Road Pavements Forum

Heavy Vehicle Simulator evaluation of the Super-Slab® pre-fabricated concrete panels for pavement rehabilitation

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20 – 21 May 2014

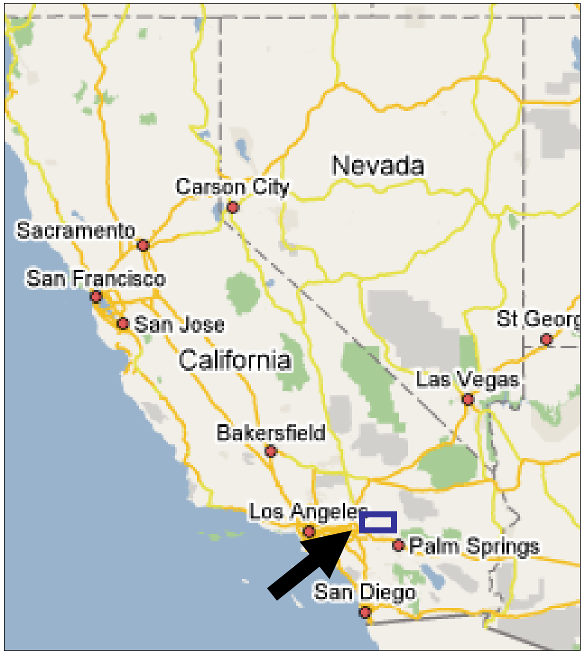
our future through science

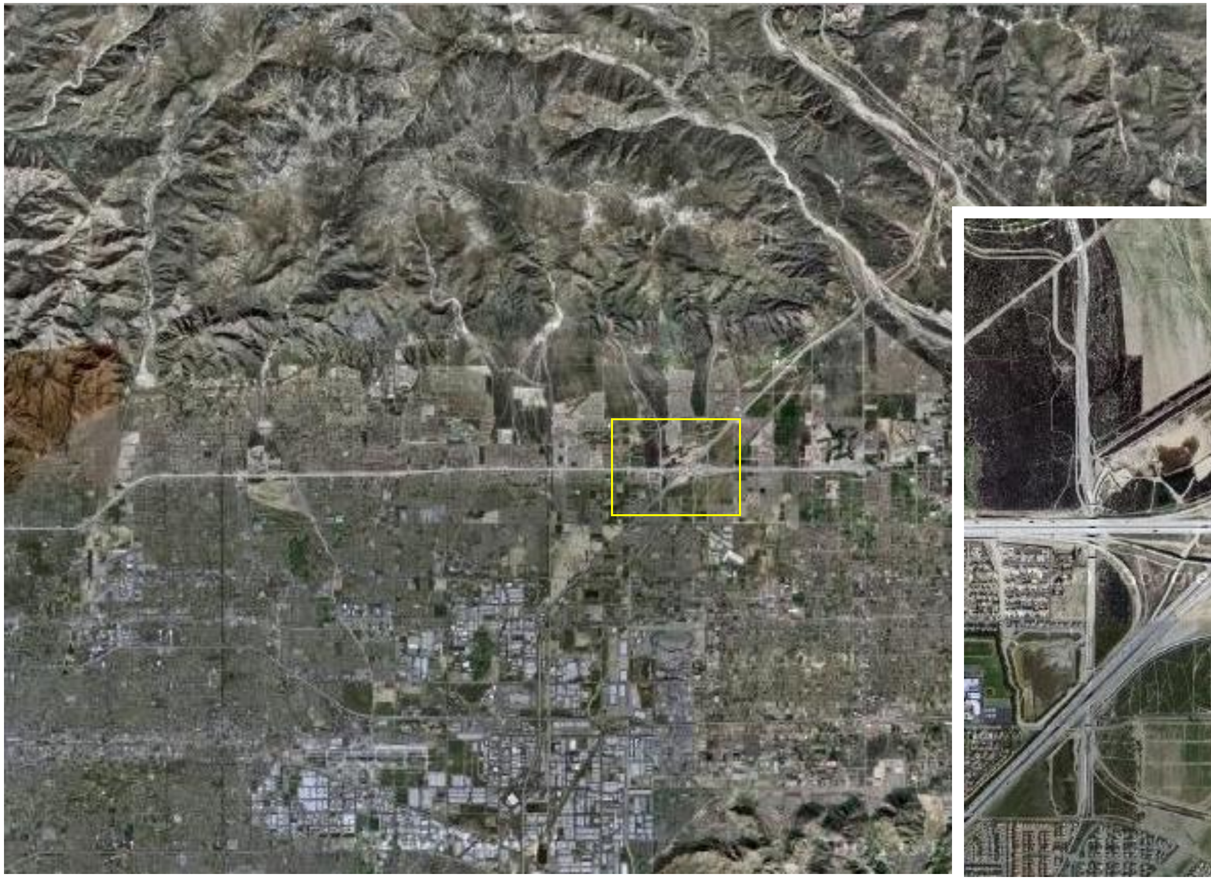
Outline

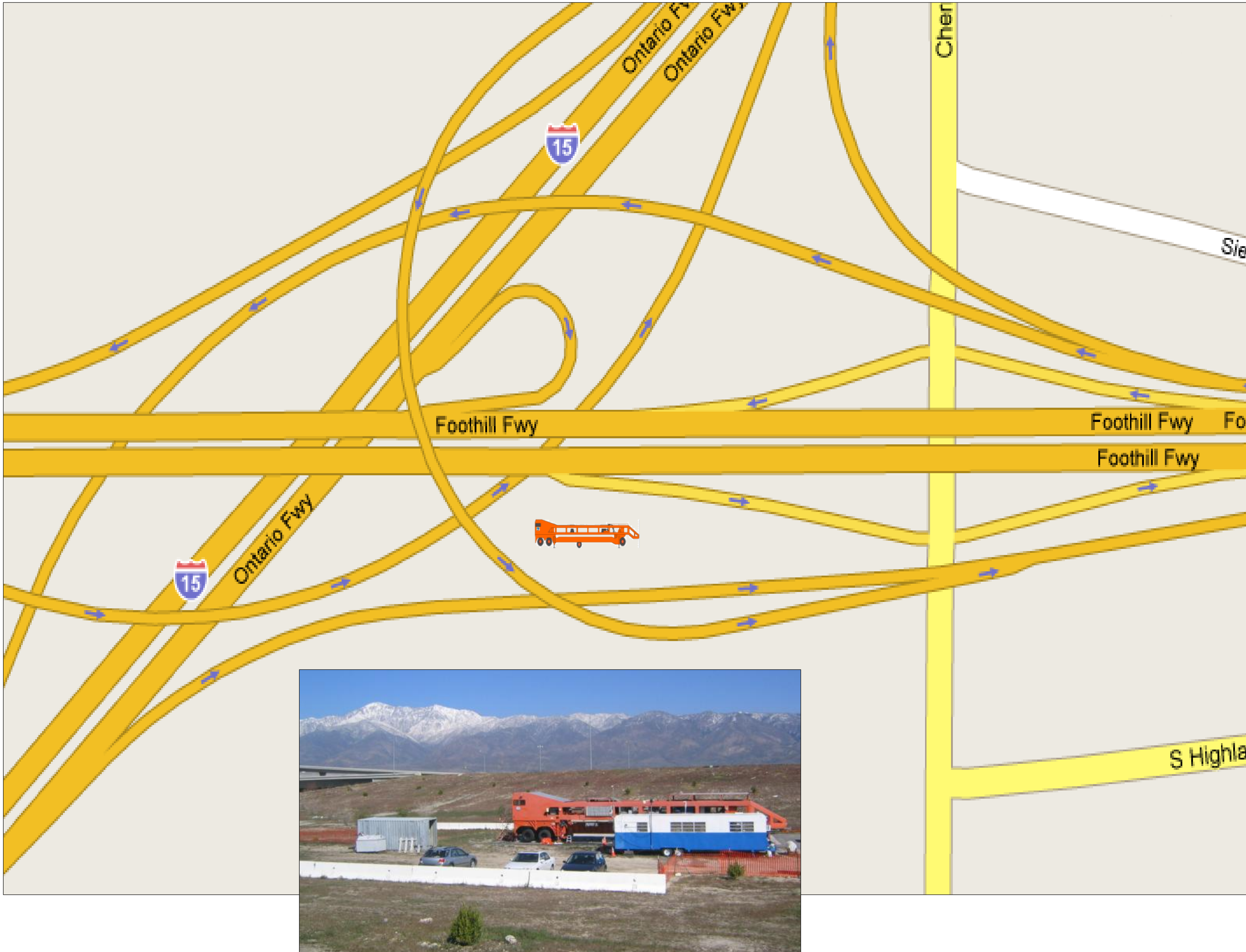
1. *HVS testing site*
2. *Super-Slab® construction steps*
3. *Slab curl behaviour after placement with and without dowels*
4. *Load Transfer efficiency results (un-grouted and grouted transverse joints)*
5. *HVS loading test results*
6. *Post-mortem investigations*
7. *Summary and Conclusions*

