AASHTO Technology Implementation Group
Nomination of Technology Ready for Implementation

Sponsoring DOT	1. Sponsoring DOT (State): California Department of Transportation		
Primary Technical Contact	2. Name: Michael Samadian		
	Organization: California Department of Transportation / Division of Research and Innovation		
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Technology Description

3. Name of Technology:
Construction Analysis for Pavement Rehabilitation Strategies (CA4PRS) Software

4. Briefly describe the technology.

CA4PRS estimates the maximum distance and duration of highway rehabilitation or reconstruction projects under a given set of constraints such as scheduling interfaces, pavement materials and design, contractor logistics and resources, and traffic operations. As a knowledge-based computer system (Windows-base) on a Microsoft Access database, it uses Monte Carlo simulation, critical path method (CPM) analysis, and linear scheduling technique. *CA4PRS* is designed to help highway agencies and paving contractors make construction schedule decisions that balance rehabilitation productivity, traffic inconvenience, and agency cost. Added benefit comes when *CA4PRS* results are integrated with macroscopic and microscopic traffic simulation tools for estimating road user delay cost due to construction work zone closures for highway rehabilitation / reconstruction especially under high traffic volume in the urban network.

5. Briefly describe the history of its development.

The original concept of the *CA4PRS* model and partial funding of the field case studies was funded by the California Department of Transportation through the Partnered Pavement Research program. *CA4PRS* was developed by the Institute of Transportation Studies (ITS) in the University of California at Berkeley (UCB) with support from an FHWA pooled-fund (SPR-3(098)) sponsored by the State Pavement Technology Consortium (California, Florida, Minnesota, Texas, and Washington Department of Transportation (DOT)). The American Concrete Pavement Association (ACPA) and the National Asphalt Pavement Association (NAPA) have contributed partial funding for the field case studies in the validation process.

State of Development

6. For how long and in approximately how many applications has your organization used this technology?

CA4PRS has been validated and successfully implemented on several urban freeway rehabilitation / reconstruction projects with high traffic volume in California since 1999. The software was validated on the I-10 Pomona project (Caltrans first concrete long-life pavement rehabilitation strategy (LLPRS) project) during one 55-hour weekend closure. The software was then used to develop the construction staging-plan for the I-710 Long Beach project (the first asphalt LLPRS project). The *CA4PRS* software was used in conjunction with traffic simulation models to select the most economic rehabilitation scenario during the initial planning and design stages of a reconstruction project on I-15 Devore in San Bernardino.

Other sponsoring states DOTs have applied *CA4PRS* to develop construction staging plan for urban highway rehabilitation such as on the I-5 Seattle project by WSDOT and on the I-494 St. Paul project by MNDOT.

7. What additional development is necessary to enable routine deployment of the technology?

The current version 1.0 of *CA4PRS* is ready for deployment without any further development.

CA4PRS is currently being upgraded with the FHWA pooled-fund to include: (1) more rehabilitation strategies such as rehabilitation of continuously reinforced concrete pavement (CRCP)) in the version 1.5 and (2) the traffic simulation module integrated with the schedule analysis in the version2.0.

8. Have other organizations used this technology? If so, please list organization names and contacts.

Organization	Name	Phone	E-mail
Caltrans	Michael Samadian	(916) 324-2048	michael_samadian@dot.ca.gov
TXDOT	Michael Murphy	(512) 465-3686	mmurphy@dot.state.tx.us
MnDOT	Dave Johnson	(651) 779-5608	dave.johnson@dot.state.mn.us
WSDOT	Linda Pierce	360-709-5470	piercel@wsdot.wa.gov
FLDOT	Bouzid Choubane	352-955-6302	bouzid.choubane@dot.state.fl.us

