A WEB-BASED TRAINING SITE FOR SOFTWARE DEVELOPED AT UTEP

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16. Abstract

Through several research projects, UTEP has developed several software packages for pavement design and analysis. A web-based site was created to house these software packages and to provide training to TxDOT pavement engineers. The main objective of this project was to develop the web-site. The site includes online tutorials of software packages that have been developed through TxDOT projects by the Center for Transportation Infrastructure Systems (CTIS). Users are able to go through the online modules to train on the software. At the end of the training modules, users will be able to download and use the software.

This website offers training for five software packages pertaining mainly to the design and analysis of flexible pavements. The software packages are: REPP2000, SMART, RECIPPE, JIM, and DFINE.

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ABSTRACT

Through several research projects, UTEP has developed several software packages for pavement design and analysis. A web-based site was created to house these software packages and to provide training to TxDOT pavement engineers. The main objective of this project was to develop the web-site. The site includes online tutorials of software packages that have been developed through TxDOT projects by the Center for Transportation Infrastructure Systems (CTIS). Users are able to go through the online modules to train on the software. At the end of the training modules, users will be able to download and use the software.

This website offers training for five software packages pertaining mainly to the design and analysis of flexible pavements. The software packages are: REPP2000, SMART, RECIPPE, JIM, and DFINE.

IMPLEMENTATION STATEMENT

This was an implementation research project. The website has been successfully developed on time. Training modules for five different software packages developed at UTEP for TXDOT have been placed in one web site. The website is self-sustained with little interaction required by the web site administrator. The web site was designed to permit addition of future programs without any need for recoding.

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PROBLEM STATEMENT

Through several research projects, UTEP has developed software packages for pavement design and analysis. A web-based site was needed to house these software packages and to provide training to TxDOT pavement engineers. These software packages would also be made available to consultant engineers working for TxDOT in designing department projects.

OBJECTIVE

The main objective of the project was to develop a web-site that included an online tutorial of software packages that have been developed through TxDOT projects by the Center for Transportation Infrastructure Systems (CTIS). Users would be able to go through the online modules designed to provide training exercises on each specific software package. At the end of the training modules, the users will be able to download and use the program.

The development of the web-site will be modular to ensure ease in future modifications and or addition of software packages that will be developed for TxDOT.

ORGRANIZATION OF REPORT

In Chapter 2 of this report, a brief description of all software hosted on the website is presented. Chapter 3 provides information on the development of the web site. The navigation tools, the training module, the training process and beta testing of the web site are also included in that chapter. Finally, Chapter 4 presents summary and concluding remarks regarding this project.

CHAPTER TWO – BACKGROUND

INTRODUCTION

This website offers training for five software packages pertaining mainly to the design and analysis of flexible pavements. The software packages are: REPP2000, SMART, RECIPPE, JIM, and DFINE. Each software package will be briefly discussed in this chapter.

SYSTEM REQUIREMENTS

To access and run the training programs, the following items are necessary: a) a recent version of either MS Internet Explorer or Netscape web browser, and b) an active internet connection. Also preferable, is a monitor display set at resolution of at least 800 by 600 pixels. Most of the training modules were design at that resolution. Another preference is that the computer has English as the language default setting and no additional languages installed on the system such as (Spanish or Chinese). These additions could cause the training module not to function properly.

PROGRAMS INCLUDED IN THE TRAINING WEB SITE

The term program and software will be used interchangeably to refer to the software packages in the training web site. As mentioned before, five programs are selected and loaded on the website at this initial stage. As more programs are developed for TXDOT, those programs could be easily made available for training on the web site. A brief description of each of the five programs is presented next.

REPP2000 (Rational Estimation of Pavement Performance)

Rational Estimation of Pavement Performance (REPP2000) is state-of-the-art software that was developed under TxDOT Project 0-1711 entitled "Development of a Rational Method for Determination of Remaining Life of Existing Flexible Pavements". The software combines artificial neural network (ANN) technology with uncertainty analysis to determine the performance of a flexible pavement using measurements from the Falling Weight Deflectometer

(FWD) without using backcalculation. The artificial neural network technique is based on the understanding of how the information is processed in the brain and was aimed to develop the mathematical relationships that would reproduce a similar process. The ANN models were developed to estimate the critical strains, tensile and compressive strains at layer interfaces based on FWD data and layer thickness. The critical strains were then used to compute the remaining life of the pavement based on two failure criteria: a) subgrade rutting and b) fatigue cracking.

REPP2000 also incorporates uncertainty into the analysis. The uncertainties in the layer thickness and in the deflection basin on the predicted remaining life of a pavement are considered. The uncertainty analysis was carried out using the Monte Carlo simulation. The final outcome of REPP2000 is not only the remaining life of the pavement, but it goes one step further. The remaining life estimates are used to develop pavement performance curves. These curves that are used to describe the pavement performance can be adjusted with functional distress based on condition surveys obtained from Pavement Management System (PMS). Figure 2.1 shows the overall process behind REPP2000. For further information on the program, refer to TxDOT Research Reports: 1) 1711-1 - Artificial Neural Network-Based Methodologies for Rational Assessment of Remaining Life of Existing Pavements, 2) 1711-2 - Artificial Neural Network Models for Assessing Remaining Life of Flexible Pavements, and 3) 1711-3F - Stiffness Properties of Composite Pavements Using Artificial Neural Network-Based Methodologies.
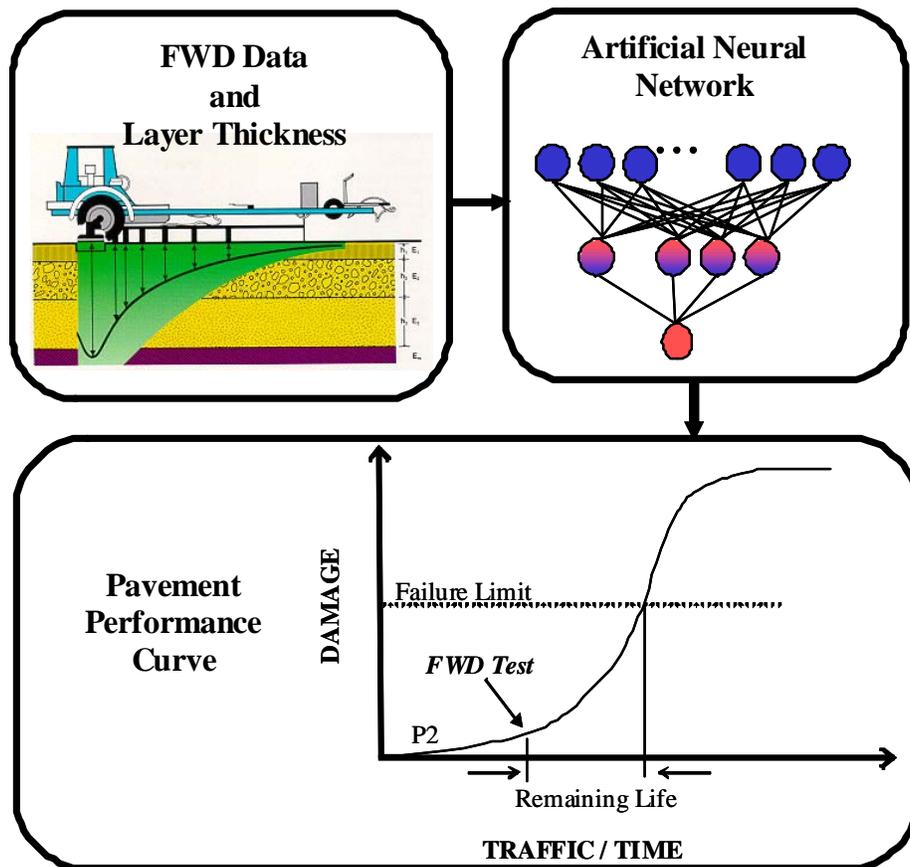

