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RUTGERS PAVEMENT RESOURCE CENTER

2008 PROGRAM

January 2011

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Abstract
The primary objective of the Rutgers Pavement Resource Program (PRP) is to use the extensive laboratory and field pavement testing equipment and staff expertise of the Pavement Resource Program in all aspects of Pavement Engineering to assist the New Jersey Department of Transportation's Pavement and Drainage Management Systems Unit in developing pavement management system strategies, innovative materials, improved pavement design tools, and advanced laboratory and field data collection equipment aimed at enhancing network condition by optimizing available capital resources. The primary goals of the current program are to:

1. Enhance the Department's Pavement Management System,
2. Develop and implement an advanced Ground Penetrating Radar (GPR) system to supplement inventory information of state highway pavement structures,
3. Assist in the planning, design, construction and management of a NJDOT ride quality facility for the certification of equipment utilized by NJDOT, consultants and contractors for construction contract pay adjustments.
4. Provide ongoing support for implementation of Mechanistic-Empirical Pavement Design on an as needed basis to support the Department's $225 million annual paving program, and
5. Develop a NJ-LTPP program to assess the pavements designed with the new M-E Pavement and Design Guide (MEPDG) to determine the "as constructed" level 1 inputs for the MEPDG and enhance the predicted pavement performance models for 00, top down and bottom up cracking and rutting, and
6. Provide technical support and data collection to support the developing and NJDOT unofficial "Quiet Pavement Policy" developed by the Pavement Technologies Group.

Key Words
Pavement Management System, MEPDG,

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EXECUTIVE SUMMARY

The mission of Rutgers University's Center for Advanced Infrastructure and Transportation (CAIT) Pavement Resource Program (PRP) is to provide pavement engineering support to the New Jersey Department of Transportation (NJDOT)'s Pavement and Drainage Management Systems (P&DMS) Unit.

The activity was a partnership between federal and state transportation agencies and the academic institution of Rutgers University to provide technical and educational services to address transportation infrastructure in New Jersey. The Center supported the NJDOT by providing staff and resources to address pavement engineering, performance modeling, material characterization, operational issues, training, and other technical support as needed by the Pavement and Drainage Management Systems Unit.

The goal of the Pavement Resource Program was to assist in developing the tools and apply the resources of the Center to optimize the funds available through the NJDOT's capital program to improve the condition of New Jersey highway pavements. The condition of New Jersey's pavements has declined steadily over the past decade as available resources have been committed to other needs. The significant backlog of pavement maintenance and rehabilitation has resulted in a significant increase in vehicle operating costs to NJ motorists.

A fresh approach to pavement management using the latest technology was needed to help restore New Jersey's highway infrastructure to a state of good repair with limited available resources. The Pavement Resource Program served as an extension of the NJDOT's Pavement and Drainage Management Systems Unit and functioned as the primary research and technology arm to address the unit's needs. It was organized to rapidly respond to the Department's need for implementation of advanced pavement evaluation and asset management technologies.

The PRP worked to develop asset management tools, database architecture, material testing and evaluation, validation and implementation of new technologies, methodologies and materials. The services provided by the joint NJDOT/CAIT pavement engineering program included field and laboratory testing and evaluation, development of advanced pavement information systems, and specialized training/educational programs for NJDOT and its consulting pavement engineers.

INTRODUCTION

The primary objective of the Rutgers Pavement Resource Program (PRP) is to utilize the extensive laboratory and field pavement testing equipment and staff expertise of the Pavement Resource Program in all aspects of Pavement Engineering to assist the New Jersey Department of Transportation's Pavement and Drainage Management Systems Unit in developing pavement management system strategies, innovative materials, improved pavement design tools, and advanced laboratory and field data collection equipment aimed at enhancing network condition by optimizing available capital resources.

The primary goals of the current program are to:

1. Enhance the Department's Pavement Management System,
2. Develop and implement an advanced Ground Penetrating Radar (GPR) system to supplement inventory information of state highway pavement structures,
3. Assist in the planning, design, construction and management of a NJDOT ride quality facility for the certification of equipment utilized by NJDOT, consultants and contractors for construction contract pay adjustments.
4. Provide ongoing support for implementation of Mechanistic-Empirical Pavement Design on an as needed basis to support the Department's $225 million annual paving program
5. Develop a NJ-LTPP program to assess the pavements designed with the new M-E Pavement Design Guide (MEPDG) to determine the "as constructed" level 1 inputs for the MEPDG and enhance the predicted pavement performance models for 00, top down and bottom up cracking and rutting, and
6. Provide technical support and data collection to support the developing and NJDOT unofficial "Quiet Pavement Policy" developed by the Pavement Technologies Group.

