I-15 Ontario Project: Technology Implementation for Accelerated Concrete Pavement Rehabilitation

Eul-Bum Lee,[1] Seungwook Lim,[2] Jonathan C. Hartog,[3] and David K. Thomas[4]

ABSTRACT

As highway agencies across the country attempt to balance rebuild existing highways while they reduce congestion and user delays and improving safety, the use of accelerated highway rehabilitation methods has become a necessity. This has been the case for the California Department of Transportation (Caltrans), which recently undertook a major concrete pavement rehabilitation project on I-15 near the city of Ontario, California. The I-15 Ontario Corridor carries about 200,000 ADT with 4-6 lanes each direction, about 6 percent of which is heavy trucks during peak hours. The size of the project is approximately $86 million in the engineer's estimate cost. It is scheduled to start construction on February 2009 and to be completed by April 2010. The major scope of the project is the replacement of concrete pavement on two outside lanes in both directions along the 7.5-km (4.7-mi) stretch. Due to a complexity of construction access and rehabilitation process, the project was designed to implement various types of concrete pavement rehabilitation methods. Basically, the old concrete pavement will be replaced with one of: (1) normal portland cement concrete (28-day curing-time mix); (2) rapid strength concrete (12-hour curing-time mix); (3) fast-setting hydraulic cement concrete (4-hour curing-time mix); or (4) precast concrete panel. Construction scheduling and analysis program CA4PRS (Construction Analysis for Pavement Rehabilitation Strategies) was used to demonstrate that the combination of the rehabilitation methods was the most cost-effective strategy on project to shorten construction duration, to minimize lane closure impact, and to achieve longer-life pavement design. To take the advantage of unique experimental technologies being adopted on the I-15 Ontario Project, Caltrans plans to conduct field monitoring studies with the FHWA and UC Berkeley researchers to compare rehabilitation process and progress, and work-zone traffic impact between the design and material types.

HIGHWAY REHABILITATION

Most of the major highways in the United States were built during the 1960s and 1970s and have exceeded their design lives, which has motivated the transportation agencies responsible for them to shift focus from construction of new highways to the rehabilitation of existing facilities. Because highway rehabilitation projects often cause congestion, safety concerns, and limited access for road users, agencies face a challenge in finding economical ways to renew

[1] Eul-Bum Lee, Ph.D., P.E., PMP, Associate Researcher, Pavement Research Center, University of California at Berkeley, 109 McLaughlin Hall, Berkeley, CA 94720; phone: 510-665-3637; email: eblee@berkeley.edu.

[2] Seungwook Lim, Ph.D., P.E., Research Engineer, Division of Research and Innovation, California Department of Transportation, 1101RSt., Sacramento, CA 95811; email: s.david.lim@dot.ca.gov

[3] Jonathan C. Hartog, P.E., Senior Transportation Engineer, District 8, California Department of Transportation, 464 W. Fourth St., 6th Floor, San Bernardino, CA 92401; email: jonathan_c_den_hartog@dot.ca.gov

[4] David K. Thomas, P.E., Senior Supervising Engineer (PE), Parsons Brinckerhoff Quade and Douglas, Inc., Suite 210, 685 East Carnegie Dr., San Bernardino, CA 92408; email: thomasd@pbworld.com

deteriorating roadways in metropolitan areas. It is estimated that the annual costs to drivers, businesses, and transportation agencies incurred by highway construction traffic delays total $43 billion, $21 billion of which is in extra fuel consumption (Edwards 1998). The California Trucking Association estimates that the impact of early opening of freeways saves their "commercial operators more than $250 per truck trip or $500,000 per day" in trucking costs (Carr 1994).

Severe traffic disruption at construction work zones on urban highway networks is the primary source of conflict between transportation agencies and abutting communities. The frequent conflicts among these parties have brought to the fore the need to expedite construction to ameliorate the impact on motorists and affected businesses. To expedite construction, the Federal Highway Administration (FHWA) and the Transportation Research Board have recommended experimenting with new approaches that are believed to have the potential to reduce construction time (Herbsman and Glagola 1998). However, an innovative accelerated construction approach to urban highway pavement projects, typically requiring extended closures, might not be accepted by the public without a substantial public outreach effort.

In 1998, the California Department of Transportation (Caltrans) initiated the Long-Life Pavement Rehabilitation Strategies (LLPRS) program to rebuild aging and deteriorating pavements in the urban network. The LLPRS program was initiated because most State highways have exceeded their 20-year design lives and will require rehabilitation to maintain safety and function. The obstacles of highway rehabilitation, including significant costs and work zone delays, demonstrate the need for effective planning of highway closures to ensure that the most appropriate alternative is selected. Caltrans has successfully demonstrated the advantage of accelerated pavement rehabilitation on its LLPRS projects in urban highway networks, including I-10 Pomona concrete rehabilitation project (2000), I-710 Long Beach AC rehabilitation project (2002), and I-15 Devore concrete rehabilitation project (2004).

