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# 0-5445-P2

# MANUAL FOR WEB-BASED TxDOT RIGID PAVEMENT DATABASE

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*TxDOT Project 0-5445: Project Level Performance Database for Rigid Pavements in Texas*

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*Web-Based Information System for Rigid Pavements*

*User's Manual*

Texas Department of Transportation

*July 9, 2009*

This document provides description of the rigid pavement database (called RPDB in this document) developed under TxDOT Research Project 0-5445. This document also provides a breakdown of the various components of the RPDB, including the database contents, managing and storing the data, developing a user-interactive web-application for enabling access to the database within a network, and accessing the data from the web-application. This document provides the end users and administrators with instructions to effectively manage, update, and retrieve the data from the RPDB using the tools within the web-application. In this sense, this document constitutes a user's manual for RPDB. The RPDB might undergo certain modifications as further research efforts identify important information that needs to be included for the proper evaluation of portland cement concrete (PCC) pavement. For example, in the mechanistic-empirical pavement design guide (MEPDG), transverse crack spacing and load transfer efficiency (LTE) at transverse cracks in continuously reinforced concrete pavement (CRCP) are currently considered important variables in predicting CRCP performance. Based on that finding, substantial efforts were made to collect accurate information for those two variables statewide and they are the two primary structural responses included in the RPDB. More recent research efforts in other TxDOT research projects identified other variables that could be as important, such as deflection. The software used to develop this RPDB is quite versatile, and any future modification to the current RPDB could be achieved with minimal effort. Whenever changes and modifications are made to the RPDB structure or other structural responses are included, proper documentation will be made.

The RPDB can be accessed at the following URL:

http://mapserver.gis.ttu.edu/txtechdot

**RPDB Contents**

The RPDB involves three types of data input files:

A. General Pavement Section Information

B. Detailed Pavement Section Testing Data

C. On-site Pictorial Presentation for Each Test Section

*A. General Pavement Section Information:*

- These files contain all the basic information necessary to geographically identify a particular pavement section.

- The GPS start and end coordinates provided are essential for plotting the particular pavement section onto a base map of the State of Texas using the ArcGIS software ArcMap. This base map along with the plotted test sections are then shared onto a server and used to develop a user-interactive web-service. Thus, this information is pivotal in providing the input for the Web-Based Information System.

- This data is presented in Microsoft Excel or Microsoft Access formats in order to be readily compatible with the current ArcGIS software (ArcMap 9.3 and ArcGIS Server 9.3).

- This data also includes the Test Section ID, District Name, County Name, Direction, Reference Marker, Pavement Type, number of lanes, etc., so as to enable identifying a particular test section by querying the desired criteria.

- The file containing the test section data should be named as per the Test Section ID for easy identification.

*B. Detailed Pavement Section Testing Data:*

- These files contain information on the structural responses of the pavement test sections and condition information. The data includes transverse crack spacing, falling weight deflectometer (FWD) deflections, and load transfer efficiency (LTE).

- All pavement testing data files are stored in Microsoft Excel 2007 or Microsoft Access 2007 format for uniformity and easy access to the users.

- A separate file for each testing data is created and named according to the Section ID and the type of test data in order to enable query-based

analysis. These files are stored in a common folder containing data for the corresponding road section.

*C. On-site Pictorial Presentation for Each Test Section:*

- These files provide the actual graphical images of the pavement sections.

- These files should be present in JPEG, GIF, PNG, or TIFF formats.

- Similar to all other file types, these files should be labeled in accordance with the Section ID because the query analysis uses Section ID and picture number as the key.

- The picture folder for each section should be stored in a folder labeled with the test Section ID and stored in the base folder containing all the detailed data for that particular section.

For the presently developed web-application, the following names for files are used:

1. General Pavement Section Information: ***GI_"Section I.D"***

2. Detailed Pavement Section Testing Data:
   - For FWD Data: ***FWD_"Section ID"***
   - For LTE Data: ***LTE_"Section ID"***

All the data files for a particular pavement section are stored in the same folder named according to its corresponding Section ID.

**GIS (Geographic Information Systems) Data Contents**

In addition to the test data for the pavement sections, for the development of the web-application, considerable amount of GIS data needs to be accessed and stored using ArcGIS Server. This data is essential in developing the map document (.mxd), which forms the basis for developing a map service in the web-application. This data is present in various formats such as shapefiles, imagery, layer files, and database files. All of this data is stored in one common folder for ease of access while specifying the path from the map document. The following files are required for developing the web-application and are stored in a common folder named "Data": (1) shapefiles for the counties in Texas, roads in each county, digitized start and end points for each test section, digitized line shapefile to connect the two points for a test section, and (2) NAIP 2005 imagery for the counties in consideration.

