APPENDIX O

USER’S GUIDE TO THE REFLECTION CRACKING MODEL
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-1</td>
<td>AC over AC pavement at Lincoln, Maine (WF)</td>
<td>O-23</td>
</tr>
<tr>
<td>O-2</td>
<td>AC over JRC pavement at Beaver, Pennsylvania (WF)</td>
<td>O-23</td>
</tr>
<tr>
<td>O-3</td>
<td>AC over FC over AC pavement at Frederick, Maryland (WF)</td>
<td>O-24</td>
</tr>
<tr>
<td>O-4</td>
<td>AC over CRC pavement at Minnesota, Washington (WF)</td>
<td>O-24</td>
</tr>
<tr>
<td>O-5</td>
<td>AC over PetroGrid over PCC pavement at Waco, Texas (WNF)</td>
<td>O-25</td>
</tr>
<tr>
<td>O-6</td>
<td>AC over PetroGrid over AC pavement at Amarillo, Texas (DF)</td>
<td>O-25</td>
</tr>
<tr>
<td>O-7</td>
<td>AC over AC pavement at Pittsylvania, Virginia (WNF)</td>
<td>O-26</td>
</tr>
<tr>
<td>O-8</td>
<td>AC over FC over AC pavement at Yazoo, Mississippi (WNF)</td>
<td>O-26</td>
</tr>
<tr>
<td>O-9</td>
<td>AC over AC pavement at Deaf Smith County, Texas (DF)</td>
<td>O-27</td>
</tr>
<tr>
<td>O-10</td>
<td>AC over AC pavement in Pinal, Arizona (DNF)</td>
<td>O-27</td>
</tr>
<tr>
<td>O-11</td>
<td>Ac over Petrotac Std. 1 over PC pavement at New York, New York (WF)</td>
<td>O-28</td>
</tr>
</tbody>
</table>
The Reflection Cracking Prediction System for HMA Overlays Program includes three main parts which are **General Information** input, **Pavement Related** input, and **Output**. Pavement related input includes **Traffic**, **Climate**, and **Structure & Material Properties**.
The **General Information** allows the selection of five types of overlay in this program. **Design Life** is the maximum number of days to analyze and predict the appearance the extent and severity of reflection cracking. **Construction Information** gives the date when construction is completed and the overlay is placed in service.
Annual Average Daily Truck Traffic (AADTT) and Annual Number of Axles (ANA) for each category are the user input options in the Traffic Load Input. Operational Speed is the design speed limit in miles per hour.
Traffic Load Input

Vehicle Class
- Single Axle
- Tandem Axle
- Tridem Axle
- Quad Axle

Traffic Input Mode
- Annual Average Daily Truck Traffic (AADTT)
- Annual Number of Axles (ANO) for each category

- Category No. 1
- Category No. 2
- Category No. 3
- Category No. 4
- Category No. 5
- Category No. 6
- Category No. 7

- Operation Speed (mph)
- Traffic Axle Growth (%)
Climate data includes air temperature, wind speed, solar radiation, albedo, emissivity, and absorption data. The User can choose any of the 150 weather stations in this program, or can use the EICM model from the MEPDG to generate the *.icm climate data, and load the generated *.icm data into this program. In order to choose the weather station from the database within this program, the user should select the Climate Data Using Model. The climate data from this database can provide the information from 1984 to 2002. Therefore, the user can choose to repeat any specified year in their reflection cracking prediction, or the user can choose the year to start a sequence of years of the climate data.
**Structure & Material Properties** information includes the pavement layer thickness, mixture and binder data. When the input data is completed, the color of the Edit button turns from red to green.
In the AC overlay, **Aggregate Gradation** and **Volumetric Properties** are required. For the input of the **Binder Property**, three levels are considered in this program. Level one requires the user to provide all six of the binder the parameters. Level two parameters are specified by giving the Superpave binder performance grade. The climatic zone input in the previous climatic input provides the remainder of the binder information from historical data on binders used in that region. With Level three input, all of the parameters are determined from our database of the mean binder data used in the previously specified climate zone.
In the input for the \textbf{Existing AC} layer, the Level one input of the backcalculated FWD modulus can be at more than one temperature. Levels two and three input can be a measured or an assumed modulus value.
Inputs for **Base** and **Subgrade** layers require moduli and Poisson Ratios. Since the modulus varies with the temperature, Level one input requires **Monthly Values** of the layer moduli. Level two and three input requires only a mean annual **Typical Value** of the layer modulus.
The next step is to provide the calibration parameter set. To complete this step, the user can go to **Options** and click **Calibration Settings**. This program provides two options to the user which are default calibration parameters and the user’s own calibration parameters. If the user selects the default parameter, the program will employ a set of calibration parameters that depends on the climatic zone and pavement structure that the user provides in **General Information** and **Climate Input**. The user can also click **Show Default Values** to see these values. If the user selects to input their own calibration parameters, the user needs to input all of the 15 $\alpha$ parameters and 15 $\beta$ parameters. However, in the case that the user does not have calibration data for one or more severity levels, they will need to input **zero** in each blank box of that severity level for both $\rho$ and $\beta$. Click **OK** to finish the calibration setting.
If all of the required input information is completed, the color of the button of each part should turn from a red color to a green color. Then click the **Analysis** button and this program will start to analyze the reflection cracking.
When **Analysis Status** shows **Completed**, the output results are ready to be viewed on the right side.
The results are shown in Excel files. The **Input Summary** Table shows the summary information of this pavement. The **General Result** summarizes the information of reflection cracks due to thermal, shearing, and bending. It also shows the summary of the three severity levels (LMH, MH, and H severity). The Cracking Plot shows the severity curves as a percentage of the total crack length in the original pavement surface versus the number of days.
No. of Days when ‘% Total Length of Cracks’ = 100/e based on crack severities (L–Light, M–Medium, H–High)