I-15 ONTARIO PROJECT

Project Overview

The I-15 Ontario Project is a 7.5-km (4.7-mi) pavement rehabilitation project on the Interstate highway I-15 near the city of Ontario, about 40 mi (64 km) east of Los Angeles, in Riverside County. The project section with a total of about 40 lane-mi (64 lane-km) of rehabilitation begins at the I-15/Route-60 junction (KP 82.8, PM 51.4) and continues across the San Bernardino/Riverside County line to Seventh Street (KP 6.1, PM 3.8), just north of the I-10 / I-15 interchange. Figure 1 shows the project location. The I-15 Ontario corridor carries about 200,000 average daily traffic on its 4 to 6 lanes each direction with about 6 percent heavy trucks during peak hours.

The project proposes to rehabilitate concrete pavement sections of the two outside lanes in both directions along with interchange ramps, freeway-to-freeway connectors, and asphalt concrete (AC) shoulders. Other major features of the project include widening the inside shoulder, widening the median roadway and structure crossings to accommodate traffic detours during construction, and pavement grinding of all lanes. To replace the two outside lanes during rehabilitation, the mainline traffic needs to be shifted. A temporary two-lane detour will be created in the median by paving the median and widening several bridge structures (Figure 2). This widened median temporary detour with lane shifts during construction will be used for the majority of the project area except in some specific locations (more details are described in the following sections).

The following four pavement rehabilitation types using different concrete materials are designed to replace the existing concrete pavement (9-in. [229-mm] slab on top of a 4-in. [102-mm] cement-treated base and aggregate base) on the I-15 Ontario project. Details of the respective rehabilitation methods are discussed in the following sections.

- Portland cement concrete (PCC) pavement: about 25 lane-km (16 lane-mi)
- Rapid-strength concrete (RSC) pavement: about 12 lane-km (7 lane-mi)
- Precast pavement: about 3 lane-km (2 lane-mi)
- Fast-setting hydraulic cement concrete (FSHCC) pavement: about 5 lane-km (3 lane-mi)

The selection of the pavement type and material mainly depends on the rehabilitation location, taking into account lane closures for traffic control and construction access. Caltrans engineers believe that traditional rehabilitation practice in California would repair the pavement in small sections at a time using standard FSHCC with partial-lane closures during nighttime. This nighttime rehabilitation method is characterized by low production per closure, more expensive material cost, and a less durable pavement (15–20 years in pavement design life).

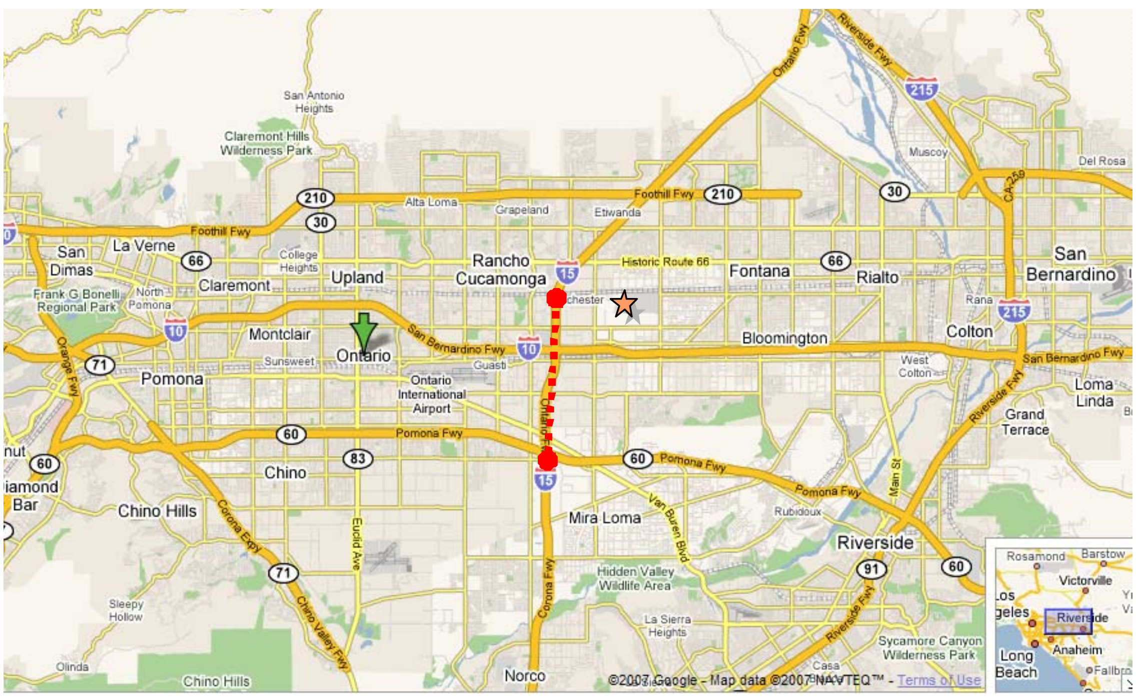

Figure 1. I-15 Ontario rehabilitation project location and boundary.