**Internal Structure of RPDB**

Figure 1 illustrates the internal structure of the RPDB along with the interactions among various components in the RPDB.

```
                           ┌──────────────────┐
                           │    Detailed      │
                           │    Pavement      │
                           │  Testing Data    │
                           │     Files        │
                           │  (FWD, LTE)      │
                           └────────┬─────────┘
                                    │
┌──────────────────┐               │              ┌──────────────┐
│    General       │    Arc    ┌───────────┐      ▼              │  On-Site     │
│    Pavement      │    Map    │    Map    │  ┌──────────────┐   │   Test       │
│    Section       │    9.3    │ Document  │  │ ArcGIS Server│◄──│  Section     │
│  Information     │──────────►│  (.mxd)   │─►│     9.3      │   │  Pictures    │
│    (GPS          │           └───────────┘  └──────┬───────┘   │              │
│  Coordinates),   │                                 │      ▲     └──────────────┘
│   Shapefiles,    │                                 │      │
│    Imagery       │                                 │      │
└──────────────────┘                                 │      │
                                          ArcGIS      │      │
                                          Server      │      │
                                          Manager     ▼      │
                                              ┌───────────────────────┐
                                              │ Web-Based Digital Map │
                                              │   and Inquiry         │
                                              │    Interface          │
                                              └───────────┬───────────┘
                                                          │
                                                          ▼
                                      ┌───────────────────────────────────────┐
                                      │ Geographic Test Section Location       │
                                      │ (on the map), General and Testing      │
                                      │ Information                            │
                                      └───────────────────────────────────────┘
```
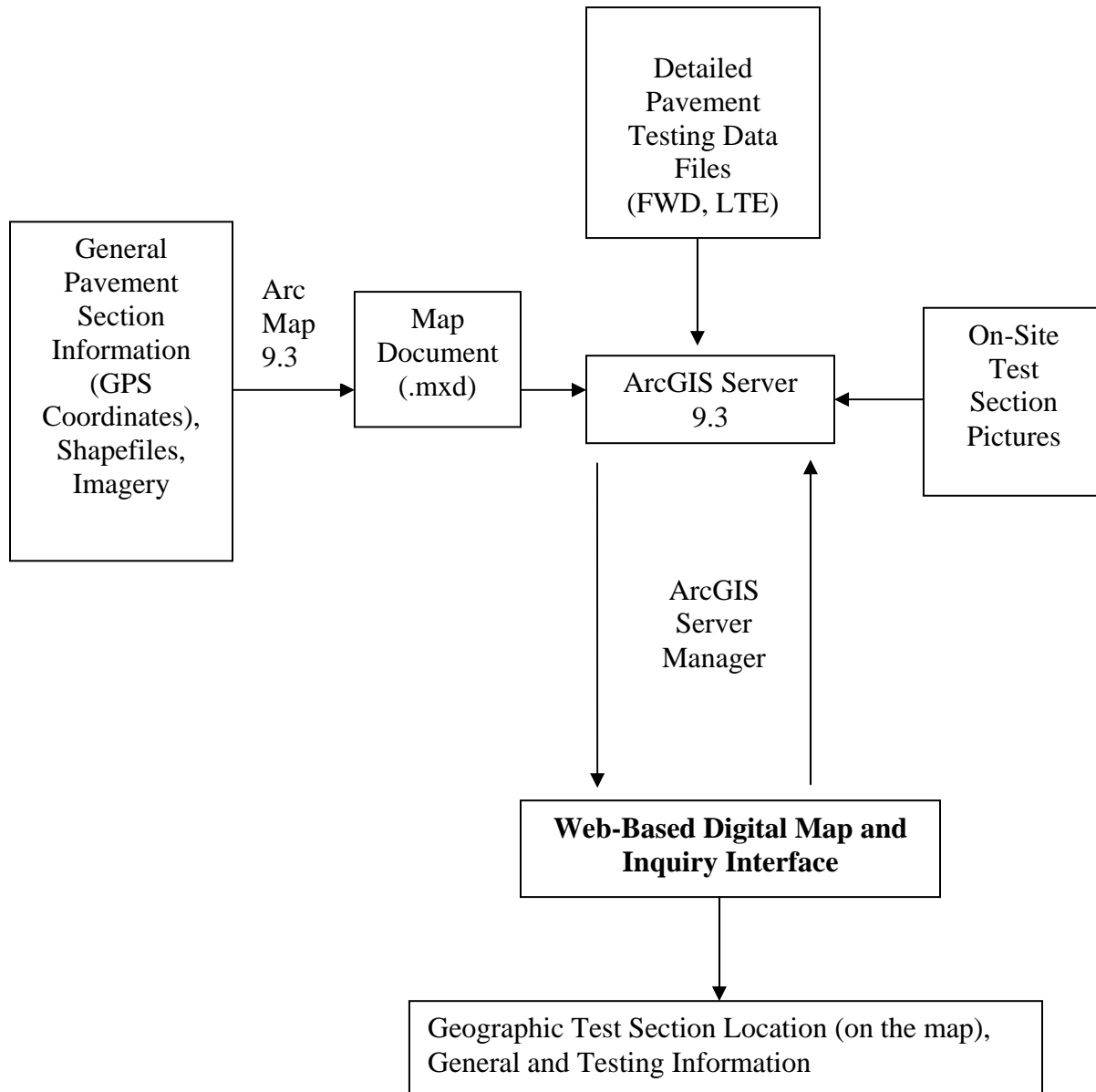
**Figure 1: RPDB internal structure diagram**

The pavement test section data as well as the GIS data need to be shared over a server in order to effectively update the data, develop the web-application, reflect changes in the data in the web-application, and assure ease of access to the Server Manager/Administrator, Webpage Developer, and the end user. The server

also needs to have a domain so that the application that is accessed over a network can call the data from the server. The space required on the server to store the database depends on the size of the database as well as on how user-interactive and graphically rich the web-application needs to be.

For the presently developed web-application, the MapServer at the Center for Geospatial Technology at Texas Tech University is used to host the database and develop the application. For developing the application, ArcGIS Server software is installed on the server being used to share the data and, using ArcGIS Server Manager, the web-based interface is developed. The Map document stored as an .mxd file, the GIS data in the folder "*Data,*" and the pavement section data in the folder "*Web*" are shared over the MapServer.

## Managing the Data

For the access of the RPDB, three levels of accounts are provided: (1) Server Manager/Administrator, (2) Webpage Developer, and (3) User.

- The Server Manager/Administrator is responsible for maintaining and updating all the data files as well as the shapefiles and the map document on the server. The Manager is authorized to update general pavement data, detailed pavement testing data files, field pictures and plotting the test sections onto the base map.

- The Webpage Developer utilizes the ArcGIS Server Manager and writes all the required codes in order to develop and maintain the website and has access to the database hosted on the server. However, the developer cannot update or introduce changes onto the database on the server.

- The Users can access the database online, query and download files but do not have the authorization to update the database. Since it is expected that the RPDB will be shared within TxDOT, a user/administrator login module is used to validate the user accessing the database online. This module shall include a username and password which upon verification would grant access to the database.

## Development of the Web-Application

The web-application that provides a user-interactive interface for accessing the pavement test data and making a query based analysis is developed in a two-step process. This process involves first developing a map document with all the

geographic attributes using ArcMap and then sharing the data and developing the web-application using ArcGIS Server.