Potential for Payoff	9. What benefits has your organization realized from using this technology? Include cost savings, safety improvements, transportation efficiency or effectiveness, environmental benefits, or other advantages over other existing technologies. Application of the *CA4PRS* model to urban freeway rehabilitation projects in California, including the I-10 Pomona, I-710 Long Beach, and I-15 Devore projects, has demonstrated its value in saving millions of dollars for both Caltrans and road users. In 2004 the I-15 Devore reconstruction project (the stretch of 5.5 km) was completed within only two 9 days of one-roadbed continuous closures with around-the-clock construction operation instead of 10 months of traditional nighttime closures as justified with the CA4PRS model. The innovative and integrated approach of "Rapid Rehab with accelerated construction" on this project saved $2.6 million of the agency cost as well as the significant reduction of overall road user cost by the schedule compression. CA4PRS can evaluate various traffic lane closure strategies and pavement design alternatives for highway rehabilitation with the goal of maximizing new pavement life expectancy and construction production and minimizing traffic delay and agency costs. The *CA4PRS* model can also facilitate teambuilding among engineers from design, construction, and traffic operations to mutually arrive at an optimal solution in their decision making process. Paving contractors and consultants will find *CA4PRS* useful for checking construction staging-plans, identifying critical resources constraining production, and quantifying the probability of meeting incentives/disincentives and cost (A) plus schedule (B) contracts. CA4PRS can be incorporated with traffic simulation and life-cycle cost analysis models to maximize on-schedule construction production and minimize costs for the agency and road users for highway rehabilitation and reconstruction projects, especially in urban areas. It can save time in construction and the opening of the road to the public in a fastest time and the least traffic delays.
Implementation Potential	10. Please describe what actions another transportation agency would need to take to adopt this technology. Another agencies might contact the Office of Technology Licensing (Tel: (510)643-7201, Email: vlanier@berkeley.edu) in the University of California at Berkeley for more information about the CA4PRS software including purchasing.
	11. What is the estimated cost, effort, and length of time required for procurement or adoption by another transportation agency? The software is available from the University of California at Berkeley with the cost of about $1,500 for the government agency and $3,000 commercial sector per license. Minimum 2-day hands-on training class is recommended for the end users with the approximate cost of $7,000 per training (for about 15 trainees with the training facility provided by DOT). CA4PRS training is provided by Dr. E.B. Lee (Tel: 510)665-3637, Email: eblee@berkeley.edu) in EBL. Consulting, INC., the CA4PRS model developer. Over last three years, about 300 transportation engineers (design, construction, materials, and traffic) in the sponsoring DOTs have been trained, and some of them are able to implement the *CA4PRS* software in the rehabilitation analysis of the actual project by themselves.
	12. What organization(s) currently supply and provide technical support for this technology? Limited technical support is provided by the Institute of Transportation Studies in the University of California at Berkeley. A number of papers are published in the professional journals including: Lee, E.B, and Ibbs, C.W, "A Computer Simulation Model: Construction Analysis for Highway Rehabilitation Strategies (CA4PRS)." *Journal of Construction Engineering and Management, ASCE*, Vol. 131, No. 4, pp-449-458, April, 2005.
	13. Please describe any legal, regulatory, social, intellectual property, or other issues that could affect ease of implementation. Purchasing of the software license (sole source) is available through the Office of Technology Licensing in the University of California at Berkeley. The 5-State DOTs (CA/FL/MN/TX/WA) have a privilege of unlimited license. ACPA distributes the CA4PRS software license to its member.
Willingness to Champion	14. Is the sponsoring DOT willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? ☒ Yes ☐ No
Date Submitted	15. Date: March 11, 2005

16. Please include image(s) of sketches or photographs, if available 6 Image(s) are attached. *(See more information attached)*
    - *The CA4PRS brochure in the attachment.*
    - *1 Table and 4 Figures included as reference in the attachment.*

