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FWD Testing as a Quality Control Tool

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Introduction

- Falling Weight Deflectometer (FWD)
- Testing during construction (PSTS101)
- Development of benchmark criteria
- Methodology based on Foundation Surface Modulus (FSM)
- Case Study
- Limitations and Considerations

Heavy Duty Pavements in QLD

- DTMR recommends HILI pavements for roads that carry more than 1000 ESA's in the design lane at time of opening.
- HILI Pavements:
  - PCP, JRCP, CRCP
  - Flexible Composite
  - Deep Strength Asphalt
  - Full Depth Asphalt

Working Platform

- Requires working platform underneath HILI pavements:
  - Granular material stabilised with min. 2 % cement
  - 1 MPa < UCS < 2 MPa
  - Working platform properties specified in PSTS101 and Pavement Design Manual
- Contractor to analyse FWD data to determine general stiffness and identify sections for further testing

Working Platform

- No acceptance/benchmark criteria in PSTS101
- Problematic in contractual environment
- Assessment procedure:
  - Cleary defined benchmark criteria prior to construction
  - Unique solution and high repeatability
  - Minimum analysis and fast turnaround time
  - Consider impact of combined underlying layers

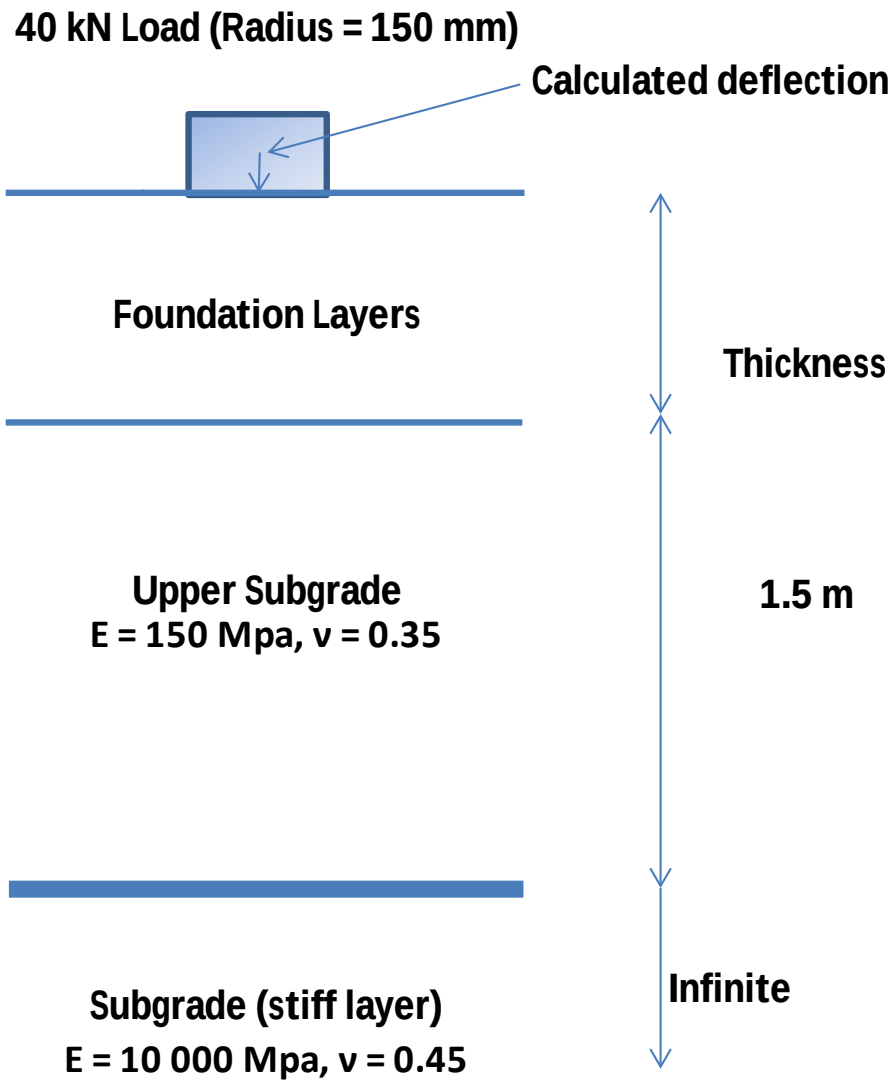
FWD Analysis

- Two ways to evaluate FWD data:
  - Deflection bowl parameters (max deflection, curvature, layer indices)
  - Backcalculation of layer stiffness
- Backcalculation not considered practical during construction:
  - Non-uniqueness of solutions
  - Requires specialised software
  - Requires experienced pavement engineers
- Deflection bowl parameters considered more appropriate:
  - High repeatability, measurable, low level of analysis