*Developing the Map Document*

- The Map document developed for the web-application using ArcMap contains different shapefiles for the county boundaries *(Counties)* and imagery files for the counties as well as the road layers for the different counties across the state. Figure 2 shows a graphical illustration of map document.
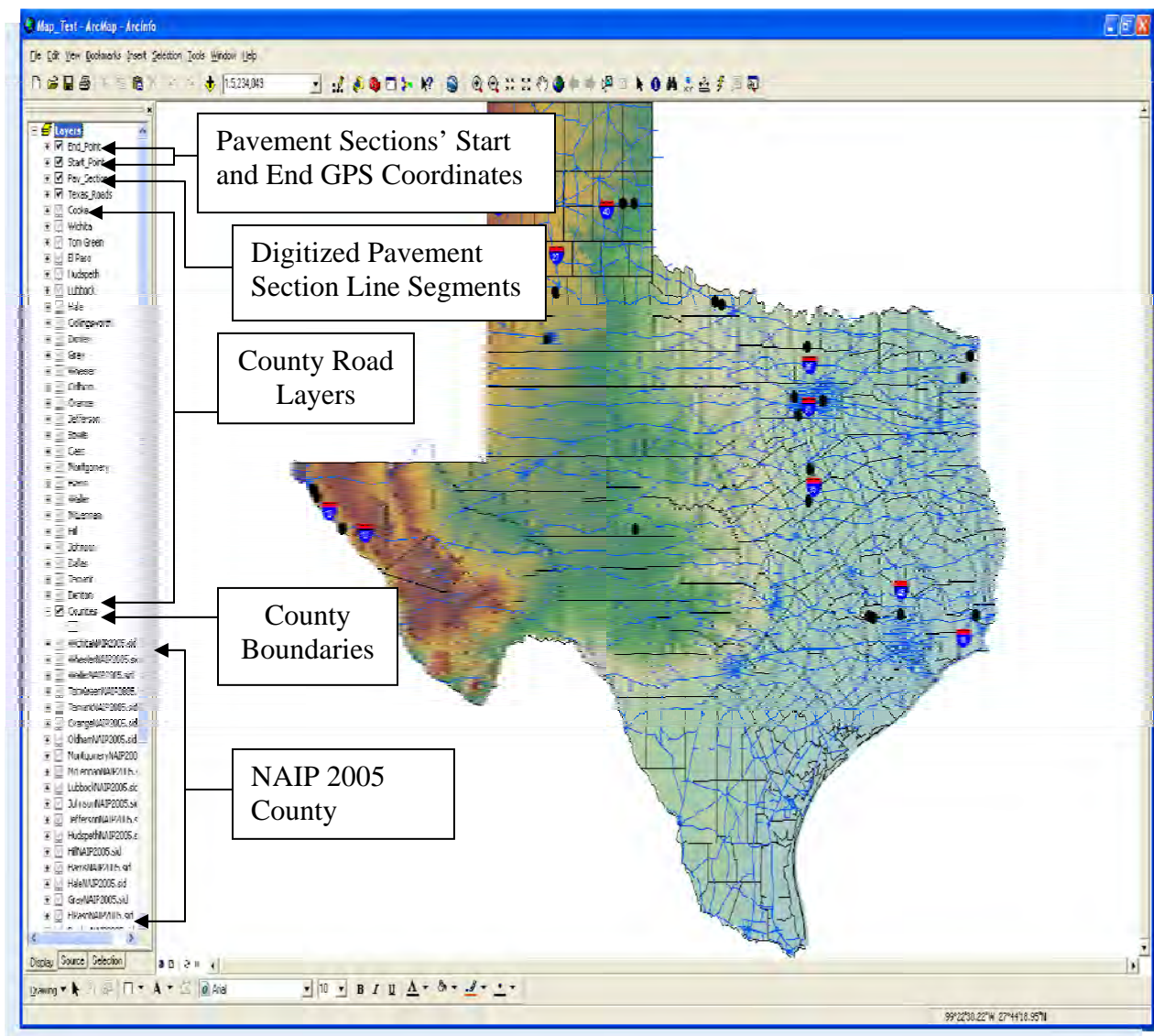
**Figure 2: Map Document**

- All shapefiles and image files are directly added to the Map document from their respective folders on the server using the *Add Data* Tool.

- The GPS Coordinates for the start and end points of the pavement test sections are stored in an Excel sheet on the sever and these can be directly added to the Map Document using the tool *Add X-Y Coordinates* in ArcMap.

- For connecting the end points of the test sections, a shapefile called *Pav_Sections* is first created in Arc Catalog and consecutively added to the map document. Thereafter, using the *Editor* Toolbar in ArcMap, each pair of end points is graphically joined and when these changes are saved, a digitized layer containing the pavement test sections is created.

- The attribute table for the *Pav_Sections* shapefile is added with a field that specifies the Section ID for each test section and also with fields for the general information as well as test results. The General Information and Test Result fields specify the path wherein the corresponding files for the test sections are stored on the server. Figure 3 shows attributes of pavement sections.