Task Summary

Pavement Management Systems

<u>Background</u>

The Pavement Resource Program agreed to continue from previous year's work to provide technical support to the NJDOT Pavement and Drainage Management Systems Unit by working with the unit staff in establishing and implementing a comprehensive pavement strategy toolbox that optimizes capital investment by selecting the right fix at the right time on the right pavement. These strategies were to be included into the new Deighton Infrastructure Management System.

The treatment strategies will expand on the current rehabilitation and reconstruction treatment by developing Preventive Maintenance (PM) decision trees or treatment rules, default/draft performance curves, failure criteria and timing or condition to apply the treatment (moving from Fair to Good), impact of treatment on condition (e.g., smoothness level, distress level, rutting level), performance of the activity (condition over time) based on condition of the pavement before the PM treatment. The Pavement Resource Program agreed to work with the unit staff to finalize a new surface distress index that incorporates load and non-load associated distresses and rutting and a combined final pavement index for use in prioritizing annual pavement program for CPM and Maintenance Operations. The Pavement Resource Program worked with the unit staff and Deighton to develop a Remaining Service Life (RSL) analyses for PMS summary reporting to the FHWA and the State Legislature.

In an effort to maintain high levels of expertise with in the NJDOT's Pavement and Drainage Management Systems Unit, the Pavement Resource Program will develop a PMS procedures manual including the data management, performance models, decision trees, economic analysis, and reporting of the Deighton Infrastructure management system and provide ongoing technical support and training of the unit personnel in the operation of the Deighton PMS. To assist with the implementation of the new PMS and training of the NJDOT staff, the Pavement Resource Program used the expert oversight of Katie Zimmerman of Applied Pavement Technology, Inc. The Pavement Resource Program would continue to use the Deighton experts to address the NJDOT's needs through ongoing maintenance and support agreements.

Work Performed

During the early stages of the project, the PRP worked with Deighton to develop a maintenance agreement. The PRP also worked with Deighton and the NJDOT staff during site visits to refine the dTIMS PMS to incorporate committed projects, 2008 pavement condition data, and refine the pavement analysis sections. The PRP staff also worked to develop a NJDOT Deighton dTIMS PMS manual for future users of the system. The user manual would be reviewed and accepted by the PRP, Deighton support staff, and the NJDOT PMS staff. (Appendix A) The staffs also worked diligently on revising the analysis segments of dFrag analysis for additional analysis runs.

The PRP worked with Deighton and NJDOT to evaluate modifications to the dTIMS PMS section definitions to be New Jersey specific. They also met to evaluate the budget scenario results for the 2010-2020 program. The highway definitions were modified due to changes in the Straight Line Diagrams (SLD) descriptions. Some section definitions were adjusted based on 2010 pavement condition data. The current 2010 pavement condition data was inputted into the dTIMS.

Ride Quality of New and Rehabilitated Pavements

Background

The Pavement Resource Program agreed to continue providing technical support to the NJDOT Pavement and Drainage Management Systems Unit by working with the unit staff in establishing and implementing calibration procedures, and assist in management of a proposed NJDOT International Roughness Index (IRI) calibration and certification facility (based on the Texas TI model). The Pavement Resource Program would develop a procedures manual for data collection and analysis of calibration of high speed profilers based on the NJDOT's standard walking profiler. The Pavement Resource Program agreed to facilitate training of NJDOT and industry staff on the use of high speed and portable profilers to enhance pavement and bridge deck ride quality.

Work Performed

The Pavement Resource Program coordinated the training of NJDOT staff on the use of the SurPro2000 walking profilers with International Cybernetics (ICC) and the installation and training of the Dynatest Portable Profilers.

The certificate of insurance for the New Jersey Department of Transportation was provided to the New Jersey Turnpike to use a section of pavement between Exits 8A and 9 on the northbound truck lanes side to be used as a test site for the NJDOT's walking profilers and van.

