Improved Prediction Models for PCC Pavement Performance-Related Specifications, Volume II: PaveSpec 3.0 User's Guide

U.S. Department of Transportation

Federal Highway Administration
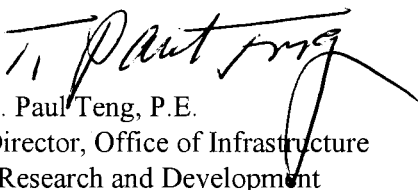
FOREWORD

The development of performance-related specifications has long been a goal of the highway industry. Recently, prototype performance-related specifications for portland cement concrete paving were developed and field tested in several States. Using such specifications, a highway agency can upon construction predict the performance of a pavement and forecast the pavement's life-cycle costs. The benefits to the agency having such a capability can be significant.

This report is the second of a two-volume set. It contains a user's guide for the PaveSpec software that was upgraded during the research described in the first volume. The software can be used to assist agencies in developing their own performance-related specifications. It can also be used during paving construction to calculate an adjustment in contractor's pay to reflect the predicted performance of the as-constructed pavement. This report will be of interest to engineers and technicians concerned with quality assurance, specifications, and the construction of concrete pavements.

Sufficient copies of this report are being distributed to provide a minimum of two copies to each FHWA resource center and division office, and eight copies to each State highway agency. Direct distribution is being made to the division offices. Additional copies for the public are available from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161.

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16. Abstract

The current performance-related specifications (PRS) methodology has been under development by the Federal Highway Administration (FHWA) for several years and has now reached a level at which it can be implemented by State highway agencies. PRS for highway pavements depend heavily on performance prediction models to determine the impact of varying levels of construction quality. This study focused on the improvement of the key distress and smoothness prediction models used in the PRS for jointed plain concrete pavement (JPCP). Performance models for transverse joint faulting, transverse slab cracking, transverse joint spalling, and smoothness (International Roughness Index [IRI]) were evaluated and then improved substantially. This was accomplished using a comprehensive national database of JPCP performance data, along with sound statistical and engineering techniques. Performance model calibration guidelines were also developed so that a State can calibrate any of these models specifically to its pavement performance data.

The PaveSpec PRS demonstration software was upgraded to Version 3.0 under this study. Some of the specific improvements incorporated in PaveSpec 3.0 include: 1) incorporation of the improved distress indicator models, as well as the ability to calibrate or modify the default models, 2) sensitivity analysis capibilities, 3) expected pay charts, and 4) online help. Appendix A of this report contains a complete updated PaveSpec User's Guide.

This volume is the second of two volumes. The other volume is:
FHWA-RD-00-130   Volume I: Final Report

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LIST OF ACRONYMS AND ABBREVIATIONS

AC   Asphalt concrete
ADT   Average daily traffic
AQC   Acceptance quality characteristic
CPF   Composite pay factor
ESAL   Equivalent single-axle load
FHWA   Federal Highway Administration
FWD   Falling weight deflectometer
IRI   International Roughness Index
JPCP   Jointed plain concrete pavement
LCC   Life-cycle cost
M&R   Maintenance and rehabilitation
PCC   Portland cement concrete
PF   Pay factor
PI   Profile index
PIARC   Permanent International Association of Road Congresses
PRS   Performance-related specification
PSF   Percentage of sublots failed
PW   Present worth
PW$ Present-worth dollars
SD   Standard deviation
SF   Spalling model site factor
SHA   State highway agency

CHAPTER 1: INTRODUCTION

PaveSpec is designed to develop and demonstrate performance-related specifications (PRS) for jointed plain concrete pavements (JPCP). The software has specifically been designed to help State highway agencies (SHA's) determine rational performance-related pay factors (and pay adjustments) for JPCP *highway* pavements. Version 3.0 of PaveSpec was completed in support of the Federal Highway Administration (FHWA) project titled "Validation of Performance Models for Portland Cement Concrete Pavement Construction." For further information about the theory and practice of PRS, consult FHWA Reports FHWA-RD-98-155, -156, and -171.[1,2,3,4]

The software is driven by a simulation engine that is used to simulate pavement performance and associated life-cycle costs (LCC's) for both as-designed and as-constructed pavements. PaveSpec allows the user to express pavement performance in terms of the following distress indicators:

- Transverse slab cracking.
- Transverse joint faulting.
- Transverse joint spalling.
- Pavement smoothness over time—International Roughness Index (IRI).

Each of the distress indicator models is a function of many variables, including one or more of the following five acceptance quality characteristics (AQC's):

- Concrete strength.
- Slab thickness.
- Air content.
- Initial smoothness.
- Percent consolidation around dowels.

Using the current PRS approach, lot pay factors are computed based on a comparison of the simulated LCC's for the as-designed and as-constructed pavements.

WHAT CAN YOU DO WITH PaveSpec?

Before one can effectively use PaveSpec to develop a PRS, it is important to understand the capabilities of the software. Currently, the software is divided into three parts that allow the user to accomplish the following tasks:

- Develop a specification—the program's *Specification Wizard* is used to develop a project-specific PRS.

- Analyze a developed specification—PaveSpec provides two tools for analyzing a developed specification: sensitivity analysis and expected pay charts. A

specification-dependent sensitivity analysis is used to investigate the effects of AQC changes on pay factors, while expected pay charts help analyze the risks for both the agency and the contractor.

- Use a specification—performance-related lot pay factors (and pay adjustments) may be computed based on actual AQC field data.

The details of each of these major capabilities are described in separate chapters in this report.

DATA ORGANIZATION

PaveSpec stores its data in files called *databases*. Each database may be named and saved as a separate file to a disk. Databases are made up of smaller data elements called *documents*. All documents used within PaveSpec are classified as *modules*, *specifications*, or *specification-dependent documents*. Specific document types within each classification are described in the following sections.

Modules

Modules are stand-alone sets of user-defined variables that are independent of any particular specification. Descriptions of the different module types are as follows:

Pavement Design—Contains pavement design-related input variables required by the distress indicator models. Examples of the variables contained in the Pavement Design module include *Pavement Type*, *Transverse Joint Spacing*, and *Dowel Bar Diameter*.

Design Traffic—Contains traffic-related information required to calculate yearly equivalent single-axle loads (ESAL's) over the chosen analysis period. Examples of variables contained in the Design Traffic module include *Cumulative ESALs* at a given year*, Traffic Growth Type,* and *Traffic Growth Rate.*

Climatic Variables—Contains climate-related input variables required by the distress indicator models. Examples of the variables contained in the Climatic Variables module include *Average Annual Freezing Index, Average Annual Air Freeze Thaw Cycles*, and *Climatic Zone.*

Maintenance and Rehabilitation Plan—Contains the step-by-step rules making up the maintenance and rehabilitation (M & R) plan. The plan is used to determine the M & R activities to be applied to the pavement in response to the simulated distress indicators, and when those activities will be applied.

Unit Costs—Contains unit cost information used to compute LCC's resulting from the estimated M & R activities. Unit costs are organized into maintenance, localized rehabilitation, and global rehabilitation costs.

There can be any number of each type of module defined within a database; however, only one of each type of module is specific to a developed specification.

Specifications

Specification documents summarize all aspects of the PRS development procedure, including the developed PRS preconstruction output. More than one specification may be developed and saved within each database. A specification document is developed by completing all of the steps in the PaveSpec *Specification Wizard*. When developing a specification, the user is required to select (or define) modules for each of the five module types. That is, for each specification, the user indicates which Pavement Design, Design Traffic, Climatic Variables, Maintenance and Rehabilitation, and Unit Costs modules are to be used for estimating pavement performance and subsequent LCC's.

Specification-Dependent Documents

Specification-dependent documents are those that are specifically developed in reference to a chosen specification. Four different types of specification-dependent documents are used within PaveSpec: *Use Specification*, *Drill-Down*, *Sensitivity Analysis*, and *Expected Pay*. If the parent specification is deleted, any corresponding specification-dependent documents are also deleted. Details of the four specification-dependent document types are as follows:

Use Specification—The use specification documents contain actual AQC field sampling and testing data entered by the user. A separate document is used for each project (i.e., data for multiple lots of the same project are entered into one use specification document). The output report associated with this document type contains lot and project pay factor (and pay adjustment) summaries.

Drill-Down—This document type allows a user to view the performance (distress indicators) or LCC details of any selected simulated sublot that went into an overall simulated-lot LCC. A simulated-lot LCC is typically the mean of at least 500 simulated sublot LCC's, and the standard specification output report only contains a summary of these LCC's. Therefore, if users want to see details of one of these specific simulated sublots, they must create a drill-down document. The resulting document provides detailed performance, M & R, and LCC information at the lot and sublot level. This type of document is very helpful when trying to understand project-specific interactions between performance and LCC's.

Sensitivity Analysis—The sensitivity analysis document provides the user with a method of investigating the effects of AQC mean or standard deviation changes on Level 1 pay factors and pay adjustments. The user may define more than one scenario within a given sensitivity analysis document. Sensitivity analysis scenarios can be defined as a *Direct Analysis Scenario*, *One-Dimensional Analysis*, or *Two-Dimensional Analysis.*

Expected Pay—This document type provides the user with a graphic representation of an acceptance plan that shows the relationship between the actual quality of a lot and its expected pay (i.e., mathematical pay expectation, or the average pay the contractor can expect to receive over the long run for submitted lots of a given quality).[5] Specifically, expected pay charts identify the probability of achieving different chosen pay factor levels over a range of AQC mean. Each pay factor chart is developed for a specific combination of AQC type, number of sublots, and AQC standard deviation.

Details of each of these specification-dependent document types are discussed in chapters 5, 6, 7, and 8, respectively.

CHAPTER 2: GETTING STARTED

SYSTEM REQUIREMENTS AND RECOMMENDATIONS

PaveSpec is written for IBM-compatible computers running a Windows 95 (or newer) operating system. To run PaveSpec, a computer must have the following minimum system specifications:

- 486 processor running Windows 95, Windows 98, or NT.
- 8 MB of RAM.
- 1 MB of hard-disk space.
- Mouse or other pointing device.
- VGA or better graphics card (ideally 800 x 600 pixels or 1024 x 768 pixels).

The performance of the software will be greatly enhanced if the system has at least a 150-MHz Pentium processor and 16 MB of RAM.

SETUP OF PaveSpec

For the best performance, it is recommended that PaveSpec be installed on, and run from, your computer's hard drive; however, the program may also be run directly from a floppy disk. The details of each method are described in the following sections.

Installing PaveSpec to a Hard Drive

If you wish to copy PaveSpec to your computer's hard drive, it is recommended that you create a directory that will house the PaveSpec program file and any database files that you may create.

1. Start Windows 95, Windows 98, or NT. Insert the floppy disk or CD-ROM containing PaveSpec.

2. Use *Windows Explorer* or *My Computer* to locate the *pavespec3.exe* file.

3. Select the *pavespec3.exe* file by clicking on the file name.

4. From the *Edit* menu, select *Copy*.

5. Click on the existing folder to which you would like to copy the *pavespec3.exe* file. (You may also create a new folder by selecting *New* and then *Folder* from the *File* menu.)

6. Select *Paste* from the *Edit* menu to copy *pavespec3.exe* to the selected folder.

7. To run PaveSpec from the hard drive, locate *pavespec3.exe* and double-click on the file name. (You may create a shortcut and place it on your desktop for convenience—see Windows Help for information on creating shortcuts.)

Running PaveSpec from a Floppy Disk

1. Start Windows 95, Windows 98, or NT and insert the floppy disk.

2. Select *Run* from the *Start* menu.

3. Type **<drive>:pavespec3**, where <drive> is the letter designation of the floppy drive. Then click on the OK button.

WHAT YOU SEE WHEN YOU START PaveSpec

The primary elements of the PaveSpec main window are identified in figure 1. When you first open the program, a blank database appears in the PaveSpec main window.

Menu Bar

The menu bar includes four items: <u>F</u>ile, <u>E</u>dit, <u>W</u>indow, and <u>H</u>elp. To display the available PaveSpec commands, click on the heading of your choice. You can then click on any of the commands shown in the drop-down box.

<u>File Menu</u>

The file menu, shown in figure 2, contains 15 commands, each of which is described briefly in this section.

New Database—Opens a new PaveSpec database.

Open—Opens a previously saved PaveSpec database.

Close—Closes the active PaveSpec database.

Save—Saves the active PaveSpec database. If the active database has been named and saved previously, the database will be saved under the previously defined file name. If the file has not been named and saved previously, the program will prompt the user to enter a file name and storage location.

Save As—Allows the user to save the active database under a new name or in a new location.

Page Setup—Allows the user to specify page formatting for printing (e.g., paper size, page orientation, and margins).
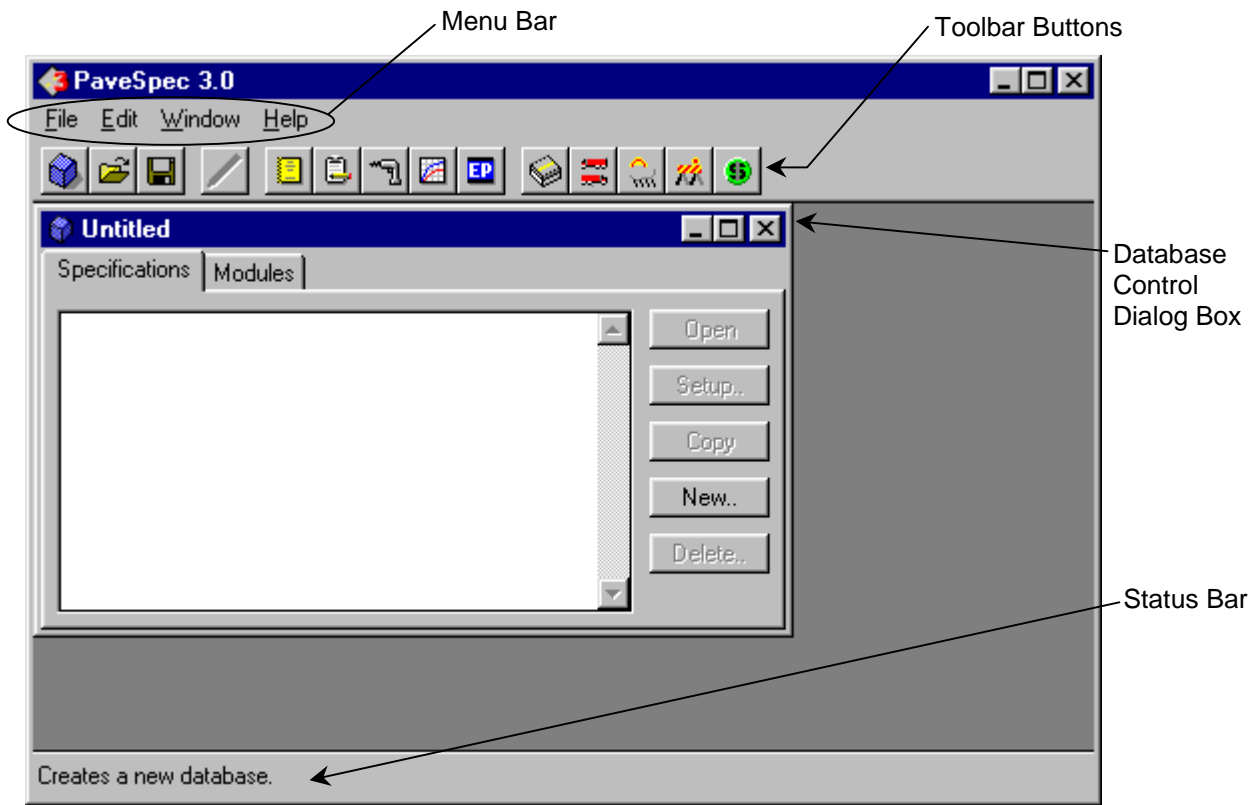
Figure 1. PaveSpec main window.
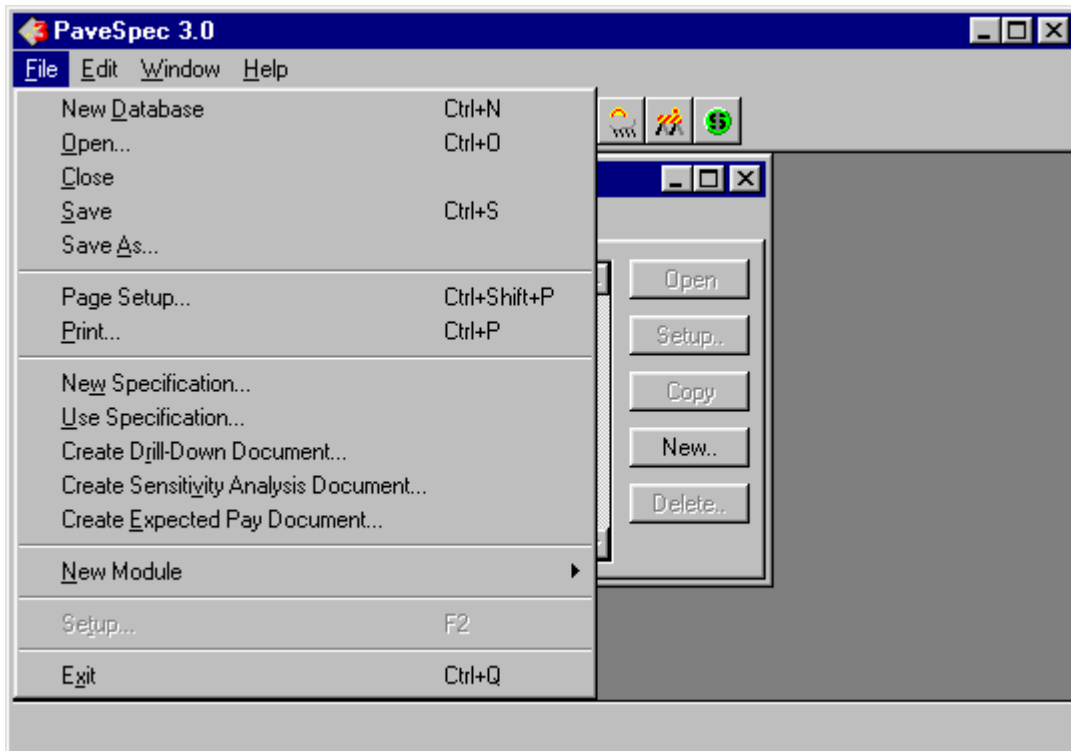
Figure 2. PaveSpec *File* menu.

Print—Opens the *Print* dialog box in preparation for printing the selected PaveSpec item.

New Specification—Creates a new specification within the active database.

Use Specification—Allows the user to enter actual AQC field data into a previously defined specification and determine corresponding PRS-based lot pay factors and pay adjustments. More details on using a specification are contained in chapter 5 of this appendix, *Using a Specification*.

Create Drill-Down Document—Allows the user to investigate the simulation details of a previously developed specification. More details on creating and using drill-down documents are contained in chapter 6 of this appendix, *Drill-Down Documents*.

Create Sensitivity Analysis Document—Allows the user to investigate the sensitivity of a previously developed Level 1 specification (pay factors and pay adjustments) to changes in AQC means or standard deviations. More details on creating sensitivity analysis documents are contained in chapter 7, *Sensitivity Analysis Documents*.

Create Expected Pay Document—Allows the user to investigate risks (to the contractor and agency) associated with a previously developed Level 1 specification. Specifically, the user can observe the probability of achieving different chosen pay factor levels (e.g., 90, 100, 110 percent pay factors) over a range of AQC means. More details on creating expected pay documents are contained in chapter 8, *Expected Pay Documents*.

New Module—Creates a new module. A secondary menu will appear showing the five available types of modules: *Pavement Design*, *Design Traffic*, *Climatic Variables*, *Maintenance and Rehabilitation Plan*, and *Unit Costs*.

Setup—Allows the user to set up (define or edit) the specification currently selected in the *Database Control* dialog box. Specification definition or editing is accomplished using the *Specification Wizard* (see chapter 3, *Developing a Specification*).

Exit—Exits the PaveSpec program.

Edit Menu

The edit menu contains the following three commands:

Copy Selected Page—Copies a selected output report page to the Clipboard.

Models—Opens the *Global Model Definitions* dialog box, which allows the user to *modify* or *calibrate* any defined distress indicator model. Details of the specific procedures used to modify or calibrate models are described in chapter 4, *Distress Indicator Model Modification/Calibration.*

Preferences—Opens a pop-up dialog box that allows the user to 1) specify the preferred units (English or metric) used throughout the program and 2) set the simulation engine (random-number generator) *seeds.* In setting the simulation engine seeds, the user has the following two options:

- *Use same initial seed for all simulations.* This selection makes it so that the simulations are not random from one specification simulation to the next (the initial simulation seed is always set equal to zero). Each time the user simulates a new specification, the same random numbers between 0 and 1 are used to determine AQC sample values.

- *Randomize initial seed for all simulations.* This selection makes it so that the simulations are completely random from one specification simulation to the next. Each time the user simulates a new specification, different random numbers between 0 and 1 are used to determine AQC sample values. This is the recommended (default) option.

<u>Window and Help Menus</u>

These menus contain commands that are common to most, if not all, Microsoft Windows programs. See your Windows Help for further information.

Toolbar Buttons

The PaveSpec toolbar buttons provide quick access to many common PaveSpec commands. To activate a toolbar button, simply click on it.

Creates a new database.

Opens an existing database.

Saves the current database.

Allows the user to change the setup of the document currently highlighted in the *Database Control* dialog box. This function works on all specification, module, and specification-dependent documents.

Creates a new specification document in the current database.

 Creates a new use specification document in the current database.

 Creates a new drill-down document in the current database.

 Creates a new sensitivity analysis document in the current database.

 Creates a new expected pay document in the current database.

 Creates a new pavement design module in the current database.

 Creates a new design traffic module in the current database.

 Creates a new climatic variables module in the current database.

 Creates a new maintenance and rehabilitation plan module in the current database.

 Creates a new unit costs module in the current database.

Database Control **Dialog Box**

The *Database Control* dialog box is used to organize all of the documents in a given database. The *Database Control* window is divided into two tabbed sections: *Specifications* and *Modules.* To move from one tab to the other, click on the tab names.

<u>*Specifications* Tab</u>

All of the developed specifications and specification-dependent documents within the open database are displayed in the *Specifications* tab, as shown in figure 3. Each specification-dependent document is attached to its parent specification using a visual outline. The visual outline may be expanded or compressed by clicking on the boxes that contain plus (+) or minus (–) signs. The example in figure 3 shows a database containing two different developed specifications, *Specification 1* and *Specification 2,* with two specification-dependent documents attached to *Specification 1.*

The buttons within the *Specifications* tab perform the following functions:

 Allows the user to view the output report accompanying the highlighted document.

 Allows the user to edit the highlighted document.

 Makes a copy of the highlighted document.

 Allows the user to create a new document of the same type as the

highlighted document.

Delete.. Deletes the highlighted document.
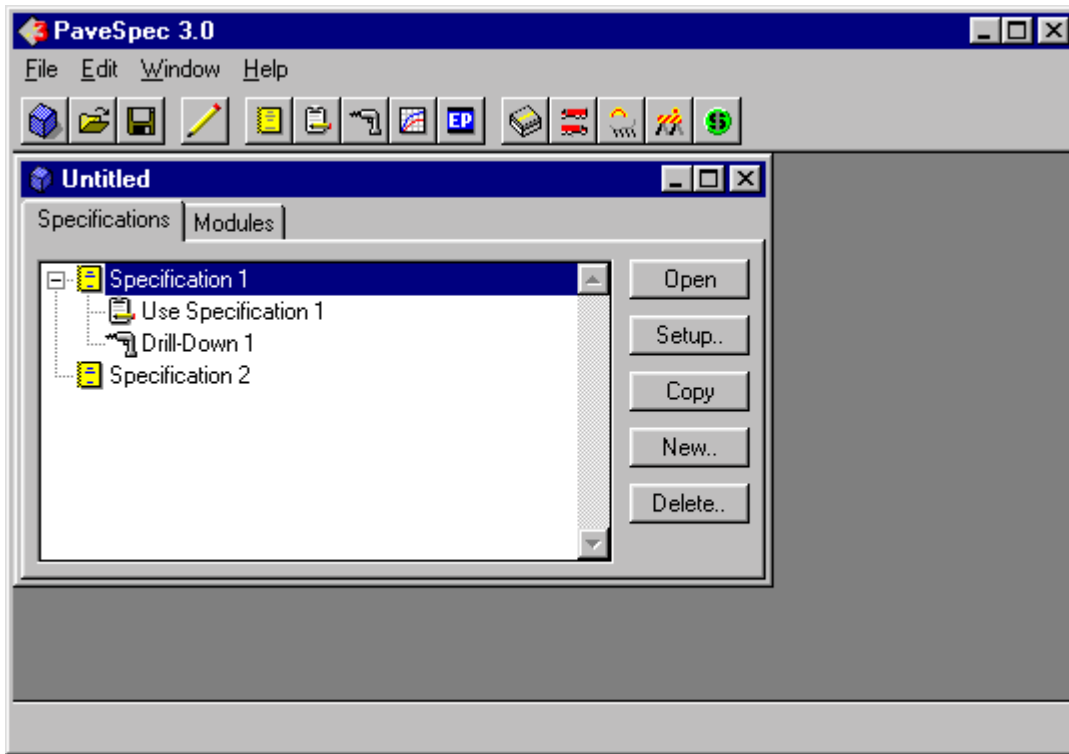
Figure 3. *Database Control* dialog box—*Specifications* tab.

Note: A ⚠ symbol next to a developed specification indicates that the specification needs to be resimulated to reflect one or more changes to variables (or modules) affecting the preconstruction output. To update the specification, simply resimulate using the *Specification Wizard*. A ⚠ symbol will also appear next to any existing specification-dependent document when its parent specification has been resimulated. A specification-dependent document may be updated by redefining the document's details in *Setup* mode.

Modules Tab

All of the user-defined module documents within the open database are stored in the *Modules* tab. This tab also makes use of a visual outline to organize the five different types of module documents. An example of the *Modules* tab is presented in figure 4. The buttons on this tab basically perform the same functions as the buttons in the *Specifications* tab. The only difference is that there is no **Open** button, as there are no output reports accompanying a module document.
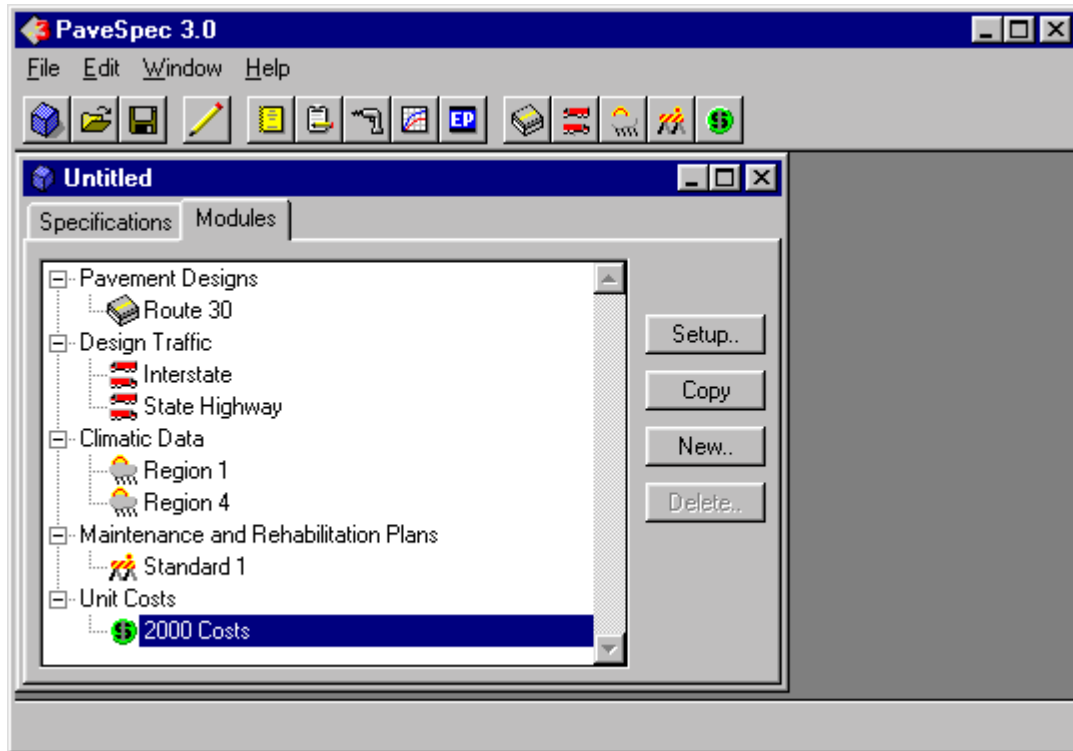
Figure 4. *Database Control* dialog box—*Modules* tab.

Status Bar
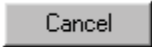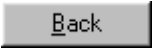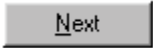
The PaveSpec status bar provides information describing a highlighted menu item or toolbar button. To obtain feedback via the status bar, move the pointer over the menu item or toolbar button of interest. Text describing the item will appear in the status bar.

CHAPTER 3: DEVELOPING A SPECIFICATION

In PaveSpec, a project-specific PRS is created or edited using the *Specification Wizard*. This feature consists of 11 sequential steps (dialog boxes) that lead the user through all aspects of developing a PRS-based specification. This chapter contains detailed descriptions of each dialog box in the *Specification Wizard*, as well as instructions on how to use them. An explanation of the output report is included in chapter 9, *PaveSpec Output Reports*.

SPECIFICATION WIZARD CONTROL BUTTONS

Each dialog box included in the *Specification Wizard* is equipped with four control buttons. The buttons may be activated by clicking on them. The function of each of these buttons is described below:

Save	Allows the user to save the current specification document and return to the PaveSpec main window. A specification document can only be saved after the specification has been simulated (i.e., after step 9 of the *Specification Wizard* has been completed).
Cancel	Allows the user to quit the current specification development procedure (without saving changes) and return to the PaveSpec main window.
Back	Moves backward to the previous dialog box in the *Specification Wizard*.
Next	Moves forward to the next dialog box in the *Specification Wizard*.

PAGE 1—BASIC SPECIFICATION INFORMATION

Whenever you choose to set up a new or previously developed specification, PaveSpec will start the *Specification Wizard*, and the *Basic Specification Information* dialog box will appear. This dialog box allows you to name the current specification, choose the type of specification to be developed (Level 1 or Level 2), and enter general descriptive project information. An example of this dialog box is presented as figure 5.

Name and Specification Level

To change the name of the current specification, type a new name in the *Project Name* input box. The name you enter will show up as the specification document name in the *Specifications* tab of the *Database Control* dialog box.

The specification type must also be selected in this dialog box. Currently, the user may choose to develop only a Level 1 specification or both Level 1 and Level 2 specifications at the same time. When defining specifications, the data required (and,

Figure 5. *Basic Specification Information* dialog box.

therefore, the data input screens) vary depending on what specification type is selected. Any such differences will be identified in this chapter.

Project Identification

There are five different inputs grouped under the *Project Identification* heading— *State*, *County*, *Project ID*, *Traffic Direction*, and *Additional Description* (the *Additional Description* input box is a notepad where you may enter any additional project information.) These fields are included to allow the user to document descriptive information about the project to which the developed specification applies. The data entered or selected in these fields are optional.

PAGE 2—DIMENSIONS AND LANE CONFIGURATION

Inputs used to describe the project's lane configuration, location, and length are contained in the *Dimensions and Lane Configuration* dialog box, an example of which is presented in figure 6.

Figure 6. *Dimensions and Lane Configuration* dialog box.

Lane Information

Choose the appropriate lane configuration describing the project's layout from the *Configuration* list box. The lane configuration is expressed as a combination of the total number of lanes making up the road (both traffic directions) and whether traffic (going in opposite directions) is divided by a median or barrier. The following six lane configurations are available to the PaveSpec user:

- *Two, Undivided*—Two-lane highway (one lane in each direction) with no median or barrier.

- *Four, Undivided*—Four-lane highway (two lanes in each direction) with no median or barrier.

- *Four, Divided*—Four-lane highway (two lanes in each direction) divided by a median or barrier.

- *Six, Divided*—Six-lane highway (three lanes in each direction) divided by a median or barrier.

- *Eight, Divided*—Eight-lane highway (four lanes in each direction) divided by a median or barrier.

