CA4PRS and Traffic Modeling Integration for Highway Rehabilitation
- Case Study on I-15 Devore Reconstruction -

CWZ Traffic Modeling Workshop
March 20-21, 2007

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CA4PRS

(Construction Analysis for Pavement Rehabilitation Strategies)

FHWA pooled fund study (CA, MN, TX, WA)
AASHTO/TIG CAST Promotion
CA4PRS Analysis Framework and Modules

Step 1
- Alternatives
  - Schedule Constructible?
    - No
    - Production (km) Closure Duration
    - Yes
    - HCM (D-C) Model Queue & Delay

Step 2
- Traffic Tolerable?
  - No
  - Total Cost Budget & Scope
  - Yes

Step 3
- Cost Affordable?
  - No
  - PS&E Package Supplementary
  - Yes
- Staging plan Traffic plan
Analysis Parameters
Comparing Alternatives

Scheduling
- Nighttime
- Weekend
- Daytime (shift)
- Continuous
- Mobilization
- Lead-lag Time
- Curing & Cooling

Design
- PCC
- CRCP
- AC Overlay
- Full-depth AC
- Cross-section
- Concrete Mix
- AC Mix

Logistics
- Full Closure
- Partial Closure
- Concurrently
- Sequentially
- Trucks
- Plant
- Crew
PCC Concurrent Work Method
Full Closure of Construction Roadbed

Traffic Roadbed

Construction Roadbed

- Demolition
- AC Base
- PCC Paving

Mob. 0 12 24 36 48 60 72 hour

progress (km)

SB TRAFFIC  NB TRAFFIC

ACCESS  RECONSTRUCTION
PCC Sequential Work Method
Half Closure of Construction Roadbed

Traffic Roadbed

Construction Roadbed

- Demolition
- AC Base
- PCC Paving
- De-mob.
Portland Cement Concrete (JCPC)

Typical Caltrans Pavement Cross-section

<table>
<thead>
<tr>
<th>Existing Profile</th>
<th>New Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONCRETE</td>
<td>CONCRETE</td>
</tr>
<tr>
<td>203mm (8&quot;)</td>
<td>203mm (8&quot;)</td>
</tr>
<tr>
<td>CTB 102mm (4&quot;)</td>
<td>CTB 102mm (4&quot;)</td>
</tr>
<tr>
<td>AB 305mm (12&quot;)</td>
<td>AB 305mm (12&quot;)</td>
</tr>
<tr>
<td>SG</td>
<td>SG</td>
</tr>
</tbody>
</table>

(a) 203 mm Concrete Slab

<table>
<thead>
<tr>
<th>CONCRETE</th>
<th>LCB/ACB</th>
<th>New PCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>205mm (8&quot;)</td>
<td>152mm (6&quot;)</td>
<td>New</td>
</tr>
<tr>
<td>CTB 102mm (4&quot;)</td>
<td></td>
<td>PCC</td>
</tr>
<tr>
<td>AB 305mm (12&quot;)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) 305 mm Concrete Slab

Removal:
- Removed
- Retained

New:
- New PCC
- New Base
Milling and AC Overlay

Typical Caltrans Pavement Cross-section

Existing AC Pavement

<table>
<thead>
<tr>
<th>Layer</th>
<th>Thick.</th>
<th>Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAC-O</td>
<td>25 mm</td>
<td>0.5 hour</td>
</tr>
<tr>
<td>Type C</td>
<td>76 mm</td>
<td>2 hour</td>
</tr>
<tr>
<td>Type C</td>
<td>51 mm</td>
<td>1 hour</td>
</tr>
</tbody>
</table>

Total thick. = 152 mm (6")

Aggregate Base Subgrade

Existing AC Pavement
Implementation Projects
CA4PRS Implementation Projects

I-710 Compton Project  
In development

I-710 Long Beach Project  
2003

I-10 Pomona Project  
1999

I-15 Devore Project  
2004

I-15 Ontario Project  
In development

Use by other sponsoring DOTs
- I-5 Seattle (WA), PCC
- I-494 St. Paul (MN), AC
I-10 Pomona (CA) Project, 2000
I-710 Long Beach (CA) Project, 2002
I-15 Devore 1 (CA) Project, 2004
I-15 Devore 2 Project, 2006
I-15 Devore Experience  
(CA4PRS Demonstration)
I-15 Devore Reconstruction Project
(6-8 lanes PCC pavement built in 1969-1975)
I-15 Devore Daily Traffic Patterns
- Approximately 130,000 ADT (15% trucks)
- Weekdays Commuters + Weekend Leisure