| FID | Shape | ID | SECTION_ID | Gen_Info | FWD | LTE |
|---|---|---|---|---|---|---|
| 0 | Polyline | 0 | 5-I27-1 | /5-I27-1/GI_5-I27-1.xlsx | /5-I27-1/FWD_5-I27-1.xlsx | /5-I27-1/LTE_5-I27-1.xlsx |
| 1 | Polyline | 0 | 5-LP289-1 | /5-LP289-1/GI_5-LP289-1.xlsx | /5-LP289-1/FWD_5-LP289-1.xlsx | /5-LP289-1/LTE_5-LP289-1.xlsx |
| 2 | Polyline | 0 | 25-I40-1 | /25-I40-1/GI_25-I40-1.xlsx | /25-I40-1/FWD_25-I40-1.xlsx | /25-I40-1/LTE_25-I40-1.xlsx |
| 3 | Polyline | 0 | 24-I10-1 | /24-I10-1/GI_24-I10-1.xlsx | /24-I10-1/FWD_24-I10-1.xlsx | /24-I10-1/LTE_24-I10-1.xlsx |
| 4 | Polyline | 0 | 24-I10-2 | /24-I10-2/GI_24-I10-2.xlsx | /24-I10-2/FWD_24-I10-2.xlsx | /24-I10-2/LTE_24-I10-2.xlsx |
| 5 | Polyline | 0 | 24-I10-3 | /24-I10-3/GI_24-I10-3.xlsx | /24-I10-3/FWD_24-I10-3.xlsx | /24-I10-3/LTE_24-I10-3.xlsx |
| 6 | Polyline | 0 | 24-I10-4 | /24-I10-4/GI_24-I10-4.xlsx | /24-I10-4/FWD_24-I10-4.xlsx | /24-I10-4/LTE_24-I10-4.xlsx |
| 7 | Polyline | 0 | 3-US287-1 | /3-US287-1/GI_3-US287-1.xlsx | /3-US287-1/FWD_3-US287-1.xlsx | /3-US287-1/LTE_3-US287-1.xlsx |
| 8 | Polyline | 0 | 3-US287-2 | /3-US287-2/GI_3-US287-2.xlsx | /3-US287-2/FWD_3-US287-2.xlsx | /3-US287-2/LTE_3-US287-2.xlsx |
| 9 | Polyline | 0 | 3-I35-1 | /3-I35-1/GI_3-I35-1.xlsx | /3-I35-1/FWD_3-I35-1.xlsx | /3-I35-1/LTE_3-I35-1.xlsx |
| 10 | Polyline | 0 | 2-I820-1 | /2-I820-1/GI_2-I820-1.xlsx | /2-I820-1/FWD_2-I820-1.xlsx | /2-I820-1/LTE_2-I820-1.xlsx |
| 11 | Polyline | 0 | 18-I30-1 | /18-I30-1/GI_18-I30-1.xlsx | /18-I30-1/FWD_18-I30-1.xlsx | /18-I30-1/LTE_18-I30-1.xlsx |
| 12 | Polyline | 0 | 2-I35-1 | /2-I35-1/GI_2-I35-1.xlsx | /2-I35-1/FWD_2-I35-1.xlsx | /2-I35-1/LTE_2-I35-1.xlsx |
| 13 | Polyline | 0 | 9-I35-2 | /9-I35-2/GI_9-I35-2.xlsx | /9-I35-2/FWD_9-I35-2.xlsx | /9-I35-2/LTE_9-I35-2.xlsx |
| 14 | Polyline | 0 | 9-I35-1 | /9-I35-1/GI_9-I35-1.xlsx | /9-I35-1/FWD_9-I35-1.xlsx | /9-I35-1/LTE_9-I35-1.xlsx |
| 15 | Polyline | 0 | 12-US290-1 | /12-US290-1/GI_12-US290-1.xlsx | /12-US290-1/FWD_12-US290-1.xlsx | /12-US290-1/LTE_12-US290-1.xlsx |
| 16 | Polyline | 0 | 12-US290-2 | /12-US290-2/GI_12-US290-2.xlsx | /12-US290-2/FWD_12-US290-2.xlsx | /12-US290-2/LTE_12-US290-2.xlsx |
| 17 | Polyline | 0 | 12-US290-3 | /12-US290-3/GI_12-US290-3.xlsx | /12-US290-3/FWD_12-US290-3.xlsx | /12-US290-3/LTE_12-US290-3.xlsx |
| 18 | Polyline | 0 | 12-441-1-2 | /12-441-1-2/GI_12-441-1-2.xlsx | /12-441-1-2/FWD_12-441-1-2.xlsx | /12-441-1-2/LTE_12-441-1-2.xlsx |
| 19 | Polyline | 0 | 20-I10-1 | /20-I10-1/GI_20-I10-1.xlsx | /20-I10-1/FWD_20-I10-1.xlsx | /20-I10-1/LTE_20-I10-1.xlsx |
| 20 | Polyline | 0 | 19-US59-1 | /19-US59-1/GI_19-US59-1.xlsx | /19-US59-1/FWD_19-US59-1.xlsx | /19-US59-1/LTE_19-US59-1.xlsx |
| 21 | Polyline | 0 | 19-US59-2 | /19-US59-2/GI_19-US59-2.xlsx | /19-US59-2/FWD_19-US59-2.xlsx | /19-US59-2/LTE_19-US59-2.xlsx |
| 22 | Polyline | 0 | 4-I40-1 | /4-I40-1/GI_4-I40-1.xlsx | /4-I40-1/FWD_4-I40-1.xlsx | /4-I40-1/LTE_4-I40-1.xlsx |

**Figure 3: Attributes of Pavement Sections**

- After the formation of the base map containing the counties and road layers, the process of adding the GPS coordinates of the end points and connecting the pavement sections is simplified by the previously described ArcMap tools.

- As a result, every time an update is made in the pavement database with the addition of a new pavement section and data related to it, the same can be introduced on the base map by the Account Administrator/Manager and will be consecutively reflected onto the web service.

- The map document is saved onto the server, in the same base folder where the *Data* and *Web* folders have been saved.

*Authoring and Publishing a Map Service using ArcGIS Server Manager*

- ArcGIS Server Manager is used to publish the web-application.

- To log into the ArcGIS Server Manager, the username and password of the server where all the data has been stored is required, as shown in Figure 4.

**Figure 4: Logging in to ArcGIS Server Manager**

- To begin creating a web-application, the first step involves using the *Create Web Application* tab on the ArcGIS Server Manager and specifying the name of the web application and general description.

- To publish the data stored on the server using ArcGIS Manager, a connection needs to be established to the specific server where the data is stored. This connection is created by using the *Add GIS Server* tab under the *Available Services List* box, typing the server's URL, and clicking *Add Server*.

- As shown in Figure 5, from the drop-down list in the *Available Services* tab, the map document on the server that needs to be published is added to the *Selected Services*.
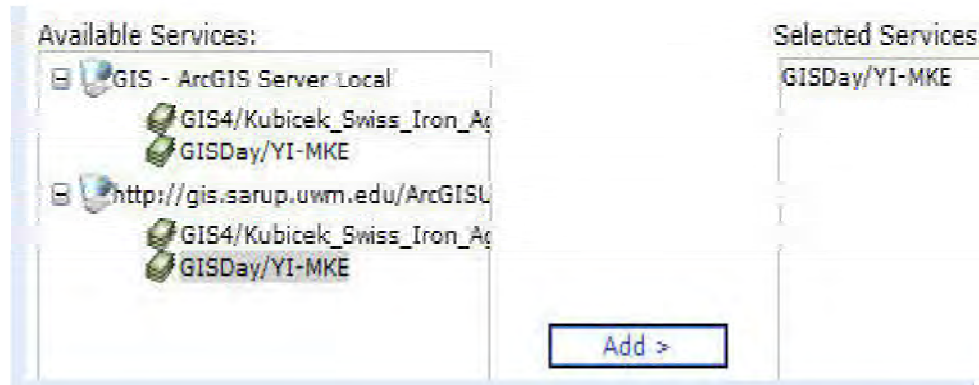