- *Ten, Divided*—Ten-lane highway (five lanes in each direction) divided by a median or barrier.

Note that the number of lanes being accepted at one time using the PRS is independent of the chosen lane configuration. For example, the lane configuration could be a six-lane divided highway; however, you may only be accepting (computing pay factors for) two lanes of paving.

Next, you must select the specific lanes that you would like to accept at one time using this specification. Select or deselect lanes by clicking on the *Accept* check box next to the lane of interest. For those lanes chosen for acceptance, lane widths must be entered in terms of either feet or meters (e.g., "12 ft" or "3.66 m"). You may toggle between English and metric units within any numerical input box using the "F2" key on your keyboard.

Select the pavement shoulder type from the *Shoulder Type* list box. The four options given are *Widened Lane, Tied PCC* (portland cement concrete), *Asphalt*, and *Other*. If *Tied PCC* is selected, you will be prompted to input a *Stress Load Transfer Efficiency*. This indicates the percent load transfer (typically between 5 and 50 percent) expected to be transferred from the outer traffic lane to the tied PCC shoulder. It is recommended that this input be set equal to 40 percent if the shoulder is constructed at the same time as the outer traffic lane (monolithic construction) and 20 percent if the shoulder and traffic lane are constructed separately.

If *Widened Lane* is selected as the shoulder type, you will be prompted to input the additional width of the widened lane. This is calculated as the difference between the widened lane width and the typical lane width. For example, if the typical lane width is 12 ft (3.66 m), and the widened lane is chosen to be 14 ft (4.27 m), the typical lane is being widened by 2 ft (0.61 m). (Note: the default units for this input box are inches.)

If you choose to accept an outer lane and an inner lane at the same time, you will need to specify the amount of *inner lane* cracking as a percentage of the predicted *outer lane* cracking. For example, if you select this number to be 100%, it will be assumed that all inner lanes being accepted will develop the same amount of cracking predicted for the outer lane. Conversely, if you select this number to be 0%, it will be assumed that all inner lanes being accepted will exhibit no cracking.

Road Location

Select whether the project is located in an urban or rural setting by choosing the appropriate item in the *Road Location* list box. This input only influences the

computation of user costs. (Note: the inclusion of user costs in a specification is optional). More details on the inclusion of user costs are contained in the *Page 7—Life-Cycle Cost-Related Modules* section.

Project Length

The starting and ending stations (expressed in ft or m) are also inputs in this *Dimensions and Lane Configuration* dialog box. The specified station values are used to compute the total project length shown below the station input boxes. These inputs are for feedback purposes only (i.e., the calculated project length does not affect simulated pay factors).

Lane Configuration Preview Window

The *Lane Configuration Preview* window provides an illustration of the type of lane configuration selected. Selecting a different item from the *Configuration* list box will change the contents of this preview window.

PAGE 3—DESIGN-RELATED MODULES

The design-related variables used in defining a specification are grouped into three module document types: *Pavement Design*, *Design Traffic*, and *Climatic Variables*. Not only does this simplify the logic of the process, but it also allows you to save and reuse groups of variables which, in turn, simplifies the data entry requirements. An example of the *Design-Related Modules* dialog box is presented in figure 7.

You may access existing modules by clicking on the appropriate list box and highlighting the name of the module you wish to use. To make changes to a displayed module, click the [Edit..] button associated with that module type. To create a new module, click on the [New..] button. Whether you decide to edit an existing module or create a new one, the data entry screens will be the same—only the displayed input values will be different. The data entry procedures for each module type will be discussed separately.

Pavement Design Module

The *Pavement Design* dialog box is made up of three tabs: *Design Inputs*, *Base Variables*, and *Description*. By default, the *Design Inputs* tab is displayed when you first enter the *Pavement Design* dialog box. An example of the *Design Inputs* tab in the dialog box used to define a *Pavement Design* module is presented in figure 8. An example of the *Base Variables* tab is shown in figure 9.

All of the required general design- and base-related user inputs are contained in the *Design Inputs* and *Base Variables* tabs, respectively. You can change the name of the

Pavement Design module by entering a new name in the *Name* box. This name will then show up as the specification document name in the *Modules* tab of the *Database*
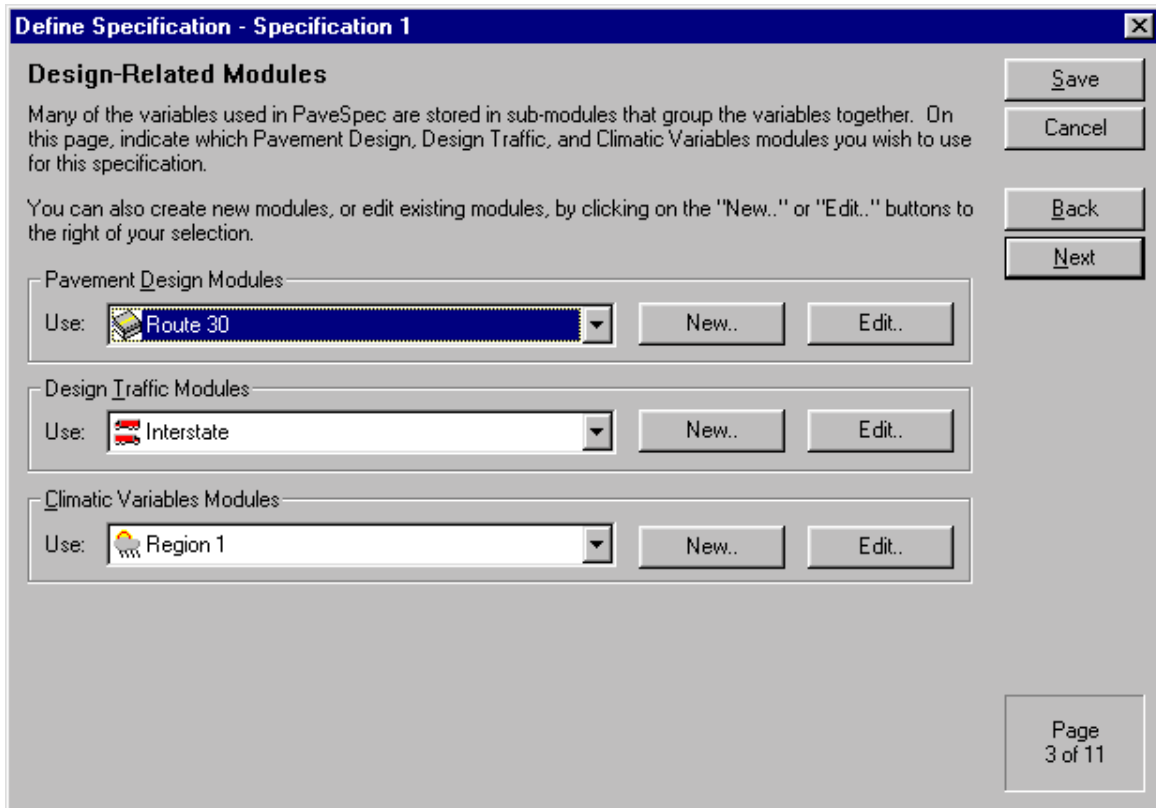
Figure 7. *Design-Related Modules* dialog box.

Define Pavement Design - Route 30

Name: Route 30   Save   Cancel

Design Inputs | Base Variables | Description

Design Life:	40 years
Pavement Type:	Jointed Plain (JPCP), Doweled
Dowel Bar Diameter:	1.5 in
Transverse Joint Spacing:	15 ft
PCC Modulus of Elasticity:	4,000,000 psi
Transverse Joint Sealant Type:	Liquid Asphalt
Modulus of Subgrade Reaction (static k-value):	150 psi/in
Water-Cement Ratio:	0.42
Percent Subgrade Material Passing the #200 (0.075-mm) Sieve	75%

Figure 8. *Design Inputs* tab in the *Pavement Design Module* dialog box.

Define Pavement Design - Route 30

Name: Route 30   Save   Cancel

Design Inputs | Base Variables | Description

Base Permeability:	Permeable
Base Thickness:	5 in
Base Modulus of Elasticity:	30,000 psi
PCC-Base Interface:	Unbonded
Base Erodibility Factor:	3.0

Figure 9. *Base Variables* tab in the *Pavement Design Module* dialog box.

Control dialog box. The specific design- and base-related inputs (in the respective *Design Inputs* and *Base Variables* tabs) are defined by entering values in the provided input boxes, or selecting appropriate values from the provided list boxes.

When entering data into input boxes, the program presents the default units in English or metric, depending on the *Preferred Units* type selected in the program preferences. You may toggle between English and metric units within any numerical input box using the "F2" key.

Brief descriptions of each design- or base-related input are included in this section. For those variables that may be expressed in terms of English or metric units, explanations of the default units are provided.

- *Design Life*—The total expected amount of time for which the chosen pavement design is expected to carry traffic loads without the application of a global rehabilitation (asphalt concrete [AC] overlay, PCC overlay, diamond grinding). This is the initial design life used in the common pavement design procedures.

- *Pavement Type*—The current specification is only valid for JPCP. The agency must identify whether the chosen pavement design is to be constructed with or without dowel bars.

- *Dowel Bar Diameter*—If the pavement is selected to be constructed with dowel bars, the agency must identify the dowel diameter. The dowel diameter is a required input in the transverse joint faulting distress indicator model. Default metric values are displayed in terms of "cm"; however, values may be entered in terms of "mm" by simply typing the value followed by "mm" (e.g., "25.4 mm"). English values must be entered in terms of "in."

- *Transverse Joint Spacing*—The transverse joint faulting and transverse slab cracking distress indicator models require average transverse joint spacing as an input. JPCP's are typically constructed using constant joint spacings (e.g., every 4.6 m) or random joint spacings (e.g., using a repeated pattern of 4.0-4.3-4.6-5.2 m). If a constant joint spacing is used, the constant value is used as the average transverse joint spacing in the distress indicator models. If a random joint spacing is selected, the appropriate transverse joint spacing is set equal to the mean of the joint spacings included in the repeated series. For example, a random joint spacing series of 4.0-4.3-4.6-5.2 m would have a mean transverse joint spacing value of 4.5 m. Acceptable metric abbreviations include "cm" and the default "m." English values may be entered in terms of "in" or the default "ft."

- *PCC Modulus of Elasticity*—The transverse joint faulting and transverse slab cracking distress indicator models require PCC modulus of elasticity as an input. The default metric units for this input are "MPa"; the default English values are "psi."

- *Transverse Joint Sealant Type*—The transverse joint spalling model is dependent on the type of transverse joint sealant material selected for use on the pavement. In the current version of the software, the agency may choose from the following four sealant types: *None* (transverse joints are not sealed), *Liquid Asphalt*, *Preformed Compression Seal*, and *Silicone.*

- *Modulus of Subgrade Reaction (static k-value)*—An effective static subgrade k-value is a required input for the transverse joint faulting and slab cracking distress indicator models. The appropriate value for use in these models is the effective static modulus of subgrade reaction (including seasonal variations) calculated for design purposes. (Note: This value is for the subgrade, not the top of base.) Additional information on determining an appropriate effective subgrade k-value is contained in appendix HH of Volume 2 of the 1993 *AASHTO Guide for Design of Pavement Structures.*[6] The static k-value is the traditional k-value of subgrade soil used in design, and is equal to one half of the dynamic k-value (that backcalculated from falling weight deflectometer [FWD] data). The default metric values for this input are "MPa/m"; the default English values are in terms of "psi/in."

- *Water-Cement Ratio*—The transverse joint spalling model is dependent on the design water-cement ratio used for the PCC mix design. This value is expressed as a number between 0 and 1.

- *Percent Subgrade Material Passing the 0.075-mm (#200) Sieve*—The IRI model is dependent on the percent subgrade material passing the 0.075-mm sieve. This value is expressed as a number between 0 and 100 percent.

- *Base Permeability*—Information regarding the permeability of the base material is required for the transverse joint faulting model. This model includes a base permeability dummy factor as an input. This dummy variable is set equal to 0 when the base is not considered permeable and is set equal to 1 when the base is considered permeable.

- *Base Thickness*—The transverse cracking model requires base thickness as an input. Default metric values for this variable are displayed in terms of "cm"; however, values may be entered in terms of "mm" by simply typing the value followed by "mm" (e.g., "25.4 mm"). English values must be entered in terms of "in."

- *Base Modulus of Elasticity*—The transverse cracking model requires a value for the base modulus of elasticity. The default metric units for this input are "MPa"; the default English values are "psi."

- *PCC-Base Interface*—The interface condition between the PCC slab and the base layer is a required input of the transverse cracking model. This input may be selected to be *Unbonded* or *Bonded* (*Unbonded* is typically chosen for JPCP unless special provisions warrant the selection of *Bonded*).

- *Base Erodibility Factor*—The transverse joint faulting model requires a value for the base erodibility factor. This factor is based on the base erodibility classes defined by the Permanent International Association of Road Congresses (PIARC).[7] The PIARC erodibility classes (modified to include a permeable drainage base layer) for the erosion potential of base/subbase materials, and the associated base erodibility factor ranges are presented in table 1. Moving from A to E, each class has approximately 10 times as much erodibility potential as the class before it (e.g., class C material is approximately 10 times as erodible as class B material).

Table 1. Base erodibility factors based on PIARC recommendations for erosion potential of base/subbase materials.[7]

PIARC Erodibility Class	Erodibility Factor	Material Description
A	0.5–1.5	Lean concrete with 8 percent cement; bituminous concrete with 6 percent asphalt cement, or a permeable drainage layer.
B	1.5–2.5	Cement treated granular material with 5 percent cement manufactured in plant; bitumen treated granular material with 4 percent asphalt cement.
C	2.5–3.5	Cement-treated granular material with 3.5 percent cement manufactured in plant; bitumen treated granular material with 3 percent asphalt cement.
D	3.5–4.5	Granular material treated in place with 2.5 percent cement, treated soils.
E	4.5–5.5	Untreated granular material.
—	5.5–7.5	No base.

The *Description* tab contains a text box in which you may enter any detailed text describing the defined *Pavement Design* module. Information entered in this text box is optional and is not used in the simulation process.

Once you are finished making changes or defining a *Pavement Design* module, click on the � Save � button. If you would like to exit the *Pavement Design* dialog box without saving your changes, click on the � Cancel � button. Clicking either button will return you to the *Design-Related Modules* dialog box.

Design Traffic Module

The *Design Traffic* dialog box includes two tabs: *Traffic Inputs* and *Description*. By default, the *Traffic Inputs* tab is displayed when you first enter the *Design Traffic* dialog box. An example of the *Traffic Inputs* tab in the *Design Traffic* dialog box is presented in figure 10.

All inputs used to compute yearly ESAL's are contained in the *Traffic Inputs* tab. This dialog box acts as a traffic calculator, allowing you to compute traffic over time on the basis of an entered cumulative design ESAL or average daily traffic (ADT) at a specified year, a defined growth rate, and a chosen growth type (simple or compound). The relationship between ESAL's and ADT is determined using the inputs defined in the *ESAL-to-ADT Ratio* section of the dialog box. Cumulative ESAL's are required by many of the distress indicator models, while yearly ADT values are used in the computation of any included user costs. (Note: the inclusion of user costs is optional.

More details on the inclusion of user costs are contained in the *Page 7—Life-Cycle Cost-Related Modules* section.)

Figure 10. *Traffic Inputs* tab in the *Design Traffic Module* dialog box.

You can change the name of the *Design Traffic* module by entering a new name in the *Name* input box. This name will then show up as the specification document name in the *Modules* tab of the *Database Control* dialog box. The remaining traffic-related inputs in the *Traffic Inputs* tab are defined by entering appropriate values.

The *Description* tab contains a text box in which you may enter any detailed text describing the defined *Design Traffic* module. Any information entered in this text box is optional, as it is not used in the simulation process.

Once you are finished making changes or defining a *Design Traffic* module, click on the ⟨Save⟩ button. If you would like to exit the *Design Traffic* dialog box without saving your changes, click on the ⟨Cancel⟩ button. Clicking either button will return you to the *Design-Related Modules* dialog box.

Climatic Variables Module

The *Climatic Variables* dialog box is made up of two tabs: *Climatic Inputs* and *Description*. By default, the *Climatic Inputs* tab (see figure 11) is displayed when you first enter the *Climatic Variables* dialog box.

Figure 11. *Climatic Inputs* tab in the *Climatic Variables Module* dialog box.

All of the climate-related user inputs are contained in the *Climatic Inputs* tab. You may change the name of the *Climatic Variables* module by entering a new name in the *Name* input box. This name will then show up as the specification document name in the *Modules* tab of the *Database Control* dialog box. The remaining climatic-related inputs in the *Climatic Inputs* tab are defined by entering values in the provided input boxes, or by selecting appropriate values from the provided list boxes. Brief descriptions of each climate-related input are included in this section. For those variables that may be expressed in terms of English or metric units, explanations of the default units are provided.

- *Average Annual Freezing Index*—The average annual freezing index is a measure of the severity of frost for a region, expressed in terms of degree-days. The IRI model requires freezing index as a direct input. Although freezing index data are readily available in most climatic characteristic databases, values may be

estimated for the continental United States using figure 12. The default metric units for freezing index are "°C-days"; the default English values are "°F-days."

- *Average Annual Precipitation*—The transverse joint faulting distress indicator model requires knowledge about the average annual amount of precipitation. The default metric units for freezing index are "mm"; the default English values are "in." Data for this variable are included in most available climatic databases.

- *Average Annual Air Freeze-Thaw Cycles*—The current transverse joint spalling distress indicator requires knowledge about the number of annual air freeze-thaw cycles (FTC's). Data for this variable are included in most available climatic databases.

- *Average Annual Number of Days Over 90 °F (32 °C)*—The average annual number of days in which the daily maximum temperature exceeds 90 °F (32 °C) is a climatic input required by the transverse joint faulting distress indicator model. Daily temperature data are readily available in most climatic databases.

- *Climatic Zone*—The United States is divided into four climatic regions based on the mean annual daily average temperature and average annual total precipitation. The appropriate climatic region is determined using table 2. Climatic zone is used by the transverse cracking distress indicator model.

Table 2. Climatic regions in the United States.

Average Annual Total Precipitation	Mean Annual Average Daily Temperature	
	≤ 13 °C	> 13 °C
≤ 635 mm	Dry-Freeze Region	Dry-Nonfreeze Region
> 635 mm	Wet-Freeze Region	Wet-Nonfreeze Region

The *Description* tab contains a text box in which you may enter any detailed text describing the *Climatic Variables* module. Because information entered in this text box is not used in the simulation process, it is optional.

Once you are finished making changes or defining a *Climatic Variables* module, click on the ⬚ Save ⬚ button. If you would like to exit the *Climatic Variables* dialog box without saving your changes, click on the ⬚ Cancel ⬚ button. Clicking either button will return you to the *Design-Related Modules* dialog box.

PAGE 4—DEFINITION OF PAVEMENT PERFORMANCE

Pavement performance is defined in page 4 of the *Specification Wizard*. An example of the *Definition of Pavement Performance* dialog box is presented in figure 13.

Pavement performance is expressed in terms of one or more of the four distress indicators (transverse joint faulting, transverse joint spalling, transverse slab cracking, and decreasing smoothness) shown in the *Distress Indicators* box. To select or deselect a distress indicator, click on the check boxes next to the distress indicator titles (a check

Note:
Mean freezing index values expressed in degree days below 32°F.

Approximate southerly limit of area where frost may be expected to penetrate pavement and base to a depth of at least 12 inches on the average of 1 year in 10.
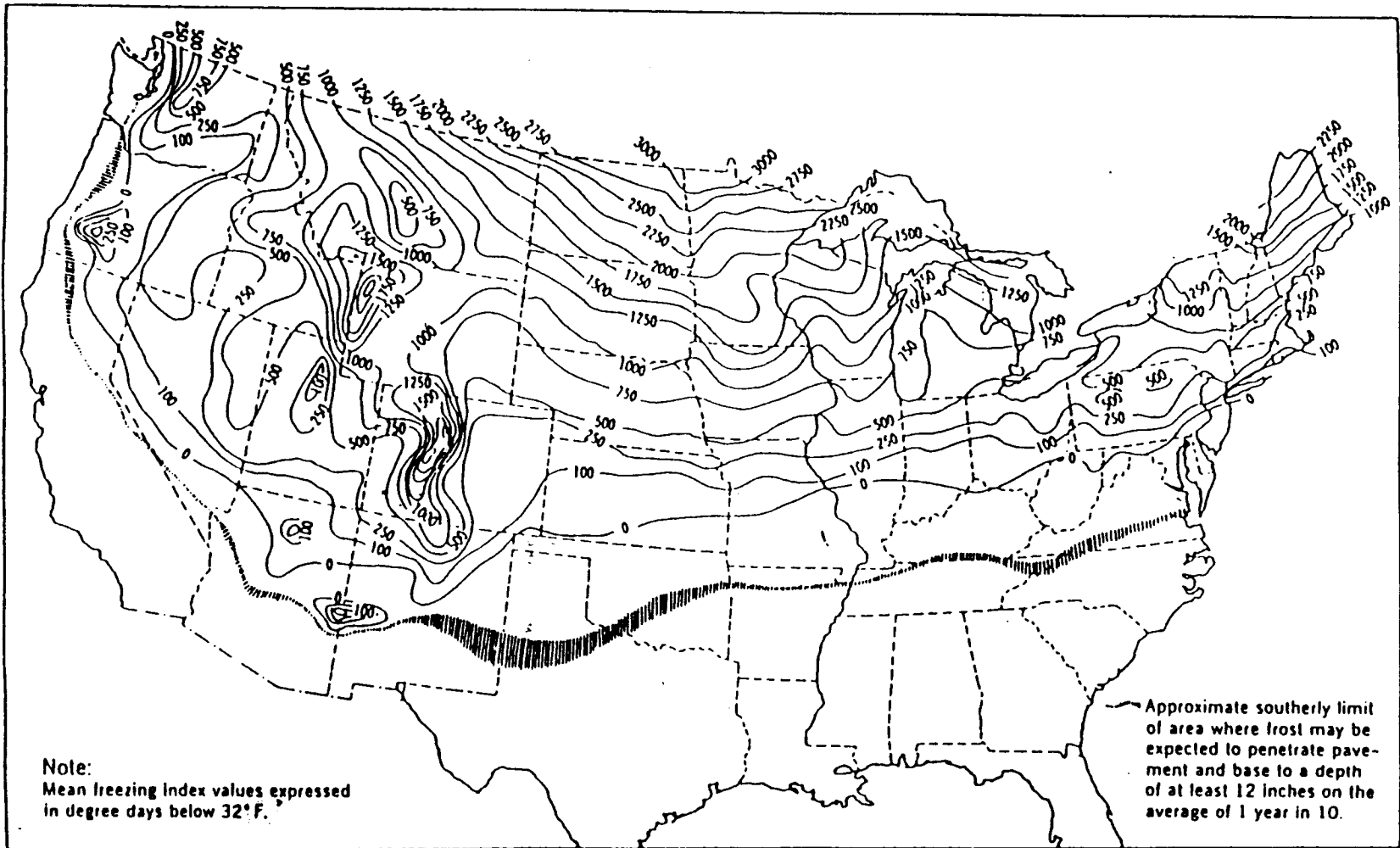
32 °F = 0 °C

Figure 12. Distribution of mean freezing index values in the continental United States (data expressed in English units).[8]
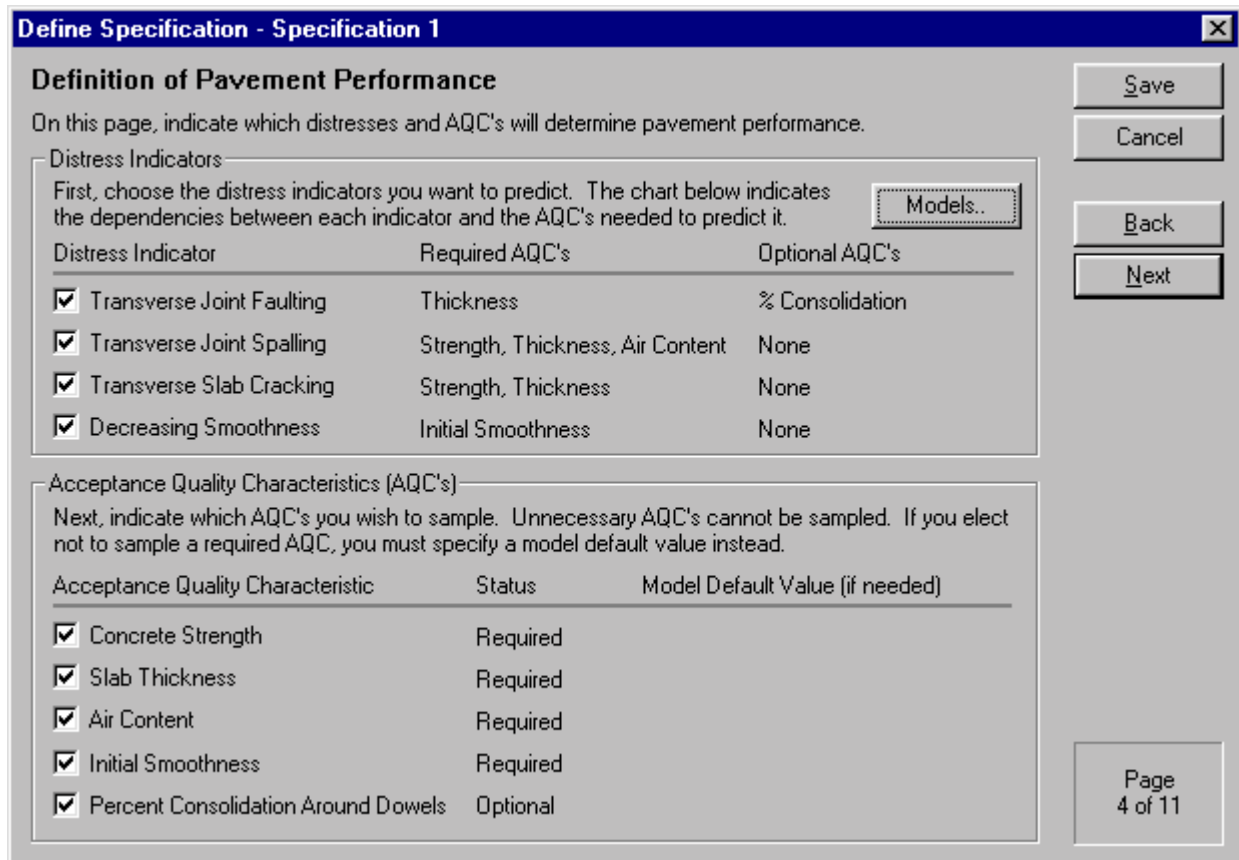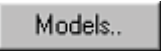
Figure 13. *Definition of Pavement Performance* dialog box.

mark signifies that the distress indicator is selected). For your convenience, the required and optional AQC's associated with each distress indicator model are listed next to each distress indicator type.

Also included in the *Distress Indicators* area of the dialog box is the [Models..] button. This button provides a direct link to the dialog box in which the specification-specific distress indicator model set is defined. The set of national distress indicator models (presented in chapter 4 of Volume I) is defined as the *default* model set.[9] If you do not wish to use one of the provided default distress indicator models, you then have the capability to *modify* or *calibrate* a model. Details of the procedures used to modify or calibrate distress indicator models are described in chapter 4 of this appendix.

The second step in defining pavement performance requires the selection of AQC's that you choose to measure in the field. The *Status* column next to the listed AQC's indicates whether each AQC is required, optional, or unnecessary. Those AQC's required by the selected distress indicator models are automatically selected for inclusion. Those AQC's that are optional may be selected or deselected by clicking on the check boxes. AQC's not required by the selected distress indicator models are automatically deselected. If you choose to deselect an AQC that is required by one of

the chosen distress indicator models, you will be asked to enter a model default value that will be used by those performance models requiring a value for that AQC.

PAGE 5—AQC SAMPLING AND TESTING

The AQC sampling and testing plans are defined in page 5 of the *Specification Wizard*. You will see a tab for each AQC that you selected in page 4 of the *Specification Wizard*. Each AQC data entry screen is discussed separately.

Concrete Strength

This AQC has two different data entry screens—one for *sampling* information and one for *testing* information. If you chose to develop a Level 1 specification only, you can toggle between the Level 1 sampling and testing data entry screens using the Level 1 Sampling and Level 1 Testing buttons. If you chose to develop a Level 1 and Level 2 specification at the same time, you can also toggle between the Level 2 sampling and testing data entry screens using the Level 2 Sampling and Level 2 Testing buttons. (Note: The Level 1 and Level 2 data entry screens are identical. Separate data entry screens are provided for each PRS level only because you can choose to use different sampling and testing plans for the different specification levels.)

An example of the *Concrete Strength Sampling* data entry screen is shown in figure 14. The data inputs contained in this screen define how concrete strength is to be sampled under the developed PRS. First, you must select a sample method from the *Sample Method* list box. If *Cores* are selected, you must choose an appropriate age from the *Timing of Cores* box. (The selected timing of cores indicates when the cores will be extracted from the pavement; this age is not necessarily the age of testing for the cores.) Next, the *Number of Samples per Sublot (n)* and *Number of Replicates per Sample (m)* are chosen. Finally, you may enter any notes regarding the defined concrete strength sampling and testing plan in the *Additional Sampling or Testing Comments* text box (this field is optional).

An example of the *Concrete Strength Testing* data entry screen is shown in figure 15. The data inputs contained in this screen define the testing procedures to be used to determine concrete strength within the developed PRS. The testing-related inputs are divided into two groups: *Testing* and *Acceptance*.

Within the testing group, the *Type of Testing* is provided as feedback. This testing type reflects the sample type chosen in the associated sampling data entry screen. The first input included in this testing group is the *Target Timing of Testing*. Use this input field to indicate the sample age at which testing is to be performed (e.g., if cylinders are to be tested at 7 days to obtain 7-day compressive strengths, this input field should be set equal to *7 days)*. If the timing of testing is chosen to be less than 28 days, you must then enter an appropriate *Test Maturity* value. This value should be equal to the
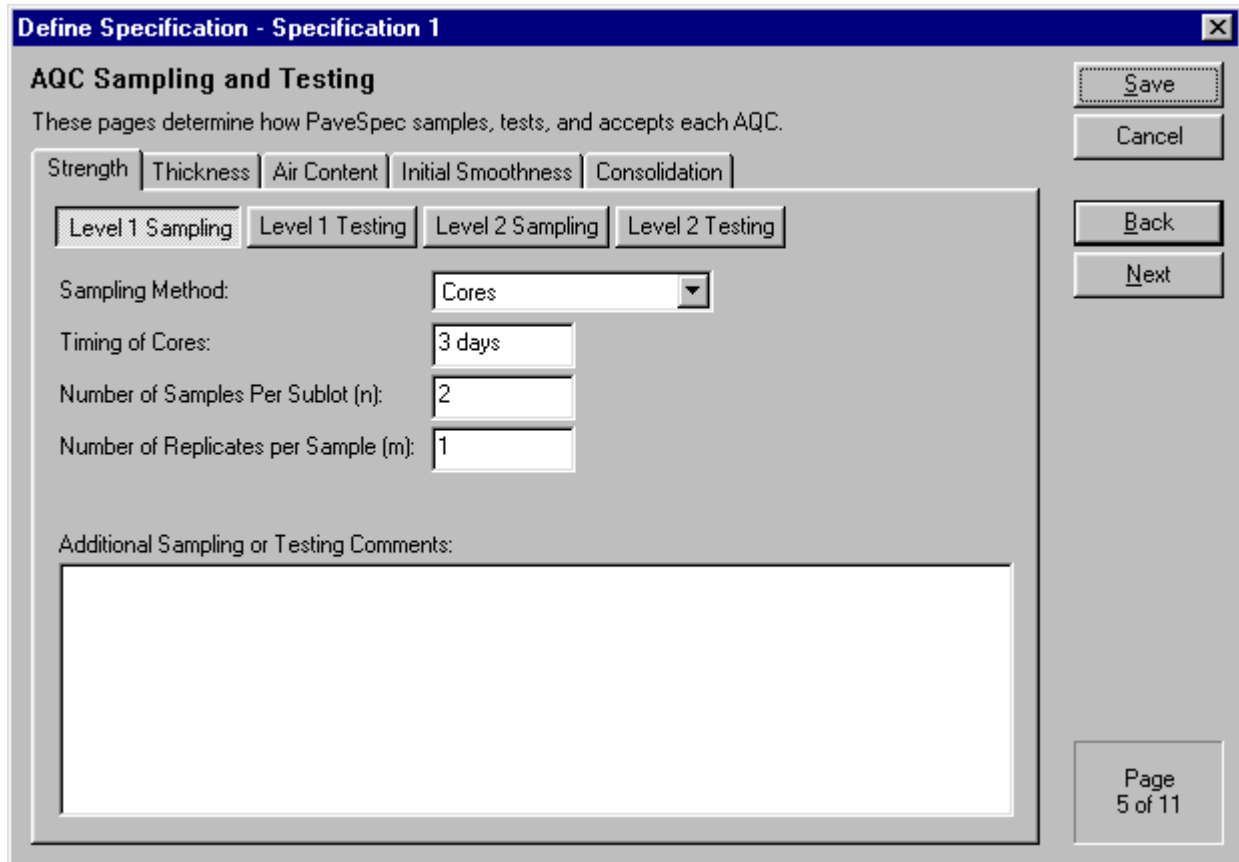
Figure 14. *AQC Sampling and Testing* dialog box (*Concrete Strength Sampling* data entry screen).

equivalent laboratory maturity representing the chosen number of days selected in the *Target Timing of Testing* list box.