Figure 2.1 - Algorithm developed for REPP2000

SMART (Seismic Modulus Analysis and Reduction Tool)

SMART was developed under TxDOT Project 0-1780 entitled "Design Moduli from Seismic Data." The major objective of creating SMART was to develop a theoretically-sound algorithm that uses seismic moduli and well-substantiated nonlinear relationships and time-dependent models to provide moduli that can be used for pavement design and analysis. Seismic methods provide fundamentally-correct linear-elastic moduli of different layers. However, seismic moduli are low-strain moduli and cannot be directly used in pavement analysis and design. The traffic load applied to the pavement is larger than that applied by the seismic source. To use seismic moduli, load-induced nonlinear and time-dependent behaviors of pavement materials have to be taken into consideration in SMART.

The input parameters (seismic moduli) are used with a structural model to determine the design moduli for each layer of pavement. One of the unique features of the program is its flexibility to incorporate data at several levels. For instance the default options in SMART allow users to analyze pavement sections without the need for complete field data. Partial seismic data (e.g. modulus of ACP from PSPA) can be substituted in for the default values. In such cases where laboratory seismic values are available, users are able to substitute those values as well. Another feature of the program is the types of material models available for each layer. SMART features both linear-elastic and three viscoelastic models for the ACP layer. As for the base, subbase and subgrade layers, one of the following three models can be used: a) linear elastic, b) nonlinear based on lab resilient modulus testing and c) nonlinear based on a model that requires plasticity index. Figure 2.2 provides an overview of the overall process behind SMART. For further information, refer to the following TxDOT Reports: 1) 0-1780-1 - Design Modulus Values Using Seismic Data Collection, 2) 0-1780-2 - A Sensitivity Study of Parameters Involved in Design with Seismic Moduli, 3) 0-1780-3 - Determination of Non-linear Parameters of Flexible Pavement Layers From Non-destructive Testing, 4) 0-1780-4 - SMART: Software for Determining Design Modulus from Seismic Data, and 5) 0-1780-5 - Validation of Software Developed for Determining Design Modulus from Seismic Testing.
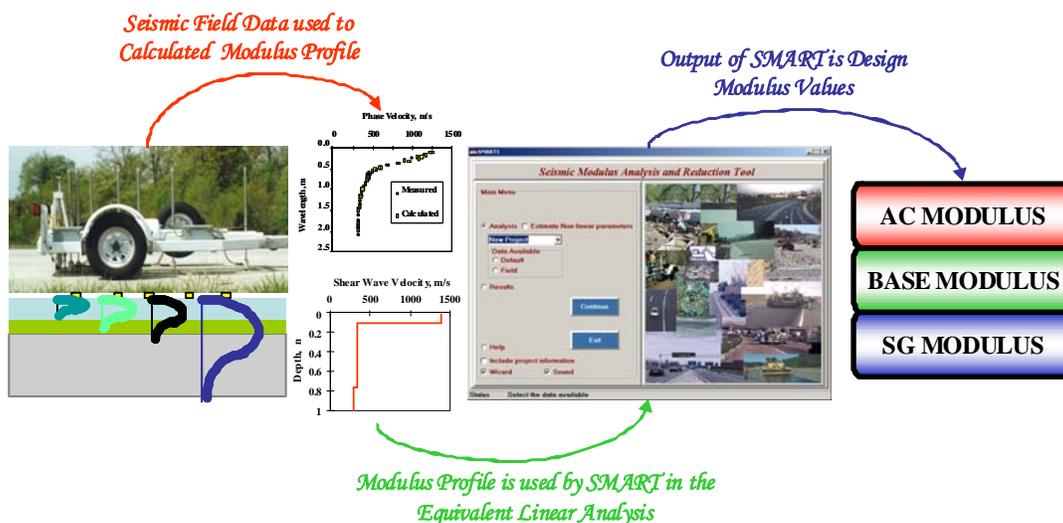

Figure 2.2 – Overall Process for the Flow of Information in SMART

RECIPPE (Rational Estimation of Construction Impact on Pavement Performance)

The software developed under TxDOT project 0-4046 entitled "Impacts of Construction Quality on Life-Cycle Performance of Pavements Using Mechanistic Analysis" is called Rational Estimation of Construction Impact on Pavement Performance (RECIPPE). For a given project, RECIPPE will guide TxDOT personnel to determine what construction parameters would significantly impact the performance, what parameters will moderately impact and those that are of small importance. The level of acceptable deviations from the target design value for each parameter is established based on quantification of the variability of the construction parameters introduced by: (a) the construction processes, (b) the material properties, (c) the models used to predict pavement performance and those used for data analysis, and (d) the resolution of the procedures used in the field for quality control.