**Figure 5: Adding the Map Document to the Web-Service**

- The next panel prompt allows the user to select tasks for the web application to perform, to be added to the service as shown in Figure 6.
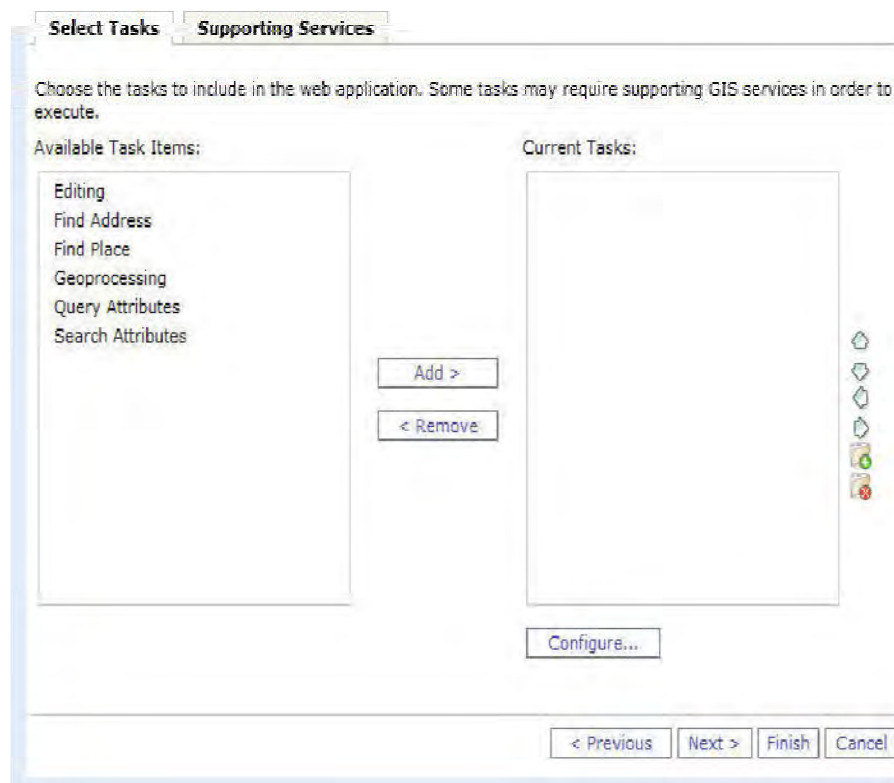


**Figure 6: Selecting and Adding Tasks to the Map Service**

- Through the *Supporting Services* tab, the attributes in each layer can be hyperlinked to a folder or file stored on the server. This is particularly essential in order to gain access to the pavement test section data from the website. The General Information, LTE, and FWD data for each section is hyperlinked to their respective files stored on the server using this service.

- The title text and the theme of the webpage are added in the subsequent prompts.

- The *Enable Map Elements* prompt allows adding other features listed in Figure 7 to the map service. These features can be customized by the Web Developer using the *Settings* tab.



**Figure 7: Adding Map Elements to the Map Service**

- After adding the map elements, the Web Service is created in a separate window as prompted by the Developer.

- An important aspect that needs to be taken care of by the Server Manager/Administrator and the Webpage Developer is that every time data is updated on the server or a map document with changes is saved onto the server, the map service needs to be restarted from the ArcGIS Manager to reflect the changes onto the website.

## Exploring the Application and Accessing the Data

- The application displays the interactive map document in the center along with the map contents in the left layers list as shown in Figure 8.
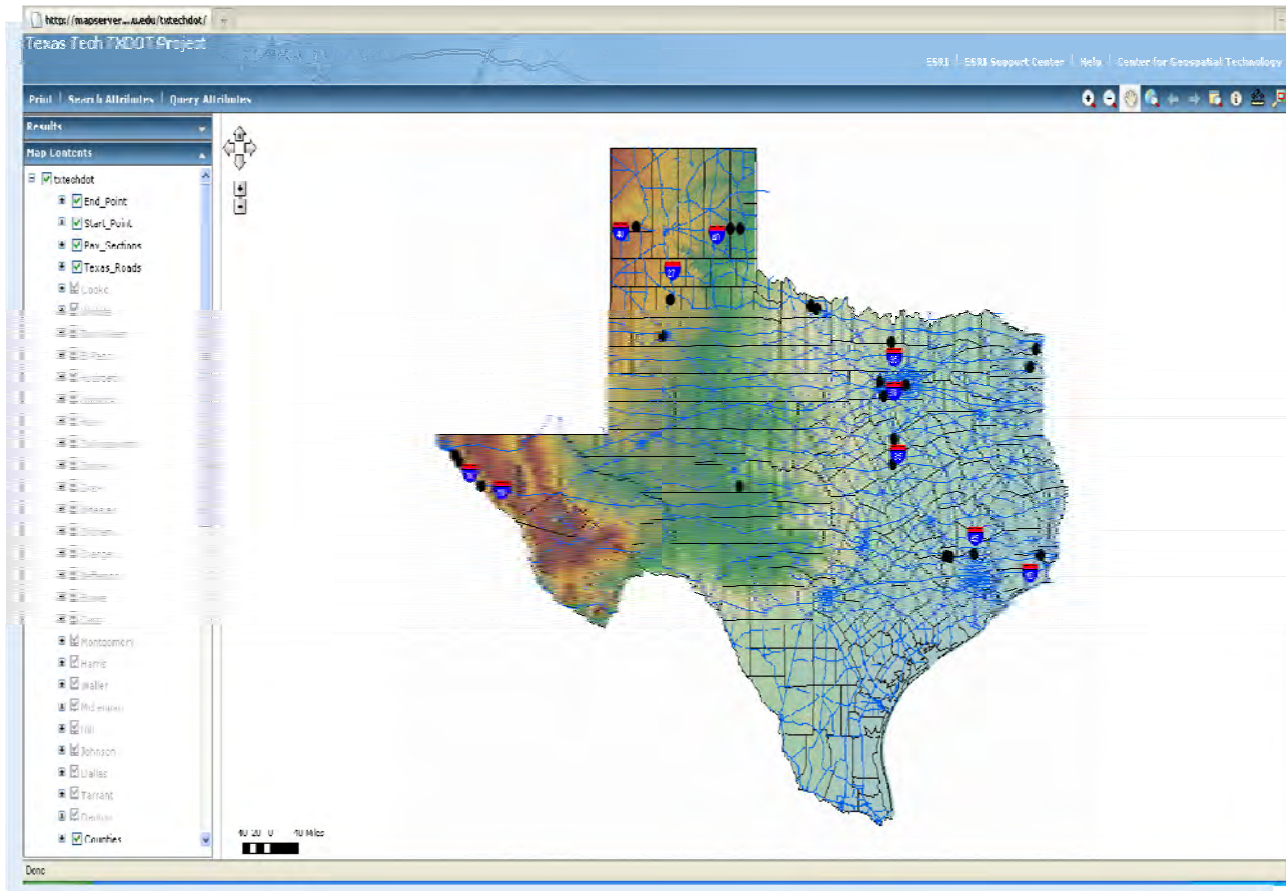


