The Phase One I-710 Freeway Rehabilitation Project: Initial Design to Performance After Six Years of Traffic

Meeting with AAPA Study Tour Group
UCPRC, CA 8/10/2010
Richmond Field Station, UC Berkeley
I-710 Project - Partnered Effort
(most recent participants)

- **Caltrans**
  - T. Bressette, W. Farnbach, C. Suszko

- **Industry**
  - J. St. Martin,

- **University of California PRC**
  - C. Monismith
I-710 Project - Partnered Effort
(some earlier participants)

• **Caltrans**
  - K. Herritt, R. Doty, J. Dobrowolski, S. Shatnawi

• **Industry**
  - L. Nawrocki, J. Copley, R. Smith, D. Chapman

• **University**
  - J. Harvey, F. Long
Presentation

• Mix designs
• Structural section designs
  • full-depth AC
  • overlay on cracked and seated PCC
• Aspects of construction
• Some lessons learned
• Phase II structures
Rehabilitation of Interstate - 710

- Full-Depth Asphalt Concrete replacement under overpasses
- Overlay of PCC (cracked-seated)
Design & Analysis

Trial cross section

Trial mix design

Conditioning (Aging & Water)

Performance Tests

Analysis Performance Prediction

Final mix design & structural section

Unacceptable

Acceptable
Long-Life Asphalt Pavement

- QC/QA specifications
- Polymer modified binders
- Improved aggregate requirements
- Modified mix design method
Trial Mix Design

- San Gabriel aggregate

- Binders
  - Conventional: \( \text{AR-8000} \)
  - Polymer modified: \( \text{PBA-6a}^* \)

- Hveem Stabilometer—to establish range of binder contents
Trial Mix Design

- Range of binder contents
  - 4.2 - 5.7% (by wt of aggregate)
- Conventional dense-graded mix, Caltrans specs.
- All crushed materials
Final Mix Design - Rutting

\[ N_{\text{supply}} = M \times N_{\text{demand}} \]

- **Performance test**
  - No
  - Yes

- **Traffic**
  - No
  - Yes

Input

\[
\begin{align*}
N_{\text{supply}} & \quad \text{Performance test} \\
N_{\text{demand}} & \quad \text{Traffic} \\
N_{\text{supply}} & = M \times N_{\text{demand}}
\end{align*}
\]
Shear Test
\( N_{\text{demand}} - (PBA-6A) \)

- Design ESALs - first five years
  \( \beta 30 \times 10^6 \) ESALs
- \( N_{\text{demand}} = 660,000 \)
  
  \[ M \times \text{Design ESALs} \times TCF \times SF \]

\( \beta M = 5 \)
\( \beta TCF = 0.116 \)
\( \beta SF = 0.04 \)
Design Binder Content

Asphalt content (percent by weight of aggregate)

Temperature = 50°C

- PBA 6A
- AR 8000

N @ γ_p = 5%

- 660,000 repetitions
- 146,000 repetitions
HVS Rutting Study
Rutting Study Layout

- 25 m section
- 33 tonnes AC
- Placed on jointed PCC
- 150 mm
- K-barrier on one side of section
- 3 m
- 4 m
Mix Performance Evaluation

![Graph showing rut depth vs. HVS Load Applications for different mixes: 38-mm ARHM-GG, 62-mm ARHM-GG, 75-mm DGAC AR-4000, 76-mm PBA-6A. The graph indicates that 38-mm ARHM-GG and 62-mm ARHM-GG have rut depths of less than 20,000 reps, while 75-mm DGAC AR-4000 and 76-mm PBA-6A have rut depths of approximately 170,000 reps. The graph also highlights the 1/2 inch rut depth threshold.]
Thickness Design - Fatigue Analysis

Input

$N_{\text{supply}}$

Performance test

$N_{\text{demand}}$

Traffic

$N_{\text{supply}} \geq M \times N_{\text{demand}}$

No

Yes
Design Considerations

- Fatigue in asphalt concrete
- Deformation in unbound layers
- Subsequently, design checked by CalME
Design Considerations

Asphalt Concrete

Base

Subgrade

$\varepsilon_t$

$\varepsilon_v$
Input

• Structural section (full-depth)
• Traffic (200 million ESALs)
• Environment (T = 20°C)
• Trial mixes & pavement section
Input

- Reliability ($M=5$)
- $f(\text{traffic estimate} \& \text{testing variability})$
- Performance criterion
  - Wheel path cracking $\leq 10\%$
Trial Pavement Sections

- **PBA-6A**
- **AR-8000**
- **AR-8000** *(rich bottom)*
- **subgrade*
Fatigue
Fatigue Test Results

![Graph showing fatigue test results for different samples.]

- **AR-8000, 4.7% AC, 6% AV**
- **AR-8000, 5.2% AC, 3% AV**
- **PBA-6A, 4.7% AC, 6% AV**
- **PBA-6A, 5.2% AC, 3% AV**
Fatigue

$N_{supply} \geq M \times N_{demand}$?

