CHAPTER 3 REALCOST VERSION 2.5CA

3.1 Methodology

This chapter discusses LCCA methodology in detail, along with *RealCost Version 2.5CA* installation and operation instructions, which will allow the engineer to effectively utilize the program to perform LCCA. This chapter shows the engineer the *RealCost Version 2.5CA* input panels with detailed step-by-step instructions on how to successfully execute the program.

1. Gather project information:

    - Existing pavement type
    - Project scope
    - Project location
        - Post mile limit
        - Climate region
    - Expected construction year
    - Traffic information
        - AADT for Construction Year (total for both directions)
        - Single Unit Truck Percentage
        - Combination Truck Percentage
        - Annual Growth Rate of Traffic
        - Operating Speed
        - Number of lanes (each direction)
        - Traffic Hour Distribution (if available)
        - Lane closure window
    - Remaining service life of existing pavement (for widening)
    - Maintenance Service Level (MSL)

2. Select pavement alternatives.
   Use the Pavement Type Selection Flowcharts as specified in Section 2.3.1 or the preferred methodology recommended by your district for selecting pavement alternatives. Selection of pavement alternatives must follow the requirements specified in Section 2.3 of this manual.
   After selecting the pavement alternatives, determine the pavement structure associated with their design lives and estimate initial construction costs.
3. Determine the "Analysis Period."
   Once the alternatives are selected, use Table 2-1 to determine the appropriate analysis period.
4. Determine the traffic flow information.
   Use Table 3-1 to determine the traffic flow inputs for *RealCost Version 2.5CA*. Traffic flow inputs include:

    - Maximum AADT total for both traffic directions
    - Free Flow Capacity of the facility

- Queue Dissipation Capacity of Work Zone
- Expected maximum queue length

5. Determine the future rehabilitation sequence.
   For each pavement alternative selected, *RealCost Version 2.5CA* retrieves the recommended M&R schedule for future maintenance and rehabilitation activities. Appendix 4 lists the database for the various maintenance sequences, which are incorporated in *RealCost Version 2.5CA*.
6. Determine initial construction cost.
   See Section 2.8.3 for information on how to develop initial construction costs.
7. Determine the future rehabilitation cost.
   There is a cost associated with each of the future rehabilitation activities in the sequence. See Section 3.5.3 for information on how to determine these costs.
8. Determine the "Work Zone Duration."
   Work Zone Duration (WZD) is the estimated number of days lane closures are in effect for the entire project construction work. For each alternatives and activities, determine the WZD. For initial construction WZD, it is advised to consult with area Construction Engineer to verify the estimate. For each future rehabilitation activity WZD, use Tables 3-4 to 3-7 as shown in this chapter.
9. Evaluate the results.

Developing quality input data and knowing how to use it to best estimate the life-cycle cost is the true challenge of the analysis. Use your engineering judgment.

3.2 Installing & Starting *RealCost Version 2.5CA*

3.2.1 Installation

In order to prepare a life-cycle cost estimate using *RealCost Version 2.5CA*, the software must first be installed. The software can be downloaded from: http://www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/LCCA_index.html.

Follow the installation instructions provided on the website. Because *RealCost Version 2.5CA* is an add-on program designed to run in Microsoft Excel 2007 (or later), it should not require installation by Caltrans' IT staff.

3.2.2 Start Up

Select "*RealCost Version 2.5CA*" from the Windows "Start Menu", Programs > RealCost > RealCost 2.5CA, or from a shortcut on your desktop to launch the program.

When prompted by Excel, choose "Enable Macros" to run *RealCost Version 2.5CA*. Excel will also prompt a message regarding Active X controls. Click "OK" to dismiss the message as shown in Figure 3-1.

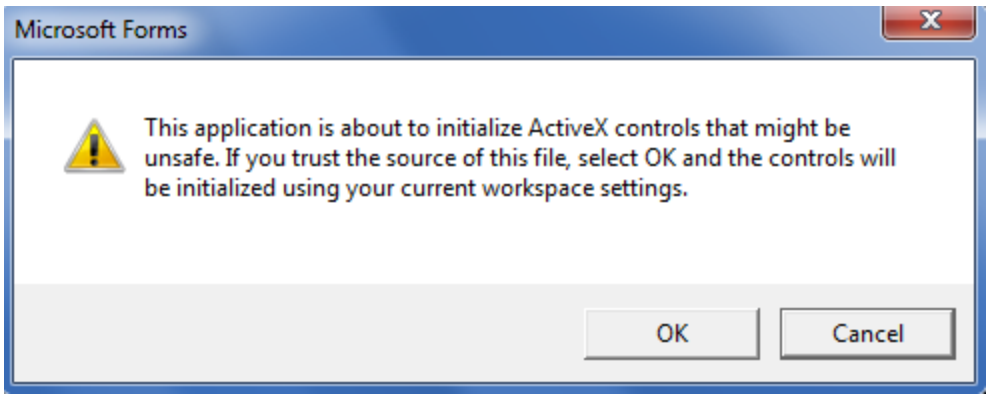


Figure 3-1 Active X Control Excel Message

Immediately after the worksheet appears, the "Switchboard" panel will open over it. If the "Switchboard" does not appear, go to the "Tools" drop down menu, select "Macro," and change the security to medium. If the "Switchboard" is closed, it can be reopen by clicking the "Click to START" button, as shown in Figure 3-2, located in the "start" tab of the spreadsheet (first tab).

Figure 3-2 Initial Panel "Click to START"

3.3 *RealCost Version 2.5CA* Program Operations

Figure 3-3 shows the "Switchboard" for the *RealCost Version 2.5CA* program. This is the backbone or main menu for using the program, and it allows navigation between the sections.

The "Switchboard" consists of five sections as shown in Figure 3-3. The sections are listed as:

- Project-Level Inputs
- Alternative-Level Inputs
- Input Warnings
- Simulation and Outputs
- Administrative Functions

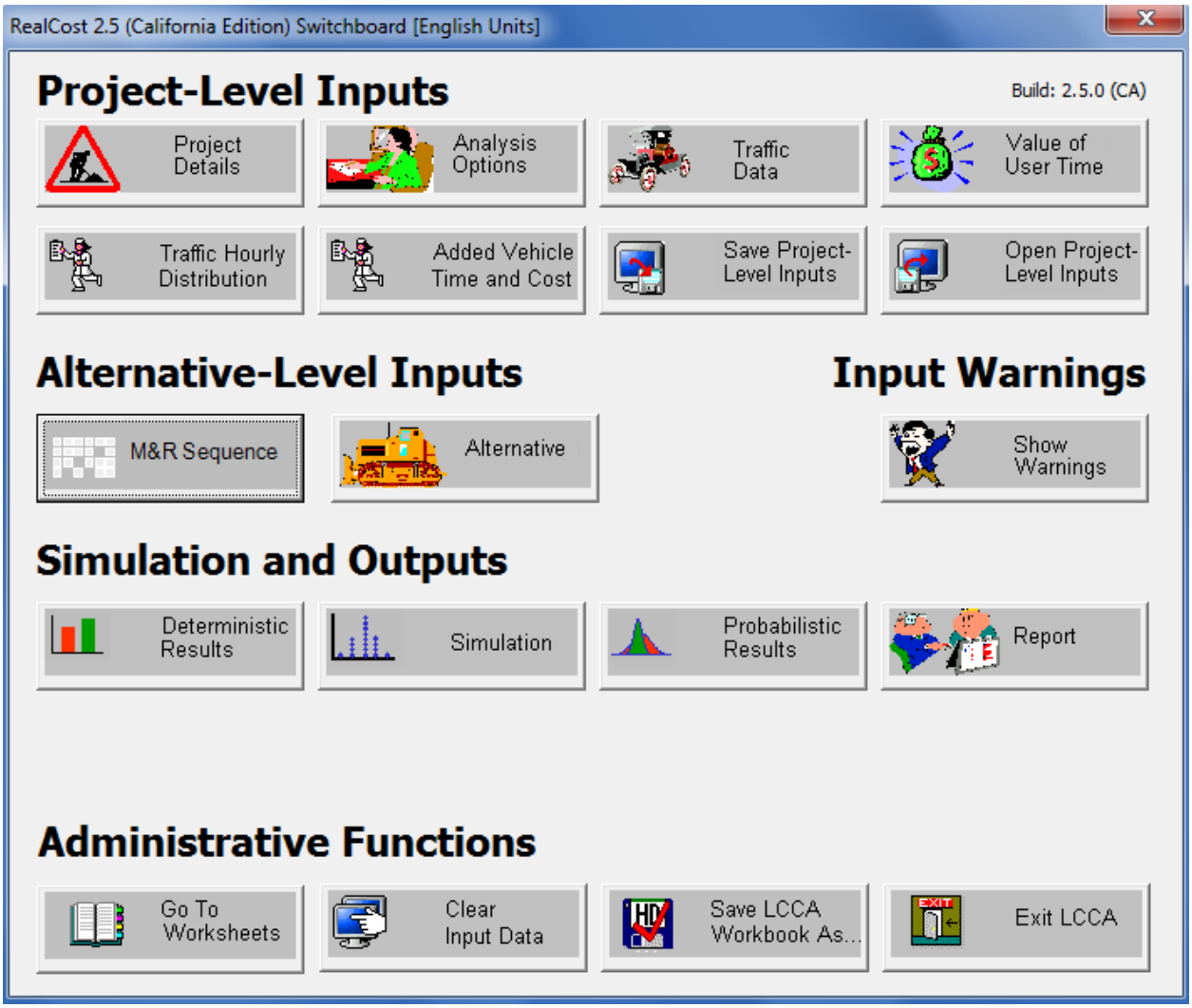


Figure 3-3 *RealCost Version 2.5CA* "Switchboard"

Note:
The program allows you to input data through the "Switchboard". This chapter contains instructions for entering information by using the "Switchboard" which must be use. "Worksheets" are available for the engineer to view, which show the data for the project. The "Worksheets" should not be used to change data directly on them.

The "Switchboard" can be closed by clicking the "X" in the upper right-hand corner. To restore it later, click the "Click to START" in the start menu box.

3.4 Project-Levels Inputs

Gathering the necessary project information may be challenging and may require that the engineer be resourceful in finding all the data resources. Information can be obtained on the Caltrans website, while other data needs can be filled by contacting functional units within the District for information.

The information should include the following:

- Existing pavement type (Project inspection)
- Remaining service life of existing pavement (for widening) (District Maintenance or Materials Unit)
- Project location (PID and project programming)
- Project climate region (Caltrans climate map – see LCCA website)
- Project scope (PID and project programming)
- Potential final pavement surface type & project type
- Maintenance Service Level
- Expected construction year (Funding information and PID)
- Construction scheme such as staging, direction, construction windows, etc.
- Traffic information (i.e. Caltrans Traffic Operations website)

3.4.1 "Project Details" Input

The "Project Details" panel is shown in Figure 3-4 and is used to enter the project information details. Except for "Project Length" input data, information entered here will not be used in the analysis. This information is used to identify the project. "Project Length" input is used to automatically estimate the annualized maintenance cost in the "Alternative" input panel, as discussed in section 3.5.2. Once all the project documentation details are entered, click the "Ok" button to return to the "Switchboard" or the "Cancel" button to start over.

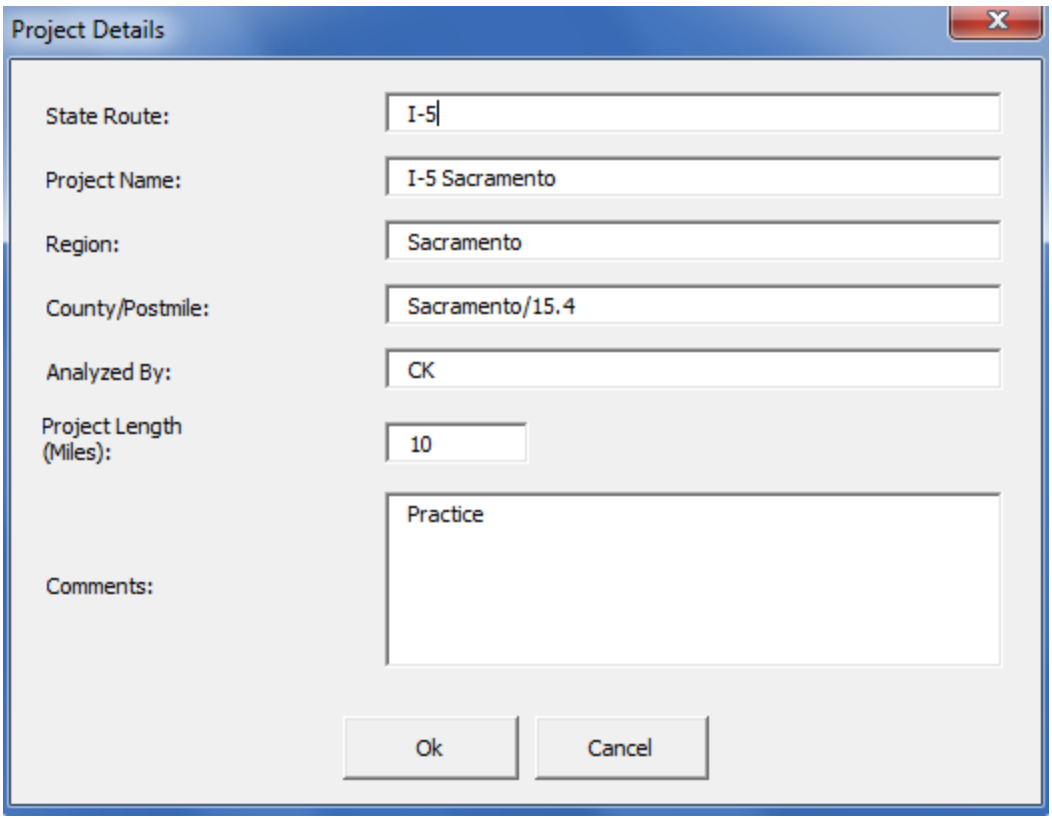


Figure 3-4 Project Details Panel

3.4.2 "Analysis Options" Input

The "Analysis Options" panel, as shown in Figure 3-5, is used to define values that will be applied to all pavement alternatives in the analysis. This panel is where the actual analysis input for the project begins. The data inputs and analysis options available on this panel are detailed below.

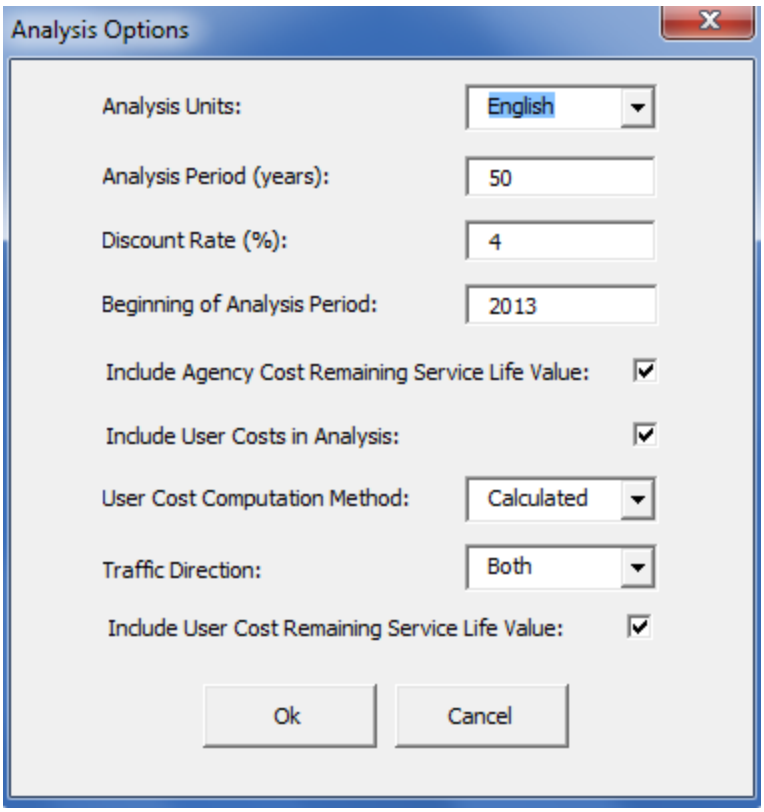


Figure 3-5 Analysis Options Panel

- ***Analysis Units*:** Select either "English" or "Metric" to set the units to be used in the analysis. Caltrans uses "English" units for cost estimate purposes.
- ***Analysis Periods (years)*:** Enter an analysis period (in years) during which project alternatives will be compared. Table 2-1 lists appropriate analysis periods. **When comparing three or more alternatives, determine the analysis period using the longest design life.**
- ***Discount Rate (%)*:** Enter the Caltrans default value of 4 percent for deterministic analysis.
- ***Beginning of Analysis Period*:** Enter the year in which construction of the project alternative is expected to begin. This is the same as the construction year ADT found in the design designation or traffic projections for the project, which are provided by the Traffic Forecasting Unit (see Figure 3-6 from HDM Index 103.1). This should be the same year as the construction year AADT from the design designation, typically, the end of construction year. If the project did not require a design designation (i.e. traffic projections) or traffic projections were not done, use the year you expect the project will end construction.

ADT (2015) = 9800	D = 60%
ADT (2035) = 20 000	T = 12%
DHV = 3000	V = 70 mph
ESAL = 4 500 000	TI_{20} = 11.0

Figure 3-6 Design Designation

- ***Include Agency Cost Remaining Service Life Value*:** Select the checkbox for *RealCost Version 2.5CA* to automatically calculate and include the prorated share of the agency cost of the last future rehabilitation activity if it extends beyond the analysis period.
- ***Include User Costs in Analysis*:** Select the checkbox to have *RealCost Version 2.5CA* include user costs (see Section 2.8.2) in the analysis and display the calculated user costs results.

Note:

As an option, CA4PRS can be used to calculate the user costs for the life-cycle cost analysis. CA4PRS (Rapid Rehab Software) is software developed by Caltrans and others to compare the impacts on construction schedules and the traveling public of various traffic management alternatives. One of the outputs from the program is user costs. The program is currently limited on what options it can investigate but is being expanded as resources allow. The latest version of CA4PRS and the user manual can be obtained from the Division of Research and Innovation website at:

http://www.dot.ca.gov/research/roadway/ca4prs/ca4prs.htm

If CA4PRS data is used, analyses will be needed for all of the initial construction options and future rehabilitation options. If CA4PRS generated data is used, select "Specified" under "User Cost Computation Method".