**Figure 8: Web-Application**

- The black colored dots appearing on the map document represent the location of the pavement test sections. Various tools in the application are used to visualize the graphical test sections on the pavement and gain corresponding test information.

- The functions of various tools on the tool bar located in the top right corner in the order from left to right are described below:

1. ***Zoom In and Zoom Out***: This tool allows the user to zoom in and out on the map document. Using the Zoom In tool, the user can adjust the extent of the map wherein the actual pavement test section is visible graphically on the imagery layer. By clicking and dragging a rectangle around the

visible black dots on the full extent of the map (Figure 9), the tool zooms down to the level at which the pavement test sections are visible.
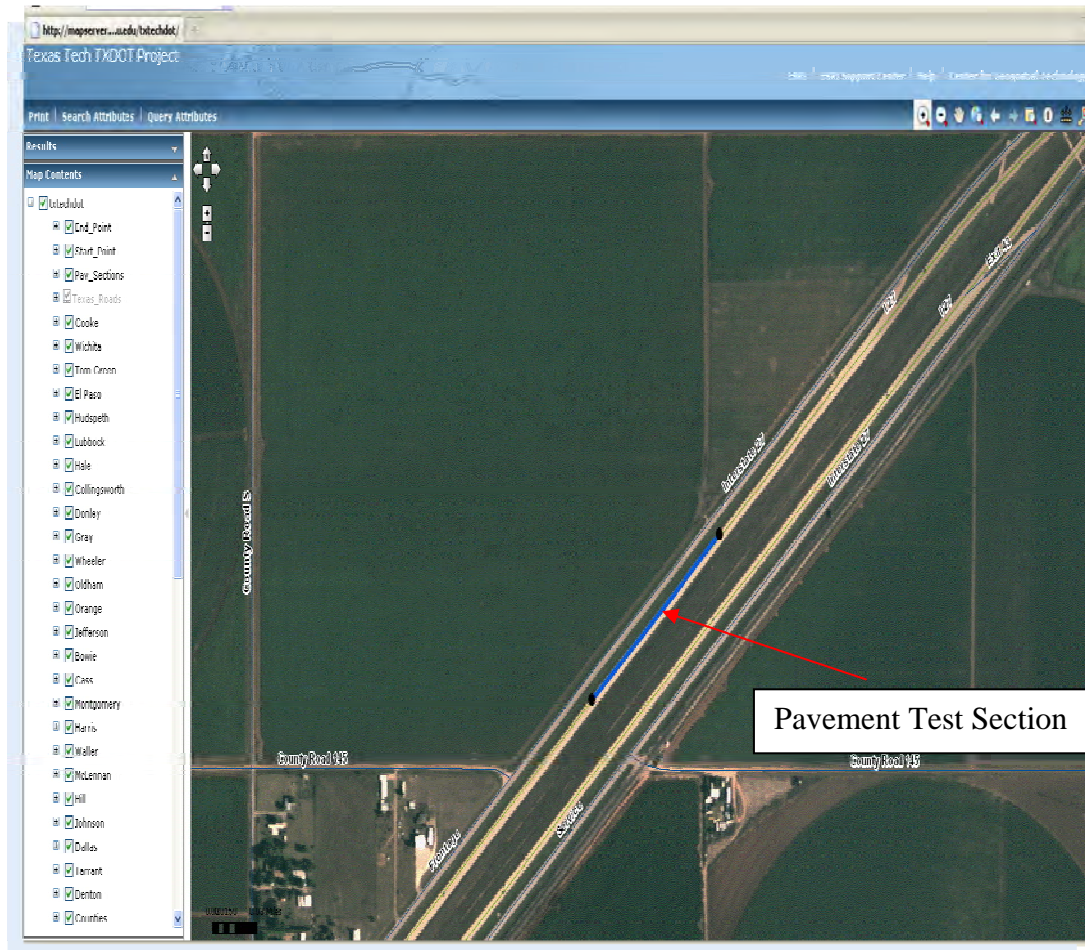


**Figure 9: Zooming into the Pavement Test Section**

2. *Pan*: The Pan tool allows the user to pan around the map and can be used to identify features around the Test Pavement Sections. The pan tool allows the user to pan anywhere around the map while the four panning buttons on the top left of the map document allow the user to pan in those four directions.

3. *Full Extent*: This tool allows the user to go back to the original full extent of the map when the map is in a zoomed in or zoomed out state.

4. *Back/Forward extent*: This tool is used for going back to the previous view of the map or moving forward to the next view of the map. This function is exactly the same as the back/forward arrows used in Internet Explorer to access web addresses.