RECIPPE can be used in two modes a) pre-construction and b) post or during construction. In pre-construction mode, the number of samples is determined for each parameter identified as important in impacting performance variability based on construction practice. This could eventually provide an alternative means to the minimum guide schedule to determine sampling frequency.

In the post construction mode, the software provides monitoring of the variability for each parameter using control charts that are generated based on in-situ and laboratory tests, which are performed for quality control (QC). The inspector or project engineer can easily monitor the variability of each parameter impacting performance thus maximizing effectiveness of inspection and testing resources during construction. Figure 2.3 provides an overall interpretation of the algorithm used in RECIPPE. For further information, refer to the following TxDOT research report: 1) 0-4046-1 - Optimizing Construction Quality Management of Pavements Using Mechanistic Performance Analysis, 2) 0-4046-2 - Development of a Validation Process for Parameters Utilized in Optimizing Construction Quality Management of Pavements, 0-4046-3 - Calibration of Material Models for Estimating Impact of Construction Quality on Life Cycle Performance of Pavements, and 0-4046-4 – Case studies Using RECIPPE.
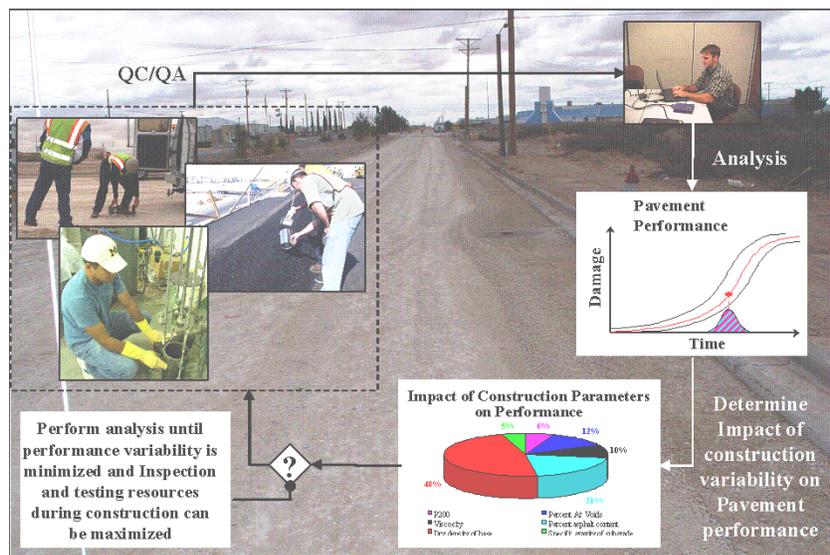

Figure 2.3 – Methodology Employed by RECIPPE for Quality Control

JIM (Joint Inversion Method)

Two programs were developed under TxDOT Project 0-4393 entitled "Integration of Nondestructive Testing Data." The first program is called Joint Inversion Method (JIM) and its main objective is to estimate the stiffness parameters of pavements using data from different nondestructive testing devices. With several different testing devices available today, there is no shortage of the information that can be gathered regarding the pavement condition. However, each method has its own strengths and weaknesses. When the results from multiple testing devices are conflicting, the dilemma arises over which one to accept. Such decisions should be made rationally. One approach that can help achieve this goal is to combine the data from the different pavement collection devices and performing a joint inversion. In this type of inversion or "backcalculation", the inherent strength of each method dominates the analysis, resulting in a more robust and stable algorithm.

JIM is a backcalculation method that relies on the joint analysis of the raw data from the seismic-based and deflection-based methods. JIM handles four devices of interest (FWD, SPA, PSPA and GPR) with FWD and SPA selected by default. The other two devices PSPA and GPR are used as complementary inputs to strengthen the joint inversion process. PSPA data are very stable for the top layer of a pavement system. In a three layer flexible pavement system PSPA provides a good indication of the ACP modulus. Likewise, the GPR provides a good indication of the thickness of the ACP layer and in certain cases the base layer. The information, if available, can be used to reduce the number of backcalculated parameters. Figure 2.4 illustrates the flow of information and the process used to determine pavement layer moduli. Both the seismic dispersion curve and the FWD deflections are used as input. The output is moduli of pavement layers. For more detail on JIM, refer to TxDOT research reports: 1) 0-4393-1 - Feasibility of Integration of Non-Destructive Testing Data Analysis Techniques, 2) 0-4393-2 - Implementation of Data Fusion Techniques in Nondestructive Testing of Pavements, and 3) 0-4393-3 - Case Studies on Application of Data Integration Techniques to Nondestructive Testing of Pavements.
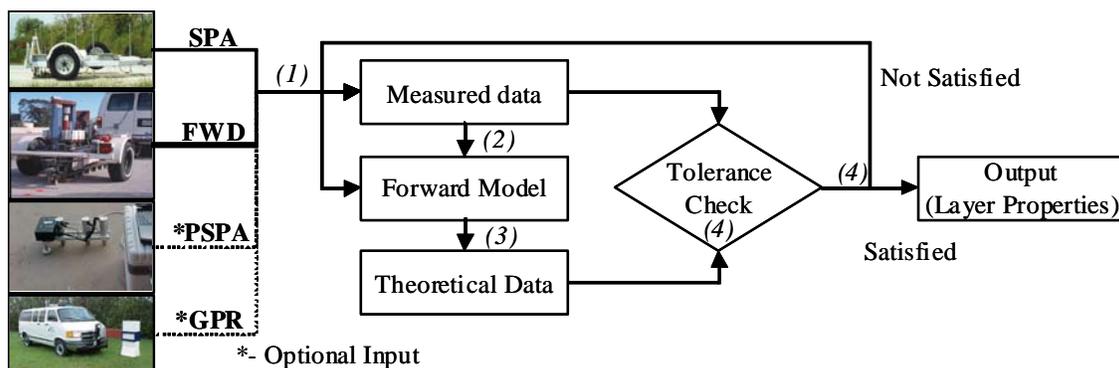

Figure 2.4 - Joint Inversion Algorithm Flow Chart

DFINE (Data Fusion for Intelligent Nondestructive Evaluation of flexible pavement)

The second integration approach, developed under TxDOT Project 0-4393, was to fuse the results from the existing NDT analyses. This process was a means to rationally reconcile the results from different methods to arrive at consistent values. Data fusion is a process by which one source of data can be logically selected over another, or by which data from several available sources can be combined or "fused." As each method for analyzing pavements has its own strengths and weaknesses, it is only reasonable to attempt to utilize all methods to develop a better overall characterization of a pavement. As the parameters being measured are not "exact" and are subject to inherent errors, all information that has merit should be considered to some extent.