- ***User Cost Computation Method*:** Select "Calculated" to have *RealCost Version 2.5CA* calculate user costs based on project-specific input data.
- ***Traffic Direction*:** Directs *RealCost Version 2.5 CA* to calculate user costs for the "Inbound" lanes, the "Outbound" lanes, or "Both" lanes. Select the traffic direction that will be affected by work zone operations. "Inbound" is used for the direction where traffic peaks in the AM hours. "Outbound" is used for the direction where traffic peaks in the PM hours. "Both" is used when construction is occurring in both directions.
- ***User Cost Remaining Service Life Value (RSLV)*:** Select the checkbox to have *RealCost Version 2.5CA* include the RSLV of a project alternative. Once all the analysis options are defined, click the "Ok" button to return to the "Switchboard".

3.4.3 "Traffic Data" Input

Much of this data can be accessed from within *RealCost Version 2.5CA* or the Traffic Operation's website; however, the engineer should check with the districts traffic unit for the latest and most current data. Traffic data inputs include the follow data:

1. AADT for construction year
2. Single Unit Truck percentage
3. Combination Trucks percentage
4. Normal operating speed
5. Numbers of lanes open under normal conditions

The "Traffic Data" panel is shown in Figure 3-7 and is used to enter project-specific traffic data that will be used to calculate work zone user costs in accordance with the method outlined in the FHWA's *LCCA Technical Bulletin* (1998) and "Life-Cycle Cost Analysis in Pavement Design."

Traffic data is developed by the district's Traffic Operations unit for PIDs and PRs when pavement work is involved. Some of the data for the "Traffic Data" panel can be found in the design designation as shown in Figure 3-6, traffic projections generated for a specific project, or from the Division of Traffic Operations website (*http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/index.htm*).

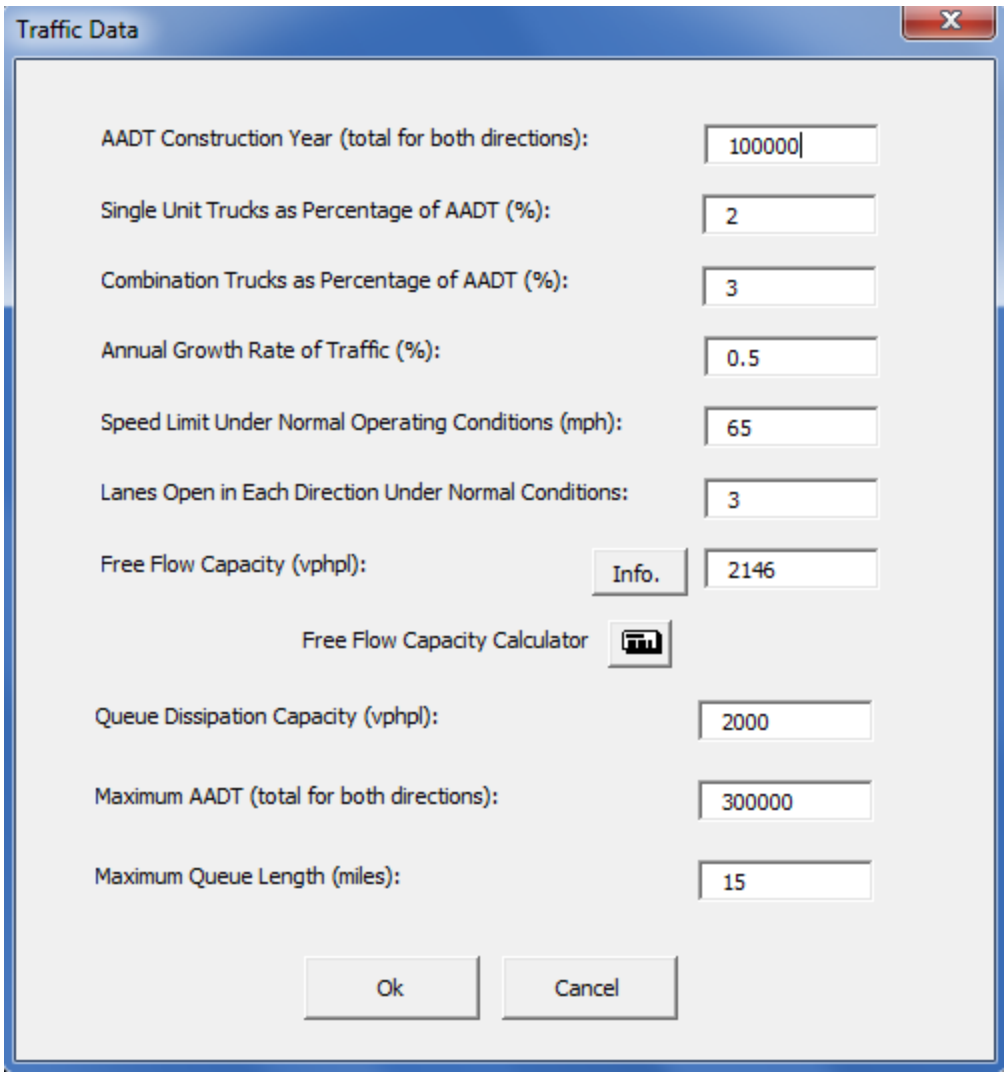


Figure 3-7 Traffic Data Panel

- ***AADT Construction Year (total for both directions)*:** Enter the annual average daily traffic (AADT) total for both directions in the beginning year of the analysis. This is the same as the construction year ADT found in the design designation or traffic projections for the project (see HDM Index 103.1 and Figure 3-6). For an example of what to do if a design designation or traffic forecast was not developed for the project, see Appendix 6.

- ***Single Unit Trucks as Percentage of AADT (%)*:** Enter the percentage of the AADT that is single unit trucks (i.e., commercial trucks with two-axles and four tires or more) by doing the following:

RTE	DIST	CNTY	POST MILE	LEG	DESCRIPTION	VEHICLE AADT TOTAL	TRUCK AADT TOTAL	TRUCK % TOT VEH	TRUCK AADT TOTAL By Axle 2	3	4	5+	% TRUCK AADT By Axle 2	3	4	5+	EAL 2-WAY (1000)	YEAR VER/ EST
001	12	ORA	R.129	A	DANA POINT, JCT. RTE. 5	36500	2270	6.22	770	1074	304	122	33.93	47.32	13.39	5.36	213	03E
001	12	ORA	R.78	A	DANA POINT, DOHENY PARK ROAD	38300	1865	4.87	633	883	250	100	33.93	47.32	13.39	5.36	175	03E
001	12	ORA	9.418	B	LAGUNA BEACH, JCT. RTE. 133 NORTH	37900	659	1.74	258	303	61	38	39.08	45.98	9.2	5.75	59	03E
001	12	ORA	9.418	A	LAGUNA BEACH, JCT. RTE. 133 NORTH	37900	659	1.74	258	303	61	38	39.08	45.98	9.2	5.75	59	03E

Figure 3-8 Average Annual Daily Truck Traffic Information

Go to the Division of Traffic Operations Traffic Data Branch website (***http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/index.htm***) and find the most current file of "Average Annual Daily Truck Traffic" data available is shown in Figure 3-8.

Find the "% Truck AADT" for 2-axle trucks (TA) at the project location. There may be several values given within the limits of the project. Choose the one that best represents the overall project, the average, or the weighted average.

Then, obtain the truck traffic volume (T) from the design designation (HDM Topic 103.1, Figure 3-8). This value is measured as a percentage. If there is no design designation, use the Total Trucks % value from the Division of Traffic Operations web site referred to above (use selection process similar to the one used for 2-axle truck).

> **Note:**
> The total truck volume in the design designation does not need to match the total truck percentage on the Division of Traffic Operations website. If there is a wide disparity in values between the two numbers, the engineer should refer this to the district's Traffic Operations Unit to review the accuracy of the traffic projections in the design designation and have the design designation updated if necessary.

Use Equation 3-1 to calculate the "Single Unit Trucks as Percentage of AADT (%)" (Assumption: "Total Trucks %" and "Single Unit Trucks %" will remain the same in future years):

$$SUT = T \times (\frac{TA}{100})$$ (Equation 3-1)

Where:

SUT = Single Unit Trucks as Percentage of AADT (%)

T = Truck Traffic Volume (% of AADT Total)

TA = 2-Axle Percent (percentage of Truck AADT Total)

Example 3.1:
Given:
Total Trucks % = 6.22 %
2-Axle % = 33.93 %
Find:
The Single Unit Trucks as Percentage of AADT

Using Equation 3-1, the Single Unit Trucks as Percentage of AADT (%) is

$$6.22 \times (\frac{33.93}{100}) = 2.11\%$$

- ***Combination Trucks as Percentage of AADT (%)*:** Enter the percentage of the AADT that is combination trucks (i.e., trucks with three axles or more). This value is obtained by subtracting the "Single Unit Trucks as Percentage of AADT (%)" (SUT) from the "Total Trucks % (percentage of AADT Total)" (T).

$$ComboTrucks = T - SUT$$ (Equation 3-2)

- ***Annual Growth Rate of Traffic (%)*:** Enter the percentage by which the AADT in both directions will increase each year. Contact the Division of Transportation System Information for the "Annual Growth Rate of Traffic" or calculate the approximate value with the available AADT values (in the most current and future years) using the following equation:

$$A = [(\frac{FT}{MT})^{(\frac{1}{FY-MY})} - 1] \times 100$$ (Equation 3-3)

Where:

A = Annual Growth Rate of Traffic (%)

FT = Future Year AADT (total for both directions) obtained from the project design designation (HDM 103.1)

MT = Most Current Year AADT (total for both directions) obtained from the project design designation (HDM 103.1)

FY = Future Year in which AADT is available

MY = Most Current Year in which AADT is available

Example 3.2:

Given:
Future Year AADT (total for both directions) = 18,000 (year 2025)
Most Current Year AADT (total for both directions) = 9,800 (year 2005)

Find:
Using Equation 3-3, the Annual Growth Rate of Traffic is:

$$[(\frac{18,000}{9,800})^{(\frac{1}{2025-2005})} - 1] \times 100 = 3.09\%$$

- ***Speed Limit under Normal Operating Conditions (mph)*:** Enter the posted speed limit at the project location. If the project is a new construction, enter an anticipated speed limit based on traffic laws. District Traffic Operations can provide a recommendation if needed.

- ***Lanes Open in Each Direction under Normal Conditions*:** Enter the number of lanes open to traffic in each direction under normal operating conditions of the facility. For new construction and/or widening of an existing roadway, enter the number of lanes[1] that will open after completing the initial construction.

Use Table 3-1 to determine the traffic flow inputs for *RealCost Version 2.5CA*. Traffic flow inputs include:

- Maximum AADT total for both traffic directions
- Free Flow Capacity of the facility
- Queue Dissipation Capacity of Work Zone
- Expected maximum queue length, per Table 3-1

[1] Using the ultimate lane configuration and entering a "Work Zone Duration" ("Alternative 1," Figure 3-17) of zero for the initial construction of each new construction or widening alternative will generate acceptable results of the analysis of future rehabilitation activities.

Table 3-1 Traffic Input Values

	Two-Lane Highways			Multi-Lane Highways		
Type of Terrain	Level	Rolling	Mountainous	Level	Rolling	Mountainous
Free Flow Capacity (vphpl)	1,620	1,480	1,260	2,170	1,950	1,620
Queue Dissipation Capacity (vphpl)	1,710	1,570	1,330	1,700	1,530	1,270
Maximum AADT Per Lane	40,955	37,390	31,850	53,773	48,305	40,140
Work Zone Capacity (vphpl)(3)	1,050	960	820	1,510	1,360	1,130
Maximum Queue Length	One or two exits prior to the work zone or 7.0 miles if the estimated maximum queue length is longer than 7.0 miles			One or two exits prior to the work zone or 5.0 miles if the estimated maximum queue length is longer than 5.0 miles		

Notes:

(1) Derived from Highway Capacity Manual 2000.

(2) Refer to the calculation procedures included in Appendix 5, "Traffic Inputs Estimation".

(3) Assumed one lane to be open for traffic in single-lane highways and two or more lanes to be open for traffic in multi-lane highways.

- ***Free Flow Capacity (vphpl):*** Enter the number of vehicles per hour per lane (vphpl) under normal operating conditions. Table 3-1 provides typical values for standard lane and shoulder widths for various types of terrain. If there are nonstandard lane and shoulder widths or if it is desired to get a more specific free flow capacity, click the "Free Flow Capacity Calculator" in *RealCost Version 2.5* shown in Figure 3-7 to open a panel that calculates free flow capacities based upon the Highway Capacity Manual (1994, 3rd Ed.) shown in Figure 3-9, "Free Flow Capacity Calculation". To use the calculator, the following project-specific information is shown: number of lanes in each direction, lane width, proportion of trucks and buses (for state highways use % of trucks only), upgrade, upgrade length (for multiple slopes use the average grade throughout the project), obstruction on two sides, and distance to obstruction/shoulder width (Where the existing shoulder width is unknown, use the standard shoulder width as the input). When the "Calculate" button is clicked, the Free Flow Capacity (vphpl) is entered onto Figure 3-9, "Free Flow Capacity Calculation" panel. Click "Copy to Free Flow Capacity Field" button to import the calculated free flow capacity into Figure 3-7, "Traffic Data Panel."

  An alternate procedure for estimating "Free Flow Capacity" can be found in Appendix 5.

- ***Queue Dissipation Capacity (vphpl):*** Enter the vehicles per hour per lane capacity of each lane during queue-dissipation operating conditions. Table 3-1 provides values for typical two-lane and multi-lane (in each direction) highways.

As an alternative, estimate the queue dissipation capacity using the procedures for "Queue Dissipation Capacity" in Appendix 5.

- ***Maximum AADT (total for both directions)*:** Enter the maximum AADT (total for both directions) at which the traffic growth will be capped. This value recognizes that there is only so much traffic that can be placed on a roadway in a 24-hour period. Table 3-1 provides recommended per lane values for typical two-lane and multi-lane highways, multiply the value by the total number of lanes for both directions to obtain the Maximum AADT. As an alternative, the volume may be estimated using the procedures for "Maximum AADT" in Appendix 5.
- ***Maximum Queue Length (miles)*:** Enter a practical maximum length of queue in miles. Reasonable maximum queue length could be one or two exits prior to the work zone or an exit that leads to a reasonable alternate route. Queue-related user costs, which are based upon queue length, will be calculated with this value in cases when the *RealCost*-calculated queue lengths exceed this value. If a project-specific value is not available, enter seven (7) miles for two-lane highways and five (5) miles for multi-lane highways respectively as shown in Table 3-1.

Note:
Appendix 5 provides an explanation on the demand-capacity model – queuing theory – that RealCost uses in calculating maximum queue length.

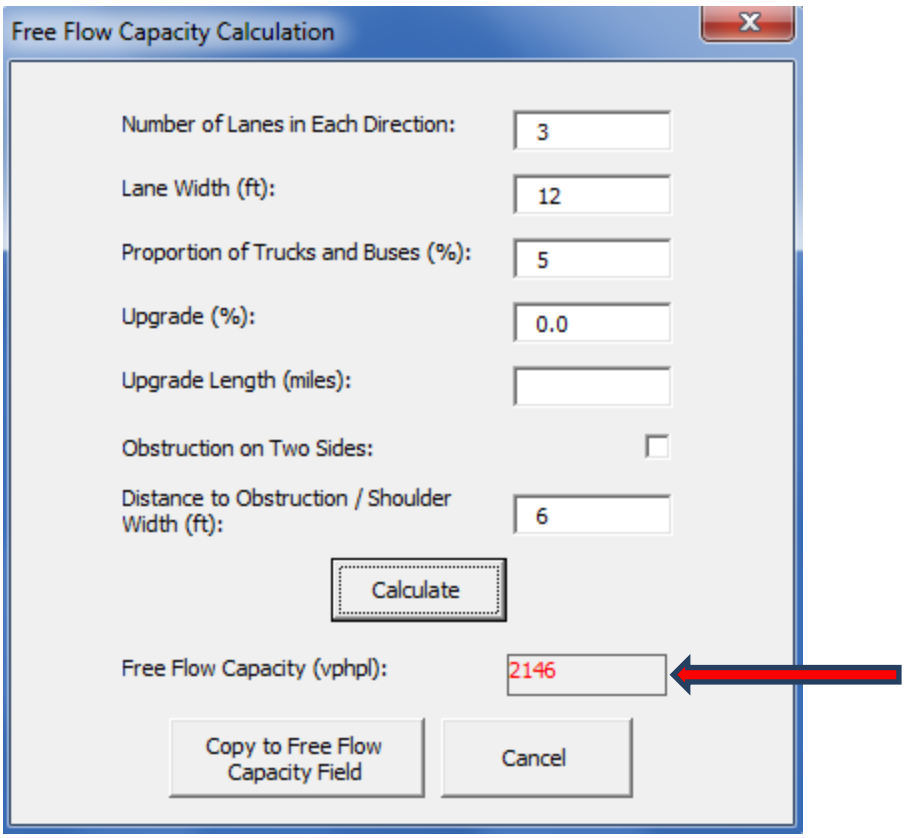


Figure 3-9 "Free Flow Capacity Calculation" Panel

Note:
An alternate procedure for estimating "Free Flow Capacity" can be found in Appendix 5.

3.4.4 Value of User Time

Figure 3-10 shows the 2013 default values for "Value of User Time" and is used to estimate cost applied to an hour of user time. The dollar value of user time can be different for each type of vehicle and is used to calculate user costs associated with delay during work zone operations. These values are updated annually by Caltrans' Economic Analysis Branch. **Use the most up to date Value of User Time values, which can be found at the LCCA website.** Once the dollar values have been entered, click the "Ok" button to return to the "Switchboard" or click the "Cancel" button to start over.

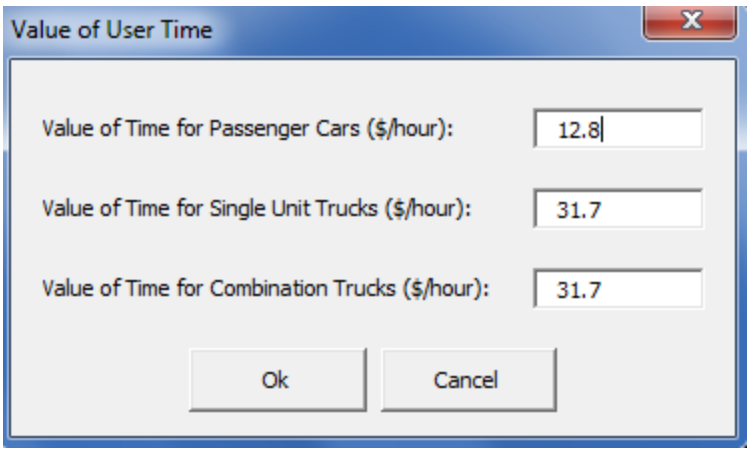


Figure 3-10 Value of User Time

3.4.5 Traffic Hourly Distribution

The "Traffic Hourly Distribution" panel is shown in Figure 3-11 and is used to convert AADT to an hourly traffic distribution. If project-specific data is not available, there are four default traffic patterns to select from, which were generated by Caltrans 2009 traffic count data at selected highway locations and can be used for any location in the State. However, the district's Traffic Operations should be contacted before making the decision to use the default values for your project.

