Federal Highway Administration
CA4PRS Peer Exchange Workshop
St. Louis, MO

CA4PRS Application for Determination of Incentive/Disincentive Dollar Amount

Jae H. Pyeon
Assistant Professor
Department of Civil and Environmental Engineering
San Jose State University

E. B. Lee
Associate Researcher
Institute of Transportation Studies (UC-PRC)
University of California at Berkeley
Agenda

• Overview of I/D Contracting
  – I/D provisions for Early Completion
  – Issues for Implementation of I/D Contracting
  – Evaluation of I/D Project Performance
  – Selection of I/D Projects
  – Determination of I/D Dollar Amount

• Case Study
  – I-80 Sacramento Project

• Recommendations for Future Study
Improving Time Performance of Highway Construction Contracts

INCENTIVE APPLICATION STRATEGY

SELECTION OF INCENTIVE PROJECTS
- Quality of contract documents
- Rating scheme

SELECTION OF CONTRACTORS & DESIGNERS
- Classification
- Barriers to implement SUE technology

APPROPRIATE SUE LEVEL
- Cost-Benefit analysis

APPROPRIATE INCENTIVE AMOUNT
- User cost analysis
- Best practice

DELAY PREVENTION STRATEGY

Implementing details

BEST PRACTICE FOR AVOIDING UTILITY RELOCATION DELAYS

Improving Time Performance of Highway Construction Contracts

(Pyeon 2005)
Average Time and Cost Savings: I/D vs. Non-I/D

(Pyeon 2010)
Decision Support Model to Predict Project Performance of I/D Contracts

I/D CONTRACTING PROJECT SIMULATION: Performance Index

PERFORMANCE INDEX SELECTION

TIME PERFORMANCE

- OTPI: Time Performance Index Based on Original Contract Duration
  \[ = \frac{\text{Final Duration} - \text{Original Contract Duration}}{\text{Original Contract Duration}} \]

- PTPi: Time Performance Index Based on Present Contract Duration
  \[ = \frac{\text{Final Duration} - \text{Present Contract Duration}}{\text{Present Contract Duration}} \]

COST PERFORMANCE

- OCPI: Cost Performance Index Based on Original Contract Cost
  \[ = \frac{\text{Final Cost} - \text{Original Contract Cost}}{\text{Original Contract Cost}} \]

- PCPI: Cost Performance Index Based on Present Contract Cost
  \[ = \frac{\text{Final Cost} - \text{Present Contract Cost}}{\text{Present Contract Cost}} \]

I/D CONTRACTING PROJECT SIMULATION: Project Variables

PROJECT VARIABLE SELECTION

- PROJECT TYPE
- CONTRACT TYPE
- DISTRICT
- PROJECT SIZE
- PROJECT LENGTH
- MAX. INCENTIVE PROPOSED
- DAILY INCENTIVE AMOUNT

START  < BACK  NEXT >  CANCEL
Simulation Results

Simulation Results for Project No. 412481

Regression Coefficients

Max Incentive Proposed: Medium
District: 06
Project Type: Resurfacing/Paving
Project Length: Above Average
Contract Type: I/D
Project Size: Medium
Daily Incentive Amount: Large

Coefficient Value

Probability

OTPI

5.0%
90.0%
0.195
0.433
5.0%

Frequency

OTPI

0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5.0%
90.0%
5.0%

INDEX : OTPI
Systematic Procedures to Determine I/D Dollar Amount Using CA4PRS

- **STEP 1**: Set up a schedule baseline
- **STEP 2**: Estimate the impact of work-zone on traveling public
- **STEP 3**: Use a factor to discount the value of the road user cost to match with agency cost
- **STEP 4**: Set up the maximum incentive amount using the closure incentive bonus and the achievable maximum number of closures
Case Study:
I-80 Sacramento Project

• **Purpose of the project**
  – To rehabilitate about 8.6 miles of the existing roadway on I-80 in the City of Sacramento

• **Need for the project**
  – The concrete pavement has deteriorated in both directions
  – The Nos. 2 and 3 lanes are currently at first- and third-stage cracking and are beyond regular maintenance repair
  – The outside shoulder is spalling and separating from the mainline roadway

• **Annual Average Daily Traffic (AADT) on I-80 with three lanes**
  – Each direction is app. 140,000
  – Expected to increase to app. 200,000 by 2030
    • With roughly 10% of trucks

• **Total project costs** for all elements of the project
  – Currently estimated at $93.1 million

• **CA4PRS** was used as a Value-Engineering analysis tool
  – Construction is expected to start 2011
Case Study: I-80 Sacramento Project

