APPENDIX I
GENETIC ALGORITHM AND SOFTWARE TOOL FOR CALIBRATING ACP PERFORMANCE PREDICTION MODELS

GA Steps

GA Step 1: Initialization

As mentioned earlier, there are eight DVs (β_p, A_p ,β_l , A_l, β_m, A_m, β_h, A_h) that affect the objective function. Firstly, the DVs are generated using a uniform distribution within the ranges shown in Eq. I-1 and I-2. However, as discussed earlier, the objective function is very sensitive to β. It was observed that for β higher than a certain value (depending on the value of coefficient *A*), the produced L values (not the objective function) are all near 0. This significantly retards the search convergence. To overcome this problem, the *A* coefficient is generated by a uniform distribution in the range of [1, 1000] and β is generated by a uniform distribution in the range of 0 and a dynamic maximum value (MAX), which is calculated based on the generated A.

$1 < \beta_p , \beta_l , \beta_m , \beta_h < MAX$ .....(I-1)

$1 < A_p , A_l , A_m , A_h < 1000$ .....(I-2)

Where:
β_p , β_l , β_m , β_h , A_p , A_l , A_m , A_h are Decision Variables; and MAX = dynamic maximum value calculated based on generated *A*.

GA Step 2: Parent Selection

Ranking selection was devised in the algorithm to preserves a constant selection pressure by sorting the population on the basis of the fitness and then allocating selection probabilities according to their rank.

GA Step 2: Crossover

Whole Arithmetic crossover is the most commonly used continuous and real-valued operator (Michalewicz and Fogel 2010) and was used in this work. α is a random number generated in the range of [0,1] with a uniform distribution.

$\text{Child 1} = \alpha.\underline{x}_1 + (1-\alpha).\underline{y}_2$ .....(I-3)

$\text{Child 2} = \alpha.\underline{x}_2 + (1-\alpha).\underline{y}_1$ .....(I-4)

GA Step 3: Mutation

Nonuniform Mutation with Normal Distribution is used. This method is achieved by adding a value (either positive or negative) according to a normal distribution with a mean value of zero and a user-defined standard deviation.

GA Step 4a: Convergence-Survivor Selection

Replace Worth was used in this process because it is normally considered the preferred survivor selection method in which individuals are replaced in the population. In this scheme, the worst members are selected for replacement.

GA Step 4b: Convergence-Constraint Handling

In this problem, the infeasible search space is convex and constitutes a reasonable part of the whole search space. Thus, *Rejecting Infeasible Solutions* is selected as the preferred constraint handling method.

GA Step 4c: Convergence-Stopping Criteria

The degree of homogeneity of the population is one useful measure of convergence. Monitoring the "best-so-far" objective fitness is also a simple and effective measure for the stopping criterion (De Jong 2006). In this work, a combination of both measures is used as the stopping criterion. In other words, the loop ends, only when the "best-so-far" objective fitness does not change for a number of iterations and the difference between the best fitness value and the 20th best fitness within the population is less than a certain limit (defined by the user).

Software Tool

The GA was coded in a software tool to facilitate the model calibration process. This software tool has four main components (see Figure I1), as follows:

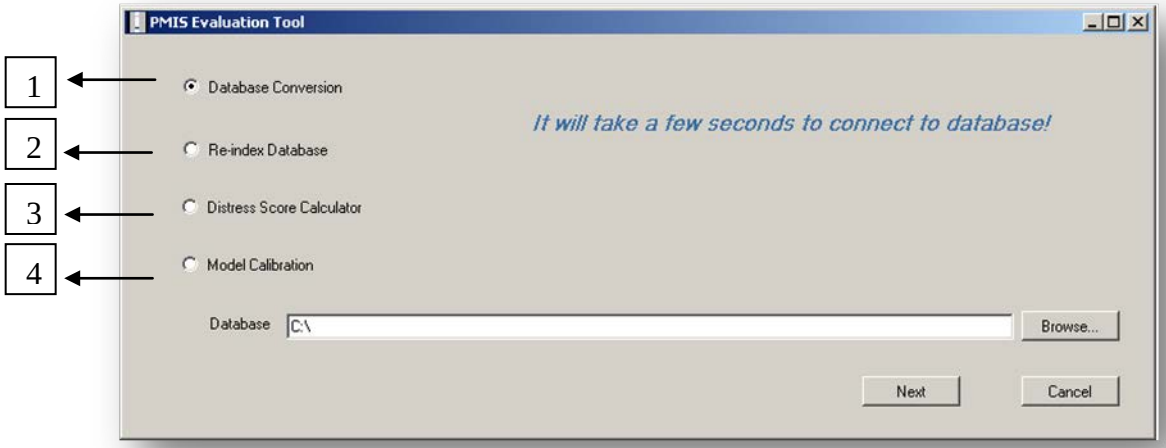

Figure I1. Initial Graphical Interface of the Software.