The PRP meticulously prepared the Pavement Profiler Certification Test Section. The PRP used the Rutgers SurPRO pavement reference profiler to collect and analyze reference profiler measurements. The PRP worked with NJDOT PMS staff to organize field profiler data collection with the NJDOT's Dynatest portable and ICC profilers. The PRP analyzed the profile and IRI data and prepared and delivered a report to NJDOT. (Appendix B)

The PRP conducted field training of the SurPRO walking profiler for the regional and Trenton staff of the Bureau of Materials. The PRP also coordinated Pavement Profiler Certification for the Bureau of Materials Regional and Trenton offices. Data collected by the Bureau of Materials was reviewed and analyzed and each office received a summary report of the data collected and analyses performed. (Appendix C)

Mechanistic-Empirical Pavement Design Guide (MEPDG)

Background

The Mechanistic Empirical Pavement Design Guide (MEPDG) provides a realistic evaluation of the development of pavement distresses, a design methodology previously not utilized by most state agencies. The material, climatic, and traffic type dependence of the distress predictions requires extensive testing and data inputs that NJDOT currently does not hold. And due to the new methodologies and concepts included in the MEPDG, many state agencies have not been properly introduced and trained to the new design software.

To minimize the delay of the NJDOT Pavement Technologies group in implementing and using the MEPDG, the Pavement Resource Program has identified key areas that need to be explored and evaluated for a prompt and accurate implementation of the MEPDG:

- Develop material databases for the proposed MEPDG, select NJDOT pavements to be utilized for distress evaluation and local recalibration of the pavement distress models currently incorporated in the software to more accurately represent New Jersey materials, traffic and environmental conditions.
- Providing facilities, coordination, and instructors for training pertaining to preventative maintenance, pavement preservation and MEPDG implementation. This training will be conducted in a large group environment at the Center for Advanced Infrastructure and Transportation (CAIT), as well as on-call related services at the NJDOT.

- Conduct laboratory and field testing of materials for characterization of pavement structures and their individual components for roadways under NJDOT jurisdiction to support the MEPDG material inputs.
- Develop a consolidated list of inputs for MEPDG for levels 1-3
- Organize meetings with NJDOT traffic organizations to discuss traffic data needs and modification to consultant agreement for data collection.
- Develop a NJ-LTPP program to assess the pavements designed with the new M-E Pavement Design Guide (MEPDG) to determine the "as constructed" level 1 inputs for the MEPDG and enhance the predicted pavement performance models for 00, top down and bottom up cracking and rutting.

Work Performed

Two of the MEPDG test sections (I-195 and I-287) were cored and sampled. Site specific traffic data and Falling Weight Deflectometers (FWD) were conducted and analysis was performed. The extracted HMA cores from the I-195 section were tested for dynamic modulus, asphalt binder properties, volumetrics, and gradation. The test data from the cores was used to populate the required material properties in the MEPDG for the asphalt mixtures. The back-calculated modulus values from the FWD were used as modulus inputs in the MEPDG.

The PRP collected materials (asphalt mix and binder) produced for the jobs being placed and testing was conducted on the materials to enable the PRP to collect pavement distress data and the generation of the pavement distress prediction models.

Non-Destructive Equipment

Background

The Infrastructure Condition Monitoring Program (ICMP) group agreed to increase its support and services for various NJDOT units. The objective was to develop and deploy the latest NDE/NDT technologies for evaluating and monitoring the condition of the transportation and utilities infrastructure and assist with Transportation Asset Management.

Work Performed

The PRP continued to analyze the input of Ground Penetrating Radar (GPR) into the HPMA. Missing sections were identified by the staff of PRP and GPR data for those sections was collected, analyzed, and inputted into the HPMA.

Geographic Information Systems (GIS)

Background

The Pavement Resource Program agreed to continue to provide technical support to the NJDOT Pavement and Drainage Management Systems Unit by working with the unit staff in establishing and implementing Arc GIS layers for subgrade soil type locations (Rutgers Soils Maps), material characterization, and properties. These enhanced GIS tools will provide additional information for the modeling of PMS performance and MEPDG implementation.

The Pavement Resource Program agreed to develop an Access database and Arc GIS layers for experimental material application and preventive maintenance/pavement preservation treatments, locations, properties, and performance. This database and GIS tool would provide the means to track PM and innovative treatment locations (constructed by Maintenance Operations personnel or contracts), and assess performance, and costs. The new Deighton PMS has enhanced capabilities to use GIS tools to illustrate the condition and other data contained in the PMS database. The Pavement Resource Program will work with the unit staff in establishing, document, and implementing of Arc GIS tools to enhance the use of Deighton PMS.