This process is called data fusion. Three different fusion methods were incorporated into a program called Data Fusion for Intelligent Nondestructive Evaluation of flexible pavement (DFINE): a) Weighted Average, b) Statistical Weighted Average, and c) Fuzzy Logic. The first two methods are a modification of the traditional averaging with weights incorporated based on the site statistics and the backcalculation errors from different NDT analyses. Fuzzy logic, which tries to handle vagueness or ambiguity that is the result of human thinking, was used for fusing the NDT results from multiple devices. The fuzzy logic method allows for the creation of rules that attempt to function in a manner that changes a subjective decision into a mathematical rule. These decisions, in turn, can be used to combine or filter data. In this case, the rules are used as a means to fuse results of the NDT analyses. Figure 2.5 presents a snapshot of the DFINE. For further information on this program, refer to TxDOT research reports: 1) 0-4393-1 - Feasibility of Integration of Non-Destructive Testing Data Analysis Techniques, 2) 0-4393-2 - Implementation of Data Fusion Techniques in Nondestructive Testing of Pavements, and 3) 0-4393-3 - Case Studies on Application of Data Integration Techniques to Nondestructive Testing of Pavements.
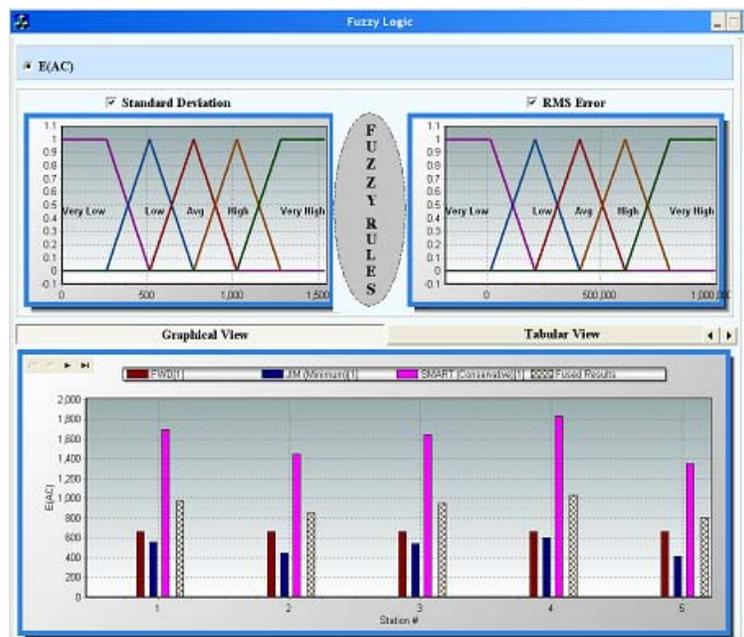

Figure 2.5 - The Fuzzy Logic Menu in DFINE

CHAPTER THREE – DEVELOPMENT OF TRAINING WEB-SITE

INTRODUCTION

The process for developing the web site was in two stages: a) Design and Coding. This website was the third of a series of web sites that was initiated by TxDOT regarding software that was developed by Texas universities. The first two web sites developed were one at TTI to provide training for software developed at Texas A&M and one at CTR for software developed at UT Austin. Since the source code and design of the two web sites were made available, the development of the UTEP web site was rather straightforward.

DEVELOPMENT PROCESS

As a first step in designing the web site, an investigation was carried out to determine the design tools and web site features of the other two training web sites (TTI and CTR). From both a developer's and a user's standpoint, both web sites had advantages and short comings. Having access to the source code and access to the project designers of both websites proved valuable. It helped to identify the scope of the training web site that was to be developed at UTEP. Another aspect that went into the design stage of the web site was the time frame given to this project. A general outline was presented to the project director. It was agreed that the web site should incorporate some of the features of the other two training web sites, but to reduce the animation features due to time constraints. Also, a simpler design for the training exercises will facilitate incorporating future programs. The web site training was designed for two levels of access: a) access to trainees or users and b) access to administrator. The language used in developing or coding the web site was PHP with MYSQL as the database for storing information.

Web Site Interface for Trainee

The main use of this web site is to train users on software developed for TxDOT at UTEP. This user is classified for the purpose of this report as a trainee. The flow of the web site for the trainee is presented in Figure 3.1. The flow presented in Figure 3.1 will be expanded on using snapshots from the web site. Figure 3.1 presents, at the top of the chart, a "Welcome" page that is designated as the main page of the web site. Figure 3.2 shows a screen shot of the main page. The "welcome" page introduces the website and guides users to three links. The first link leads

to a login page where users can login to carryout the training. The second link leads users to a navigation guide page. This page provides few sets of instructions about navigating through this web site. The third link is for registering new users.
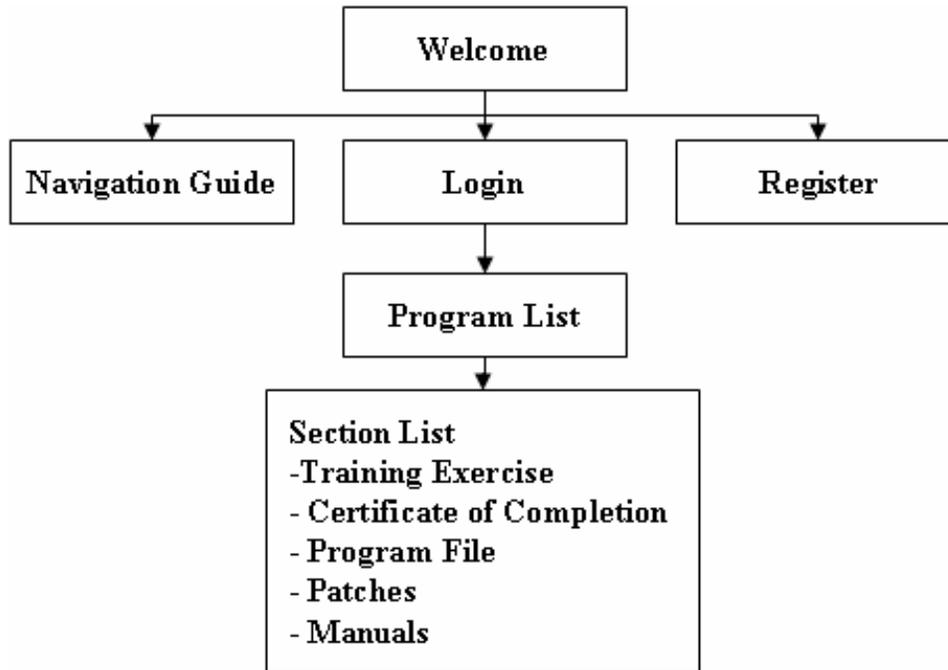