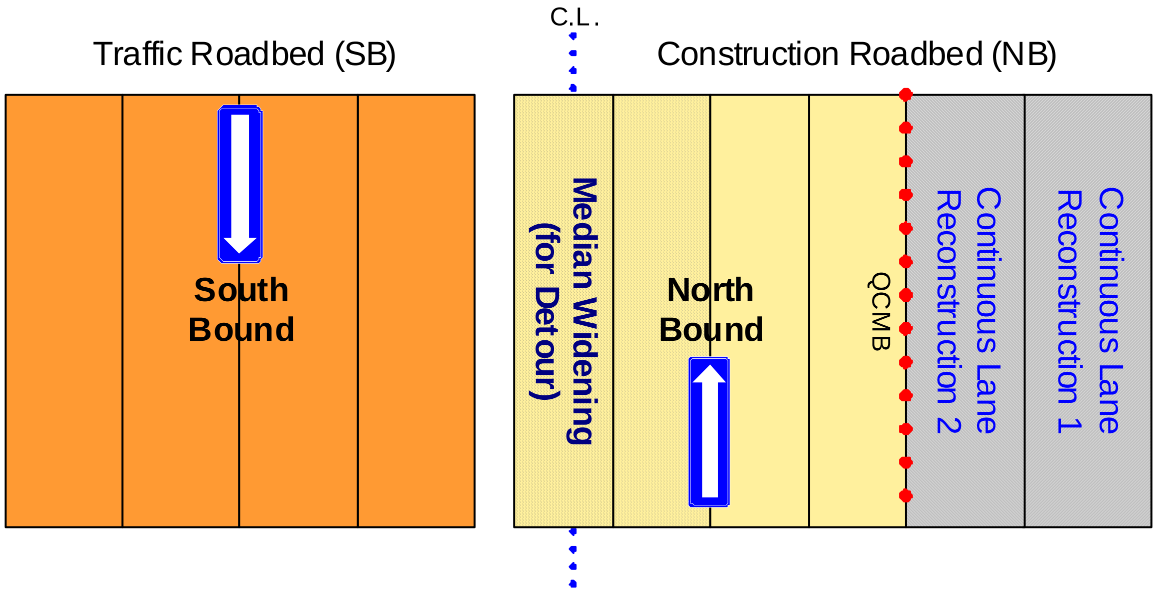

Figure 2. Plan view of the construction roadbed (NB) with two lanes shifted to the widened median for rehabilitation of the outer two lanes.

Rehabilitation Construction Scheme

It is estimated that the traveling public will be impacted by construction for 260 days total (not including the duration of the median detour widening behind K-rail without lane closures). This number only includes days where temporary reductions in the number of travel lanes are required and weekend full-connector closures are in place. The total length of the construction contract is estimated to be about 410 working days (about 2 years of construction). The overall construction contract will impact all hours of the day and week. Normal construction operations will occur from 7:00 a.m. to 3:30 p.m. protected by temporary railing. Traffic impact during this time will be minimal with traffic shift to the widened median, and will occur in the form of reduced lane widths and/or no shoulders. Rehabilitation work during nighttime lane closures from 9 p.m. to 4:00 a.m. Monday through Thursday includes pavement grinding, random slab replacement, shoulder rehabilitation, precast panel replacement, and bridge approach slab replacements. Weekend closures from 10:00 p.m. Friday to 4:00 a.m. Monday will be used for rehabilitation of freeway-to-freeway connectors, precast panel replacement, and mainline weaving areas.

Extensive public outreach will be arranged to keep the public informed of the latest closures and construction progress in order to minimize inconvenience to the public. Some of these outreach efforts include brochures and mailers, a project Web page linked from the district's home page, media releases, public meetings, and changeable message signs deployed within and around the construction limits. Caltrans will also be working closely with the affected cities of Rancho Cucamonga and Ontario and with the counties of San Bernardino and Riverside to minimize the impacts to local arterials during construction.