Test Site

- Interchange I-15 and SR210 in San Bernardino county






Ontario Fwy
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Foothill Fwy
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Pre-cast slabs

- Intended as a rapid replacement option for damaged concrete pavements
- Individual slabs or a whole section of the pavement may be replaced
- Super-Slab® pavement system:
  - “*Interconnecting series of precast concrete slabs that can be installed and placed into service immediately*
  - *Placed on perfectly smooth subgrade to provide full bedding as well as the challenge of connecting adjacent slabs to uniformly transfer load from one slab to another*”

Pre-cast concrete plant

April 2005

Slab thickness = 225mm 4.57 x 3.96m

Dowels: proxy coated 38mm diameter

Site preparation

Test site not constructed on existing, damaged pavement

CTB construction

SG CBR: 45 – 80
FWD stiffness: 100 MPa

CTB: 150 mm (“Class B”)
FWD stiffness:
300 – 650MPa

Construction steps

1. Sand bedding layer (8mm) on top of CTB
2. Placement of the pre-cast slabs (open to traffic after placement)
3. Next day closure: Grouting of the slabs:
   - Dowel grout
   - Bedding grout
   - Transverse joint sealant

Sand bedding layer

- Compaction, water application
- Precision blading

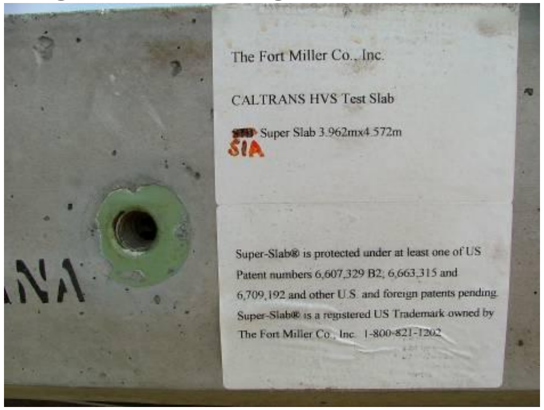
Marking of corner locations

Slabs details

Epoxy coated dowel-bars cast into the transverse edge

Dowel-bar recesses and bedding grout confinement strip

Female end of the tie-bars cast into the longitudinal edge of the slab



Male to female connection

Placement: Day 1

Lifting of the slab from the flat-bed

Precise placement of the slab

Fixing the tie-bars on the longitudinal edge

Placement of the slab on the adjacent lane

Placement (cont’d): Day 1

Spraying of the dowel-bars with a bond-breaker

Misalignment of adjacent slabs causing surface irregularities

Plastic spacers being driven into the joints between the un-grouted slabs

Expanding foam used for sealing of the outer edges of the joints

Grouting: Next day

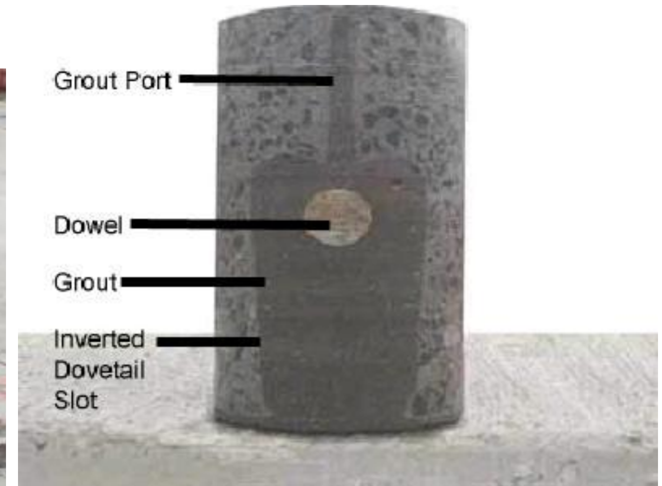
Filling of the dowel and tie-bar cavities with grout

