CIRCLY – what modulus values for stress dependent materials?

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Continues to be an issue

- 2006 presented on modulus over weak subgrades
- Worth revisiting to try and get consistency in approach
- **Peer review work reveals a variety of interpretations**
- 2004 Austroads Guide and 2007 NZ Supplement are still NZTA current design documents.
- **Austroads Pavement Technology series not approved as the design standard by NZTA, no NZ Supplement, yet**.
- Typically issues arise with unbound or modified materials:
  - Under stiff layers
  - Over weak subgrades
- Not enough guidance on FBS layer design to limit stress

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Austroads 2004 – Design

- Table 6.4(a) and (b) reflect the stress dependency:
  - 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 8.1(d) reflects the possible strength gain for a layer:
  - Gives two sub-layering design equations to determine modulus increase above a subgrade
  - One for selected subgrade materials (subgrade improvement layer)
    - Modulus gain factor is 2 to the power of (thickness of layer / 150)
  - One for granular materials above subgrade, subgrade improvement layer or aggregate layers
    - Modulus gain factor is 2 to the power of (thickness of layer / 125)

Austroads 2004

- An example:
  - 150 mm asphalt (E = 2000 MPa)
  - 300 mm unbound granular AP40 subbase
  - CBR 3% subgrade

- Table 6.4 maximum E for subbase is 330 MPa (high std) or 230 MPa (normal standard), however ……..
- Table 8.1 modulus is 30 MPa to 160 MPa at top of subbase

- E value is often overestimated in these scenarios
- Another case is subbase under a 250 mm FBS layer, where Table 6.4 would allow maximum subbase E = 210 MPa

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Foamed Bitumen Stabilised Layers

- Do we check the modulus based on strength gain over the layer below? Check NZ Supplement …….
  - Phase 1, high E, ? value? Then reduces to Phase 2 steady state E.
  - No, it is often assumed to be E = 800 MPa, no sublayering.
- FBS design is not required to obey the Austroads unbound/modified rules, should it be classified as bound?
  - No, it also escapes tensile fatigue scrutiny, ductile behaviour.
  - BUT there must be a limit to what stress it can tolerate
- Question - Will it give the assumed modulus in service?
  - Only if the supporting structure enables compaction to be achieved.
  - Arnold suggests: Limit design stress to 40% of tensile stress at break in flexural beam testing, then it will maintain design E value in service.

Lessons

- We need to have a design methodology that is clear to young designers, currently it has many interpretations
- The methodology needs to flag limits on modulus gain, both due to stress dependency and gain above layers below
- More guidance on stress limits in foamed bitumen mechanistic design is required, either limiting tensile stress to less than 50% of rupture stress (give typical values), or limit strength gain above layers below based on Austroads
- FBS phase 2 strength needs confirmation after construction

Recommendations

- Check assumptions for layer modulus using Austroads stress dependency and strength gain rules.
- Need guidance to designers in the NZ Supplement for FBS:
  - Ratio of Phase 1 modulus to Phase 2 (assumed 800 MPa) modulus
  - Limits for tensile stress at base of FBS.
- Model expected deflections under known loads. Model an initial higher value for FBS layers (Phase 1 value) for immediate construction verification.
- Use deflection testing for layers in construction to verify the pavement modelled deflections have been achieved.
- For FBS have deflection testing verification after one year to check Phase 2 steady state designed stiffness is achieved.