The Acceptance group illustrates the steps required to estimate the 28-day flexural strength (required by the distress indicator models) based on the chosen sample type and timing of testing. Each of these steps will change based on the chosen sampling and testing procedures. If a button is visible next to any step description, a specific relationship needs to be defined. For example, the [Cylinder = [0.85 * Core] + 0] button is visible next to step 2 in figure 15. This button indicates that the user must define a cylinder vs. core relationship as part of the selected testing procedure. Clicking on the [Cylinder = [0.85 * Core] + 0] button brings up the *Core-to-Cylinder Strength Relationship* dialog box shown in figure 16.

The dialog box shown in figure 16 is used to define the appropriate linear relationship between cylinder and core strength. The equation form is displayed directly beneath the *Form* box. Next, the coefficients defining the actual chosen relationship are defined in the supplied coefficient input boxes. The chosen equation

Figure 15. *AQC Sampling and Testing* dialog box (*Strength* testing data entry screen).
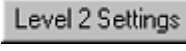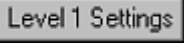
Figure 16. *Core-to-Cylinder Strength Relationship* dialog box.

coefficients are then shown in the actual developed equation displayed beneath the coefficient input boxes. Finally, the right side of the dialog box shows a preview graph to help you visualize the defined relationship.

The button associated with step 3 of the concrete strength acceptance procedure (if required) brings up a dialog box that allows you to define the required *Laboratory-Created Maturity Equation* (strength versus maturity relationship). The *Equation Definition* dialog box is nearly identical to the *Core-to-Cylinder Strength Relationship* dialog box. The only difference is that the equation form is not limited to linear. Available equation forms include *Linear, Second-Order Polynomial, Third-Order Polynomial, Exponential, Logarithmic,* and *Power.* The final piece of information required under step 3 is the specified *28-day Maturity.* This value is the equivalent maturity measured in the laboratory at 28 days.

Finally, the button associated with step 4 allows you to define an appropriate *Compressive-to-Flexural Strength* relationship (if required). This pop-up dialog box is also nearly identical to the *Core-to-Cylinder Strength Relationship* dialog box. The only difference is that the equation form is not limited to linear. Available equation forms include *Linear, Second-Order Polynomial, Third-Order Polynomial, Exponential, Logarithmic,* and *Power.*

Slab Thickness

Selecting the *Thickness* tab brings up a data entry screen used to define the slab thickness sampling and testing plan. An example of this data entry screen is shown in figure 17. If you chose to develop a Level 1 and Level 2 specification at the same time, separate data entry screens are provided for each specification level. You can toggle between the Level 1 and Level 2 data entry screens using the [Level 1 Settings] and [Level 2 Settings] buttons. (Note: The Level 1 and Level 2 data entry screens are identical.) If you chose to only develop a Level 1 specification, only the [Level 1 Settings] button will be displayed.

The data inputs contained in this data entry screen define how slab thickness is to be sampled under the developed PRS. First, you must select a sample type from the *Sampling Method* list box: *Use Strength Cores, Independent Cores, Probe,* or *Ground-Penetrating Radar.* If the sampling method selected is *Use Strength Cores,* the remaining input boxes reflect the concrete strength sampling plan defined in the *Strength* tab.

Additional required slab thickness sampling plan inputs include the *Timing of Samples, Number of Samples per Sublot (n),* and *Number of Replicates per Sample (m).* Finally, you may enter any relevant notes in the *Additional Sampling or Testing Comments* text box (this field is optional).

Figure 17. *AQC Sampling and Testing* dialog box (*Thickness* data entry screen).

Air Content

Selecting the *Air Content* tab allows you to define the air content sampling and testing plan. An example of this data entry screen is shown in figure 18. If you chose to develop a Level 1 and Level 2 specification at the same time, separate data entry screens are provided for each specification level. You can toggle between the Level 1 and Level 2 data entry screens using the Level 1 Settings and Level 2 Settings buttons. (Note: The Level 1 and Level 2 data entry screens are identical.) If you chose to only develop a Level 1 specification, only the Level 1 Settings button will be displayed.

The data inputs on this screen define how air content is to be sampled under the developed PRS. You must first select one of the following three sample types provided in the *Sampling Method* list box: *Cores, Air Pressure Meter,* or *Danish Air Void Analyzer.* If *Cores* is selected as the sampling method, you must then specify when the cores are to be extracted from the pavement. (Note: The *Timing of Samples* input box is automatically set equal to *At Construction* if the sample type selected is *Air Pressure Meter* or *Danish Air Void Analyzer.*) Next, you must define values for the other required air content sampling plan inputs, including the *Number of Samples per Sublot (n)* and *Number*

Figure 18. *AQC Sampling and Testing* dialog box (*Air Content* data entry screen).

of Replicates per Sample (m). Finally, you may enter relevant notes in the *Additional Sampling or Testing Comments* text box (field is optional).

Initial Smoothness

Selecting the *Initial Smoothness* tab allows you to define the sampling and testing plan associated with measuring initial smoothness. An example of this data entry screen is shown in figure 19. If you chose to develop a Level 1 and Level 2 specification at the same time, separate data entry screens are provided for each specification Level. You can toggle between the Level 1 and Level 2 data entry screens using the ⎡Level 1 Settings⎤ and ⎡Level 2 Settings⎤ buttons. (Note: The Level 1 and Level 2 data entry screens are identical.) If you chose to only develop a Level 1 specification, only the ⎡Level 1 Settings⎤ button will be displayed.

The inputs required on this data entry screen define how initial smoothness is to be sampled under the developed PRS. First, you must select the appropriate *Initial Smoothness Indicator* that specifies how initial smoothness is to be measured. The following three indicator types are available:

Figure 19. *AQC Sampling and Testing* dialog box (*Initial Smoothness* data entry screen).

- Profile Index (measured using a 0.0-mm blanking band).
- Profile Index (measured using a 5.1-mm blanking band).
- International Roughness Index.

Second, if applicable, a button will appear that allows you to define an initial smoothness relationship between the chosen initial smoothness indicator and IRI. This relationship is required to determine the initial IRI value in the prediction of smoothness over time.

Based on the chosen settings for *Initial Smoothness Indicator*, the appropriate equation type will be displayed. Clicking on the equation button will bring up the *Define Initial Smoothness Relationship* dialog box. This dialog box is nearly identical in layout and function to the *Core-to-Cylinder Strength Relationship* dialog box shown in figure 16. Using this dialog box, you can change the equation type or adjust the coefficients to define the appropriate initial smoothness relationship. More information on selecting an appropriate initial smoothness relationship is included in chapter 8 of Volume I.[9]

Other inputs included on this *Initial Smoothness* data entry screen include the *Number of Pass Locations per Sublot (n)*, *Number of Replicates per Pass Location (m)*, and the *Profilograph Reduction Method*. Additional text boxes are also included to allow you to

enter comments related to the *Pass Locations* and the *Timing of Samples* (these two text fields are optional).

Percent Consolidation Around Dowels

Selecting the *Consolidation* tab brings up a data entry screen used to define the percent consolidation around dowels sampling and testing plan. An example of this data entry screen is shown in figure 20. If you chose to develop a Level 1 and Level 2 specification at the same time, separate data entry screens are provided for each specification level. You can toggle between the Level 1 and Level 2 data entry screens using the Level 1 Settings and Level 2 Settings buttons. (Note: The Level 1 and Level 2 data entry screens are identical.) If you chose to only develop a Level 1 specification, only the Level 1 Settings button will be displayed.

Figure 20. *AQC Sampling and Testing* dialog box (*Consolidation* data entry screen).

The data inputs contained on this screen define how percent consolidation around dowels is to be sampled under the developed PRS. Under the current PRS approach, percent consolidation around dowels is measured by conducting relative density testing of core samples. Additional inputs required on this data entry screen include the *Number of Samples per Sublot (n)*, *Timing of Samples* (timing of extracting cores), and the

Number of Replicates per Sample (m). You may also enter additional notes in the *Additional Sampling or Testing Comments* text box (this field is optional).

PAGE 6—AQC AS-DESIGNED TARGET VALUE DEFINITION

The as-designed target AQC target means and standard deviations are defined on page 6 of the *Specification Wizard.* If you chose to define a Level 1 and Level 2 specification at the same time, this dialog box will contain two tabs titled *Level 1 Settings* and *Level 2 Settings.* If you only chose to develop a Level 1 specification, only the Level 1 tab will be visible. The Level 1 and Level 2 data entry screens are identical, and an example is presented in figure 21.

Figure 21. *AQC As-Designed Target Value Definition* dialog box.

Selection of the Method Used to Determine As-Designed LCC's

First, you must decide on the method by which you would like to determine the as-designed target LCC. The following options are available:

- *Estimate LCC Through Simulation*—This is the recommended method for estimating the as-designed target LCC because it incorporates both the AQC target means and standard deviations.

- *Calculate LCC Using AQC Means Only*—If you want to simulate LCC's that are not influenced by the AQC variability (standard deviation), you may choose this option. You will only be required to enter the appropriate AQC means.

The remainder of the data entry sheet contains input fields used to select the AQC as-designed target values. Only values for those AQC's selected for inclusion in the PRS are required. The input fields for those AQC's not included in the specification are grayed out, signifying that you cannot enter data.

If you choose to estimate the LCC through simulation, for each AQC included in the specification you must identify a *Sample Method* by which samples will be determined, a target AQC *Mean* value, and a target AQC standard deviation (*Std Dev*). You can choose from two different methods for determining samples within the simulation of the as-designed LCC: *Distribution* or *Means Only*. If *Distribution* is chosen, random as-designed samples are determined based on a normal distribution defined by the inputted AQC mean and standard deviation. If *Means Only* is chosen, sample values are assumed to be equal to the mean value that you specify. For this case, we assume that the variability of this AQC is not important. For example, let's assume that concrete strength is specified at 3,500 psi. Therefore, only one strength pay factor curve (the case for strength std dev = 0 psi) will be developed in the strength pay factor chart. All other pay factor curves will be simulated with the strength samples specified equal to 3,500 psi (with std dev = 0 psi). Similarly, if the *Calculate LCC Using AQC Means Only* option is chosen, all AQC pay factor charts will only contain one curve each (the case with std dev = 0).

As mentioned previously, PaveSpec uses English units as defaults. Values input in metric units are automatically converted to the corresponding English units. When entering an appropriate value in one of these input boxes, type the value followed by the appropriate units abbreviation (e.g., "254 mm"). Acceptable unit abbreviations for each AQC are as follows:

- Concrete Strength—Default metric values are displayed in terms of "MPa," whereas English values are in terms of "psi."
- Slab Thickness—Acceptable metric abbreviations include "mm" and the default metric unit "cm." The default English values are expressed in terms of "in."

- Air Content—Default units for this field are "%."

- Initial Smoothness—Default metric values are expressed in terms of "mm/km," while English values are in terms of "in/mi."

- Percent Consolidation Around Dowels—Default units for this field are "%."

Within any numerical input box, you may toggle between default English and metric units using the "F2" key.

Finally, the *Sampling and Testing Summary* area of the dialog box provides feedback regarding the specific sampling and testing procedures defined on page 5 of the *Specification Wizard*. This information is important because the AQC target values typically differ for different sampling and testing procedures.

Selection of Appropriate AQC Target Values

Selecting the appropriate as-designed AQC target values (means and standard deviations) is one of the most important tasks facing the governing agency when developing a specification. Its importance warrants the inclusion of guidelines for their selection in this user's guide. The remainder of this section presents the AQC target selection guidelines as they were generally outlined in a previous report by Hoerner and Darter.[1]

The chosen target AQC's define the agency's desired pavement quality. In the current PRS approach, this desired quality is defined as the quality for which the agency is willing to pay 100 percent of the contractor-submitted bid price. If the contractor constructs a pavement that is measured to have better AQC quality than that defined by the as-designed target AQC's, then (on average) the contractor will receive an incentive payment (greater than 100 percent of the bid price). Conversely, if the as-constructed AQC pavement quality is measured to be less than that defined by the as-designed AQC target values, then (on average) the contractor will receive a disincentive payment (less than 100 percent of the bid price).

Initially, it is recommended that the AQC target values be set to represent the quality levels specified under the agency's current specifications. If appreciably lower quality levels are specified for the target values, the result will be decreased performance. If appreciably higher quality levels are specified, contract bid prices are likely to increase. While such higher quality levels (with attendant higher bid prices) might well result in lower overall LCC's, it would be difficult for an agency to justify increases in specified quality without first having some experience with PRS (i.e., knowledge of the effect of specified quality on bid price and expected performance).

For an agency to select AQC target levels that represent the quality levels currently being specified, the agency must have a thorough understanding of its current specifications, and particularly its acceptance plans. The agency must first identify the AQC quality levels (means and standard deviations) for which its current acceptance plans are asking. Sometimes, these quality levels are not obvious. In fact, the currently specified quality levels may be different than what the agency actually desires (i.e., something other than what the agency intended to specify). To identify exactly what quality level the agency is currently specifying, the agency's expected pay curves should be utilized. The expected pay curve is a graphic representation of an acceptance plan that shows the relation between the actual quality of a lot and its expected pay.[5] That quality level (on an expected pay curve), for which the agency is willing to pay 100

percent of the contractor-submitted bid price, should be interpreted as the currently specified quality level for each AQC. If the agency has not developed expected pay curves, computer programs are currently available (such as R.M. Weed's OCPLOT) to assist the highway agency in their development.[10] If the agency acceptance plan cannot easily be converted to an expected pay curve, it is suggested that the agency develop a new acceptance plan so that the SHA can clearly determine the quality level currently being specified. The new acceptance plan should, of course, consider the typical quality levels being achieved by contractors in the State.

The agency-defined AQC target values are dependent on the chosen AQC acceptance sampling and testing plan. The recommended AQC means and standard deviations may change based on test type and number of replicate test results. For example, if concrete strength were being measured using 28-day cylinder compressive strengths, the AQC target values would be very different than those recommended for the case where 28-day beams were being tested for flexural strength. It is important to have knowledge of the proposed acceptance sampling and testing plan prior to construction so that the appropriate AQC target values can be defined.

As stated previously, initially, the target means should be selected to be equal to the AQC values for which the contractor would expect to receive 100 percent pay. Ideally, these values should correspond to the values used for design purposes. Target standard deviations should be determined by analyzing historical AQC data or by referring to published estimates of standard deviations. (Typical AQC standard deviations [based on measured field data] previously summarized for use with PRS are presented in table 3.)[3] If the agency has a reasonable amount of good historical data representative of an AQC, it is strongly recommended that the agency analyze these data to determine appropriate AQC target means and standard deviations. The following steps can be used to determine target values based on historical AQC construction data:

1. Identify an AQC for which target values need to be determined (e.g., concrete strength).

2. Identify the sampling and testing type to be used for accepting the AQC in the field (e.g., cylinders from material taken from in front of the paver).

3. Identify historical projects that not only use the same sampling and testing types, but are also believed to have been constructed with AQC quality matching that desired by the agency.

4. Compute the sample mean and unbiased standard deviation using all of the representative sample values for each project (note: a sample *value* is the mean AQC value at a chosen location [i.e., a sample value could be the mean of replicate test values]). Sample means are computed using equation 1.

Table 3. Summary of target within-lot standard deviations for PCC pavement acceptance quality characteristics.[3]

Acceptance Quality Characteristic	Sample Type	Within-Lot Standard Deviations for Different Numbers of Replicates (n) per Sample				
		n = 1	n = 2	n = 3	n = 4	n = 5
Compressive Strength, MPa	3-day Cylinder	3.13	2.21	1.81	1.56	1.40
	3-day Core	2.10	1.48	1.21	1.05	0.94
	14-day Cylinder	3.37	2.38	1.95	1.69	1.51
	28-day Cylinder	3.10	2.19	1.79	1.55	1.39
	28-day Core	2.63	1.86	1.52	1.31	1.18
Splitting Tensile Strength, MPa	3-day Cylinder	0.55	0.39	0.32	0.28	0.25
Flexural Strength, MPa	3-day Beam	0.41	0.29	0.24	0.20	0.18
	14-day Beam	0.43	0.30	0.25	0.21	0.19
	28-day Beam	0.30	0.21	0.18	0.15	0.14
	Predicted 28-day	0.21	0.15	0.12	0.10	0.09
Slab Thickness, mm	Cores	8.0	5.7	4.6	4.0	3.6
	Radar	9.5	6.7	5.5	4.7	4.2
Air Content, %	Before Paver	0.75	0.53	0.43	0.37	0.33
	After Paver	0.78	0.55	0.45	0.39	0.35
	Linear Traverse	1.90	1.34	1.10	0.95	0.85
Initial Smoothness, mm/km	Profile Index—5.1-mm blanking band	27.1	19.2	15.6	13.6	12.1
	Profile Index—0.0-mm blanking band	49.9	35.3	28.8	25.0	22.3
Percent Consolidation Around Dowels, %	Below Dowels	1.06	0.75	0.61	0.53	0.47
	Above Dowels	1.16	0.82	0.67	0.58	0.52
	Between Dowels	1.13	0.80	0.65	0.57	0.51

$$\overline{\overline{X}} = \frac{\displaystyle\sum_{i=1}^{n}\sum_{j=1}^{m} x_{ij}}{n*m} \tag{1}$$

where:

$\overline{\overline{X}}$ = The computed lot mean of $n*m$ AQC specimen test values.

x_{ij} = Any of the $n*m$ ($i = 1$ to n, $j = 1$ to m) specimen test values.

n = Number of random sampling locations.

m = Number of replicate specimen values per sampling location.

Corrected unbiased sample standard deviations are computed using equation 2.

$$s = \left(\frac{1}{C_{SD}}\right)\sqrt{\frac{\displaystyle\sum_{i=1}^{n}\left(\overline{X}_i - \overline{\overline{X}}\right)^2}{n-1}} \tag{2}$$

where:

s = The computed unbiased (corrected) standard deviation of sample values determined at n random sampling locations.

C_{SD} = Correction factor (based on a sample size on n sample locations) used to obtain unbiased estimates of the actual lot standard deviation, σ. Appropriate C_{SD} values are determined using table 4.

$\overline{X}_i$ = Any of the representative sample values (either measured directly from one test specimen, or computed as the mean of m replicate test values) determined at n random sample locations.

$\overline{\overline{X}}$ = The computed lot "grand" mean of n AQC sample values.

n = Number of random sampling locations.

5. Analyze the computed project AQC unbiased standard deviations and use them to identify appropriate AQC target standard deviations. (Note: The computed sample means should be checked against the assumed target means.) The computed data should give the agency knowledge about what type of quality has been provided on similar paving projects by the contractors. It is up to the agency to interpret these results and decide on appropriate AQC target means and standard deviations that define the true quality desired. The target standard deviation includes both testing and process or materials variation.

Table 4. Correction factors used to obtain unbiased estimates of the actual standard deviation.

Number of Sample Values, n	Correction Factor, C_{SD}
2	0.7979
3	0.8862
4	0.9213
5	0.9399
6	0.9515
7	0.9594
8	0.9650
9	0.9693
10	0.9726
30	0.9915
50	0.9949

Although historical data should ideally be used to determine appropriate AQC target means and standard deviations, the initial recommendations for determining these values are summarized in table 5.

PAGE 7—LIFE-CYCLE COST-RELATED MODULES

The life-cycle cost-related variables used in defining a specification are grouped into two types of module documents—*Maintenance and Rehabilitation Plan* and *Unit Costs* modules. Again, this organization not only simplifies the logic of the process, but it also allows you to save and reuse these groups of variables, which, in turn, simplifies the data entry process. An example of the *Life-Cycle Cost-Related Modules* dialog box is presented in figure 22.

You can access existing modules by clicking on the appropriate list box and highlighting the module name you wish to use. To make changes to a displayed module, click the ⬚ Edit.. button associated with that module type. To create a new module, click on the ⬚ New.. button. Whether you decide to edit an existing module or create a new one, the data entry screens will be the same (only the displayed input values will be different). The data entry procedures for each module type will be discussed separately.

Maintenance and Rehabilitation Plan Module

The *Maintenance and Rehabilitation Plan* dialog box includes a *Name* input box and four tabs titled *Maintenance, Local Rehab, Global Rehab,* and *Description.* By default, the

Table 5. Initial recommendations for determining AQC target means and standard deviations.[1]

Acceptance Quality Characteristics	Initial Recommendations for Target Mean	Initial Recommendations for Target Standard Deviation
Concrete Strength	The target mean should be interpreted from a developed expected pay curve. This value should be equal to the current agency mean strength input used in the pavement design procedure (see note 1).	These values should be based on historical project testing data. If no historical data are readily available, the values may initially be based on published data (see note 4). Both the variations due to testing and to materials should be included (see note 5).
Slab Thickness	The target mean should be interpreted from a developed expected pay curve. This value should be equal to the current agency design thickness determined from the pavement design procedure (see note 2).	
Entrained Air Content	The target mean should be set equal to the current agency-designed entrained air content. This AQC is only significant in areas with significant freezing temperatures.	
Initial Smoothness	The target mean should be interpreted from a developed expected pay curve (see note 3).	
Percent Consolidation Around Dowels	The target mean should be determined from testing conducted by the agency to determine typical levels achieved, or from published data.	

Notes: [1]The *AASHTO Guide for Design of Pavement Structures* requires a flexural strength, third-point loading, 28 days curing (M_r).[6] If another testing type is selected for the AQC (such as 28-day cylinder compressive strength [f'c]), then a correlation using the project materials must be established and utilized. For example, if the design input to AASHTO is 4.48 MPa flexural strength, and the correlation is f'c = $(M_r/0.83035)^2$, then the corresponding target mean would be based on a design compressive strength of 29.13 MPa. If strength at any other time than 28 days is desired for the AQC, then correlations with maturity must be established for the project materials.

[2]Most design procedures, such as the AASHTO design procedure, include a formal engineering reliability design provision. Others include various safety factors. Either of these approaches result in a slab design thickness that already includes a large safety factor or high design reliability. Thus, the design slab thickness is the mean slab thickness that is desired in the field, not an arbitrarily increased value.

[3]The value specified here for the profile index (PI) or IRI should be related to the 100 percent payment level specified in the agency's smoothness specification. The lower the PI specified, the higher the design initial serviceability.

[4]Recommended AQC standard deviations (originally presented in appendix D of the report titled *Guide to Developing Performance-Related Specifications for PCC Pavements, Volume III: Appendixes C Through F*) are presented in table 3.[3]

[5]The standard deviation is highly dependent upon the number of replicate tests involved. For example, if the mean of two concrete cylinders (both from one batch of concrete) represents one test for a site, the standard deviation for this case will be less than for the case when only one cylinder is used to represent the site.
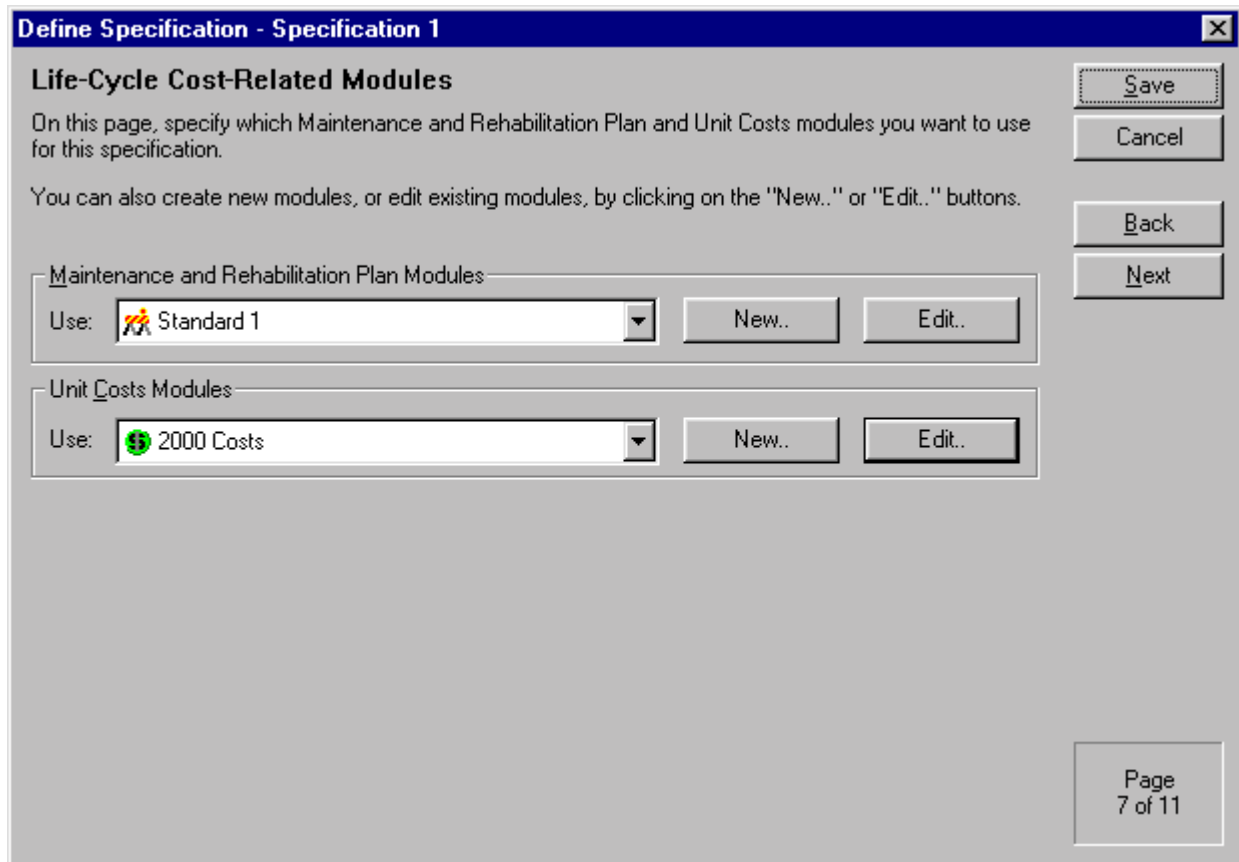
Figure 22. *Life-Cycle Cost-Related Modules* dialog box.

Maintenance tab is displayed first. An example of this dialog box, used to define a *Maintenance and Rehabilitation Plan* module, is presented in figure 23.

You can change the name of the *Maintenance and Rehabilitation Plan* module by entering a new name in the *Name* input box. The name you enter will show up as the specification document name in the *Modules* tab of the *Database Control* dialog box.

<u>*Maintenance* Tab</u>

The *Maintenance* tab allows you to define the type, amount, and timing of routine maintenance activities used in the computation of LCC's. Three different types of maintenance activities may be considered: transverse joint sealing, longitudinal joint sealing, and transverse crack sealing. To select one or more of these maintenance activities for inclusion in the M&R plan, click on the activity's name or the corresponding check box.

The details of the routine maintenance plan are determined by defining how often the sealing crew will go to the field and what percentage of joints or cracks will be sealed each time they go to the field. For example, if the agency typically seals 100
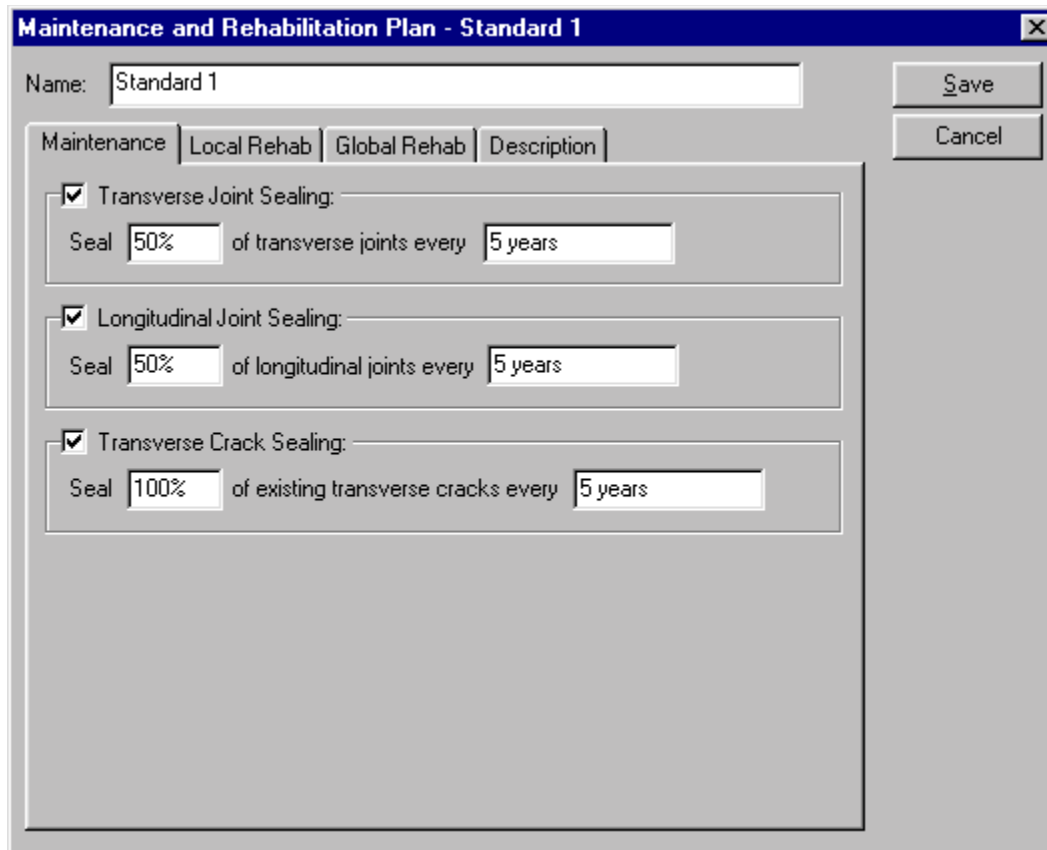
Figure 23. *Maintenance* tab in the *Maintenance and Rehabilitation Plan Module* dialog box.

percent of transverse joints every 3 years on a repetitive schedule, the transverse joint sealing sentence should read "Seal 100% of transverse joints every 3 years." You should define each of these descriptive sentences carefully to match the routine maintenance methods actually used by your agency.

<u>*Local Rehab* Tab</u>

The *Local Rehab* tab (displayed in figure 24) allows you to define the localized rehabilitation plan in terms of a step-by-step prioritized procedure. Specifically, you can:

- Specify and prioritize the types of localized rehabilitation to be applied in response to the predicted pavement performance.

- Specify the trigger values used to determine when each rehabilitation activity is to be applied.

- Define the conditions that trigger the first application of a global rehabilitation.

