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15. Supplementary Notes

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16. Abstract

This is an addendum to the users manual of the comprehensive software package termed HIgh PERformance PAVing (HIPERPAV). This package, which incorporates the complex models developed, can be used as a stand-alone product to verify the overall effect of specific combinations of design, construction, and environmental inputs on early-age behavior of a PCCP (Portland cement concrete pavement) and BCO (bonded concrete overlay). This report provides color illustrations and an update of information in the users manual.

This volume is the third in a series. The other volumes in the series are:

FHWA-RD-98-167 Volume I: Final Report
FHWA-RD-98-168 Volume II: HIPERPAV Users Manual

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HIPERPAV Version 2.4 is an enhanced version of HIPERPAV Version 2.1. The objective of this addendum is to describe these improvements to the program and to explain any added features that were not included in the HIPERPAV Version 2.1 Users Manual, as well as to provide examples of the input and output screens for the program in color.

1. GETTING STARTED

Upon execution, the initial splash screen is displayed, as shown in figure 1.

Figure 1. HIPERPAV Version 2.4 splash screen.

After the software has loaded, the main menu appears (figure 2). The Menu Items and Toolbar features are discussed in the next section, as is the software execution procedure.

Figure 2. HIPERPAV Version 2.4 main menu components.

Menu Items

The File, Inputs, Run, View, and Help pull down menus are identical to the ones in HIPERPAV Version 2.1. However, the About HIPERPAV box in the Help pull down menu has changed (figure 3). It now has internet links to the Transtec, FHWA Turner-Fairbank and HIPERPAV web sites. Transtec and HIPERPAV information e-mail addresses are also included.

Figure 3. HIPERPAV Version 2.4 about box.

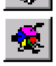
Toolbar

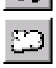
The toolbar of HIPERPAV Version 2.4 is shown in figure 4.

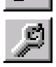
Figure 4. HIPERPAV Version 2.4 toolbar.

Four of the icons have been modified. They are:

 Opens the *General Design Parameters* dialog box for the current analysis module

 Opens the *Mix Design Parameters* dialog box for the current analysis module

 Opens the *Environmental Parameters* dialog box for the current analysis module

 Opens the *Construction Parameters* dialog box for the current analysis module

Software Execution

To execute the software, a new data input file or an existing data file can be opened via the menu items or the toolbar. The default window is shown in figure 5. The appearance of the Design Inputs, Mix Design Inputs, Environmental Inputs, Construction Inputs and Open Analysis Control Panel icons have been enhanced in Version 2.4 for both HIPERPAV (New JCP or jointed concrete pavement) and HIPERBOND (BCO or bonded concrete overlay) Analysis.

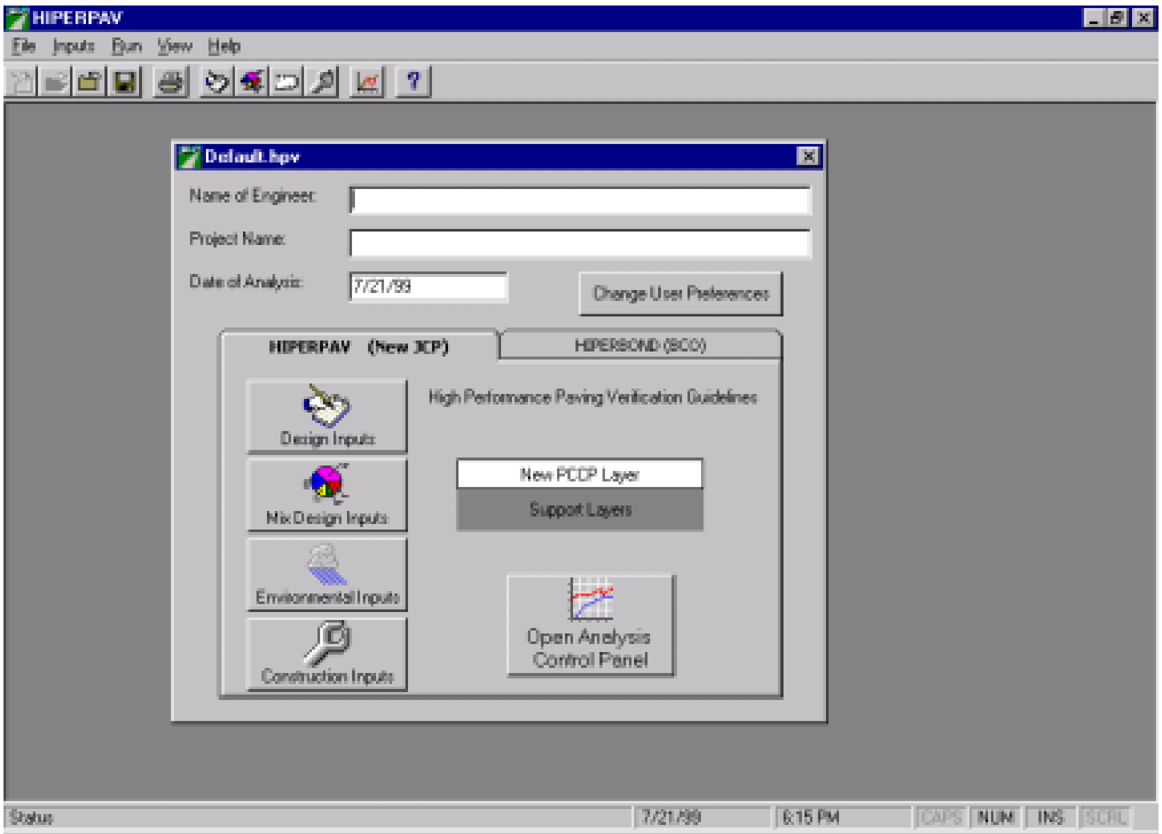


Figure 5. HIPERPAV Version 2.4 main menu with open document.

