Conquering the Challenges of Heavy Duty Pavements in California

John Harvey

Developments in Heavy Duty Pavements
Monday 3.30 pm
Overview

• For Long-Life Rehabilitation and Reconstruction
  Caltrans uses:
  – Design method able to account for local climate, materials, traffic, and to be continuously updated for new materials
  – Pavement designs and specifications to minimize thickness, speed construction time
  – Performance related specifications for asphalt materials
  – Continuous and full directional closures in urban areas
  – Extensive traffic management planning and monitoring

• Outline:
  – Development of approaches
  – Details and experience
  – Lessons learned
Want Long Life, Fast Construction, Minimum Traffic Delay, Low Cost

• Pavement design strategies:
  – Longer life pavements take longer to construct
  – Materials vary locally and change over time

• Construction windows/traffic delays:
  – Urban areas are all about traffic delay
    • Shorter windows less efficient for construction
    • Some strategies impossible in 7-10 hour windows
    • Alternative windows: 55 hour weekend, 72 hour weekday, continuous
  – Rural areas use normal traffic handling

• Requires Pavement Engineering + Construction Engineering + Traffic Engineering

• Compete with concrete on all of these items
Origins of the California approach

Northridge earthquake damaged four bridges on the Santa Monica Freeway in Los Angeles
- Closure estimated to cost LA economy $1M per day

C.C. Myers, Inc. won the contract to replace them for $14.9M
- Contract completion 140 days
- $200,000 per day bonus for each day prior to the 140 days
- Completed the job in 66 days, 74 days early
Origins of the California approach

Lessons Learned

Innovative materials

• fast-setting concrete for ramps

Full closures

• unavoidable in this case

Schedule incentives

• if warranted by economic losses due to longer closures
I-10 Concrete Lane Replacement with 55 hour Weekend Closure in 2000

- 2.8 lane-km removed, replaced, opened to traffic
- Fast-setting concrete
- Moveable concrete barrier
- Back-up mixing plant
- Concurrent operations
- 1 ½ lanes available for traffic
- Need to remove closure and open within 4 hours if too much traffic delay

![Progress of Rehabilitation](image)
I-10 Concrete Lane Replacement with 55 hour Weekend Closure in 2000

Lessons Learned

Moveable barrier worked well for fast closure changes

Some things contractors focused on were not necessarily the most important items controlling productivity

- Contractors: mixing plant, paver speed
- Experience:
  - adequate trucking
  - dedicated lanes for each concurrent operation
  - it’s a traffic problem on both sides of the barrier
  - need for simple and predictable materials
- Asphalt industry said “Hey, we can also innovate”
Projects to date

• Long Beach projects 2002-20XX
  – Four phases
  – About $650M
  – ME design

• 2012-2014 projects
  – Also pilots for inclusion of 25% RAP
  – About $100M
  – CalME design
Current Long-Life Strategies

Typical now

- 200-225 mm PCC
  - or
  - 200-350 mm AC

- 100-150 mm CTB
  - or AB

- 150 mm AS

- Crack and Seat PCC, Place Thick AC Overlay

- Remove PCC or AC, Replace with full-depth AC structure

- Remove PCC, Replace with 200-300 mm CRC or JPC
  - Retain or replace existing base
Crack, Seat and Overlay

Sacrificial layer – safety, noise, RHMA-O
Top layer – rutting, cracking, PMB
Middle layer – cracking, rutting 25% RAP
Bottom layer – cracking, 15% RAP
Cracked and Seated PCC

Base layers
subgrade

25-50 mm
75-100 mm*

Design thickness*
fabric

30 mm
Existing grade

* Designed with CalME
Full-Depth Asphalt Concrete

Sacrificial layer – safety, noise, RHMA-O
Top layer – rutting, cracking, PMB
Middle layer – cracking, rutting, 25 % RAP
Rich Bottom layer – cracking, 15% RAP
Granular (recycled PCC) or CTB base
subgrade

Existing grade

25-50 mm
75-100 mm*

Design thickness*

50-75 mm*
0 or 150 mm

* Designed with CalME
Rich-Bottom Layer

• Definition
  – Same materials as middle layer except for RAP content
  – 0 to 3 % air-voids
  – Bitumen content increased by contractor to achieve compaction (previously required +0.5%)