The complete list of localized rehabilitation steps is organized into a prioritized list in the main scroll box of this data entry screen.
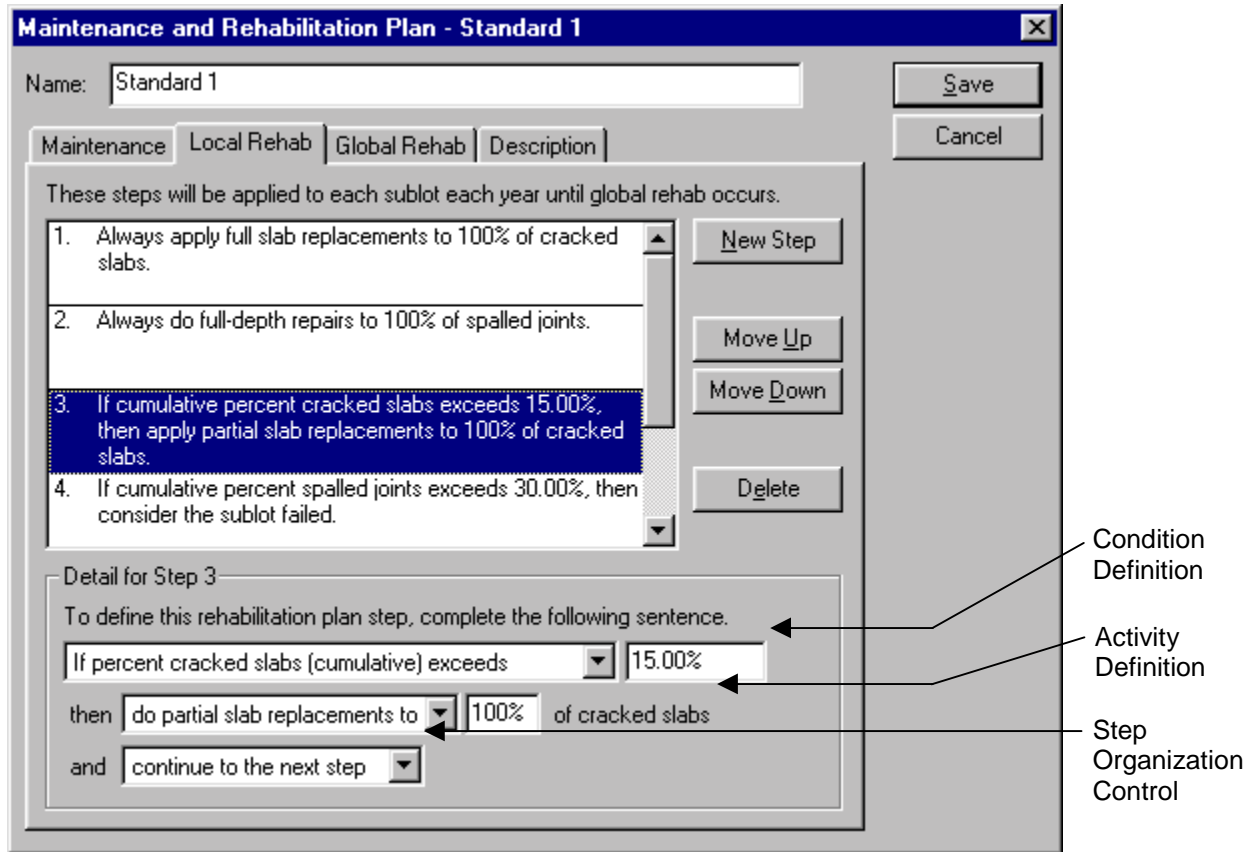
Figure 24. *Local Rehab* tab in the *Maintenance and Rehabilitation Plan* dialog box.

To create a new step in the prioritized list, first select the step in the list that you would like the new step to follow. Next, click on the `New Step` button. To change the order of the steps at any time, use the `Move Up` and `Move Down` buttons. To delete a step from the list, highlight it and click on the `Delete` button.

Condition Definition of a Localized Rehabilitation Step

The details making up each step in the prioritized list are defined using the input fields grouped at the bottom of the data entry screen. When an existing step is selected, the input settings making up the step description are defined by making changes in these input fields. Each step description is developed in the form of an *If…then* statement (i.e., if a certain pavement condition is present, then do activity X).

The first of the three lines of inputs (the *Condition Definition* line, as shown in figure 24) is used to define a specific pavement condition. The first list box on the *Condition*

Definition line allows you to select a pavement performance-related *condition* to which an action is to be applied. The list is mostly made up of predetermined "If" statements; however, you can also select to apply rehabilitation activities every year by selecting

Always from the list, or at constant intervals (e.g., every 2 years) by selecting *Every* from this list. The different mechanisms available for determining when localized rehabilitation is applied are described below.

> *Applied at regular time intervals*—If the agency is confident that it will apply a certain type of localized rehabilitation activity at regular time intervals over the life of a pavement, then select *Every* from the condition list. The second box in the *Condition Definition* line then becomes the input box for the specific time interval. For example, the *Condition Definition* line could read *Every 3 years.*

> *Based on individual sublot performance conditions*—Using the PRS approach, the performance of each sublot is expressed in terms of predicted distress indicators. It is recommended that the timing of the first global rehabilitation for a lot be based on the percentage of sublots determined to be failed.[1] It is recommended that global rehabilitation is triggered when 10 to 30 percent of the sublots have "failed." This will cause the variation of the AQC's to have a significant impact.

> One method for determining if a particular sublot is failed is by comparing the predicted distress indicator levels with user-defined trigger values. The *Condition Definition* list box contains the following seven sublot pavement performance conditions to which defined trigger six may be applied:

> - If percent cracked slabs (cumulative) exceeds…. This condition triggers on the cumulative percentage of cracked slabs (both fixed and unfixed).

> - If percent cracked slabs (unfixed) exceeds…. This condition triggers on only the unfixed percentage of cracked slabs (i.e., cumulative percentage of cracked slabs minus the cumulative amount already fixed).

> - If average transverse joint faulting exceeds….

> - If percent spalled joints (cumulative) exceeds…. This condition triggers on the cumulative percentage of spalled joints (both fixed and unfixed).

> - If percent spalled joints (unfixed) exceeds…. Triggers on only the unfixed percentage of spalled joints (i.e., cumulative percentage of spalled joints minus the cumulative amount already fixed).

> - If IRI is greater than….

If any of these seven items is selected, the user then enters the corresponding trigger value in the second *Condition Definition* input box. The appropriate units for the corresponding trigger values are the following:

- Percent cracked slabs—Default unit for this trigger value is "%."

- Average transverse joint faulting—Acceptable metric abbreviations include "cm" and the default units of "mm," with the default English values in terms of "in."

- Percent spalled joints—Default unit for this trigger value is "%."

- IRI—Metric values are expressed in terms of "mm/km," while English values are in terms of "in/mi."

Based on the cumulative amount of applied localized rehabilitation for an individual sublot— An individual sublot may also be considered failed if certain amounts of repairs (localized rehabilitation) have been applied (e.g., the sublot is considered failed if 35 percent of the total slabs have been replaced). The *Condition Definition* list box contains the following four sublot cumulative localized rehabilitation conditions to which defined trigger values may be applied:

- If repaired joints per mile exceeds….
- If percent of repaired joints exceeds….
- If repaired slabs per mile exceeds….
- If percent of repaired slabs exceeds….

If any of these four items is selected, the second *Condition Definition* input box becomes the input box for the corresponding trigger value. The appropriate units for the corresponding trigger values are the following:

- Repaired joints per mile—This indicator is expressed as a number with no dimensions.

- Percent of repaired joints—Default unit for this trigger value is "%".

- Repaired slabs per mile—This indicator is expressed as a number with no dimensions.

- Percent of repaired slabs—Default unit for this trigger value is "%".

*Based on the lot average of sublot performance conditions—*If you do not want to use the percentage of sublots failed approach for determining the timing of the first global rehabilitation application, you can choose to base this event on the average of the yearly predicted sublot distresses. In other words, at each year of

the analysis life, the individual sublot distresses are computed and then averaged for the entire lot. These lot averages of yearly sublot distresses are then compared with user-defined trigger values to determine the timing of the first global rehabilitation application. The *Condition Definition* list box contains the following lot average conditions to which defined trigger values may be applied:

- If lot average percent cracked slabs exceeds….
- If lot average transverse joint faulting exceeds….
- If lot average percent spalled joints exceeds….
- If lot average IRI is greater than….

If any of these items is selected, the second *Condition Definition* input box becomes the input box for the corresponding trigger value. The appropriate units for the corresponding trigger values are the following:

- Lot average percent cracked slabs—Default unit for this trigger value is "%".

- Lot average transverse joint faulting—Acceptable metric abbreviations include "cm" and the default units of "mm," whereas English values are expressed in terms of "in."

- Lot average percent spalled joints—Default unit for this trigger value is "%."

- Lot average IRI—Metric values are expressed in terms of "mm/km," while English values are in terms of "in/mi."

The last input in the *Condition Definition* list box is *If percent sublots failed exceeds….* This allows you to use the percent sublots failed (PSF) condition that will trigger the first application of a global rehabilitation. If this item is selected, the user then enters the corresponding trigger value in the second condition definition input box. The PSF trigger value is expressed in units of "%."

Activity Definition of a Localized Rehabilitation Step

Once a specific condition is defined, you must determine what type of activity to apply in response to it. The second line of input fields in the *Localized Rehab* data entry tab (referred to as the *Activity Definition* line, as shown in figure 24) is used to define this responsive activity. The available activity items are described below.

Do nothing—You have the option to select *Do no rehab for this step* from the activity list. If this item is selected, the remaining input boxes making up the *Activity Definition* line disappear.

Apply localized rehabilitation in response to individual sublot performance conditions—If you have selected a condition item that defines a trigger on an individual sublot performance condition (e.g., If percent cracked slabs exceeds 10%), then the following localized rehabilitation-responsive activities are available:

- Do partial slab replacements to….
- Do full slab replacements to….
- Do full-depth repairs to….
- Do partial-depth repairs to….

If any of these four items is selected in the activity input list box, the second input box will allow you to input a percentage of the cracked slabs or spalled joints that will be replaced during the year. Those cracked slabs or spalled joints that are not fixed during a particular year are carried over to the next year.

Note: The localized rehabilitation activities are limited to repairing cracked slabs (transverse slab cracking) or spalled joints (transverse joint spalling). The effects of transverse joint faulting and pavement smoothness (IRI) are addressed with global rehabilitation.

Designate the sublot as failed—If the PSF method is being used to determine the timing of the first global rehabilitation application, you need a method to designate the sublot as failed. Therefore, in response to a defined set of individual sublot performance conditions, or cumulative applied localized rehabilitation, you can choose the *consider the sublot failed* activity item.

Apply a global rehabilitation scenario—You may choose to apply a global rehabilitation in response to any of the available condition types. The activity list contains three predefined global rehabilitation scenarios (these will be discussed under the explanation of the *Global Rehab* tab). These correspond to the following three choices contained in the activity input list:

- Begin global rehab scenario 1.
- Begin global rehab scenario 2.
- Begin global rehab scenario 3.

Step Organization Control

The third line of input fields in the *Localized Rehab* data entry tab (referred to as the *Step Organization Control* input, as shown in figure 24) provides some additional control for determining the behavior of the prioritized list. This list box contains the following three inputs:

- Continue to the next step.

- Jump to step number.
- STOP for this year.

These determine what action is to be taken after the defined activity of a step is applied. The default value for this input list box is *Continue to the next step*; however, the other two options become very useful when organizing a complicated prioritized list.

<u>*Global Rehab* Tab</u>

The *Global Rehab* tab allows you to define up to three different global rehabilitation scenarios. Each scenario includes the localized rehabilitation to be completed before the first global rehabilitation application, as well as details of how global rehabilitations are to be applied over the analysis period. An example of the *Global Rehab* tab is displayed in figure 25.

Figure 25. *Global Rehab* tab in the *Maintenance and Rehabilitation Plan* dialog box.

The *Global Rehab* tab contains buttons that allow you to define up to three different global rehabilitation scenarios. (Note: The input fields are identical within each of the three scenario data entry screens.)

On the *Global Rehab* screen, the first area (titled *Prior to First Global Rehabilitation Application*) allows you to define the types and amount of localized rehabilitation to be completed prior to applying the first global rehabilitation. The localized rehabilitation is limited to repairing transverse joints (from transverse joint spalling) or repairing cracked slabs (from transverse slab cracking). You may first select which of these localized rehabilitation types to apply (if any) by clicking on the corresponding check box. If a localized rehabilitation type is selected for inclusion, you must enter the percentage (between 0 and 100 percent) of spalled joints or cracked slabs you wish to repair, then select the method to be used to repair them.

The second area on this screen (titled *Global Rehabilitation Sequence*) is used to define the details of the global rehabilitation schedule making up the scenario. The scenario allows you to define different global rehabilitations up until the fourth application. For example, you could choose to apply diamond grinding for the first two scheduled global rehabilitations and asphalt overlays for all subsequent applications. You must also enter an assumed life for each chosen global rehabilitation (i.e., number of years until next global rehabilitation is applied), as well as an assumed smoothness value in terms of IRI at the start and end of the global rehabilitation's life. The smoothness during the defined rehabilitation life is assumed to decrease linearly from the chosen starting smoothness value to the chosen ending smoothness value.

Description Tab

The *Description* tab contains a text box in which you may enter any detailed text describing the defined *Maintenance and Rehabilitation Plan* module. Information entered in this tab is not used in the simulation process, so it is completely optional. A blank *Description* tab is illustrated in figure 26.
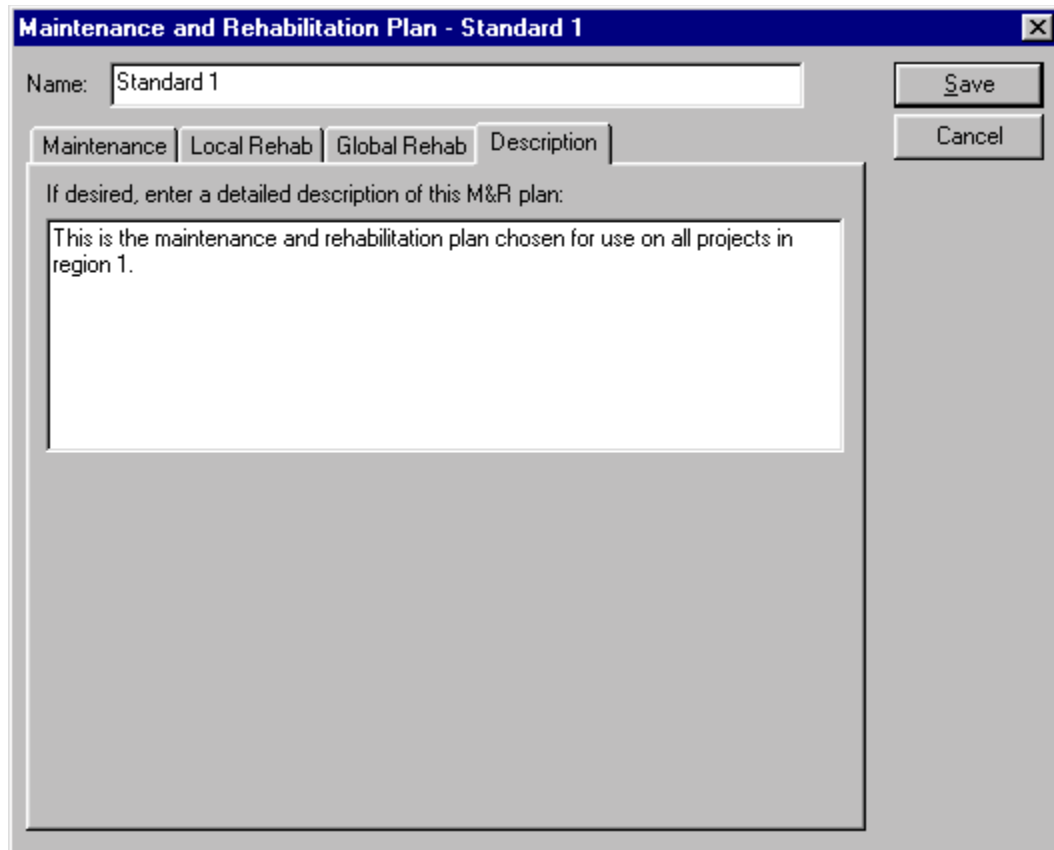
Figure 26. *Description* tab in the *Maintenance and Rehabilitation Plan* dialog box.

Saving or Exiting the Maintenance and Rehabilitation Plan Module Dialog Box

Once you are finished defining a *Maintenance and Rehabilitation Plan* module, click on the [Save] button to save your named module. If you would like to exit the *Maintenance and Rehabilitation Plan* dialog box without saving your changes, click on the [Cancel] button. Clicking either button will return you to the *Life-Cycle Cost-Related Modules* dialog box.

Unit Costs Module

The *Unit Costs* dialog box includes a *Name* input box and three tabs titled *Maintenance, Rehabilitation,* and *Other.* By default, the *Maintenance* tab is displayed first. An example of the dialog box used to define a *Unit Costs* module (with the default *Maintenance* tab displayed) is presented in figure 27.

Figure 27. *Maintenance* tab in the *Define Unit Costs* dialog box.

You may change the name of the *Unit Costs* module by entering a new name in the *Name* input box. The name you enter will show up as the specification document name in the *Modules* tab of the *Database Control* dialog box.

Maintenance Tab

The maintenance-related unit costs are defined in the *Maintenance* tab (shown in figure 27) of the *Define Unit Costs* module dialog box. For each listed maintenance activity, you must enter an appropriate unit cost in dollars and select the appropriate unit from the corresponding list box. Inputs are only required for those maintenance activities used in the defined M & R plan; those input fields not required are grayed.

Rehabilitation Tab

The localized and global rehabilitation-related unit costs are defined in the *Rehabilitation* tab. An example of the *Rehabilitation* tab is shown in figure 28. For each listed rehabilitation activity, you must input an appropriate unit cost in dollars and select the appropriate unit from the corresponding list box. Inputs are only required for those rehabilitation activities used in the defined M & R plan; those input fields not required are grayed.

Figure 28. *Rehabilitation* tab in the *Define Unit Costs* dialog box.

<u>*Other* Tab</u>

The *Other* tab contains miscellaneous unit cost-related items required to compute LCC's. An example of the *Other* tab is shown in figure 29.

Figure 29. *Other* tab in the *Define Unit Costs* dialog box.

Annual Inflation and Interest Rates

Two important LCC-related inputs on in this tab include the interest and inflation rates. These two values are used to calculate the discount rate used to determine present worth LCC's. The discount rate is estimated as the difference between the interest and inflation rates, representing the real value of money over time. This relationship is shown below in equation 3.

$$\text{DISCOUNT} = \text{INTEREST} - \text{INFLATION} \tag{3}$$

where:

DISCOUNT = Estimated discount rate, percent.
INTEREST = Estimated interest rate, percent.
INFLATION = Estimated inflation rate, percent.

The interest rate, often referred to as the *market* interest rate, is associated with the cost of borrowing money and represents the earning power of money.[11] The inflation rate is typically defined as the rate of increase in the prices of goods and services (construction of highways) and represents changes in the purchasing power of

money.[11] In 1997, FHWA recommended that LCC's should be calculated using "a reasonable discount rate that reflects historical trends over long periods of time."[11] Past research in the United States has revealed that the real long-term rate of return on capital (i.e., the discount rate) has generally been between 3 and 5 percent.[11,12] It is recommended that the agency select an appropriate discount rate value in this range.

Full- and Partial-Depth Repair Related Inputs

Three of the input boxes on the *Other* tab define the assumed widths used to determine the pavement area replaced with a partial- or full-depth repair. Specifically, the input boxes allow the user to define the *assumed width of a full-depth repair of a transverse joint*, *assumed width of a partial-depth repair of a transverse joint*, or *assumed width of a partial slab replacement*.

User Cost Related Inputs

The final inputs in the *Other* tab relate to the consideration of user costs in the life-cycle cost calculations. As described in a 1999 report by Hoerner and Darter, the concept of basing the contractor pay adjustment on estimated future costs incurred by pavement users has long been debated when discussing PRS.[1] User costs are defined as pavement condition-related costs incurred by the users of the facility over the chosen analysis period. In the current PRS approach, total annual user cost values are computed as the sum of the following four user cost types defined by McFarland and presented in a recent report discussing LCC's:[11,13]

- Travel-time costs—motorist delay costs spurred by detours, work zones, or closures associated with construction, rehabilitation, and maintenance activities. These costs can be a major portion of total user costs. Rougher pavements can reduce traffic speeds, representing another source of travel-time costs.

- Vehicle operating costs—costs associated with fuel and oil consumption, tire wear, emissions, maintenance and repair, and depreciation. Like travel-time costs, these costs make up a significant percentage of the total user costs.

- Accident costs—costs associated with accidents due to rough or slippery roads. The American Association of State Highway and Transportation Officials (AASHTO) has subdivided accident costs into fatal accidents, nonfatal accidents, and property damage.[6] These costs can be a significant portion of the total user costs; however, they are very difficult to estimate because the value of a human life and the cost of a debilitating injury are very controversial.

- Discomfort costs—costs associated with rough roads. This category is probably the most difficult to estimate and generally contributes little to total user costs in

North America, particularly in light of the smoother pavements required for heavily trafficked pavements.

Using user cost tables developed by McFarland, total annual user costs are computed as a function of road type (e.g., two-lane-undivided, four or more lanes-divided), yearly traffic, and level of smoothness.[13] Because the inclusion of user costs in the lot LCC's used to compute PRS pay adjustments continues to be a controversial issue, the current version of PaveSpec allows the user to include a *percentage* of the estimated total user costs over the chosen analysis period. This specified user cost percentage is defined as a number between 0 and 100 in the *user cost percentage to include* input box.
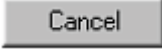
If the agency does not believe that any user costs should influence the pay factor, this percentage may be set to zero. However, if user costs are included, it is recommended that the agency include a specific percentage that results in pay factors with which the agency is comfortable. Typically, user cost percentages up to 5 percent have resulted in reasonable pay factors. Larger percentages result in pay adjustments that are quite high.

The second user cost related input box in the *Other* tab is the *year to use for user cost inflation.* This box should be set equal to the year in which the project being considered is to be built. The defined inflation rate is used to inflate McFarland's historical user cost tables to the year defined in this input box.

Detailed Description Box

The text box included in the *Other* tab allows you to enter text describing the defined *Unit Cost* module. This field is optional.

Saving or Exiting the *Define Unit Costs* Module Dialog Box

Once you are finished making changes or defining a *Unit Cost* module, click on the [Save] button to save your named module. If you would like to exit the *Unit Cost* dialog box without saving your changes, click on the [Cancel] button. Clicking either button will return you to the *Life-Cycle Cost-Related Modules* dialog box.

PAGE 8—SIMULATION CONTROL

Details regarding the simulation process are defined on page 8 of the *Specification Wizard.* The tab displayed when you first enter this page, titled *Generic Settings,* contains all of the simulation parameters that do not change between a Level 1 and Level 2 specification. The additional tabs depend on the AQC's you selected to include in the specification. Clicking on the appropriate AQC tab will bring up a data entry

screen used to define the Level 1 pay factor curves for that AQC. An example of the *Simulation Control* dialog box is presented in figure 30.
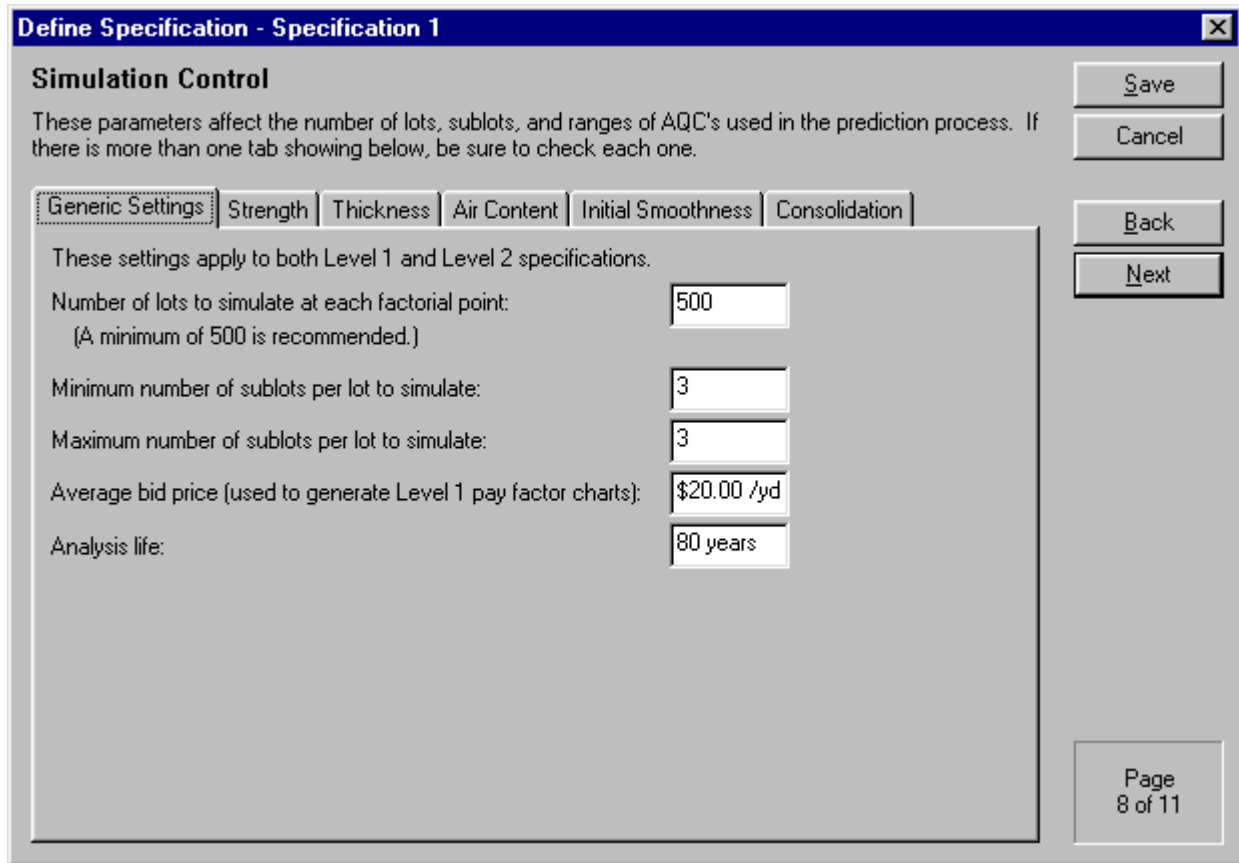
Figure 30. *Simulation Control* dialog box.

Generic Settings **Tab**

The *Generic Settings* tab (displayed in figure 30) is made up of five different inputs that define the simulation procedures used to develop Level 1 and Level 2 preconstruction output. First, you must define the number of lots used to simulate each factorial point (500 is recommended as a minimum). If this value is set at 500, it means that the as-designed LCC will be computed as the average of 500 simulated lot LCC's. For the Level 1 pay factor curves, each simulated point used to define each curve will also be based on the average of 500 simulated lot LCC's.

The second and third inputs in the *Generic Settings* tab define the minimum and maximum number of sublots per lot to be considered in the simulations. These inputs are required because an agency never knows ahead of time (i.e., before going out into the field) how many sublots will make up the next lot. Since the number of sublots per lot affects the computed pay factors, the program allows you to simulate the same specification for different numbers of expected sublots per lot. The minimum and

maximum sublots selected in these inputs define the range over which preconstruction output will be simulated. For example, if you select to simulate 1 to 4 sublots per lot, different Level 1 pay factor curves will be developed for the cases of 1, 2, 3, and 4 sublots. For the Level 2 specification, four different as-designed LCC's (representing 1, 2, 3, and 4 sublots) will be simulated.

The fourth input on this tab is the assumed contractor bid price used to compute the Level 1 pay factors. It is recommended that this assumed price be an average contractor bid price computed using historical agency bid price data. This input may be entered in metric units of "$/m²" or English units of "$/yd²."

Finally, the last input defines the analysis life used for computing LCC's. This is the period of time over which future M & R costs are to be considered in the LCC analysis.

AQC-Related Tabs

The tabs for the included AQC's are identical in layout and function. Each AQC-related tab is provided to define the Level 1 pay factor curves (for the specific AQC) that make up the Level 1 preconstruction output. An example of one of these tabs (*Strength*) is presented in figure 31.

Figure 31. Example of an AQC-related tab within the *Simulation Control* dialog box.

Each AQC-related tab is used to define a factorial design of combinations of AQC mean and standard deviation. The simulated pay factors are used to develop Level 1 pay factor curves. The AQC-related tab is divided into the following three areas:

- *Means*—Use these three input boxes to define the minimum and maximum mean values, as well as the total number of mean values to be considered in the factorial design. The total range identified by the selected minimum and maximum values is divided equally based on the total number of means being considered. (Note: The target mean will always be included as one of the factorial's means; therefore, it may be added as an extra mean value if needed.) The Level 1 target mean is displayed for your convenience.

  Standard Deviation (SD)—Use these three input boxes to define the minimum and maximum standard deviation values, as well as the total number of standard deviation values to be considered in the factorial design. A separate pay factor curve (and corresponding equation) will be developed for each chosen standard deviation value. Just as with the mean values, the total range identified by the selected minimum and maximum standard deviation values is divided equally based on the total number of standard deviations being considered. The target standard deviation will always be included as one of the factorial's standard deviations; therefore, it may be added as an extra standard deviation value if needed. The Level 1 target standard deviation is displayed for your convenience.

- *Preview*—The preview area shows a tabular interpretation of the factorial design created by your choices of means and standard deviations. A pay factor will be simulated for each combination of mean and standard deviation shown in this preview box. Any changes made in the *Means* and *Standard Deviation* areas will be reflected in the preview.

PAGE 9—BUILDING DOCUMENT AND PRECONSTRUCTION OUTPUT

The simulation of preconstruction output begins on page 9 of the *Specification Wizard*. The *Building Document and Preconstruction Output* dialog box is provided as a status window for this simulation process. An example of this dialog box is presented in figure 32.

This dialog box is divided into two parts. The first part contains a list of the different tasks being performed, including initializing (building) the specification output document, conducting the as-designed simulations, conducting the simulations defined in the AQC Level 1 factorials, and summarizing the simulated data. The percentage completed is displayed beside each task description.

An *Overall Completion Status* bar is also included at the bottom of the dialog box. This status bar shows the in-progress status of the number of lots and sublots being predicted (simulated). When complete, the visual status bar will be replaced with a
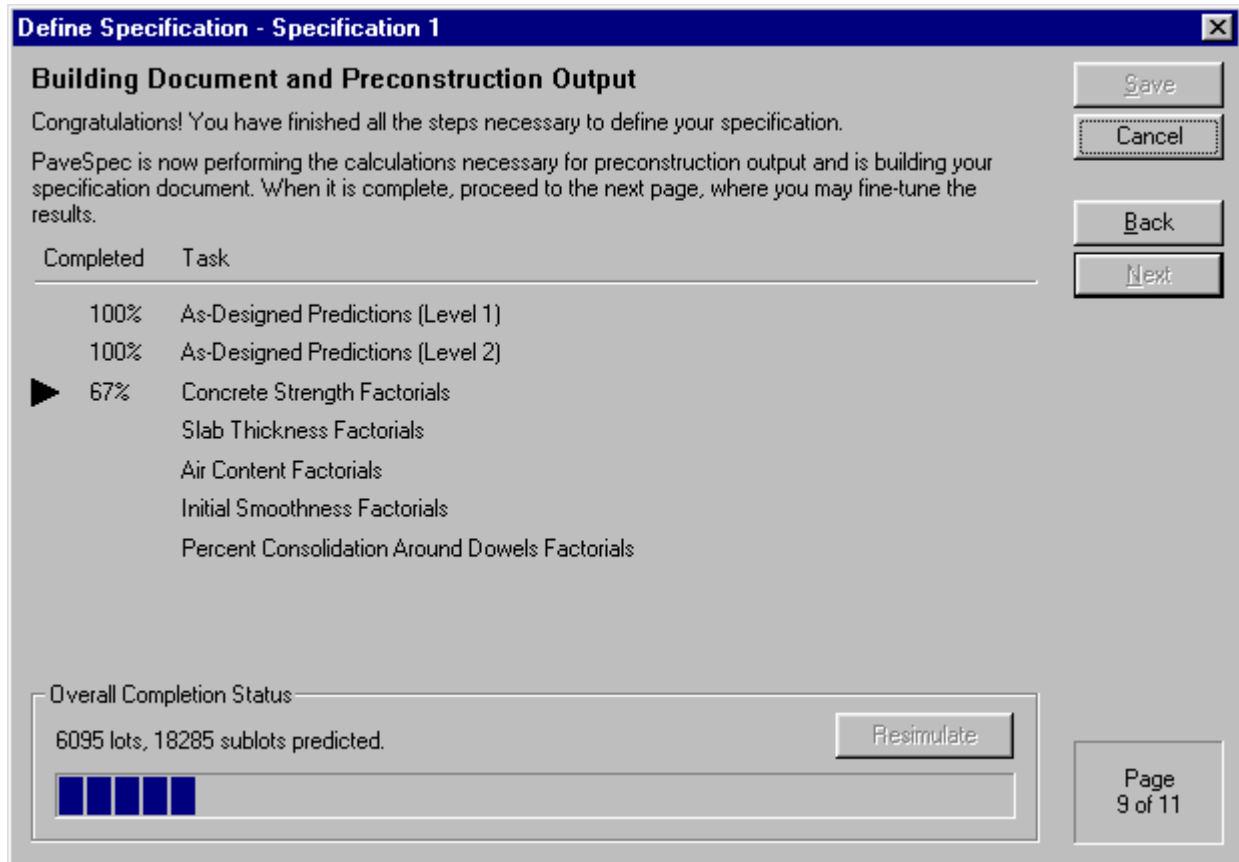
Figure 32. *Building Document and Preconstruction Output dialog box.*

message that states, *The document is up-to-date with your specification settings.* If changes are made in any previous step of the *Specification Wizard* after the simulation is complete, the specification document will be resimulated when you get to this page. In addition, you may manually resimulate the specification at any time by simply clicking on the [Resimulate] button.