Time of day

Vehicles per hour

Expected CWZ capacity
I-15 Devore Project Summary
Southern California (San Bernardino)

• About 130,000 ADT (15% heavy trucks)
  – Unique traffic pattern: weekday commuter and weekend leisure (to and from Las Vegas)

• Two truck lane reconstruction: 3 miles long
  – for each direction outside truck lane reconstructed, slab replacements in second truck lane
  – Rebuilt with 12” PCC (12-hour mix) with 6” AC base
  – One roadbed full closure with counter-flow traffic
  – Two 9-days continuous closures (24/7 operations)
  – Completed in October and November, 2004

• Saved $6M agency and $2M RUC compared with traditional nighttime closures
## I-15 Devore Pre-Construction Analysis with CA4PRS: Schedule-Traffic-Cost

<table>
<thead>
<tr>
<th>Construction Scenario</th>
<th>Schedule Comparison</th>
<th>Cost Comparison ($M)</th>
<th>Max. Peak Delay (Min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Closures</td>
<td>Closure Hours</td>
<td>User Delay</td>
</tr>
<tr>
<td>One Roadbed Continuous (24/7)</td>
<td>2</td>
<td>400</td>
<td>5.0</td>
</tr>
<tr>
<td>72-Hour Weekday Continuous</td>
<td>8</td>
<td>512</td>
<td>5.0</td>
</tr>
<tr>
<td>55-Hour Weekend Continuous</td>
<td>14</td>
<td>770</td>
<td>14.0</td>
</tr>
<tr>
<td>10-Hour Night-time Closures</td>
<td>220</td>
<td>2,200</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Public reactions has changed 72-hour closures to one-roadbed continuous closures
CA4PRS Demonstration (PCC and AC)
Schedule and Traffic Module (PeMS)

I-15 Devore Project
(Construction Work-zone)
Continuous construction around the clock (24/9)

NB Construction: Oct. 3’rd – 13’th (9 days), 2004
SB Construction: Oct. 23’rd – Nov. 3’rd (9 days), 2004

FHWA Public Roads: Jan/Feb 2007
http://www.fhwa.dot.gov/publicroads/07jan/05.htm
I-15 Devore Pavement Cross-section and Lane-closure Scheme

Old section

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>205 mm</td>
</tr>
<tr>
<td>Cement Treated Base</td>
<td>102 mm</td>
</tr>
<tr>
<td>Aggregate Base</td>
<td>305 mm</td>
</tr>
</tbody>
</table>

New section

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid Strength Concrete</td>
<td>290 mm</td>
</tr>
<tr>
<td>AC Base</td>
<td>152 mm</td>
</tr>
<tr>
<td>Aggregate Base</td>
<td>152 mm</td>
</tr>
<tr>
<td>Subgrade</td>
<td></td>
</tr>
</tbody>
</table>

Construction Access

Segment 1

<table>
<thead>
<tr>
<th>Area</th>
<th>Details</th>
</tr>
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<tbody>
<tr>
<td>South bound</td>
<td>Moveable Barrier</td>
</tr>
<tr>
<td>Movable Change</td>
<td></td>
</tr>
<tr>
<td>North bound</td>
<td>Quick Change</td>
</tr>
</tbody>
</table>

Traffic roadbed

Construction roadbed

Lane Reconstruction Random Slab Replacement

Progressive Staging

SBNB

SBNB

SBNB
Median Cross-over (South end)
Slab Removal (Non-impact Demolition)
Excavation (10” Milling) of Cement Treated Base and Aggregate Base
AC (AR-8000) Base (3” x 2 lifts) Paving
Shuttle Buggy Feeds Concrete for Paving
PCC Paving: Outer & Inner Truck Lanes
Dynamic (3/2) Lane Closure with QCMB