When executing the HIPERBOND (BCO) model, a warning message appears that cautions about the unvalidated nature of this model (figure 6). It has not been extensively calibrated or validated and should be used only at the users risk.

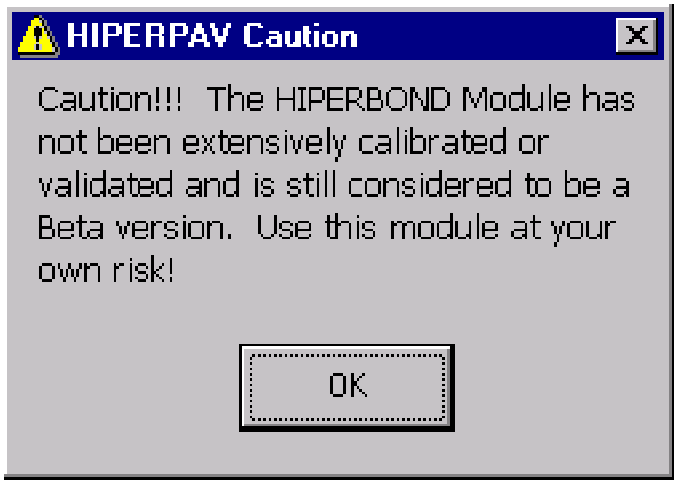


Figure 6. HIPERPAV Version 2.4 caution screen for HIPERBOND (BCO).

2. HIPERPAV MODULE INPUTS

Enhancements to the HIPERPAV Version 2.4 categories of input (Design, Mix Design, Environmental and Construction) will now be discussed.

Design Inputs (Figure 7)

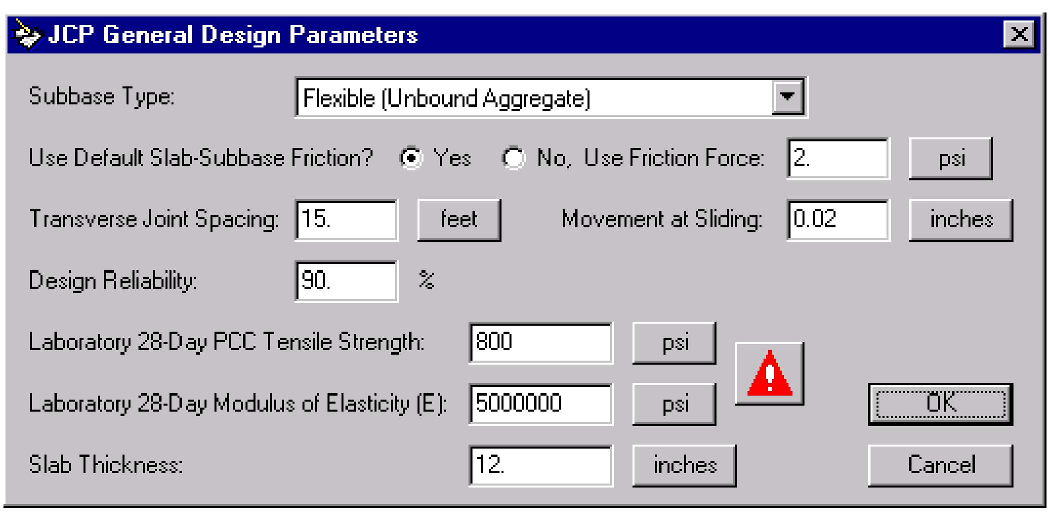
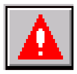


Figure 7. HIPERPAV Version 2.4 JCP general design parameters.

The JCP General Design Parameters dialog box is shown in figure 7. Three modifications have been made:

- Additional subbase types have been added in Version 2.4. Hot Mix Asphaltic Concrete (HMAC) and Asphalt Stabilized subbases are classified as either ‘Rough’ or ‘Smooth’ (figure 8). The default values of Slab-Subbase Friction and Movement at Sliding now change as a function of Subbase type.
- Laboratory 28-Day PCC Tensile Strength is input, rather than its Flexural Strength.
-  A warning note is added that explains the need for Laboratory-Measured values of 28-day Tensile Strength and Modulus of Elasticity (figure 9).

The same changes were made to the HIPERBOND (BCO) module as well.