PAGE 10—LEVEL 1 PRECONSTRUCTION OUTPUT CONTROL

After the specification has been simulated, the *Level 1 Preconstruction Output Control* dialog box allows you to specify the Level 1 regression equations fit through the simulated pay factor data. An example of this dialog box is presented in figure 33.

The *View equations for* list box contains a list of all the available simulated pay factor charts. Each chart represents the simulated data for the combination of one AQC and one number of sublots per lot. For example, if you selected all five AQC's for inclusion

in the specification, and you chose to simulate Level 1 preconstruction output for four different numbers of sublots per lot, then this list box will contain 5 * 4 = 20 Level 1 pay factor charts. You may view any pay factor chart by selecting it from the *View equations for* list box or by using the ![<<] and ![>>] buttons to scroll through the list.
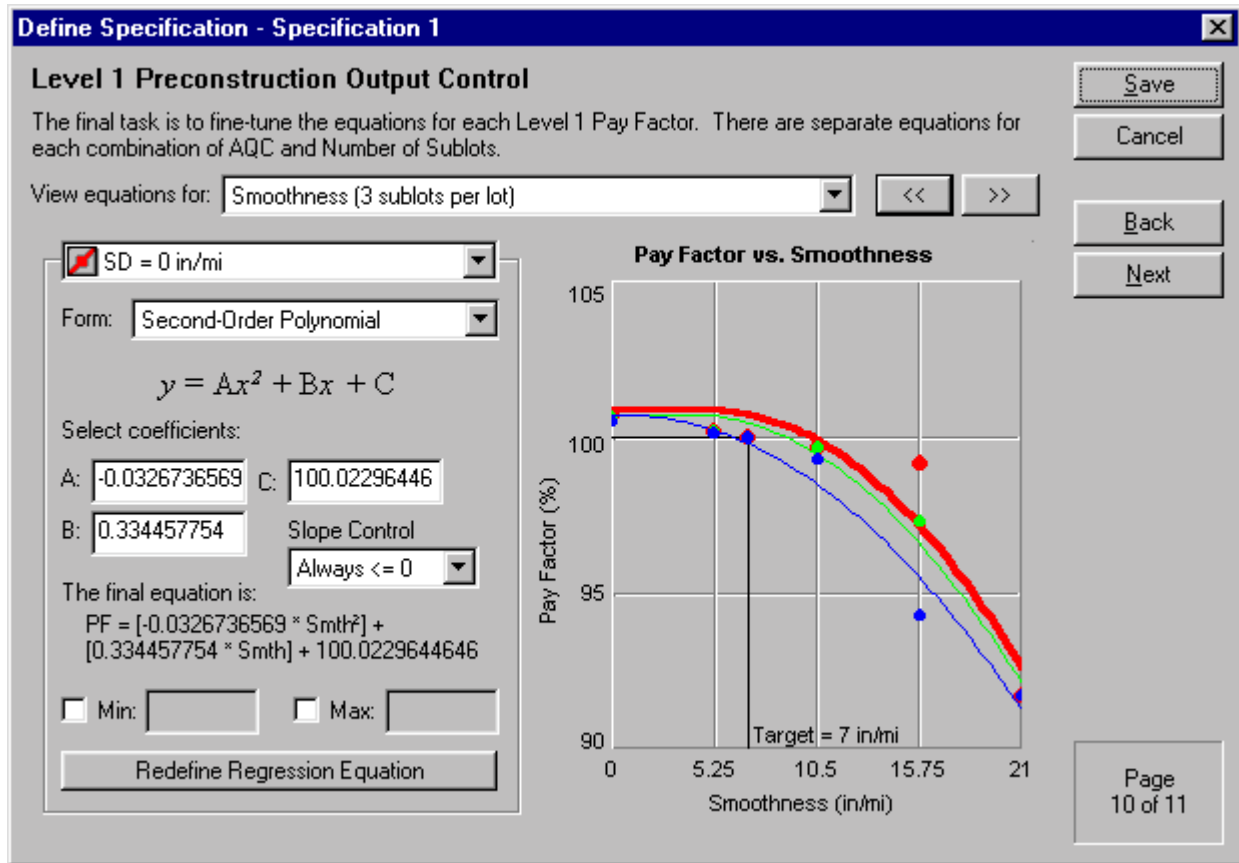
Figure 33. *Level 1 Preconstruction Output Control* dialog box.

Each pay factor chart contains simulated data making up the pay factor curves, and each pay factor curve is specific to one standard deviation. The area on the left side of the *Level 1 Preconstruction Output Control* dialog box contains a number of different input fields used to specify the pay factor curves and corresponding equations. You can select a particular pay factor curve within the selected pay factor chart using the list box below the *View equations for* box. This box contains a list of all available pay factor curves by AQC standard deviation. This list is also color-coded to match the curves in the displayed pay factor chart.

After you select a specific pay factor curve, you may use the remaining input fields to define the regression equation representing this curve. The first step is to select the regression equation *form* you would like to use. The program provides five different equation forms: linear, second-order polynomial, third-order polynomial, exponential,

and logarithmic. An example of the chosen equation form is displayed below the *Form* box.

By default, when you first select a different equation form, the displayed coefficients are those automatically determined by the program's regression analysis tool. The final equation (including coefficients) will be displayed at the bottom of the dialog box. You may also choose to change the equation coefficients. If you wish to reset the coefficients to those determined automatically by PaveSpec, simply click on the

Redefine Regression Equation button.

To avoid unwanted slope changes resulting from the determined regression equation, you may use select different options in the *Slope Control* list box. Selecting the *Always ≥ 0* option will ensure that the pay factor curve determined from regression will always have a slope greater than or equal to zero as AQC values increase. Conversely, selecting the *Always ≤ 0* option will ensure that the pay factor curve determined from regression will always have a slope less than or equal to zero as AQC values increased. Selecting the *As-Determined* option will keep the pay factor curve exactly as determined from the regression equation. PaveSpec will use the selection made when determining actual pay factors in the *Use Specification* part of the program.

Additional control over each defined pay factor equation is provided by the *Min* and *Max* input boxes. These inputs are used to apply selected minimums and maximums, respectively, to the current pay factor chart. To specify a minimum or maximum, simply check the appropriate check box and enter the chosen limit value. PaveSpec will use any selected pay factor minimums or maximums when determining actual pay factors in the *Use Specification* part of the program.

It is recommended that you view each pay factor curve independently to make sure you are content with the defined curve and corresponding equation. The Level 1 individual AQC pay factor equations defined in this dialog box will be used in the field to compute Level 1 individual AQC contractor pay factors.

PAGE 11—LEVEL 1 COMPOSITE PAY FACTOR EQUATION DEFINITION

To compute an overall Level 1 lot pay factor, a Level 1 composite pay factor equation needs to be defined as a function of the individual AQC Level 1 pay factors. This dialog box allows you to define the actual composite pay factor equation to be used in the computation of contractor pay factors. An example of this composite pay factor-related dialog box is presented in figure 34.

First, you must choose the composite pay factor equation form from the provided list box. Five different equation forms are provided: *Simple Average*, *Weighted Average*, *Product*, *Minimum*, and *Maximum*. If *Weighted Average* is chosen as the equation form, the individual weighting factors are entered in the provided input boxes. The final

defined Level 1 composite pay factor equation, used in the computation of actual contractor pay factors, is then displayed toward the bottom of this dialog box.

Figure 34. *Level 1 Composite Pay Factor Equation Definition* dialog box.

CHAPTER 4: DISTRESS INDICATOR MODEL MODIFICATION/CALIBRATION

PaveSpec 3.0 provides a user with two different methods for changing the default distress indicator models. The first method allows the user to *modify* a distress indicator model by changing any of its numerical coefficients (note: only the coefficients may be changed; the model form cannot be altered). The second method allows the user to *calibrate* a default model to a user-defined data set that reflects local conditions. This chapter describes all aspects of the model modification/calibration section of the program, including a description of the user interface and the specific procedures used to adjust distress indicator models.

GLOBAL MODEL DEFINITIONS

To view complete lists of all of the modified/calibrated models included in a given database, select *Models* from the *Edit* menu. This action will open the *Global Model Definitions* dialog box, an example of which is presented in figure 35.
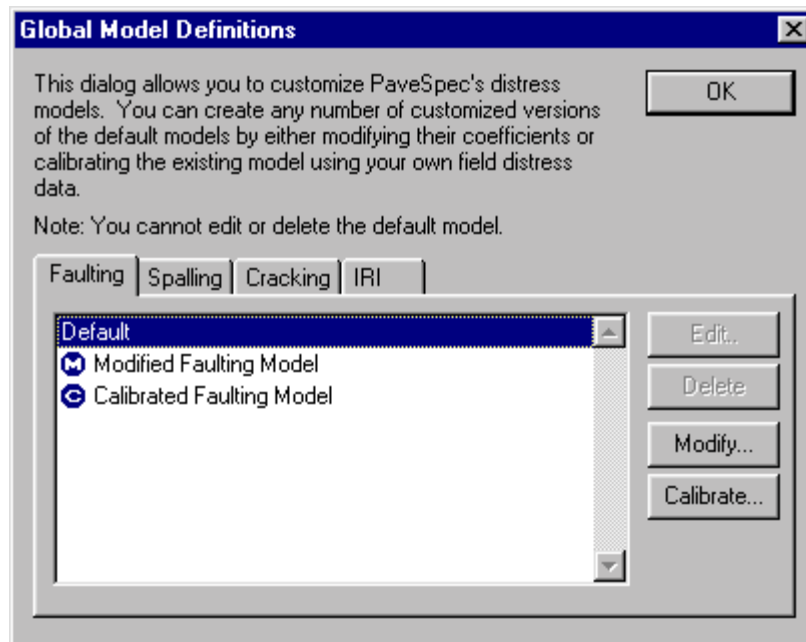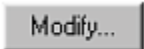
Figure 35. Example of the *Global Model Definitions* dialog box.

The *Global Model Definitions* dialog box is made up of four tabs, each associated with a different distress indicator model. Within each tab, a list of all of the available defined distress-specific models are displayed. (The list will always contain the *Default* model as this model cannot be edited or deleted.) Within each list of model definitions, a model that has been *modified* is indicated by an ⓜ next to the model definition name,

whereas a model that has been *calibrated* is indicated by a ⊙. The user may define and save as many different modified and calibrated model definitions as desired.

The buttons within the *Global Model Definitions* dialog box perform the following functions:

Edit..	Allows the user to edit the highlighted model definition.
Delete	Deletes the highlighted model definition.
Modify...	Starts the interface that allows the user to modify (change model coefficients) the highlighted model definition.
Calibrate...	Starts the interface that allows the user to calibrate the highlighted model definition (to a user-defined data set).

SELECTING MODEL DEFINITIONS TO BE USED IN THE DEVELOPMENT OF A GIVEN SPECIFICATION

When developing a specification, the user must indicate which model definitions are to be used when predicting pavement performance. The chosen model definitions can greatly affect many aspects of the developed specification, including the pay factor charts. To view the currently selected model definitions, click on the [Models..] button in the *Definition of Pavement Performance* dialog box (page 4 of the *Specification Wizard).* This action will open the *Specification Specific Model Definitions* dialog box, an example of which is presented as figure 36.
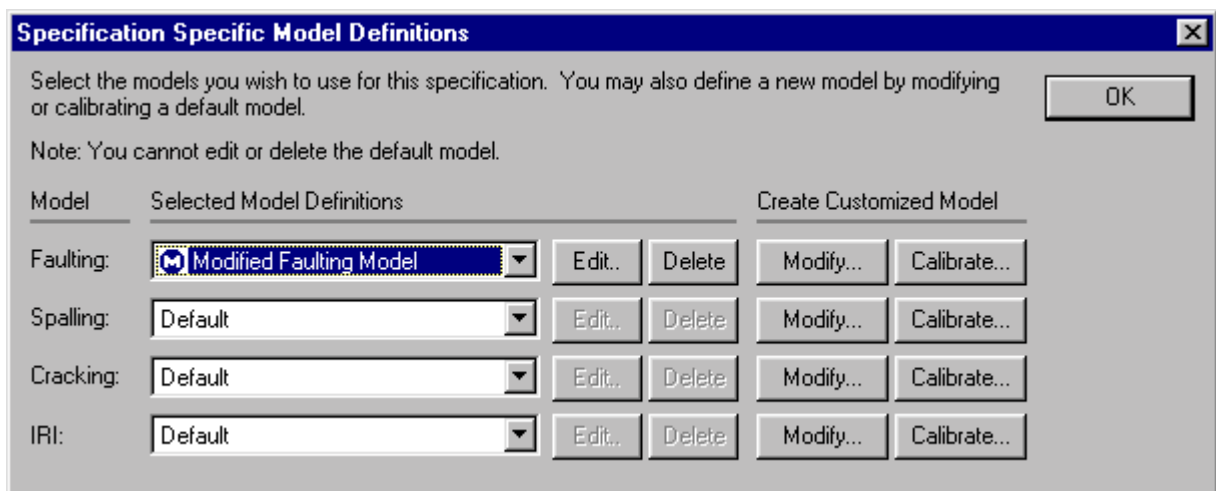
Figure 36. Example of the *Specification Specific Model Definitions* dialog box.

The *Specification Specific Model Definitions* dialog box shows all of the model definitions that are currently selected for use in the development of the specification. To use a different previously defined model definition, simply click on the appropriate

list box and select the desired name from the list. The selected model definition name will then be displayed next to the associated model type. This dialog box also includes the same edit, delete, and model customization buttons that are provided in the *Global Model Definitions* dialog box.

PROCEDURE FOR MODIFYING A MODEL

To modify a model from the *Global Model Definitions* dialog box, highlight the name of the model definition you want to modify and click on the [Modify...] button. To modify a model from the *Specification Specific Model Definitions* dialog box, simply click on the [Modify...] button associated with the model definition you wish to modify. Either action will open a dialog box that will allow you to change any numerical coefficients associated with the selected model type. The details of these model modification procedures differ with distress indicator type. The different user interfaces associated with modifying each of the four distress indicator model types are discussed separately below.

Modifying the Transverse Joint Faulting Model

Choosing to modify the transverse joint faulting model will open the *Modify Faulting Model* dialog box, shown in figure 37.
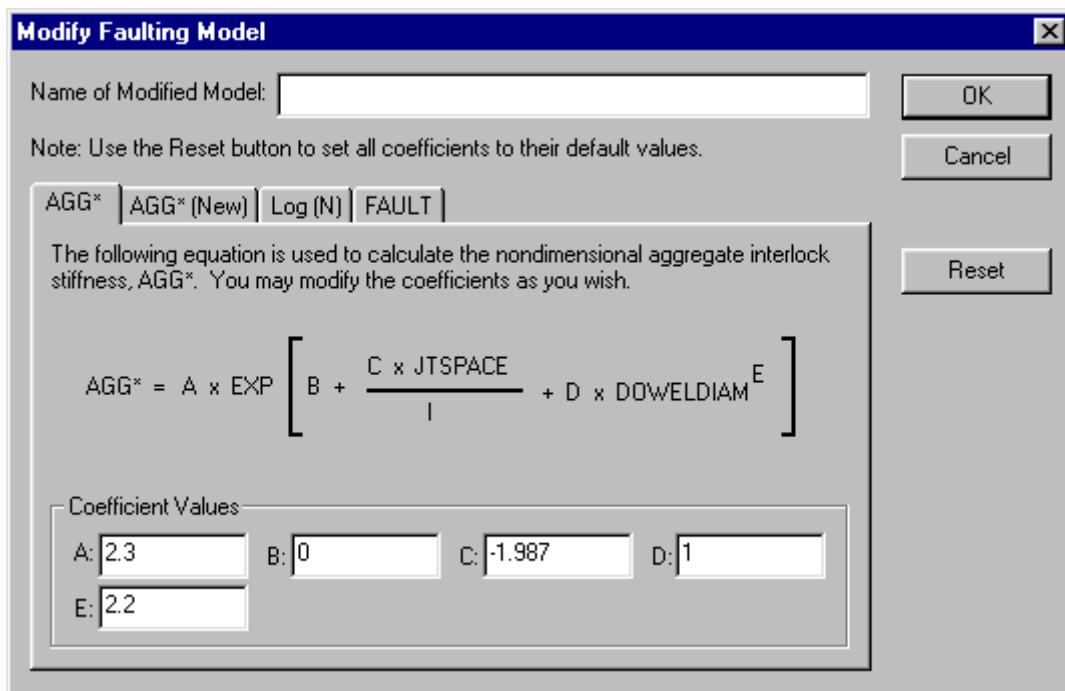
Figure 37. Example of the *Modify Faulting Model* dialog box.

Computing transverse joint faulting using the given model is a complex multi-step procedure. However, only four of the many equations making up the transverse joint faulting computational procedure can be altered by changing equation coefficients. Details of these four equations are presented in table 6 and include a general description of the equation, the equation's functional form, and a summary of the default coefficients. For reference, table 7 includes definitions of the other variables included in the four equations. A complete explanation of all of the detailed steps making up the transverse joint faulting model computational procedure is contained in chapter 4 of Volume I.[9]

The four tabs of the *Modify Faulting Model* dialog box contain groups of input boxes for the coefficients associated with the respective modifiable equations in the transverse joint faulting computational procedure. To change any available equation coefficient, simply change the numerical value in the appropriate input box. Use the information included in tables 6 and 7 to identify the appropriate input boxes.

After coefficient changes have been made, to name the current set of model coefficients, type the desired model definition name in the *Name of Modified Model* input box. To change all of the coefficients back to the default values, click on the Reset button. To save the current modified model definition, click on the OK button. To exit this dialog box without saving the current coefficient changes, click the Cancel button.

Modifying the Transverse Joint Spalling Model

Choosing to modify the transverse joint spalling model will open the *Modify Spalling Model* dialog box (see figure 38).

Computing transverse joint spalling involves a two-step procedure. The first step requires the computation of the site factor (SF) coefficient that represents the given project. Second, the SF coefficient is used in the final spalling model in which the cumulative spalling is predicted in terms of the percentage of medium- and high-severity spalled joints. Both of these equations are expressed visually in the *Modify Spalling Model* dialog box. Table 8 includes definitions of the variables included in the spalling equations. A detailed explanation of the transverse joint spalling model is contained in chapter 6 of Volume I.[9]
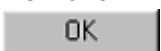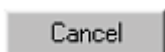
To change any available equation coefficient, simply change the numerical value in the appropriate input box. After coefficient changes have been made, to name the current set of model coefficients, type the desired model definition name in the *Name of Modified Model* input box. To change all of the coefficients back to the default values, click on the Reset button. To save the current modified model definition, click on the OK button. To exit this dialog box without saving the current coefficient changes, click the Cancel button.

Table 6. Explanation of equations in the transverse joint faulting model procedure that may be modified.

User Interface Tab Name	Model Step Description	Model Procedure Step	Model Form	Default Coefficients
AGG*	Nondimensional aggregate interlock stiffness, *AGG**	Step 2a	$AGG^* = \mathbf{A} * \mathbf{EXP}\left(\mathbf{B} + \dfrac{\mathbf{C} * JTSPACE}{l} + \mathbf{D} * DOWELDIAM^{\mathbf{E}}\right)$ Note that "EXP(number)" function returns "e" (the base of the natural logarithm) raised to the power of the number in parentheses.	A = 2.3 B = 0 C = –1.987 D = 1 E = 2.2
AGG* (New)	Relationship used to adjust AGG* to account for the effects of percent consolidation. If percent consolidation is included, the *AGG*(New)* equation (at right) is valid; else, *AGG*(New) = AGG** (computed in step 2a).	Step 2b	$AGG*(New) = 10^{[\log(AGG^*) + \mathbf{A}(\%CON - 100)]}$	A = 0.27
Log(N)	Equation used to predict the allowable number of ESAL applications (N).	Step 4	$Log(N) = \mathbf{A} - Log(EROD) + \mathbf{B} * \left(\dfrac{\mathbf{C} + \mathbf{D} * PERM *}{(1 - DOWEL)}\right) *$ $Log\left[DE * \left(\dfrac{\mathbf{E} + \mathbf{F} * DOWELDIA + \mathbf{G} *}{DOWELDIA^2}\right)\right]$	A = 0.785983 B = –0.92991 C = 1 D = 0.40 E = 1 F = –1.432 G = 0.513
FAULT	Final faulting equation (used to compute actual faulting values for both the as-designed and as-constructed cases).	Step 5	$FAULT = DAMAGE^{\mathbf{A}} * [\mathbf{B} + \mathbf{C} * Days90 + \mathbf{D} * PRECIP]$	A = 0.275 B = 0.1741 C = –0.0009911 D = 0.001082

Note: The displayed "Model Procedure Step" refers to the specific step of the procedure outlined in chapter 4 of Volume I.[9]

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Table 7. Transverse joint faulting model variables.

Variable Symbol	Variable Explanation
*AGG**	Nondimensional aggregate interlock stiffness.
AGG(New)*	Nondimensional aggregate interlock stiffness adjusted for the effects of percent consolidation.
DAMAGE	*n/N*
Days90	Number of days per year with the maximum temperature greater than 90°F (32°C).
DE	Computed differential energy density, lbf ∕ in.
DOWEL	Presence of dowel bars (0 if no dowels, 1 if dowels are present).
DOWELDIA	Dowel diameter, in.
EROD	Base erodibility factor (number between 0.5 and 7.5).
FAULT	Average transverse joint faulting in JPCP, in.
JTSPACE	Slab length (transverse joint spacing), ft.
l	Radius of relative stiffness, in.
n	Actual number of applied cumulative ESAL's, millions.
Log(N)	Log of allowable number of applied cumulative ESAL's, millions.
%CON	Percent consolidation around dowels, % (number between 0 and 100).
PERM	Base permeability (0 if not permeable, 1 if permeable).
PRECIP	Average annual precipitation, in.

Figure 38. Example of the *Modify Spalling Model* dialog box.

Table 8. Transverse joint spalling model variables.

Variable Symbol	Variable Explanation
AGE	Pavement age, years.
AIR%	PCC air content, percent (expressed as a value between 0 and 100).
SF	Computed site factor coefficient that reflects many project specific variables.
f'c	28-day compressive strength, psi.
FTCYC	Average annual number of air freeze-thaw cycles.
h_PCC	PCC slab thickness, in.
%SPALLED	Percentage of medium- and high-severity spalled joints (expressed as a value between 0 and 100).
PREFORM	Presence of a preformed joint seal (1 if preformed seal is present, 0 if other sealant type or no sealant is present).
WC_Ratio	Water/cement ratio for the PCC mix.

Modifying the Transverse Slab Cracking Model

Choosing to modify the transverse slab cracking model will open the *Modify Cracking Model* dialog box. An example of the *Modify Cracking Model* dialog box is shown in figure 39.

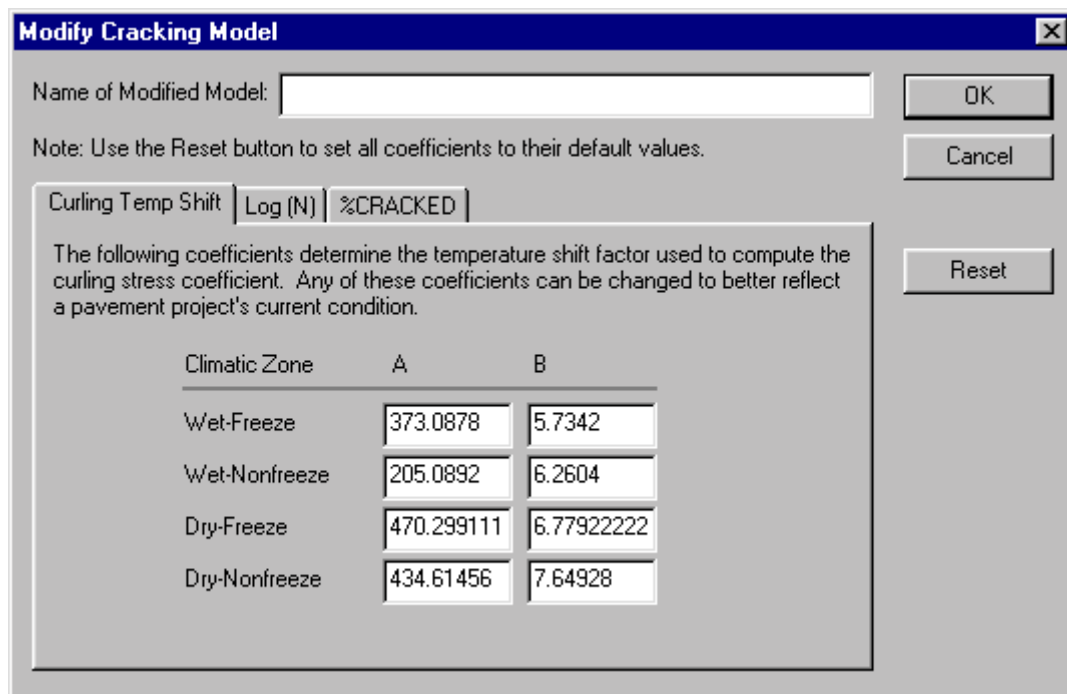Figure 39. Example of the *Modify Cracking Model* dialog box.

The overall transverse joint cracking model consists of a complex multi-step procedure. Only three of the many equations making up this procedure can be altered by changing equation coefficients. The three tabs included in the *Modify Cracking Model* dialog box are respectively dedicated to these models. Details of these equations are

presented in table 9 and include a general description of the equation, the equation's functional form, and a summary of the default coefficients. For reference, table 10 includes definitions of the other variables included in the three equations. A complete explanation of all of the detailed steps making up the transverse joint cracking model computational procedure is contained in chapter 5 of Volume I.[9]

The three equation specific tabs in the *Modify Cracking Model* dialog box contain groups of input boxes for the coefficients associated with the respective modifiable equations in the transverse cracking computational procedure. To change any available equation coefficient, simply change the numerical value in the appropriate input box. Use the information included in tables 9 and 10 to identify the appropriate input boxes.

After coefficient changes have been made, to name the current set of model coefficients, type the desired model definition name in the *Name of Modified Model* input box. To change all of the coefficients back to the default values, click on the [Reset] button. To save the current modified model definition, click on the [OK] button. To exit this dialog box without saving the current coefficient changes, click the [Cancel] button.

Modifying the International Roughness Index (IRI) Model

Choosing to modify the IRI model will open the *Modify IRI Model* dialog box. An example of this dialog box is shown in figure 40.

IRI is computed using a relatively simple equation that is mainly a function of other distress indicators. This equation is expressed visually in the *Modify IRI Model* dialog box. Note that the "INT(number)" function returns the integer portion of the computed number in parentheses. Table 11 includes definitions of the variables included in the IRI equation. A detailed explanation of the IRI model is contained in chapter 7 of Volume I.[9] Note that the inputs required by the IRI model are expressed in metric units.
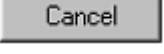
To change any model coefficient, simply change the numerical value in the appropriate input box. After coefficient changes have been made, to name the current set of model coefficients, type the desired model definition name in the *Name of Modified Model* input box. To change all of the coefficients back to the default values, click on the [Reset] button. To save the current modified model definition, click on the [OK] button. To exit this dialog box without saving the current coefficient changes, click the [Cancel] button.

Table 9. Explanation of equations in the transverse cracking model procedure that may be modified.

User Interface Tab Name	Model Step Description	Model Procedure Step	Model Form	Default Coefficients
Curling Temp Shift	Table of coefficients associated with determining the temperature shift factor used to compute the curling stress coefficient.	Step 3.2	**Climatic Zone** **A** **B** Wet-Freeze 373.0878 5.7342 Wet-Nonfreeze 205.0892 6.2604 Dry-Freeze 470.2991 6.7792 Dry-Nonfreeze 434.6146 7.6493 Any of these coefficients can be changed to better reflect a pavement project's current conditions. Refer to chapter 5 of Volume I for more details regarding this model.[9]	
Log(N)	Equation used to predict the allowable load repetitions (N).	Step 5	$Log(\,N\,) = \mathbf{A} * \left(\dfrac{STRESS\_COMB}{MR} \right)^{\mathbf{B}}$	A = 2.13 B = −1.2
%CRACKED	Final cracking equation (used to compute actual cracking values for both the as-designed and as-constructed cases).	—	$\%CRACKED = \dfrac{100}{1 + \mathbf{A} * FD^{\mathbf{B}}}$	A = 1.16 B = −1.3

Note: The displayed "Model Procedure Step" refers to the specific step of the procedure outlined in chapter 5 of Volume I.[9]

Table 10. Transverse cracking model variables.

Variable Symbol	Variable Explanation
Log(N)	Log of allowable number of applied cumulative ESAL's, millions.
STRESS_COMB	Combined load and temperature stresses (adjusted for the presence of the base layer).
MR	PCC modulus of rupture, psi.
FD	Cumulative fatigue damage.
%CRACKED	Percentage of cracked slabs (expressed as a value between 0 and 100).
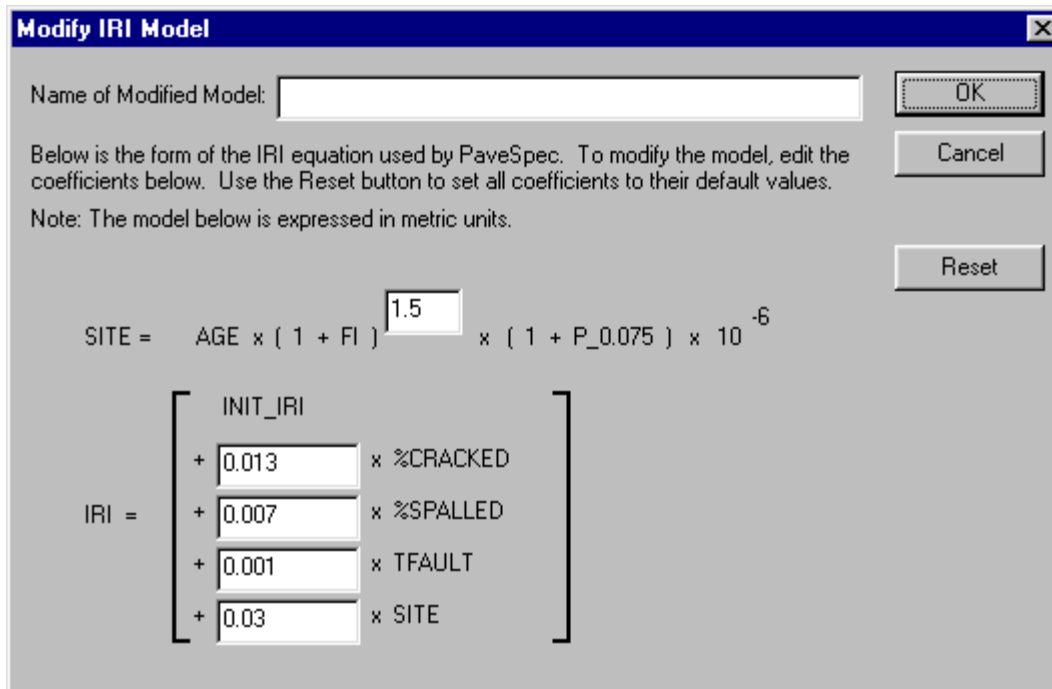
Figure 40. Example of the *Modify IRI Model* dialog box.