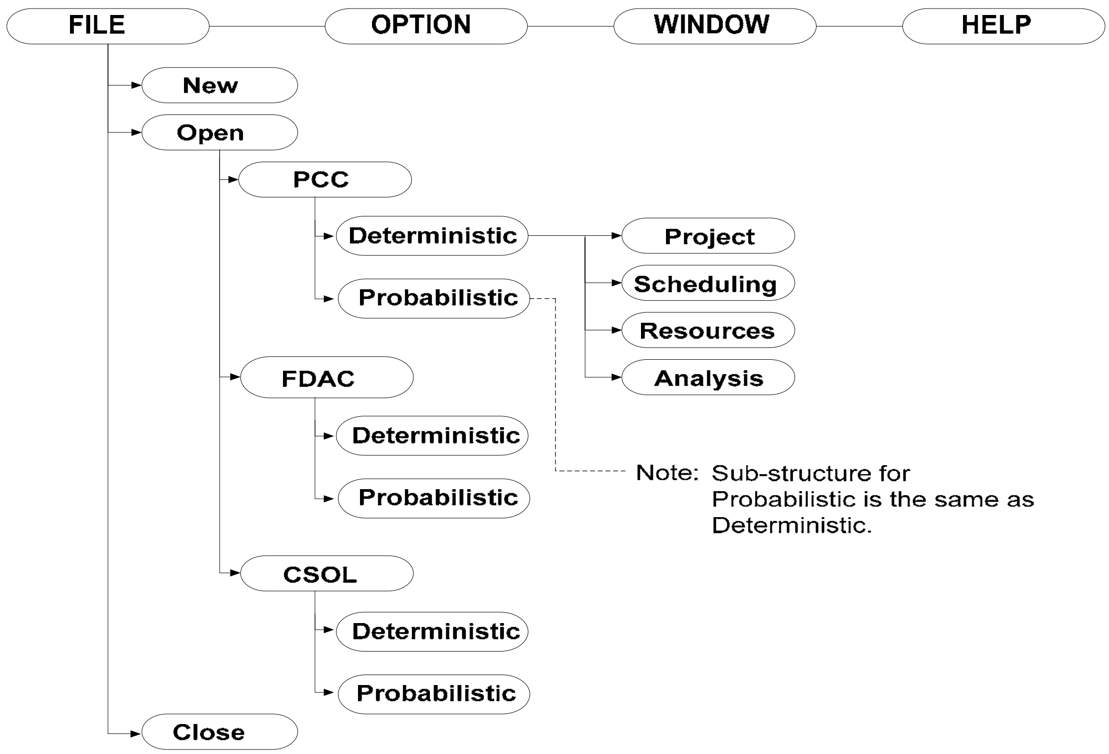

Figure 1: *CA4PRS* menu structure and analysis hierarchy.

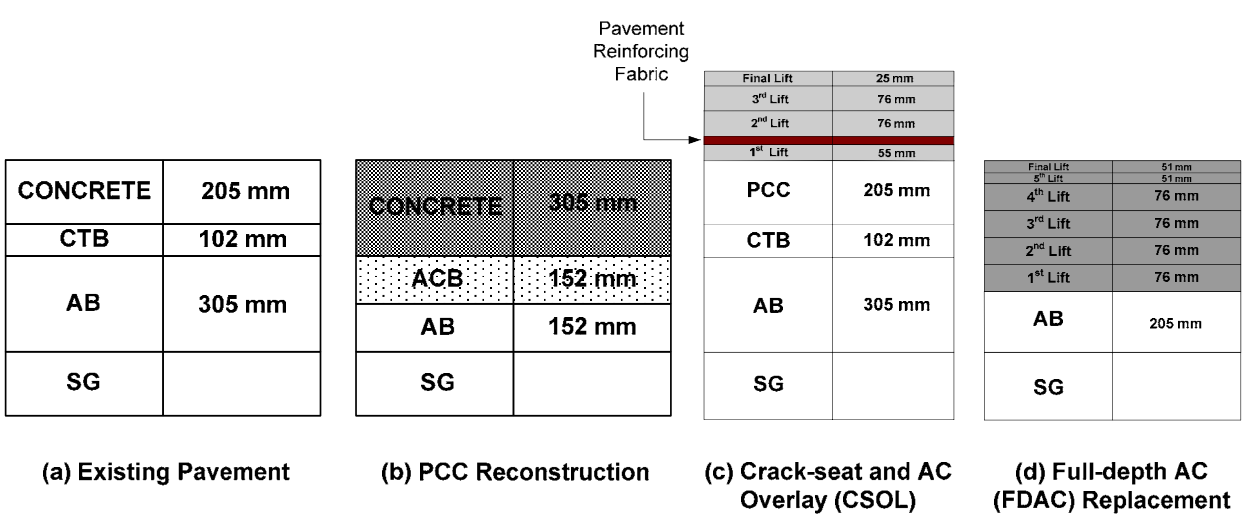

Figure 2: Examples of typical pavement cross-section changes in the *CA4PRS* model