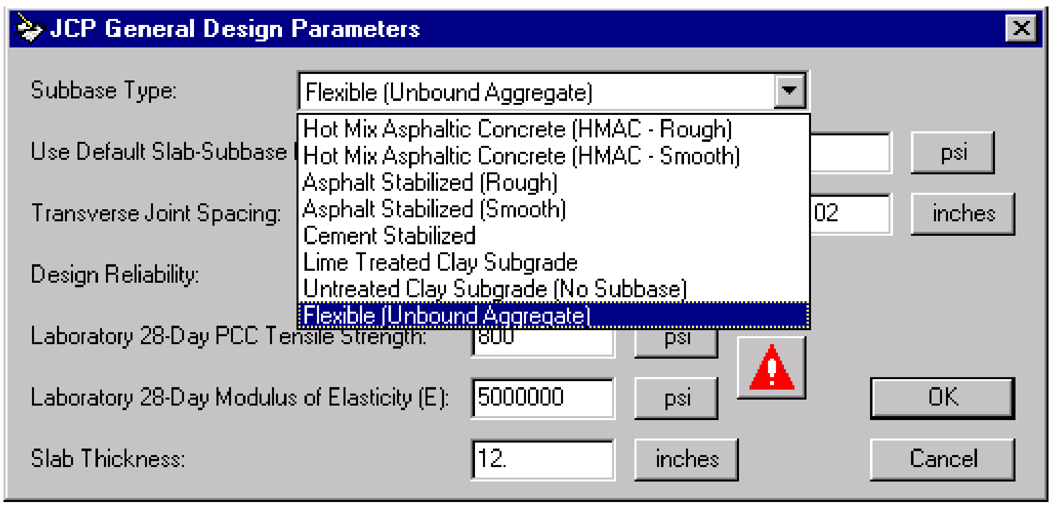


Figure 8. HIPERPAV Version 2.4 JCP general design parameters: subbase types.

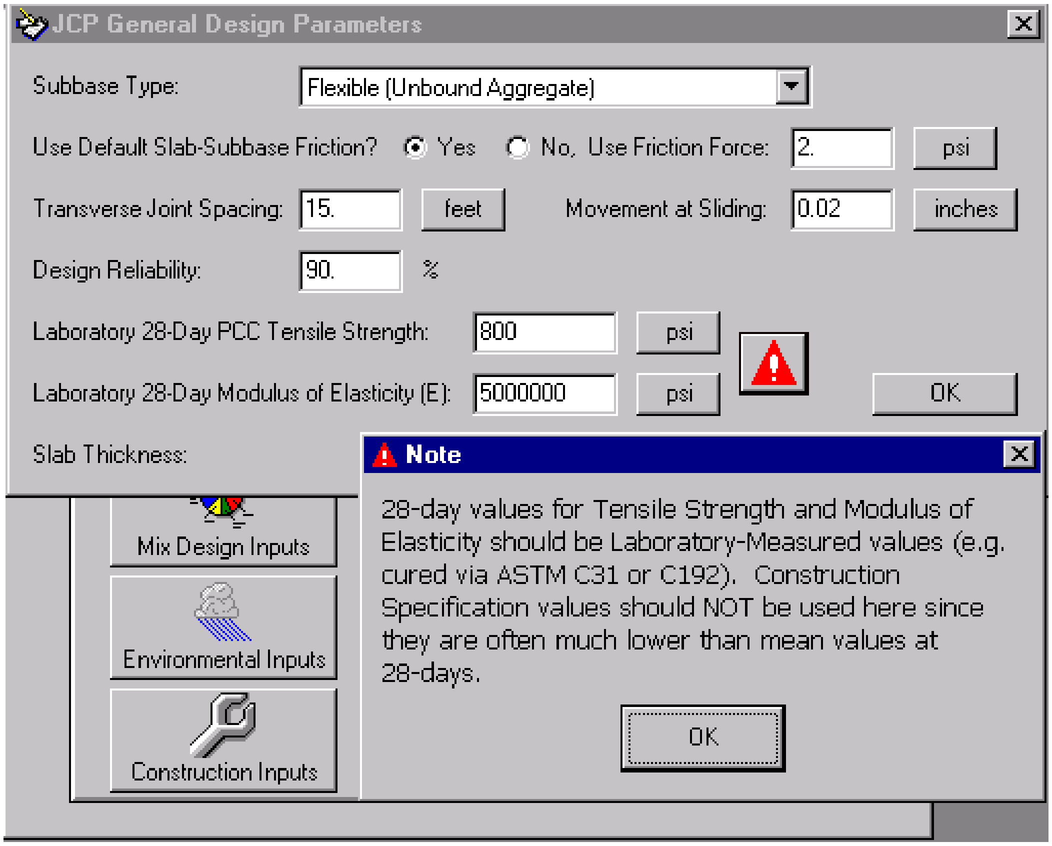
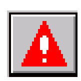


Figure 9. HIPERPAV Version 2.4 JCP general design parameters note.

Mix Design Inputs (Figures 10 and 11)

Enhancements have also been made to the JCP Mix Design Parameters in HIPERPAV Version 2.4, which are:

- In the Enter Maturity Data box,  a warning note has been added that explains the Maturity Method used in HIPERPAV (figure 10).
- A warning note has been added that warns the user in interpreting the results when using Chemical Admixtures due to the lack of verification (figure 11).
- A warning note has been added that warns the user in interpreting the results when using Mineral Admixtures due to the lack of verification (figure 12).
- The default value of Aggregate Thermal Coefficient is displayed for the selected Coarse Aggregate Type.
- Type C Fly Ash is incorporated into the mix design.
- Water/Cementitious Materials (w/cm) Ratio is immediately calculated based on the input mix design (figure 13).