VARIOUS REHABILITATION METHODS

PCC Rehabilitation

Typically, pavement on the two outside truck lanes will be replaced with a new 12-in. (305-mm) PCC slab and new 6-in. (152-mm) AC base, as long as the roadway has enough space to shift main lanes traffic to the widened median. The rehabilitation will take place behind K-rails during daytime with two lanes closed. However, the roadway during PCC rehabilitation will still have a minimum four lanes open as the median will be widened with concrete before main-lane rehabilitation for detours. As there is no lane closure impact with shifted traffic using the median detour, the contractor is allowed to use normal PCC (type II), which requires days or weeks for curing before opening to traffic. However, the total estimated cost of the median widening is about $8 million ($1 million for pavement widening and $7 million for bridge widening), which is still cheaper than other rehabilitation types (like FSHCC rehabilitation during nighttime) considering savings in agency cost and traffic delay cost (as discussed later). The widened median pavement will be reserved for a HOV lane in the future (probably about 10 years after the rehabilitation project is done).

Demolition of the existing concrete pavement will be done first, and the 6-in. (152-mm) AC base will be placed before paving the new 12-in. (305-mm) PCC slab. The PCC rehabilitation will be applied to the areas between the interchanges without major in and out traffic. According to the Caltrans historical bid database, the average unit price of PCC rehabilitation including demolition in California is about $\$200/m^3$ (Caltrans 2007).

Precast Rehabilitation

To reduce the length of construction time impacting the traffic and traffic delays as a result of these restrictive areas, and to provide a high-quality, long-lasting pavement, it is proposed to apply precast slab replacement method in these areas. The precast method will allow the contractor to perform the continuous lane replacement quickly during nighttime or weekend closures while maintaining construction quality and minimizing traffic delays. A stretch of concrete pavement about 3 lane-km (2 lane-mi) long was selected to receive precast rehabilitation. Typically, the old 9-in. (229-mm) PCC slab will be removed and replaced with the same thickness of precast on top of a newly placed thin bedding with fine sands for better contact with the precast slab.

There are two types of precast rehabilitation on the project: continuous lane replacement and random slab replacement, which will be selected depending on the conditions of old PCC pavement. Majority of precast rehabilitation areas will be replaced with precast panels for the whole lane, as so-called continuous precast lane replacement. This will happen during 55-hour weekends with full closures of the area on auxiliary lanes (but through traffic on main lanes are open, as the same as the rapid-strength RSC rehabilitation). Estimated unit price (measured by area) of precast replacement in California is about $\$300/m^2$, which is equivalent to a volume price of $\$1,400/m^3$.

The precast panels are designed and manufactured under ideal conditions for long-term durability. Coupled with the dowel bar reinforcing at each transverse joint, the slabs are fully supported with a precisely graded subgrade and bedding grout that could minimize joint differentials and provide a longer lasting, smoother profile. As such, the precast rehabilitation is expected to substantially reduce the need for roadway maintenance and to generate a reliable stretch of roadway.

In a separate previous study, FHWA/Caltrans and the University of California Pavement Research center conducted accelerated loading tests with a heavy vehicle simulator (HVS) on a test strip (see Figure 3 and Figure 4) near the I-15/ Route-210 interchange to evaluate the performance and durability of precast panels (Kohler et al. 2008). Test results appeared to support an anticipated life span of over 30 years for the precast panel. Recommended performance goals in smoothness regarding the implementation of the precast panel replacement technology is less than 48 in/mi (768 mm/km) as measured by International Roughness Index (IRI). More specifically, the precast concrete tested on the study, the Super-Slab system, seems able to withstand 24 hours of highway traffic (at least 88,000 equivalent single-axle loads [ESALs]) in the ungrouted condition. From the HVS tests, there is no evidence to believe the Super-Slab system would fail before 140 million ESALs (Techtransfer 2008).

Although the initial cost for precast replacement is higher than other traditional rehabilitation methods, cost savings are realized due to the extended life of precast panels and lower life-cycle costs than those for traditional rehabilitation strategies. Furthermore, the reduced construction time translates to a reduction in the amount of time in which the traveling public is impacted by construction activities. This results in a lower road-user cost from construction delays.

Figure 3. The construction the HVS testing-site for the precast pavement rehabilitation for the I-15 Ontario project.

Figure 4. Accelerated pavement testing using HVS on the precast panels for the I-15 Ontario project.

Rapid-Strength-Concrete Rehabilitation

Based on Caltrans' experience and practice on previous accelerated urban concrete pavement rehabilitation projects such as the I-15 Devore rehabilitation project, a special concrete mix using Type III cement, called rapid-strength concrete or RSC in California, will be used for some specific areas on the I-15 Ontario project. An RSC mix makes it possible to open the project to traffic 12 hours after its placement while still allowing for slipform paving (Long-life 2007). Specific areas such as auxiliary (accelerating or decelerating) lanes to/from ramps and freeway-to-freeway connectors will receive pavement rehabilitation using RSC, which earns 400 lbf/in^2 (2.76 MPa) flexural strength within 12 hours after mixing and placement. These RSC rehabilitation areas are closed completely during the weekend, while through traffic on the main lanes does not have lane closures. Pavements on the connectors are candidates for RSC rehabilitation. Similar to the PCC rehabilitation cross-section change, the 12-in. (305-mm) RSC slab will be cast in place on top of the new 6-in. (152-mm) AC base. Typical unit cost of RSC rehabilitation in California is about \$600/m^3.