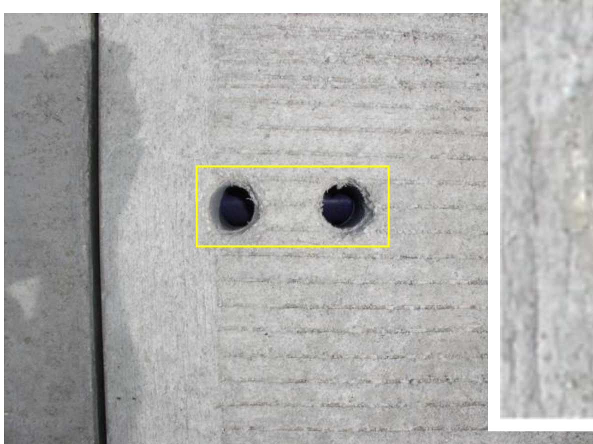
Removal of excess grout

Injection of the bedding grout

Excess bedding grout pouring from the exit hole

Dowel grout





Bedding grout

Foam gaskets preventing bedding grout from spreading outside concrete slab area

Bedding grout channels

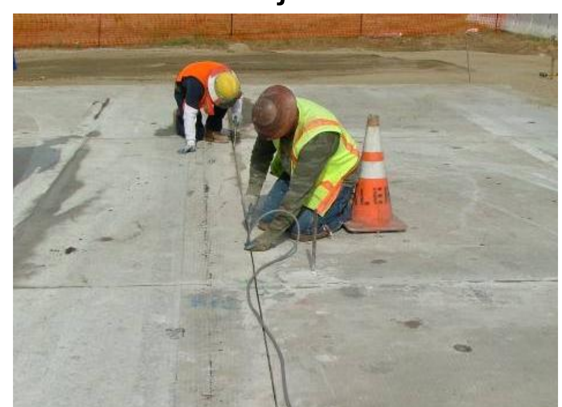
Shoulder, grinding and sealing

Shoulder filling

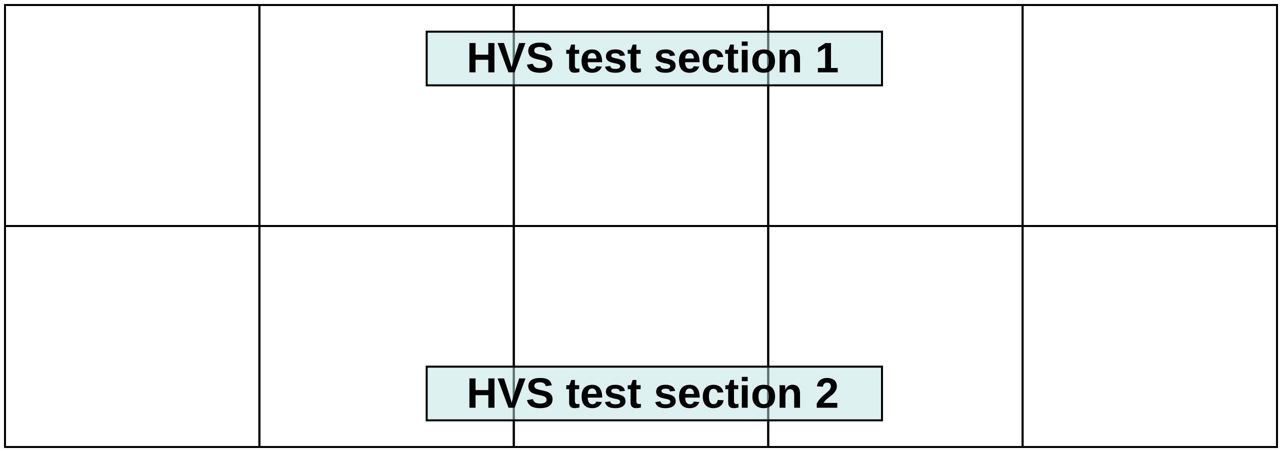
Shoulder compaction

Level grinding of the surface

High density foam strip installed in the joints



HVS Test Plan



- Ungrouted load test
- Thermal curl test

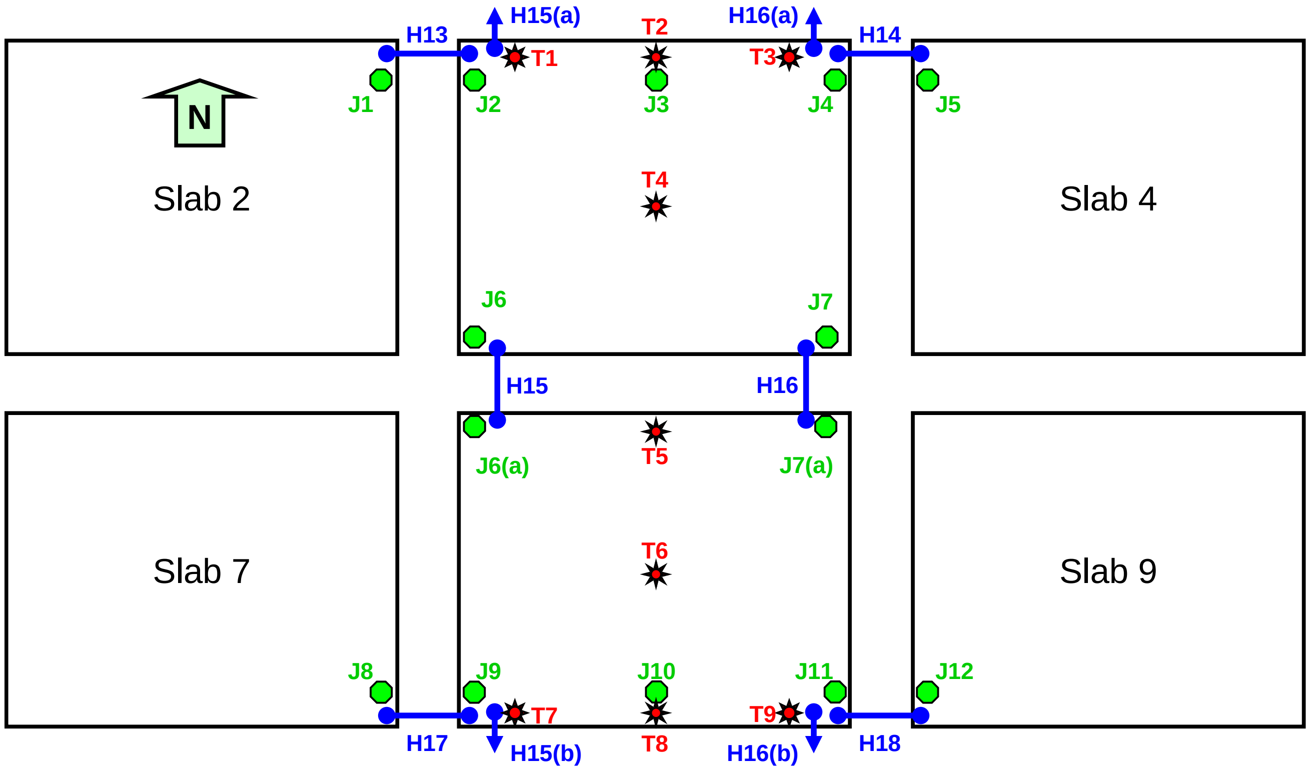
Preliminary tests on Day 1 construction

- Very high wheel-load test, dry
- High wheel-load test, dry
- High wheel-load test
- Very high wheel-load test, wet

Final tests after grouting

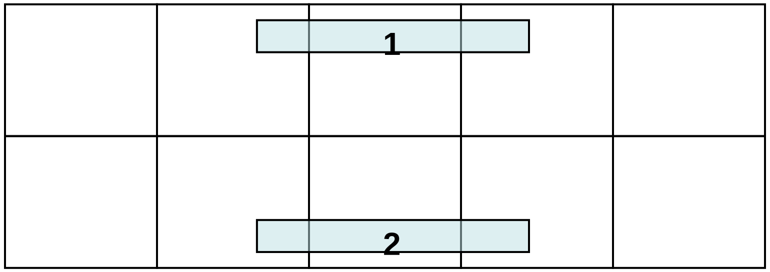
Instrumentation

- Thermocouples
- Multi-depth Deflectometer stacks (MDDs)
- Joint Deflection Measurement Devices (JDMD), H & V



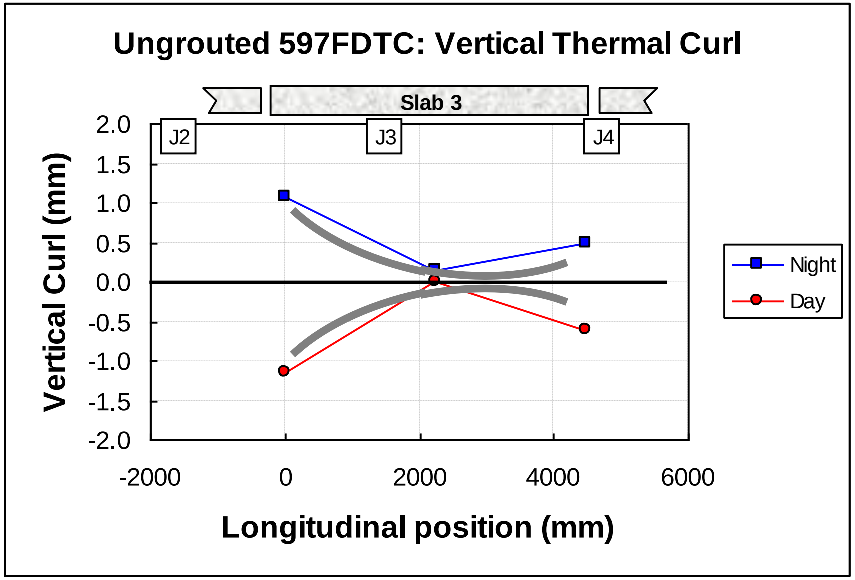
Thermal curl & Un-grouted load tests

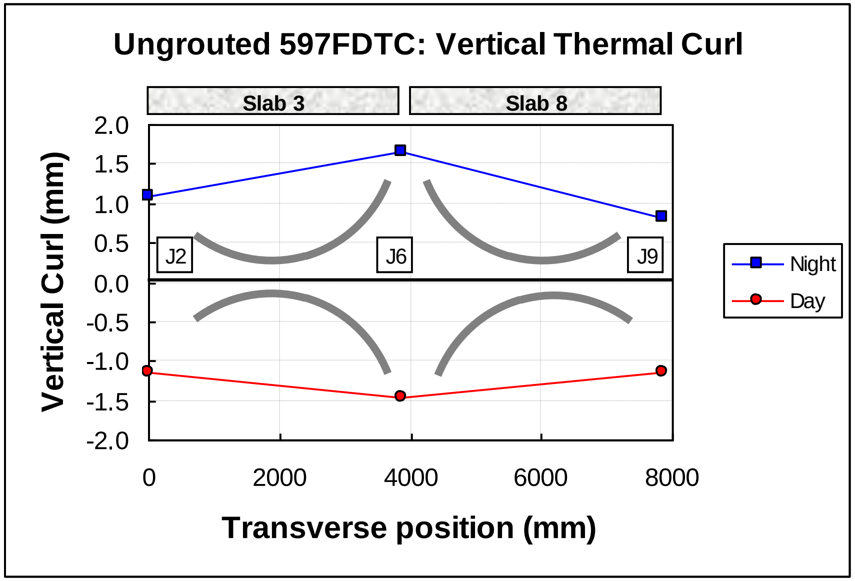
- Thermal curl:
  - 24 hr, no wheel load. Thermal curling measurements
- Load test, Ungrouted:
  - Simulate exposure to traffic from time of placement to before grouting
  - Based on traffic counts on I-15
  - 16,000 load repetitions at 60kN, unidirectional traffic
  - Approximately 88,000 ESALs (4.2 exp damage factor)