Figure 3-12 through Figure 3-15 show the four different traffic patterns that are available to choose from.

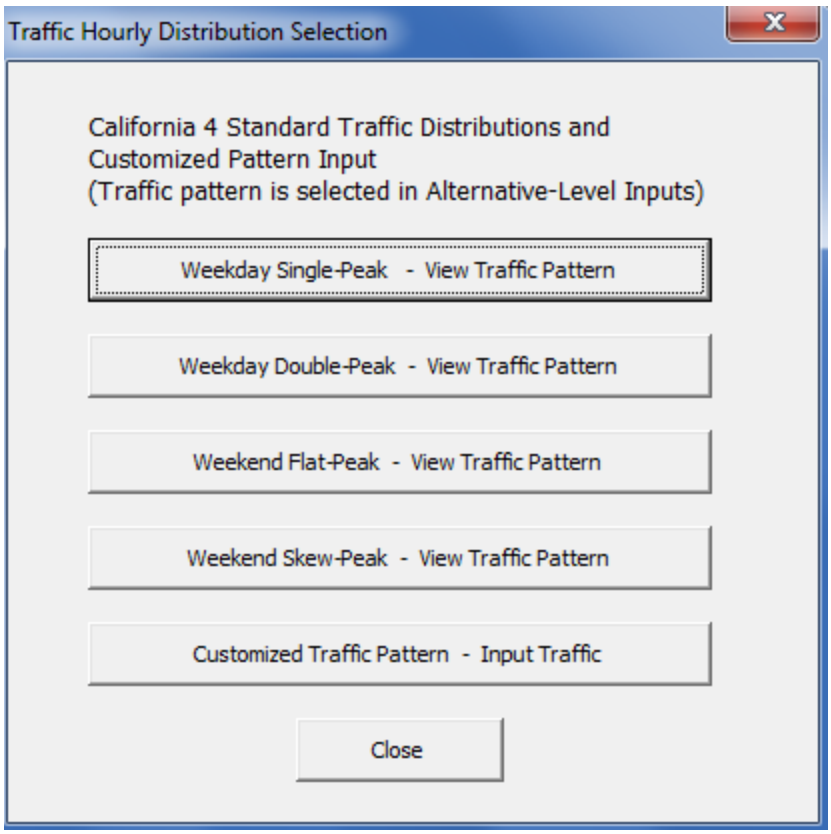
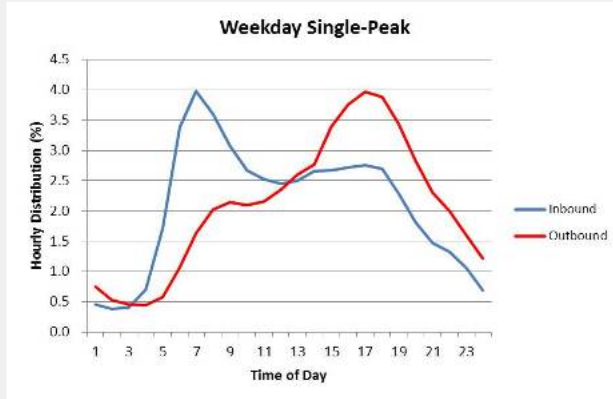


Figure 3-11 Traffic Hourly Distribution Selection

The Weekday Single Peak traffic pattern contains one peak period for each direction. A morning-peak appears in one direction, and an afternoon-peak appears in the other. Figure 3-12 shows a Weekday Single Peak pattern. This traffic pattern is often observed in the boundary areas of central business districts (CBDs) or perimeters of downtown areas.

(1) Weekday Single-Peak

Hour	AADT (%)	Inbound (%)	Outbound (%)
0 - 1	1.20	38	62
1 - 2	0.91	42	58
2 - 3	0.87	47	53
3 - 4	1.15	61	39
4 - 5	2.30	75	25
5 - 6	4.46	76	24
6 - 7	5.61	71	29
7 - 8	5.63	64	36
8 - 9	5.22	59	41
9 - 10	4.78	56	44
10 - 11	4.69	54	46
11 - 12	4.81	51	49
12 - 13	5.10	49	51
13 - 14	5.43	49	51
14 - 15	6.06	44	56
15 - 16	6.49	42	58
16 - 17	6.73	41	59
17 - 18	6.57	41	59
18 - 19	5.74	40	60
19 - 20	4.64	39	61
20 - 21	3.78	39	61
21 - 22	3.33	40	60
22 - 23	2.65	40	60
23 - 24	1.90	36	64



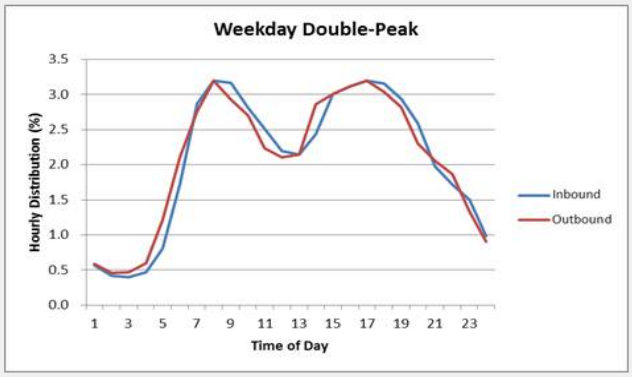
Close

Figure 3-12 Weekday Single Peak Traffic Hourly Distribution Pattern

The Weekday Double Peak traffic pattern contains two peak periods for both directions. The first peak appears and diminishes in the morning for both directions, and the second peak appears and diminishes in the afternoon for both directions. Figure 3-13 shows a Weekday Double Peak traffic pattern. This traffic pattern is often observed on urban freeways inside central business districts (CBDs) or downtown areas during weekdays.

(2) Weekday Double-Peak

Hour	AADT (%)	Inbound (%)	Outbound (%)
0 - 1	1.18	49	51
1 - 2	0.88	48	52
2 - 3	0.86	46	54
3 - 4	1.07	44	56
4 - 5	2.02	40	60
5 - 6	3.83	45	55
6 - 7	5.63	51	49
7 - 8	6.40	50	50
8 - 9	6.10	52	48
9 - 10	5.52	51	49
10 - 11	4.75	53	47
11 - 12	4.30	51	49
12 - 13	4.30	50	50
13 - 14	5.30	46	54
14 - 15	6.02	50	50
15 - 16	6.24	50	50
16 - 17	6.40	50	50
17 - 18	6.20	51	49
18 - 19	5.76	51	49
19 - 20	4.90	53	47
20 - 21	4.04	49	51
21 - 22	3.59	48	52
22 - 23	2.84	53	47
23 - 24	1.89	52	48



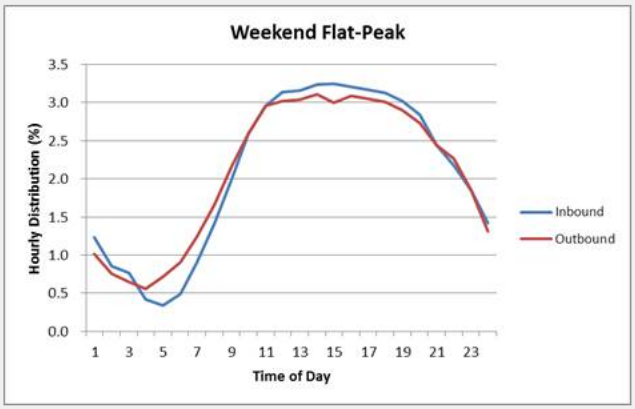
Close

Figure 3-13 Weekday Double Peak Traffic Hourly Distribution Pattern

The Weekend Flat Peak traffic pattern contains one flat peak period for each direction throughout most of the day. The curve shape is gentle and flat during the peak period. Figure 3-14 shows a Weekend Flat Peak pattern. This traffic pattern is mostly observed on urban freeways inside CBDs or downtown areas during Saturdays and Sundays.

(3) Weekend Flat-Peak

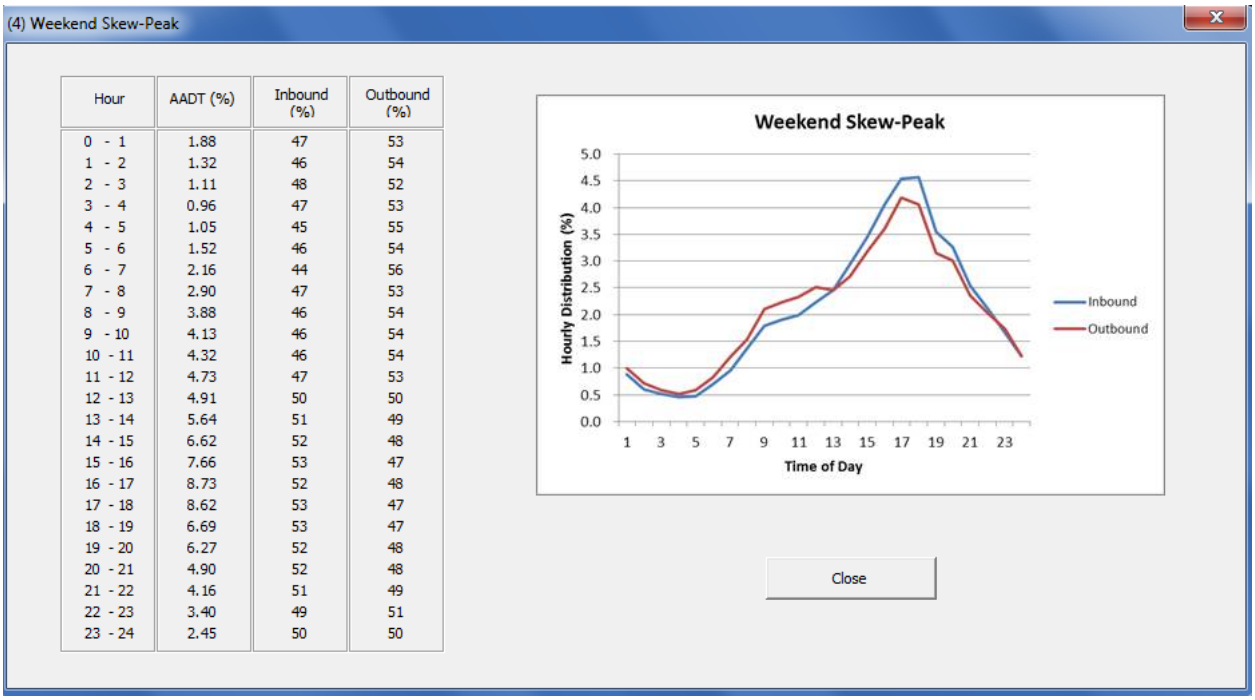
Hour	AADT (%)	Inbound (%)	Outbound (%)
0 - 1	2.25	55	45
1 - 2	1.61	53	47
2 - 3	1.41	54	46
3 - 4	0.99	43	57
4 - 5	1.05	32	68
5 - 6	1.39	35	65
6 - 7	2.15	42	58
7 - 8	3.07	46	54
8 - 9	4.17	48	52
9 - 10	5.18	50	50
10 - 11	5.93	50	50
11 - 12	6.16	51	49
12 - 13	6.20	51	49
13 - 14	6.35	51	49
14 - 15	6.24	52	48
15 - 16	6.30	51	49
16 - 17	6.21	51	49
17 - 18	6.13	51	49
18 - 19	5.92	51	49
19 - 20	5.57	51	49
20 - 21	4.88	50	50
21 - 22	4.43	49	51
22 - 23	3.70	50	50
23 - 24	2.73	52	48



Close

Figure 3-14 Weekend Flat Peak Traffic Distribution Pattern

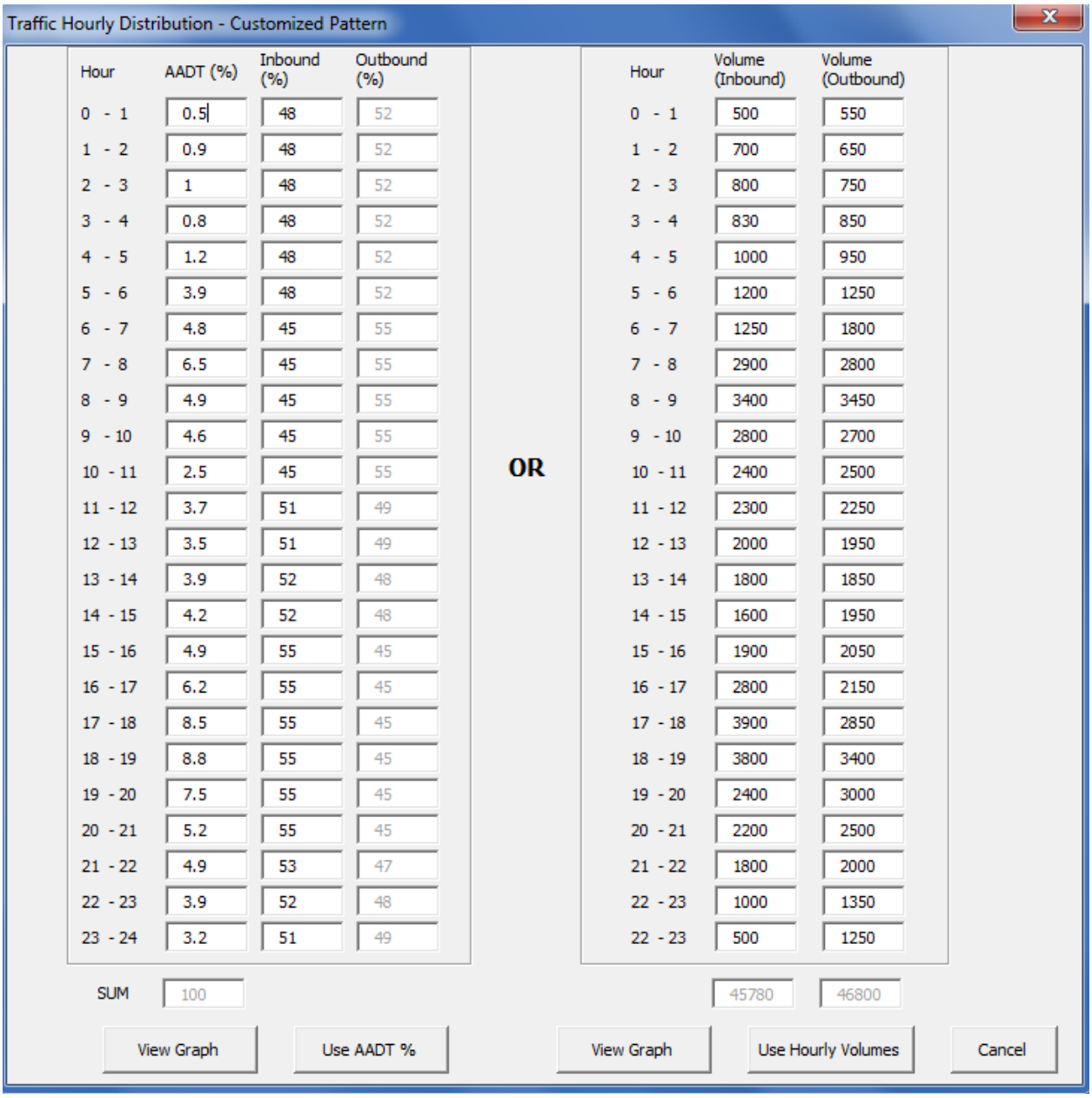
The Weekend Skew Peak traffic pattern contains one sharp evening peak period for each direction. The curve shape is skewed and narrow during peak period. Figure 3-15 shows an example of Weekend Skew Peak pattern. This pattern is particularly observed on freeways connecting leisure sites, including amusement parks and tourist destinations.



Hour	AADT (%)	Inbound (%)	Outbound (%)
0 - 1	1.88	47	53
1 - 2	1.32	46	54
2 - 3	1.11	48	52
3 - 4	0.96	47	53
4 - 5	1.05	45	55
5 - 6	1.52	46	54
6 - 7	2.16	44	56
7 - 8	2.90	47	53
8 - 9	3.88	46	54
9 - 10	4.13	46	54
10 - 11	4.32	46	54
11 - 12	4.73	47	53
12 - 13	4.91	50	50
13 - 14	5.64	51	49
14 - 15	6.62	52	48
15 - 16	7.66	53	47
16 - 17	8.73	52	48
17 - 18	8.62	53	47
18 - 19	6.69	53	47
19 - 20	6.27	52	48
20 - 21	4.90	52	48
21 - 22	4.16	51	49
22 - 23	3.40	49	51
23 - 24	2.45	50	50

Figure 3-15 Weekend Skew Peak Traffic Distribution Pattern

In addition to the four California standard traffic hourly distribution patterns, the customization function allows users to input a site-specific traffic hourly distribution pattern by selecting the customized Input Traffic button in the Traffic Hourly Distribution window. In the Traffic Hourly Distribution—Customized Pattern window that appears in Figure 3-16, engineers can directly input either hourly proportions and directional split proportions or hourly volumes for inbound and outbound. By clicking the relevant View Graph button after inputting either traffic pattern by AADT or hourly traffic volumes, engineers can obtain a corresponding graph of the customized traffic patterns, which can then be selected for each activity of the respective alternative.



Traffic Hourly Distribution - Customized Pattern

Hour	AADT (%)	Inbound (%)	Outbound (%)
0 - 1	0.5	48	52
1 - 2	0.9	48	52
2 - 3	1	48	52
3 - 4	0.8	48	52
4 - 5	1.2	48	52
5 - 6	3.9	48	52
6 - 7	4.8	45	55
7 - 8	6.5	45	55
8 - 9	4.9	45	55
9 - 10	4.6	45	55
10 - 11	2.5	45	55
11 - 12	3.7	51	49
12 - 13	3.5	51	49
13 - 14	3.9	52	48
14 - 15	4.2	52	48
15 - 16	4.9	55	45
16 - 17	6.2	55	45
17 - 18	8.5	55	45
18 - 19	8.8	55	45
19 - 20	7.5	55	45
20 - 21	5.2	55	45
21 - 22	4.9	53	47
22 - 23	3.9	52	48
23 - 24	3.2	51	49
SUM	100		

OR

Hour	Volume (Inbound)	Volume (Outbound)
0 - 1	500	550
1 - 2	700	650
2 - 3	800	750
3 - 4	830	850
4 - 5	1000	950
5 - 6	1200	1250
6 - 7	1250	1800
7 - 8	2900	2800
8 - 9	3400	3450
9 - 10	2800	2700
10 - 11	2400	2500
11 - 12	2300	2250
12 - 13	2000	1950
13 - 14	1800	1850
14 - 15	1600	1950
15 - 16	1900	2050
16 - 17	2800	2150
17 - 18	3900	2850
18 - 19	3800	3400
19 - 20	2400	3000
20 - 21	2200	2500
21 - 22	1800	2000
22 - 23	1000	1350
22 - 23	500	1250
	45780	46800

View Graph | Use AADT % | View Graph | Use Hourly Volumes | Cancel

Figure 3-16 "Traffic Hourly Distribution—Customized Pattern" Panel

Traffic hourly distribution patterns are not selected in Traffic Hourly Distribution Figure 3-11 panel and are shown for viewing purposes only. Selection is made in the "Alternative" panel. If traffic hourly distribution is known, data can be inputted in this panel and selected in the "Alternative" panel as "Customized".