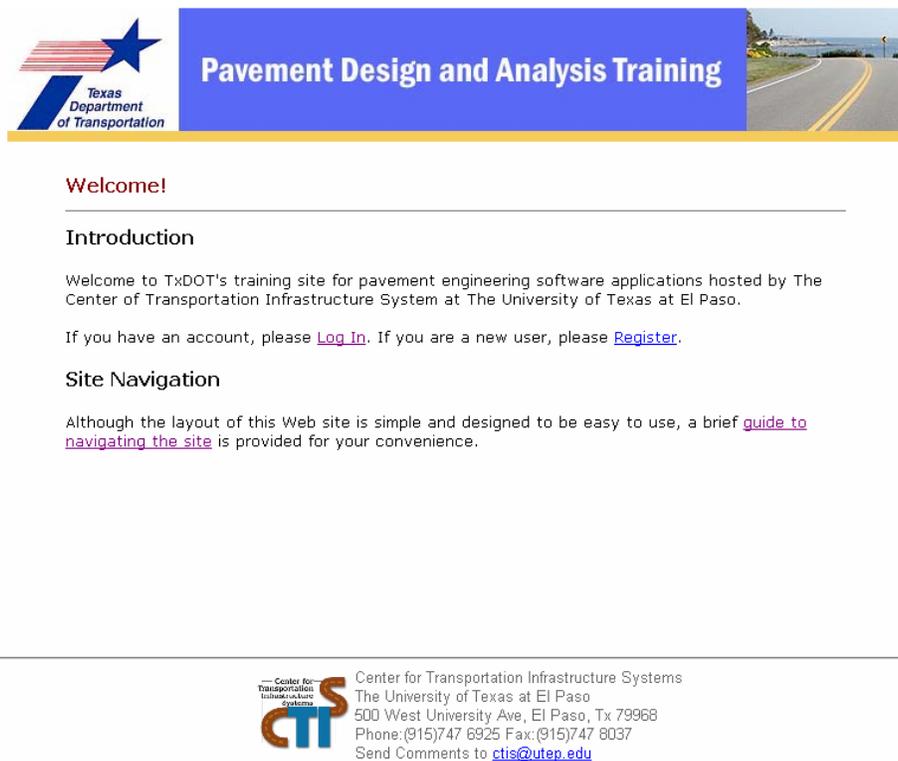**Figure 3.1 - Flow Chart of the Software Training Web Site from a Trainee Aspect**

Figure 3.2 - The Web Site Welcome Page

Figures 3.3 through 3.5 show the login, navigation guide and registration page, respectively. The login page is for registered user to logon to the training modules (Tier 2 of Figure 3.1). Figure 3.3 shows that the login page also provides a link for users that lose or forget their passwords. If users follow that link and provide a user ID, their user password will be emailed to them. If for some reason users do not have access to their user ID, they are to contact the web site administrator at ctis@utep.edu to obtain their password. This email contact can also be used to address any other issues concerning the training web site.

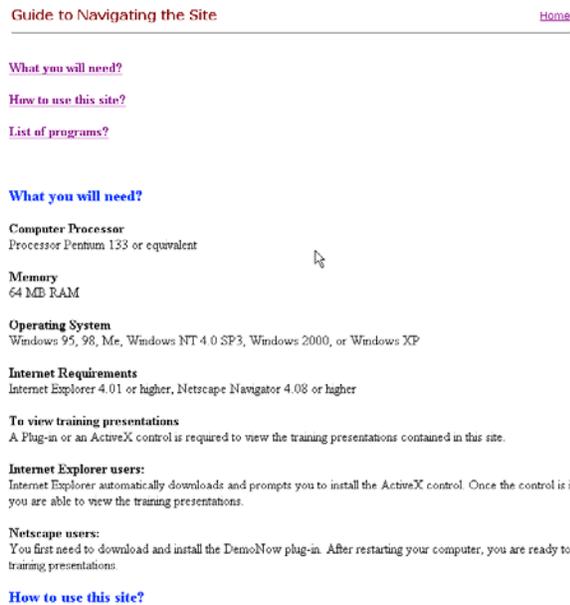**Figure 3.3 - The Web Site Login Page**
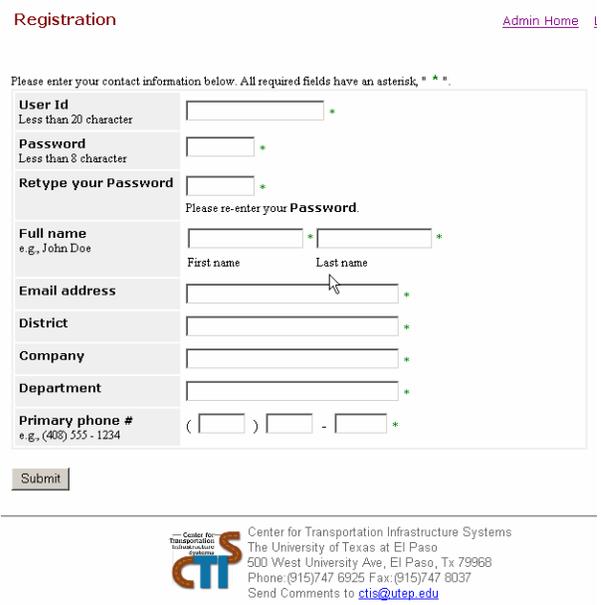

