Pavement Type Selection and Constructability Software

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Pavement Type Selection

Why is a protocol needed?

- Provide guidance on the selection of pavement type
- Ensure pavement type selection is based on sound engineering and economic criteria
  - Least expensive: BST
  - Longest lived: PCCP

New Protocol

- Application
  - New construction
  - High ADT and high truck traffic roadways
    - Ramps
    - Collector-distributors
    - Acceleration-deceleration lanes
  - Reconstruction
  - Mainline widening
    - if same pavement type as existing, pavement type selection process is not necessary

New Protocol

- Three primary considerations
  - Pavement design
    - Primarily settlement concerns
  - Life cycle cost analysis
  - Engineering analysis

Decision

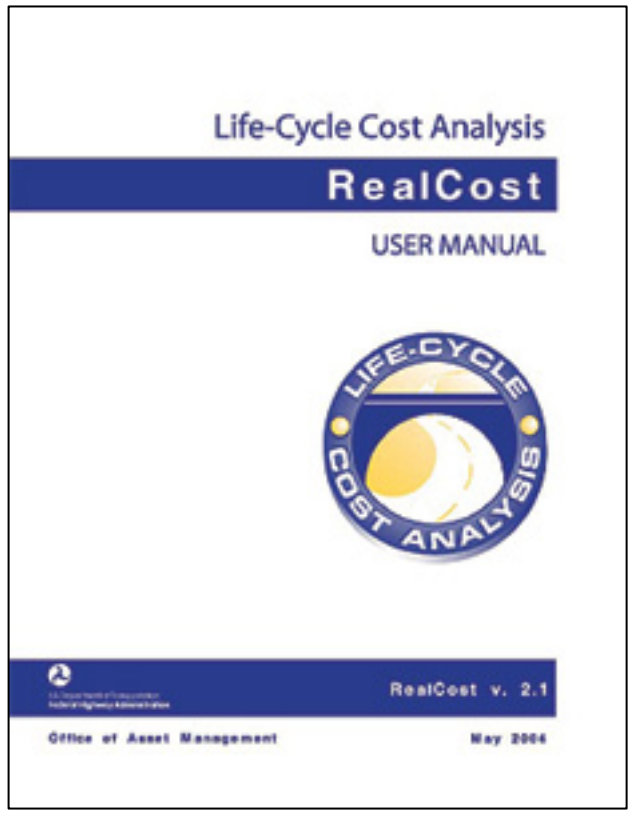
- If differential settlement is > 2 inches
  - Select the hot mix asphalt alternative
  - Else, conduct life cycle cost analysis
- If life cycle cost between options > 15 percent
  - Choose lower cost option
  - Otherwise, conduct engineering analysis
- Engineering analysis
  - Preferred pavement type is selected based on justifiable engineering based decisions

Pavement Design

- Settlement issues
- Traffic
- Materials (availability and performance)
- Climate and drainage
- Use of recycled materials
- Pavement design
- Construction and operational considerations

Life Cycle Cost Analysis

- "Life Cycle Cost Analysis in Pavement Design" FHWA-SA-98-079
  - Publication and software: http://www.fhwa.dot.gov/infrastructure/asstmgmt/lccasoft.htm

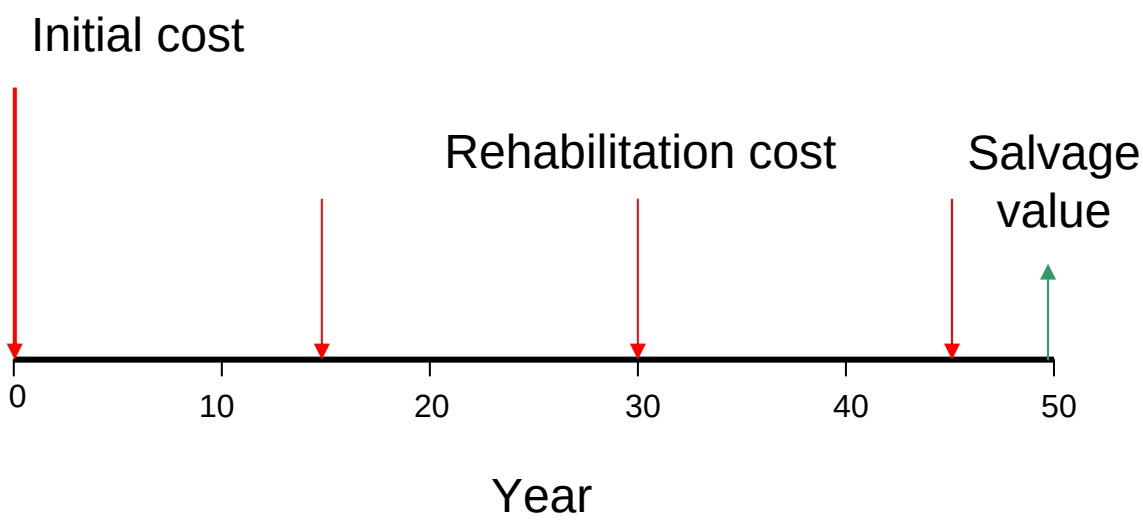


Life Cycle Cost Analysis

- Net present value
  - Deterministic
  - Probabilistic
- Performance period
  - Based on pavement management system
  - Other engineering based estimates
- Cost to consider:
  - Initial construction costs
  - Future rehabilitation costs
  - Maintenance costs (often difficult to measure)
  - Salvage costs
  - User costs

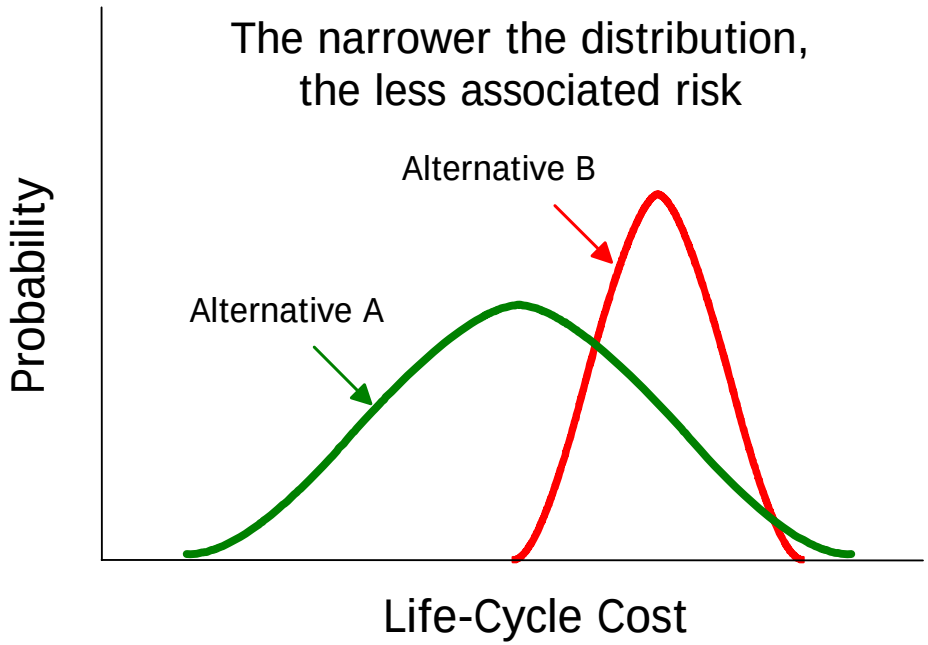
Life Cycle Cost Analysis

- Deterministic analysis
  - Discrete value
    - Cost (i.e. $10.5 million)
    - Rehabilitation timing (i.e. every 15 years)
  - Results in a single life cycle cost estimate
  - Fails to consider variation of multiple inputs
  - Fails to convey degree of uncertainty in cost estimate, timing, traffic, etc.