3.4.6 Added Vehicle Time and Cost

An example of the "Added Time and Vehicle Stopping Costs" panel is shown in Figure 3-17. This section of the program is used to adjust the default values for added time and added cost per 1,000 stops. The default values are based upon the National Cooperative Highway

Research Program (NCHRP) Study 133 (1996), *Procedures for Estimating Highway User Costs, Air Pollution, and Noise Effects.* These values are used to calculate user delay and vehicle operating costs due to speed changes that occur during work zone operations. The "Idling Cost per Veh-Hr ($)" is used to calculate the additional vehicle operating costs that result from moving through a traffic queue under stop-and-go conditions.

An escalation factor is built into the program to escalate the vehicle operating cost associated with speed change and idling by entering the current year and the associated transportation-component Consumer Price Index (CPI). The current year will be the year when construction is expected to begin. Table 3-2 shows the transportation-component CPI's collected and projected by the Bureau of Labor Statistics. Since the statewide transportation-component CPI's are not available yet, the U.S. transportation-component CPI's (in bold text) can be used. The values for specific areas like Los Angeles (LA), San Francisco (SF), and San Diego (SD) can be used for those specific areas. Figure 3-17 is the added cost for 2012. CPI values are updated annually. For current Transportation CPI values, see the LCCA website.

Added Time and Vehicle Stopping Costs

Initial Speed (mph)	Added Time per 1,000 Stops (Hours)			Added Cost per 1,000 Stops ($)		
	Passenger Cars	Single Unit Trucks	Combination Trucks	Passenger Cars	Single Unit Trucks	Combination Trucks
0	0	0	0	0	0	0
5	1.02	0.73	1.1	4.104	14.06	51.1024
10	1.51	1.47	2.27	13.4216	31.4944	117.7848
15	2	2.2	3.48	23.0432	51.5128	197.5544
20	2.49	2.93	4.76	33.0448	73.568	288.8912
25	2.98	3.67	6.1	43.5784	97.2344	389.9408
30	3.46	4.4	7.56	54.872	121.9496	498.8792
35	3.94	5.13	9.19	66.9712	147.2576	613.8368
40	4.42	5.87	11.09	80.104	173.2344	732.9592
45	4.9	6.6	13.39	94.3464	197.7216	854.4528
50	5.37	7.33	16.37	109.9112	221.8592	976.4632
55	5.84	8.07	20.72	126.8744	244.5528	1097.0904
60	6.31	8.8	27.94	145.464	272.0496	1214.4648
65	6.78	9.53	31.605	165.7104	297.6768	1291.4528
70	7.25	10.27	39.48	187.8872	317.7712	1399.9656
75	7.71	11	47.9	212.0856	341.8024	1508.4784
80	8.17	11.73	57.68	238.412	365.8336	1617.0064
Idling Cost per Veh-Hr ($):				1.0529	1.1675	1.2537

Cost Escalation

Base Transp. Component CPI:	217.3
Base Year:	2012
Current Transp. Component CPI:	217.3
Current Year:	2012
Escalation Factor:	1.00

Escalate

Restore Defaults Ok

Note: "Escalation Factor" value returns to 1.00 after the escalation has been performed.

Figure 3-17 "Added Vehicle Time and Cost" Panel

Example 3.3:

For a 2013 year analysis:

Enter "2013" for "Current Year" and "217.3" for "Current Transp. Component CPI"

Click the "Escalate" button *(see Figure 3-17).*

The program will update the cost data. To get back to the default values, click the "Restore Defaults" button.

Note: *2012 is the default base.*

Table 3-2 Transportation Component Consumer Price Indexes

Year	US	LA CMSA(1)	SF CMSA(2)	SD CMSA(3)
1996	**143.0**	144.3	133.5	150.8
1997	**144.3**	145.2	133.6	152.2
1998	**141.6**	142.6	132.0	149.4
1999	**144.4**	146.8	135.8	152.1
2000	**153.3**	154.2	143.1	162.4
2001	**154.3**	155.3	143.7	164.9
2002	**152.9**	154.5	141.0	163.0
2003	**157.6**	160.3	144.9	168.0
2004	**163.1**	166.5	149.6	175.6
2005	**173.9**	174.8	156.1	185.5
2006	**180.9**	181.6	161.5	190.4
2007	**184.7**	183.2	166.6	193.2
2008	**195.5**	192.6	176.3	200.7
2009	**179.3**	178.6	166.7	184.7
2010	**193.4**	190.9	178.1	200.4
2011	**212.4**	207.8	190.8	222.7
2012	**217.3**	214.0	197.3	227.7

Notes:

* Source: US Department of Labor, Bureau of Labor Statistics

http://www.bls.gov/cpi/

(1) LA CMSA (Consolidated Metropolitan Statistical Area): includes counties of Los Angeles, Orange, Riverside, San Bernadino, & Ventura.

(2) SF CMSA (Consolidated Metropolitan Statistical Area): includes counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, & Sonoma.

(3) SD CMSA (Consolidated Metropolitan Statistical Area): includes county of San Diego.

Once all the "Project Level Inputs" has been completed, click the "Ok" button to return to the "Switchboard" or the "Cancel" button to start over.

3.4.7 Save Project-Level Inputs

To save the project level inputs file, go back to the "Switchboard" as shown in Figure 3-3, and select the "Save Project-Level Inputs" button, or select "Save LCCA Workbook As…" button to save all modified level inputs including traffic data inputs. *RealCost Version 2.5CA*

will save the project-level inputs at the specified location. The project input file will be automatically saved with a *.LCC extension. To retrieve the file later, select the "Open Project Level Inputs" button located on the "Switchboard".

Note:
Saving the project-level inputs does not make any changes made to default data in "Traffic Hourly Distribution" or "Added Time and Vehicle Stopping Costs." Any of this project-specific data must be reentered when reopening *RealCost Version 2.5CA*. If required, use "Save LCCA workbook as" button to save all modified level inputs.

3.5 Alternative-Level Inputs

3.5.1 "M&R Sequence" Input

After the "Project-Level Inputs" entries are completed, select the "M&R Sequence" button from the "Switchboard" menu to begin the "Alternative-Level Inputs". In this section of the program, M&R sequence schedule is selected for each pavement alternatives as shown in Figure 3-18, which is an example of "M & R Sequence Selection".

Up to four pavement alternatives can be compared simultaneously in one analysis run. If more than four pavement alternatives are to be analyzed, additional runs will be required.

Make selections for the "General Criteria," which is a common input for all pavement alternatives.

- Project Type. From the drop down menu, choose the project type:
  1.) New Construction/Reconstruction/Widening,
  2.) Rehabilitation, or
  3.) CAPM (Although LCCA is not required on CAPM projects, the option is available with *RealCost Version 2.5CA*)
- Climate Region. Choose the value from the Caltrans Pavement Climate Regions Map based on the geographical location of the project as shown in Figure A4-1 in Appendix 4 and available on the following website:
  http://www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/Climate.html

  The choices are:

  1) North Coast
  2) Central Coast
  3) South Coast
  4) Inland Valley
  5) High Mountain
  6) High Desert
  7) Desert
  8) Low Mountain

9) South Mountain

- Maintenance Service Level. This value is selected from the drop down menu. The choices are 1, 2, or 3.

Next make selections for each of the pavement alternatives.

- Final Pavement Surface. There are 15 selection to choose from as shown in Table 3-3:

Table 3-3 Final Pavement Surface Choices

Final Pavement Surface		
Flexible	Rigid	
HMA	JPCP	CRCP
HMA W/OGFC	JPCP CPR A	CRCP PR A
HMA W/RHMA	JCPC CPR B	CRCP PR B
RHMA	JCPC CPR C	CRCP PR C
RHMA W/ RHMA O	Composite—HMA or RHMA over Rigid (crack, seat, and overlay)	

- Design Life. Choose from

1) 5 or 10 years (for CAPM projects)
2) 20 years
3) 40 years

Once all selections are made, click on "Find M&R Sequence"

For each pavement alternative, the program automatically selects the appropriate M&R schedule from Appendix 4 tables and transfers the data as shown in Figure 3-18.

Note:

Not all combination of inputs will yield a M&R schedule. For example, if a 20 year design life and final pavement surface of JPCP CPR A is selected, the M&R sequence schedule will be "N/A" because JPCP CPR A only applies to 5 or 10 year design life.

The automatic inputs include the "Activity Number", "Activity Name", "Year of Action", "Annual Maintenance Cost ($)", and "Activity Service Life (Years)", for each pavement alternative as shown in Figure 3-18, "M&R Sequence Selection" panel.

- ***Activity Number***: The sequential order of each activity. Activity 1 is the initial construction activity. Activity 2 and above are future rehabilitation activities.
- ***Activity Name***: The name of the pavement strategy.
- ***Agency Maintenance Cost ($1000):*** *RealCost Version 2.5 CA* automatically enters "Maintenance Costs," this includes the costs of preventive, corrective, and routine maintenance treatments to preserve or to extend the service life of initial construction and any future rehabilitation activities. Cost is per lane mile.
- ***Activity Service Life (years):*** The activity service life of initial construction and future rehabilitation activities are automatically entered by the program. Refer to Appendix 4 for the appropriate pavement M&R schedule that shows the activity service lives estimated for the initial construction and the future rehabilitation activities each pavement alternative.

Click the check box for the pavement alternatives to analyze. Click "OK" to transfer information to the "Alternative" panel or click the "CANCEL" button to start the procedure over.

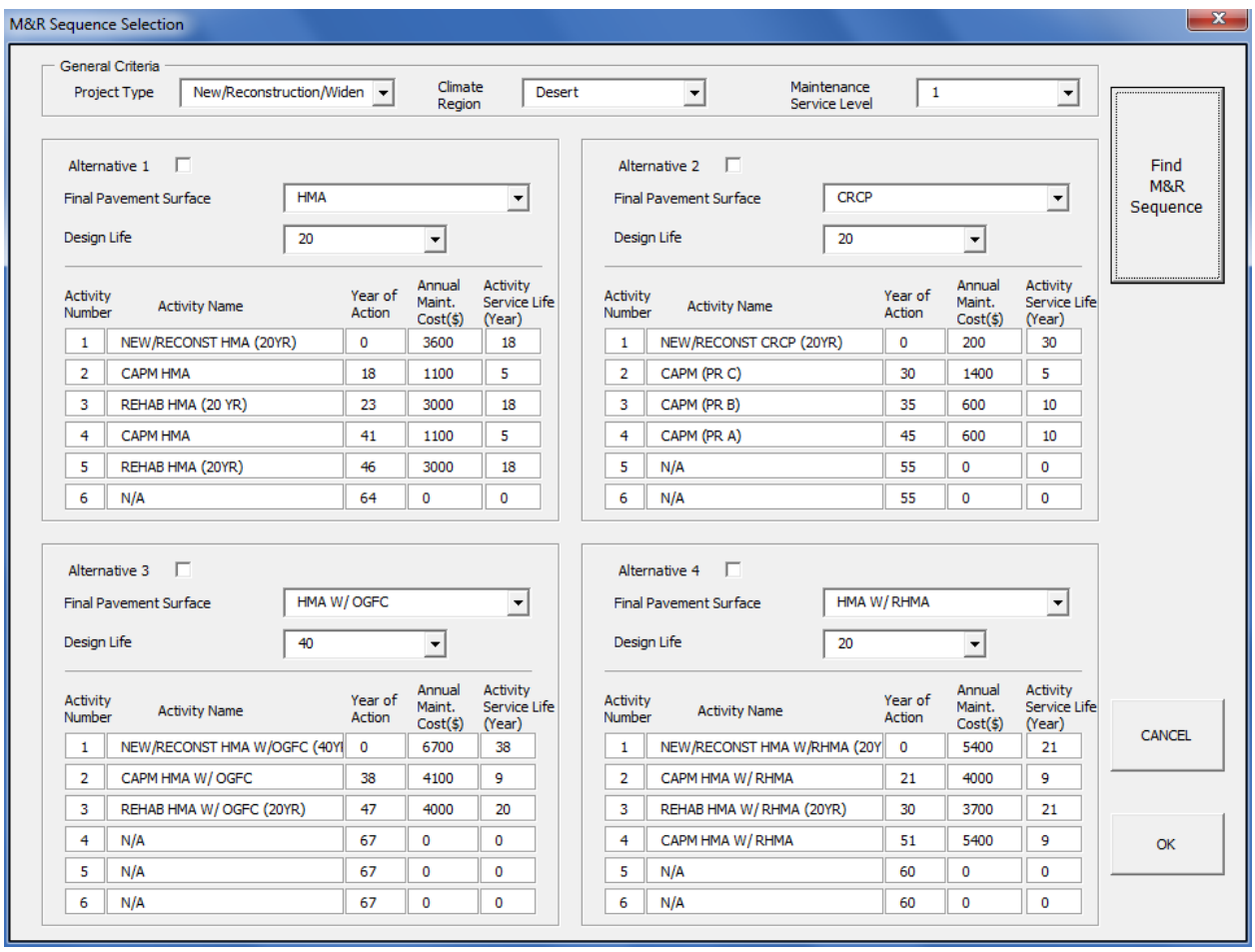


Figure 3-18 Example of M&R Sequence Selection Panel

3.5.2 "Alternative" Input

The Alternative panels between each of the pavement alternatives are identical and are used to input information for the alternative being analyzed. The rehabilitation activities for each alternative are transferred from the "M&R Sequence" panel. Each activity is in sequential order. For example, Activity 1 is the initial construction and Activity 2 is the next rehabilitation activity after initial construction.

The data inputs required under each activity tab on the panel are described below.

DESCRIPTION

- ***Alternative Description:*** Enter a new description for the pavement alternative such as "20-yr Rehab (HMA Overlay)."
- ***Activity Description:*** The activity description is automatically transferred from the "M&R Sequence" panel. Additional description should be added.

ACTIVITY COST AND SERVICE LIFE INPUTS

- ***Agency Construction Cost ($1000):*** Under the "Activity 1" tab, enter the total initial construction cost in thousands of dollars for each of the pavement alternatives (see section 2.8.3, 'Initial Costs"). For each future rehabilitation activity after the initial construction (Activity 1), use the "COST" button calculator to estimate the total rehabilitation cost, which is entered in as thousands of dollars. There are four future rehabilitation and CAPM cost estimate calculators shown in Figure 3-19, "Cost Estimate". Instructions for the future rehabilitation cost calculators are detailed in section 3.5.3.

    1. Flexible or Composite Rehabilitation
    2. Rigid Rehabilitation
    3. Flexible or Composite CAPM
    4. Rigid CAPM

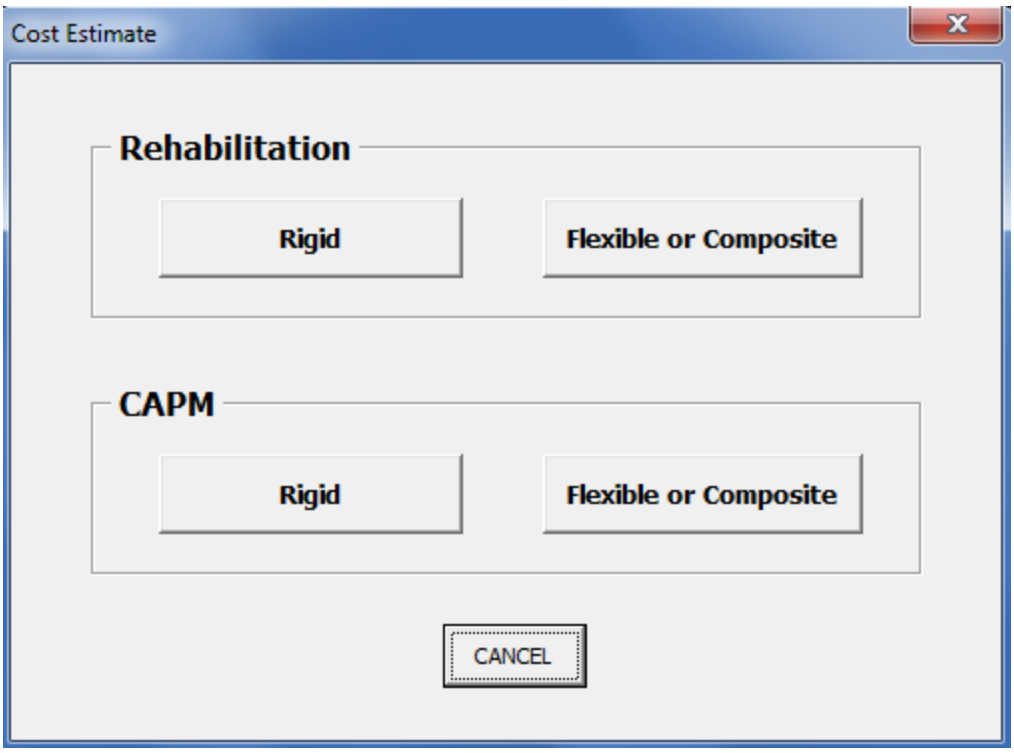
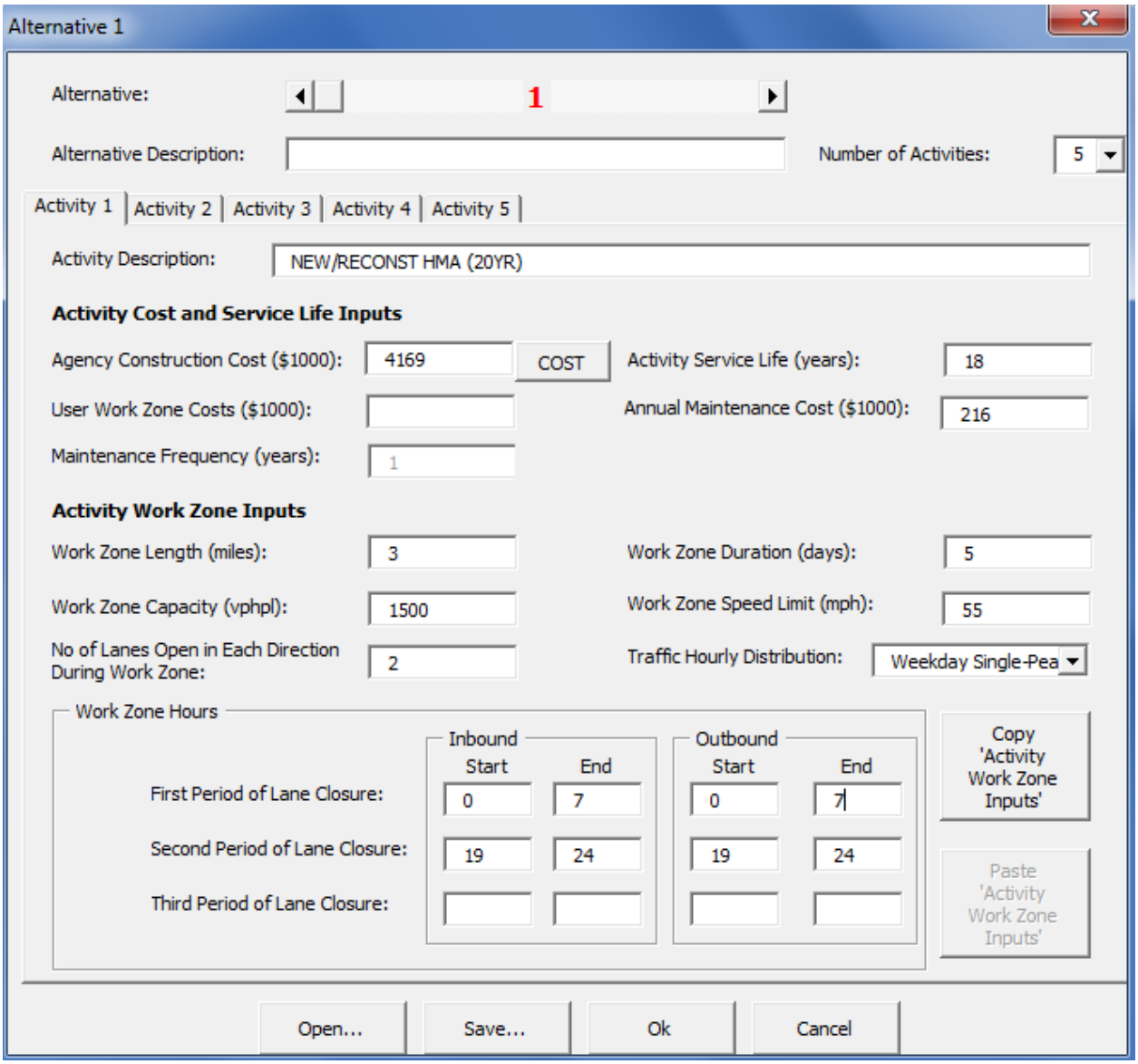