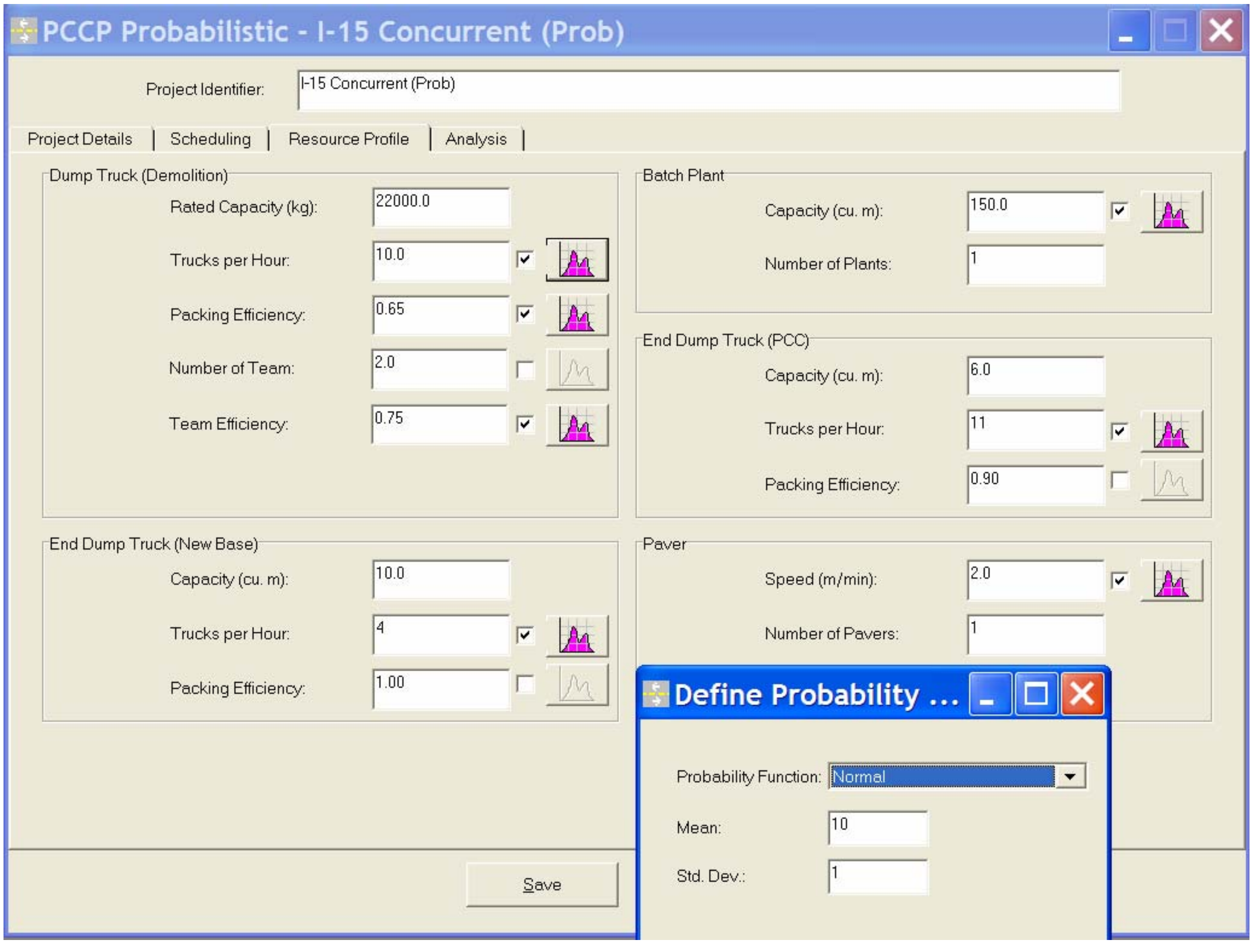

Figure 3: *Resource Profile* input window in the concrete probabilistic mode.