- The median is to be widened 17 feet with asphalt concrete pavement in both directions
  - Designed for future HOV lanes in order to shift traffic during construction as primary detours

- Various random failed concrete slabs in the No. 1 lane will be replaced

- The Nos. 2 and 3 lanes will be replaced completely utilizing jointed plain concrete pavement (JPCP) with about 14-inch concrete slabs and 4-inch AC base

- The No. 3 lane is to be paved 14 feet wide
  - Will provide lateral support for the lane
Case Study: I-80 Sacramento Project

• Non-stop construction
  – About 10 lane-mile segments on the mainline near off- and on-ramp areas at 7 interchanges are selected for weekend works using 12-hour curing-time rapid strength concrete

• Whereas majority of pavements in other areas are rebuilt using normal concrete with daytime-shift works behind K-rails with shifted detour traffic to the median side
I/D Dollar Amount Decision

• **STEP 1: Set up a schedule baseline**
  – Total number of weekend closures needed for the pavement rehabilitation, estimated from the CA4PRS schedule module
  – Inputs for CA4PRS Schedule Analysis
    • Project Details
    • Schedule Analysis
      – Closure Option, Section Profile, Lane Width, Curing Time, Working Method
I-80 Sacramento Project:
CA4PRS Schedule Analysis Input Screen (1)

Project Description:
Caltrans District 3 - I-50 Contiuu Improvement (HCT widening and Pavement Reconstruction) Project

Analyst Name: Jae H. Pyeon and E. E. Lee

Route Name: I-80 West Sacramento

Begin MP: 0.30

End MP: 6.30

Objective/Scope (lane miles): 10.80

Location: West Sacramento, Sacramento County, CA

500 ft (150 m) -> Total = 2000 ft (600 m)
Weekend Scope = 2000 ft x 2 lanes x 7 Interchanges x 2 Direction = 10.6 lane-miles (17 lane-km)
20-year Design = 1.15 JTCP / 0.85 FHA

Project Notes:
3 lanes open (after median widening) with one-lane counter-flow traffic

Save  Close
I-80 Sacramento Project:
CA4PRS Schedule Analysis Output Screen

Resource Utilization - 8-1. PCC I-80 Sacramento Project Weekend - 7 Interchanges Area (ID Analysis)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Allocated</th>
<th>Utilized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demolition Hauling Truck (per hour per ton)</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Base Delivery Truck (per hour)</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Batch Plant (cu-yd/hour)</td>
<td>117.7</td>
<td>70.6</td>
</tr>
<tr>
<td>Concrete Delivery Truck (per hour)</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Power Speed (ft/min)</td>
<td>6.6</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Construction Window: Weekend Closure (55 Hours/Weekend)
Working Method: Sequential Single Lane (T1)
Season Profile: PECP. 12.0 inches, New Base 4.2 inches
Curing Time: 12-Hours
Objective/Scope (lane-miles): 10.60
Closure Production (lane-miles): 0.52

Closure Production (c/ft-miles): 0.53

Construction Windows Needed To Meet Objective/Scope: 20.15
Demolition Quantity (cu. yd): 1851.6
New Base Quantity (cu. yd): 432.0
Concrete Quantity (cu. yd): 1419.6
Constraint Resource: Demolition Hauling Truck, Base Delivery Truck, Concrete Delivery Truck
Demolition to Paving: 1:1.50
Demolition Hours: 13.4
Paving Hours: 201
Schedule Analysis Results

• About Twenty 55-hour weekend closures in total
  – The CA4PRS schedule analysis
    • Pavement rehabilitation of I-80 for the seven interchanges area
  – Mathematically derived from:
    • The total rehabilitation scope of about 10.6 lane-mile
    • The typical rehabilitation progress of about half-mile (0.53 lane-mile) per weekend closure

• It is recommended to add about four weekend closures for schedule contingency
  – Based on Caltrans experiences on the similar previous pavement rehabilitation projects

• It might be practical to utilize these four extra weekend closures as the source of the maximum incentive closures
I/D Dollar Amount Decision

• **STEP 2: Estimate the impact of work-zone on traveling public**
  – Road user cost per weekend closure using the Caltrans standard hourly time value
    • $11.51 per car and $27.83 per truck
  – Inputs for CA4PRS WZ User Delay Cost Analysis
    • Roadway Capacity Information
      – Before and During Construction
    • Traffic Information
      – Traffic Demand
      – Vehicle Costs
## I-80 Sacramento Project: CA4PRS WZ User Delay Cost Analysis Output Screen