1- Database Conversion: This module allows for reading and processing Access database files extracted from the PMIS database (see Figure I2).

2- Re-index Database: This functionality improves the computational speed of processing data and running the calibration process (see Figure I3).

3- Distress Score Calculator: This module allows the user to compute DS of any given pavement section by entering pavement type, district, county, last M&R treatment type, and 20-year projected ESALs (see Figure I4).

4- Model Calibration: This module applies the computational process (and solves the optimization problem) of calibrating the ACP performance prediction models (see Figures I5 and I6).

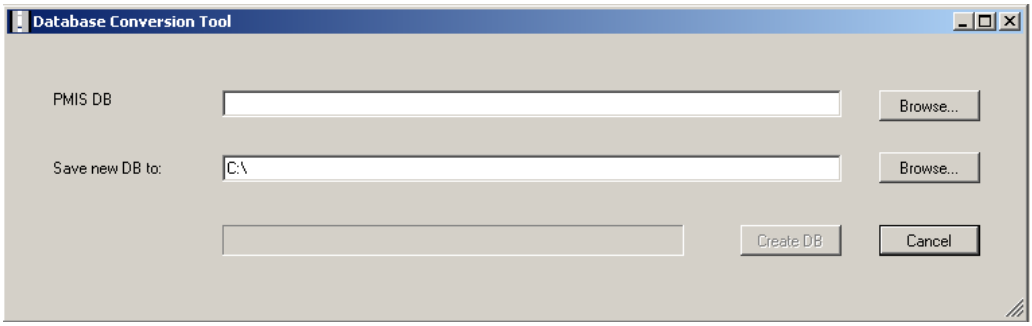

Figure I2. Database Conversion Module.

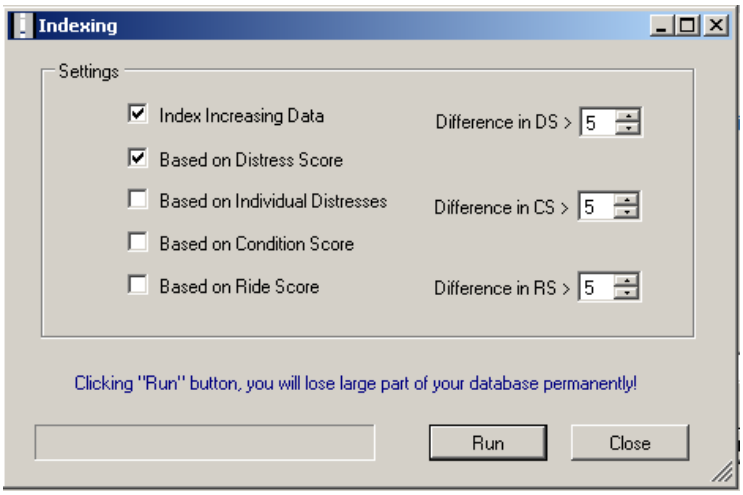

Figure I3. Graphical User Interface for Database Indexing.

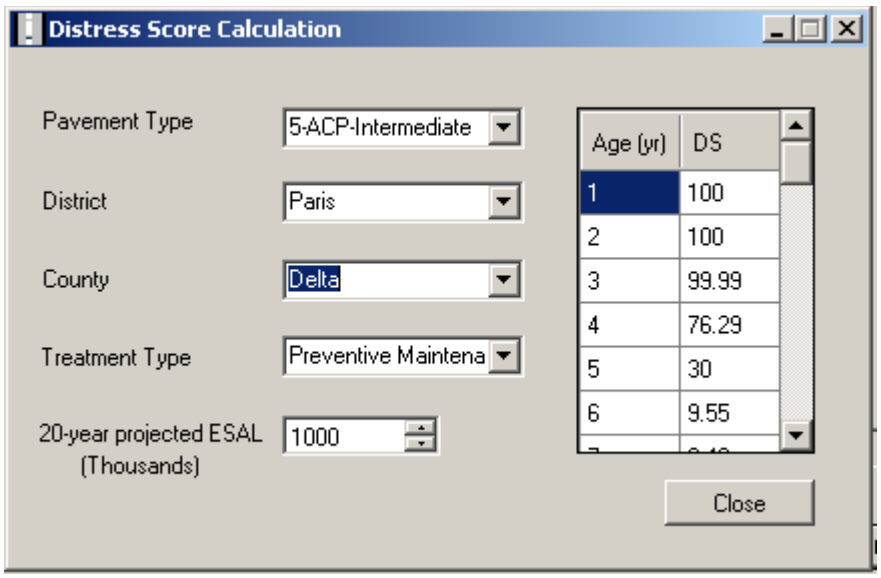

Figure I4. Distress Score Calculator.