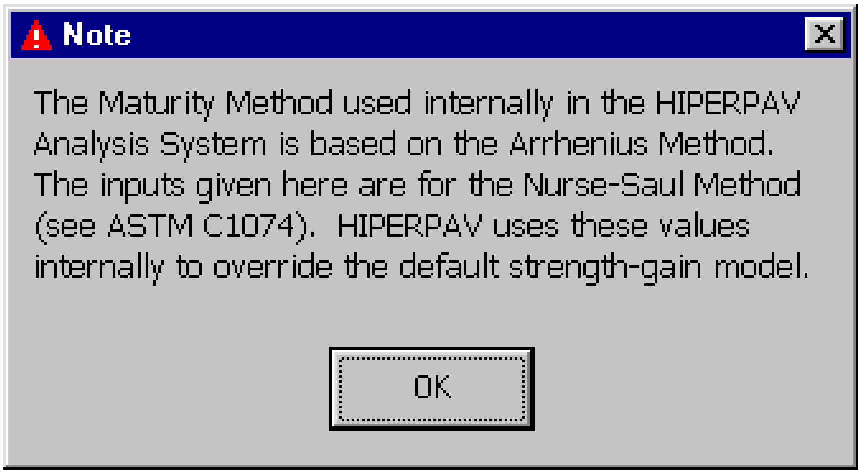


Figure 10. HIPERPAV Version 2.4 JCP mix design parameters: laboratory maturity data warning.

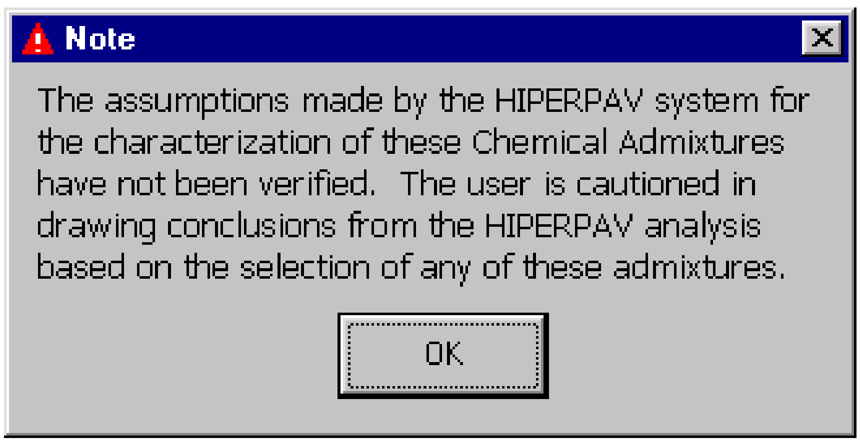


Figure 11. HIPERPAV Version 2.4 JCP mix design parameters: chemical admixture use warning.

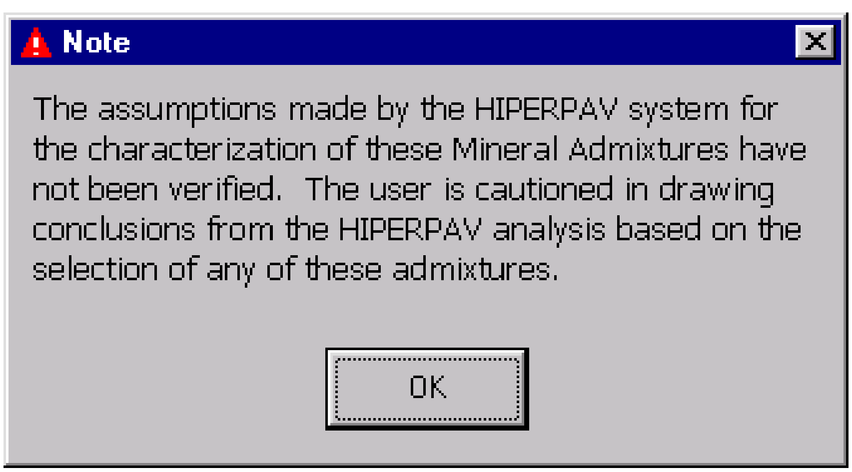


Figure 12. HIPERPAV Version 2.4 JCP mix design parameters: mineral admixture use warning.