Figure 3.4 - Quick Guide the Web Site   Figure 3.5 - The Web Site Registration Page

The navigation guide page, illustrated in Figure 3.4, provides information regarding the computer system specifications, the means for using the web site, and the list of programs available to be trained on. Figure 3.5 shows the items or requirements that are necessary for users to provide when registering. One of the main features built into this page is a flag that prevent Non-TXDOT personnel from registering. Only those with TxDOT email extensions are permitted to register directly through the web site. Other persons can be registered by contacting the web site administrator if they have permission from TXDOT. This feature provides control over the training web site. Once users complete the registration and submit their information, the administrator receives an email and registers users manually using the "administrative" features of the web site. At that time an email will be sent to users with notification to proceed. By manually registering users, the administrator can have a better handle on the process and reduce maintenance issues in the long term. The "administrative" features will be discussed later in this chapter.

In reference to Figure 3.1, the next tier in the flow is after the login process. After a successful login, users will be directed to the page that provides a listing of the programs that are available for users to be trained on. If the log in is unsuccessful and users have tried several times, they are to email the system administrator. Figure 3.6 shows an example of the program listing after a successful login. For each program, a link is provided that leads users to a set of training exercises. At this time five programs are available on the website: REPP2000, SMART, JIM, DFINE, and RECIPPE. Users can select to train on any program of interest.

Figure 3.6 - The Web Site Program Listing Page

Figure 3.7 shows an example of the training exercises. REPP2000 is selected as an example to illustrate the training exercises in the web site. For REPP2000, six training sections or modules are listed. Next to each exercise, the access, and the progress status is provided. These two status indicators are important because they signify to users the progression to follow in training. The exercises need to be followed in order of their presentation. Users are first permitted access to the first training module. Figure 3.8 shows a sample of the page that is activated once a training module is selected. To run the training exercise, users should select the "Demo NOW" button. Once one exercise is completed, the next exercise can be accessed and so on. Also, once a module is completed, users will have access to that module at any time in the future. Another feature presented in Figure 3.7 is a Certificate of Completion. Once all modules are completed, users can download and print a Certificate of Completion. Also, after all training modules are completed, users can download the program, and any other patches or manuals associated with it.

Figure 3.7 - Example of the Web Page for that Lists the Training Exercises

Figure 3.8 - Web Page Where the Training Exercise is Activated

The training modules were designed using a software called DemoShield, by InstallShield Software Corporation. This product is made specifically to design material such as tutorials and training tools. This tool was selected for designing the training modules since it could be used similarly as a PowerPoint presentation with more sophisticated features. This made it easy for developing the training modules. A template was developed so that every program could have similar instructional format and that it could be easily adopted for future programs without the need for coding or recoding. Any PowerPoint presentation can be easily reproduced in DemoShield and could be made consistent in format if the template is used. Figure 3.9 presents a sample of the template. Each screen in the training module will have similar features to the example presented in the figure. The general features are:

a)   The instructional guide section is where instructions are provided to guide users in going though the program step by step.
b)   The program space is where the program image is featured. The image in the program space is "active" and contains hidden links. By following the instruction provided in the instructional guide, user can proceed to the next action in the program. This process is designed to simulate the process of using the program directly, but in a controlled fashion.
c)   The "tips" feature is very useful in providing information and detail explanation about the program as users go through the exercises.
d)   The Training Navigator is the master navigator used to either "go back" one step, "go home" to the first slide, and or "exit" the module. If users select to "exit" the training module before completion they will have to start the process for that particular exercise from the beginning. If users select the "go home" feature, then users will start on the first slide of that training module. There are no "next" buttons in the training navigator. The purpose for not having this feature is for users to follow the instructional guide to proceed forward using the "active" program.
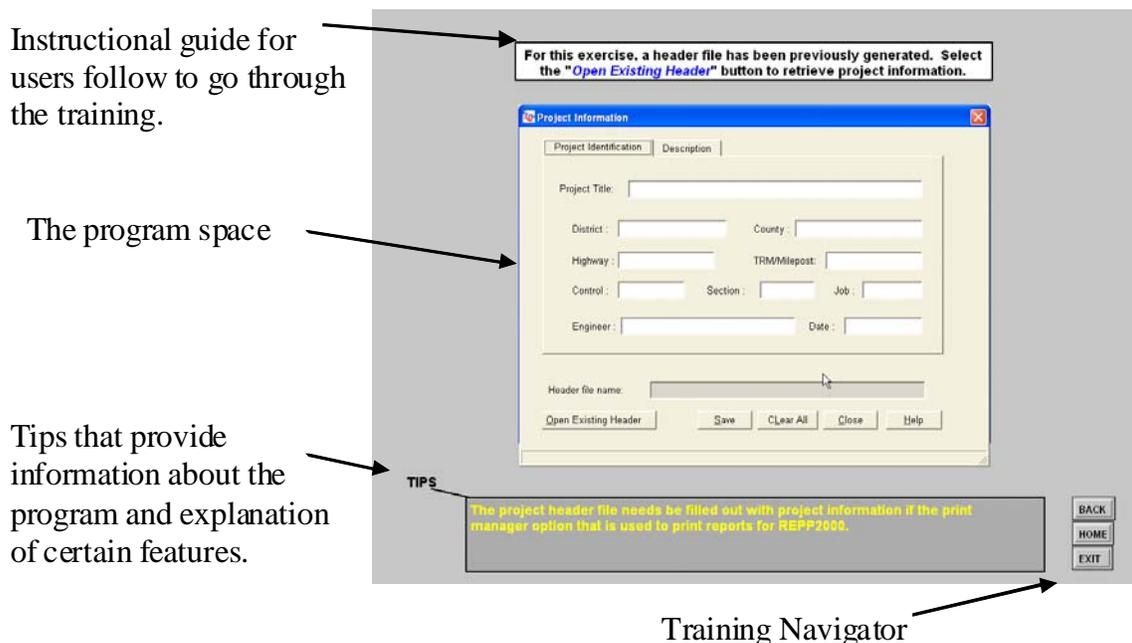

Figure 3.9 - Sample of the Template Used to Develop the Training Exercises

As mentioned previously, once each training exercise is complete users can proceed to the next exercise. After completing all training exercises, users can print a certificate of completion and download the program, updates and the program's manual if available. The training manuals were created for older programs that were developed. This training web site serves as the training manual for software developed more recently and as such newer programs might not have a training manual.