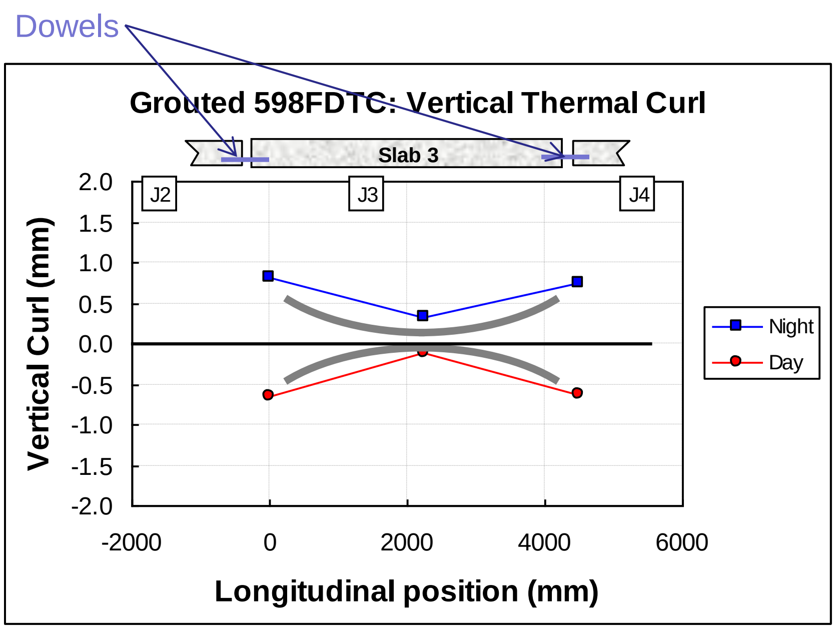
Thermal curl behaviour

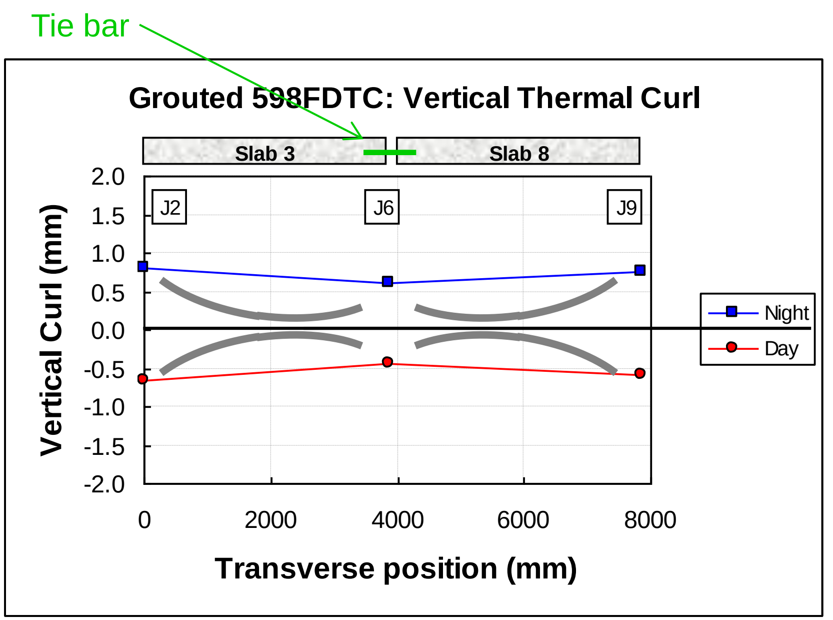
- Thermal slab edge movements
  - Vertical: 1.6 mm
    (4°C colder on the surface to 18 °C hotter on the surface)
  - Horizontal (longitudinal) : 0.9mm (ΔTsurface 17 to 42°C)