Life Cycle Cost Analysis

- Probabilistic analysis
  - Range of likely inputs and the likelihood of there occurrence
  - Allows for calculation of variation in multiple inputs
  - Outputs express the likelihood that a cost will actually occur



RealCost

- FHWA developed software (actually a former WSDOT employee)
- Input project details
- Output
  - Deterministic
  - Probabilistic analysis

Input Screens

Alternative 1

Alternative Description:

Initial Construction | Rehabilitation 1 | Rehabilitation 2 | Rehabilitation 3 | Rehabilitation 4 | Rehabilitation 5 | Rehabilitation 6

Activity Description:

Activity Cost and Service Life Inputs

Agency Construction Cost ($1000):

Activity Service Life (years):

User Work Zone Costs ($1000):

(Inactive if User Costs are to be Caculated by Software)

Maintenance Frequency (years):

Agency Maintenance Cost ($1000):

Activity Work Zone Inputs

Work Zone Length (miles):

Work Zone Duration (days):

Work Zone Capacity (vphpl):

Work Zone Speed Limit (mph):

No of Lanes Open in Each Direction During Work Zone:

Work Zone Hours

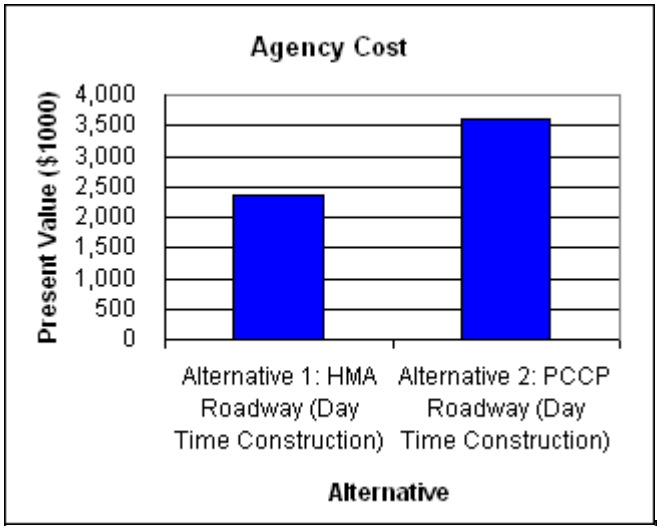
	Inbound Start	Inbound End	Outbound Start	Outbound End
First Period of Lane Closure:				
Second Period of Lane Closure:				
Third Period of Lane Closure:				

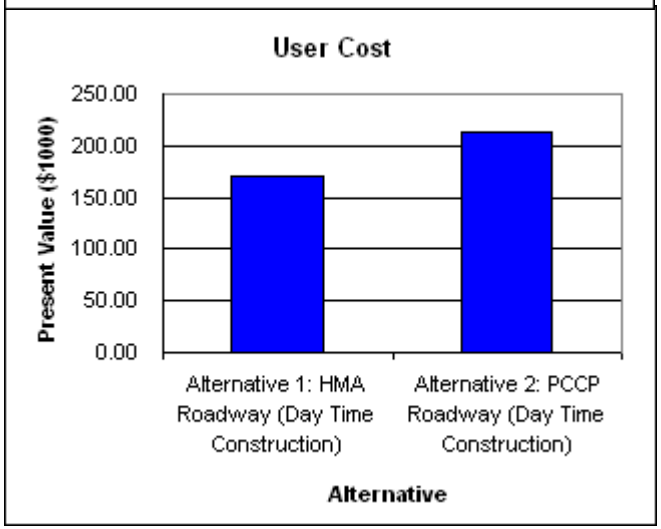
Copy Activity

Paste Activity

Open... | Save... | Ok | Cancel

Deterministic Analysis





Deterministic Results

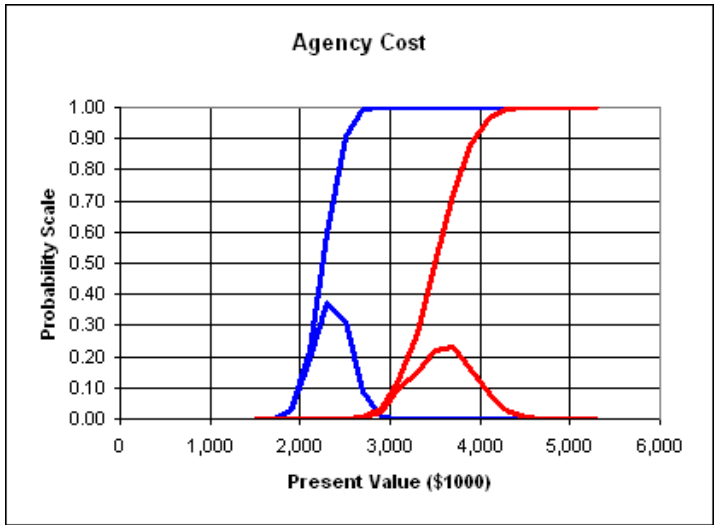
Deterministic Results

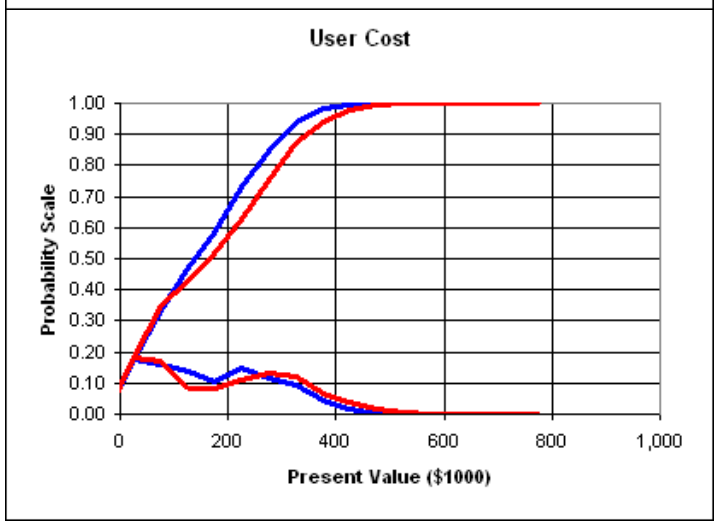
Total Cost	Alternative 1: HMA Roadway (Day Time Construction)		Alternative 2: PCCP Roadway (Day Time Construction)	
	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)
Undiscounted Sum	*$2,879.69*	*$559.78*	*$3,833.67*	*$544.86*
Present Value	**$2,350.10**	**$171.47**	**$3,609.56**	**$213.65**
EUAC	$109.40	$7.98	$168.03	$9.95

