used with Tables 3 and 4 (Austroads, 2006b).

6 Pavement thickness

Table 4 may be used to determine the thickness of the stabilised base layer for different street types[2] with a separate wearing course consisting of a sprayed seal[3] and/or thin asphalt layer up to 40 mm in thickness. The design thickness in Table 4 includes an allowance for a construction tolerance of -10 mm to +20 mm. No further thickness increase for construction tolerances should be applied.

For roads within car park areas where delivery vehicles are likely to travel, use thicknesses for street types F to H.

[2] Each street type has an indicative design traffic (IDT) for either a 20 or 40 year design period.
[3] For stabilised base layers with cementitious binders, the use of bituminous seals has been highly successful. However, in certain circumstances the use of PMB seals or geotextile seals may provide greater flexibility in the wearing course.

Table 3 Indicative traffic levels for different street types (Austroads, 2006b).
Note: Direction Factor (DF) is 0.5, except for Minor Street with single lane traffic where DF= 1.0

Street type	Indicative Design Traffic (DESA)	Design period (years)	AADT two-way	Heavy vehicles (%)	Design AADHV (single lane)	Annual growth rate (%)	Cumulative Growth Factor (Table 7.4)	Axle groups per heavy vehicle	Cumulative HVAG over design period	ESA/HVAG
Minor with single lane traffic	3 x 10^3	20	30	3	0.9	0	20	2.0	13,140	0.2
	5 x 10^3	40				0	40	2.0	26,280	0.2
Minor with two lane traffic	4 x 10^3	20	90	3	1.35	0	20	2.0	19,710	0.2
	8 x 10^3	40				0	40	2.0	39,420	0.2
Local access with no buses	4 x 10^4	20	400	4	8	1	22.0	2.1	128,480	0.3
	9 x 10^4	40				1	48.9	2.1	285,576	0.3
Local access with buses	8 x 10^4	20	500	6	15	1	22.0	2.1	240,900	0.3
	1.5 x 10^5	40				1	48.9	2.1	535,455	0.3
Local access in industrial area	1.5 x 10^5	20	400	8	16	1	22.0	2.3	256,960	0.4
	3 x 10^5	40				1	48.9	2.3	571,152	0.4
Collector with no buses	4 x 10^5	20	1200	6	36	1.5	23.1	2.2	607,068	0.6
	10^6	40				1.5	54.3	2.2	1,427,004	0.6
Collector with buses	8 x 10^5	20	2000	7	70	1.5	23.1	2.2	1,180,410	0.6
	2 x 10^6	40				1.5	54.3	2.2	2,774,730	0.6

Table 4 Cemented base layer thickness (mm) for different subgrade strengths and traffic levels with a thin bituminous or asphalt surfacing.

Street Type[1]	IDT[2] (DESAs)	Cemented base layer thickness (mm)[5] Design subgrade strength (CBR)				
		< 3%	3% - 5%	6% - 10%	11% - 15%	> 15%
A. Minor with single lane traffic	3 x 10^3	200	*175*	*150*	*150*	*150*
B. Minor with two lane traffic	4 x 10^3	200	*175*	*150*	*150*	*150*
C. Car park with no delivery vehicles	8 x 10^3	225	200	*175*	*150*	*150*
D. Local access with no buses	4 x 10^4	225	200	*175*	*150*	*150*
E. Local access with buses	8 x 10^4	250	225	200	*175*	*175*
F. Local access in industrial area	1.5 x 10^5	**275**[3]	250[4]	225	200	*175*
G. Collector with no buses	4 x 10^5	**300**[3]	275[4]	250	225	200
H. Collector with buses	8 x 10^5	**325**[3]	300[4]	275	250	225

Notes:
1. Street type as defined in Austroads pavement design guide and shown in Figure 4.
2. Indicative design traffic in DESAs based on work by Austroads and shown in Table 3.
3. In the dark shaded region it is recommended to stabilise the subgrade. Refer section 7.
4. In the light shaded region it is suggested to stabilise the subgrade. Refer section 7.
5. In some regions of Australia the minimum thickness is 200 mm (values in italics).