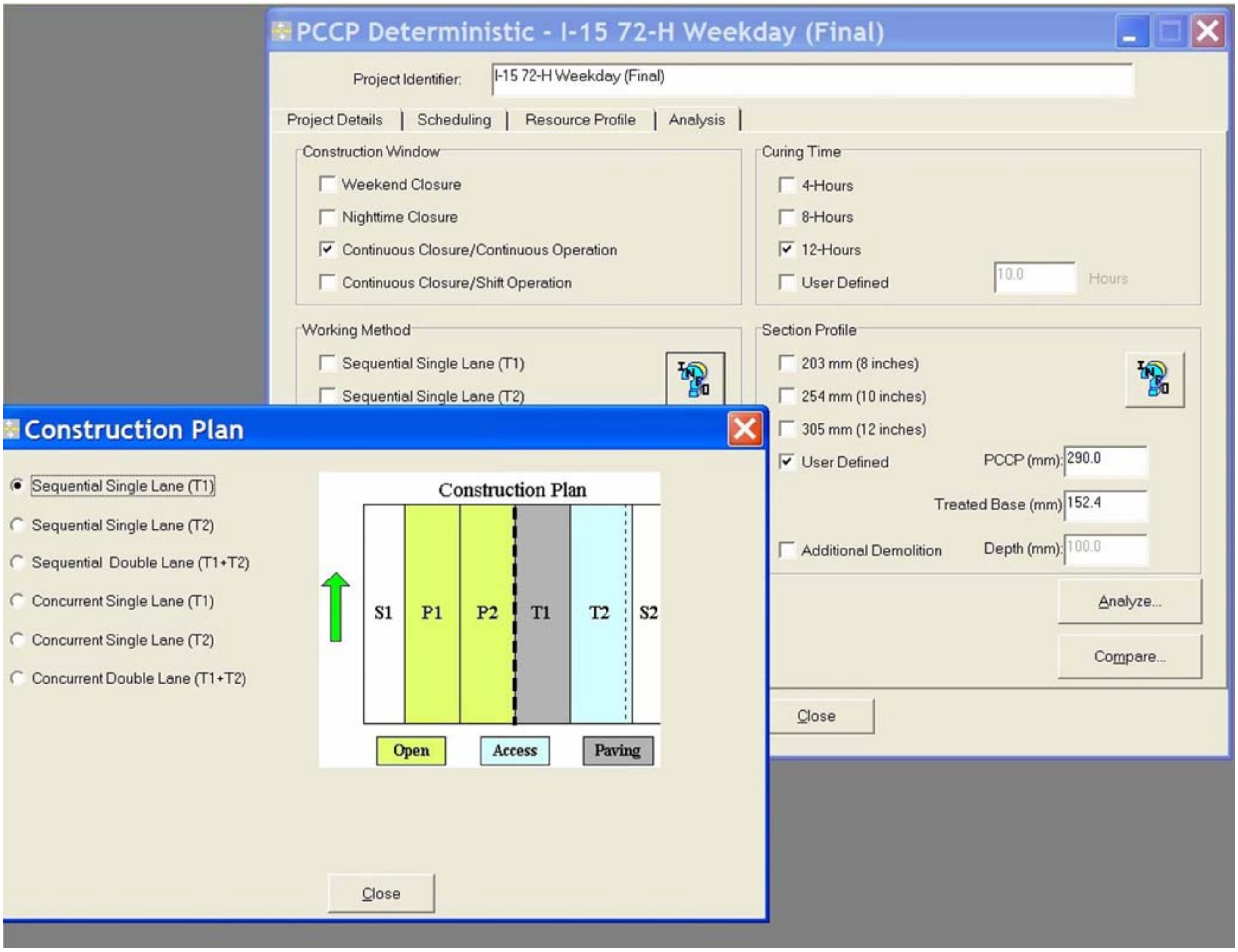

Figure 4: *Analysis* input window in the concrete module.