Fast-Setting Hydraulic Cement Concrete Rehabilitation

Damaged PCC pavements on inside lanes will be removed and replaced (cast in place) with new concrete slab using FSHCC, which has enough flexural strength to open to traffic within 4 hours after mixing. This random slab replacement will take place during nighttime for mostly about 7 hours with partial-lane closure for the areas where other rehabilitation types (i.e., PCC rehabilitation during weekdays, precast rehabilitation, or RSC rehabilitation during weekends) are not applied. The southern part of the project area does not have enough space on the median to shift traffic for detour.

The area's lane configuration, from a geometric point of view, is not good enough to apply the weekend closure strategy to use RSC rehabilitation. PCC pavement on this southern area will be rebuilt with FSHCC pavement even for the outside truck lanes as continuous lane reconstruction in small piece-by-piece with nighttime closures. The unit price of FSHCC rehabilitation in California is currently about $900/m^3$, due to high material cost to use special calcium aluminates cement and unique admixtures.

As Caltrans' experience shows on its long-life pavement rehabilitation demonstration projects, such as on the I-10 Pomona project, FSHCC pavement rehabilitation during nighttime has a production downside compared to PCC or RSC pavement rehabilitation. Lower productivity resulted mainly from (1) the longer discharging cycle of ready-mixer trucks, which slowed concrete delivery and (2) using a roller-screed paving machine rather than a slipform paver due to high concrete slump (Lee et al. 2002).

INNOVATIVE FEATURES

As previously mentioned, the I-15 Ontario project showcases a variety of pavement rehabilitation designs, materials, and construction approaches. Among the latter are continuous lane reconstruction and random slab replacement of the respective material types. The project also has a variety of lane closure strategies, including traditional nighttime and daytime closures, and more innovative means such as extended weekend closures. Construction scheduling and analysis software CA4PRS (Construction Analysis for Pavement Rehabilitation Strategies) was utilized to select the most effective lane-closure tactics under given traffic and construction conditions. It incorporates many variables, such as pavement section, construction access, and lane closures, and production rates for estimating the construction schedule, and work zone traffic delay and agency cost for a particular rehabilitation strategy. Two steps described in this section were taken in the design of this project to reduce the congestion impact to the traveling public.

Work-Zone Simulation for TMP

The work-zone safety and mobility rule requires State and local governments to comply with the rule on Federal-aid projects no later than October 12, 2007. One of the three main components of the rule is to develop procedures to assess and manage work-zone safety and the mobility impacts of individual projects Analysis may necessitate the use of analytical tools, depending on the degree of analysis required. Some tools, such as QuickZone and CA4PRS, were designed for work-zone-related analysis. Other traffic analysis tools that were not designed specifically for work zones may also be useful for analyzing work zone situations (Work-zone 2008).

To anticipate traffic delays and impacts, a traffic model of the local arterial network was created for the I-15 Ontario project by the project team using mesoscopic traffic network modeling, so-called Dynameq software. Mesoscopic traffic simulation software enables planners to evaluate congested network scenarios with dynamic equilibrium benchmarks, a time-varying version of the same well-understood equilibrium assignments that have provided consistency for comparison in static analysis for years.

Dynameq's equilibrium traffic assignment results represent user optimal network conditions that are immediately useful as an upper-bound on network performance. In summary, Dynameq provides a more simplified yet realistic traffic model that can be calibrated with fewer parameters. It performs simulations more quickly than microscopic models, allowing more time for analyzing multiple scenarios. It means that a Dynameq model is more cost effective to develop and run for a model of this scale.

And by using Dynameq, more alternatives can be analyzed, increasing the likelihood of choosing a staging alternative that has the least impact on the traveling public. For this project, Dynameq was used to analyze the impacts of the most significant freeway-to-freeway connector closures and adjust the project staging to minimize the impact to the traveling public. According to the network simulation for the work zone analysis, specifically for the I-15 NB to I-10 EB/WB connector closures, the major diversion routes for the trips that used to take the connectors without the construction closure are through local arterials such as Milliken, Haven, and Etiwanda. This detoured traffic combined with the detoured traffic due to the connector closures results in the traffic increase on the network shown in Figure 5.

The knowledge gained from the traffic network simulations is used to address concerns that our partners, including the residents in surrounding cities, counties, and traveling public, may have about the impacts of the construction, and to demonstrate to them the level of effort used to minimize those impacts.