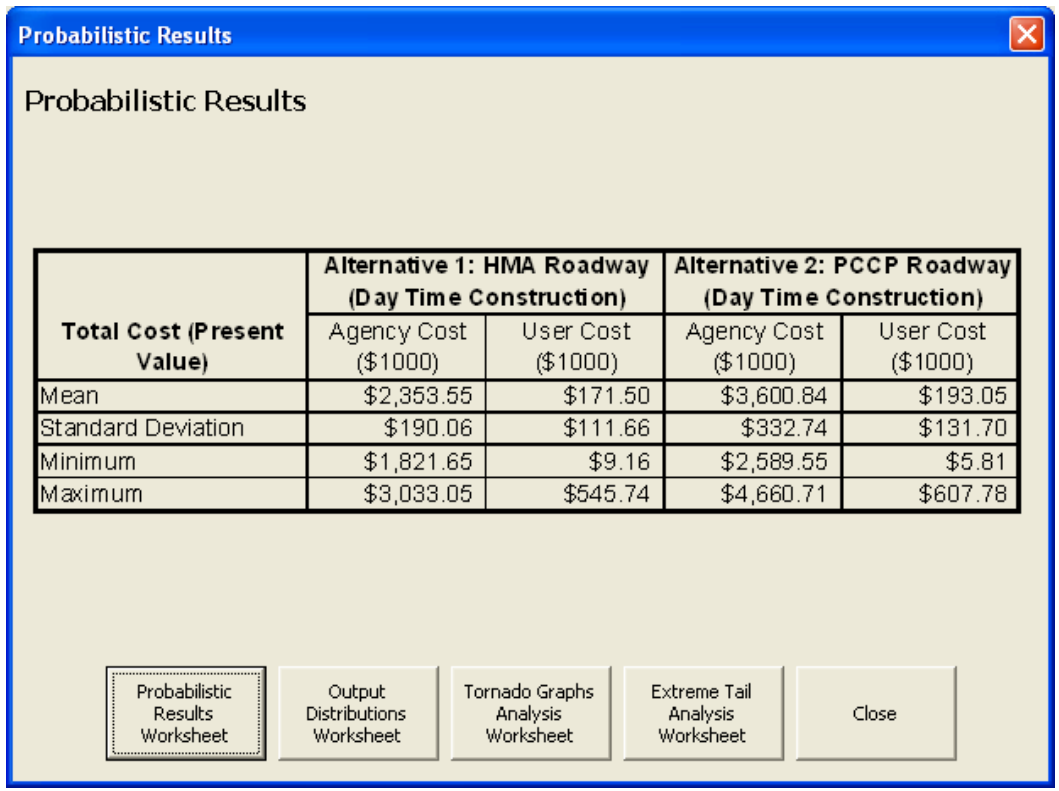
Lowest Present Value Agency Cost	**Alternative 1: HMA Roadway (Day Time Construction)**
Lowest Present Value User Cost	**Alternative 1: HMA Roadway (Day Time Construction)**

Go to Worksheet Close

Probabilistic Results







Total Cost (Present Value)	Alternative 1: HMA Roadway (Day Time Construction)		Alternative 2: PCCP Roadway (Day Time Construction)	
	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)
Mean	$2,353.55	$171.50	$3,600.84	$193.05
Standard Deviation	$190.06	$111.66	$332.74	$131.70
Minimum	$1,821.65	$9.16	$2,589.55	$5.81
Maximum	$3,033.05	$545.74	$4,660.71	$607.78

Engineering Analysis

- Air pollution impacts
- Surrounding neighborhood impacts
- Haul routes
- Business impacts
- Noise
- Safety
- Pavement type continuity
- Maintenance concerns
- Other risk factors

Submittal

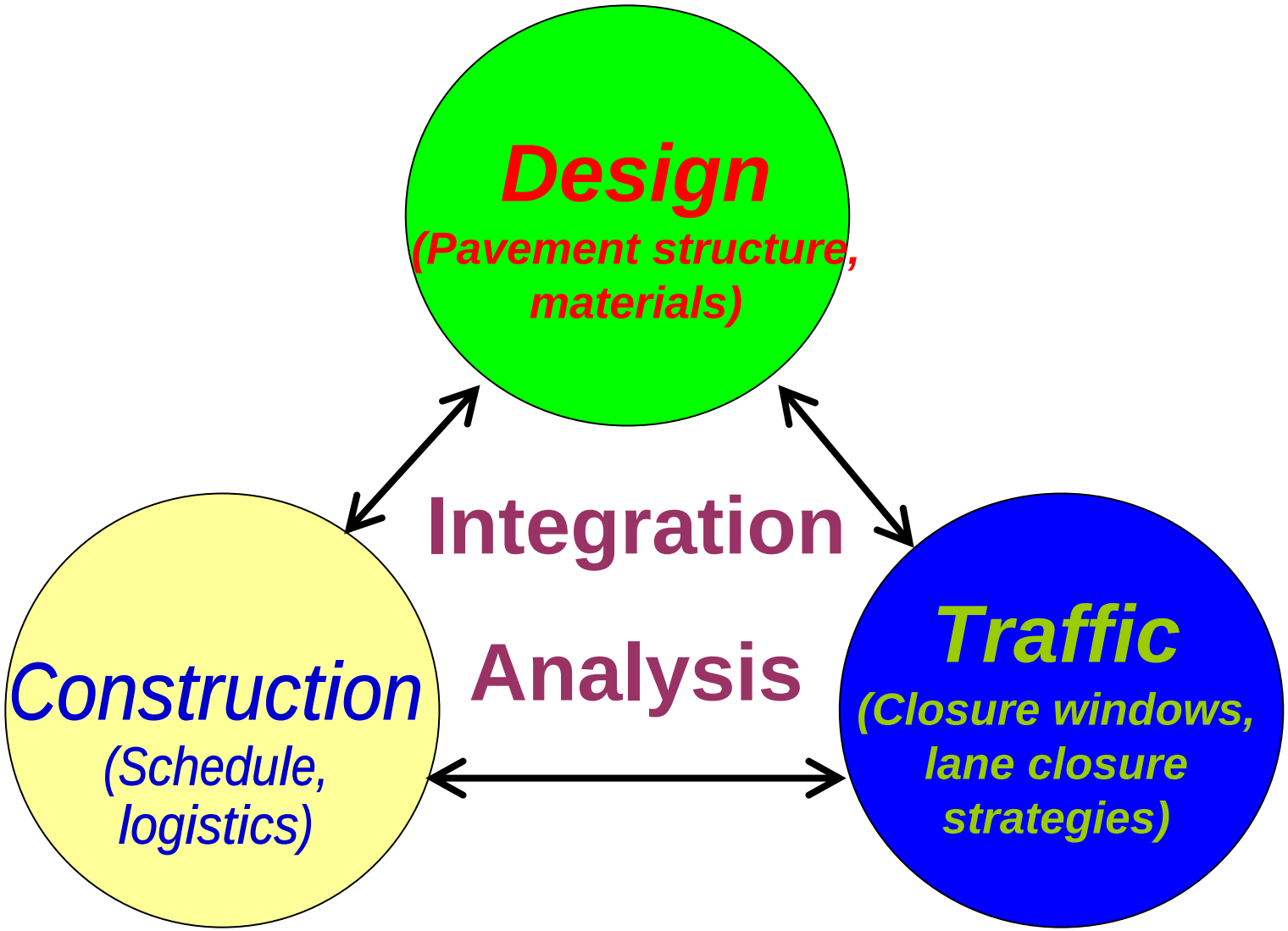
- Typically conducted by Project Office
  - Coordination with Region and HQ Materials Laboratories
    - Geotechnical assessment (if needed)
    - New pavement design thickness
    - Rehabilitation treatments and timing