Table 11. IRI model variables.

Variable Symbol	Variable Explanation
AGE	Pavement age, years.
TFAULT	Total joint faulting cumulated per km, mm.
FI	Freezing index, °C-days.
INIT_IRI	Initial IRI (before the pavement is opened to traffic), m/km.
IRI	International roughness index, m/km.
%CRACKED	Percentage of cracked slabs (expressed as a value between 0 and 100).
%SPALLED	Percentage of medium- and high-severity spalled joints (expressed as a value between 0 and 100).
P_0.075	Percent subgrade material passing the 0.075-mm (#200) sieve (expressed as a value between 0 and 100).
SITE	Computed site factor coefficient that reflects many project-specific variables.

PROCEDURE FOR CALIBRATING A MODEL

To calibrate a model from the *Global Model Definitions* dialog box, highlight the name of the model definition you want to modify and click on the [Calibrate...] button. To calibrate a model from the *Specification Specific Model Definitions* dialog box, simply click on the [Calibrate...] button associated with the model definition you wish to calibrate. Either action will open a distress-specific model calibration dialog box that will allow you to calibrate the selected model type. The function of these calibration dialog boxes

is similar for all distress types. An example of the *Calibrate Faulting Model* dialog box is presented in figure 41.
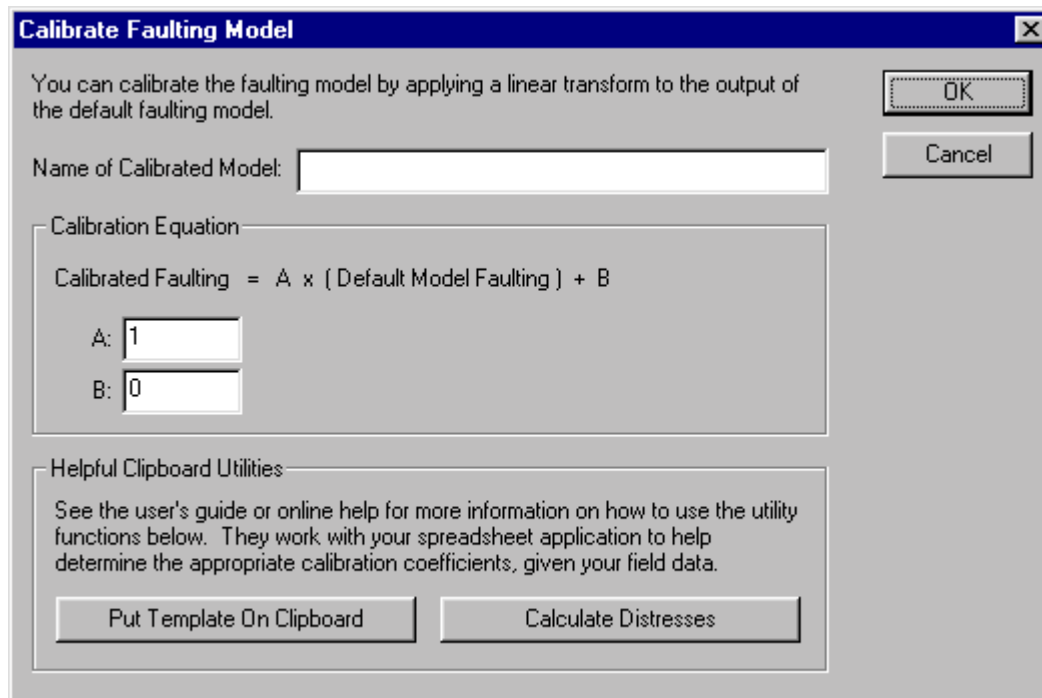
Figure 41. Example of the *Calibrate Faulting Model* dialog box.

To calibrate an existing distress indicator model, the user must complete a general three-step procedure to determine the appropriate *calibration coefficients* required in the *calibration equation*. Each step of this procedure is briefly described in this section. Where appropriate, the details of how to effectively use PaveSpec to aid in completing each step are explained. More details on the theory behind the calibration procedure are contained in chapter 9 of Volume I.[9]

Step 1: Compile Model Calibration Data Set

The calibration data set should contain *actual* measured distress indicator values (at different points in time), as well as any related pavement design, climatic, and traffic model inputs that are required by the distress model being calibrated. PaveSpec provides a template that can be used to make sure the required data set is compiled in the correct format. Clicking on the [Put Template On Clipboard] button will copy the current model-specific template to the Clipboard within Microsoft Windows (see the Microsoft Windows Help for a detailed explanation of the Clipboard). Next, open a new worksheet in a spreadsheet software (e.g., Microsoft Excel), select the location where you would like to paste the copied template, and use the spreadsheet commands to paste the template into the worksheet.

The pasted template will contain a header row of variable names and units associated with the inputs required by the specific model. Explanations of the specific header names and their associated distress indicator models are included in table 12 (note: this table is organized alphabetically by header name). Finally, compile the calibration data set by placing the appropriate input values in the rows below the header row.

Step 2: Use PaveSpec to Calculate Predicted Distresses

After the calibration data set has been compiled, the data set must be imported into PaveSpec so that distresses can be predicted using the model being calibrated. A predicted distress value will be determined for each row of data in the calibration data set.

Importing the calibration data set into PaveSpec is a two-step process. First, select the entire calibration data set (including the row of header values) in your spreadsheet program and copy the selected range to the clipboard. Return to PaveSpec and click on the [Calculate Distresses] button. If the calibration data set has been compiled in the correct format, a positive feedback message will be displayed. Conversely, any errors found in the calibration data set will be indicated. Upon successfully processing the data, PaveSpec will copy *one* column of predicted distresses back to the clipboard. Paste these values into the appropriate worksheet.

Step 3: Conduct Regression Analysis to Determine Calibration Coefficients

Use a spreadsheet software package (e.g., Microsoft Excel) to conduct the required linear regression of predicted values (determined from PaveSpec) versus actual values (measured in the field). Determine the A and B calibration coefficients corresponding to the linear regression equation shown as equation 4.

$$Predicted\ Values = A*(Actual\ Values) + B \qquad (4)$$

These calibration coefficients are then also used in the corresponding calibration equation with the following form:

$$Calibrated\ Model = A*(Default\ Model) + B \qquad (5)$$
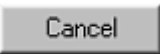
Upon determining the A and B calibration coefficients corresponding to a particular calibration data set, enter these coefficients in the appropriate *Calibration Coefficient* input boxes in the model-specific calibration dialog box. To save the current modified model definition, click on the [OK] button. To exit this dialog box without saving the current coefficient changes, click the [Cancel] button.

Table 12. Explanation of the template header names.

Header Name	Variable Name	Associated Model(s)	Variable Explanation
Actual Cumulative ESAL's, millions	n	Faulting, Cracking	Actual number of applied cumulative ESAL's, millions.
Age, years	AGE	Spalling, IRI	Pavement age, years.
Air Content, % (0 to 100)	AIR%	Spalling	PCC air content, percent (expressed as a value between 0 and 100).
Annual Air Freeze-Thaw Cycles	FTCYC	Spalling	Average annual number of air freeze-thaw cycles.
Average Annual Precipitation, in	PRECIP	Faulting	Average annual total precipitation, in.
Average Faulting per Joint, in	FAULT	IRI	Average transverse joint faulting per joint, in.
Base Erodibility Factor	EROD	Faulting	Base erodibility factor (number between 0.5 and 7.5).
Base Modulus of Elasticity, psi	E_BASE	Cracking	Base layer modulus of elasticity, psi.
Base Permeability (0 or 1)	PERM	Faulting	Base permeability (0 if not permeable, 1 if permeable).
Base Thickness, in	h_BASE	Cracking	Thickness of the base layer, in.
Climatic Zone (1, 2, 3, 4)	—	Cracking	Climatic zone within the United States (where Wet-Freeze = 1; Wet-Nonfreeze = 2; Dry-Freeze = 3; Dry-Nonfreeze = 4).
Days >90 °F	Days90	Faulting	Number of days per year with the maximum temperature greater than 90°F (32°C).
Dowel Diameter, in	DOWELDIA	Faulting	Dowel diameter, in.
Freezing Index, °F-days	FI	IRI	Freezing index, °F-days.
Include Percent Consolidation (0 or 1)	—	Faulting	Indicator of whether or not the computed faulting is dependent on the measured percent consolidation around dowels (1 if percent consolidation is considered, 0 if not considered).
Initial IRI, in/mi	INIT_IRI	IRI	Initial IRI—measured before opened to traffic, m/km.
Joint Spacing, ft	JTSPACE	Faulting, Cracking, IRI	Slab length (transverse joint spacing), ft.
Outside Shoulder Type (1, 2, 3)	SHOULDER	Cracking	Outer shoulder type (1 = widened lane; 2 = tied PCC shoulder; 3 = other shoulder type [including AC and none]).
PCC 28-day Compressive Strength, psi	f'c	Spalling	28-day PCC compressive strength, psi.
PCC Modulus of Elasticity, psi	E_PCC	Faulting, Cracking	PCC modulus of elasticity, psi.
PCC Modulus of Rupture, psi	MR	Cracking	PCC modulus of rupture (third-point loading), psi.

Table 12. Explanation of the template header names (continued).

Header Name	Variable Name	Associated Model(s)	Variable Explanation
PCC Slab Thickness, in	h_PCC	Faulting, Spalling, Cracking	Thickness of the PCC slab, in.
PCC Water-to-Cement Ratio	WC_Ratio	Spalling	Water-to-cement ratio of the PCC mix.
PCC/Base Interface (0 or 1)	BOND_COND	Cracking	Interface condition between the PCC slab and the base layer (0 = bonded; 1 = unbonded).
Percent Consolidation, % (0 to 100)	%CON	Faulting	Percent consolidation around dowels, % (expressed as a value between 0 and 100; if percent consolidation is not considered, this value should be set equal to 100).
Percent Cracked Slabs, % (0 to 100)	%CRACKED	IRI	Percentage of cracked slabs (value between 0 and 100).
Percent Passing 0.075-mm Sieve (0 to 100)	P_0.075	IRI	Percent subgrade material passing 0.075-mm (#200) sieve.
Percent Spalled Joints, % (0 to 100)	%SPALLED	IRI	Percentage of medium- and high-severity spalled joints (expressed as a value between 0 and 100).
Presence of Dowels (0 or 1)	DOWEL	Faulting	Presence of dowel bars (0 if no dowels, 1 if dowels are present).
Presence of LCB (0 or 1)	LCB	Faulting	Presence of lean concrete base (1 if present, 0 if not present).
Presence of Preformed Compression Seal (0 or 1)	PREFORM	Spalling	Presence of Preformed Compression Seal (0 if preformed seal is present, 0 if other sealant type or no sealant is present).
Presence of Widened Lane (0 or 1)	WIDENLANE	Faulting	Presence of a widened lane (1 if present, 0 if not present).
Static k-value, psi/in	KVALUE	Faulting, Cracking	Static modulus of subgrade reaction, psi/in.
Tied PCC Shoulder Stress LTE, % (5 to 30)	STRESS_LTE	Cracking	Stress load transfer efficiency associated with a tied PCC shoulder, % (expressed as a value between 5 and 30). Note: this value is only needed when a tied PCC shoulder is present.
Widened Lane Amount, in	ADDWIDTH	Faulting	Additional width provided by the widened lane, in.

—indicates that there is no model variable name for this header

CHAPTER 5: USING A SPECIFICATION

After a specification has been defined, and the corresponding preconstruction output has been generated, the specification may then be used to accept as-constructed JPCP lots. This chapter describes all aspects of the *Use Specification* section of the program, including entering actual AQC field data, generating and viewing PRS lot pay factors and pay adjustments, and viewing project summary reports.

CREATING AND EDITING *USE SPECIFICATION* DOCUMENTS

Each *Use Specification* document is developed in reference to a previously simulated specification. A new *Use Specification* document can be created using one of the following three methods:

1. Select the *Specification* document of interest in the *Specifications* tab of the *Database Control* dialog box, then select *Use Specification* from the *File* menu.

2. Select the *Specification* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the [icon] toolbar button.

3. Select a previously defined *Use Specification* document under the same specification (contained in the *Specifications* tab of the *Database Control* dialog box), then click on the New.. button.

An existing *Use Specification* document can be edited using one of the following methods:

1. Select the *Use Specification* document of interest in the *Specifications* tab of the *Database Control* dialog box, then select *Setup* from the *File* menu.

2. Select the *Use Specification* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the [icon] toolbar button.

3. Select the *Use Specification* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the Setup.. button.

USE SPECIFICATION MAIN SCREEN

When you create a new *Use Specification* document, the dialog box shown in figure 42 will appear. This dialog box consists of two parts: a *Name* input box and a project summary area.
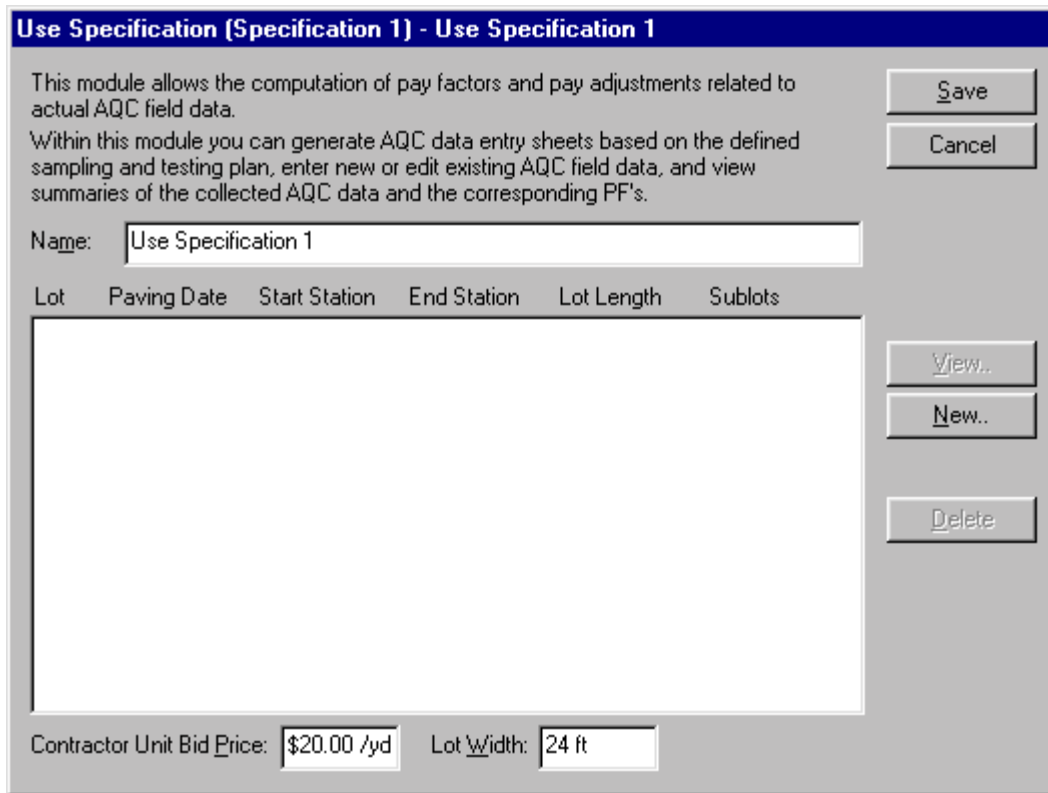
Figure 42. Example of the *Use Specification* document main screen.

You may change the name of the *Use Specification* document by entering a new name in the *Name* input box. The name you enter will show up as the *Use Specification* document name in the *Specifications* tab of the *Database Control* dialog box.

The project summary area contains general information about the user-defined as-constructed lots—lot number, paving date, starting and ending stations, computed lot length, and the number of sublots contained in each lot. When you first begin to create a new *Use Specification* document, this area will be blank (as shown in figure 43).

Finally, you must also enter the actual *Contractor Unit Bid Price* (note that a selected *average* bid price was used to develop the specification) and final *Lot Width* to be used in determining the actual contractor pay adjustments. Although the lot width is defined in the specification development steps, the actual value used for computing pay adjustments is required here to avoid any confusion.

Creating a New Lot

To define a new lot in an open *Use Specification* document, click on the [New..] button. This action will add a new lot to the end of the list in the project summary area. Clicking on the [New..] button will also bring up the *View/Edit Lot* dialog box.

Editing an Existing Lot
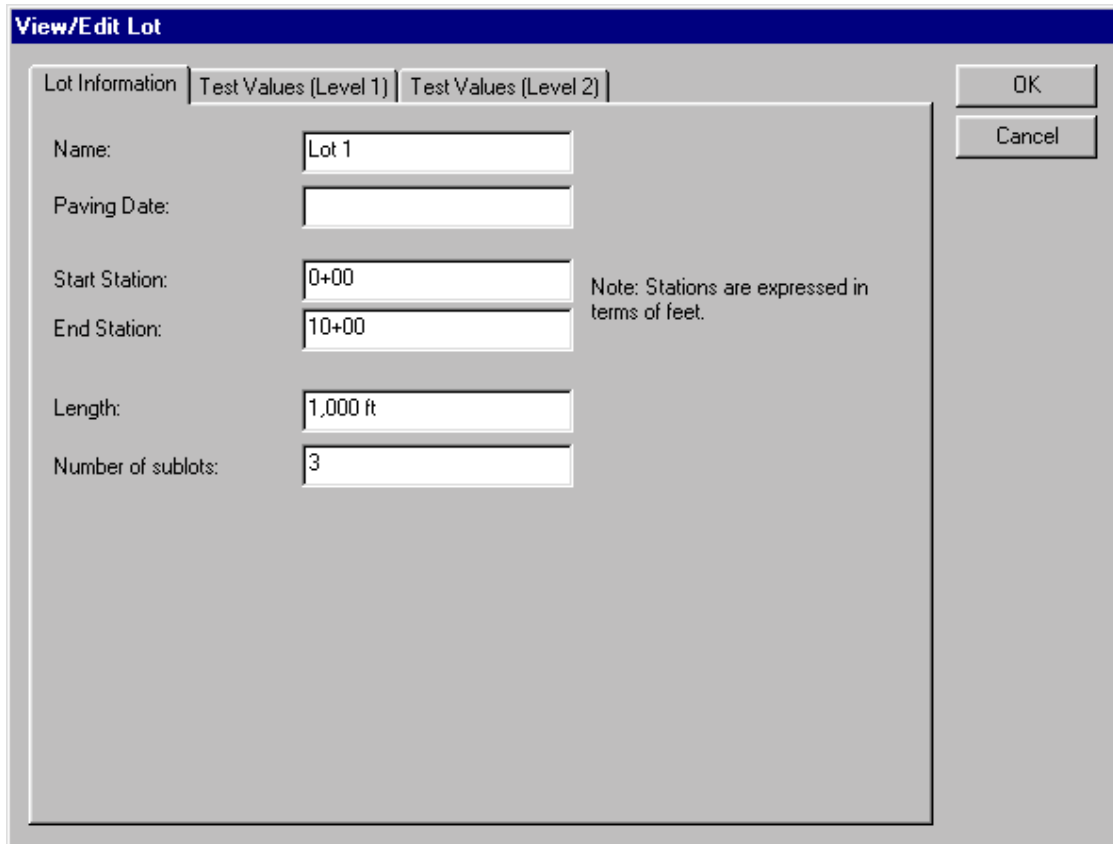
To edit an existing lot, first select the lot in the project summary area, then click the ╴View..╴ button. This action will activate the *View/Edit Lot* dialog box. Double-clicking on a lot description will also bring up the *View/Edit Lot* dialog box.

Deleting an Existing Lot

To delete an existing lot, first select the lot in the project summary area. Next, click the ╴Delete..╴ button. This action will remove the selected lot from the list in the project summary area.

ENTERING ACTUAL LOT INFORMATION

Actual AQC field data are entered into PaveSpec using the *View/Edit Lot* dialog box. This dialog can contain up to three different tabs: *Lot Information, Test Values (Level 1),* and *Test Values (Level 2).* The *Test Values (Level 2)* tab will only be available if you chose to simulate a Level 1 and Level 2 specification at the same time. (Note: The input fields under the *Test Values (Level 1)* and *Test Values (Level 2)* tabs are identical.) An example of the *View/Edit Lot* dialog box is presented in figure 43.

Figure 43. Example of the *View/Edit Lot* dialog box.

General Lot Information

When you are creating or editing a lot, the general lot information is contained in the *Lot Information* tab of the *View/Edit Lot* dialog box. The inputs defined within this tab are used to describe the lot in the project summary area of the *Use Specification* document main screen.

When you choose to create a new lot, the default lot *Name* will automatically be set to the next consecutive lot number (i.e., if the previous new lot name was *Lot 4*, the next new default lot *Name* will be *Lot 5*). You can rename the lots if you choose to do so.

The *Start Station*, *End Station*, and lot *Length* inputs all have default metric units of "m" and default English units of "ft." Note: For the Lot Length, you may toggle between metric and English units using the "F2" key.

Enter the number of sublots expected to be included in the given lot into the *Number of sublots* input box.

Actual AQC Test Value Data

Actual AQC specimen testing data are input for Level 1 and Level 2 specifications in the *Test Values (Level 1)* and *Test Values (Level 2)* tabs, respectively. If you are creating a new lot, the *Test Values* tabs will appear mostly blank, as shown in figure 44.

These tabs allow you to enter AQC specimen test data for all the user-chosen AQC's. Clicking on the buttons across the top of the data input screen (labeled by AQC name) allows you to toggle between data input screens for each chosen AQC.

Prebuilding a Specimen List

As mentioned previously, when you are defining an actual lot for the first time, the specimen list within each AQC data input screen will be blank. You can prebuild an AQC specimen list that reflects your choices for the estimated number of sublots per lot and the previously chosen AQC sampling and testing plan. For example, if you had estimated four sublots per lot, and you defined your strength sampling plan to include five strength samples (sampling locations) per sublot with two replicates per sampling location, then the strength specimen list would be prebuilt to include 4 * 5 * 2 = 40 specimens.

To use the *Prebuild List* option, simply click on the Prebuild List button on the AQC data input screen. Use the vertical scroll bar to view the complete list of specimens. An example of a prebuilt list is shown in figure 45.
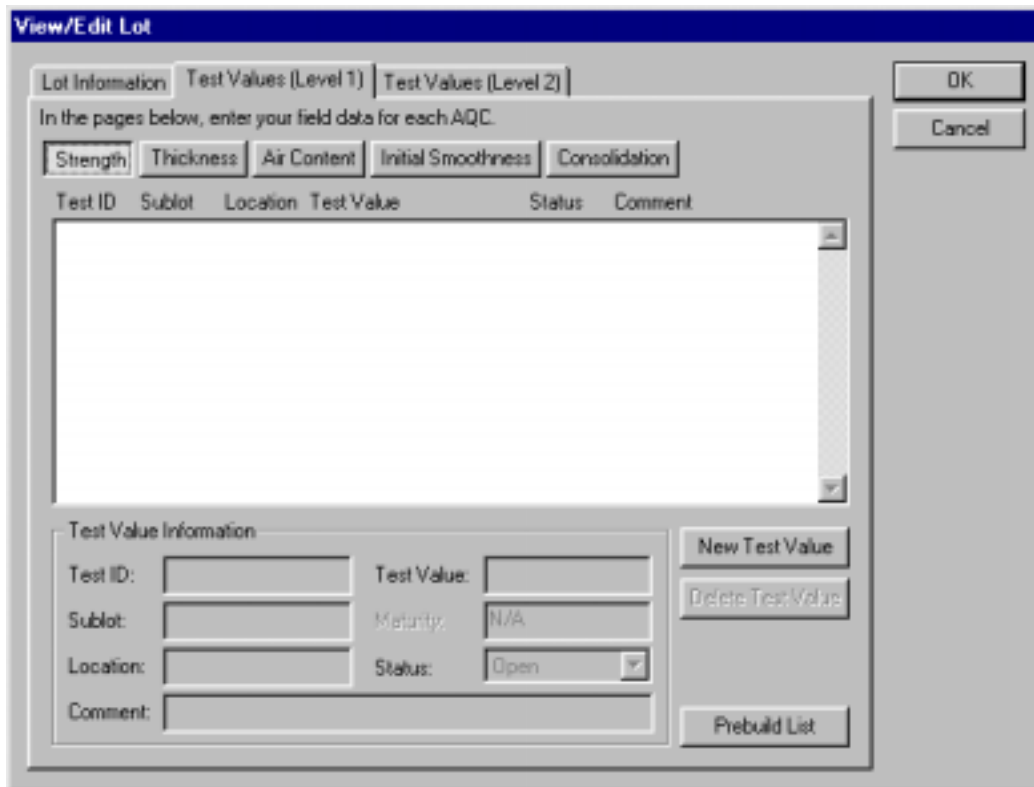
Figure 44. Example of a *Samples* tab in the *View/Edit Lot* dialog box.
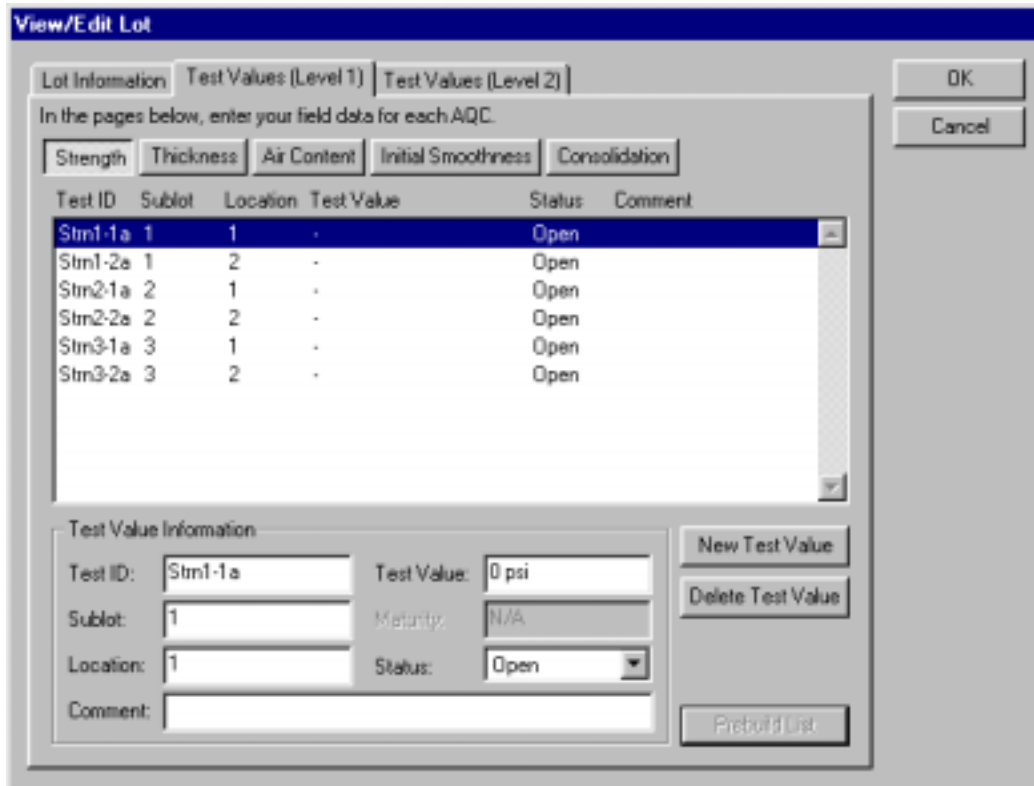
Figure 45. Example of a prebuilt list in the *View/Edit Lot* dialog box.

When you use the *Prebuild List* command, PaveSpec assigns default specimen ID's to each of the AQC specimens. Each default ID is made up of the following parts:

- *AQC Specimen Type Code*—The first few characters of the default specimen ID designate the AQC type (*Strn* = strength, *Thk* = thickness, *Air* = air content, *Smth* = initial smoothness, and *Cons* = percent consolidation around dowels).

- *Sublot Number*—The number following the AQC specimen type code designates the corresponding sublot (e.g., the sample ID of "Strn1a2" represents sublot 1).

- *Sample Location*—The letter following the AQC sublot number designates the sample location within the sublot (e.g., the sample ID of "Strn1a2" represents sample location "*a*" within sublot 1).

- *Replicate Number*—The last number in the default ID represents the specimen replicate number at the chosen sample location (e.g., the sample ID of "Strn1a2" represents replicate "2" at sample location "a").

Adding a Specimen Test Value Manually

You may choose to input the AQC testing data information manually (one specimen at a time). To insert one new AQC test value at the end of the current AQC specimen list, click on the New Test Value button on the chosen AQC data input screen. This function can be used to create a new test value list or to add test values to an existing list.

Deleting a Specimen Test Value

To delete an AQC specimen test value, first select the specimen by clicking on it in the AQC specimen list. Then click the Delete Test Value button.

Defining Test Specimen Characteristics

AQC specimen characteristics are defined using the input fields grouped into the *Test Value Information* area of the AQC data input screens. To change the characteristics defining an AQC specimen, first select the specimen from the AQC specimen list. The currently defined specimen characteristics will be reflected in the data input fields in the test value information area. The different AQC specimen characteristics are defined below:

Test ID

The test ID is used to differentiate between specimens. It consists of any combination of letters and numbers unique to one specimen.

Sublot

The *Sublot* input is used to define the sublot from which the current specimen was taken. You may define the sublot in terms of any combination of numbers or letters.

Location

The *Location* input box is used to identify the location of the current specimen. This input is typically defined as the longitudinal station number where the specimen was taken; however, any appropriate description may be used to define the specimen location.

Status

The *Status* list box identifies how the current specimen test value is to be used by PaveSpec in the computation of the lot pay factor. The three different status types are defined as follows:

- *Open*—This is the default status of any new test value. These test values will not be used in the computation of the lot pay factor.

- *Accept*—Those test values that are assumed to be "good" test values (and, therefore, chosen to be used for acceptance) should be changed to the *Accept* status. Only those test values showing a status of *Accept* will be used by PaveSpec in the computation of lot pay factors.

- *Reject*—Any test values that are chosen to be excluded from the acceptance procedure shall be marked with a status of *Reject.* Rejected test values will not be used in the computation of lot pay factors.

Test Value

The measured field test value for the current AQC specimen is input into the *Test Value* box. Acceptable units for each AQC are as follows:

- *Concrete Strength*—Metric values are expressed in terms of "MPa," while English values are in terms of "psi."

- *Slab Thickness*—Acceptable metric abbreviations include "mm" and the default units of "cm," whereas English values are expressed in terms of "in."

- *Air Content*—Default units for this field are "%."

- *Initial Smoothness*—Metric values are expressed in terms of "mm/km," while English values are in terms of "in/mi."

- *Percent Consolidation Around Dowels*—Default units for this field are "%."
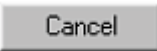
Maturity

The *Maturity* input box is only available within the strength AQC data input screen, and is only required when strength testing is conducted at less than 28 days of age. When appropriate, the sample maturity at the time of testing may be recorded in this input box. Metric values for the *Maturity* input box are "°C-hrs," while English values are expressed in terms of "°F-hrs."
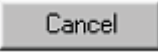
Comment

A text input box is provided to allow you to type a comment corresponding to a particular specimen test value.

Exiting the *View/Edit Lot* Dialog Box

When you are finished defining AQC testing data for the current lot, click on the OK button to save your changes. If you would like to exit the *View/Edit Lot* dialog box without saving your changes, click on the Cancel button. Clicking either button will return you to the *Use Specification* document main window.

SAVING A *USE SPECIFICATION* DOCUMENT

Once you are finished making changes or defining a new *Use Specification* document, click on the Save button to save your named document. If you would like to exit the *Use Specification* document without saving your changes, click on the Cancel button. Clicking either button will return you to the PaveSpec main window.