7 Lime stabilised subgrades

The possible applications of lime stabilisation of subgrades are to:

- increase subgrade stiffness
- reduce the PI of insitu pavement material
- enhance volumetric stability
- modify subbase layers to improve stiffness of the pavement

An increase in subgrade stiffness will reduce the thickness of base layers and require less material from quarries. Also, when road usage changes (ie an increase in heavy traffic) a pavement material may subsequently show signs of distress leading to the need to rehabilitate the road.

Rather than reducing the design life of the treatment through thin granular pavements it is recommended that lime stabilisation will allow the full use of the existing granular pavement without the need to place an overlay material and hence, change the inlets to drainage structures.

The design of pavements with lime stabilisation of the subgrade is covered in the lime stabilisation technical note (AustStab, 2006b).

Figure 5 shows a diagrammatic solution for subgrade stabilisation of existing roads with existing kerb and gutter. A similar approach can be used when no kerb and gutter exists. Subsurface drainage is not shown in these figures and should be considered in pavements subject to wet conditions.

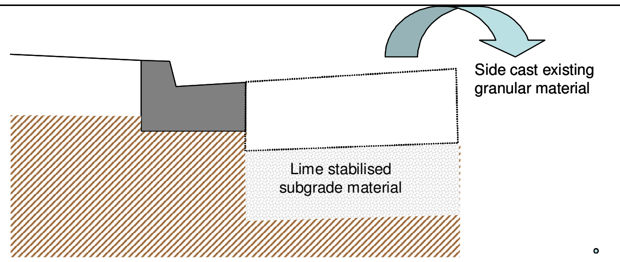
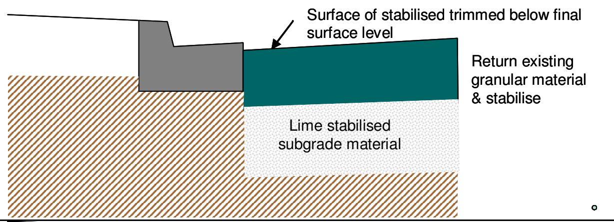
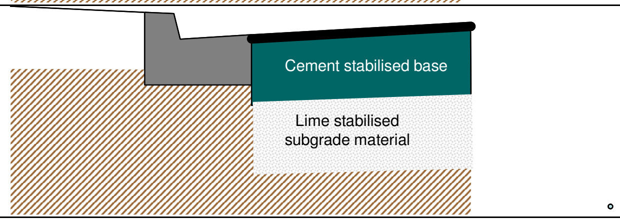
<table>
<tr><td>
</td><td>A. Existing pavement material is side cast to expose top of subgrade. Depth of side cast material to include design depth of basecourse stabilisation, an allowance for bulking due to volumetric change and an allowance for final wearing course thickness. Total bulking & wearing course thickness to be disposed.
Lime is spread at specified rate and mixed to specified depth. After compaction the side cast granular material is returned and lightly compacted.
Note: All services should be identified before construction work commences, and any service that needs to be lowered should be carried out before side casting.</td></tr>
<tr><td>
</td><td>B. Cementitious binder is spread at specified rate and mixed to specified depth. Surface is trimmed below the lip of the gutter to allow surface treatment to be constructed after initial curing of pavement material.</td></tr>
<tr><td>
</td><td>C. Construction of final wearing surface. Where a thin asphalt layer is to be the wearing course, it is recommended that a SAMI seal is used prior to placing the asphalt.</td></tr>
</table>

Figure 5 Subgrade stabilisation with existing kerb and gutter.

8 Design example

A local access road with bus traffic in a large rural regional centre is to be rehabilitated using insitu stabilisation. The typical wearing surface for this road type is 30 mm of dense graded asphalt between kerb and gutters, with a strain alleviating membrane interlayer (SAMI) applied to the surface of the stabilised layer.

The existing road has been investigated and after laboratory testing the design CBR is 8% and the existing granular base and subbase material is 250 mm.

The traffic consultant for the council has established that the design traffic is about 500 AADT and a 20 year life is sought for this treatment. The other traffic assumptions in Table 3 are consistent with this access road. Therefore, the design traffic is 8 x 10^4 DESAs.

In summary the design inputs are:

Subgrade strength	8%
Design traffic	8 x 10^4 DESAs

Using Table 4, the stabilised layer thickness is 200 mm. Figure 6 summarises the pavement cross-section.