### Work-Zone Traffic Analysis - 8-1. PCC I-80 Sacramento Project Weekend - 7 Interchanges Area (I/O Analysis)

#### Summary

<table>
<thead>
<tr>
<th>Item</th>
<th>Before Construction</th>
<th>During Construction</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eastbound</td>
<td>Westbound</td>
<td>Eastbound</td>
</tr>
<tr>
<td>Maximum Delay (min)</td>
<td>u.u</td>
<td>u.u</td>
<td>4.7</td>
</tr>
<tr>
<td>Maximum Queue (files)</td>
<td>n.n</td>
<td>n.n</td>
<td>1.0</td>
</tr>
<tr>
<td>Minimum Speed (mph)</td>
<td>65.0</td>
<td>65.0</td>
<td>13.9</td>
</tr>
<tr>
<td>Daily User Cost ($)</td>
<td>$0</td>
<td>$0</td>
<td>$31,522</td>
</tr>
<tr>
<td>Per Closure User Cost ($)</td>
<td>$0</td>
<td>$0</td>
<td>$33,045</td>
</tr>
<tr>
<td>Total User Cost per Direction ($)</td>
<td>$0</td>
<td>$0</td>
<td>$756,536</td>
</tr>
<tr>
<td>Total User Cost ($)</td>
<td>$0</td>
<td>$3,425,230</td>
<td>$5,125,280</td>
</tr>
</tbody>
</table>

**Note:** The total user cost difference is highlighted in red.
WZ User Delay Cost

• The CA4PRS Traffic module shows that each 55-hour weekend closure causes app. $300,000
  – App. $60,000 for the east bound traffic
  – App. $220,000 for the west bound traffic

• This means that if the contractor reduce one weekend closure, it will save about 1/3 million dollar road user cost
I/D Dollar Amount Decision

- **STEP 3: Use a factor to discount the value of the road user cost to match with agency cost**
  - Usually state DOTs treat the value of $1 road user cost less than their real cost (I/D) $1
  - A discount factor might be used to convert the closure road user cost to the closure I/D payment to the contractor
    - The discount factor is usually in the range of 1 through 5
    - Depends on the project situation
      - Lane closure impact and political priority of the project completion
Discount Factor

• I-15 Devore project
  – A discount factor of 4 is used → 75% discount

• I-80 Sacramento project
  – If “3” is used as the discount factor
    • Then the closure I/D amount should be one-third of the closure road user cost of app. $300,000
    • $100,000 I/D amount for one weekend closure
  – If the discount factor 4 is used
    • Then the I/D amount is $75,000 per weekend closure
      – i.e., $300,000/4=$75,000.
I/D Dollar Amount Decision

• **STEP 4: Set up the maximum incentive amount using the closure incentive bonus and the achievable maximum number of closures**
  
  – Total 4 weekend closures for a contingency
    
    • Added on top of the baseline closure number 20 weekends
    
    • The maximum incentive amount (as a cap) can be limited to:
      
      – DF=3: $400,0000 ($100,000 per closure X 4 closures)
      – DF=4: $300,0000 ($75,000 per closure X 4 closures)

  – No limitation for the maximum disincentive (penalty) amount is recommended
    
    • To make sure that the project completion is not out of agency’s control

  – The cap of the incentive payment should be also considered with respect to the project budget limit
Conclusions and Recommendations

- **Agency cost saving** from the closure number reduction should be included in the incentive amount calculation
  - Less closures require less **traffic handling costs**
    - Moveable concrete barriers and detour and advisory signs
  - Less closures will reduce **the project and TMP costs**
    - Work-zone incident management, so-called COZEERP (construction zone enhanced enforcement program) to provide California highway patrol service
    - About $95 per hour per officer and towing services (freeway patrol service)
Conclusions and Recommendations

• Less closures also saves agency’s supporting cost
  – Field engineer’s time on site and administration cost can be reduced proportionally
    • Usually about 5 engineers and inspectors per shift and 3 shift per day is needed to the non-stop construction on weekend

• The contractors might bear additional cost
  – Probably be enough triggered by the incentive bonus to shorten closures number
  – The contractors need to utilize more resources
    • Equipment, plants, and labors on site to achieve more construction production

• In fact, the contractors can get some advantage in their cost saving with less closures as they can reduce their project overhead cost
Future Study

• More advanced Incentive/Disincentive amount assessment procedure and calculation module should be developed
  – To cover not only the baseline of the road user cost but also other factors
    • Project cost saving or cost results from the traffic costs, agency supporting cost, contractors’ cost, etc.

• More systematic procedures to determine a Discount Factor

• CA4PRS can be expanded to accommodate the analytical capability of more comprehensive I/D dollar amount calculation with the additional factors discussed above
Any Questions?