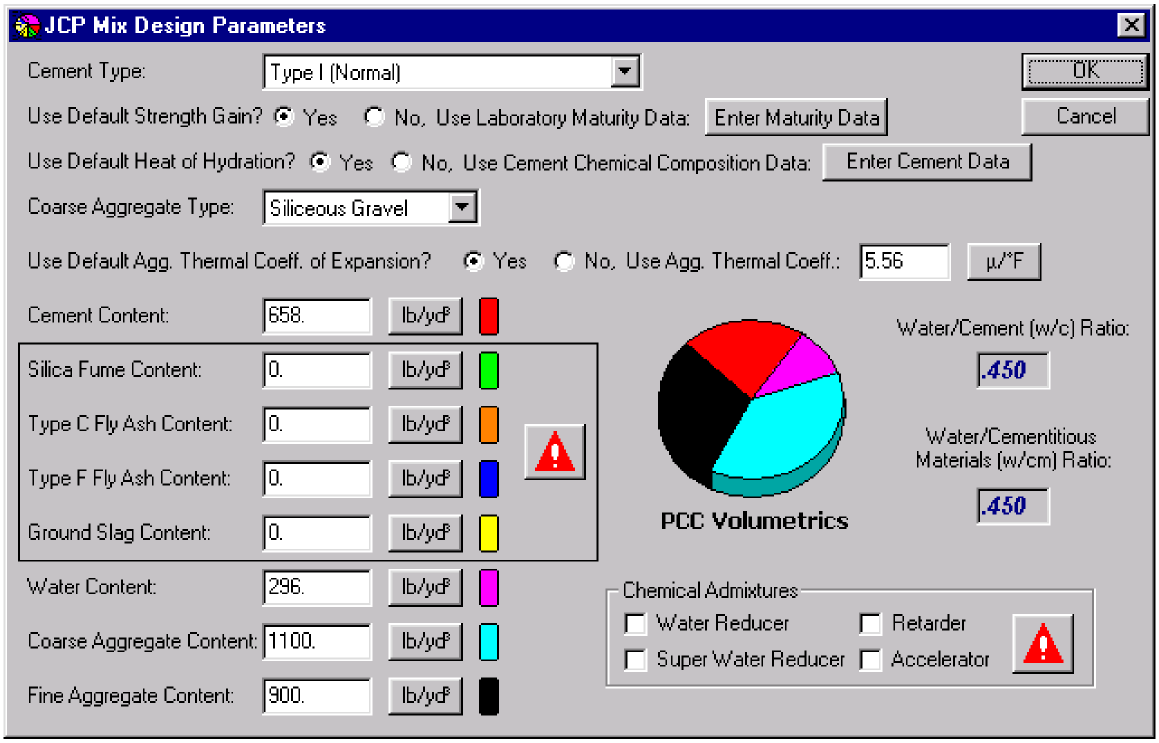


Figure 13. HIPERPAV Version 2.4 JCP Mix Design Parameters.

The same enhancements were also made to the HIPERBOND (BCO) model.

Environmental Inputs

No modifications were made.

Construction Inputs (Figure 14)

Several modifications have been made to the JCP Construction Parameters prompt box:

- Age of Opening to Traffic (found in HIPERPAV Version 2.1) has been deleted.
- Age at Application of Curing has been added.
- Age at Removal of Curing has been added. This is applicable only when polyethylene sheeting, cotton mats or burlap curing methods are used.

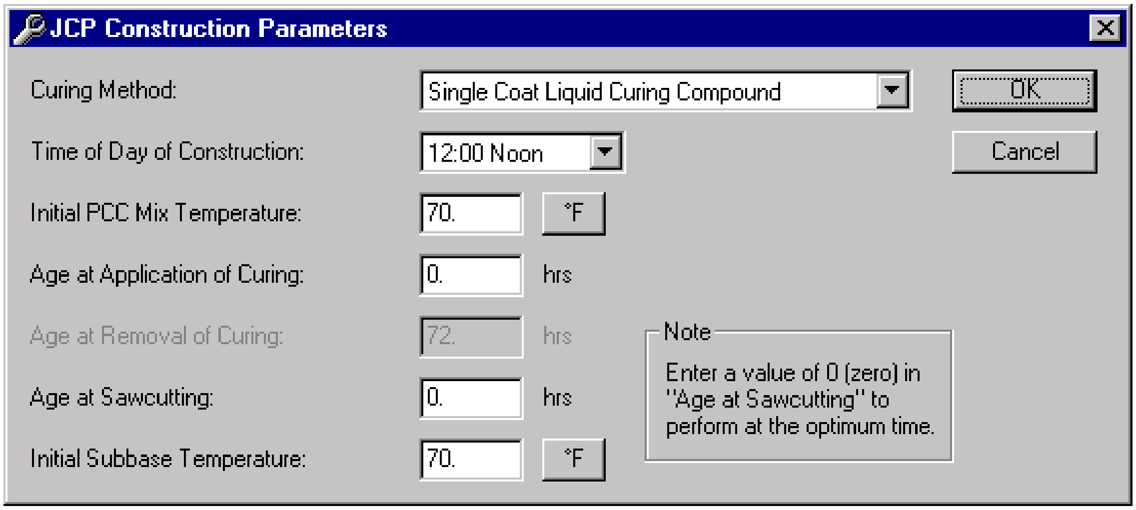


Figure 14. HIPERPAV Version 2.4 JCP construction parameters.

3. HIPERPAV CONTROL PANEL

The layout of the HIPERPAV JCP Control Panel (figure 15) has been modified in HIPERPAV Version 2.4:

- The Moisture Loss Distress Analysis has been renamed Evaporation Rate Analysis (HIPERMOIST).
- The legend and the current values display boxes have been rearranged.