CHAPTER 6: DRILL-DOWN DOCUMENTS

A developed Level 1 or Level 2 specification is typically based on thousands of individually determined lot LCC's, each of which is determined by simulating sublot performance and estimating associated sublot LCC's. Obviously, it would be nearly impossible to present this immense amount of data in a comprehensible format, nor would the typical user have an interest in such detail. For those users who do wish to see the detailed lot or sublot performance or LCC information, the *Drill-Down* document is provided.

As an example, let's say that the user has chosen to define the as-designed LCC based on the simulation of 500 lots. The user could then use the *Drill-Down* document feature to look at the distresses and LCC's that were simulated for sublot 2 in lot 421. Such detailed investigations allow the user to really understand how the chosen M & R plan is functioning, as well as to compare the types and magnitudes of the different included LCC's. This chapter describes all aspects of the *Drill-Down* document program feature.

CREATING AND EDITING *DRILL-DOWN* DOCUMENTS

Each *Drill-Down* document is developed in reference to a previously simulated specification. A new *Drill-Down* document may be created using one of the following three methods:

1. Select the Specification document of interest in the *Specifications* tab of the *Database Control* dialog box, then select *Create Drill-Down Document* from the *File* menu.

2. Select the *Specification* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the ⬚ toolbar button.

3. Select a previously defined *Drill-Down* document under the same specification (contained in the *Specifications* tab of the *Database Control* dialog box), then click on the ⬚ New.. button.

An existing *Drill-Down* document may be edited using one of the following methods:

1. Select the *Drill-Down* document of interest in the *Specifications* tab of the *Database Control* dialog box, then select *Setup* from the *File* menu.

2. Select the *Drill-Down* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the [pencil icon] toolbar button.

3. Select the *Drill-Down* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the Setup.. button.

DRILL-DOWN DOCUMENT MAIN SCREEN

When you create a new *Drill-Down* document, the pop-up dialog box shown in figure 46 will appear. This dialog box consists of a *Name* input box, a series of controls that allow you to select the simulation scenario of interest, and a summary area showing a list of the simulated lots that make up the defined simulation scenario. Details on how to use this dialog box are described in this section.

Drill-Down Document

This document lets you examine one of the lots from the Level 1 AQC series in detail. First, choose a name for your document and the basic set in which you're interested.

Name: Drill-Down 1

Prediction Set: Concrete Strength Factorials   Number of Sublots: 3

Next, select the mean and standard deviation of the factorial prediction set you want to view.

Mean: 4,000 psi   Standard Deviation: 400 psi

The following list shows the lots that comprise the set of predictions you have selected. Choose a lot from the list and click "OK" to generate a full report for that lot.

Number	Str	Thk	Air	Smth	Cons	PW LCC
1	4,213 psi	10.04 in	7.16%	7.86 in/mi	100.23%	$404,763/mi
2	3,966 psi	10 in	7.16%	7.11 in/mi	98.65%	$405,364/mi
3	3,989 psi	10.13 in	7.21%	7.51 in/mi	100.11%	$405,177/mi
4	3,936 psi	9.85 in	7.55%	7.34 in/mi	99.81%	$403,048/mi
5	3,955 psi	10.06 in	7.14%	6.52 in/mi	100.1%	$405,390/mi
6	3,891 psi	9.91 in	7.64%	8.23 in/mi	100.04%	$405,373/mi
7	3,786 psi	10.08 in	7.33%	6.61 in/mi	99.89%	$403,489/mi
8	4,007 psi	9.97 in	6.85%	6.79 in/mi	100.21%	$405,754/mi
9	4,125 psi	10.16 in	6.72%	7.16 in/mi	100.11%	$405,602/mi
10	4,076 psi	10.08 in	7.57%	7.07 in/mi	100.13%	$402,371/mi
11	4,109 psi	9.98 in	6.77%	6.8 in/mi	100.33%	$405,534/mi
12	4,029 psi	10.01 in	6.28%	7.41 in/mi	100.07%	$404,494/mi
13	4,030 psi	10.02 in	6.93%	6.91 in/mi	99.49%	$403,200/mi
14	3,945 psi	9.92 in	6.87%	7.36 in/mi	100.25%	$406,148/mi

Mean present-worth life cycle cost for this set: $404,744/mi

OK   Cancel

Figure 46. Example of the *Use Specification* document main screen.

Name Input Box

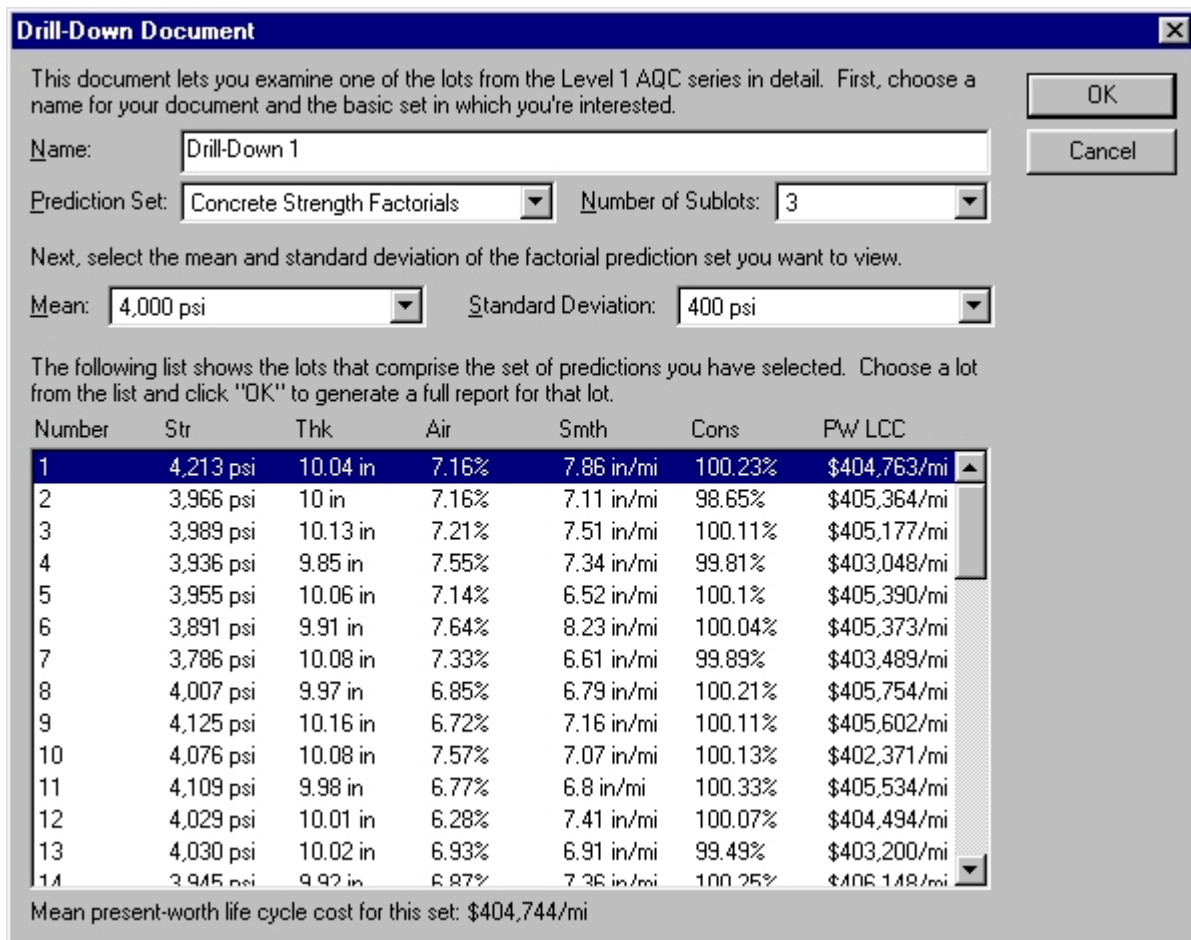You may change the name of the *Drill-Down* document by entering a new name in the *Name* input box. The name you enter will show up as the *Drill-Down* document name in the *Specifications* tab of the *Database Control* dialog box.

Prediction Set List Box

Use the *Prediction Set* control as a first step toward selecting the set of simulated lots that you would like to have displayed in the summary area. This list box will contain one or more of the following:

- *As-Designed Predictions (Level 1)*—Those simulated lots used to determine the Level 1 as-designed LCC.

- *As-Designed Predictions (Level 2)*—Those simulated lots used to determine the Level 2 as-designed LCC.

- *Flexural Strength Factorials*—Those simulated lots used to determine each simulated factorial point making up the Level 1 strength pay factor curves.

- *Slab Thickness Factorials*—Those simulated lots used to determine each simulated factorial point making up the Level 1 slab thickness pay factor curves.

- *Air Content Factorials*—Those simulated lots used to determine each simulated factorial point making up the Level 1 air content pay factor curves.

- *Initial Smoothness Factorials*—Those simulated lots used to determine each simulated factorial point making up the Level 1 initial smoothness pay factor curves.

- *Percent Consolidation Around Dowels Factorials*—Those simulated lots used to determine each simulated factorial point making up the Level 1 percent consolidation around dowels pay factor curves.
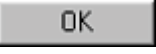
Number of Sublots List Box

If you have chosen to develop preconstruction output for different numbers of sublots, the *Number of Sublots* list box will reflect that choice. Use this control to select the particular number of sublots for which you would like to view data. The lot information displayed in the summary area will, therefore, be specific to this selected number of sublots.

Mean and *Standard Deviation* List Boxes

The last two controls used to determine what simulated lots will appear in the summary area of the dialog box are the *Mean* and *Standard Deviation* list boxes. (Note: These list boxes are only valid when viewing Level 1 factorial prediction sets.) Use these controls to display the summary of lots simulated for a particular combination of AQC mean and chosen standard deviation. A different set of simulated lots would exist for each combination of prediction set, number of sublots, AQC mean, and AQC standard deviation.

Generating the *Drill-Down* Document Output Report

To generate a drill-down document output report for one of the lots displayed in the summary area, select the lot from the list by single-clicking with the mouse (the selected lot will become highlighted) and hit the ⬚ OK button. You may also generate this output report by double-clicking on the appropriate lot. Either of these actions will close the *Drill-Down* document main screen and return you to the *Database Control* dialog box in the PaveSpec main window.

If you would like to exit the *Drill-Down* document without saving your changes, click on the ⬚ Cancel button. Clicking either button will return you to the *Database Control* dialog box in the PaveSpec main window.

To view the output report associated with a saved *Drill-Down* document, either select the document from the list (in the *Database Control* dialog box in the PaveSpec main window) by single-clicking with the mouse and hitting the ⬚ Open button, or double-click on the appropriate document name in the list. The content of the *Drill-Down* output report is described in more detail in chapter 9 of this appendix.

CHAPTER 7: SENSITIVITY ANALYSIS DOCUMENTS

After a Level 1 specification has been developed, agencies and contractors are both interested in determining how the specification will function before it is actually used in the field. PaveSpec has the ability to generate different sensitivity analysis documents to investigate the behavior of a developed specification. Specifically, the *Sensitivity Analysis* document allows the user to view the sensitivity of the pay factor or pay adjustment with respect to changes in AQC means and standard deviations.

For investigating any given Level 1 specification, the following three types of sensitivity analysis scenarios are available:

- *Direct Settings Analyses*—The user defines one AQC quality scenario (a distinct combination of required AQC means and standard deviations) representing the quality for *one* assumed as-constructed lot. The associated output report provides details regarding the composite pay factor and pay adjustment associated with the one defined AQC scenario.

- *One-Dimensional Analyses*—The user defines a series of AQC quality scenarios by choosing to vary *one* of the required AQC means or standard deviations over a selected range. For example, the user could choose to vary mean thickness (keeping all other AQC means and standard deviations constant) and observe the changes in composite pay factor or pay adjustment. The result is a one-dimensional factorial design of AQC quality scenarios. The associated output report provides details regarding the composite pay factor and pay adjustment associated with each AQC scenario defined in the one-dimensional analysis.

- *Two-Dimensional Analyses*—The user defines a series of AQC quality scenarios by varying *two* of the required AQC means or standard deviations at the same time. For example, the user could choose to vary mean thickness and standard deviation concurrently (keeping all other AQC means and standard deviations constant) and observe the changes in composite pay factor or pay adjustment. The result is a two-dimensional factorial design of AQC quality scenarios. The associated output report provides details regarding the composite pay factor and pay adjustment associated with each AQC scenario defined in the two-dimensional analysis.

The details of creating and defining sensitivity analysis documents within PaveSpec are discussed in the following sections.

CREATING AND EDITING *SENSITIVITY ANALYSIS* DOCUMENTS

Each *Sensitivity Analysis* document is developed in reference to a previously simulated specification. A new *Sensitivity Analysis* document may be created using one of the following three methods:

1. Select the *Specification* document of interest in the *Specifications* tab of the *Database Control* dialog box, then select *Create Sensitivity Analysis Document* from the *File* menu.

2. Select the *Specification* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the ▨ toolbar button.

3. Select a previously defined *Sensitivity Analysis* document under the same specification (contained in the *Specifications* tab of the *Database Control* dialog box), then click on the New.. button.

An existing *Sensitivity Analysis* document may be edited using one of the following methods:

1. Select the *Sensitivity Analysis* document of interest in the *Specifications* tab of the *Database Control* dialog box, then select *Setup* from the *File* menu.

2. Select the *Sensitivity Analysis* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the ✎ toolbar button.

3. Select the *Sensitivity Analysis* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the Setup.. button.

SENSITIVITY ANALYSIS DOCUMENT MAIN SCREEN

When you create a new *Sensitivity Analysis* document, the pop-up dialog box shown in figure 47 will appear. This box consists of a *Name* input box, a sensitivity analysis *Scenario Master List*, and a *Selected Scenario Information* feedback area. Details regarding the different parts making up this dialog box are described in this section.

Name Input Box

You may change the name of the *Sensitivity Analysis* document by entering a new name in the *Name* input box. The name you enter will be saved and show up as the *Sensitivity Analysis* document name in the *Specifications* tab of the *Database Control* dialog box.
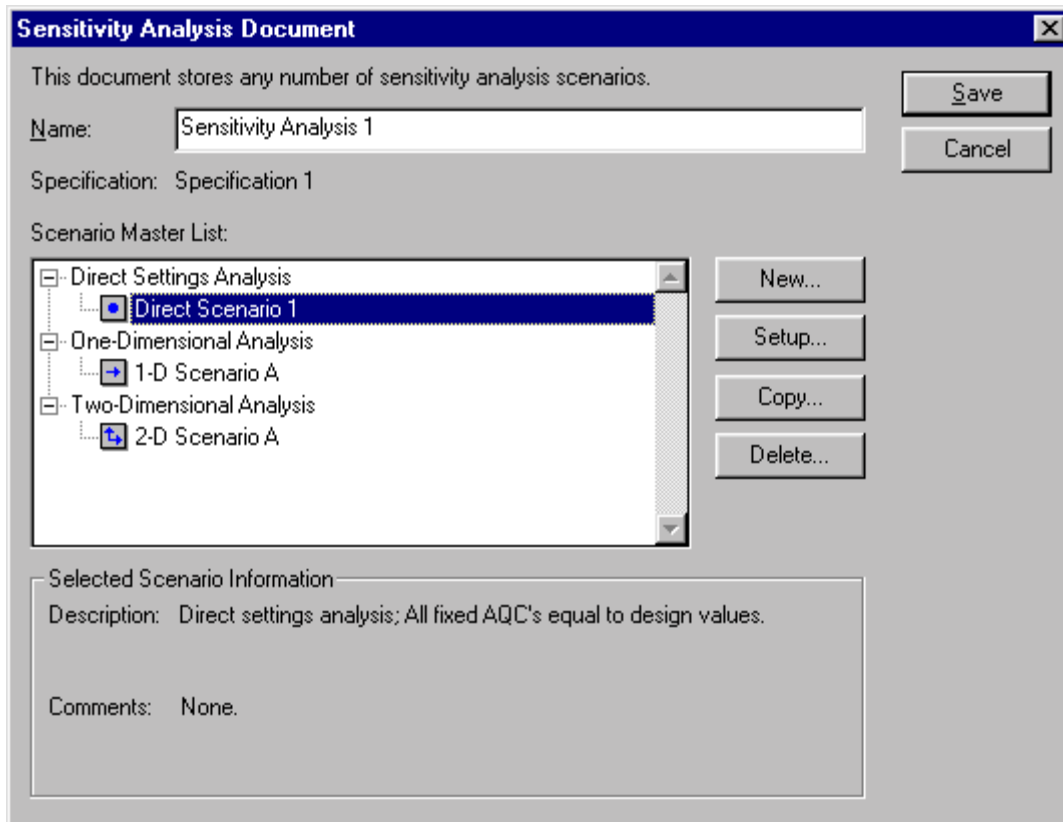
Figure 47. Example of the *Sensitivity Analysis* document main screen.

Scenario Master List

The *Scenario Master List* shows all of the currently defined sensitivity analysis scenarios. The defined scenarios are organized hierarchically by scenario type in the master list under the headings *Direct Settings Analysis*, *One-Dimensional Analysis*, and *Two-Dimensional Analysis*. In addition, the scenario type is identified by different icons, where ▪ indicates a *Direct Settings Analysis*, ➔ indicates a *One-Dimensional Analysis*, and ⬆ indicates a *Two-Dimensional Analysis*.

To create a new sensitivity analysis scenario, simply select the appropriate type heading in the master list, and click on the New.. button. To copy a currently defined scenario, select the defined scenario you wish to copy, and click on the Copy button. To edit a currently defined sensitivity analysis scenario, select the defined scenario you wish to edit, and click on the Setup.. button. Finally, to delete a currently defined sensitivity analysis scenario from the master list, select the defined scenario you wish to delete, and click on the Delete.. button.

Selected Scenario Information Feedback Box
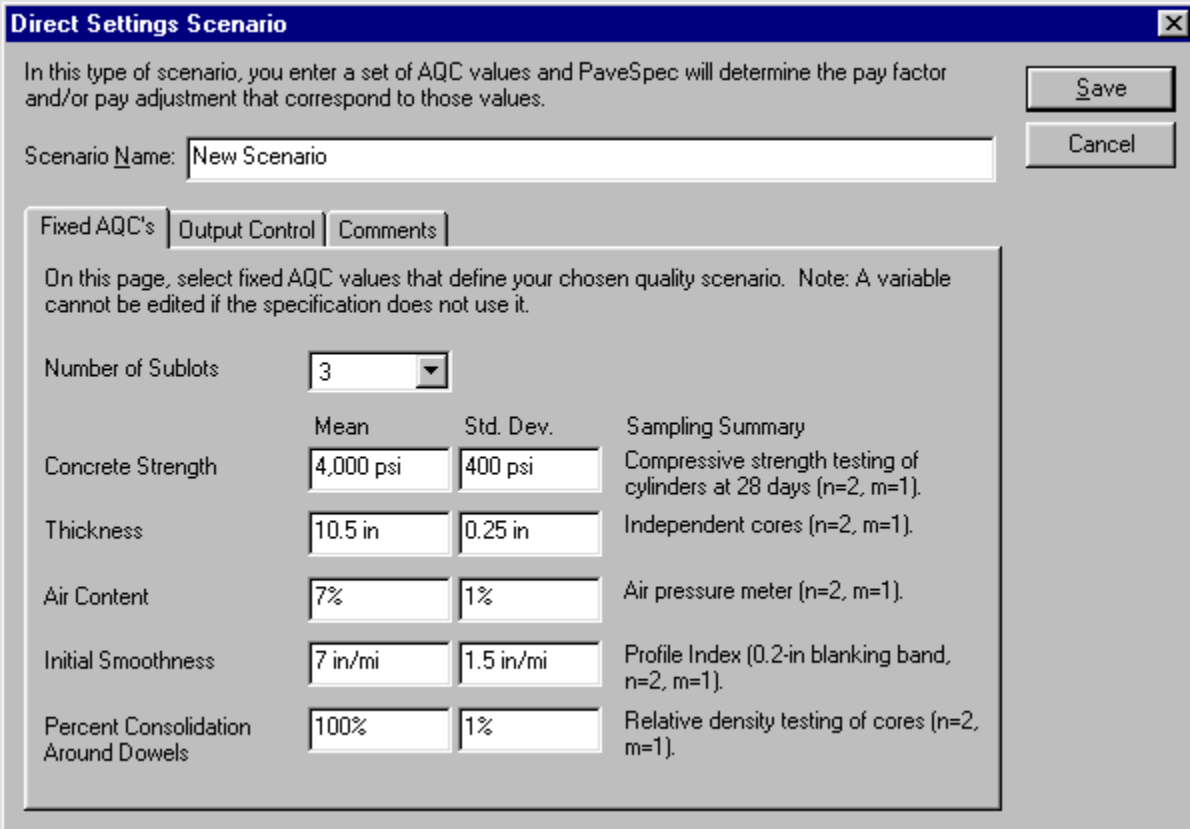
The *Selected Scenario Information* feedback box contains descriptive information about the currently selected sensitivity analysis scenario. The information not only includes a brief general description of the defined scenario, but also contains any user comments defined during the scenario development process.

DEFINING A SENSITIVITY ANALYSIS SCENARIO

The procedures required when defining a sensitivity analysis scenario differ slightly for each scenario type. The development of each of the three sensitivity analysis document types is described separately in the following sections.

Defining a *Direct Settings Analysis* Scenario

When the user selects to define a new *Direct Settings Analysis* scenario in the *Sensitivity Analysis Document* main screen, the *Direct Settings Scenario* dialog box is opened. (This dialog box will also be opened when the user chooses to set up a currently defined direct settings analysis scenario). An example of the *Direct Settings Scenario* dialog box is displayed in figure 48.

Figure 48. Example of the *Fixed AQC's* tab in the *Direct Settings Scenario* dialog box.

The *Direct Settings Scenario* dialog box consists of a *Scenario Name* input box and three different tabs used to define the current scenario. To customize the name of the sensitivity analysis scenario, change the text in the *Scenario Name* input box. Details of the three tabs included in the dialog box are described separately below.

Fixed AQC's Tab

The *Fixed AQC's* tab (shown in figure 48) contains a series of inputs used to define a specific AQC quality scenario. First, the *Number of Sublots* list box contains the different number of sublots for which pay factor curves were developed. Select an appropriate number from the *Number of Sublots* list box that matches the hypothetical case you would like to investigate.

To define a specific quality scenario, enter the chosen AQC mean and standard deviation values into the appropriate input boxes. A pay factor and pay adjustment associated with this quality scenario will then be computed and included in the output report.

Output Control Tab

The controls on the *Output Control* tab determine what type of output will be included in the output report. An example of this tab is shown in figure 49. The output report will always contain the computed Level 1 Composite Pay Factor (i.e., the corresponding check box on this tab will always be selected) associated with the specified quality scenario. In addition, the user may also choose to compute the related pay adjustment. To include the corresponding pay adjustment in the output report, click on the *Level 1 Pay Adjustment* check box and input the appropriate assumed bid price in the adjoining input box.

Comments Tab

The text input box in the *Comments* tab is provided to allow you to type comments corresponding to the particular sensitivity analysis scenario. Any comments entered in this text input box will be displayed in the *Selected Scenario Information* feedback box in the *Sensitivity Analysis Document* main screen. An example of this tab is shown in figure 50.

Defining a *One-Dimensional Analysis* Scenario

When the user selects to define a new *One-Dimensional Analysis* scenario in the *Sensitivity Analysis Document* main screen, the *One-Dimensional Sensitivity Analysis Scenario* dialog box is opened. (This dialog box will also be opened when the user chooses to set up a currently defined one-dimensional analysis scenario). An example of the *One-Dimensional Sensitivity Analysis Scenario* dialog box is displayed in figure 51.

Figure 49. Example of the *Output Control* tab in the *Direct Settings Scenario* dialog box.
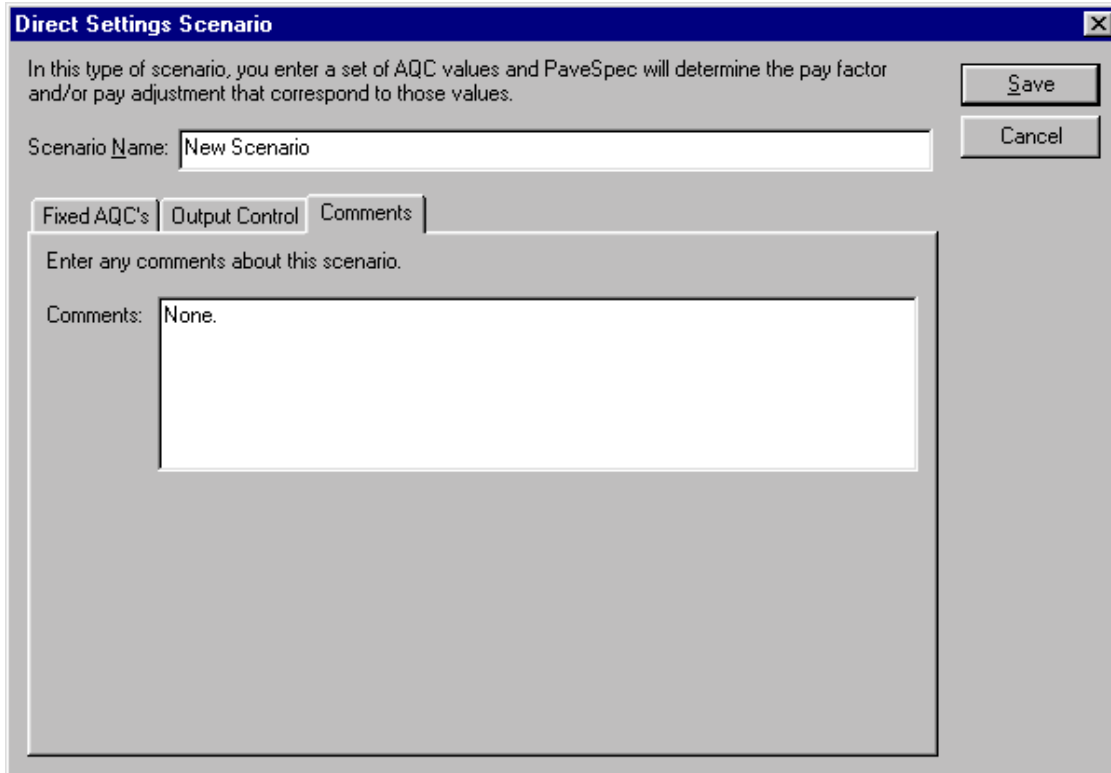
Figure 50. Example of the *Comments* tab in the *Direct Settings Scenario* dialog box.
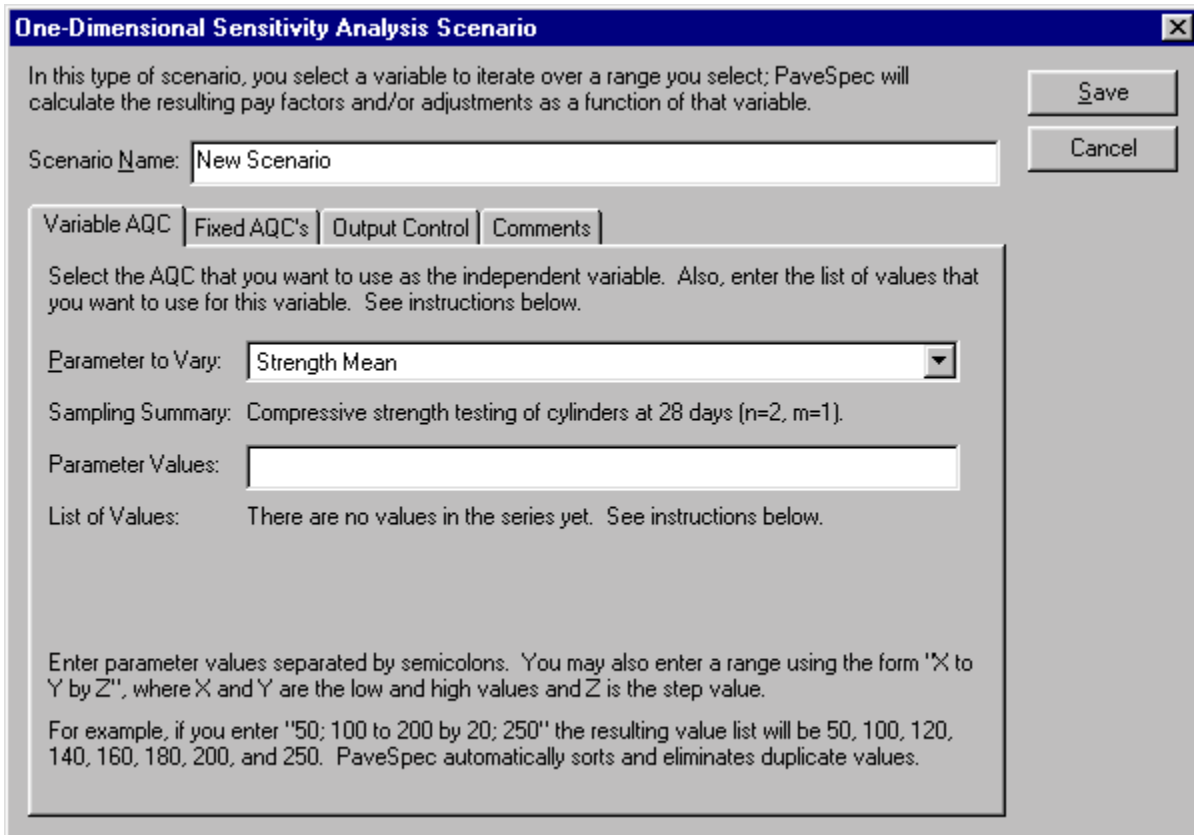
Figure 51. Example of the *One-Dimensional Sensitivity Analysis Scenario* dialog box.

The *One-Dimensional Sensitivity Analysis Scenario* dialog box consists of a *Scenario Name* input box and four different tabs used to define the current scenario. To customize the name of the sensitivity analysis scenario, change the text in the *Scenario Name* input box. Details of the four tabs included in the dialog box are described separately below.

Variable AQC Tab

The *Variable AQC* tab (shown in figure 51) contains input controls that allow you to not only select the one AQC variable you wish to vary, but also define an array of values for that variable that will be used to define individual quality scenarios.

First, choose the AQC mean or standard deviation you wish to investigate by selecting it from the *Parameter to Vary* list box. Next, specify the array of values for the AQC being varied (used to define the individual quality scenarios) within the *Parameter Values* input box. These values may be defined by using any of the following methods:

- *Specified values*—You may input specific values that you want to be included in the array of parameter values. For example, entering "40; 50; 150" in the *Parameter Values* input box would build an array of values containing 40, 50, and 150.

- *Range of values*—Instead of defining specific values, you may also choose to define a range of values to be included in the array of parameter values. A range of values is defined by identifying the lower and upper limits of the range, and a step value to be used between the lower and upper limits. For example, if you want to define a range in which lower limit = 100, upper limit = 300, and step value = 50, you would enter "100 to 300 by 50" in the *Parameter Values* input box. The resulting array of values would contain 100, 150, 200, 250, and 300.

- *Combination of specific values and defined ranges*—When defining the array of parameter values, you may choose to include a combination of specific values and defined ranges. For example, entering "40; 50; 150; 100 to 300 by 50" in the *Parameter Values* input box would build an array of values containing 40, 50, 100, 150, 200, 250, and 300 (duplicates are ignored).

Fixed AQC's Tab

The *Fixed AQC's* tab contains a series of inputs used to define values for those AQC's that will not be varied in the one-dimensional sensitivity analysis. The AQC values defined on this tab will be held constant for each quality scenario investigated in the sensitivity analysis. The look and function of this *Fixed AQC's* tab is identical to the *Fixed AQC's* tab that is accessed in the *Direct Settings Analysis* scenario (an example of this tab was previously illustrated in figure 48).

Output Control Tab

The controls on the *Output Control* tab determine what type of information will be included in the output report. The output report will always contain the computed Level 1 Composite Pay Factors associated with each defined quality scenario. In addition, the user may also choose to compute the related pay adjustment. To include the corresponding pay adjustment in the output report, click on the *Level 1 Pay Adjustment* check box and enter the appropriate assumed bid price in the adjoining input box. The look and function of this *Output Control* tab are identical to the *Output Control* tab that is accessed in the *Direct Settings Analysis* scenario (an example of this tab was previously illustrated in figure 49).