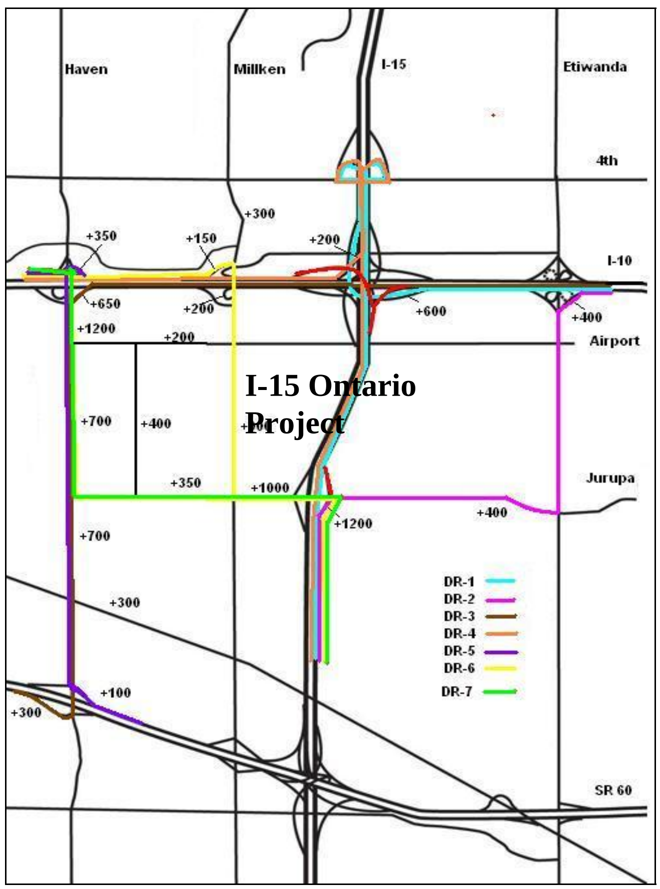

Figure 5. The mesoscopic traffic network simulation using Dynameq indicates detour volume to local arterials during the connectors (I-15 NB to I-10EB/WB) closure on weekend.

CA4PRS Software

One innovation in the effort to reduce highway construction time and its impact on traffic is the CA4PRS software. CA4PRS is a decision-support tool for transportation agencies that helps in selection of the most effective and economical strategies for highway maintenance and rehabilitation projects (Lee and Ibbs 2005). Funded through an FHWA pooled-fund study supported by a multistate consortium including California, Minnesota, Texas, and Washington, CA4PRS was developed by the Institute of Transportation Studies of the University of California, Berkeley, with technical collaboration from the FHWA Turner-Fairbank Highway Research Center.

The program incorporates three interactive analytical modules: a Schedule module that calculates project duration, a Traffic module that quantifies the impact of work zone lane closures and a Cost module that compares agency cost and traffic handling cost between alternatives.

Demonstrations have shown that CA4PRS is user-friendly, easy to learn, and valuable in any project phase. Users can evaluate various “what if” scenarios for combinations of alternative rehabilitation strategies, including pavement cross sections and material types, construction windows and lane closure tactics, and contractor logistics and constraints. CA4PRS has helped agencies, contractors, and consultants save engineering time, improve estimate accuracy, and streamline team work in preparing project design and traffic management plans. CA4PRS results can also be integrated with traffic simulation models to quantify the impact of work zone lane closures on the entire highway network, including local arterials and neighboring freeways.

Since 1999, the capabilities of CA4PRS have been confirmed on several major highway rehabilitation projects in several States including California, Washington, and Minnesota. The software was validated on the I-10 Pomona project in California, in which 2.8 lane-km (1.7 lane-mi) of concrete pavement were replaced in one 55-hour weekend closure. The software was also used to develop a construction staging plan for the I-710 Long Beach Project, in which 26 lane-km (16.1 lane-mi) of AC were reconstructed in eight 55-hour weekend closures.

Recently, CA4PRS was used with traffic simulation models to select the most economical rehabilitation scenario for the I-15 Devore project. The 4.5-km (0.6-mi) concrete pavement reconstruction on the I-15 Devore project, which would have taken 10 months using traditional nighttime closures, was completed over two 9-day periods using one-roadbed, continuous closures with counter-flow traffic and around-the-clock construction (Lee and Thomas 2007). Implementing continuous closures rather than repeated nighttime closures in this project resulted in significant savings of $6 million in agency costs and $2 million in road user costs. Other sponsoring State transportation departments have also used CA4PRS for analyses of corridor rehabilitations, including the reconstruction of I-5 through Seattle, Washington, and the rehabilitation of I-394 and I-494 in St. Paul, Minnesota.