QCMB Operation Video
I-15 Devore Command Center
Roadmap for D8 Traffic Cameras and Signs
Traffic Camera on TV Screen
I-15 Devore Project
(Traffic Modeling Experience)
I-15 Devore: Traffic Analysis Models Integrated with CA4PRS

• Step 1: Demand-Capacity Model (HCM)
  - Road user cost: Compare all scenarios
  - Select the most economical scenario: Total cost
  - Sensitivity for TMP (Demand reduction, CWZ capacity)

• Step 2: Macro Traffic Simulation (FREQ)
  - Focus on the Selected Construction Scenario
  - Baseline for Incentives/disincentives and A+B contract
  - Develop lane closure charts

• Step 3: Microscopic Simulation (PARAMICS)
  - Blocking Freeway Connector: I-210 to I-15 NB
  - Truck restriction during peak hours through CWZ
  - Relocate the junction split location
Sensitivity Analysis (1):  
Demand Reduction: Road User Cost  
Demand-Capacity

- Estimated by D-C model
FREQ Macro-simulation
Segment 1 Northbound Closure (NB traffic)

Before Construction

Free Flow

Demand <= Capacity

Congestion

bottle neck

DAY-1 EXISTING CONDITIONS
Paramics: Macroscopic Simulation Model
Simulation Sensitivity Analysis (1)
Truck Restriction Strategy (during Construction)

<table>
<thead>
<tr>
<th>Segment 1 NB</th>
<th>No Restriction</th>
<th>Restriction</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Flow Rate (vehicle/hour)</td>
<td>1,738</td>
<td>1,598</td>
<td>-8.1</td>
</tr>
<tr>
<td>Total Travel Time (vehicle-hour)</td>
<td>2,796</td>
<td>2,300</td>
<td>-17.7</td>
</tr>
<tr>
<td>Average Travel Time (MM:SS)</td>
<td>24:08</td>
<td>21:35</td>
<td>-10.6</td>
</tr>
<tr>
<td>Average Speed (km/hr) on CWZ</td>
<td>52.0</td>
<td>63.7</td>
<td>+22.5</td>
</tr>
</tbody>
</table>

*Estimated in Paramics simulation.*
## Simulation Sensitivity Analysis (2)
### I-15/I-215 SB Lane Split Strategy

<table>
<thead>
<tr>
<th>Origin To Destination</th>
<th>No Action</th>
<th>Lane-split</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-15 North To I-15 South</td>
<td>Average Travel Time (min.)</td>
<td>32.0</td>
<td>22.8</td>
</tr>
<tr>
<td></td>
<td>Through-traffic (veh/hr)</td>
<td>2,492</td>
<td>2,948</td>
</tr>
<tr>
<td></td>
<td>Max. Queue (km)</td>
<td>5.5</td>
<td>2.0</td>
</tr>
<tr>
<td>I-15 North To I-215 South</td>
<td>Average Travel Time (min.)</td>
<td>23.1</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>Through-traffic (veh/hr)</td>
<td>1,752</td>
<td>1,993</td>
</tr>
<tr>
<td></td>
<td>Max. Queue (km)</td>
<td>5.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>
## Comparison of Traffic Models in Analysis

**CA4PRS (Demand-Capacity), FREQ, and Paramics**

<table>
<thead>
<tr>
<th>Traffic Analysis Tool</th>
<th>Efforts (weeks)</th>
<th>Total Delay (vehicle-hours)</th>
<th>Max. Delay Per closure (min.)</th>
<th>Max. Queue (mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NB</td>
<td>SB</td>
</tr>
<tr>
<td>CA4PRS (HCM)</td>
<td>1</td>
<td>618,000</td>
<td>75</td>
<td>40</td>
</tr>
<tr>
<td>FREQ</td>
<td>3</td>
<td>631,000</td>
<td>47</td>
<td>35</td>
</tr>
<tr>
<td>PARAMICS</td>
<td>20</td>
<td>-(*)</td>
<td>48</td>
<td>26</td>
</tr>
</tbody>
</table>