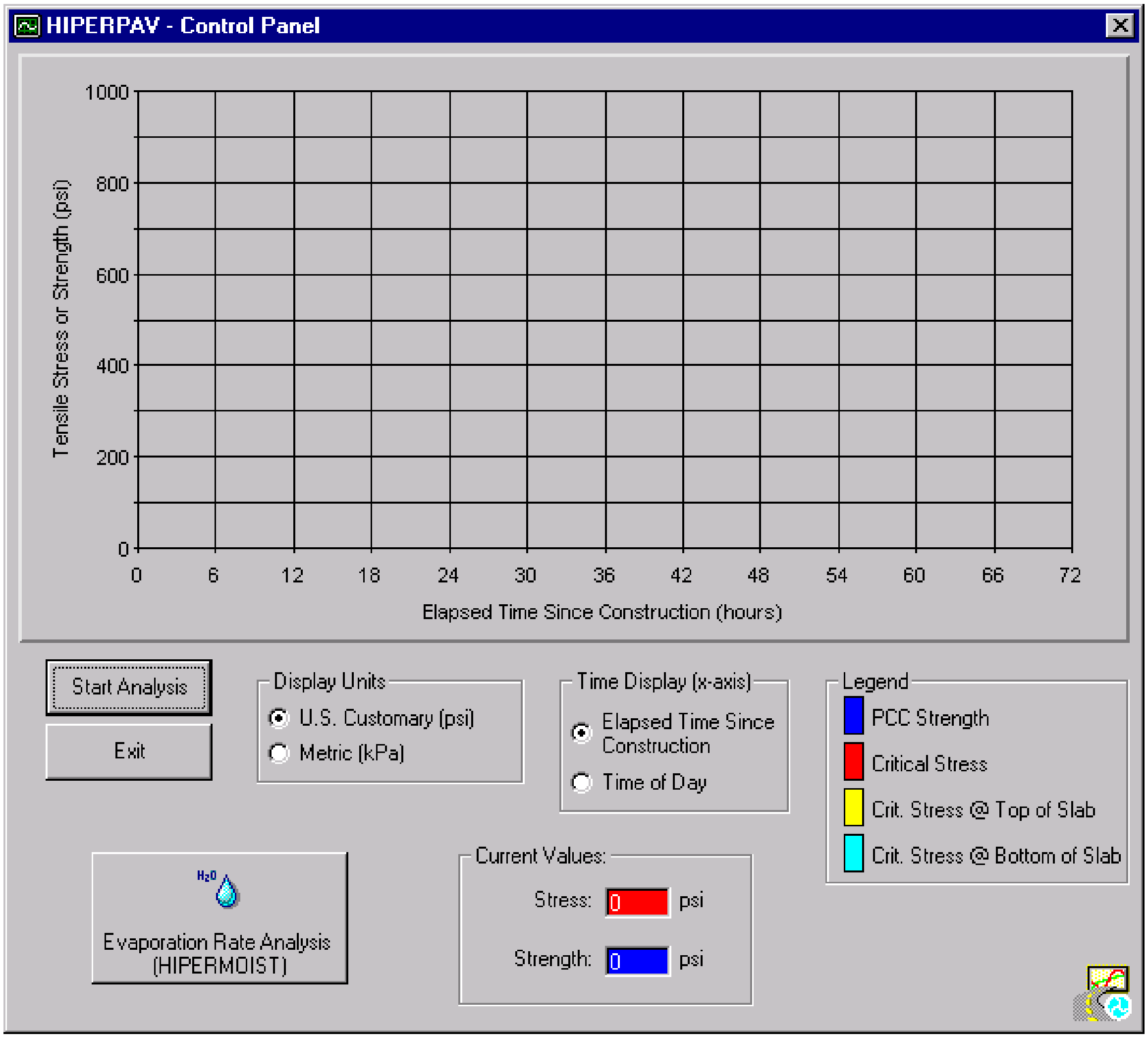


Figure 15. HIPERPAV Version 2.4 JCP control panel.

4. MOISTURE LOSS ANALYSIS CONTROL PANEL

No changes were made.

5. INTERPRETATION OF HIPERPAV ANALYSIS RESULTS

HIPERPAV executes a series of powerful algorithms that calculate the PCC pavement stress and strength development for the first 72 h following placement. A graphical screen appears and the analysis results are plotted in real time. The user can observe the strength and stress development and assess the behavior of the pavement based on user inputs. HIPERPAV identifies possible problem areas in the given set of inputs and informs the user of the potential for early-age damage.

Figure 16 shows an output screen for the default run. In this case, the mix design, the pavement design and the construction practices during PCC pavement placement all contribute to a high probability of good performance. The PCC strength curve is the top curve. It is higher than the critical stress curve at all times during the first 72 h. Note the cyclical manner of the critical stress curve. Peaks in the stress curve correspond to critical periods, either when axial stresses are dominant or when curling stresses are dominant. The former dominate in the early-morning hours and the latter just after midday. For this scenario, the probability of PCC pavement distress (random transverse cracking) is low because the critical stress does not exceed the strength during the first 72 h after placement.

Figure 17 shows an output screen for a run where the combination of mix design, pavement design, construction and weather conditions during placement result in poor PCCP performance. The difference between this run and the default one is the addition of a cold front at 30 h. Lower ambient temperatures induce a "thermal shock" which can lead to premature cracking.