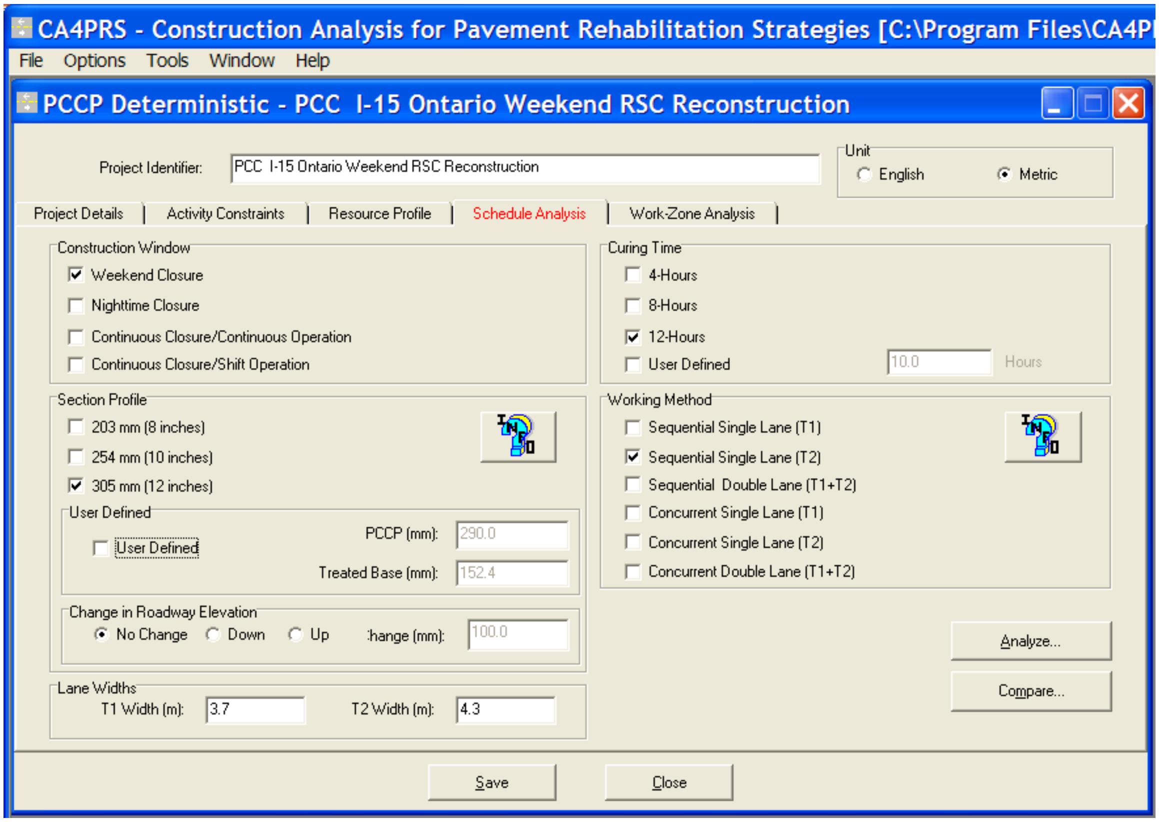

Figure 6. Input window of CA4PRS software used in the preconstruction analysis of the I-15 Ontario project to compare schedule, traffic, and cost between the rehabilitation alternatives.

CA4PRS Analysis Summary

The CA4PRS schedule analysis estimated the approximate duration of construction operations in terms of the number of weeks or weekends required for the following four different closure types on the I-15 Ontario project (see Figure 6 for the input window):

- About 25 weeks of construction operations during weekdays are required for median detour paving (PCC and AC) without major traffic lane closures.
- About 35 weeks of construction operations are needed during weekdays for main-lane pavement rehabilitation using normal PCC without major traffic lane closures, as the traffic is shifted to the median detours.
- About 32 weekends of operations during 55-hour weekend closures are need for pavement rehabilitation on main lanes, ramps, and connectors with ramps and connectors closed.
- About 8 weeks of operations are needed during weekday nighttime (7-hour) closures for main-lane pavement (FSHCC) rehabilitation for the segment south of Mission Boulevard.

A CPM (critical path method) schedule was developed as a milestone for the 55-hour weekend closures based on a typical rehabilitation process and production estimates for the major operations (demolition, AC-base paving, and PCC paving). The CPM schedule analysis indicates that the optimal distance of pavement rehabilitation during a typical 55-hour weekend closure is about 1 kilometer (1 lane-km) (0.6 lane-mi) with sequential operations due to one-lane construction access limitation. A total of 38 hours might be assigned for the main operations with 17 hours of non-operation during a 55-hour weekend closure.

A summary of the components evaluated in the integrated construction/traffic/cost analysis using the CA4PRS software is provided in Table 1 by construction scenario. The analysis components listed include schedule (closure duration), traffic (road user costs), maximum traffic delay per closure, and agency costs. Road user costs were discounted (divided by 3 as "soft money") before being added to agency costs (as "hard money") to derive the total cost for the construction scenario. Also provided is the cost ratio for each scenario as compared to the Original scheme.