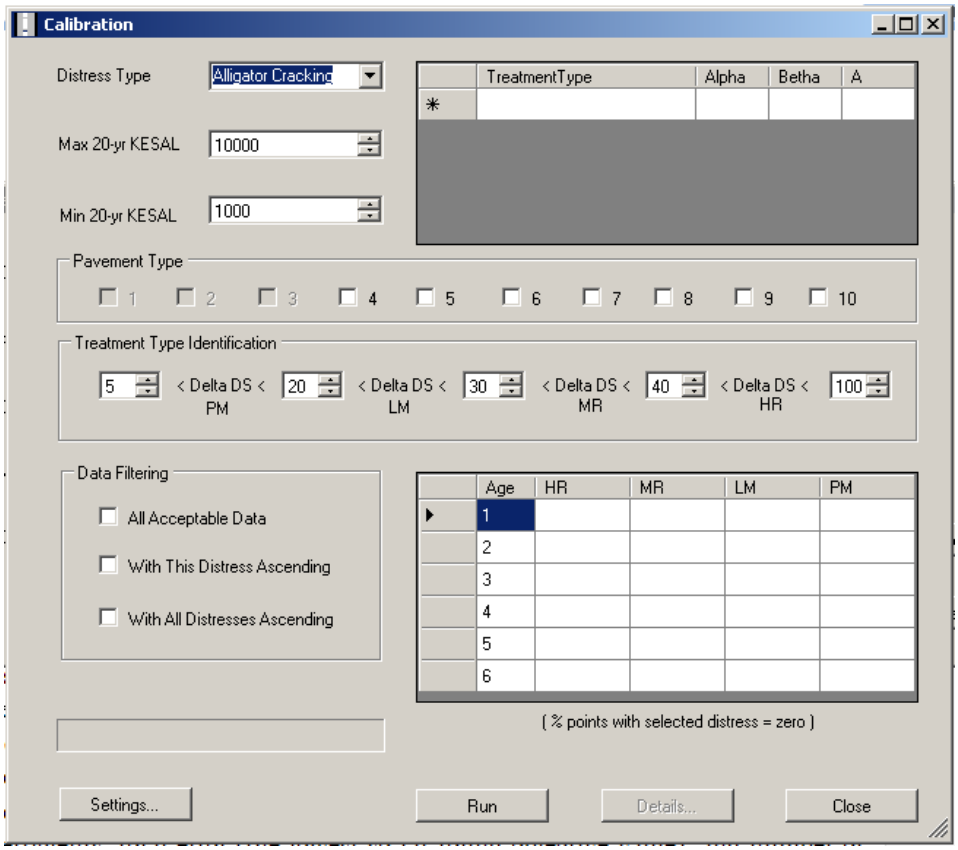

Figure I5. Model Calibration Graphical Interface.

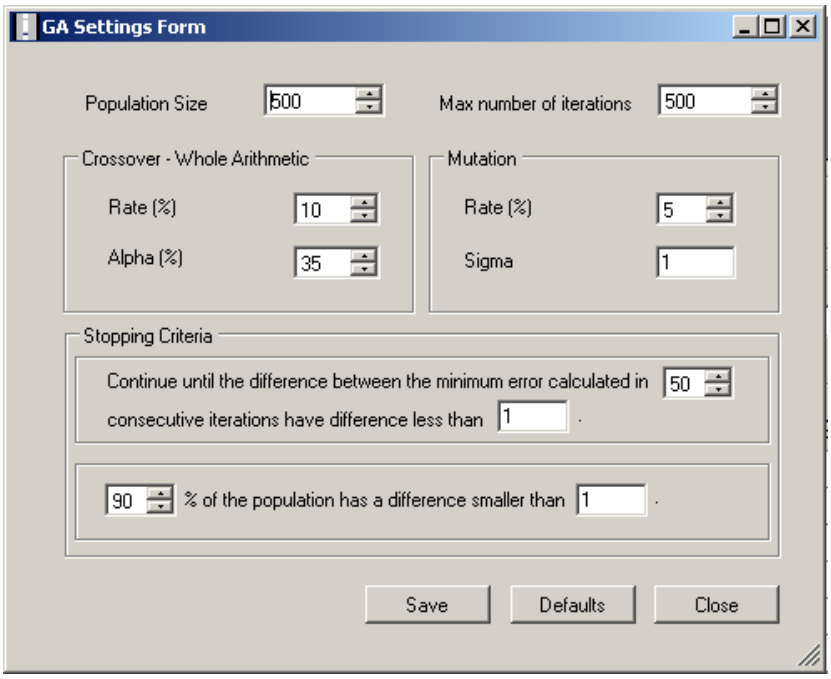

Figure I6. GA Settings Graphical Interface.