Recommended Approach

- Foundation Surface Modulus (FSM)
- Adopted by UK Highways in their performance specifications
- Composite value based on contribution of underlying layers i.e. max. deflection
- $E = \frac{2\times(1-\upsilon^2)\times R\times P}{D}$
- Determine theoretical FSM of design foundation model and compare to measured FSM during construction

Theoretical Model (Chaddock)



Recommended Approach

- The theoretical values should be adjusted to allow for field conditions (confinement effect of pavement, deterioration of cemented materials, future strength gain)
- IAN 73/06 recommends the following factors:
  - 0.8 for unbound materials (confinement effect)
  - 1.5 for fast-setting cemented materials (deterioration in-service)
  - 0.75 for slow-setting materials (future strength gain)
- Use factors in interim, requires further refinement for local conditions

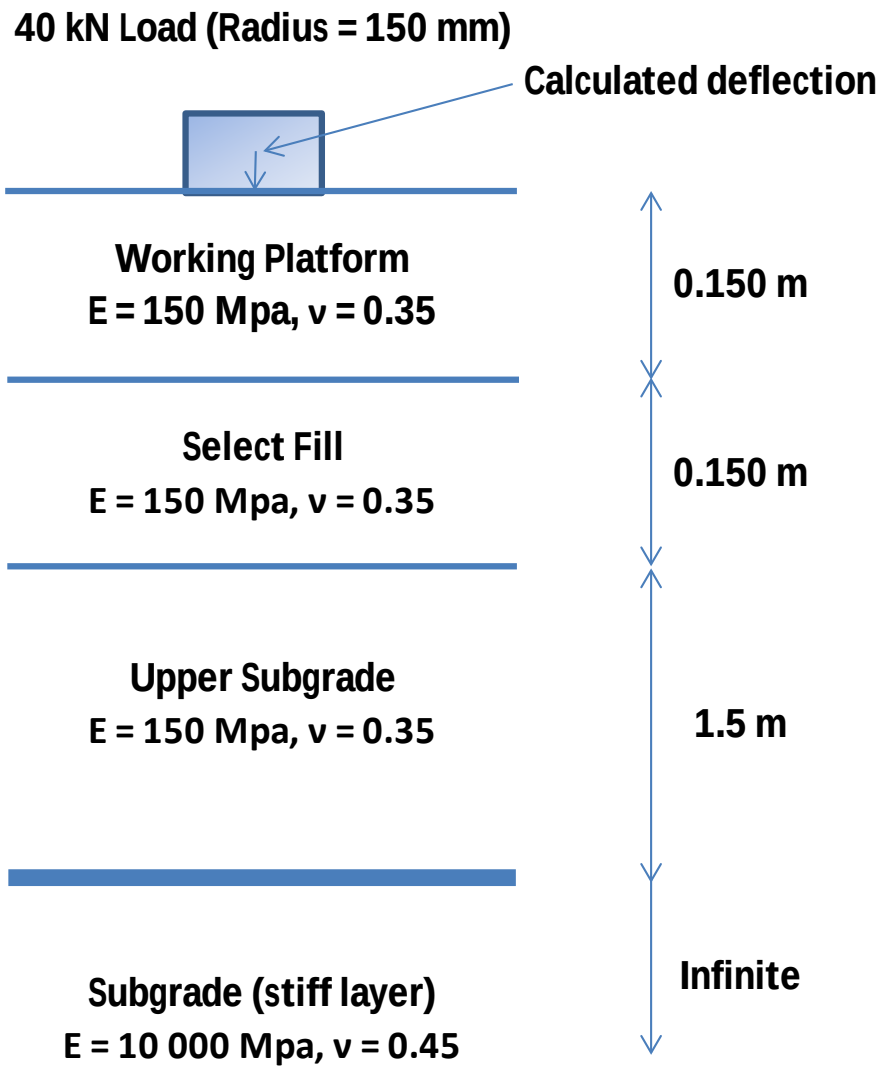
Benchmark Criteria

- Benchmark criteria = theoretical value x adjustment factor
- Compare measured FSM / deflections to benchmark criteria to identify potential problem areas
- Designer includes project specific criteria in Annexure to PSTS101

Case Study

- Upgrade of existing 2 lane highway to a 4 lane motorway west of Brisbane
- Heavy duty pavement:
  - 45 mm SMA
  - 45 mm Dense graded AC with PMB
  - 300 mm Dense graded AC with Class 600 binder
  - 150 mm Working platform (UCS = 1.5 MPa)
  - 150 mm Select Fill (CBR 45)
  - Subgrade (CBR 20)