The comparison shows that the Original (widening detour) scheme (Scenario 1) would have the lowest total cost of $79 million, followed closely by the CSOL (crack and seat [PCC] and overlay [AC]) 55-hour Weekend (Scenario 5) with a total cost of $83 million (5 percent higher). The analysis findings indicate that the PCC ("Rapid Rehab") 55-hour Weekend (Scenario 2) would have the highest total cost of $123 million, 56 percent higher than the Original scheme. The analysis concludes that the Traditional nighttime closure approach (Scenario 4) is the least economical (68 percent higher) alternative with the estimated construction schedule of about 5 to 6 years. This relative comparison in total cost among the scenarios justified the preliminary decision of D8 management in selecting the Original scheme as the most economical scenario.

Table 1
Preconstruction Analysis for Schedule–Traffic–Cost Comparison Using CA4PRS for the I-15 Ontario Project

Scenario	Closure Duration	Traffic: Road User Cost, $M*	Traffic: Delay, min.	Cost ($ Millions): Agency Cost*	Cost ($ Millions): Total	Cost Ratio, %
1–Original (widening detour)	35 weekends	3	16	78	79	100
2–PCC 55-hour Weekend	35 weekends	119	363	83	123	156
3–Progressive Continuous	8 weeks	123	363	77	118	149
4–Traditional Nighttime	1,220 nights	133	22	88	133	168
5–CSOL, 55-hour Weekend	20 weekends	69	363	60	83	105

* Road user costs are discounted (divided by 3 as "soft money") before being added to agency costs (as "hard money").
** Agency cost estimate using CA4PRS was adjusted in the final PS&E package due to the escalation of pavement material items.
CSOL = Crack and seat (PCC) and overlay (AC)

CONSTRUCTABILITY AND FOLLOWUP STUDY

Constructability Issues

A number of constructability issues were addressed to compare some design and construction alternatives from the production and scheduling perspective. It was concluded that (1) RSC is more productive than FSHCC in the concrete mix design, (2) AC is more productive than lean concrete in the base type, and (3) the nonimpact demolition (slab lift) method is preferable to impact demolition (slab rubblization) due to noise concerns inherent in the slab demolition method.

Guidelines for the contractor contingency plan were outlined to deal with potential risk management on this Rapid Rehab II project with emphasis on applicability and practically of the plan. The contingency plan addresses contractor's logistics in case of emergency, including (1) unstable subgrade replacement with aggregate base or AC, (2) use of two concrete mixes to offset a schedule delay, and (3) standby paving materials such as AC cold mix and preparation of secondary batch plants.

Three levels of time value provisions are recommended to be specified in the contract to ensure the completion of a project on time: (1) incentives/disincentives requirements for the number of 55-hour weekend closures, (2) late-opening penalty at the end of 55-hour weekend closure, and (3) cost-plus-time (A+B) contracting for the entire project. Two types of incentives / disincentives provisions are recommended to encourage and ensure that the contractor completes the 55-hour weekend closure on time or ahead of schedule: the primary incentives provision to minimize the total number of 55-hour weekend closures required; and the secondary late opening penalty to avoid considerable traffic congestion from a delay in opening closed ramps and connectors on the following Monday morning.

Some state-of-practice innovations and technologies were recommended to be adopted, such as automated work-zone information systems and a project Web site for more proactive public outreach and participation. These have been substantially beneficial to road users on previous Caltrans LLPRS projects. The implementation of these innovations and technology on the I-15 Ontario Rapid Rehab II project will help achieve the goals of (1) expediting the construction schedule, (2) minimizing adverse traffic impacts on the highway network, (3) and encouraging the public to support and participate in the public outreach program.

Followup Monitoring Study

In a sense, the I-15 Ontario project is a showcase of concrete pavement rehabilitation with various types of pavement design and construction practice, based on Caltrans successful experience from the LLPRS projects. Caltrans tries to take advantage of unique experimental situations with variety of pavement rehabilitation on the I-15 Ontario project. It is planned to collect schedule and production data during construction, which is scheduled to start construction in spring 2009, and to compare the cost of construction in conjunction with life-cycle cost analysis between the different rehabilitation types.

Field evaluations will be conducted for the pavement conditions before and after construction using inertial profiler for roughness and FWD for stiffness, which would quantify the improvement of rehabilitation for each strategy. Pavement condition monitoring will continue for a certain period of time (e.g., 5–10 years) after the construction to identify the performance difference between the material types (PCC, precast, RSC, and FSHCC) as well as the rehabilitation strategies (continuous lane reconstruction versus random slab replacement).

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