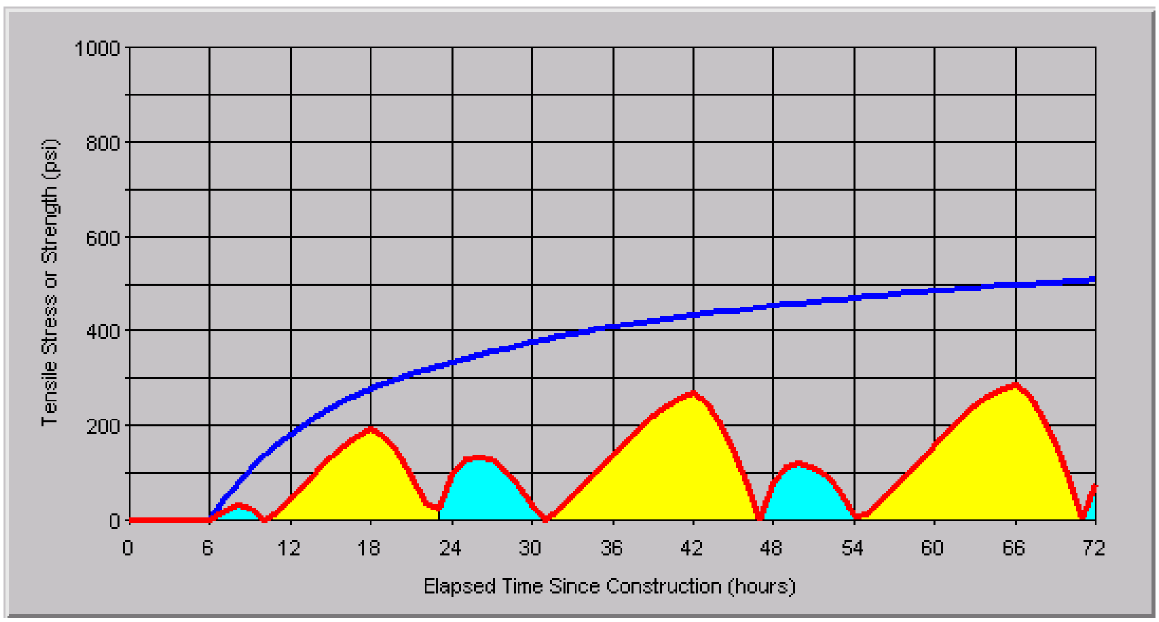


Figure 16. HIPERPAV module postprocessor output screen of good performance.

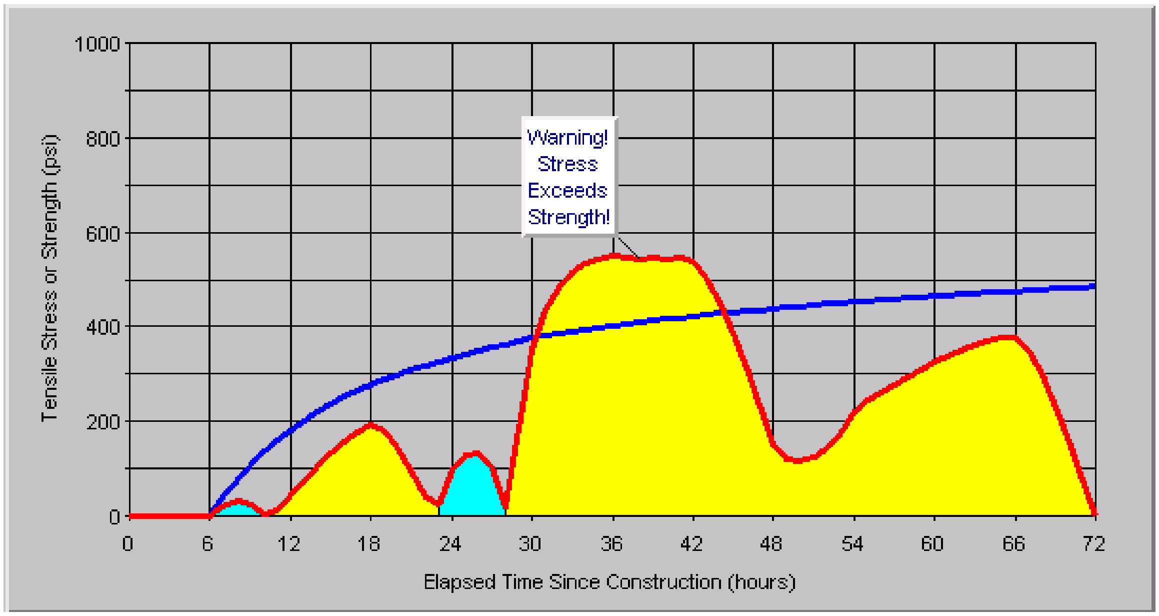


Figure 17. HIPERPAV module postprocessor output screen of poor performance.

6. INTERPRETATION OF HIPERBOND ANALYSIS RESULTS

The results of the HIPERBOND module are plotted in four curves: two curves for the time dependent critical shear and tensile stresses at the bond interface and two curves for the corresponding strength in the shear and tensile directions. As with the HIPERPAV module, the stress and strength curves are compared. The shear stresses are compared to the shear strengths, and the tensile stresses are compared to the tensile strengths. If stress exceeds strength in either shear or tension, delamination is possible. Figure 16 shows the default run for a set of inputs that yield good performance. As can be seen, neither of the stress curves exceed the corresponding strength curves; thus, good performance is anticipated. Figure 17, however, shows a run for inputs that cause the BCO system to perform poorly. A tensile failure is predicted to occur during the first 72 h. This failure could lead to excessive delamination and to shorter pavement life. The sensitivity of the input variables to the HIPERBOND module analysis should be assessed. If several combinations of inputs are satisfactory, then the most economical (or available) input values should be used.