Web Site for Administrator

The development of a web site for the administrator was performed to facilitate the maintenance of the website, to eliminate the need for additional coding or designing when a new program is added, and for administrator to manage the web site with no experience in programming. Figure 3.10 presents the flow of information for the web site administrator. The first two tiers are the same as the user's web site. The administrator actually logs-on from the same page as the user. However, the administrator links to a different page where he or she has control over a) registration, b) program, c) user, d) section, and d) patch.

The registration link leads to a web page where the administrator loads-up the information provided by a new user and uploads it to the database. This process automatically sends an email to users that their account is activated and they can then proceed with training. This process provides control to the administrator to register any person for training with TXDOT approval.

The program, section and patch links lead to web pages that are designed to provide the administrator with an easy process for loading new programs and their corresponding training modules. If a new program and corresponding training modules are available, then the administrator needs to only load those programs by browsing the hard drive and selecting those folders where the information is contained and the training is automatically setup. Also, if a patch is developed at a later date, once uploaded by the administrator, an email is automatically sent to those users that have completed the training of that specific software.
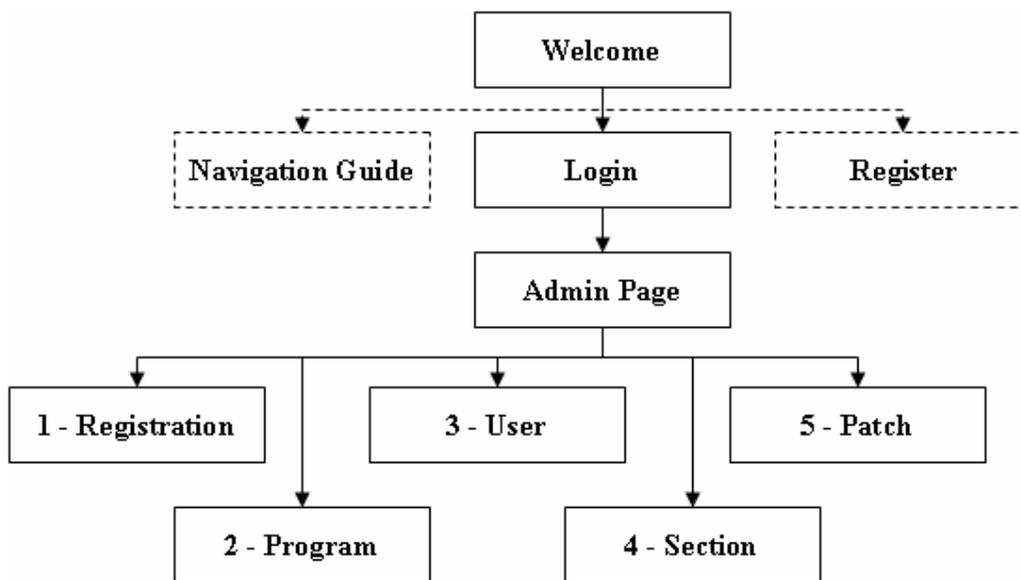

Figure 3.10 - Flow Chart of the Web Site Used by the Administrator

The "user" page (shown in the flowchart of Figure 3.10) allows the administrator to view information and progress of each user. This provides one means of control for the administrator to correct problems encountered by users. It can also be used to circumvent the process for special TxDOT personnel that are not required to go through the training but require the download of a particular program.

PROTOCOL TO ADD A NEW PROGRAM

One of the main advantages of administering to this web site is that no coding is required to add new training modules. The items required to generate and add a new training module is as follows:

1) DemoShield. This is the software that needs to be used to generate or create the training module. DemoShield is very easy to use (simlar to PowerPoint). A template is included on the website to download as an administrator and used to create the training module. The Administrator can also forward this template to any person that is involved in developing software at UTEP for TxDOT and needs to incorporate the product on the training web site.
2) Training module(s). First an outline should be developed. This could be generated in PowerPoint or any other software. As a guideline, users can follow the training modules of any of the software currently on the web site. The first module is an introduction to the software which includes: summary of the theory and brief explanation of the overall algorithm or methodology. Also, provided at the end of the introductory module is a reference list of the research project reports. The remaining training modules are exercises that take users step by step through the software. Each exercise is geared to using specific features of the software.
3) The software. Developers need to create a zip file that would include all software components necessary for users to install on their system after downloading the zip file.
4) An icon. An icon is required for the software. This is a file with the following extension (*.ico). A generic icon can be used.
5) User's manual. If a user's manual is generated, in addition to the training modules, it should also be made available.
6) Update. Any updates of the software need to be zipped in a file and made available.

Creating Training Module

A sample of creating a slide in the training module is included in Figure 3.11. The first part of the slide shows DemoShield in edit mode and the template for training is loaded. The DemoShield shows several features that can be used to add many components to the slide presentation. In Figure 3.11a the template shows the main features that are used: a) Instructional guide, b) Hotkey, c) Program space, d) Tips, and d) Training navigator. This slide can be duplicated as many times as necessary. To add the appropriate material to each component, the designer can copy each component and type or paste the material that is appropriate. For the example presented in Figure 3.11, first the instruction to users to {Please check the "New Folder" option in the project options tab of JIM} is loaded in the instructional guide component (as shown in Figure 3.11b). Next, a snapshot is taken of the software and pasted in the program