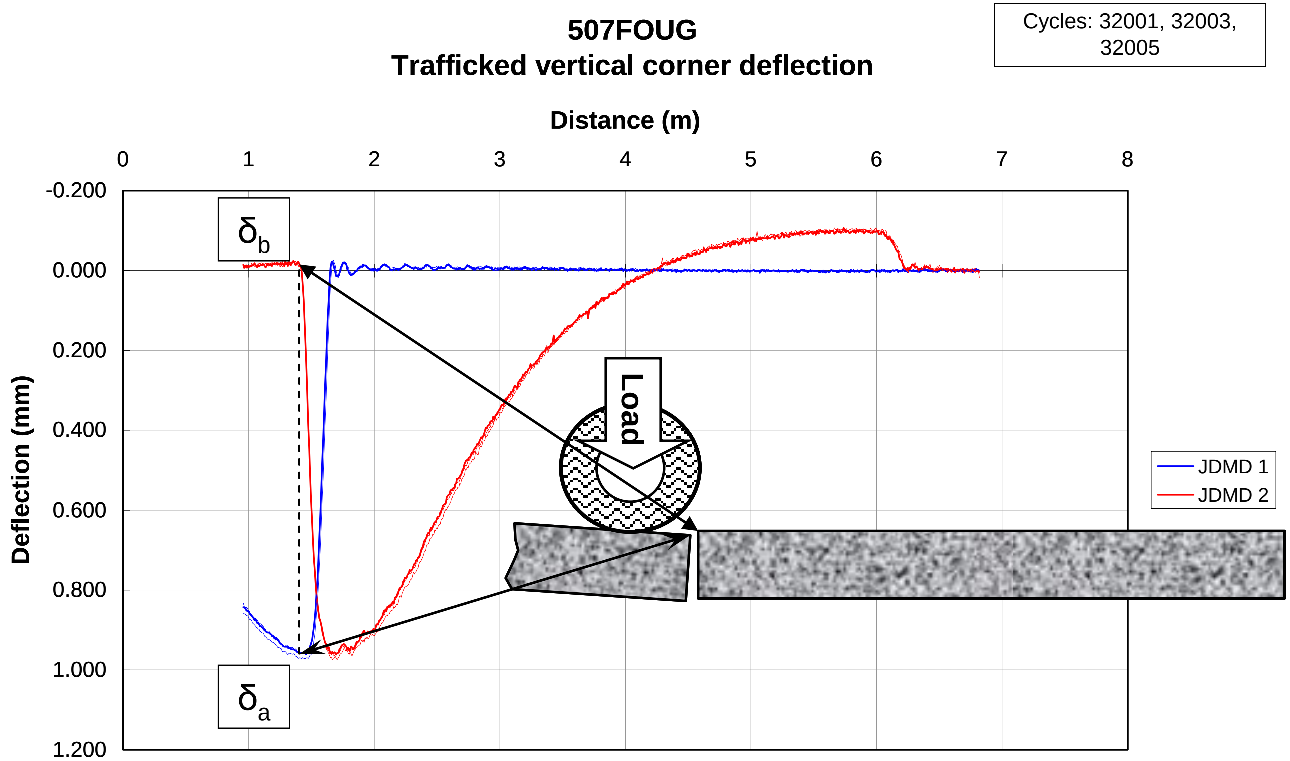


Thermal curl after grouting





Load Transfer Efficiency typical

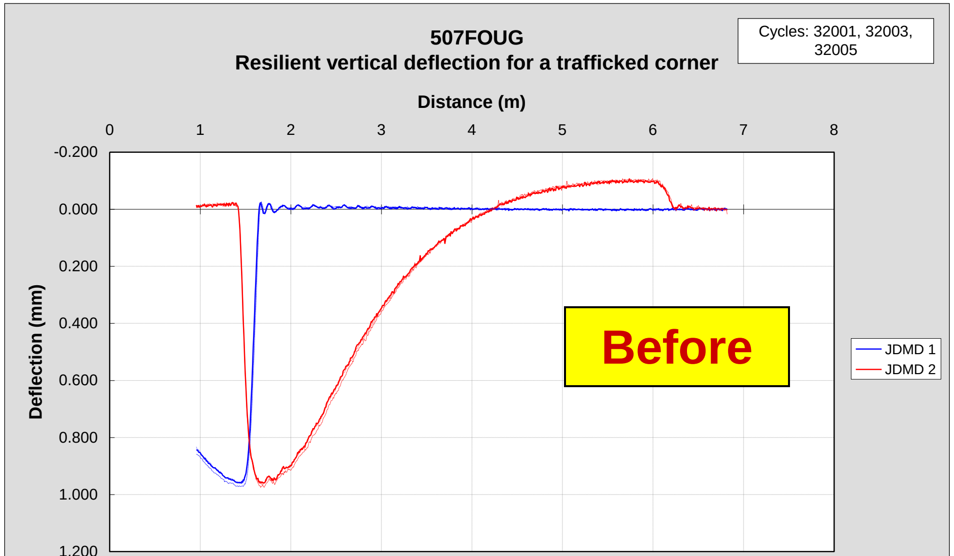


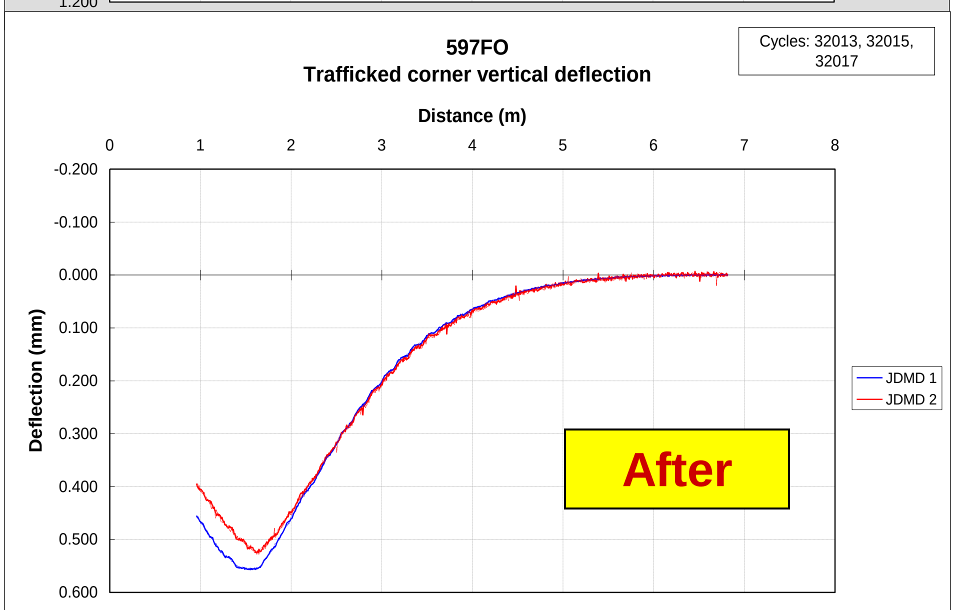
Load Transfer Efficiency (LTE)= δ_b/δ_a

δ_a = Peak deflection on approach slab

δ_b = Simultaneous deflection on leave slab

Regular test, section 1,Grouted

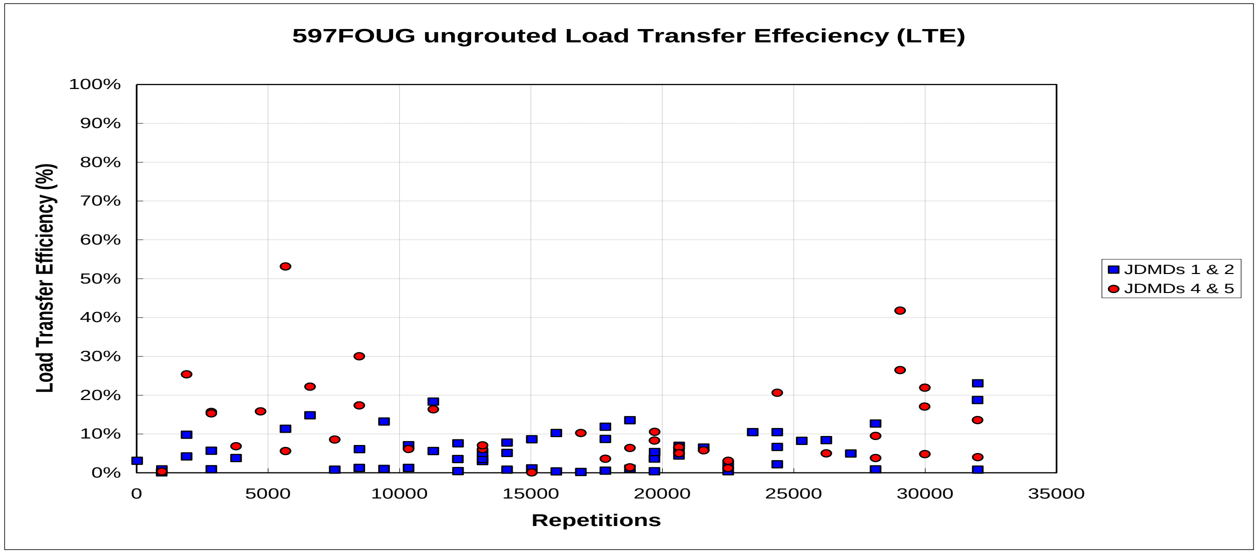


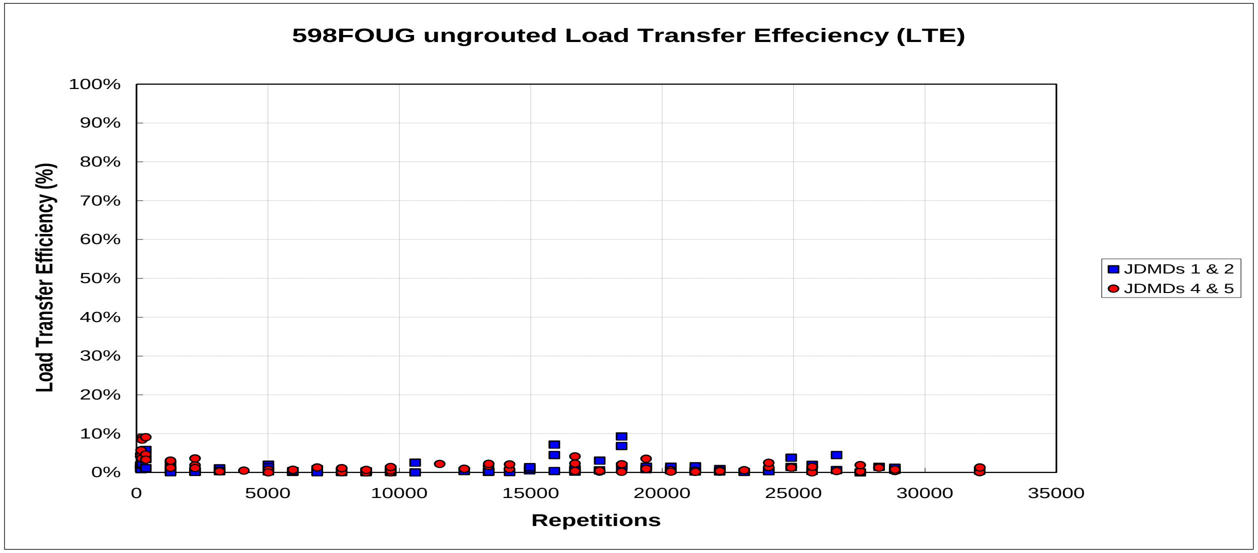


Bedding grout and dowel grout were applied:

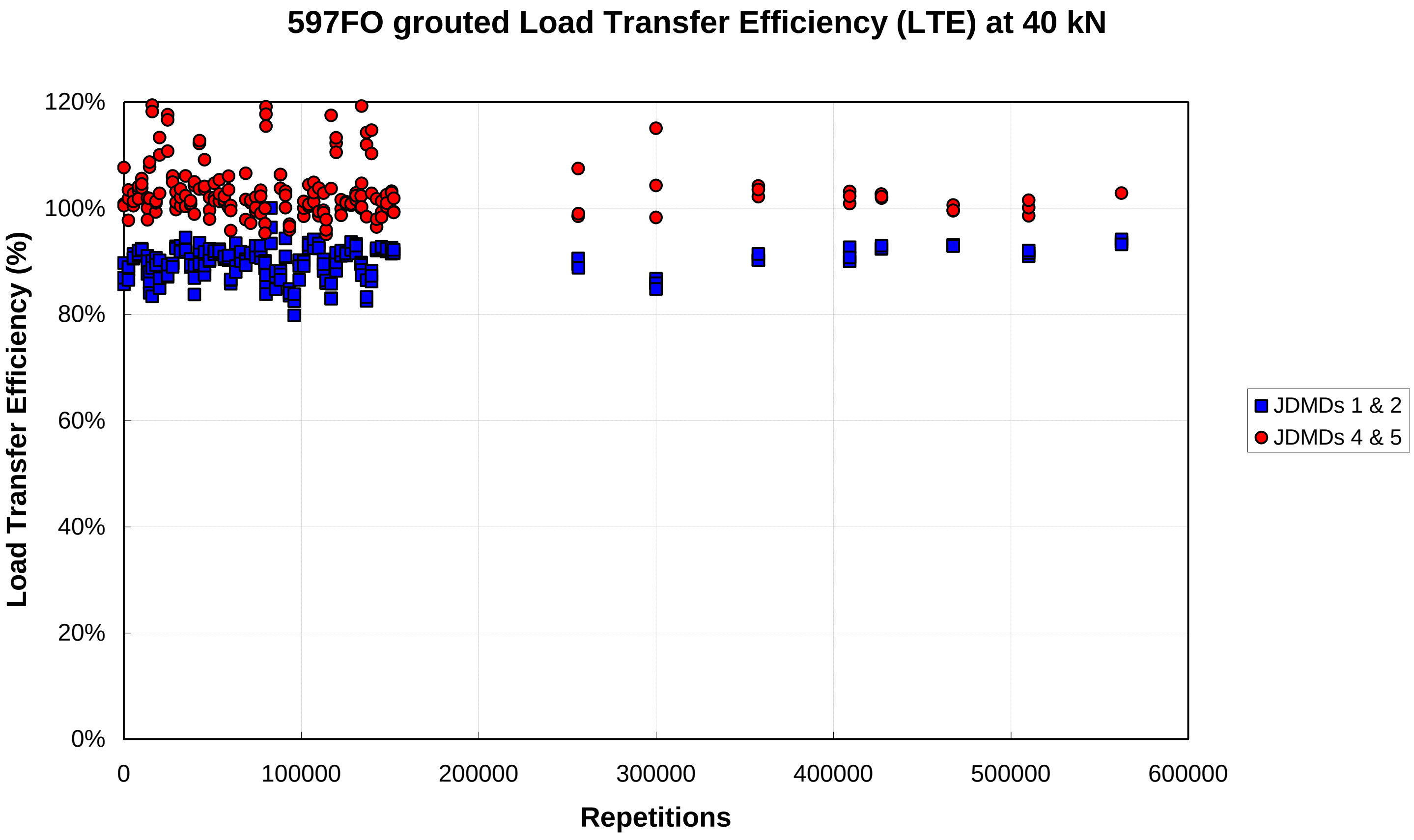
1. Greatly improved LTE:
   - The two sides of the joint move together
2. Reduced deflection
   - 1mm → 0.5mm
   - Reduce stresses in the slab and the subbase
3. Eliminated rocking

LTE un-grouted, sections 1 and 2





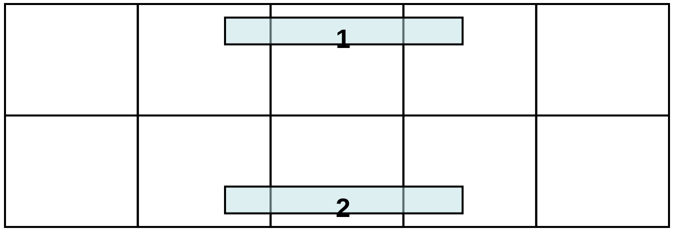
LTE after grouting



Load tests, grouted slabs

Chronological order of tests

- Un-grouted load tests:
  - May 26th to June 8th, 2005



- Regular tests (after grouting):
  - Section 1, dry: June - Sept, 2005
  - Section 2, dry: Sept - Feb, 2006
  - Section 2, wet: Feb - May, 2006
  - Section 1, wet: May - Aug, 2006

Section 1= very high load levels, aircraft tire (150kN)

Section 2= high load levels, dual truck tires (60 and 100kN)

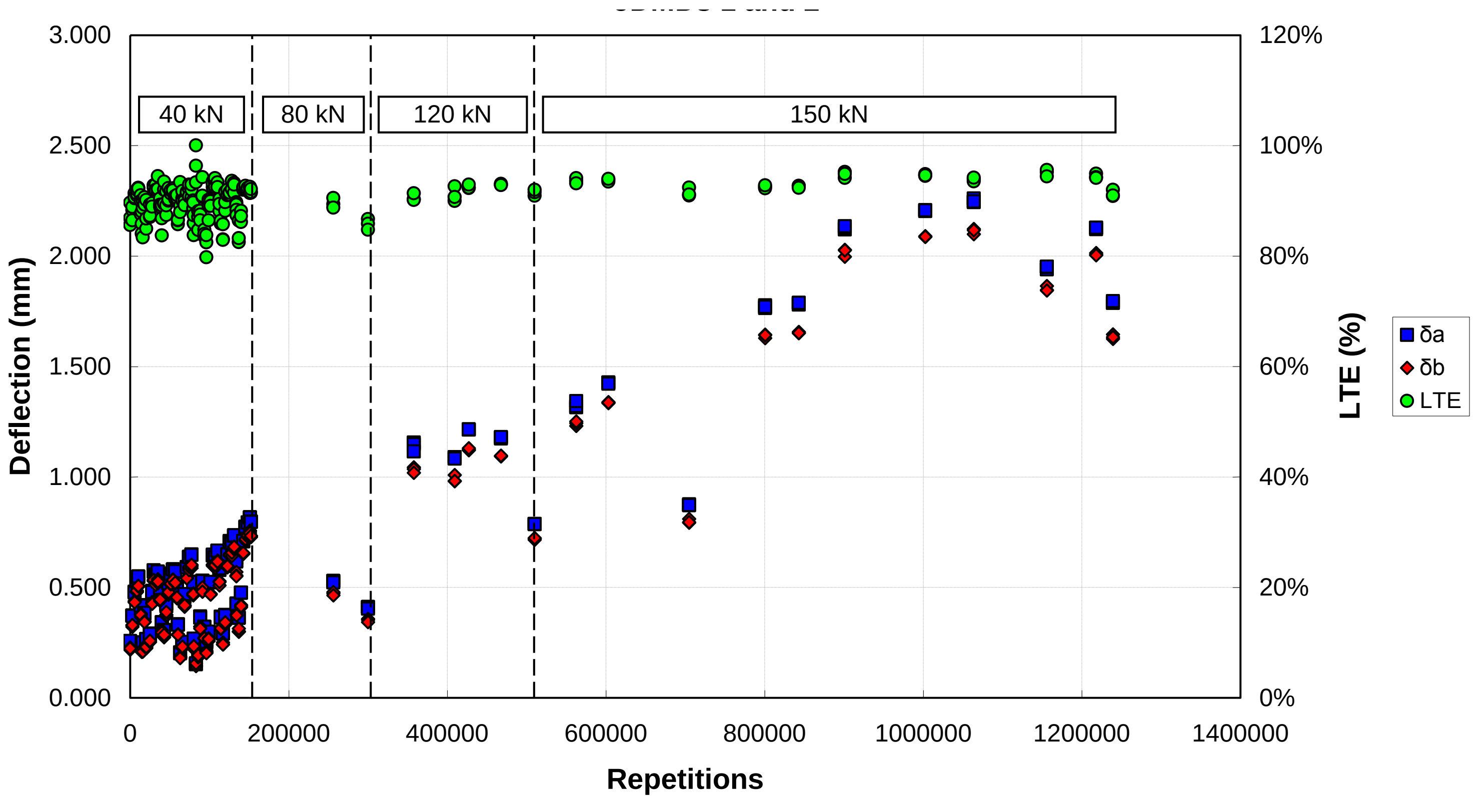
Load tests, un-grouted

- Load deformations (40kN load)
  - Vertical deflections of 0.6 to 1.0mm, and 0.8 to 1.6mm
  - Horizontal movement: 0.2 to 0.3mm, and 0.15 to 0.2mm