* Reference: NB peak-hour delay = 2,863 v-h for Paramics vs 3,250 v-h for FreQ
I-15 Devore Project
(Automated Work-zone Information Systems)
AWIS: Automatic work-zone information systems
## Displayed Messages on PCMS Units

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>N B</th>
<th>S B</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>TRAVEL TIME NORMAL</td>
<td>TRAVEL TIME NORMAL</td>
</tr>
<tr>
<td>#2</td>
<td>TRAVEL TIME 20MIN</td>
<td>TRAVEL TIME 25MIN</td>
</tr>
<tr>
<td>#3</td>
<td>TRAVEL TIME 30MIN</td>
<td>TRAVEL TIME 35MIN</td>
</tr>
<tr>
<td>#4</td>
<td>TRAVEL TIME 40MIN DETOUR 10E=&gt;215N</td>
<td>TRAVEL TIME 45MIN DETOUR 215S</td>
</tr>
<tr>
<td>#5</td>
<td>TRAVEL TIME 50MIN DETOUR 10E=&gt;215N</td>
<td>TRAVEL TIME 55MIN DETOUR 215S</td>
</tr>
<tr>
<td>#6</td>
<td>TRAVEL TIME 60+MIN DETOUR 10E=&gt;215N</td>
<td>TRAVEL TIME 65+MIN DETOUR 215S</td>
</tr>
</tbody>
</table>
Detour Sign toward I-10 East on Permanent CMS

NORTH 15 DEVORE
CONGESTED
USE 10E TO 215N
AWIS Server Screen in Command Center
Travel Time Message Sign Display:

I 15 NB RTE 210 TO I 215
TRAVEL TIME NORMAL

(Travel time message generated on: Wed Oct 13 12:41:00 2004)
## Traffic Measurement Summary (Before- versus During-construction)

<table>
<thead>
<tr>
<th></th>
<th>Route</th>
<th>ADT</th>
<th>Peaks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CWZ</strong></td>
<td>I-15 NB</td>
<td>-16%</td>
<td>-17%</td>
</tr>
<tr>
<td></td>
<td>I-15 SB</td>
<td>-19%</td>
<td>-18%</td>
</tr>
<tr>
<td><strong>Detours</strong></td>
<td>I-215 SB</td>
<td>+15%</td>
<td>+16%</td>
</tr>
<tr>
<td></td>
<td>I-10 EB</td>
<td>+10%</td>
<td>+36%</td>
</tr>
<tr>
<td></td>
<td>I-215 NB</td>
<td>+3%</td>
<td>+12%</td>
</tr>
<tr>
<td><strong>Arterials</strong></td>
<td>Lytle Creek &amp; Glen Helen</td>
<td>+7%</td>
<td>+6%</td>
</tr>
<tr>
<td></td>
<td>Major Intersections</td>
<td>+2%</td>
<td>+5%</td>
</tr>
</tbody>
</table>
I-15 Devore Project
(Public Outreach and Perception Changes)
Public Outreach to News Media
The I-15 Devore website has a total of about 100,000 visits (page views) from August through December, 2004.
Do you typically use the I-15 Freeway through Devore?

- Daily on weekdays: 94%
- Occasional weekdays: 3%
- 1-2 trips per months: 1%
- Weekend: 2%

Do you support 72-hour weekday closures?

- No, Cancel project: 14%
- No, Nighttime or weekend: 64%
- Continuous closures: 7%
- Adding lane: 4%
- Other Negatives: 11%
I-15 Devore Web-Surveys: Travel Mode Changes

Before-construction

- Alternative routes: 19.15%
- Carpool or public transit: 9.58%
- Departure time: 10.70%
- Not at all: 60.56%

During-construction

- Alternative routes: 23.88%
- Carpool or public transit: 3.73%
- Departure time: 40.30%
- Not at all: 32.09%

Travel Modes
- Alternative routes
- Carpool or public transit
- Departure time
- Not at all
Did you find AWIS travel message signs “Accurate”?

Did you utilize Real-time Traffic Map on our website?
Do you support future “Rapid-Rehab” projects?