Submittal

- Submit to HQ Materials Laboratory – Pavements
  - Maximum 90 day review period
  - Provide comment and feedback on necessary or proposed changes
    - Working closely with all parties greatly minimizes this step
  - Submit Pavement Type Selection Report
    - Including all data files used in analysis

Questions

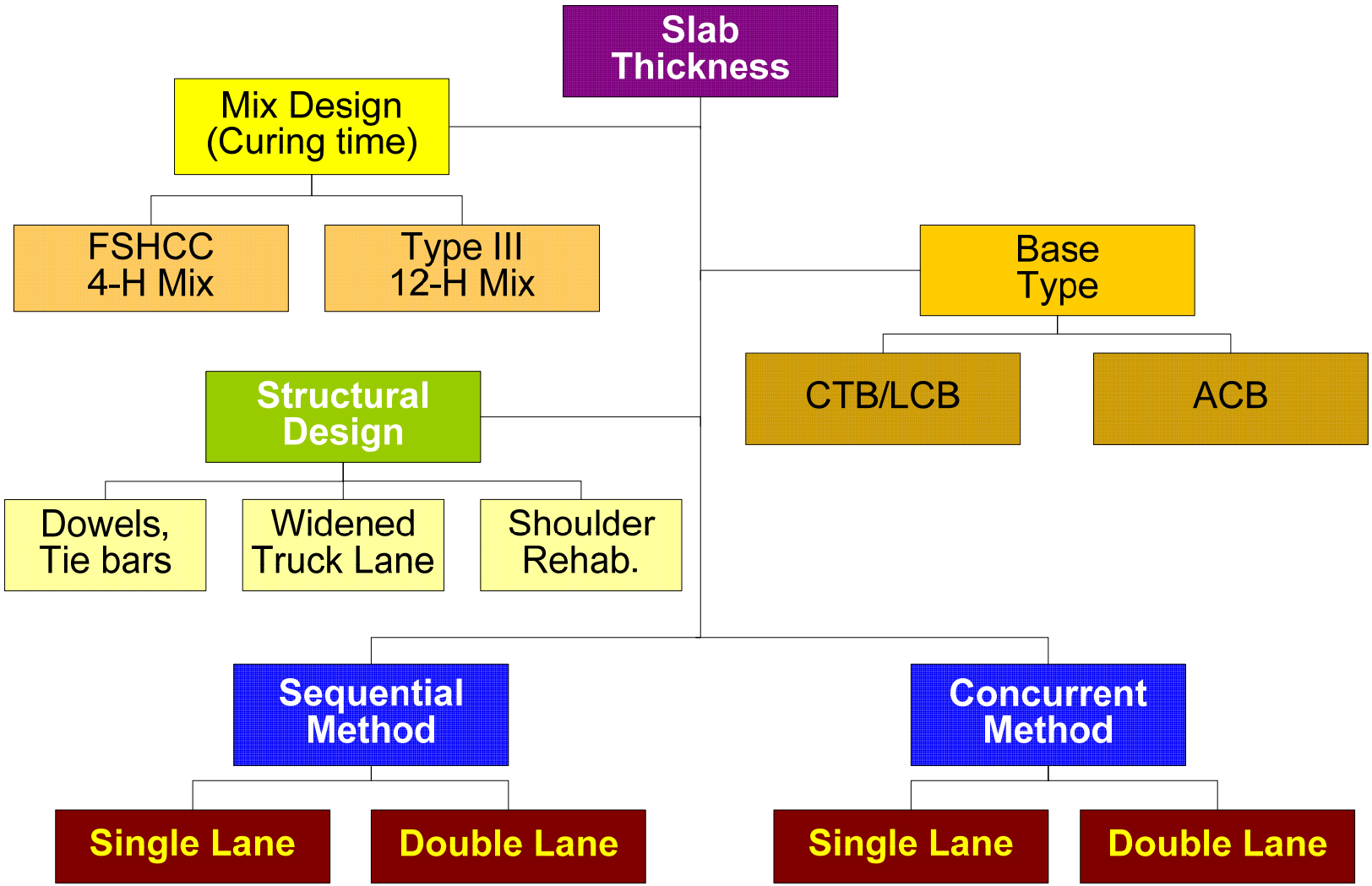
Constructability Software


Design
(Pavement structure, materials)
Integration
Analysis
Construction
(Schedule, logistics)
Traffic
(Closure windows, lane closure strategies)