Figure 3-19 "Cost Estimate" Pavement Type, Project Type Panel

- ***Activity Service Life (years):*** As discussed section 3.5.1, the activity service life is automatically transferred from the M&R Sequence panel.
- ***User Work Zone Costs ($1000):*** This field is inaccessible because the "User Cost Computation Method" panel in Figure 3-5, "Analysis Options" panel is set to "Calculated". If this is not the case, go to "Analysis Options" panel to modify the "User Cost Computation Method."
- ***Maintenance Frequency (years):*** The default value is one (1) year as the "Maintenance Frequency," because the cost of maintenance treatments shown in the M&R schedules have been annualized (see section 2.8.4)
- ***Annual Maintenance Cost ($1000):*** The Agency Maintenance Cost is automatically calculated. The project length from "Project Details" panel is multiplied by the number of lanes open in each direction from the "Traffic Data" panel times the number of directions also from the "Traffic Data" panel times the annualized maintenance cost from the "M&R Sequence" panel. The engineers may enter their own calculation. If the project length is modified after M&R Sequence is selected, M&R Sequence must be selected again to recalculate the Annual Maintenance Cost.



Note: The "Second Period of Lane Closure" requires an "End" number greater than "0".

Figure 3-20 Alternative 1 Panel

ACTIVITY WORK ZONE INPUTS

- ***Work Zone Length (miles):*** This input refers to the length (in miles) of the work zone being considered for initial construction and for each future rehabilitation activity. The work zone length should be based on what is allowed from the Traffic Management Plan (TMP) for the initial construction or historical experience. Note that the Work Zone Length (WZL) is not necessarily the full length of the project limits. It should be measured from beginning to end of the reduced speed area where the work zone speed limit will be in effect daily or nightly based on the activity. Additional information and recommendations can be obtained from the District Construction and Traffic Operations if needed.

- ***Work Zone Duration (days):*** Refers to the number of days during which the work zone will be affecting traffic. For example, if the work zone is in effect five days a week for four weeks, the duration is twenty. Determine the Work Zone Duration (WZD) using the following formula:

$$WZD = \frac{Lane - miles}{PR} \qquad \text{(Equation 4)}$$

Where:

WZD = Work Zone Duration in days

PR = Productivity Rate in lane-miles per day

Note:
Several special cases to be aware of:

Continuous lane closures – If a lane is closed for the duration of the pavement work, it is treated as a 24-hour closure (from hour 0 to hour 24) for each working day it is closed. Therefore, if the lane is closed for 3 months the total number of closures is 3 months times 21 work days per month, for a total of 63 days.

Weekend (55-hour) closures – multiply 2.3 (=55/24) by the number of closures needed in order to get the number of days needed. This is necessary because the RealCost Version 2.5CA program can only analyze closures within a 24-hour period and weekend closures last for over 2 days.

Where lanes can be detoured and work can be done behind K-rail or other separation from traffic, no lane closure is required, and hence , the work zone duration (for this work) is zero.

For initial construction, the work zone duration should be estimated as part of establishing the critical path method (CPM) schedule for the project. **Work Zone Duration is not the same as the number of working days used to build the project. WZD is the estimated number of days lane closures are in effect for project construction work.** Use a WZD of zero[1], for each of the competing alternatives, when the initial construction is a new construction or a widening. For future rehabilitations, the estimated work zone duration must be determined using the total length of pavement structure work in lane-miles, and the corresponding productivity rate from Table 3-4 to Table 3-7. See Equation 4 for the computation method for WZD.

Tables 3-4 to 3-7 provide the estimates of work that can be completed during different construction windows, such as nighttime closure, weekend closure, etc. When using

[1] Using a WZD = 0 for the initial construction of each new construction or widening alternative and entering the ultimate lane configuration in "Lanes Open in Each Direction Under Normal Conditions" ("Traffic Data," Figure 3-6) will generate acceptable results of the analysis of future rehabilitation activities.

typical M&R strategies for flexible pavements, use Table 3-4, and for rigid and composite pavements use Table 3-6. These production rates are estimates developed using *CA4PRS,* "Construction Analysis for Pavement Rehabilitation Strategies", software and assuming typical working conditions and resource configurations observed in past projects.

Relative to agency costs, user costs can have a major impact on the total life-cycle cost, so it is important to use the most cost effective traffic management practice possible. In some cases, such as when comparing flexible and rigid pavement strategies, the most cost effective traffic management plan may not be the same for all the alternatives (initial and future rehabilitation) being considered. If the traffic management plan does not provide a strategy for the initial or future rehabilitation strategy or if the strategy needs to be checked to be sure it is the most cost effective, the engineer can use the construction traffic analysis software CA4PRS (freeways only) to analyze options.

- ***Work Zone Capacity (vphpl):*** Enter the vehicular capacity of one lane of the work zone for one hour. Table 3-1 provides values for typical two-lane and multi-lane highways. As an alternative, the capacity may be estimated using the procedures for "Work Zone Capacity" in Appendix 5.
- ***Work Zone Speed Limit (mph):*** This is the expected operating speed within the work zone. Enter a speed that is 5 mph less than the posted speed limit unless there is an approved reduced speed limit for the project. Approved reductions in posted speed limits can be found in the traffic management plan.
- ***No. of Lanes Open in Each Direction During Work Zone:*** Enter the number of lanes to be open when the work zone is in effect. The number of lanes to be open applies to each direction. This information can be obtained from the traffic management plan or District Traffic Operations.

Note:
If the project is a two-lane highway, and the work zone is anticipated to be under one-directional traffic control, enter one (1) lane to be open in each direction during work zone and reduce the work zone capacity by half.

- ***Work Zone Hours:*** Enter the zone hours using a 24-hour clock (starting from 0 to 24) during which the work zone is in effect. Work zone timing can be modeled separately for inbound and outbound traffic for up to three separate periods during each day. During these hours, road capacity is limited to the work zone capacity. Work zone hours can be obtained from the TMP or District Traffic Operations. If the traffic management plan includes variable work zone hours (lane closures) for the project, use the hours that apply most often to the project as a whole.

Note:

For weekend closures, enter 0 to 24 on first period line. The end of closure time must be greater than 0.

Example:

If the nightly lane closure hour is from 8pm to 6am, then the first period line is from 0 to 6, and the second period line is from 20 to 24 for both inbound and outbound traffic.

Table 3-4 Productivity Estimates of Typical Future Rehabilitation Strategies for Flexible Pavements

Final Surface Type	Future M&R Alternative	Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure				
				Daily Closure (Weekday)		Continuous Closure		
				5 to 7-Hour Closure	8 to 12-Hour Closure	16 hour/Day Operation	24 hour/day Operation	55-hour Weekend Closure
CAPM								
HMA	Overlay	5+	1,2,3	0.84	1.73	2.9	4.81	12.25
	Mill & Overlay	5+	1,2,3	0.36	0.75	1.18	2.21	5.20
HMA w/OGFC	Overlay	5+	1,2,3	0.55	1.14	1.9	3.17	8.09
	Mill & Overlay	5+	1,2,3	0.30	0.61	0.97	1.86	4.35
HMA w/ RHMA	Overlay	5+	1,2,3	0.55	1.14	1.9	3.17	8.09
	Mill & Overlay	5+	1,2,3	0.30	0.61	0.97	1.86	4.35
RHMA-G	Overlay	5+	1,2,3	1.12	2.32	3.86	6.41	16.33
	Mill & Overlay	5+	1,2,3	0.48	1.00	1.56	2.93	6.88
RHMA-G w/RHMA-O	Overlay	5+	1,2,3	0.84	1.73	2.9	4.81	12.25
	Mill & Overlay	5+	1,2,3	0.34	0.72	1.14	2.17	5.13
Rehabilitation								
HMA	Overlay	10	1,2,3	0.47	0.98	1.63	2.72	6.94
		20	1,2,3	0.33	0.69	1.15	1.91	4.87
	Mill & Overlay	10	1,2,3	0.21	0.45	0.73	1.37	3.23
		20	1,2,3	0.15	0.31	0.49	0.93	2.18
HMA w/OGFC	Overlay	10	1,2,3	0.35	0.75	1.26	2.10	5.37
		20	1,2,3	0.27	0.57	0.95	1.58	4.04
	Mill & Overlay	10	1,2,3	0.19	0.39	0.64	1.23	2.9
		20	1,2,3	0.14	0.28	0.45	0.86	2.01
HMA w/RHMA	Overlay	10	1,2,3	0.35	0.75	1.26	2.1	5.37
		20	1,2,3	0.27	0.57	0.95	1.58	4.04
	Mill & Overlay	10	1,2,3	0.19	0.39	0.64	1.23	2.90
		20	1,2,3	0.14	0.28	0.45	0.86	2.01
RHMA-G	Overlay	10	1,2,3	0.84	1.73	2.90	4.81	12.25
		20	1,2,3	0.55	1.14	1.90	3.17	8.09
	Mill & Overlay	10	1,2,3	0.37	0.75	1.18	2.21	5.20
		20	1,2,3	0.25	0.52	0.84	1.58	3.73
RHMA-G w/RHMA-O	Overlay	10	1,2,3	0.55	1.14	1.9	3.17	8.09
		20	1,2,3	0.40	0.83	1.41	2.36	6.03
	Mill & Overlay	10	1,2,3	0.30	0.61	0.97	1.86	4.35
		20	1,2,3	0.21	0.44	0.72	1.39	3.28

Notes:

(1) Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.
(2) Production rates in the table are based on representative assumptions that are applied consistently throughout the table. These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose. More project specific user costs for some freeway situations can be obtained from the CA4PRS software.
(3) 24-hour continuous closure with 16 hours of operation per day
(4) 24-hour continuous closure with 24 hours of operation per day
(5) 55-hour extended closure over the weekend

Table 3-5 Productivity Estimates of Typical Future Rehabilitation Ramp Strategies for Flexible Pavements

Final Surface Type	Future M&R Alternative	Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure				
				Daily Closure (Weekday)		Continuous Closure		
				5 to 7-Hour Closure	8 to 12-Hour Closure	16 hour/Day Operation	24 hour/day Operation	55-hour Weekend Closure
CAPM								
HMA	Overlay	5+	1,2,3	0.51	1.02	1.71	2.85	7.29
	Mill & Overlay	5+	1,2,3	0.22	0.44	0.70	1.32	3.10
HMA w/OGFC	Overlay	5+	1,2,3	0.32	0.66	1.11	1.87	4.81
	Mill & Overlay	5+	1,2,3	0.17	0.36	0.57	1.10	2.60
HMA w/ RHMA	Overlay	5+	1,2,3	0.32	0.66	1.11	1.87	4.81
	Mill & Overlay	5+	1,2,3	0.17	0.36	0.57	1.10	2.60
RHMA-G	Overlay	5+	1,2,3	0.68	1.36	2.28	3.79	9.69
	Mill & Overlay	5+	1,2,3	0.29	0.59	0.93	1.75	4.10
RHMA-G w/RHMA-O	Overlay	5+	1,2,3	0.51	1.02	1.71	2.85	7.29
	Mill & Overlay	5+	1,2,3	0.20	0.42	0.67	1.29	3.05
Rehabilitation								
HMA	Overlay	10	1,2,3	0.28	0.57	0.96	1.61	4.13
		20	1,2,3	0.19	0.40	0.68	1.13	2.90
	Mill & Overlay	10	1,2,3	0.13	0.26	0.43	0.81	1.92
		20	1,2,3	0.09	0.18	0.29	0.55	1.30
HMA w/OGFC	Overlay	10	1,2,3	0.21	0.43	0.73	1.24	3.19
		20	1,2,3	0.15	0.33	0.55	0.93	2.40
	Mill & Overlay	10	1,2,3	0.11	0.23	0.37	0.72	1.72
		20	1,2,3	0.08	0.16	0.26	0.51	1.19
HMA w/RHMA	Overlay	10	1,2,3	0.21	0.43	0.73	1.24	3.19
		20	1,2,3	0.15	0.33	0.55	0.93	2.40
	Mill & Overlay	10	1,2,3	0.11	0.23	0.37	0.72	1.72
		20	1,2,3	0.08	0.16	0.26	0.51	1.19
RHMA-G	Overlay	10	1,2,3	0.51	1.02	1.71	2.85	7.29
		20	1,2,3	0.32	0.66	1.11	1.87	4.81
	Mill & Overlay	10	1,2,3	0.22	0.44	0.70	1.32	3.10
		20	1,2,3	0.15	0.31	0.50	0.94	2.22
RHMA-G w/RHMA-O	Overlay	10	1,2,3	0.32	0.66	1.11	1.87	4.81
		20	1,2,3	0.23	0.49	0.82	1.39	3.58
	Mill & Overlay	10	1,2,3	0.17	0.36	0.57	1.10	2.60
		20	1,2,3	0.12	0.26	0.42	0.82	1.95

Notes:

(1) Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.
(2) Production rates in the table are based on representative assumptions that are applied consistently throughout the table. These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose. More project specific user costs for some freeway situations can be obtained from the CA4PRS software.
(3) 24-hour continuous closure with 16 hours of operation per day
(4) 24-hour continuous closure with 24 hours of operation per day
(5) 55-hour extended closure over the weekend

Table 3-6 Productivity Estimates of Typical Future Rehabilitation for Rigid and Composite Pavements

Final Surface Type	Future M&R Alternative		Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure: Daily Closure: 5 to 7-Hour Closure	Daily Closure: 8 to 12-Hour Closure	Continuous Closure: 16 hour/day Operation	Continuous Closure: 24 hour/day Operation	Weekend Closure (55-Hour)
CAPM									
Flexible/ Composite	Flexible Overlay		5+	1,2,3	1.16	2.32	3.86	6.41	16.33
	Flexible Overlay w/Salb Replacements (FO+JPCP SR)	4-hr RSC	5+	1,2,3	0.63	1.69	3.05		
		12-hr RSC					1.90	4.37	12.66
Rigid-Jointed Plain Concrete Pavement (JPCP)	Concrete Pavement Rehab A	4-hr RSC	5+	1,2,3	0.48	1.79	4.17		
		12-hr RSC					1.07	3.93	16.11
	Concrete Pavement Rehab B	4-hr RSC	5+	1,2,3	0.67	2.51	5.84		
		12-hr RSC					1.50	5.51	22.56
	Concrete Pavement Rehab C	4-hr RSC	5+	1,2,3	1.67	6.27	14.61		
		12-hr RSC					3.75	13.77	56.40
Rigid-Continuously Reinforced Concrete Pavement (CRCP)	Punchout Repair A	4-hr RSC	5+	1,2,3	0.08	0.17	0.66		
		12-hr RSC					0.27	0.67	4.51
	Punchout Repair B	4-hr RSC	5+	1,2,3	0.11	0.24	0.92		
		12-hr RSC					0.38	0.94	6.31
	Punchout Repair C	4-hr RSC	5+	1,2,3	0.27	0.60	2.31		
		12-hr RSC					0.96	2.34	15.78
Rehabilitation									
Flexible / Composite	Flexible Overlay w/ Slab Replacement **(FO + JPCP SR)**	4-hr RSC	10	1,2,3	0.31	0.89	1.66		
	Flexible Overlay w/ Slab Replacement **(FO + JPCP SR)**	12-hr RSC					0.91	2.27	6.83
	Mill, Slab Replacement & Overlay **(MSRO)**	4-hr RSC	10	1,2,3	0.19	0.50	0.85		
	Mill, Slab Replacement & Overlay **(MSRO)**	12-hr RSC					0.91	2.27	6.83
	Mill, Slab Replacement & Overlay **(MSRO)**	4-hr RSC	20	1,2,3	0.15	0.38	0.64		
	Mill, Slab Replacement & Overlay **(MSRO)**	12-hr RSC					0.49	1.10	2.82
	Crack, Seat, & Flexible Overlay (CSFOL)		10	1,2,3	0.47	0.98	1.63	2.72	6.94
			20		0.44	0.75	1.26	2.10	5.37
	Replace with Flexible		20	1,2,3	0.21	0.44	0.75	1.26	3.22
			40		0.15	0.31	0.53	0.89	2.30
	Replace with Composite	4-hr RSC	20	1,2,3	0.02	0.08	0.18		
		12-hr RSC					0.09	0.16	0.65
		4-hr RSC	40	1,2,3	0.02	0.07	0.17		
		12-hr RSC					0.08	0.15	0.60
Jointed Plain Concrete Pavement (JPCP)	Lane Replacement	4-hr RSC	20	1,2,3	0.03	0.07	0.17		
		12-hr RSC					0.04	0.16	0.62
		4-hr RSC	40	1,2,3	0.02	0.06	0.14		
		12-hr RSC					0.05	0.14	0.53
Continuously Reinforced Concrete Pavement	Lane Replacement	4-hr RSC	20	1,2,3	0.01	0.03	0.11		
		12-hr RSC					0.05	0.11	0.66
		4-hr RSC	40	1,2,3	0.01	0.03	0.10		
		12-hr RSC					0.04	0.10	0.63

FO = Flexible Overlay JPCP = Jointed Plain Concrete Pavement SR = Slab Replacement RSC = Rapid Set Concrete CRCP = Continuously Reinforced Concrete Pavement

Notes:

(1) Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.