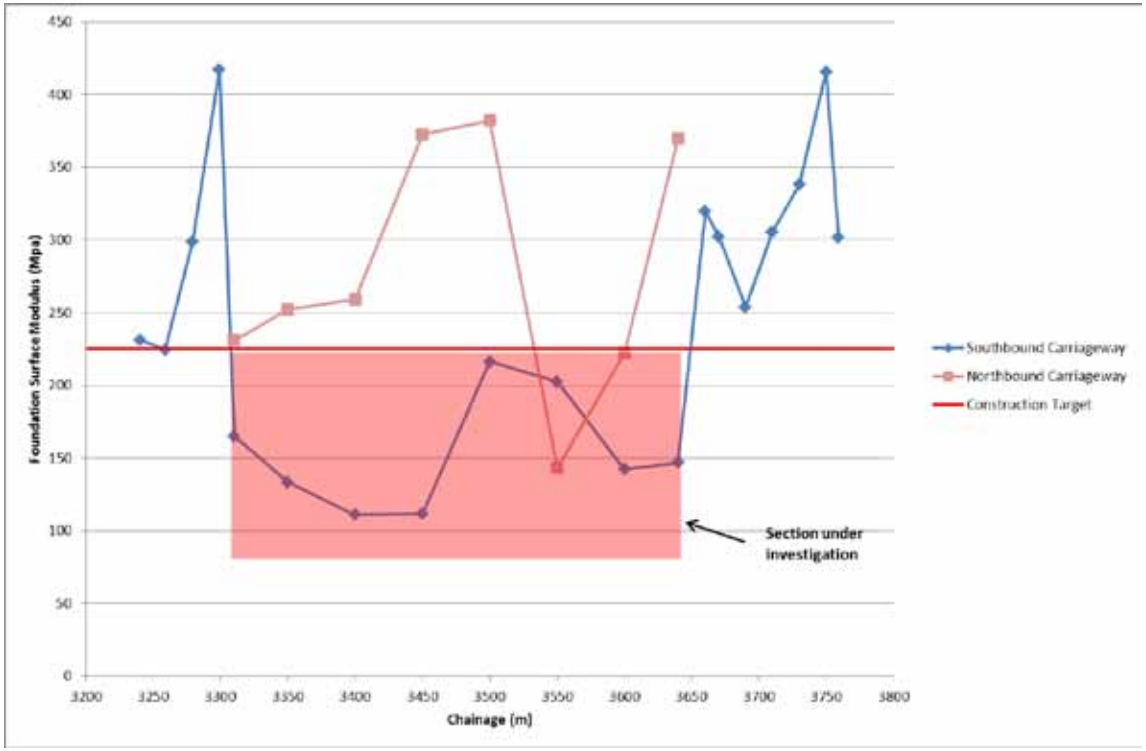
Theoretical Design Model



Benchmark Values

- Target FSM = 1.5 x 140 MPa = 210 MPa (225)
- Target deflection = 1074 µm / 1.5 = 716 µm