5. *Magnifier*: This tool is used to view a magnified image of the underlying layers of the map without actually zooming in to the particular extent. This layer provides magnified images up to 10x of the actual image. Thus, as shown in Figure 10, without zooming into the pavement section, from the full extent of the map, the underlying pavement section can be seen using the Magnifier tool.
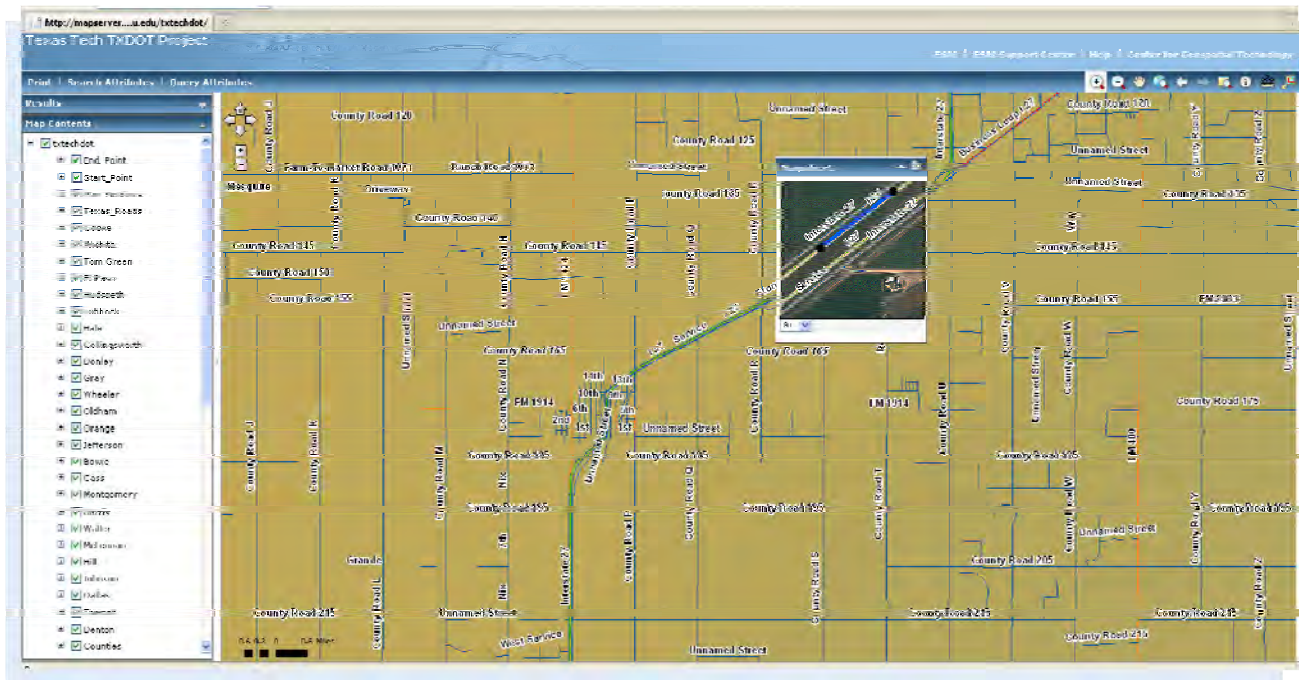


**Figure 10: View using Magnifier Tool**

6. *Map Identify*: This tool is used to identify any features on the map displayed on the application. All the data attributed with the particular layer being identified is displayed in a drop down box. However, this tool displays the information about the topmost layer in the region being identified. Hence, to retrieve test data for the pavement test section, the user needs to zoom down to the test section, and identify the pavement section marked with blue. By doing this, the map identifier displays the attributes of the pavement section layer, i.e., the General Information, LTE and FWD results. By clicking on the hyperlinks (Gen_Info, FWD, and LTE) in the drop-down menu, the particular data file for the section pops up and can be viewed or printed in Microsoft Excel format. This function is illustrated in Figure 11.
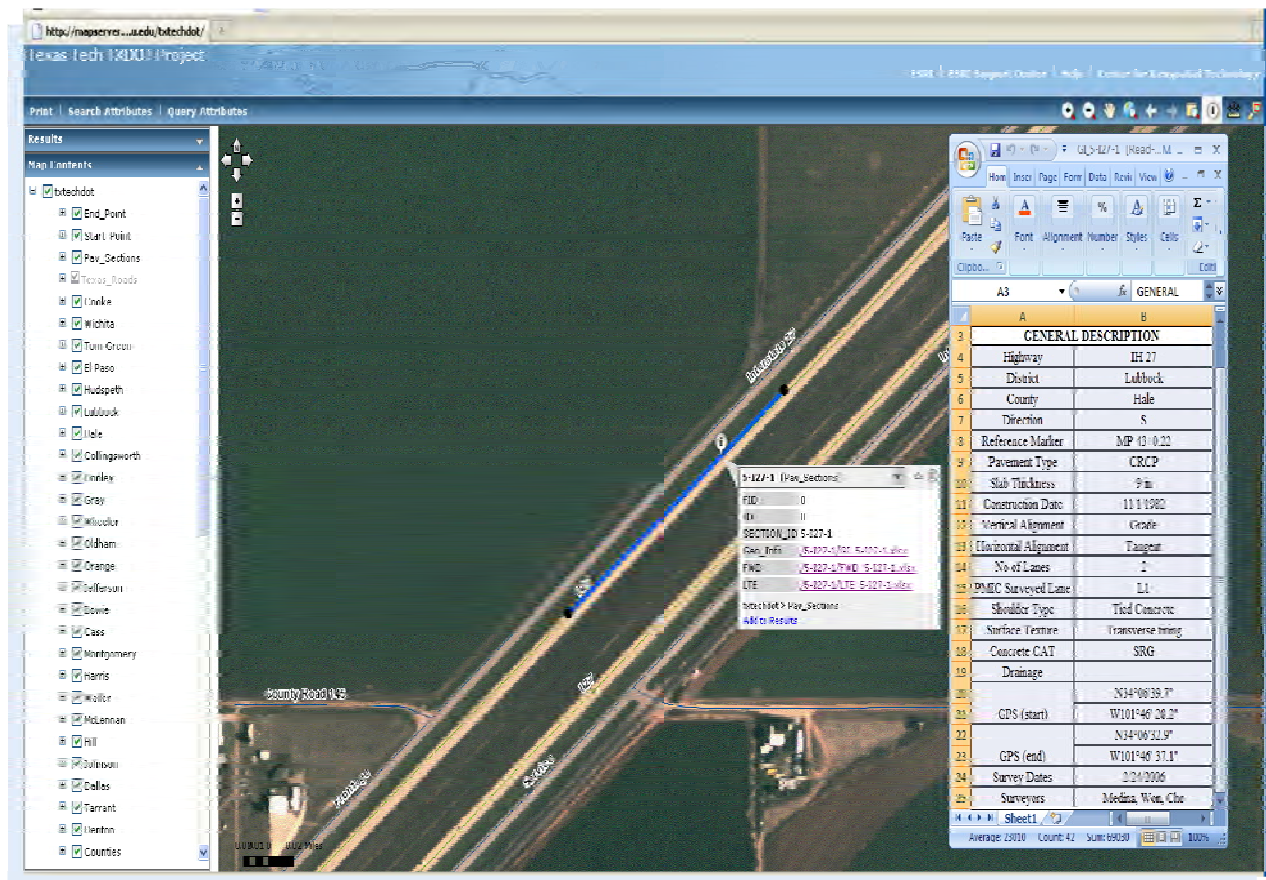
**Figure 11: Map Identify Tool and Accessing the Data**