(2) Production rates are based on the lower end of the representative assumptions for the range and are applied consistently throughout the table.
These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose.
More project specifics user cost for some freeway situations can be obtained from the CA4PRS software.

(3) 24-hour continuous closure with 16 hours of operation per day

(4) 24-hour continuous closure with 24 hours of operation per day

(5) 55-hour extended closure over the weekend

(6) Punchout Repair A involves **significant** punchout repairs and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement that had previous punchout repairs and a flexible overlay.

(7) Punchout Repair B involves **moderate** punchout repair and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement where the total number of current and previous punchout repairs exceed 4 per mile.

(8) Punchout Repair C involves **minor** punchout repairs and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement where the total number of current and previous punchout repairs do not exceed 4 per mile.

(9) Precast panel concrete pavement is under development. See HQ LCCA Coordinator for assistance.

Table 3-7 Productivity Estimates of Typical Future Ramp Rehabilitation for Rigid and Composite Pavements

Final Surface Type	Future M&R Alternative		Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure: Daily Closure: 5 to 7-Hour Closure	Daily Closure: 8 to 12-Hour Closure	Continuous Closure: 16 hour/day Operation	Continuous Closure: 24 hour/day Operation	Weekend Closure (55-Hour)
CAPM									
Flexible/ Composite	Flexible Overlay		5+	1,2,3	0.27	0.54	0.85	1.61	3.78
	Flexible Overlay w/Salb Replacements (FO+JPCP SR)	4-hr RSC	5+	1,2,3	0.20	0.43	0.71		
		12-hr RSC					0.52	1.16	3.06
Rigid-Jointed Plain Concrete Pavement (JPCP)	Concrete Pavement Rehab A	4-hr RSC	5+	1,2,3	0.28	0.60	1.26		
		12-hr RSC					0.39	1.21	4.63
	Concrete Pavement Rehab B	4-hr RSC	5+	1,2,3	0.40	0.84	1.76		
		12-hr RSC					0.54	1.68	6.43
	Concrete Pavement Rehab C	4-hr RSC	5+	1,2,3	0.99	2.10	4.41		
		12-hr RSC					1.35	4.20	16.08
Rigid-Continuously Reinforced Concrete Pavement (CRCP)	Punchout Repair A	4-hr RSC	5+	1,2,3	0.06	0.13	0.54		
		12-hr RSC					0.27	0.54	3.40
	Punchout Repair B	4-hr RSC	5+	1,2,3	0.08	0.18	0.76		
		12-hr RSC					0.26	0.76	4.76
	Punchout Repair C	4-hr RSC	5+	1,2,3	0.21	0.45	1.89		
		12-hr RSC					0.93	1.89	11.91
Rehabilitation									
Flexible / Composite	Flexible Overlay w/ Slab Replacement **(FO + JPCP SR)**	4-hr RSC	10	1,2,3	0.03	0.07	0.13		
	Flexible Overlay w/ Slab Replacement **(FO + JPCP SR)**	12-hr RSC					0.04	0.13	0.49
	Mill, Slab Replacement & Overlay **(MSRO)**	4-hr RSC	10	1,2,3	0.03	0.06	0.12		
	Mill, Slab Replacement & Overlay **(MSRO)**	12-hr RSC					0.04	0.12	0.45
	Mill, Slab Replacement & Overlay **(MSRO)**	4-hr RSC	20	1,2,3	0.03	0.06	0.11		
	Mill, Slab Replacement & Overlay **(MSRO)**	12-hr RSC					0.04	0.12	0.42
	Crack, Seat, & Flexible Overlay (CSFOL)		10	1,2,3	0.28	0.57	0.96	1.61	4.13
			20		0.21	0.43	0.73	1.24	3.19
	Replace with Flexible		20	1,2,3	0.12	0.26	0.43	0.74	1.91
			40		0.08	0.18	0.31	0.52	1.37
	Replace with Composite	4-hr RSC	20	1,2,3	0.01	0.05	0.11		
		12-hr RSC					0.04	0.10	0.39
		4-hr RSC	40	1,2,3	0.01	0.04	0.10		
		12-hr RSC					0.04	0.09	0.36
Jointed Plain Concrete Pavement (JPCP)	Lane Replacement	4-hr RSC	20	1,2,3	0.01	0.04	0.10		
		12-hr RSC					0.04	0.09	0.37
		4-hr RSC	40	1,2,3	0.01	0.04	0.09		
		12-hr RSC					0.03	0.08	0.33
Continuously Reinforced Concrete Pavement	Lane Replacement	4-hr RSC	20	1,2,3	0.01	0.02	0.06		
		12-hr RSC					0.03	0.06	0.40
		4-hr RSC	40	1,2,3	0.01	0.02	0.06		
		12-hr RSC					0.03	0.06	0.38

FO = Flexible Overlay JPCP = Jointed Plain Concrete Pavement SR = Slab Replacement RSC = Rapid Set Concrete CRCP = Continuously Reinforced Concrete Pavement

Notes:

(1) Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.

(2) Production rates are based on the lower end of the representative assumptions for the range and are applied consistently throughout the table.
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More project specifics user cost for some freeway situations can be obtained from the CA4PRS software.

(3) 24-hour continuous closure with 16 hours of operation per day

(4) 24-hour continuous closure with 24 hours of operation per day

(5) 55-hour extended closure over the weekend

(6) Punchout Repair A involves **significant** punchout repairs and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement that had previous punchout repairs and a flexible overlay.

(7) Punchout Repair B involves **moderate** punchout repair and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement where the total number of current and previous punchout repairs exceed 4 per mile.

(8) Punchout Repair C involves **minor** punchout repairs and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement where the total number of current and previous punchout repairs do not exceed 4 per mile.

(9) Precast panel concrete pavement is under development. See HQ LCCA Coordinator for assistance.

3.5.3 Cost Estimate Calculators for Future Rehabilitation and CAPM

There are four future rehabilitation and CAPM cost estimate calculators to choose from and are to be used when developing construction cost estimate for future M&R activities. The Cost Estimate window shown in Figure 3-21 appears when the "COST" button is selected in activities beyond the "Activity 1" panel. Choose the appropriate calculator that matches the rehabilitation or CAPM activity. For example, if the activity requires CAPM HMA, then the CAPM flexible calculator should be selected.

Unit prices are based on a weighted average between 2002 to 2012 from Caltrans construction contract cost database at the following website (*http://sv08data.dot.ca.gov/contractcost/*).

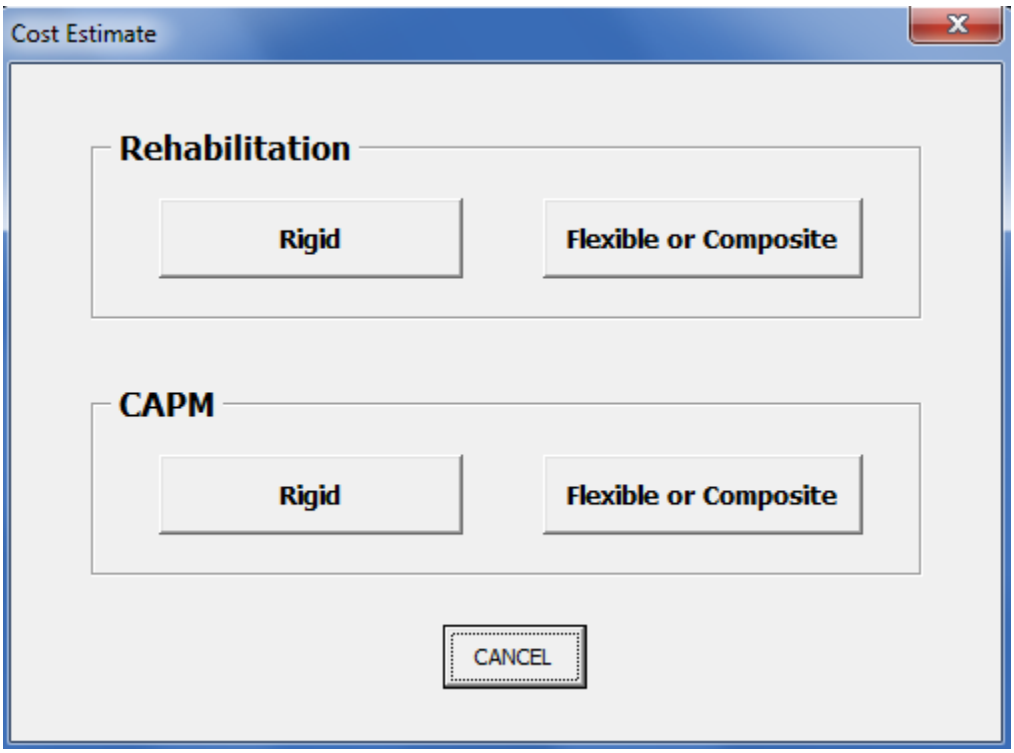


Figure 3-21 Cost Estimate Calculator Options

3.5.3.1 Rehabilitation Flexible Pavement Cost Estimator

Figure 3-22 is the cost estimator panel for the "Rehabilitation Flexible or Composite Pavement".

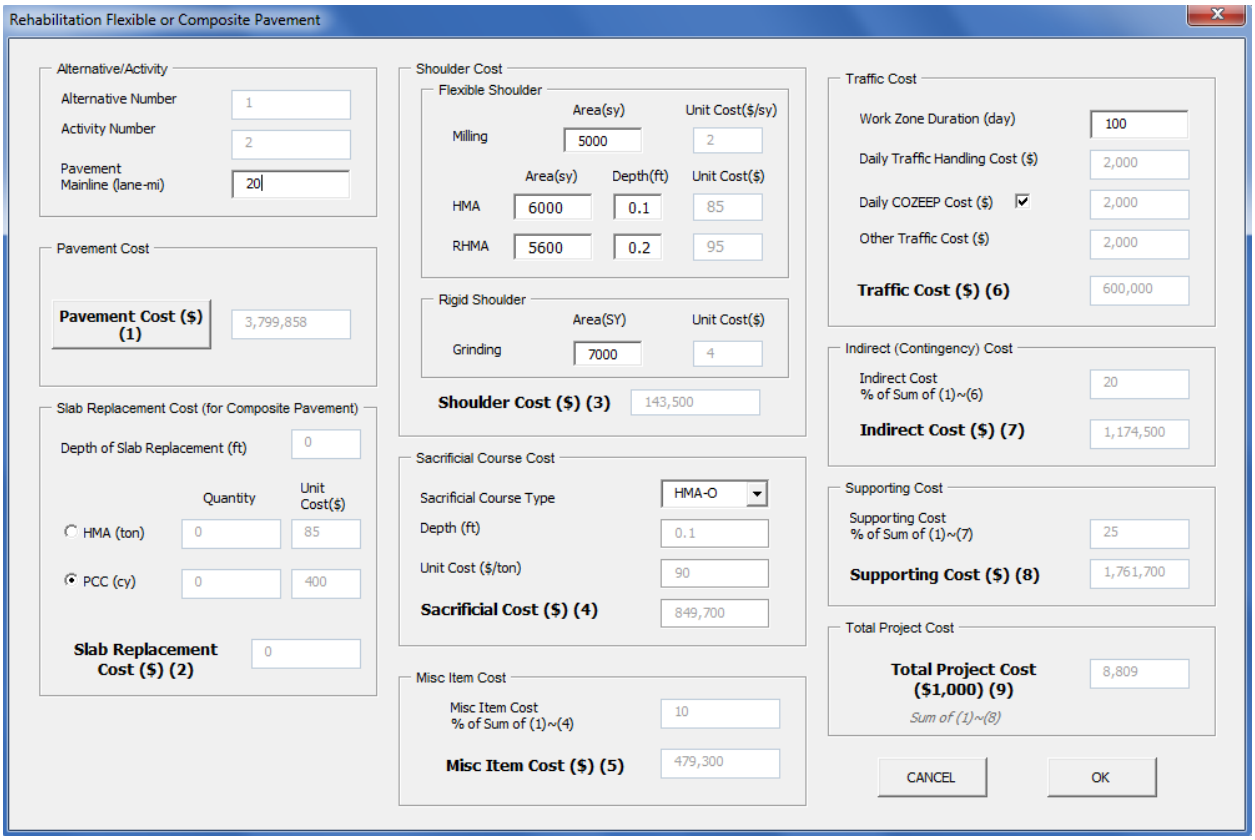


Figure 3-22 "Rehabilitation Flexible Pavement" Panel

The following are the steps to calculate the flexible pavement rehabilitation costs:

1) Enter the number of pavement lane miles in the project. Click the "Pavement Cost" button as shown in Figure 3-22, then the Figure 3-23 "Pavement Selection" Panel will be displayed.

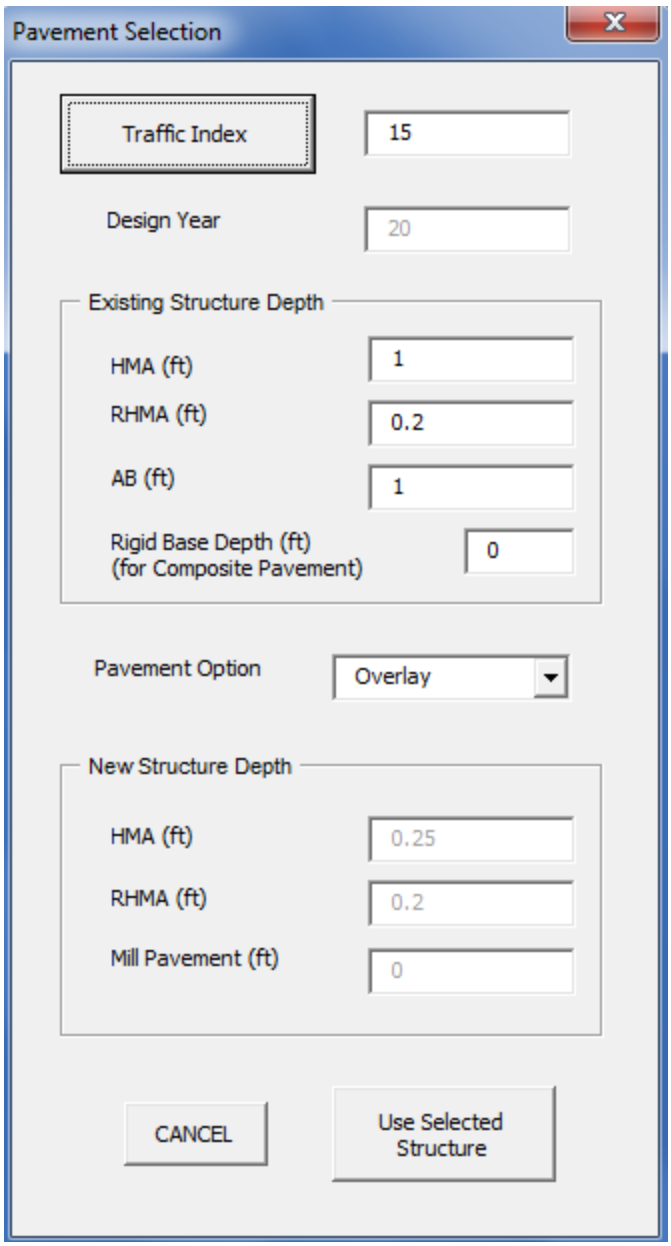


Figure 3-23 "Pavement Selection" Panel

2) Click the "Traffic Index" button, as shown in Figure 3-23, Figure 3-24 "Traffic Index (TI) Computation for Flexible Pavement" panel will be displayed.