Work Performed

To begin the process, the PRP hosted an initial technical kickoff meeting for the Soil Engineering Map Series. The Cook College Remote sensing unit started scanning the 100 map sheets for the GIS base map and the 21 county books and overview book for the engineering soils series. Once the maps were scanned, the Cook College Remote sensing unit recertified the scanned maps and rectified to the NJ State Plan 1993 coordinate system. Soil labels were completed for all counties and all of the NJ County soil manuals were scanned.

Quiet Pavements

Background

The NJDOT's Pavement Technology group initiated an unofficial Quiet Pavement Policy to help reduce the potential for pavement-related noise by selecting quieter pavement surfaces. The basis for pavement surface selection was a research report conducted by the Pavement Resource Program in 2004. Since that time, a number of new pavement surface types have been implemented in New Jersey, including High Performance Thin Overlays (HPTO), finer nominal aggregate size HMA, such as 9.5mm mixes, and a recently placed asphalt rubber OGFC. Additionally, other potential surfaces, such as asphalt rubber chip seals and asphalt rubber SMA pavements have been proposed. Unfortunately, the NJDOT does not have any current means to measure the magnitude and noise differences (increase or decrease) in the different pavement surfaces, as well as how these pavement surfaces emit noise seasonal or throughout their service life. Based on the issues identified above, the Pavement Resource Program developed the following tasks to help solve some of the more pertinent pavement noise related issues.

- Assist the Pavement and Drainage Management Systems Unit task force in developing criteria on the use of quiet pavements in NJ,
- Conduct a Noise study on new pavements or rehabilitated pavements utilizing road side and at-the-source noise measurement of various pavement surfaces to determine relationships under different climatic (seasonal), speed, traffic levels, geometric conditions, pavement surface characteristics (surface texture and roughness) and service life.

- Create an Access database and GIS map of highly sensitive noise areas where the NJDOT Pavement Technologies group could implement their unofficial Quiet Pavement Policy.

Work Performed

A contract with a private contractor (Illingworth and Rodkin) was put into motion early in the project. All of the required testing equipment, recommended by Illingworth and Rodkin was purchased. The lead research engineer for the pavement noise work has also been trained ont eh general use of the analyzer system. The vehicle fixture was being manufactured in California and was scheduled to be completed in the middle of the project period. CAIT worked with the lead research engineer out of the GM Proving Grounds in Yuma, Arizona for extensive training on pavement noise measurements and analysis. The training took place over a 1 week period and was conducted with the equipment purchased by CAIT.

NJDOT provided CAIT with locations of current and past noise concerns, as reported to NJDOT by local residents. CAIT conducted On-Board Sound Intensity (OBSI) testing on all of the noted test sections. CAIT has also conducted testing on the previous (I-95) and recent (I-78) asphalt rubber OGFC mixtures, along with polymer modified OGFC mixtures on the Garden State Parkway. The PRP delivered an interim report to the NJDOT of the work performed. (Appendix D)

On Call Testing

Background

The Rutgers Asphalt Pavement Laboratory is a valuable and useful asphalt research laboratory that could assist the NJDOT with some of their technical needs. The PRP agreed to provide timely testing as needed by the NJDOT.

Work Performed

CAIT conducted a number of on-call testing for the NJDOT. They include:

I-295 Bottom Rich Base Course (BRBC) – 5 different mixture designs were evaluated (3 from Winslow Asphalt, 1 from American Asphalt, and 1 from Trap Rock Industries).

High Performance Thin Overlay (HPTO) – 5 different mixture designs were evaluated this quarter (3 from Earle Asphalt and 2 from Trap Rock Industries).

Bridge Deck Wearing Course (BDWC) – 1 mixture design was completed. (Tilcon provided the mixture from a temporary steel bridge.) A second mixture

A report to the NJDOT pertaining to the performance of the stone mastic asphalt rubber (SMAR) mixture placed on I-295 was submitted ot the NJDOT. The purpose of the study was to evaluate the structural integrity of the SMAR. The testing concluded that the SMAR was structural sound with respect to rutting and cracking potential, but that high air voids in the material made it susceptible to moisture damage. A think life wearing course (such as a Novachip mixture) was recommended for placement over the SMAR.