Testing sequence on grouted slabs with dry and wet tests

Section	Duration (months)	Test and load conditions (pavement/ tire type)	Load repetitions (millions)	ESALs (millions)
Section 1	3 (June - Sept, 2005)	Dry / Aircraft	1.05	163
Section 2	5 (Sept 2005- Feb, 2006)	Dry / Truck dual	2.33	99
Section 2	2 (Feb - May, 2006)	Wet / Truck dual	1.13	43
Section 1	5 (May - Aug, 2006)	Wet / Aircraft	0.54	79

Typical LTE and deflections



- Deflections increased, LTE remained high

Section 2, dry

- 100 million ESALs
- 2.3 million load reps (243 800 at 60kN and 2.1 million at 100kN)
- → no distresses

Section 2, wet

- Wet testing:
  - 43 million ESALs
  - 1.1 million reps
- Application of water at the joints (380l/week) = 7mm of rain per day on the 1 x 8m test section

- Results:
- Dry+wet loading:
    - 143 millions ESALs (3.46 million reps)

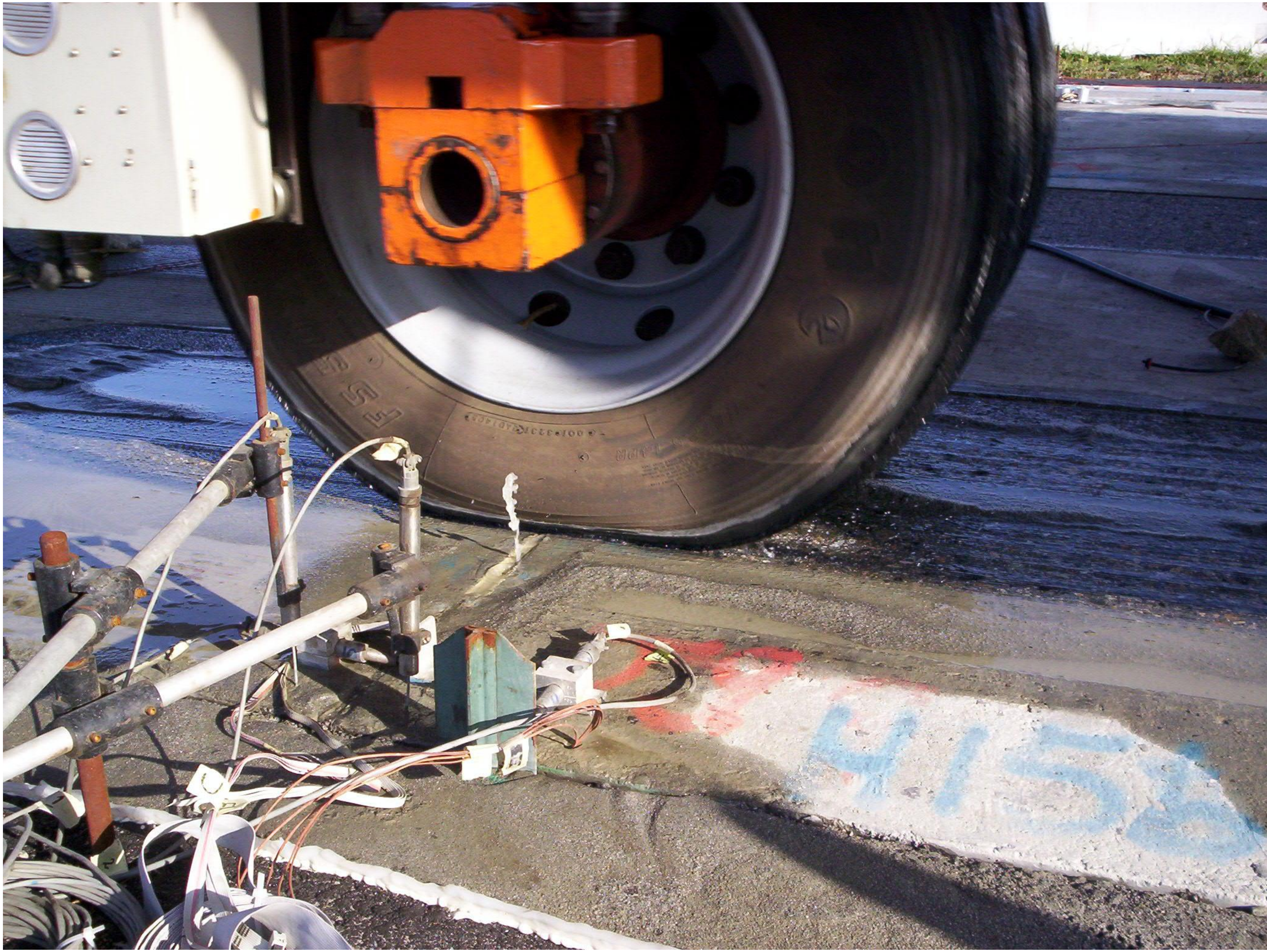
- Pumping but no other form of visual and structural distress

Wet trafficking

Water application (look at loaded tires!)

Pumped material

Pumping through the joint



Section 1, dry (Very High Loads)

- 163 million ESALs
- 1.05 million load reps (60 to 150kN)
- Cracks in one joint

- Application of water at the joints

Section 1, wet

- 79 million ESALs
- 0.54 million reps (60 to 150kN mainly 150kN)

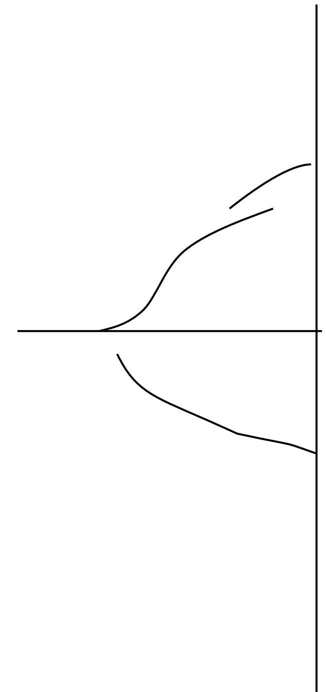
- Dry+wet loading section 1:
  - 242 millions ESALs
  - 1.6 million reps

- Results:

  → **Cracks during dry testing**

  → **Joint failures during wet testing**

Corner cracks (dry testing)



Cracks on either side of the transverse joint fully developed and extending from the transverse joint to the shoulder joint.