7. ***Measure***: This tool is used to measure the distances on the map. To measure the distance between two points, click one point and then click on the other point; the distance between the two points will show up in a display window on the map. To calculate distances along a route, keep clicking on different points on the route; the display area will show the distance between points as well as the total distance along the route.

8. ***Show Overview Map***: This tool is used to turn on and off the overview map that appears at the top right corner of the website.

9. ***Print***: The map on the website in its present extent as well as the data related to each section can be printed using the *Print* tab.

10. ***Query Attributes***: This tab is used to query and search a pavement test section according to its Test Section ID. The criteria for querying can be changed and updated using the ArcGIS Server Manager. Figure 12 shows the screen when this function is activated. To query the attributes, the test section ID of the required section can be selected from the drop-down menu in the *Query Attributes* window. After clicking *Find,* the query for

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the particular section is returned with the hyperlinks to all the attributes and data related to that particular section. The selected pavement section can be viewed on the map by right-clicking on the Section ID in the query window and clicking on the Zoom In tab. This represents the selected section on the map service on the right and the selected section is highlighted in blue color.
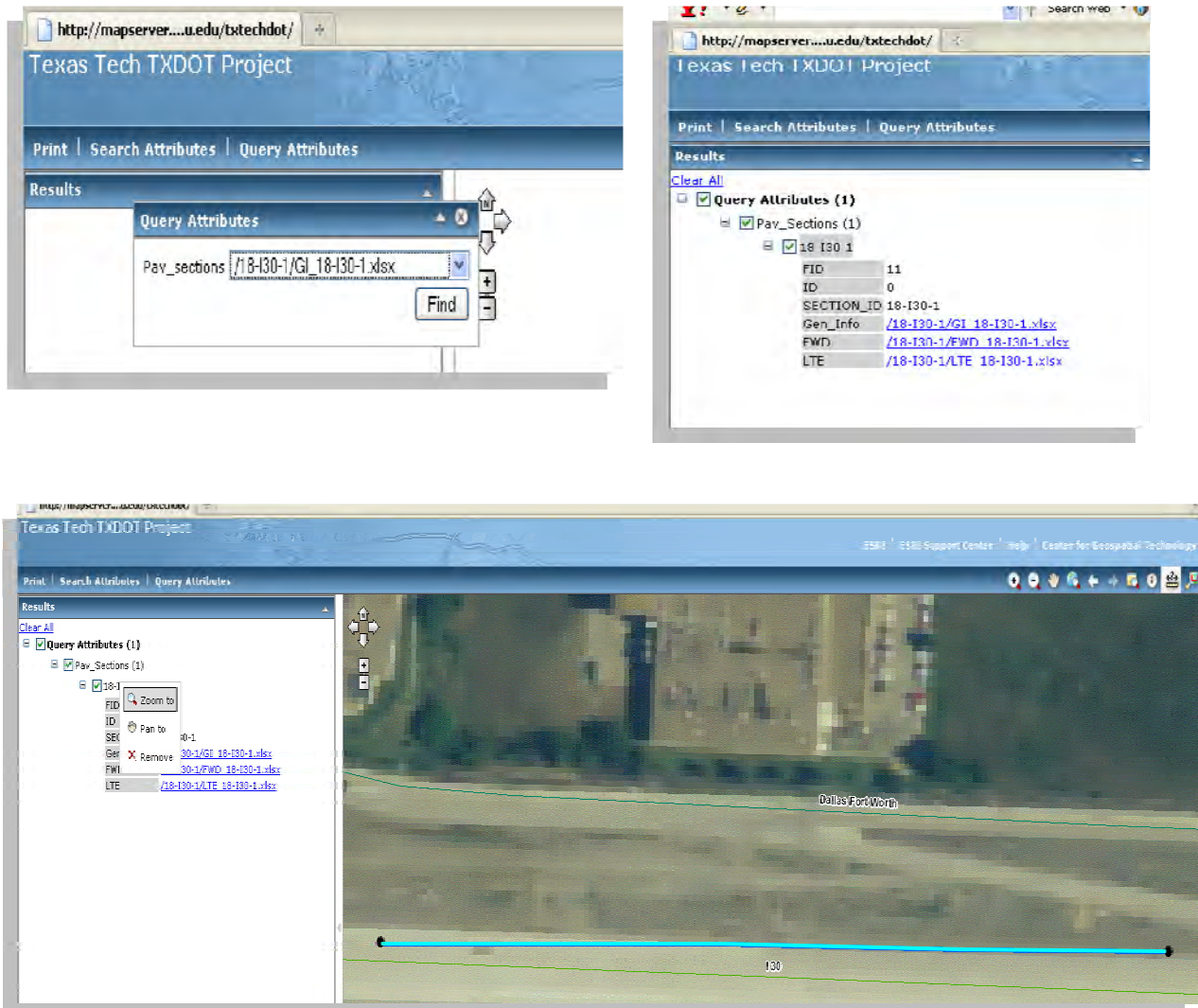




**Figure 12: Querying Attributes**

**Summary**

As discussed earlier, currently crack spacing and LTE are the primary two structural responses included in this RPDB. Other structural responses and/or more sections such as experimental sections could be included in the future. As the RPDB is further refined, proper documentation will be made.