

# tech notes

“tech notes” are a product of the State Materials Laboratory to share design and construction technology gained from projects done through WSDOT. This issue is from the Pavements Branch Constructability Software for Pavement Rehabilitation Strategies.

## Constructability Software for Pavement Rehabilitation Strategies

The contents of this document are excerpts from the Caltrans Roadway Research Notes No. 4 (November 2002). Additional information can be obtained at <http://www2.dot.ca.gov/hq/research/roadway/ca4prs/ca4prs.htm>.

### The Problem

For the rehabilitation of urban freeways with large volumes of heavy trucks and/or vehicles, the most desirable pavement section is one that provides long life (at least 50 years) and minimizes traffic delays resulting from future maintenance and rehabilitation activities. However, due to traffic delay concerns, limitations are often placed on construction closures, such that minimizing construction time is a significant objective.

### Constructability Software<sup>1</sup>

Construction productivity and traffic simulation have been recently addressed through the development of the CA4PRS (Construction Analysis for Pavement Rehabilitation Strategies or simply Constructability Software) and utilization of Paramics, a micro traffic simulation program.

The development of the Constructability Software resulted from observation of engineers with different expertise and responsibilities struggling to estimate the effects of their individual decisions on the other elements of the project. For example, materials engineers may select very expensive materials that gain strength quickly. However, this decision may be made without the knowledge of whether this material will improve construction productivity and reduce traffic delay sufficiently to justify the additional cost.

The use of Paramics resulted from discussion with traffic engineers responsible for assigning construction windows for urban freeway reconstruction. It became apparent that there is a need to have more reliable data in order to communicate and negotiate in good faith with residents and businesses that would feel the effects of the construction and traffic delays.

### What is it and what can it do?

The Constructability Software is designed to estimate the roadway length that can be rehabilitated within a set of constraints. The current “what if” scenarios include:

- Strategy type – remove and replace with full-depth Portland cement concrete (PCC), remove and replace with full-depth hot-mix asphalt (HMA); crack and seat existing PCC with HMA overlay; or overlay existing PCC with HMA
- Construction window – nighttime, weekend, or continuous closures or any combination of the above
- Lane closure tactics – partial or full closures
- Material constraints – mix design and curing time for PCC and cooling time for HMA
- Pavement structure – thickness for PCC or HMA
- Contractor’s constraints – location, capacity, and equipment availability
- Scheduling constraints – mobilization, traffic control, and lead-lag time relationships



Photo 1. Urban freeway construction.



Photo 2. Urban freeway reconstruction in Washington.

1 The Constructability Software is currently available for WSDOT use only at <http://wwwi.wsdot.wa.gov/maintops/mats/apps/CA4PRS.htm>

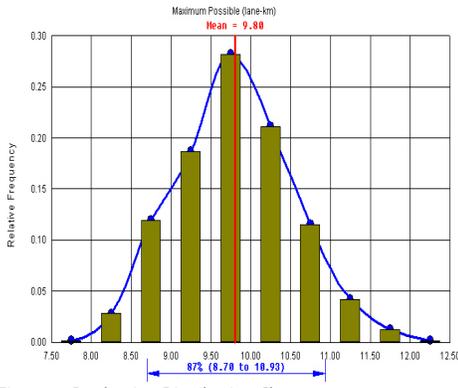


Figure 1. Production Distribution Chart.

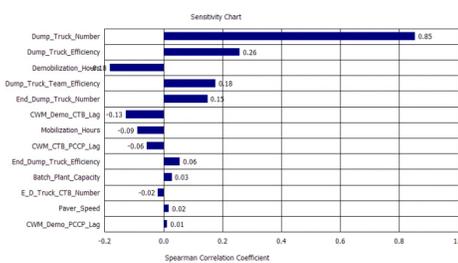


Figure 2. Sensitivity Analysis Chart

Table 1. Comparison of Construction Schedule and Traffic Delay for the I-15 CA DeVore Project.

| Construction Scenario      | Schedule Comparison   |                     | Cost Comparison (\$M) |            |            |
|----------------------------|-----------------------|---------------------|-----------------------|------------|------------|
|                            | Total No. of Closures | Total Closure Hours | Agency Cost           | User Delay | Total Cost |
| 72-Hour Weekday Continuous | 8                     | 512                 | 16                    | 5          | 21         |
| 55-Hour Weekend Continuous | 10                    | 550                 | 17                    | 10         | 27         |
| 1 Roadbed Continuous       | 2                     | 400                 | 15                    | 5          | 20         |
| 10-Hour Nighttime Closures | 220                   | 2,200               | 21                    | 7          | 28         |

This information can be analyzed in either a deterministic (no variations in individual inputs) or probabilistic (inputs treated as random variables with defined distributions) mode. Deterministic mode allows inputs as a set number and does not take into account the variability that can occur during construction (i.e. haul time variability due to traffic or plant operations, etc.). The probabilistic mode allows for the inclusion of the inherent variability during construction by allowing the user to set an average value, standard deviation, and type of distribution.

The Constructability Software can be used to maximize construction production, minimize costs for the agency, and minimize road user costs in terms of delay.

### When and where can it be used?

The Constructability Software can be used during any phase of the project; however, it is best used during planning and design to provide a clear, quantitative estimate of the optimal, cost-effective options for the specific project.

This program should be used on any major urban freeway rehabilitating project, but can be used on any major pavement rehabilitation project.

### How does it work?

This software estimates the optimal distance and duration of a pavement rehabilitation project under a given set of constraints. The basic inputs include project details (location, state route, and milepost limits), scheduling (time requirements for mobilization, cleanup, set-up of traffic control, etc.), resource profile (number of haul trucks, production plants, etc.), and analysis (construction windows, lane closure tactics, mix design, pavement structure, etc.).

The deterministic mode outputs include a production detail and production chart. The production detail summarizes the user inputs and principal analysis results (maximum production of each scenario and the number of closures required to finish the project).

The probabilistic mode generates a distribution plot (Figure 1) showing the range of rehabilitation production (in lane-miles) and a sensitivity analysis chart. The sensitivity chart allows the user to see the relative sensitivity of production to each input variable (Figure 2) – the longer the bar, the higher sensitivity to production. In this example, the number of dump trucks, followed by the dump truck efficiency is most sensitive to the production rates.

The I-15 DeVore project in California utilized the Constructability Software. This roadway, located near San Bernardino, has average daily traffic of 110,000 vehicles with nine percent trucks. The project reconstructed 2.6 miles of PCC, two lanes in each direction, for a total of 10.4 lane-miles.

Table 1 illustrates the four scenarios that were analyzed. Based on this analysis, the California DOT selected the roadbed continuous closure operation. This closure was the most economical in terms of both agency and road user costs compared to the three other scenarios.

Compared to traditional 10-hour nighttime closures, the single-roadbed continuous closure scenario requires 81 percent less total closure time, 28 percent less road user cost due to traffic delay, and 28 percent less agency cost for construction and traffic control.

### Potential Payoffs

The Constructability Software can evaluate various traffic lane closure strategies and pavement design alternatives for highway rehabilitation. The goal is to maximize pavement life expectancy and construction production while minimizing traffic delay and agency costs.

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