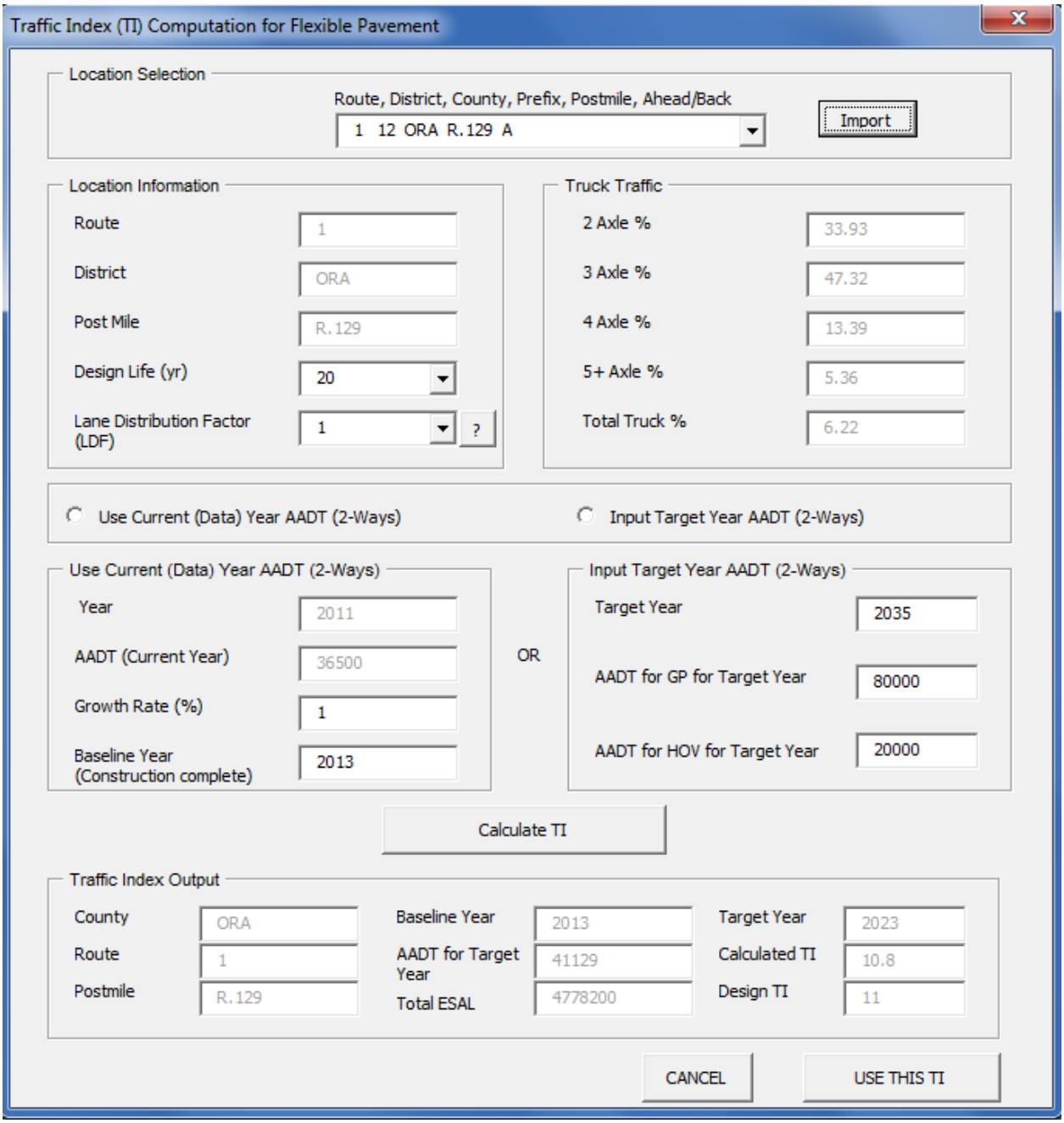


Figure 3-24 Traffic Index (TI) Computation for Flexible Pavement" Panel

3) Determine the TI by selecting the "Location Selection" and "Import" traffic data for the project. Input the construction completion year of an activity as its "Baseline Year" and the program calculates the TI. The calculated TI, is used if the "Use this TI" button is clicked in Figure 3-24. This TI is automatically entered on the "Traffic Index" panel as shown in Figure 3-23, "Pavement Selection" which is displayed again.
4) Enter the initial construction pavement structure.
5) The pavement thickness is calculated when the "Calculate Thickness" button is clicked. By clicking the "Use Selected Thickness" button, the new structure depth thickness is accepted and Figure 3-22 "Flexible Rehabilitation Pavement" panel with updated "Pavement Cost ($)(1)" is displayed.

The pavement structure of the flexible rehabilitation activity is dependent of the TI and existing pavement structure, which may be the initial construction structure section. The initial structure section is to be determined by the Materials Branch. However, the TI can be calculated by using the "Traffic Index" panel shown in Figure 3-24, which contains traffic data from the Traffic Operation's 2011 truck data. The TI may also, be furnished by the district's Traffic Operations branch, which may have more recent data.

The lane distribution factor is dependent on the number of lanes in each direction per HDM Table 613.3B. Normally, the pavement structure is designed for a uniform lane distribution factor due to excessive construction costs incurred by using multiple pavement structural thicknesses for the same section of highway.

3.5.3.2 Rehabilitation Rigid Cost Estimator

Figure 3-25 is the cost estimation panel for the "Rehabilitation Rigid Pavement".

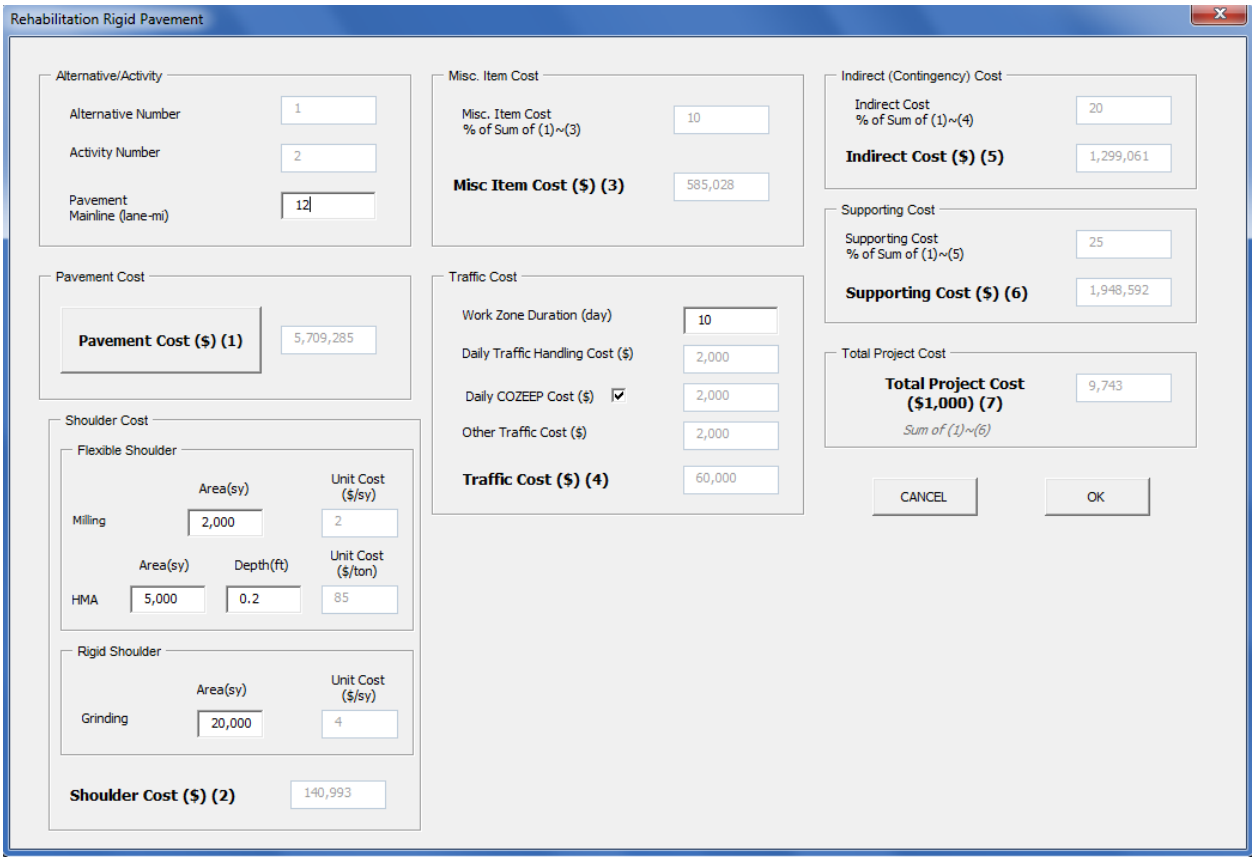


Figure 3-25 "Rehabilitation Rigid Pavement" Cost Estimation Panel

After click on "Pavement Cost ($)" button, you can calculate pavement cross-section (structure) by selecting the following in Figure 3-26, "Rehab Rigid Pavement Selection" panel:

- Climate region—Options include Coastal, Inland Valley, High Mountain and High Desert, Desert, and Low Mountain and South Mountain. The climate region information is found in the Caltrans Climate Regions Map.
- Subgrade Soil Type—Options are Type I or Type II. Refer to HDM for description of soil type.
- Traffic Index—*RealCost Version 2.5CA* branches to Figure 3-27 for calculations.
- Lateral Support Existence—Options are "Yes" or "No". Refer to HDM for description of lateral support.
- Click the check box if the project includes Remove Concrete Pavement and Base.

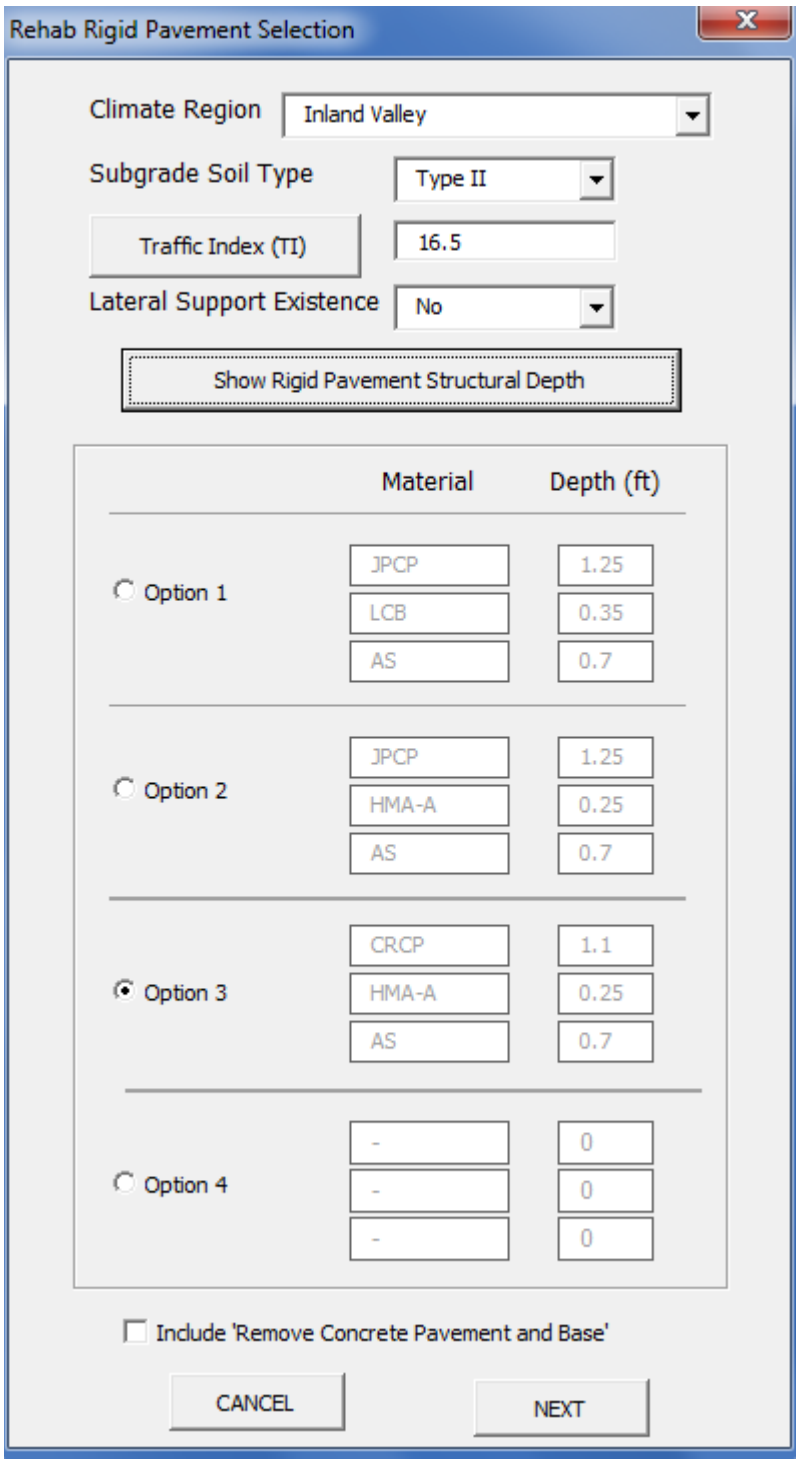


Figure 3-26 "Rehab Rigid Pavement Selection" Panel

Figure 3-27, "Traffic Index (TI) Computation for Rigid Pavement" panel allows for the selection of the project location and imports the traffic data. The TI is then calculated. Click on the "USE THIS TI" to accept the data in the pavement structure options in Figure 3-27. If the rigid pavement option is selected, then the program goes back to the panel shown in

Figure 3-26. Then click the "Show Rigid Pavement Structure Depth" button after the data entries are completed.

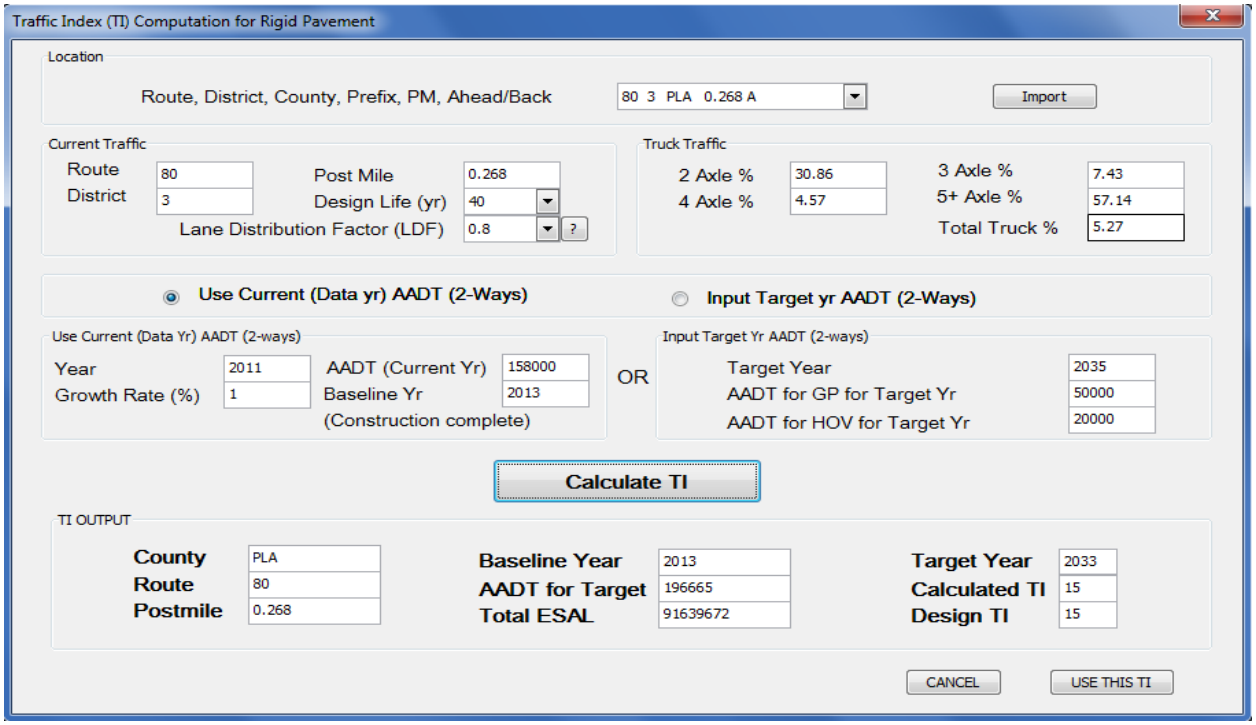


Figure 3-27 "Traffic Index (TI) Computation for Rigid Pavement" Panel

Click the "Next" button in Figure 3-26, you will see the "Rehab Rigid Pavement Cost" panel shown in Figure 3-28. Click on "OK" button, the calculated "Pavement Total Cost $" will be transferred to the "Rehabilitation Rigid Pavement" Cost Estimation Panel shown in Figure 3-25.

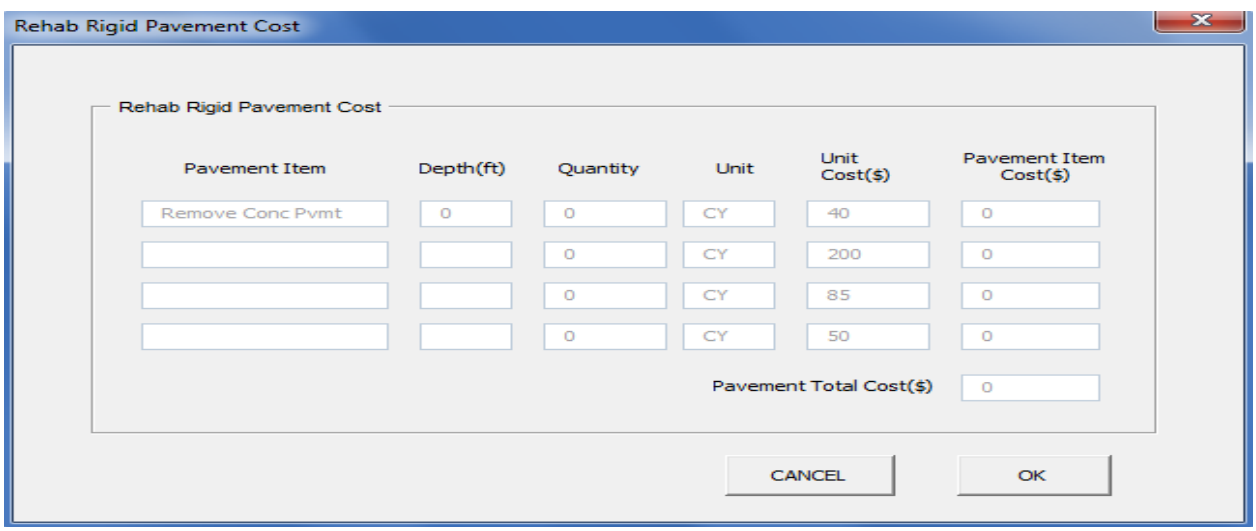


Figure 3-28 Rehab Rigid Pavement Cost Panel

3.5.3.3 CAPM Rigid Cost Estimator

Figure 3-29 shows the cost estimator for the CAPM Rigid Pavement.