Measured FSM

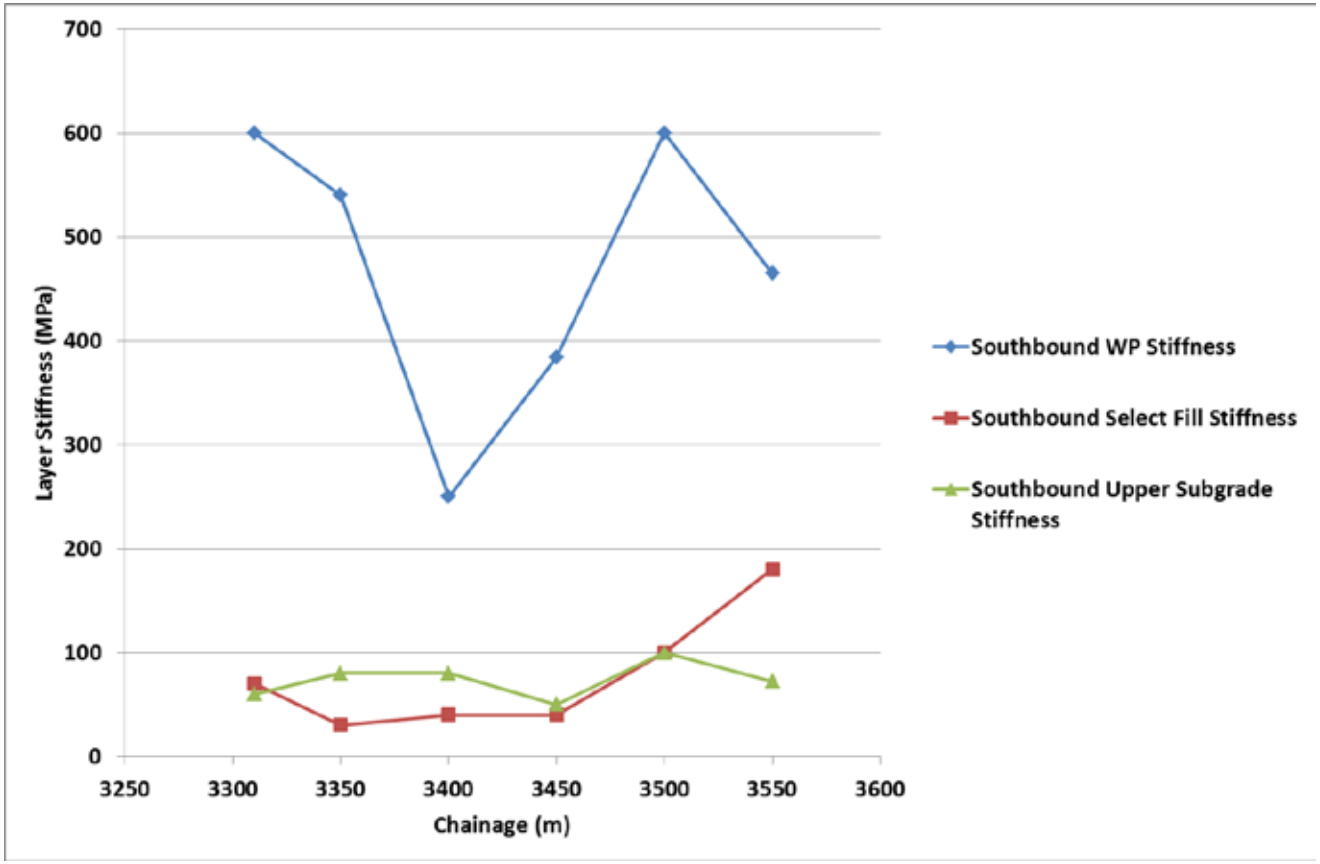


Measured Foundation Surface Modulus

Additional Investigations

- Additional investigations:
  - Backcalculation of layer stiffness
  - Dynamic Cone Penetrometer (DCP)
  - Test pits
  - Proof roll

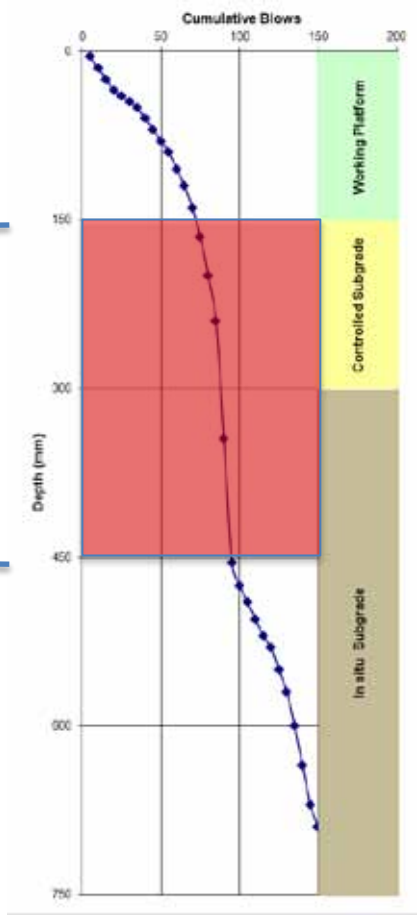
Backcalculation of Layer Stiffness



- Results indicated potential issues with underlying select fill and upper subgrade layers

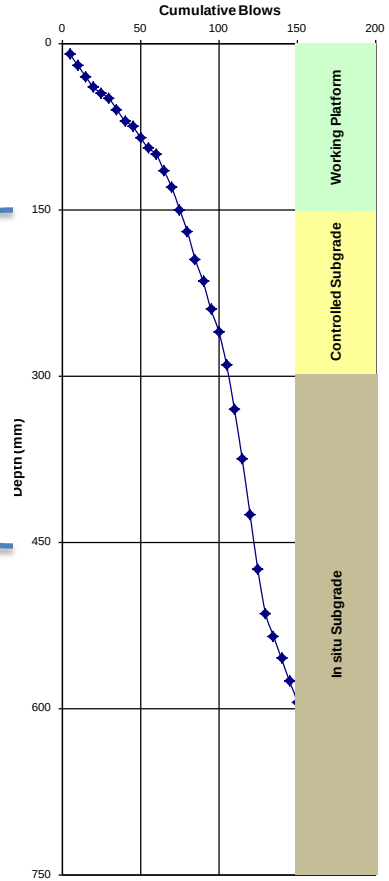
DCP Testing

12 mm/blow



FSM = 105 MPa

5 mm/blow



FSM = 215 MPa

Test Pits

- 2 test pits were excavated in the area that has been identified as having a lower FSM
- A high moisture content was observed in the select fill and upper subgrade layers

Moisture in layers below working platform

Limitations and Considerations

- Availability of equipment
- Processing time and resources
- Corrective actions during construction

Conclusions and Recommendations

- FSM concept can be applied to FWD testing during construction
- Further work required on evaluation criteria for local materials and conditions