Engineers ■ Planners ■ Managers

Mechanistic Design of Pavements on Weak Subgrades

Bruce Chappell

Weak Subgrades CBR ≤ 3%

- Design Options
  - Stabilise subgrade
  - Undercut and place subgrade improvement layer (SIL)
  - Drain to improve layer strength (may take time)
  - Use geosynthetics to gain strength
  - Place a bound layer
  - Other options?
- How to mechanistically model option(s)

Mechanistic Modelling Issues

- How well can we compact any modification we do to the subgrade?
  - What is our effective depth of compaction?
- How well can we compact layers above this weak subgrade?
- Will the subgrade strength improve over time?
- What modulus values shall we use in our mechanistic model?

Austroads Pavement Design Guide

- Table 6.4(a) and (b)
  - Give maximum vertical modulus of top sub-layer of base aggregate
  - Table 6.4 (a) for 'normal' standard material
  - Table 6.4 (b) for 'high' standard material

Table 6.4(a) Suggested vertical modulus (MPa) of top sublayer of normal standard base material

Thickness of overlying material	Modulus of cover material* (MPa)				
	1000	2000	3000	4000	5000
40 mm	350	350	350	350	350
75 mm	350	350	340	320	310
100 mm	350	310	290	270	250
125 mm	320	270	240	220	200
150 mm	280	230	190	160	150
175 mm	250	190	150	150	150
200 mm	220	150	150	150	150
225 mm	180	150	150	150	150
≥250 mm	150	150	150	150	150

* Cover material is either asphalt or cemented material or a combination of these materials.

Table 6.4(b) Suggested vertical modulus (MPa) of top sublayer of high standard base material

Thickness of overlying material	Modulus of cover material* (MPa)				
	1000	2000	3000	4000	5000
40 mm	500	500	500	500	500
75 mm	500	500	480	460	440
100 mm	500	450	410	390	360
125 mm	450	390	350	310	280
150 mm	400	330	280	240	210
175 mm	360	270	210	210	210
200 mm	310	270	210	210	210
225 mm	260	210	210	210	210
≥250 mm	210	210	210	210	210

* Cover material is either asphalt or cemented material or a combination of these materials.

Austroads PDG continued

- Table 8.1(d)
  - Gives two sub-layering design equations to determine modulus increase above a subgrade
  - One for selected subgrade materials
  - One for granular materials

Selected subgrade materials

$$E_{V\ \text{selected subgrade top sublayer}} = E_{V\ \text{insitu subgrade}} \times 2^{(\text{total selected subgrade thickness}/150)} \quad (8.1)$$

$$R = \left[\frac{E_{V\ \text{selected subgrade top sublayer}}}{E_{\text{insitu subgrade}}}\right]^{\frac{1}{5}} \quad (8.2)$$

Granular materials

$$E_{V\ \text{top granular sublayer}} = E_{V\ \text{subgrade}} \times 2^{(\text{total granular thickness}/125)} \quad (8.3)$$

$$R = \left[\frac{E_{\text{top granular sublayer}}}{E_{\text{subgrade}}}\right]^{\frac{1}{5}} \quad (8.4)$$

Example 1 – Subgrade CBR 2%

- Subgrade CBR 2%, Ev=20 MPa say
- Lab test 3% lime gives CBR 20%, **Ev=200 MPa? I wish.**
- Stabilise 300 mm depth, use effective compaction to 250 mm. Model subgrade and stabilised layer.
- Equation (8.1) the top of improvement layer Ev = $20 \times 2^{(250/150)}$ = 20X3.2=64, **Ev=60 MPa? Yikes.**
- What Ev do we use?
- Depends on compaction achieved, degree of material binding, sub-layering in model.
- Suggest in this case **Ev = 60MPa & sublayered**

Example 2 – Subgrade CBR 3%

- Subgrade CBR 3%, Ev=30 MPa say
- Try geotextile separation, plus 300 mm unbound granular aggregate and 150 AC, E=2000 MPa
- Equation (8.3) modulus at top of the granular layer Ev = $30x2^{(300/125)}$ = 30x5.3 = 158, **Ev=160 MPa**
- Table 6.4(a) 'normal std' maximum **Ev=230 MPa?**
- Table 6.4(b) 'high std' maximum **Ev=330 MPa?**
- Suggest in this case **Ev = 160 MPa and sublayered** and ignore any improvement from geotextile

Thoughts

- Easy to over-estimate Ev values of layers
- Actual Ev dependent on
  - Ability to compact various layers
  - Degree of binding of materials when stabilising
  - Whether sub-layering is applied (it should be)
- Subgrade stabilisation may not realise the improvement predicted in laboratory tests
- Depth limitations on stabilisation (300 mm) and compaction equipment (250 mm effective)
- What may appear an economical solution may not be if expected parameters are not realised