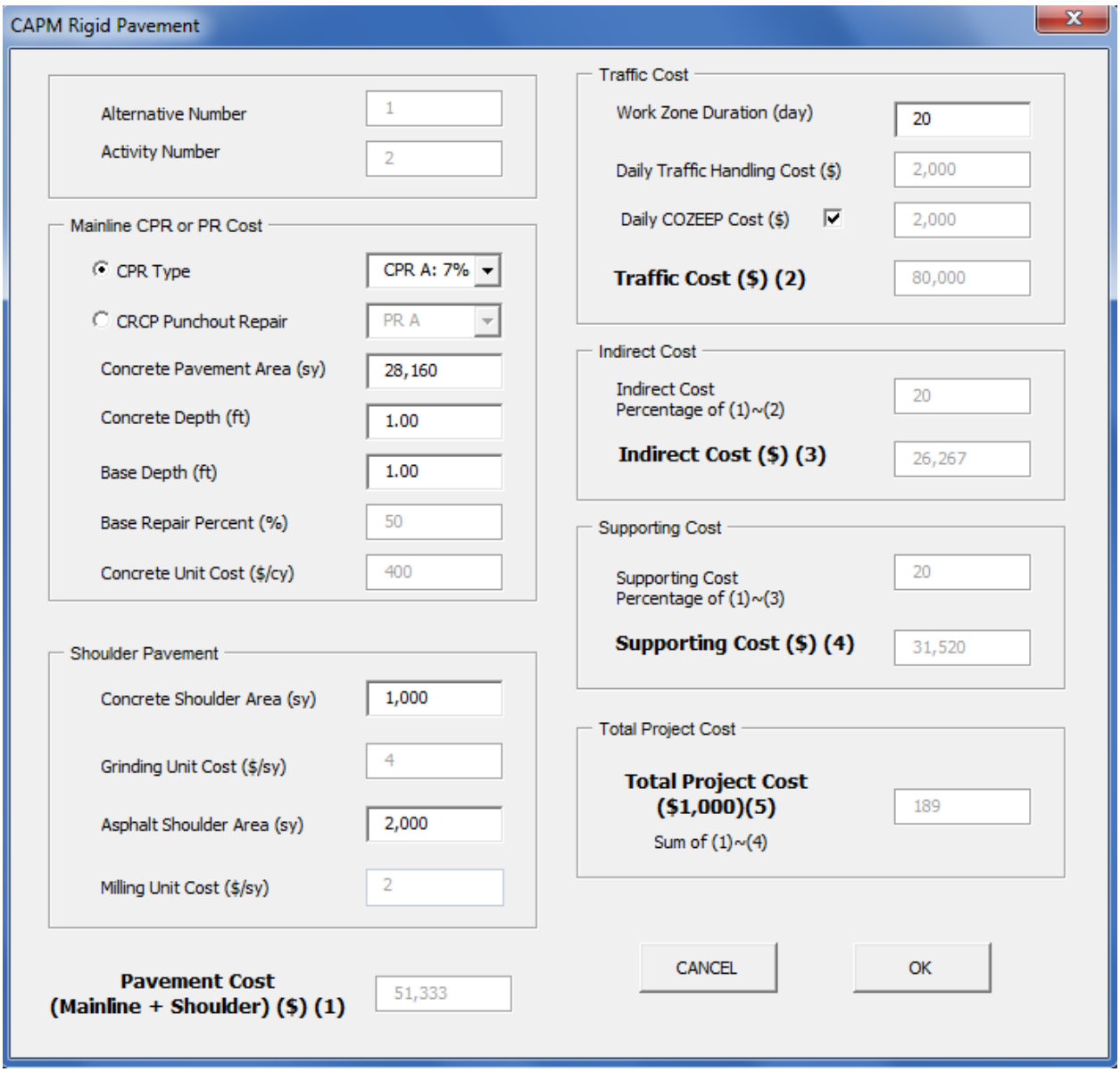
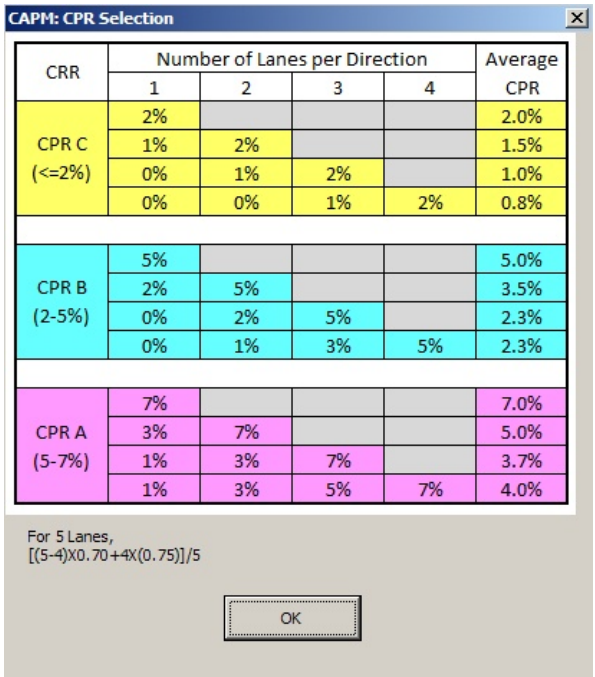


Figure 3-29 "CAPM Rigid Pavement" Estimate Data Panel

Generating an estimate for future rigid CAPM activity requires the following steps:

1) Select the appropriate concrete pavement restoration type based on Figure 3-30 and Figure 3-31.
2) Enter the pavement area in square yard.
3) Enter the concrete thickness in feet.
4) Enter base thickness in feet.
5) Enter shoulder area (square yard) in the appropriate pavement type.

6) Enter the total number of work zone duration days.
7) Press "Calculate"



CAPM: CPR Selection

CRR	Number of Lanes per Direction				Average
	1	2	3	4	CPR
CPR C (<=2%)	2%				2.0%
	1%	2%			1.5%
	0%	1%	2%		1.0%
	0%	0%	1%	2%	0.8%
CPR B (2-5%)	5%				5.0%
	2%	5%			3.5%
	0%	2%	5%		2.3%
	0%	1%	3%	5%	2.3%
CPR A (5-7%)	7%				7.0%
	3%	7%			5.0%
	1%	3%	7%		3.7%
	1%	3%	5%	7%	4.0%

For 5 Lanes,
[(5-4)X0.70+4X(0.75)]/5

OK

Figure 3-30 CAPM CPR Selection Table

For the base repair of rigid pavement for CAPM, 50 percent of damaged slabs are required to be repaired for CPR A and 25 percent of the damaged slabs are required to be repaired for CPR B. No base repair is required for CPR C.

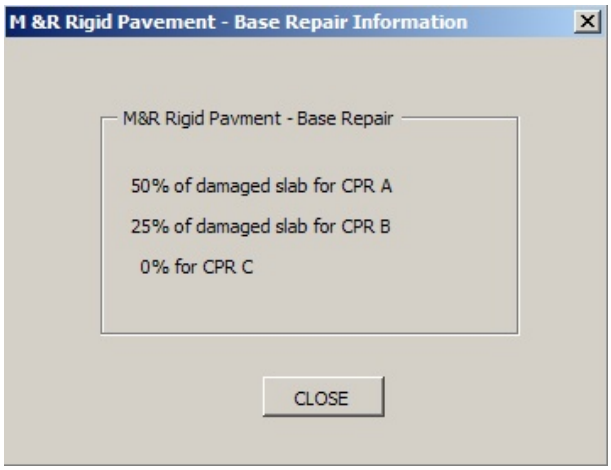


Figure 3-31 M&R Rigid Pavment – Base Repair Information Window

3.5.3.4 CAPM Flexible or Composite Pavement Cost Estimator

Figure 3-32 shows the cost estimate panel for the CAPM flexible pavement.

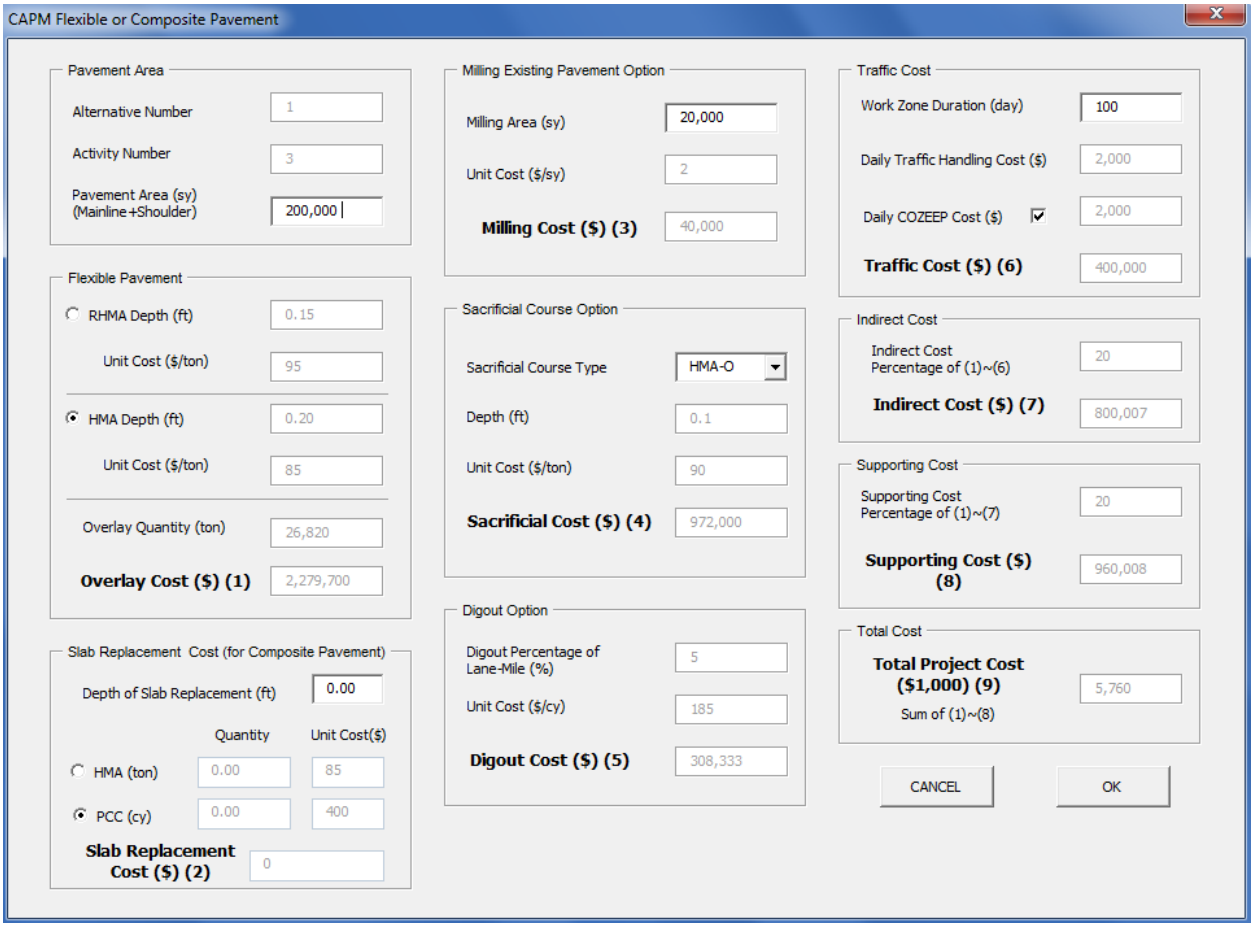


Figure 3-32 "CAPM Flexible Pavement" Cost Estimate Panel

Generating an estimate for future flexible CAPM activity requires the following steps.

1) Enter the pavement area (mainline and shoulder) in square yard.
2) Select the pavement surface type.
3) If applicable, enter the milling area in square yard.
4) If applicable, select if the sacrificial course type.
5) Enter the total number of work zone duration days.
6) Press "Calculate"

3.6 Input Warnings and Errors

To see a list of missing or potentially erroneous data, click the "Show Warnings" button on the "Switchboard", Figure 3-3, before running the analysis. Figure 3-33 shows an example of "Warnings". "Warnings" call attention to certain inputs that fall out of expected ranges and do not necessarily indicate input errors. "Errors" are fatal inputs that will prevent the program from running and providing LCCA results. If "Warnings" or "Errors" occur, it is

advisable to recheck inputs and project assumptions to ensure the analysis is realistic and accurate.

A common error is "mismatch: 13," which can mean that there is an empty input or a bad input. If this error occurs, review all inputs.

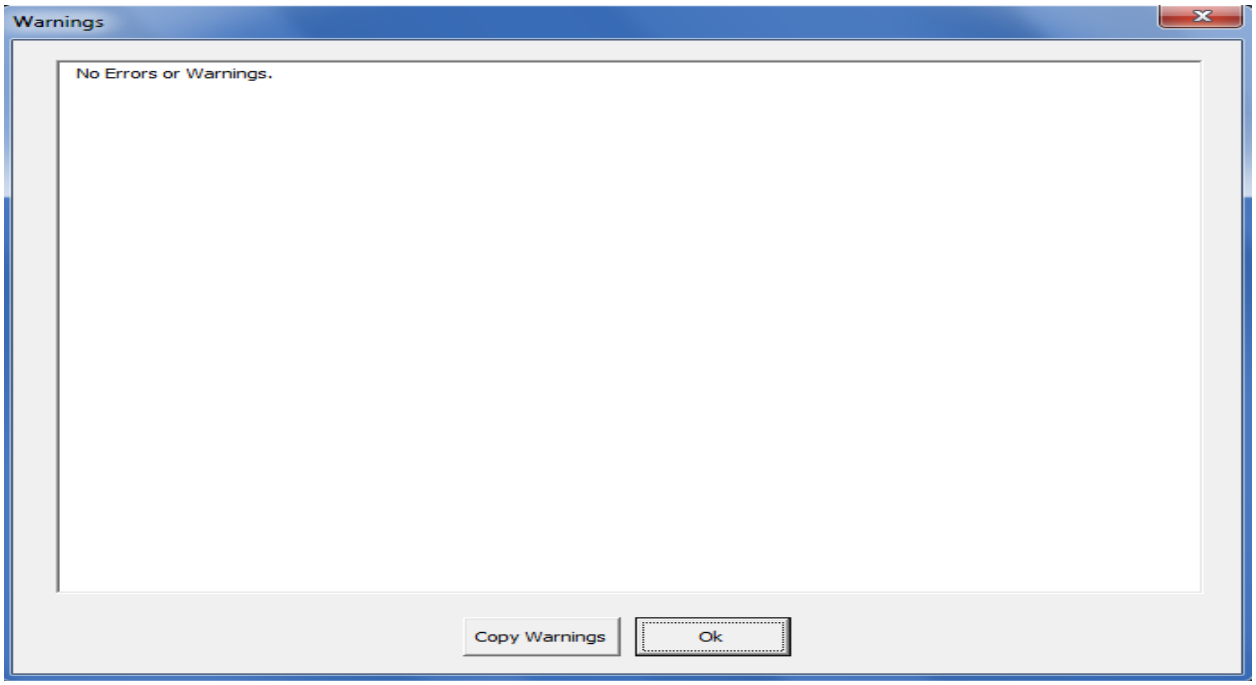
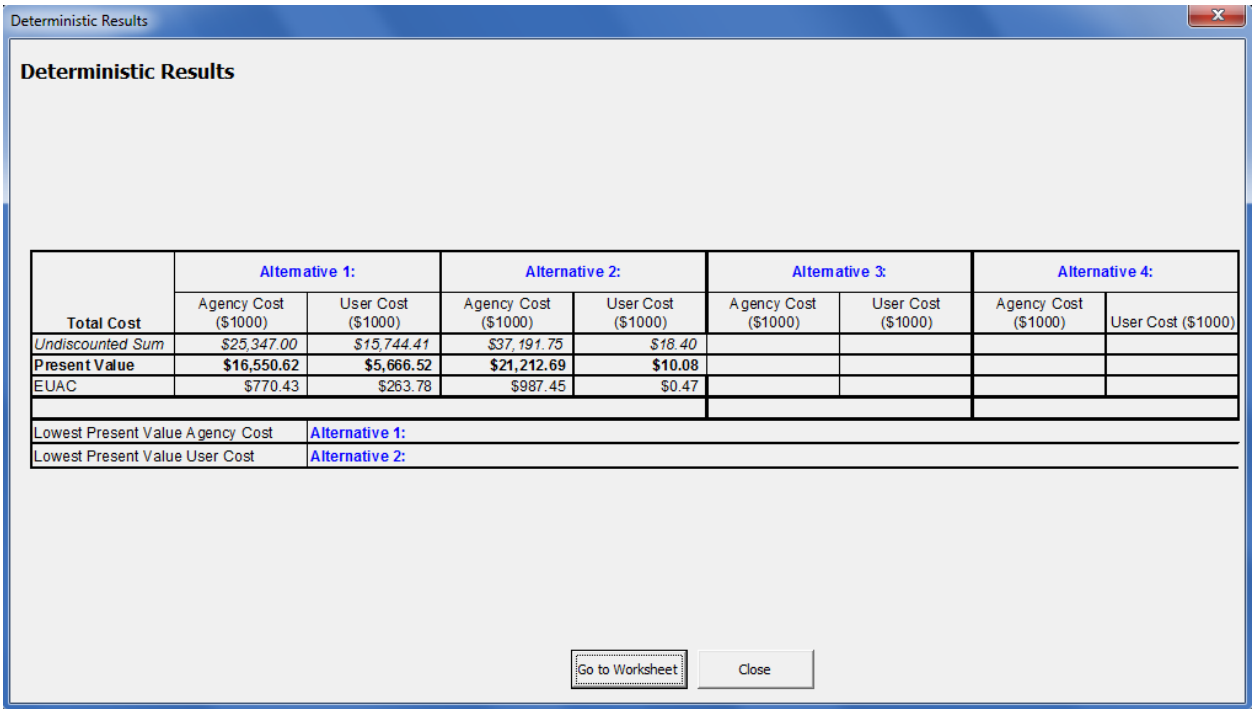


Figure 3-33 Input Warnings

3.7 Simulation and Outputs

The "Simulation and Outputs" section of the *RealCost Version 2.5CA,"*Switchboard", Figure 3-3, includes buttons to view deterministic life-cycle cost results. (The buttons to run simulations of probabilistic inputs are not active).

Deterministic Results: Click this button to have *RealCost Version 2.5CA* calculate and display deterministic values for both agency and user costs based upon the deterministic inputs. The "Deterministic Results" panel as shown in Figure 3-34, which provides a direct link "Go to Worksheet" button to the "Deterministic Results Excel Worksheet" that contains all the information needed to investigate the deterministic results.



Deterministic Results

Deterministic Results

Total Cost	Alternative 1:		Alternative 2:		Alternative 3:		Alternative 4:	
	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)
Undiscounted Sum	*$25,347.00*	*$15,744.41*	*$37,191.75*	*$18.40*				
Present Value	**$16,550.62**	**$5,666.52**	**$21,212.69**	**$10.08**				
EUAC	$770.43	$263.78	$987.45	$0.47				

Lowest Present Value Agency Cost	Alternative 1:
Lowest Present Value User Cost	Alternative 2:

Go to Worksheet Close

Figure 3-34 Deterministic Results Panel

- ***Reports***: Click this button to have *RealCost Version 2.5* produce a multi-page report that shows the "Project Level" inputs and M&R sequences. Details of the "Alternative-Level" inputs can be access through the "Agency Cost Detail" button.

3.8 Administrative Functions

The "Administrative Functions" section of the *RealCost Version 2.5CA, "*Switchboard", as shown in Figure 3-3 allows the engineer to save, clear, retrieve data, and close the "Switchboard" of *RealCost Version 2.5CA*.

- *Go to Worksheets*: Clicking this button will allow direct access to any input or result worksheet.
- *Clear Input Data*: Clicking this button clears the project-level inputs, alternative-level inputs, and results from the program and the worksheets.
- *Save LCCA Workbook As...*: Clicking this button allows you to save the entire Excel workbook, including all inputs and results worksheets, under a user-specified name.
- *Exit LCCA*: Clicking this button will close *RealCost Version 2.5CA*.