• Benefit is from increased compaction, not increased asphalt content

• Must be out of zone of rutting risk
  – More than about 150 mm below surface, depending on climate region
## Current Performance Based Laboratory Tests

<table>
<thead>
<tr>
<th>HMA Property</th>
<th>Test Type</th>
<th>Experiment Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiffness Master Curve</td>
<td>Beam bending frequency sweep</td>
<td>3 Temp x 2 Replicates = 6</td>
</tr>
<tr>
<td>Fatigue Resistance</td>
<td>Beam bending fatigue (AASHTO T 321)</td>
<td>1 Temp x 2 Strain x 3 Replicates = 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Previously used 3 T</td>
</tr>
<tr>
<td>Rutting Resistance</td>
<td>Repeated Simple Shear (AASHTO T 320) or Repeated Load Triaxial with AMPT</td>
<td>2 Temp x 3 Stress x 3 Replicates = 18</td>
</tr>
</tbody>
</table>
# Asphalt Mix Performance-Based Specification for Red Bluff Project

<table>
<thead>
<tr>
<th>Design Parameters</th>
<th>Test Method</th>
<th>Requirement</th>
</tr>
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<tbody>
<tr>
<td><strong>Permanent deformation (min.)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PG 64-28PM (with lime)(^{2a})</td>
<td>AASHTO T 320</td>
<td>360,000 stress repetitions(^{3,4})</td>
</tr>
<tr>
<td>PG 64-10 (with RAP and lime)(^{2b})</td>
<td>Modified(^{1})</td>
<td></td>
</tr>
<tr>
<td>PG 64-10 (with RAP and lime)(^{5b,7a})</td>
<td>AASHTO T 321</td>
<td>23,000,000(^{4,8})</td>
</tr>
<tr>
<td>PG 64-10 RB(^{11}) (with lime)(^{5c,7b})</td>
<td>Modified(^{1})</td>
<td>345,000,000(^{4,9})</td>
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<td>PG 64-10 (with RAP and lime)</td>
<td>AASHTO T 324</td>
<td>25,000 repetitions(^{4,8})</td>
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<td>Modified(^{1})</td>
<td>950,000 repetitions(^{4,9})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>182,000 repetitions(^{4,8})</td>
</tr>
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<td></td>
<td></td>
<td>2,700,000 repetitions(^{4,9})</td>
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<td><strong>Fatigue (min.)</strong></td>
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<td></td>
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<td>AASHTO T 321</td>
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\(^1\) Modified test method. \(^2a\) PG 64-28PM with lime. \(^2b\) PG 64-10 with RAP and lime. \(^3\) 360,000 stress repetitions. \(^4\) 360,000 stress repetitions. \(^5\) Fatigue testing specifications currently being changed to reduce testing time. \(^6\) PG 64-28PM with lime. \(^7\) PG 64-10 with RAP and lime. \(^8\) PG 64-10 (with RAP and lime). \(^9\) PG 64-10 RB (with lime). \(^10\) 20,000 repetitions.
I-710 Long-Life Asphalt with 55 hour Weekend Closures 2002

- Total corridor
  - Ports to connectors
  - 32 miles, 6 to 10 lanes

- Four phases:
  - 1 to 3, completed 2002 to 2013
  - 4 in future

- Traffic ranges
  - 57,000 ADT, 28% trucks
  - 187,000 ADT, 14% trucks
  - 230,000 ADT, 8% trucks

Caltrans traffic [http://traffic-counts.dot.ca.gov/docs/2011_aadt_truck.pdf](http://traffic-counts.dot.ca.gov/docs/2011_aadt_truck.pdf)
Before Construction

45 year old deteriorated PCC Pavement

Photo by EB Lee
Reduce Thickness to Speed Full-Depth Construction Under Bridges

Traditional materials and Asphalt Institute ME design

535 mm thick
8 % air-voids
same mix design throughout
AR-4000 std binder

ME design using
• Improved compaction
• Stiffer binder
• Rich Bottom
• 4 point beam materials characterization