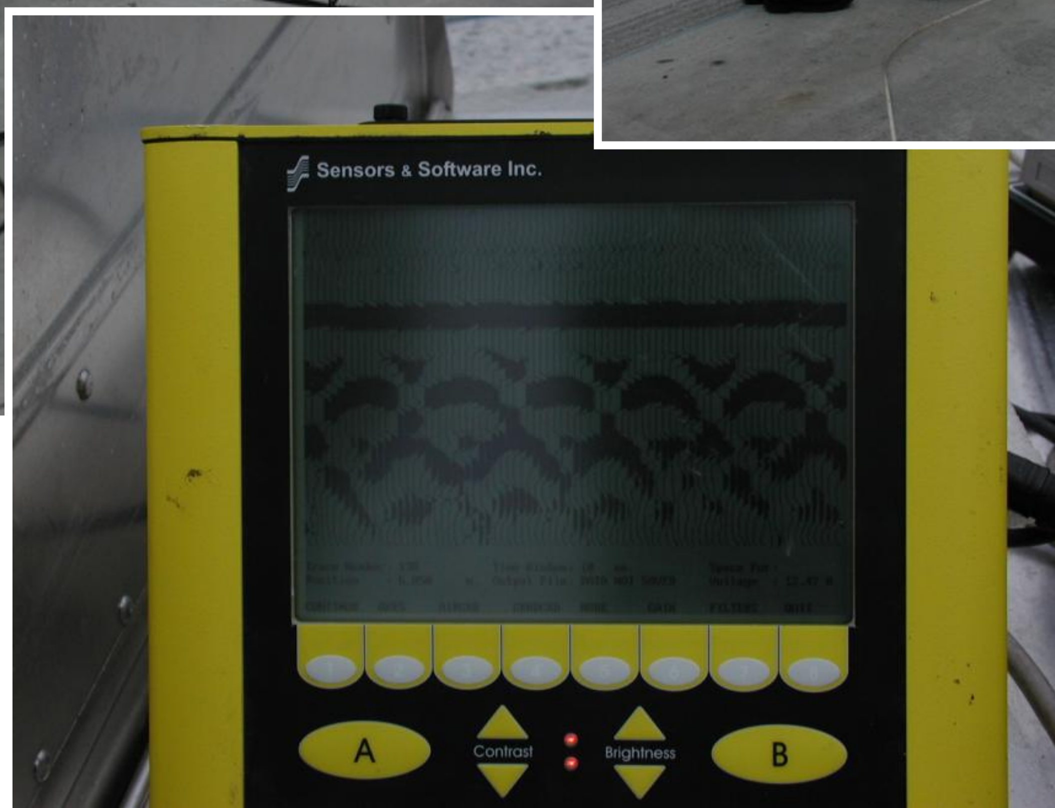
Section 1 wet, cracking

Section 1 wet, cracking

Post-mortem investigations: Void detection

- Considerable amount of material pumped from under the slab during wet trafficking

  → Void under the slab
- GPR (Ground Penetrating Radar) attempt
- Concrete segments removal
  - Dowel load transfer investigated after loading
  - Bedding material inspected
  - Transverse joint grout investigated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Contrast
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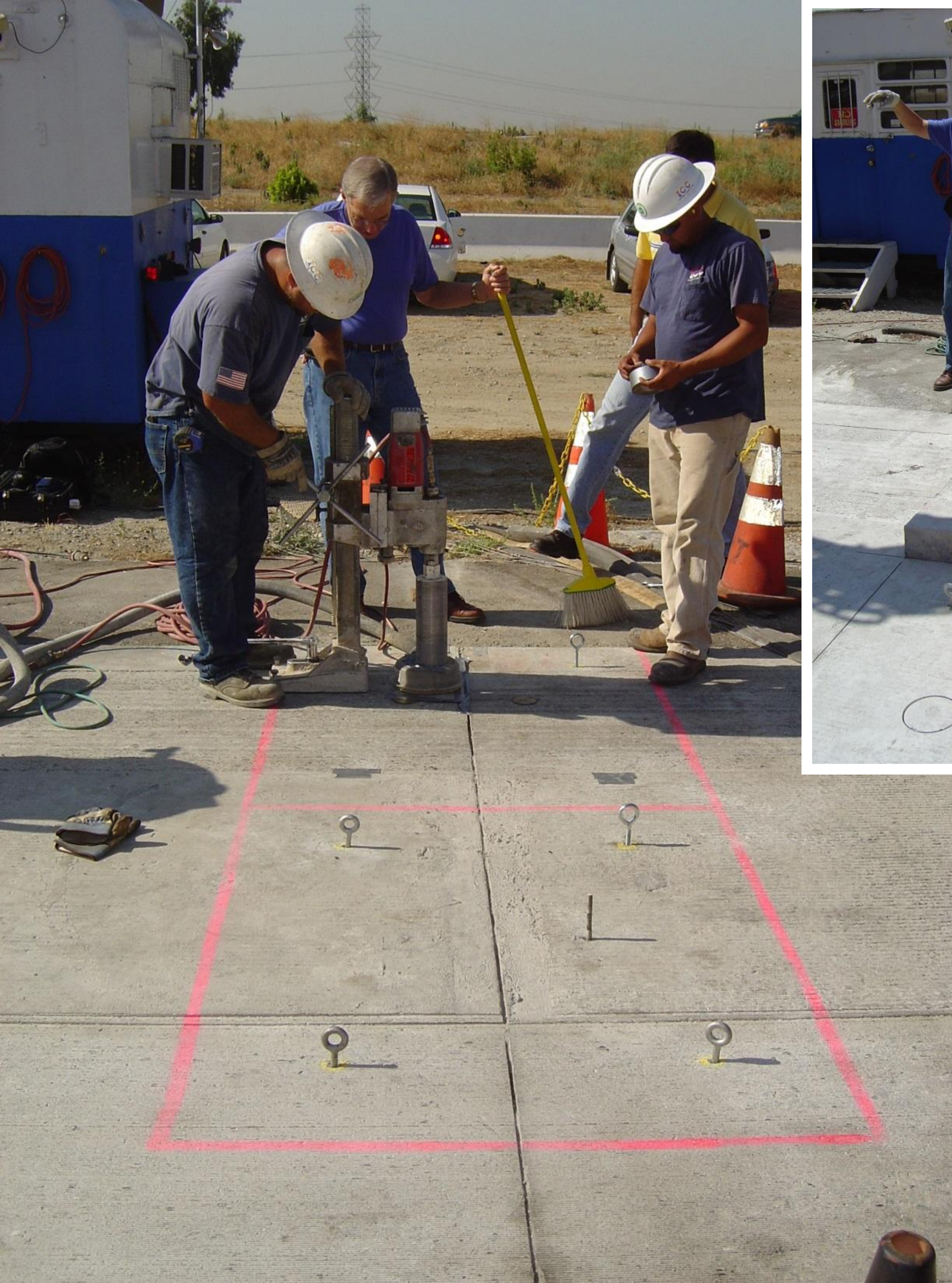



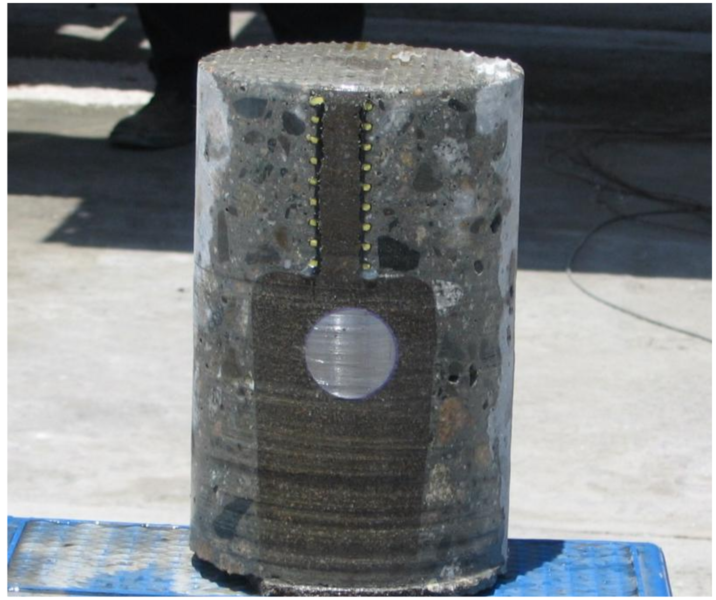


Summary

- Section 1 failed
  - More than 240 million ESALs
  - Very heavy load (150kN)

- Section 2 did not fail.
  - About 140 million ESALs
  - Heavy load (Avg. 100kN, dual truck tires)
  - Pumping, but no cracks

Conclusions

1. The Super-slab system seems capable to withstand 24-hr of highway traffic in the un-grouted condition (at least 88,000 ESALs)
2. As expected, bedding and dowel grouts improved slabs responses considerably
3. At high loads (100kN), dry and wet, no cracking occurred. Pumping did no cause damage (yet)
4. At very high loads (150kN), dry; corner cracking occurred (one joint). No failure.
5. At very high loads (150kN), wet, joint failure occurred
6. From the HVS tests there is no evidence to believe the Super-slab system would fail before 140 millions ESALs