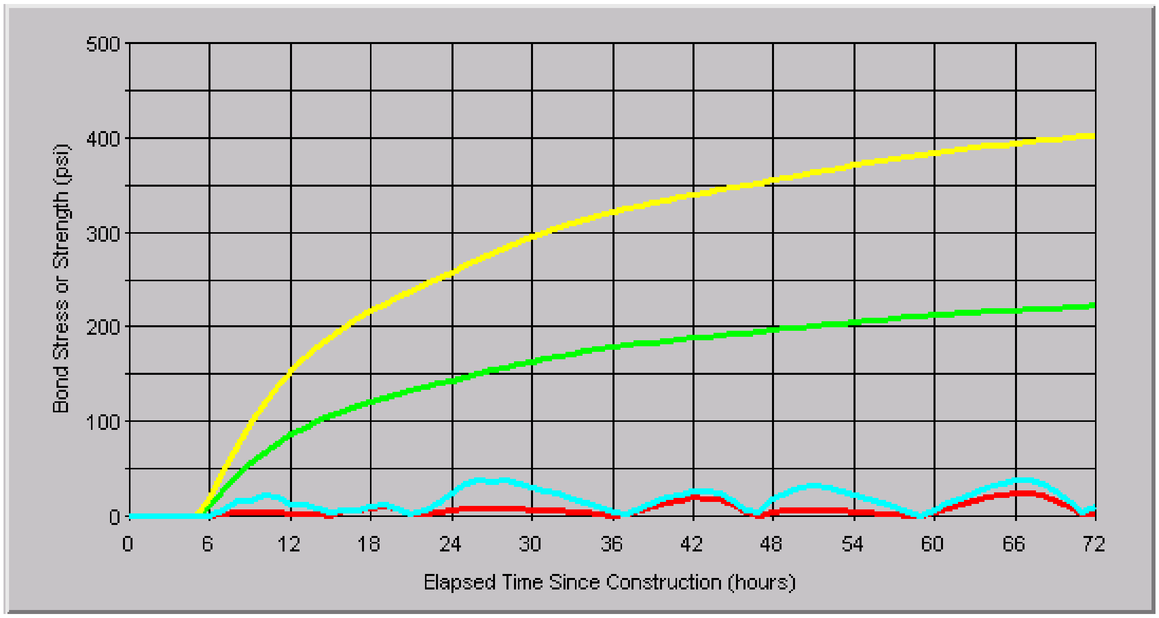


Figure 18. HIPERBOND module postprocessor output screen of good performance.

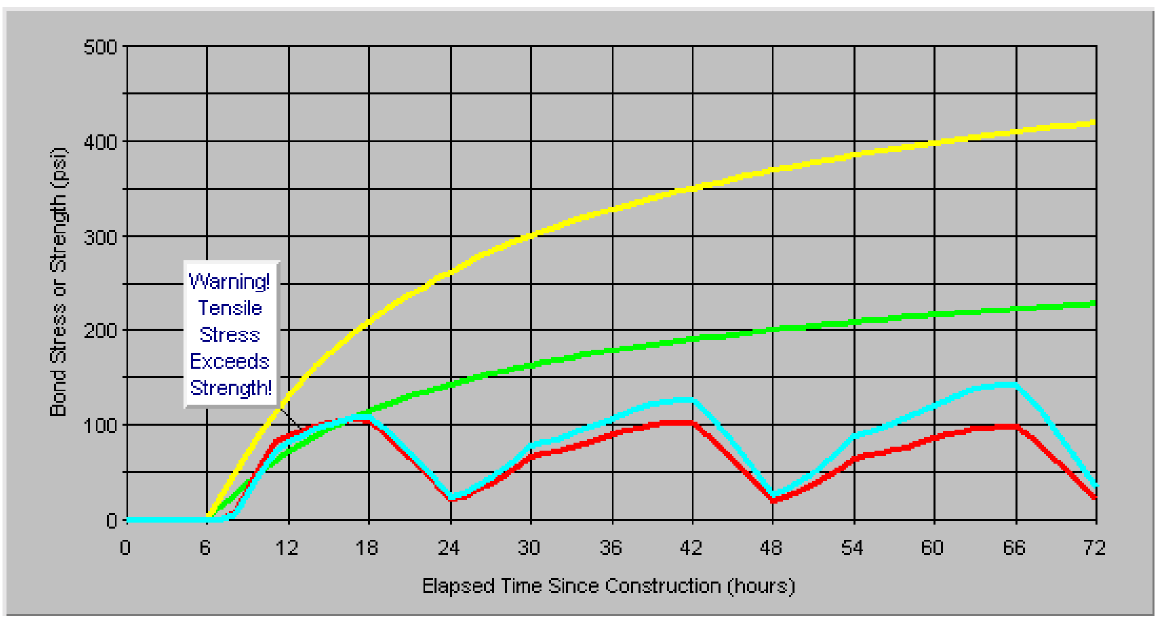


Figure 19. HIPERBOND module postprocessor output screen of poor performance.

7. PRINTING REPORTS

No changes were made.