300 mm thick
75 mm polymer 5% air-voids
150 mm AR-8000
5% air-voids
75 mm AR-8000, 2% air-voids
+0.5% binder
Staged construction:
Full directional closures, concurrent demolition and paving, 2 to 3 simultaneous asphalt paving operations
Paving Sequences Set Up
to Permit Sufficient Cooling Between Lifts
MultiCool Analysis Software sponsored to provide model
written by Voller and Timm

<table>
<thead>
<tr>
<th>Lift#</th>
<th>Thickness (mm)</th>
<th>Time, min</th>
<th>Temp (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>50.8</td>
<td>55</td>
<td>102</td>
</tr>
<tr>
<td>3</td>
<td>50.8</td>
<td>53</td>
<td>127</td>
</tr>
<tr>
<td>2</td>
<td>75.2</td>
<td>64</td>
<td>74</td>
</tr>
<tr>
<td>1</td>
<td>25.4</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Existing Layer

Free download www.ucprc.ucdavis.edu/SoftwarePage.aspx or NAPA or NCAT websites
Accelerated Long-Life Rehabilitation Strategies

- 55-hour Weekend Closures for Major Rehabilitation OK
- Incentives/Disincentives (Phase 1 example)
  - $100K incentive per weekend if fewer than ten weekend closures
  - $100K disincentive per weekend for more than ten weekend closures
  - Hourly disincentives if past Monday open time
- Contractor’s QA/QC and Pay Factor
  - Shear and fatigue PRS test results for mix approval
  - Field performance test results on asphalt content, gradation, and % of maximum theoretical density
  - Quality pay factors for the three quality characteristics
  - Maximum Obtainable Combined Pay Factor: 1.05
  - Minimum Acceptable Combined Pay Factor: 0.90
After Construction
FDAC Section near PCH

Photo by EB Lee

Monday, March 30, 2003 08:00am
Lessons Learned from Phase 1 (1/2)

• Pre-bid conference should be mandatory
• For new performance-related test procedures
  – Work to reduce time required
  – Ensure tests and analyses done the same way
• Monetary Incentives proved to be effective
  – Contractor earned $200K incentive for early completion
• Pay factor effectively encouraged quality awareness and quality workmanship:
  – $70K extra earned by contractor
  – Some quality measures not met on early closures
• Monitoring to date indicates expected performance

Lessons Learned from Phase 1 (2/2)

• Software can help to standardize information and analyses for construction productivity and traffic delay
• RapidRehab (CA4PRS) software developed by UCPRC/Caltrans/industry
• Software database captures planning assumptions and data collected from field monitoring
• Software available through Caltrans and FHWA
  www.dot.ca.gov/newtech/roadway/ca4prs/
  www.fhwa.dot.gov/research/deployment/ca4prs.cfm
Lessons Learned: Traffic Management

- Contractor did hour by hour scheduling
- Central traffic command during operations
  - Continuous monitoring and messaging
  - Daily teleconferences (all stakeholders, contractor, Caltrans, employers, public safety)
  - 24 hour look ahead, progress
  - Then given to media
- Media
  - "scare the heck out of everybody"
  - "the media is your friend" (with one exception)
Lessons Learned: Traffic Management

**Councilmember Steve Hansen**

April 23, 2014 · Sacramento, CA ·

Many of you have contacted me regarding the ongoing helicopter activity related to #fix50 and the negative impact that they are having on the surrounding neighborhoods. Yesterday, at my request, the Sacramento Police Department contacted the media to ask them to not flight as early or to potentially share video. At this point, we've also asked Congresswoman Matsui's office to assist through the FAA to change this behavior. You can file noise complaints through 311 or feel free to email me (shansen@cityofsacramento.org) while we continue to work on this.
I-5 Red Bluff
I-5 Red Bluff
Existing semi-rigid pavement, stripped AC
I-5 Weed

Varying underlying pavement thicknesses and types
I-80 Dixon

Existing badly cracked 50 year old PCC with IRI up to about 4 m/km in sections
I-80 Dixon: all night-time construction
I-80 Dixon: ready for single pass for smoothness of PMB top layer and RHMA-O surface
Summary and Takeaways