Pavement material sampled from the project site indicated the following material properties:

Plasticity Index:	10%
% Passing 0.425mm Sieve	32%
Maximum dry density	1.8 t/m^3

The pavement engineer has therefore chosen a General Blended[4] cement for the trial UCS testing. Laboratory testing with a GB cement has indicated that the UCS strength testing after 7-day standard curing temperatures is 1.5 and 3.2 MPa for binder application rates of 3 and 4% respectively. Therefore, the pavement engineer has chosen an application rate of 3.5%[5] which is specified as a spread rate of 12.6 kg/m^2.

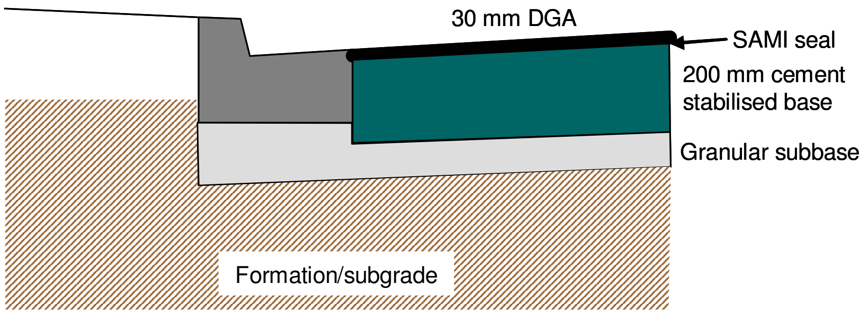


Figure 6 Summary of the design example.

9 References

Australian Standards (1996) AS1141.51 *Methods for sampling and testing aggregates - Unconfined compressive strength of compacted materials* Standards Australia, Sydney, NSW.

Austroads (2004a) *Pavement Design: A Guide to the Structural Design of Road Pavements* Sydney, NSW, Australia.

Austroads (2004b) *Pavement Rehabilitation: A Guide to the Design of Rehabilitation Treatments for Road Pavements* Sydney, NSW, Australia.

Austroads (2006a) *Guide to Pavement Technology Part 4(d): Stabilised Materials* Austroads Project No: TP1089, Sydney, NSW.

Austroads (2006b) *Guide to Pavement Technology Part 2: Pavement Structural Design* Austroads Project No: TP1159, Sydney, NSW.

AustStab (1996) *Terms* National AustStab Guidelines, Australian Stabilisation Industry Association, Chatswood, NSW.

AustStab (1999a) *Site investigations* National AustStab Guidelines, Australian Stabilisation Industry Association, Chatswood, NSW.

AustStab (1999b) *Model Specification for Insitu Stabilisation of Local Roads using Cementitious Binders* Australian Stabilisation Industry Association, Chatswood, NSW.

AustStab (2006) *Lime Stabilisation Practice* AustStab Technical Guideline, Australian Stabilisation Industry Association, Chatswood, NSW.

[4] A General Blended cement usually contains 60 to 80% of GP cement with fly ash or slag making up the balance.
[5] A 0.5% construction tolerance was added to the 3% selected from testing.

Cemented base layer thickness (mm) for different subgrade strengths
and traffic levels with a thin bituminous or asphalt surfacing.

Street Type[1]	**IDT**[2] **(DESAs)**	**Cemented base layer thickness (mm)**[5] **Design subgrade strength (CBR)**				
		< 3%	**3% - 5%**	**6% - 10%**	**11% - 15%**	**> 15%**
A. Minor with single lane traffic	3×10^3	200	*175*	*150*	*150*	*150*
B. Minor with two lane traffic	4×10^3	200	*175*	*150*	*150*	*150*
C. Car park with no delivery vehicles	8×10^3	225	200	*175*	*150*	*150*
D. Local access with no buses	4×10^4	225	200	*175*	*150*	*150*
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G. Collector with no buses	4×10^5	**300**[3]	275[4]	250	225	200
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3. In the dark shaded region it is recommended to stabilise the subgrade. Refer section 7.
4. In the light shaded region it is suggested to stabilise the subgrade. Refer section 7.
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