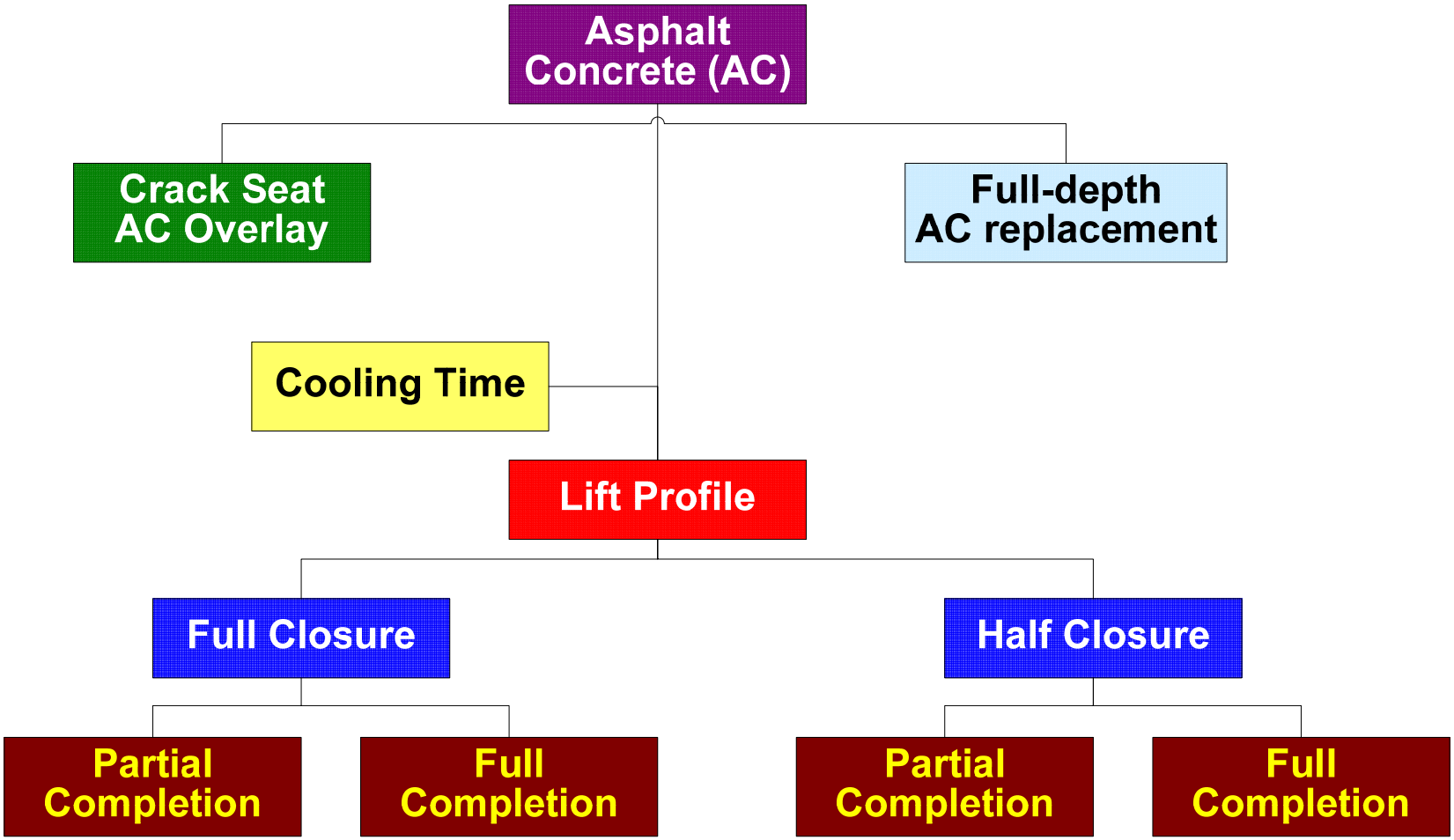
Input Categories and Parameters

- **Construction Windows**
  - 7-H or 10-H Night time
  - 55-Hour Weekend Continuous
  - Continuous Closure
    - Weekday Daytime Shift Closure
    - Continuous Operation
- **Design & Materials**
  - Concrete (PCC)
    - Type(Mix) II, III, FSHCC
    - Slab Thickness 8”,10”,12”
  - Asphalt Concrete (AC)
    - CSOL
    - Full Depth Replacement
    - Slab Thickness
    - Lifts Profile
- **Scheduling Constraints**
  - Traffic Control
  - Mobilization
  - Demobilization
  - Activity relationship (Lead-Lags)
  - Concrete Curing Time
  - AC Cooling Time (Weather)
- **Construction Methods**
  - Construction Access lanes number
  - Traffic Operation Plan
  - Demolition Methods (Non-impact, impact)
  - Reconstruction Lane Numbers
- **Logistics & Resources**
  - Dumping Area
  - Hauling Trucks (number, capacity)
  - Production-B/P (location/ capacity)
  - Delivery Trucks (number, capacity)
  - Paving machine (speed, number)