space. Then, the hotkey is sized on top of the checkbox for users to be able to interact with the presentation and check that box. Next, if tips for this screen are needed, that information is included in the tips component of the template. Finally, the properties of the buttons in the training navigator are modified to link to appropriate slides. The slide or template can be duplicated as necessary to complete a training module.
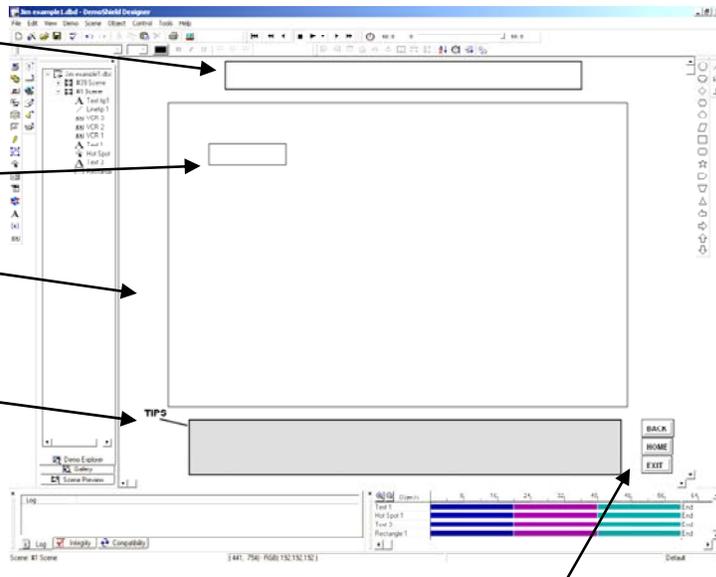
a) Before Loading Content

Instructional guide for users follow to go through the training.

Hotkey

The program space

Tips that provide information about the program and explanation of certain features.

Training Navigator

b) After Loading Content

The hotkey is place over the Checkbox for users to select in order to proceed.
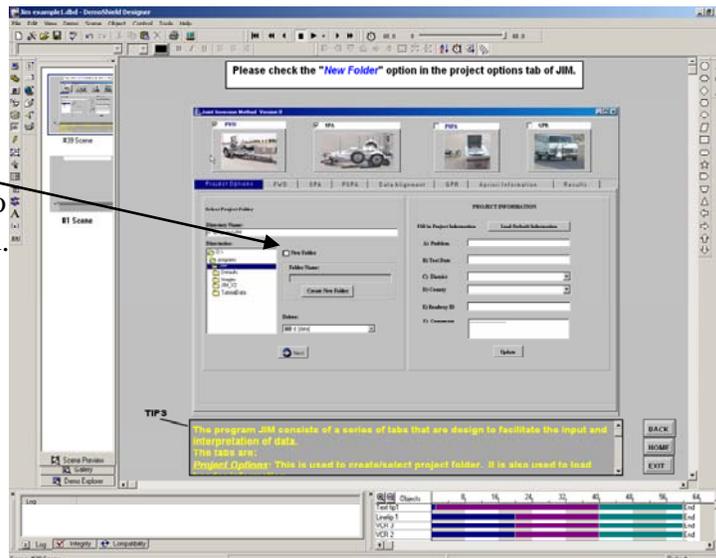
Figure 3.11 - Example of Before and After for creating a Slide for the Training Exercise

Uploading the Training Module of a New Software

Once the training modules are created and each exercise is completed, DemoShield provides a distribution wizard that allows the slide presentation to be prepared for online uploading. To upload the training module online or add new software, the administrator is required to fill the information presented in the "Add Program" page on the web site presented in Figure 3.12. This page of the web site is used to upload the software portion. Similar pages are used to upload the training modules. Once uploaded and submitted, the process of setting up the web page for training is created automatically by the webpage macros. At this point the training modules are ready for use.
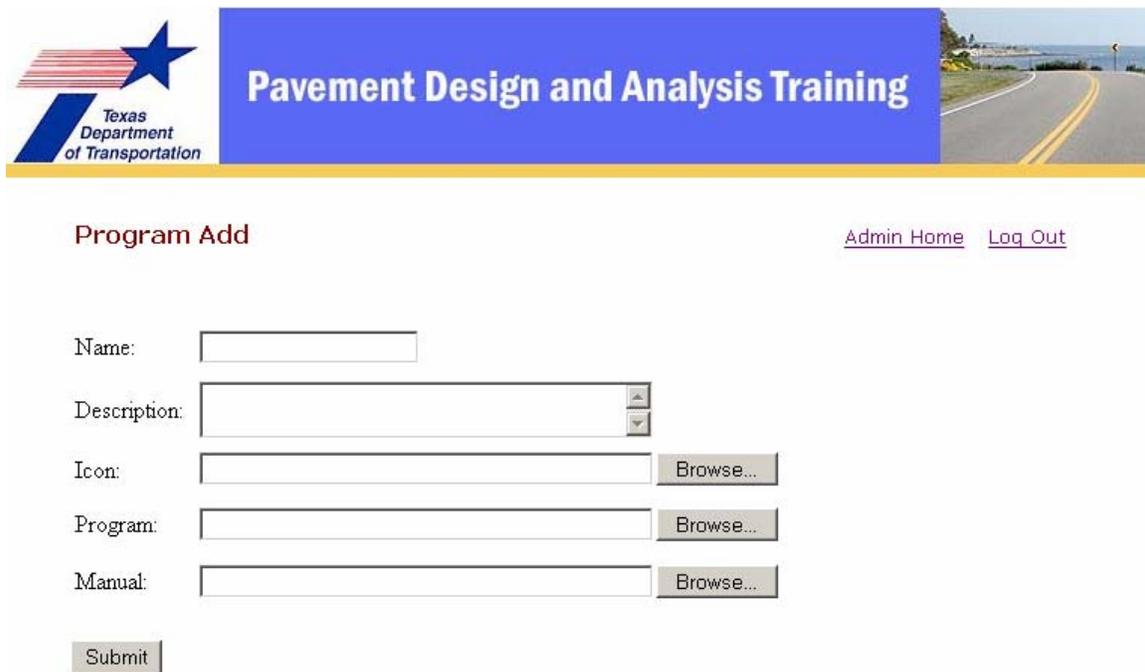
Figure 3.12 - The Web Page for Adding a New Software

CHAPTER FOUR – SUMMARY

Through several research projects, UTEP has developed software packages for pavement design and analysis. A web-based site was developed to house these software packages and to provide training to TxDOT pavement engineers. These software packages would also be made available to consultant engineers working for TxDOT in designing department projects.

Users are able to go through online modules that are designed to provide training exercises on the specific software. At the end of the training modules, users will be able to download and use the program.

The development of the web-site is modular to ensure ease of use in future modifications and or addition of software packages.