*Check vertical subgrade strain!!!*

*(controlled total thickness)*
Final Design

25 mm

6% air voids

AR-OGFC

75

PBA-6A (4.7%)

150

6%

AR-8000 (4.7%)

75

6%

AR-8000 (5.2%)

3%

(rich bottom)

subgrade
Overlays

- Asphalt Concrete
- Jointed PCC
- Cement treated Base
- Subgrade
- Leveling Course

- Fabric

- 30 mm
- 150 – 250 mm
- 200 mm
- 150 mm
Calculated Configuration

Traffic loads applied statically
symmetrical boundaries

250 mm

\( p = 725 \text{ kPa} \)

Cracks
@ 1 m
Finite Element Mesh

~ 12,000 elements, NIKE2D
Bending Strains in Mix just above Fabric

![Graph showing bending strains](image)

- 5"@900, 4"@150 ksi
- 3"@900, 5"@150 ksi
- 3"@900, 3"@150 ksi
Composite Overlay

Final overlay thickness

- 25 mm OGFC
- 75 mm PBA-6A
- 125 mm AR-8000

Fabric

Broken and seated PCC

225 mm
Full-Depth AC Comparisons

- The Asphalt Institute
- United Kingdom
- Australia
- Asphalt Pavement Alliance-U.S.
Perpetual Pavement Design Concepts

1.5 - 3” SMA, OGFC or Superpave

4” to 6” Zone Of High Compression

High Modulus Rut Resistant Material 4.5 - 6”

Max Tensile Strain

Flexible Fatigue Resistant Material 3 - 4”

Pavement Foundation
Construction Specifications

- Performance requirements based on shear and fatigue testing
- More stringent compaction requirements
- Tack coat between layers

Asphalt cement (AR- 4000)
Construction

• Six stages

• Stages 1 and 2 preliminary to rehab. of trafficked sections

• Stages 3-6 - rehab. of trafficked sections in 8 - 55 hr. weekend closures (vs. 10 originally planned)

• Use of CA4PRS (construction management program)
Construction

• **Stages 3 - 6**
  - Traffic closure
  - Crack, seat, and overlay (CSOL)
  - Full depth AC construction (FDAC)
  - Traffic opening
Contractor Staging Plan

FDAC: 362m
CSOL: 1,259m

FDAC: 406m
CSOL: 1,035m

FDAC: 840m
CSOL: 480m

FDAC: 342m
CSOL: 760m

FDAC: 321m
CSOL: 959m

Crack, Seat, and Overlay (CSOL) = 2.8 centerline
Full-Depth AC Replacement (FDAC) = 1.6 centerline-km
Placement of Leveling Course
Installation of Pavement Fabric
Placement of PBA-6A* Mix
Digout and Placement of Aggregate Base – Working Platform
Rich Bottom Layer Construction
Some Lessons Learned

• Pre-bid conference mandatory for all potential bidders

• For projects of this importance a “partnering” meeting at the outset is mandatory

β Partnering on the technical aspects extremely important!
Some Lessons Learned (cont.)

- For new test procedures included in Special Provisions insure that all involved groups perform tests and analyze resulting data the same way:
  - equipment calibration essential
  - preliminary testing of comparable specimens
Some Lessons Learned (cont.)

- Improved specification requirements based on statistical considerations desirable
- For QC/QA activities adequate staffing imperative (large quantities of materials, up to 15,000 tonnes per weekend)
Some Lessons Learned (cont.)

- Timely QA results required
- Human resources – 3 to 5 weekend closures in a row maximum; if more required, allow 1 to 2 weekend interval
Some Lessons Learned (cont.)

• In digout areas (FDAC):
  ∙ Exploratory testing imperative
  ∙ Exact location of underground utilities
Some Lessons Learned (cont.)

• **Contingency plan important**
  - Digout areas - working platform; materials easily accessible
  - Standby HMA plant(s)

• **Meteorologist for contractor**
  (construction in digout areas)
Performance Evaluation

- FWD Deflection testing (2003 through 2008)
- Back calculation of layer moduli and strains in HMA layers using MLEA
- Condition surveys
- Longitudinal and transverse profile measurements
- Noise measurements
- Laboratory testing of cores (RSST-CH) and slabs (Fatigue)
Performance Evaluation

- **Non-destructive HWD tests**
  - 11/03, NB and SB
  - 9/04, NB; 2/5, SB
  - 12/05, NB; 2/06, SB
<table>
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<tr>
<th>Location</th>
<th>Section 1 (FD)</th>
<th>Section 2 (CSOL)</th>
<th>Section 3 (FD)</th>
<th>Section 4 (CSOL)</th>
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**Deflections – SB Lane 3**

(ADJUSTED TO 19C)
Deflections – NB  Lane 3

- Deflections – NB  Lane 3
- Section 1(FD)  Section 2(CSOL)  Section 3(FD)  Section 4(CSOL)  Section 5(FD)
- PCH 405
- Deflections (Microns)
- Location
NB Lane 3 – Layer Moduli

I-710 Northbound Lane 3 Full Depth Sections - Layer Moduli with Time

![Graph showing the layer moduli of AC and Base sections over time from 2002 to 2009. The graph displays the modulus (MPa) on the y-axis and the year tested on the x-axis. Sections 1, 3, and 5 are represented with different markers for AC and Base layers.](image)
## Tensile Strain, Underside HMA Layer, in/in x 10^{-6}

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Rut Depth Measurements

SB Lane 3

Rutting (mm)

- Left WP
- Right WP

Rutting (mm):
- 12.5 mm

Station (m):
- 0+00 to 45+00
Rut Depth Measurements

NB Lane 3

Rutting (mm)

<table>
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<tr>
<th>Station (m)</th>
<th>Left WP</th>
<th>Right WP</th>
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<tbody>
<tr>
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12.5 mm
I-710 Traffic
I-710 Traffic
I-710, Phase II

- **Modifications**
  - Design traffic: \(-330 \times 10^6\) ESALs
  - Thickness of HMA base layer [PG 70-10 (AR-8000)] increased
  - Surface course: RAC-G instead of RAC-O
Concluding Thoughts

- Implementation of New Technology for Mix & Structural Design
- Strict Attention To Pavement Construction
- Constructability Considerations - Use of CA4PRS
- Successful partnering - agency, contractor and academia.
- Paving performing as expected.
Summary

• Implementation of SHRP developed technology
• Strict attention to pavement construction
• Constructability considerations; (CA4PRS)