• Performance
  – Specifications and designs appear to be working; good performance on I-710 after 13 years
  – CalME design being moved out to districts
  – Need for continuing evolution of listening to feedback and improving practice: design, construction, materials, testing, specifications, traffic management, public outreach

• Takeaways: Overall
  – Ensure sufficient early success to be able to continue
  – Think about ALL client issues, many not pavement but affected by pavement: traffic, construction scheduling, etc
  – Listen, do post-project reviews of contractor and owner and other stakeholders
Takeaways

• Design
  – Use and improve ME design method to reliably get same performance with thinner pavement
    • Must be able to evaluate materials and construction
    • Must be well calibrated including reliability
  – Take advantage of specific materials properties to thin the structure
    • The right material in the right place
    • Strategic use of modified asphalt and recycled materials to improve properties
Takeaways

• Design
  – Use construction specifications in design:
    • Compaction levels and variability for asphalt
    • Compaction levels and variability for underlying layers
    • Light stabilization of underlying materials
    • Tie asphalt PBS to ME design inputs

• Construction
  – Keep design and materials as simple as possible
  – Make sure asphalt materials are compactable
Takeaways

• Contractors
  – Time needed for materials characterization is often more important than cost
  – Need to understand effects of binder on achieving PBS are not covered by PG spec (mid-temperature stiffness and fatigue life)
  – Need to understand mix improvement process to meet PBS

• Owners
  – Incentives to go beyond spec can help spur innovation
  – Continuous improvement in terms of setting bar for design and construction
  – Need critical mass of projects to get industry investment and maintenance of expertise

• All
  – Communication essential, source of most problems
  – Work together to communicate innovation to public and tradeoffs of long life rehabilitation life cycle cost versus short term traffic issues and initial cost
Thanks

- Caltrans HQ and District 2, 4 and 7 staff
- Contractors and their consultants
- NAPA
- More info:
  - [http://calapa.net/Longlifepavement.html](http://calapa.net/Longlifepavement.html)

Caltrans wins Pavement Pioneer Award for Perpetual Pavement projects

AMANDA BAYHI

National Asphalt Pavement Association President Mike Acott (left) and California Asphalt Pavement Association Executive Director Russell Snyder (right) present the Pavement Pioneer Award to Caltrans Maintenance Chief Tony Tavares. (Photo courtesy of APA)

The California Department of Transportation (Caltrans) has received a national Pavement Pioneer Award for the long-life asphalt pavement projects recently constructed on Interstate 5 in Northern California.
Questions?

**CLOSURES**

**10 WEEKEND CLOSURES**
(Subject to change)

<table>
<thead>
<tr>
<th>Weekend 1:</th>
<th>Friday - Mon.</th>
<th>Aug. 5 - 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekend 2:</td>
<td>Friday - Mon.</td>
<td>Aug. 12 - 15</td>
</tr>
<tr>
<td>Weekend 3:</td>
<td>Friday - Mon.</td>
<td>Aug. 19 - 22</td>
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<tr>
<td>Weekend 4:</td>
<td>Friday - Mon.</td>
<td>Aug. 26 - 29</td>
</tr>
<tr>
<td>Weekend 5:</td>
<td>Friday - Mon.</td>
<td>Sept. 9 - 12</td>
</tr>
<tr>
<td>Weekend 6:</td>
<td>Friday - Mon.</td>
<td>Sept. 16 - 19</td>
</tr>
<tr>
<td>Weekend 7:</td>
<td>Friday - Mon.</td>
<td>Sept. 23 - 26</td>
</tr>
<tr>
<td>Weekend 8:</td>
<td>Friday - Mon.</td>
<td>Sept. 30 - Oct. 3</td>
</tr>
<tr>
<td>Weekend 9:</td>
<td>Friday - Mon.</td>
<td>Oct. 7 - 10</td>
</tr>
<tr>
<td>Weekend 10:</td>
<td>Friday - Mon.</td>
<td>Oct. 14 - 17</td>
</tr>
</tbody>
</table>

[Sully-Miller photos]