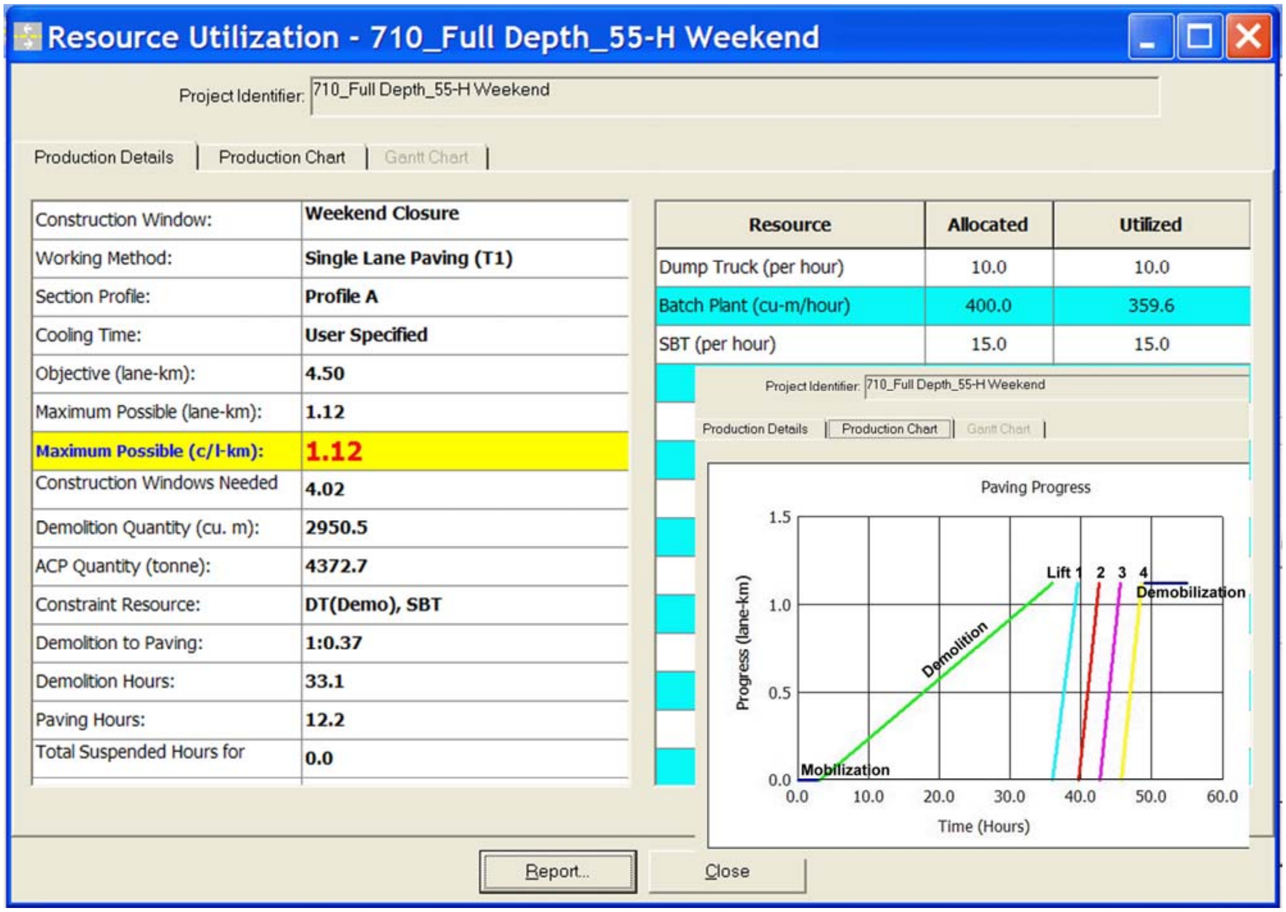

Figure 5. Output screens for the Full-depth AC replacement module.