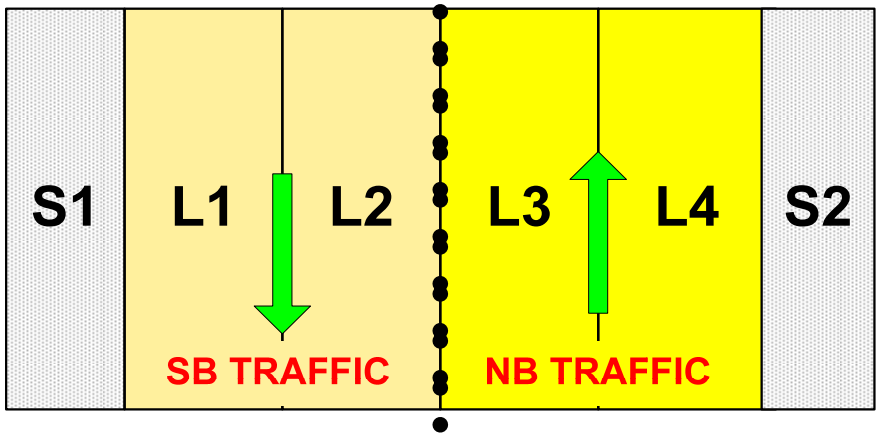
Concrete Analysis Model



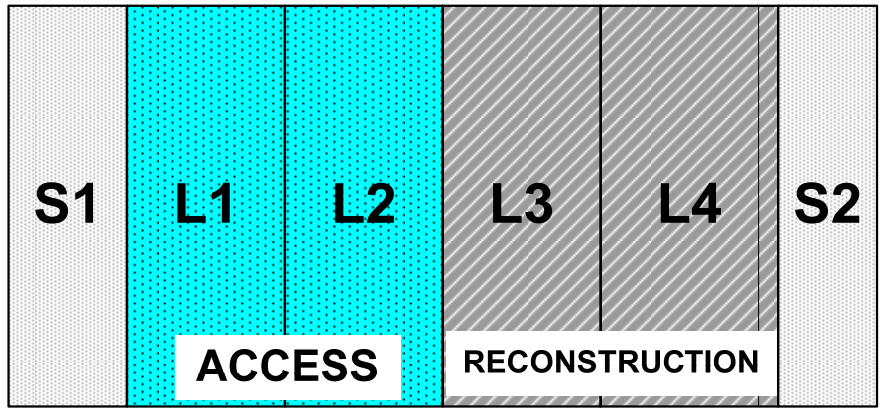
Hot Mix Asphalt Analysis Model



Concurrent Construction



Traffic Roadbed



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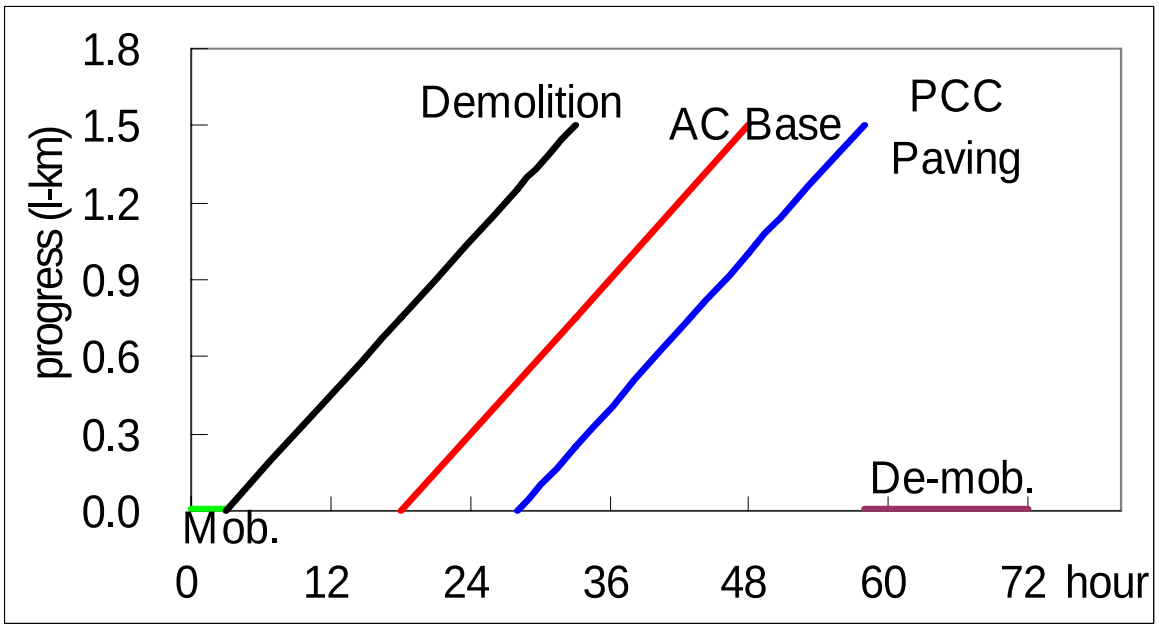
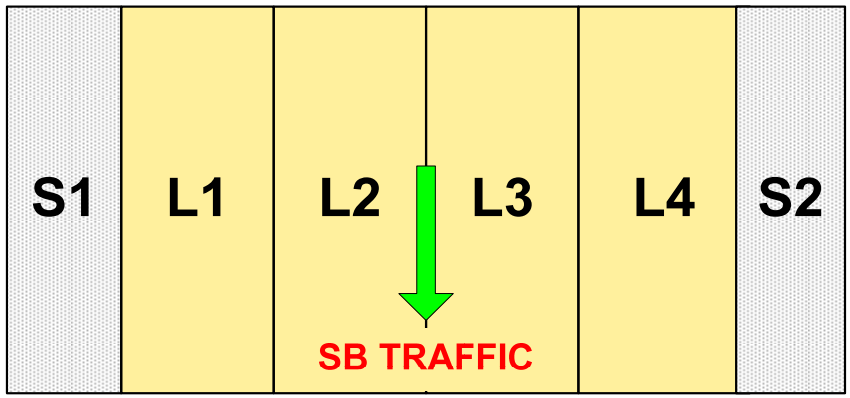
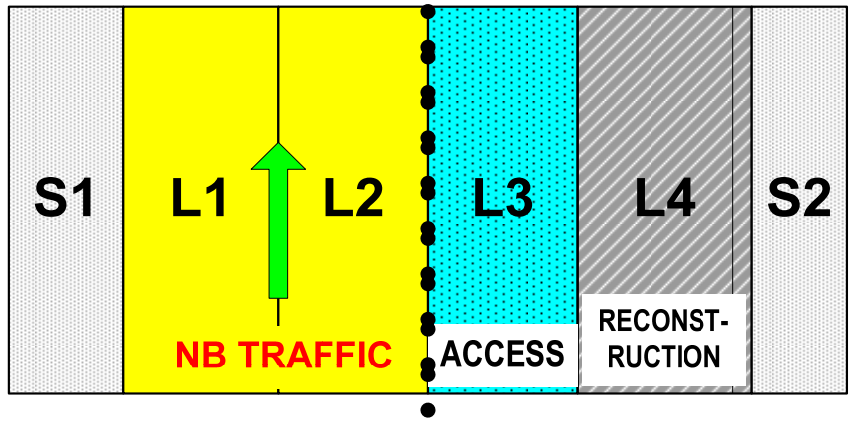