Testing for the NJDOT was also completed to evaluate whether or not a new polymer, called Elvaloy, could be used as a potential substitute for SB and SBS polymers. The PRP completed the final report for the evaluation of SBS vs Elvaloy Modified PG76-22. (Appendix E)

Strategic Plan

Background

The Pavement Resource Program will assist the Pavement and Drainage Management Unit by facilitating the development of a unit multi-year strategic plan. The CAIT organization has extensive experience in facilitating strategic plan development for the Rutgers LTAP, NJDOT Bureau of Research, and State-wide Safety Plan.

Work Performed

The PRP staff and the NJDOT staff worked to facilitate the development of draft Vision, Mission, and Goal Statements for the Strategic Plan. The PRP and NJDOT staff discussed the list of staff, customers, suppliers, and others that would participate in the production of the Strategic Plan. The NJDOT staff worked to develop survey and focus group questions. The development sessions were scheduled to begin after the completion of this project.

CONCLUSION

The Pavement Resource Program at the Center for Advanced Infrastructure and Transportation at Rutgers University was pleased to participate as an extension and partner with the New Jersey Department of Transportation to perform a variety of tasks put before them.

APPENDIX A

STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION

NJDOT
Deighton dTIMS CT
Pavement Management System
USER MANUAL

Submitted by:
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AND

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DEIGHTON
empowering asset managers

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Executive Summary

To follow draft review and final configuration to take place during training.

1. Introduction

This document is intended to provide background and instructions on using the Deighton dTIMS CT Asset Management software for the New Jersey Department of Transportation Pavement and Drainage Management Unit.

Start Window

Open a Recent Database - dTIMS CT will keep a list of up to ten recently used databases so you can pick from the list

- **Database -** This area offers five options:

  • ***Create New...*** To start with an empty desktop database link. This option is not available in the *Enterprise* version.

  • ***Create Template*...**Design and save a template for future databases. This is normally used when Analysis Sets and Budget Scenarios are designed for another office to supply elements.

  • ***Create New from Template*.....**Create a database from the template previously designed and saved.
  • ***Demo Database:*** To open the demo database select *Demo.* The demo database is the companion database to the dTIMS CT User Guide.

  • ***Compact & Repair...:*** will remove any nondescript DRPs and other unused space in the database.

- **Enter your User ID and Password -** you must enter a User ID and password in the following instances:
  - you have more users than the **dTIMS CT default user identification** and **password** of **1111, one**
  - you select a database using the function to select a database from the file system.
  - Use the ***Tools | Users*** options to:
    - add user identifiers and password combinations using unrestricted text entires of maximum 255 alpha/numeric/special characters
    - to change passwords
    - to add *Access Levels* for the user identification and password combinations

- ***Remember User Name & Password*** checked will cause the current user name and password to be written to memory and will be checked automatically as the default every time a database is selected. The database may reside in either the recent files or the file system. If the default is valid for the database, it will be opened. If another *Remember User Name & Password* is subsequently unchecked, the remembered combination will be lost.

- **On the Web** - Provides quick links to the Deighton Associates Limited website and email support.

- **Software Updates -** Deighton Associates Limited will issue software update releases to fix known software issues. At application start time dTIMS CT will now automatically detect whether your system needs a software update (provided that you are connected to the internet). If a software update is available and your installation is not current, this link will be active and if you click it the update will be installed for you. If your system does not require a service release this link will be inactive (grayed out).

Note: You must regularly exit and restart your dTIMS CT application to have this link updated.

- **Remote Key Update** - Security is programmed into the local and network keys depending upon your purchase contract. If you purchase additional dTIMS CT modules at a later date this link will allow you to enable them, provided that you are connected to the internet and that the Deighton Associates Limited License database has previously been updated and set to download.