Comments Tab

The text input box in the *Comments* tab is provided to allow you to type comments corresponding to the particular sensitivity analysis scenario. Any comments entered in this text input box will be displayed in the *Selected Scenario Information* feedback box in the *Sensitivity Analysis Document* main screen. The look and function of this *Comments* tab is identical to the *Comments* tab that is accessed in the *Direct Settings Analysis* scenario (an example of this tab was previously illustrated in figure 50).

Defining a *Two-Dimensional Analysis* Scenario

When the user selects to define a new *Two-Dimensional Analysis* scenario in the *Sensitivity Analysis Document* main screen, the *Two-Dimensional Sensitivity Analysis Scenario* dialog box is opened. (This dialog box will also be opened when the user chooses to set up a currently defined two-dimensional analysis scenario). An example of the *Two-Dimensional Sensitivity Analysis Scenario* dialog box is presented in figure 52.
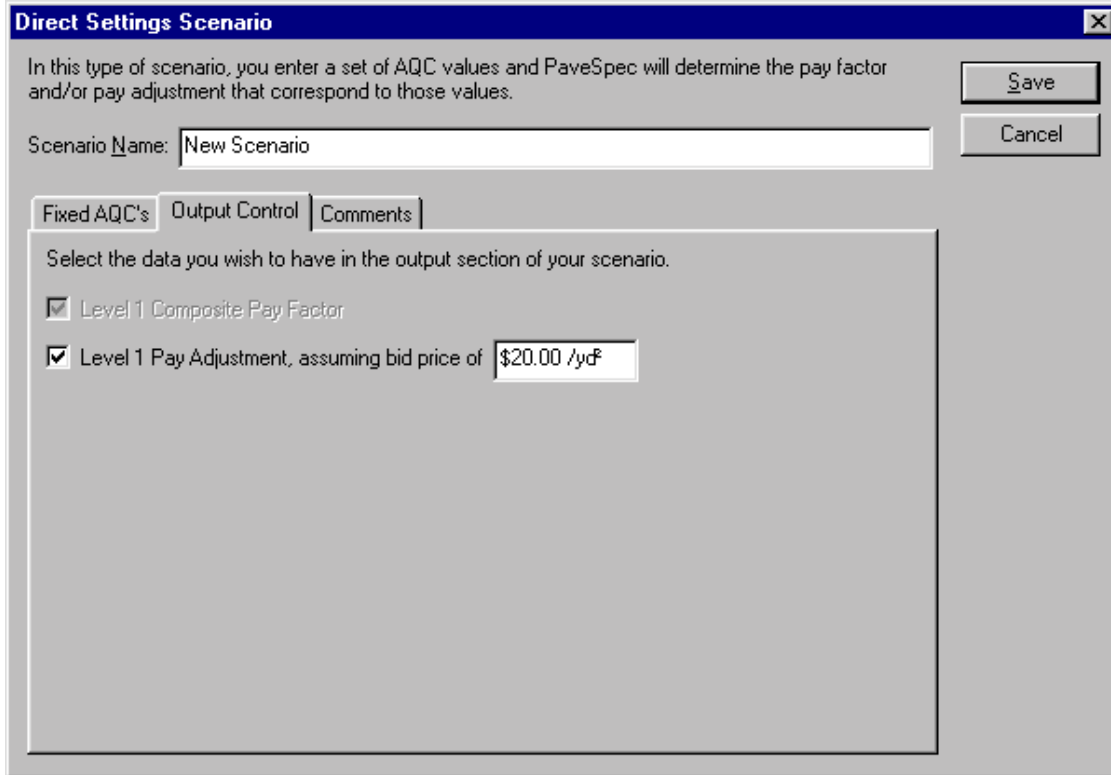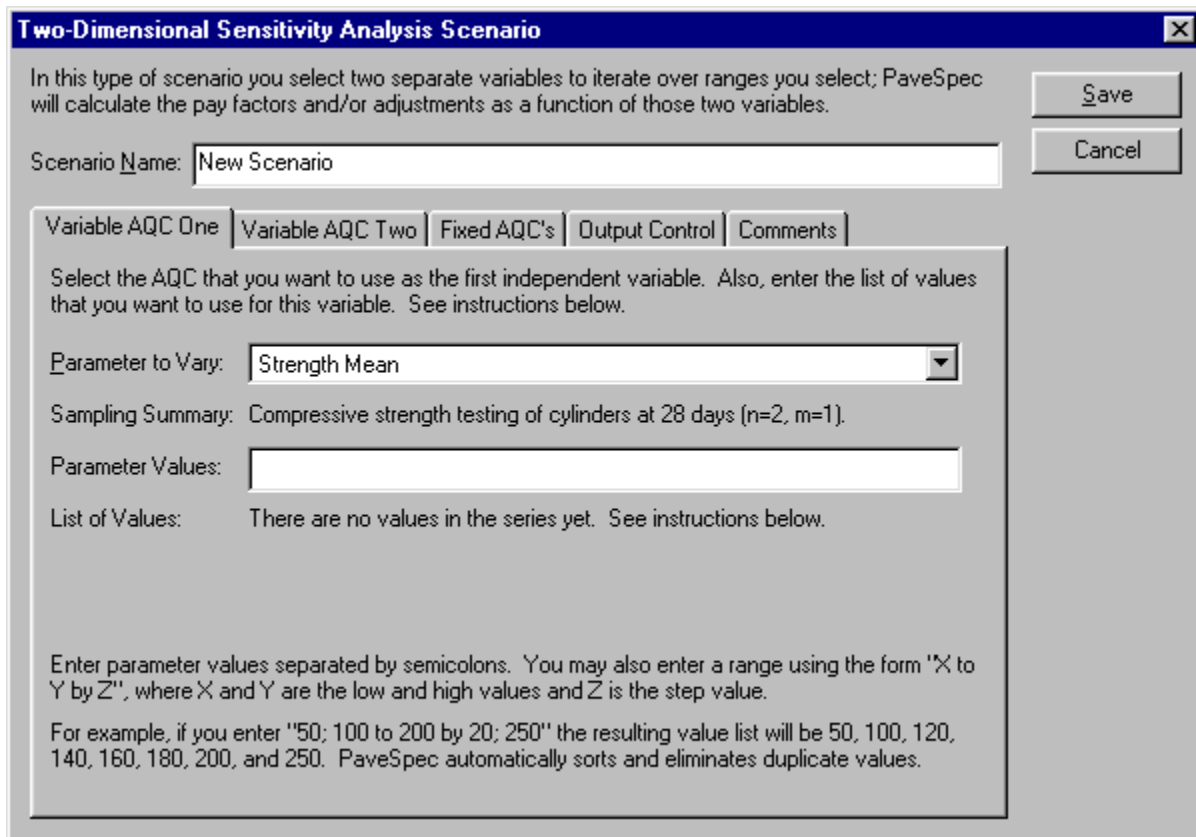

Figure 52. Example of the *Two-Dimensional Sensitivity Analysis Scenario* dialog box.

The *Two-Dimensional Sensitivity Analysis Scenario* dialog box consists of a *Scenario Name* input box and five different tabs used to define the current scenario. To customize the name of the sensitivity analysis scenario, change the text in the *Scenario Name* input box. Details of the five tabs included in the dialog box are described separately below.

Variable AQC One and *Variable AQC Two* Tabs

Variable AQC One and *Variable AQC Two* are nearly identical tabs that contain input controls that allow you to not only select the two AQC variables you wish to vary, but also define the respective arrays of values for the two AQC variables being varied. Individual quality scenarios are determined by taking all combinations of the values

defined within the two arrays. An example of the *Variable AQC One* tab is presented in figure 52.

First, define the two AQC variables (means or standard deviations) you wish to vary by selecting them from the *Parameter to Vary* list boxes contained in each tab. Next, specify the associated array of values for each chosen AQC within the respective *Parameter Values* input boxes. These values may be defined by defining specific values, defining ranges of values, or by using a combination of specified values and defined ranges. The details of each of these value defining methods are the same as those described previously in the explanation of the *Variable AQC* Tab in the "Defining a *One-Dimensional Analysis* Scenario" section.

Fixed AQC's Tab

The *Fixed AQC's* tab contains a series of inputs used to define values for those AQC's that will not be varied in the two-dimensional sensitivity analysis. The AQC values defined on this tab will be held constant for each quality scenario investigated in the sensitivity analysis. The look and function of this *Fixed AQC's* tab are identical to the *Fixed AQC's* tab that is accessed in the *Direct Settings Analysis* scenario (an example of this tab was previously illustrated in figure 48).

Output Control Tab

The controls on the *Output Control* tab determine what type of output will be included in the output report. The output report will always contain the computed Level 1 Composite Pay Factors associated with each defined individual quality scenario. In addition, the user may also choose to compute the related pay adjustment. To include the corresponding pay adjustment in the output report, click on the *Level 1 Pay Adjustment* check box and input the appropriate assumed bid price in the adjoining input box. The look and function of this *Output Control* tab are identical to the *Output Control* tab that is accessed in the *Direct Settings Analysis* scenario (an example of this tab was previously illustrated in figure 49).

Comments Tab

The text input box in the *Comments* tab is provided to allow you to type comments corresponding to the particular sensitivity analysis scenario. Any comments entered in this text input box will be displayed in the *Selected Scenario Information* feedback box in the *Sensitivity Analysis Document* main screen. The look and function of this *Comments* tab are identical to the *Comments* tab that is accessed in the *Direct Settings Analysis* scenario (an example of this tab was previously illustrated in figure 50).

GENERATING THE *SENSITIVITY ANALYSIS DOCUMENT* OUTPUT REPORT

The *Sensitivity Analysis Document* output report will automatically be generated and displayed when you choose to save the current sensitivity analysis being defined. To save the current sensitivity analysis document, simply click on the [Save] button in the *Sensitivity Analysis* document main screen. The contents of the *Sensitivity Analysis Document* output report are described in more detail in chapter 9 of this appendix.

If you would like to exit the *Sensitivity Analysis* document without saving your changes, click on the [Cancel] button. Clicking either button will return you to the *Database Control* dialog box in the PaveSpec main window.

CHAPTER 8: EXPECTED PAY DOCUMENTS

For any developed acceptance plan, it is always important to assess the risks of using the plan to both the agency and the contractor. For the Level 1 specifications developed using PaveSpec, one method of analyzing these risks is by developing expected pay charts. Expected pay charts are graphical representations of an acceptance plan that show the relation between the actual quality of a given lot and the pay the contractor can expect to receive (on average) for submitted lots of a given quality. The details of creating *Expected Pay* documents within PaveSpec are discussed in the following sections.

CREATING AND EDITING *EXPECTED PAY* DOCUMENTS

Each *Expected Pay* document is developed in reference to a previously simulated specification. A new *Expected Pay* document may be created using one of the following three methods:

1. Select the *Specification* document of interest in the *Specifications* tab of the *Database Control* dialog box, then select *Create Expected Pay Document* from the *File* menu.

2. Select the *Specification* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the toolbar button.

3. Select a previously defined *Sensitivity Analysis* document under the same specification (contained in the *Specifications* tab of the *Database Control* dialog box), then click on the button.

An existing *Expected Pay* document may be edited using one of the following methods:

1. Select the *Expected Pay* document of interest in the *Specifications* tab of the *Database Control* dialog box, then select *Setup* from the *File* menu.

2. Select the *Expected Pay* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the toolbar button.

3. Select the *Expected Pay* document of interest in the *Specifications* tab of the *Database Control* dialog box, then click on the button.

EXPECTED PAY DOCUMENT MAIN SCREEN

When you create a new *Expected Pay* document, the *Level 1 Expected Pay Chart Development* pop-up dialog box shown in figure 53 will appear. This dialog box consists
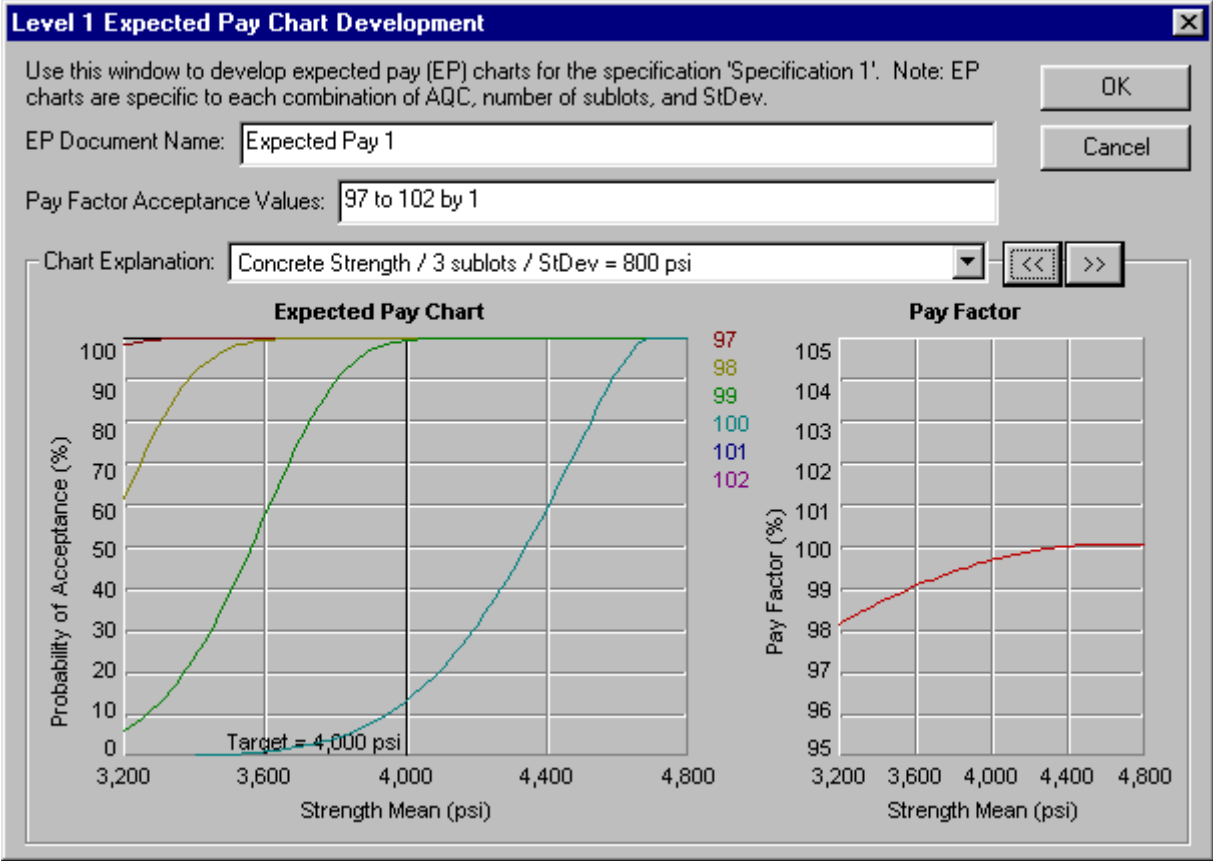
Figure 53. Example of the *Level 1 Expected Pay Document* dialog box.

of an *EP Document Name* (expected pay document name) input box, a *Pay Factor Acceptance Values* input box, and an area in which an expected pay chart and its related pay factor curve are both illustrated. Details regarding the different parts making up this dialog box are described in this section.

EP Document Name Input Box

You may change the name of the current *Expected Pay* document by entering a new name in the *EP Document Name* input box. The name you enter will be saved and shown as the *Expected Pay* document name in the *Specifications* tab of the *Database Control* dialog box.

Pay Factor Acceptance Values **Input Box**

Each individual expected pay curve corresponds to a specified pay factor acceptance value (e.g., 90%, 100%, 110%). Specifically, an expected pay curve illustrates the probability (at different AQC mean values) that the computed pay factor will be greater than or equal to a corresponding pay factor acceptance value.

The specific pay factor acceptance values, for which you would like to construct expected pay curves, are defined in the *Pay Factor Acceptance Values* input box. These values may be defined by entering specific values (e.g., "80; 90; 100"), defining a range of values (e.g., "80 to 110 by 5"), or a combination of specific values and defined ranges (e.g., "70; 80; 85 to 105 by 5"). Note that semi-colons are required between all entries in this input box.
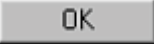
Expected Pay Chart Display Area

The bottom portion of the *Level 1 Expected Pay Chart Development* dialog box contains an area in which a selected expected pay chart and its corresponding pay factor chart are displayed. The pay factor curves shown in the pay factor chart are those defined during the specification development process. The expected pay curves on the expected pay chart correspond to those values defined in the *Pay Factor Acceptance Values* input box.

A different expected pay chart is constructed for every combination of AQC type, number of sublots, and standard deviation used in the development of the specification. Choose the specific expected pay chart you would like to view by selecting the appropriate case from the *Curve Explanation* list box.

GENERATING THE *EXPECTED PAY DOCUMENT* OUTPUT REPORT

The *Expected Pay Document* output report will automatically be generated and displayed when you choose to save the current *Expected Pay* document being defined. To save the current *Expected Pay* document, simply click on the [OK] button in the *Level 1 Expected Pay Chart Development* dialog box. The contents of the output report are described in more detail in chapter 9 of this appendix.

If you would like to exit the *Expected Pay* document development process without saving your changes, click on the [Cancel] button. Clicking either button will return you to the *Database Control* dialog box in the PaveSpec main window.

CHAPTER 9: PaveSpec OUTPUT REPORTS

PaveSpec generates five different types of output reports depending on whether you are developing a specification, using a specification, developing a drill-down document, conducting a sensitivity analysis, or developing expected pay charts. The layout and content of each of these output reports are described in detail in this chapter.

VIEWING OUTPUT REPORTS

You may view any output report by doing one of the following:

1. Select the document name in the *Specifications* tab of the *Database Control* dialog box, then click on the ▢ Open button.

2. Use the mouse to double-click on the chosen document name.

An example of an output report window containing a *Specification* output document is shown in figure 54.
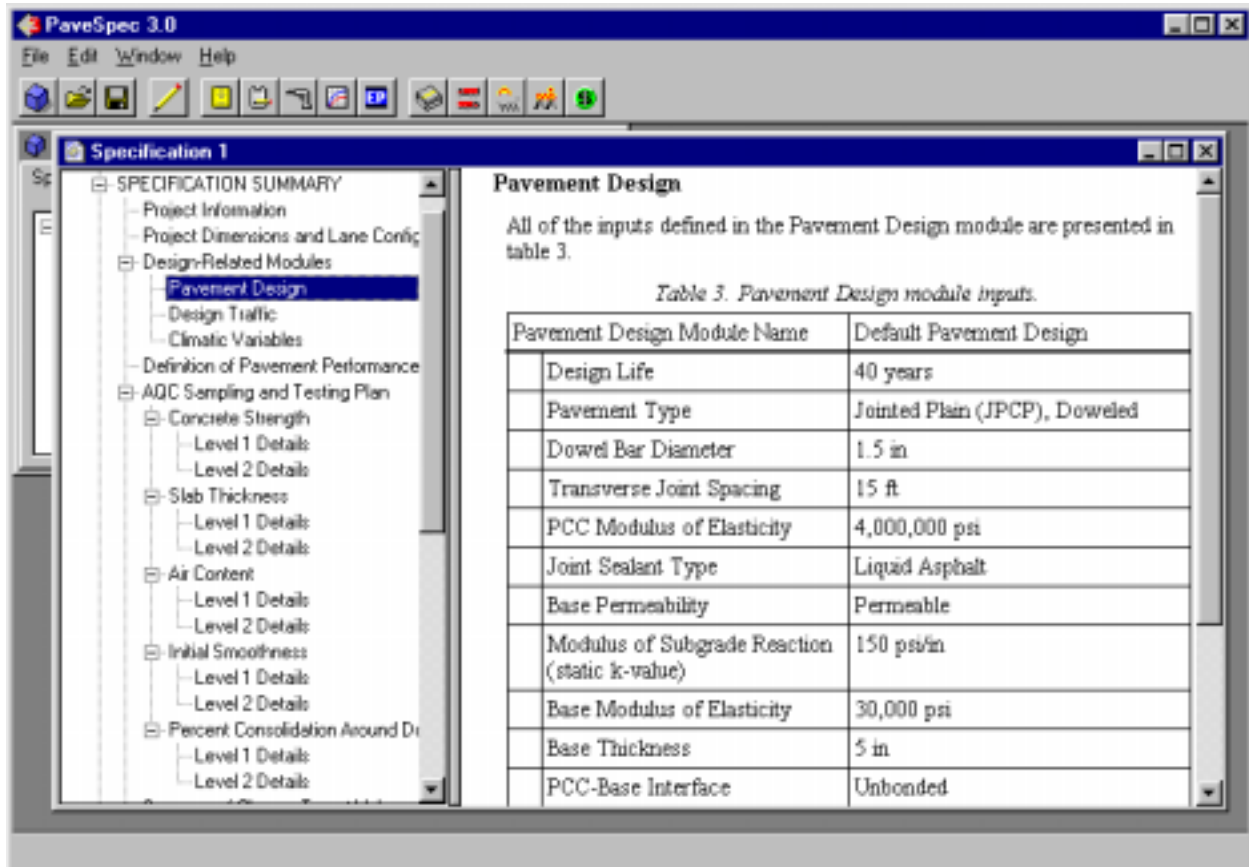
Figure 54. Example of an output report window containing a *Specification* document.

LAYOUT OF THE OUTPUT REPORT WINDOW

Every output report window is divided into two parts: a visual outline on the left and a document display area on the right. The visual outline is provided to show the complete organization of the active output document. The visual outline may be expanded or compressed by clicking on the boxes that contain plus (+) or minus (–) signs. The document display area shows the contents of the report section that is highlighted in the visual outline. To view a particular section of the output document, simply use the mouse or up and down arrow keys to select the report section you wish to view.

COPYING DATA FROM OUTPUT REPORTS

To copy data from an output report, select the section in the visual outline that you wish to copy and select *Copy Selected Page* from the *Edit* menu. This action will copy the highlighted section (including all subsections shown in the visual outline) to the Windows clipboard. This copied section may then be pasted into another software application using that software's paste command.

PRINTING DATA FROM OUTPUT REPORTS

To print data from an output report, select the section in the visual outline that you wish to print, and select *Print* from the *File* menu. This action will print the highlighted section (including all subsections shown in the visual outline) to the selected printing device.

CONTENTS OF THE SPECIFICATION OUTPUT REPORT

The specification output report is produced as a result of using the *Specification Wizard* to develop a specification and generate preconstruction output. The Specification output report is divided into two main sections: *Specification Summary* and *Preconstruction Output.*

The *Specification Summary* provides a large amount of feedback to the user regarding the inputs that were selected during the specification development process. Such items include summaries of the project general information; project dimensions and lane configuration; pavement design, design traffic, and climatic variable settings; definition of pavement performance; AQC sampling and testing plan details; chosen target values; defined M & R plan; and the defined unit costs. If this information differs between Level 1 and Level 2 specifications, the details of both are included. Brief descriptions of each subsection making up the *Specification Summary* part of the Specification output report are presented in table 13.

The *Preconstruction Output* section describes all aspects of both Level 1 and Level 2 (if a Level 2 specification is developed) preconstruction output. Such output includes

Table 13. Descriptions of the document subsections making up the *Specification Summary* part of the Specification output report.

Specification Output Report Subsection		Subsection Explanation
Project Information		Summary of the general project definition information defined on page 1 of the *Specification Wizard* (Basic Specification Information).
Project Dimensions and Lane Configuration		Summary of the project layout information defined on page 2 of the *Specification Wizard* (Dimensions and Lane Configuration).
Design-Related Modules		
	Pavement Design	Summary of the specific design-related variables making up the selected pavement design module defined on page 3 of the *Specification Wizard* (Design-Related Modules).
	Design Traffic	Summary of the details defining the design traffic module defined on page 3 of the *Specification Wizard* (Design-Related Modules).
	Climatic Variables	Summary of the specific climatic variables making up the selected climatic variables module defined on page 3 of the *Specification Wizard* (Design-Related Modules).
Definition of Pavement Performance and Selected AQC's		Summary of the chosen distress indicators and related AQC's used to define pavement performance within the developed specification. This information is defined on page 4 of the *Specification Wizard* (Definition of Pavement Performance).
AQC Sampling and Testing Plan		
	Concrete Strength	Details of the Level 1 and Level 2 concrete strength sampling and testing plans defined on page 5 of the *Specification Wizard* (AQC Sampling and Testing).
	Slab Thickness	Details of the Level 1 and Level 2 slab thickness sampling and testing plans defined on page 5 of the *Specification Wizard* (AQC Sampling and Testing).
	Air Content	Details of the Level 1 and Level 2 air content sampling and testing plans defined on page 5 of the *Specification Wizard* (AQC Sampling and Testing).
	Initial Smoothness	Details of the Level 1 and Level 2 initial smoothness sampling and testing plans defined on page 5 of the *Specification Wizard* (AQC Sampling and Testing).
	Percent Consolidation Around Dowels	Details of the defined Level 1 and Level 2 percent consolidation around dowels sampling and testing plans defined on page 5 of the *Specification Wizard* (AQC Sampling and Testing).
Summary of Chosen Target Values		Summary of the selected Level 1 and Level 2 AQC target values (means and standard deviations) defined on page 6 of the *Specification Wizard* (AQC As-Designed Target Value Definition).
Life-Cycle Cost-Related Modules		
	Maintenance and Rehabilitation Plan	Summary of the details of the selected M & R plan module defined on page 7 of the *Specification Wizard* (Life-Cycle Cost-Related Modules).
	Unit Costs	Summary of the unit cost-related variables making up the selected unit costs module defined on page 7 of the *Specification Wizard* (Life-Cycle Cost-Related Modules).

details of the procedure used to determine the representative as-designed LCC (for both Level 1 and Level 2 if appropriate); any Level 1 pay factor factorial tables; Level 1 pay factor curves and corresponding pay factor equations; and a description of the defined Level 1 composite pay factor equation. Brief descriptions of each subsection making up the *Preconstruction Output* part of the specification output report are presented in table 14.

Table 14. Descriptions of the document subsections making up the *Preconstruction Output* part of the specification output report.

Specification Output Report Subsection	Subsection Explanation
Level 1 Preconstruction Output	
Level 1 As-Designed Summary	A general summary of the procedure used to determine the representative Level 1 as-designed LCC as well as output showing the computed LCC means and standard deviations representative of each chosen number of sublots.
Level 1 As-Designed Simulation Details	A more detailed summary of the AQC samples and computed LCC's for each simulated lot used in the determination of the representative Level 1 as-designed LCC.
Level 1 Factorial Tables	Summary of the simulated individual AQC LCC's and pay factors used in the development of the Level 1 individual AQC pay factor charts. These factorials reflect those defined for each AQC on page 8 of the *Specification Wizard* (Simulation Control).
Level 1 Individual AQC Pay Factor Charts	Summary of the developed Level 1 individual AQC pay factor charts. Each chart contains plots of the pay factor curve regression equations defined on page 10 of the *Specification Wizard* (Defining Level 1 Pay Factor Equations).
Level 1 Individual AQC Pay Factor Equations	Summary of the developed Level 1 individual AQC pay factor regression equations (corresponding to each pay factor curve). These regression equations are those defined on page 10 of the *Specification Wizard* (Defining Level 1 Pay Factor Equations).
Level 1 Composite Pay Factor (CPF) Equation	Summary of the defined Level 1 composite pay factor equation defined on page 11 of the *Specification Wizard* (Level 1 Composite Pay Factor Equation Definition).
Level 2 Preconstruction Output	
Level 2 As-Designed Summary	A general summary of the procedure used to determine the representative Level 2 as-designed LCC as well as output showing the computed LCC means and standard deviations representative of each chosen number of sublots.
Level 2 As-Designed Simulation Details	A more detailed summary of the AQC samples and computed LCC's for each simulated lot used in the determination of the representative Level 2 as-designed LCC.

CONTENTS OF THE USE SPECIFICATION OUTPUT REPORT

The Use Specification output report is produced as a result of entering data in a Use Specification document. The main purpose of the Use Specification output report is to provide a summary of the actual field samples, computed pay factors, and

corresponding contractor pay adjustments. Brief descriptions of each subsection making up the use specification output report are presented in table 15.

Table 15. Descriptions of the document subsections making up the Use Specification output report.

Use Specification Output Report Subsection		Subsection Explanation
How Pay Factors Are Determined		
	Sampling and Testing Plan (Level 1 and 2)	Details of the Level 1 (and Level 2 if applicable) AQC sampling and testing plans defined for use with the specification.
	Level 1 Pay Factors	Summary of the individual AQC pay factor equations used to compute individual AQC as-constructed lot pay factors.
	Calculating the Level 1 Composite Pay Factor	Summary of the method used to compute as-constructed lot composite pay factors.
Sample Values (Level 1 and Level 2, if applicable)		
	Concrete Strength Samples	Summary of the as-constructed concrete strength samples and corresponding pay factors computed for each as-constructed lot.
	Slab Thickness Samples	Summary of the as-constructed slab thickness samples and corresponding pay factors computed for each as-constructed lot.
	Entrained Air Content Samples	Summary of the as-constructed entrained air content samples and corresponding pay factors computed for each as-constructed lot.
	Initial Smoothness Samples	Summary of the as-constructed initial smoothness samples and corresponding pay factors computed for each as-constructed lot.
	Percent Consolidation Around Dowels Samples	Summary of the as-constructed percent consolidation around dowels samples and corresponding pay factors computed for each as-constructed lot.
Project Pay Factor Summary (Level 1 and Level 2)		A complete summary of the Level 1 and Level 2 (if applicable) pay factors (individual AQC and composite) and corresponding pay adjustments computed for each as-constructed lot.

CONTENTS OF THE DRILL-DOWN DOCUMENT OUTPUT REPORT

The Drill-Down document output report is produced as a result of creating a Drill-Down document. The Drill-Down document contains simulation details for a chosen simulated lot (selected in the Drill-Down document main screen). The output report contains an overall sampling and LCC summary for the lot, as well as detailed distress and cost summaries for each of the sublots making up the lot. Brief descriptions of each subsection within the Drill-Down document output report are presented in table 16.

CONTENTS OF THE SENSITIVITY ANALYSIS DOCUMENT OUTPUT REPORT

The Sensitivity Analysis document output report is produced as a result of defining a Sensitivity Analysis document. The output report contains detailed summaries of the analysis results for each of the sensitivity analysis scenarios defined in the document's *Scenario Master List.* Brief descriptions of each subsection within the Sensitivity Analysis document output report are presented in table 17.

Table 16. Descriptions of the document subsections making up the Drill-Down document output report.

Drill-Down Document Output Report Subsection		Subsection Explanation
Lot Summary		Summary of the AQC samples generated for the chosen simulated lot, as well as an overall summary of the lot's LCC's.
	Details of Sublot…	The specific distress and cost details of each sublot within the chosen simulated lot are provided in these subsections. The details of each included sublot are presented independently in separate subdocuments of the output report.

Table 17. Descriptions of the document subsections making up the Sensitivity Analysis document output report.

Sensitivity Analysis Document Output Report Subsection		Subsection Explanation
Sensitivity Analysis Document Summary		Overall summary of the sensitivity analysis document. Specifically, this page of the output report contains brief descriptions of each of the sensitivity analysis scenarios outlined in the document's *Scenario Master List*.
	Sensitivity Analysis Scenario Details	The specific sensitivity analysis results (pay factors and pay adjustments associated with each defined quality scenario) for each defined sensitivity analysis scenario are provided in these subsections. The details of each sensitivity analysis scenario are presented independently in separate subdocuments of the output report.

CONTENTS OF THE EXPECTED PAY DOCUMENT OUTPUT REPORT

The Expected Pay document output report is produced as a result of defining an Expected Pay document. The output report contains detailed summaries of all of the specific expected pay charts defined in the expected pay document. Brief descriptions of each subsection within the Expected Pay document output report are presented in table 18.

Table 18. Descriptions of the document subsections making up the Expected Pay document output report.

Expected Pay Document Output Report Subsection		Subsection Explanation
Expected Pay Document Summary		Overall summary of the expected pay document. Specifically, this page of the output report provides a summary of the details (AQC type, number of sublots, and AQC standard deviation) that define each of the developed expected pay charts.
	Expected Pay Chart Details	The specific details for each defined expected pay chart (specific to a unique combination of AQC type, number of sublots, and AQC standard deviation) are provided in these subsections. The details of each expected pay chart are presented independently in separate subdocuments of the output report.

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