Concurrent Construction

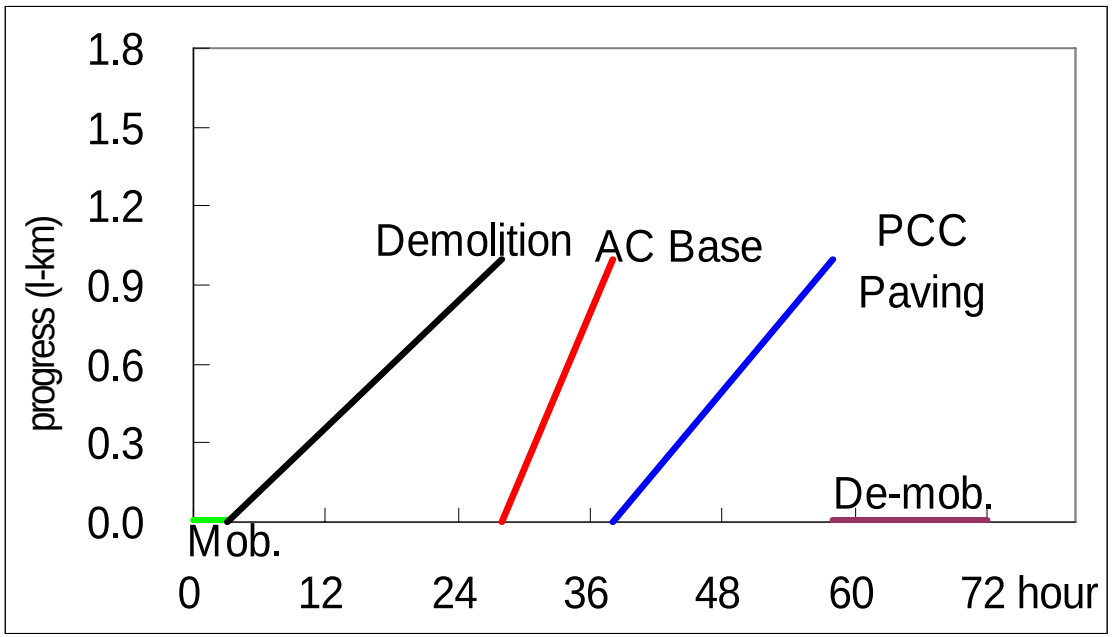
Sequential Construction



Traffic Roadbed

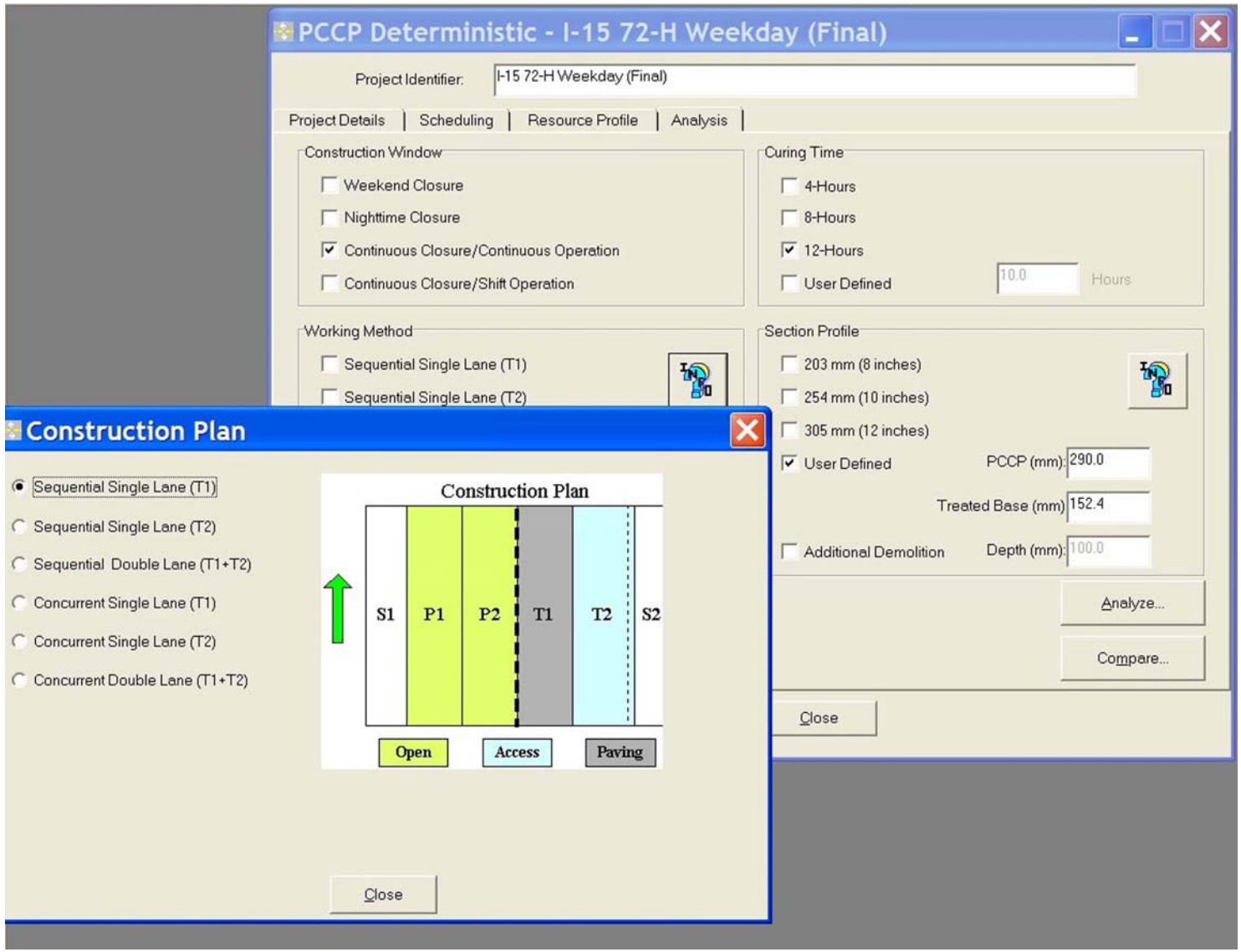


Construction Roadbed



Sequential Construction

Typical Analysis Input Screen



Analysis Output

Constructability and Productivity Analysis

File Options Window Help

Resource Utilization - I-15 Devore Continuous Closure

Project Identifier: I-15 Devore Continuous Closure

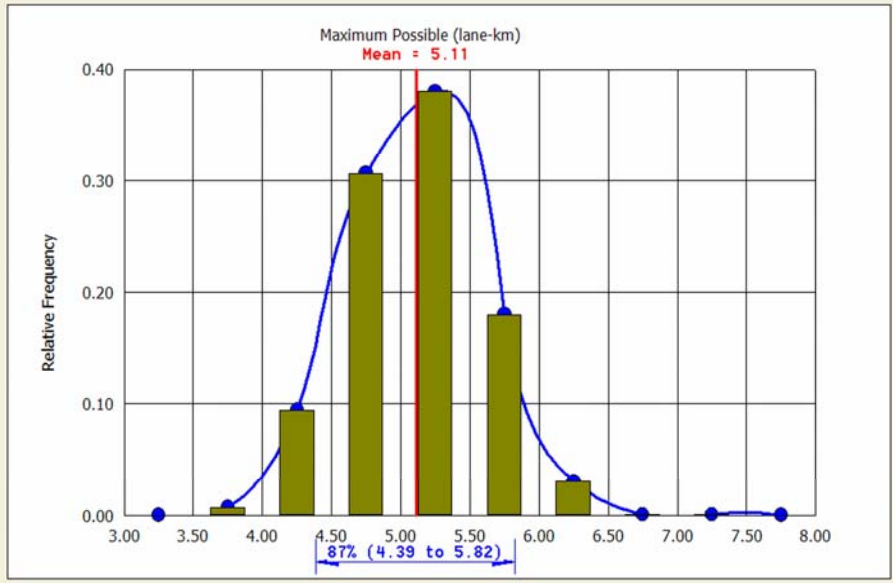
Production Details | Production Chart | Gantt Chart

Construction Window:	**Continuous Closure/Continuous**
Working Method:	**Concurrent Single Lane (T2)**
Section Profile:	**PCCP: 290.0 mm, New Base: 152.4**
Curing Time:	**12-Hours**
Objective (lane-km):	**10.50**
Maximum Possible (lane-km):	**5.13**
Maximum Possible (c/l-km):	**5.13**
Construction Windows Needed	**2.05**
Demolition Quantity (cu. m):	**9676.7**
New Base Quantity (cu. m):	**3333.5**
Concrete Quantity (cu. m):	**6343.2**
Constraint Resource:	**DT(Demo)**
Demolition to Paving:	**N/A**
Demolition Hours:	**137.0**
Paving Hours:	**137.0**

Resource	Allocated	Utilized
Dump Truck (per hour)	10.0	10.0
End Dump Truck (New Base)	4.0	2.4
Batch Plant (cu-m/hour)	150.0	46.3
End Dump Truck (PCC) (per	12.0	8.2
Paver Speed (m/min)		

Report... Close

Production Details | Production Distribution Chart | Sensitivity Chart



Material/Construction Comparison

Construction Scenario	Total Closures	Total Closure Hours	%
12-Hour PCC	*8*	*512*	*100%*
Fast-setting Cement Concrete	*8*	*500*	*98%*
Lean-concrete Base (LCB)	*10*	*656*	*128%*
Widened Truck Lane	*8*	*546*	*107%*