<table>
<thead>
<tr>
<th>Severity</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>L+M+H</td>
<td>4488</td>
</tr>
<tr>
<td>M+H</td>
<td>6733</td>
</tr>
<tr>
<td>H</td>
<td>18851</td>
</tr>
</tbody>
</table>
Figures O-1 to O-11 illustrate some results of using the reflection cracking prediction program to predict the crack extent and severity. Each of the figures is the prediction by one of the eleven sets of model calibration coefficients that were developed in this project. In some cases such as in Figure O-1, the high severity distress required over 100 days to reach 36.8% of the total length of cracks in the original pavement surface. It is the predicted development of transverse reflection cracking in an overlay over a cracked asphalt surface layer in a Wet-Freeze Climate Zone. Figures O-2 and O-3 illustrate the more common graphs of the development of the different levels of severity of reflection cracking. Figure O-2 is for an overlay over a jointed reinforced concrete pavement in a Wet-Freeze Climate Zone. Figure O-3 is for an overlay over an open-graded friction course which was used as a strain absorbing membrane interlayer (SAMI) over a cracked asphalt surface layer in a Wet-Freeze Climate Zone.

Another special case is when the high severity curve remains at zero percent of the total length of cracks in the original pavement surface. This is because there were no high severity data to use for calibration. This was the case for all of the overlaid pavements shown in Figures O-4, O-5, and O-6. Figure O-4 is for an overlay over a continuously reinforced concrete pavement in a Wet-Freeze Climate Zone. Figure O-5 is for an overlay over a geosynthetic reinforced interlayer over a jointed concrete pavement in a Wet-No Freeze Climate Zone. Figure O-6 is for an overlay over a geosynthetic reinforced interlayer over a cracked asphalt surface layer in a Dry-Freeze Climate Zone.

Figure O-7 is for an overlay over a cracked asphalt surface layer in a Wet-No Freeze Climate Zone. Figure O-8 is for an overlay over an open graded friction course which was used as a strain-absorbing membrane interlayer (SAMI) over a cracked asphalt surface layer in a Wet-No Freeze Climate Zone. Figure O-9 is for an overlay over a cracked asphalt surface layer in a Dry-Freeze Climate Zone. Figure O-10 is for an overlay over a cracked asphalt surface layer in a Dry-No Freeze Climate Zone. Finally, Figure O-11 is for an overlay with a geosynthetic reinforcing interlayer over a jointed concrete pavement in a Wet-Freeze Climatic Zone.
Figure O-1. AC over AC pavement at Lincoln, Maine (WF).

Figure O-2. AC over JRC pavement at Beaver, Pennsylvania (WF).
Figure O-3. AC over FC over AC pavement at Frederick, Maryland (WF).

Figure O-4. AC over CRC pavement at Minnesota, Washington (WF).
Figure O-5. AC over PetroGrid over PCC pavement at Waco, Texas (WNF).

Figure O-6. AC over PetroGrid over AC pavement at Amarillo, Texas (DF).
Figure O-7. AC over AC pavement at Pittsylvania, Virginia (WNF).

Figure O-8. AC over FC over AC pavement at Yazoo, Mississippi (WNF).
Figure O-9. AC over AC pavement at Deaf Smith County, Texas (DF).

Figure O-10. AC over AC pavement in Pinal, Arizona (DNF).

O-27
Figure O-11. AC over Petrotac Std. 1 over PC pavement at New York, New York (WF).