Before-construction:
- No: 56%
- Yes: 44%

After-construction:
- No: 30%
- Yes: 70%

Do you support I-15 Devore “Rapid Rehab” approach?
CA4PRS Outreach & Enhancement

• Outreach: Publications
  – Brochure
  – TR News (May/June 2004)
  – FHWA FOCUS (June 2006)
  – TRB and ASCE Journals

• V2.0: Cost Module
• V2.5: Interchange and Widening
• V3.0: Bridge Replacement
• V4.0: Life Cycle Cost Analysis (Realcost)
Thank you!

More Information?

• Contact
  – Keith Platte (AASHTO)
    • Tel: (202) 624-7830; Email: kplatte@aashto.org
  – Michael Samadian (Caltrans)
    • Tel: (916) 324-2048; Email: Michael_M_Samadian@dot.ca.gov
  – Dr. E.B. Lee (UC Berkeley)
    • (510) 665-3637; Email: eblee@berkeley.edu
  – Dr. Nadarajah Sivaneswaran (Siva) (FHWA)
    • (202) 493-3147; Email: n.sivaneswaran@dot.gov

• CA4PRS Web (Caltrans) or “CA4PRS” in Google
  http://www.dot.ca.gov/research/roadway/ca4prs/index.htm
### Paramics: LINK HEADWAY FACTOR SENSITIVITY ANALYSIS

<table>
<thead>
<tr>
<th>Link Headway Factor</th>
<th>Resulting Capacity (in veh/hr/ln)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>2,500</td>
</tr>
<tr>
<td>1.2</td>
<td>2,350</td>
</tr>
<tr>
<td>1.5</td>
<td>2,000</td>
</tr>
<tr>
<td>1.8</td>
<td>1,600</td>
</tr>
<tr>
<td><strong>2.0</strong></td>
<td><strong>1,500</strong></td>
</tr>
<tr>
<td>2.5</td>
<td>1,300</td>
</tr>
</tbody>
</table>
Deteriorated Pavement: I-10 Pomona (LA)
Caltrans LLPRS and CA4PRS

- **LLPRS: Long-life Pavement Rehabilitation Strategies**
  - Rebuild 2,500 lane-km of deteriorated roadways
  - Criteria: High traffic volume (ex. 150,000 ADT) or heavy trucks
  - Candidate projects are mostly PCC pavements in the LA & SF

- **LLPRS Objectives and Approach**
  - Provide 30-40 years of design-life with minimum maintenance
  - Get-in Get-out & Stay-out: FHWA AASHTO TRB collaboration
  - Minimizing closure impact on traffic delay and local business

- **CA4PRS: A tool for Decision-making Process**
  - FHWA pooled fund study (CA, MN, TX, WA)
  - Software tool to calculate construction duration and traffic delay for different strategies
  - Team-building, Department approval, and Public justification
Simulation calibration: Travel-time before-closure: Simulation vs. Tech-run

I-15 NB mainline travel time: Tach-run vs. Paramics

travel time (mm:ss)

02:53 04:19 05:46 07:12 08:38 10:05 11:31 12:58 14:24

02:53 04:19 05:46 07:12 08:38 10:05 11:31 12:58 14:24

2:00-3:00 3:00-3:20 3:40-4:00 4:00-4:20 4:40-5:00 5:00-5:20 5:20-5:40 5:40-6:00 6:00-6:20

tach-run  Paramics
Simulation Estimated Speed  
(before vs. during-construction)

<table>
<thead>
<tr>
<th>I-15 NB</th>
<th>PARAMICS SPEED CONTOUR - Base Run (Monday)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section number</td>
<td>0</td>
</tr>
<tr>
<td>Interval Start</td>
<td>15:00</td>
</tr>
<tr>
<td></td>
<td>15:20</td>
</tr>
<tr>
<td></td>
<td>15:40</td>
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<td></td>
<td>16:00</td>
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</tr>
<tr>
<td></td>
<td>18:40</td>
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</table>

<table>
<thead>
<tr>
<th>I-15 NB</th>
<th>CONSTRUCTION (SEG1NB) SPEED CONTOUR (Monday)</th>
</tr>
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<tbody>
<tr>
<td>Section number</td>
<td>0</td>
</tr>
<tr>
<td>Interval Start</td>
<td>15:00</td>
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<tr>
<td></td>
<td>15:20</td>
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