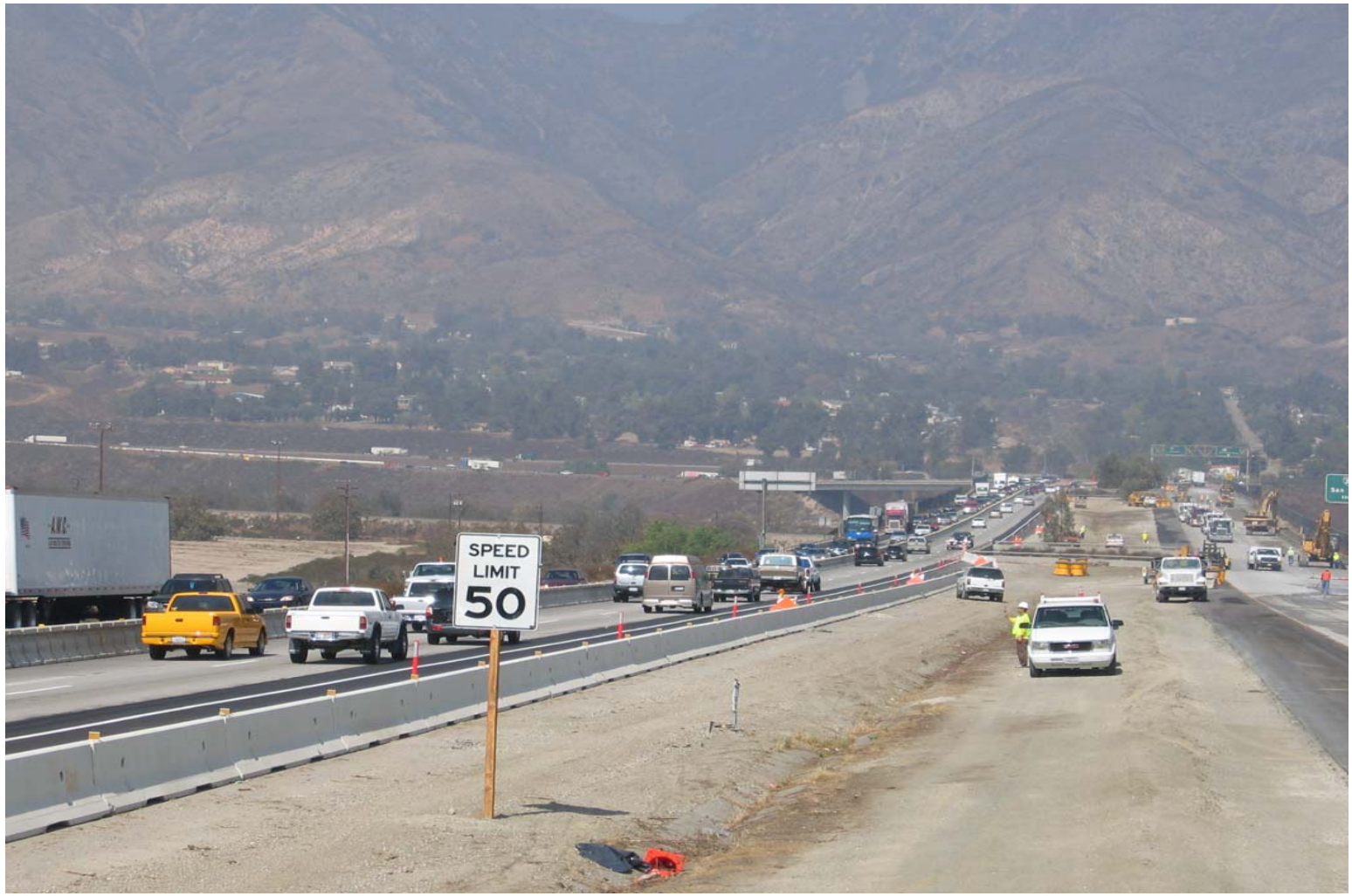
Schedule, Traffic Delay, Total Costs

Construction Scenario	*Schedule Comparison*		Cost Comparison ($M)			Max. Peak Delay (Min)
	Total Closures	Closure Hours	User Delay	Agency Cost	Total Cost	
1 Roadbed Continuous	*2*	*400*	*5.0*	*15.0*	*20.0*	80
72-Hour Weekday Continuous	*8*	*512*	*5.0*	*16.0*	*21.0*	50
55-Hour Weekend Continuous	*10*	*550*	*10.0*	*17.0*	*27.0*	80
10-Hour Night-time Closures	*220*	*2,200*	*7.0*	*21.0*	*28.0*	30

I-10 Pomona

I-710 Long Beach

I-15 Devore



WSDOT Accelerated Construction Projects

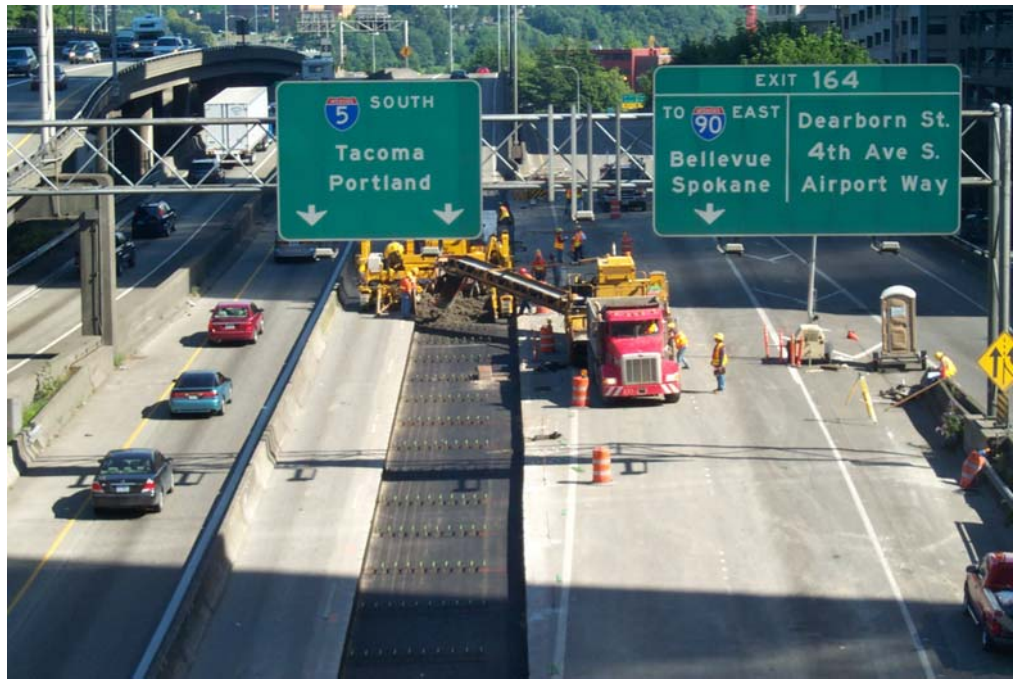
- I-5 James to Olive
- I-5 Tacoma Panel Replacements
- I-5 Pierce Co Line to Tukwila Stage 4 HOV

I-5 James to Olive

- Construction window
  - four 55 hour weekend closures
  - Friday afternoon to Monday morning
- Construction
  - April – July 2005
- ADT
  - 240,000

Critical Issues

- Ability to get answers at any hour
- Experienced personnel
- Work area access
- Contractor ability to address changed conditions
- Useable staging area



Critical Issues

- Resources for around-the-clock operation
- Rapid set materials are not required for successful opening to traffic
- Design elements and construction capabilities must be coordinated

I-5 Pierce Co Line to Tukwila Stage 4 HOV

- 55 panels in 29 hours
- 7 PM Friday to 11 PM Saturday
- Construction - July 2005
- Originally set up for 9 separate closures – reduced to one
- ADT – 180,000

I-5 Tacoma Panel Replacements

- 29 panels in 25 hours
- 10 PM Friday to 6 AM Saturday
- 7:00 PM Saturday to 12:00 PM Sunday
- Construction - August 2005
- Originally set up for 12 working days over 4 weekends
- ADT – 180,000

Software Availability

- **C**onstructability **A**nalysis for **P**avement **R**ehabilitation **S**trategies (CA4PRS)
  - Materials Lab Home Page
    - http://wwwi.wsdot.wa.gov/maintops/mats/apps/CA4PRS.htm

CA4PRS Software Enhancements

- Version 1.5a
  - User interfaces
  - Improve stability
  - Generic terminology
- Version 1.5b
  - Additional rehabilitation strategies
    - Dowel bar retrofit
    - HMA mill and fill
  - More analytical features
  - Additional highway types

CA4PRS Software Enhancements

- Version 2.0
  - Agency costs
    - Construction
    - Traffic
    - Rehabilitation
    - Incentives/disincentives
    - Cost + schedule considerations
  - Traffic impact models
    - User costs (time delay)
    - Utilize Highway Capacity Manual
  - Contracting schedule baseline

Enhancement Completion November 2006

Questions