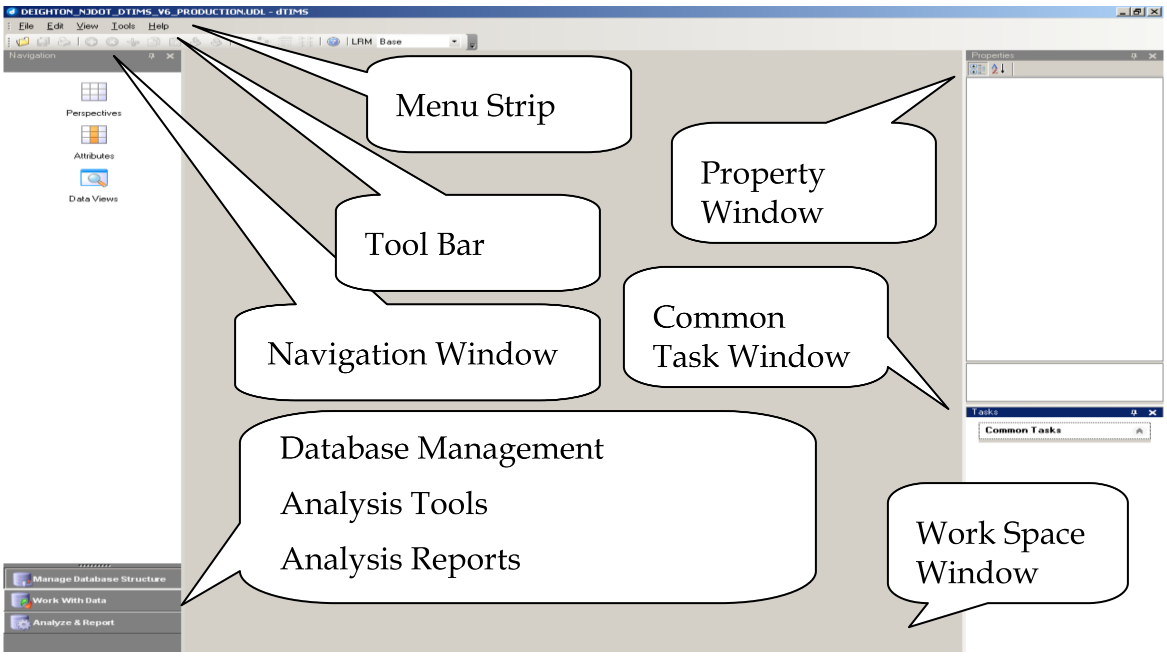
Compact and Repair Option removes the empty spaces and empty files from the database.

Perform the operation on a weekly basis or more often when you are performing annual updates to the database.

Update Available will light if dTIMS has determined by checking with Deighton that there is updated software available.

User Interface

The user interface shown below contains a main menu, tool bar, navigation pane and property and common task panes.



Menu Strip

File

Open:

Calls the Open File dialog box and asks you to select an existing dTIMS™ CT database. Files that have the extension of '.UDL' or '.dTIMS' are dTIMS™ CT databases. The '.UDL' extension is designated for dTIMS CT Enterprise databases while the '.dTIMS' extension is for dTIMS CT Desktop databases. This menu selection is only visible when you do not already have a dTIMS™ CT database open. To view which database you currently have opened go to *Help|About dTIMS CT*.

Close:

Closes the currently open dTIMS™ CT database without leaving the dTIMS™ CT application. This selection is only visible when you have a dTIMS™ CT database open.

Page Setup:

Used to set printer preference and options for your database.

Print:

Will print an object's corresponding *detail* or *summary report* or the contents of any data table

Print Preview:

Calls the Print Preview window which allows you to preview data tables or detail and summary reports without sending it to the printer.

Save:

Will save the currently selected object in the *Workspace Window* .

Save All:

Will save all objects,marked as 'dirty', in the Workspace Window .

Exit:

Closes the currently opened dTIMS™ CT database and exits the dTIMS™ CT application.

Edit

Cut:

Select this to delete the current child object and copy its data to the clipboard.

Copy:

Select this to copy the data of the current child object to the clipboard. When copying an attribute dTIMS™ CT does not copy onto the clipboard the data values associated with the attribute that is being copied. Thus, the Data Sheet View will not contain data values for this attribute.

Paste:

This selection is only enabled, if the clipboard contains this kind of child object's data. If it is enabled, and you select it, dTIMS™ CT will paste a copy of the data in the clipboard as a new object into the library. When pasting an attribute from the clipboard, dTIMS™ CT does not paste data values associated with the original attribute that has been copied. Thus, the Data Sheet View will not contain data values for this attribute.

New Item: Will add a new child object to the Workspace Window

Delete:

Select this to delete the current child object. When you initiate deleting the current child object from the current Workspace Window, dTIMS™ CT displays a list of objects affected by cascading this delete window. Based on this information, you can cancel the delete, or proceed with it.

Import:

This menu item will allow you to *import* values based on the child object you have highlighted (for example, Perspectives, Attributes, Data Views and so on)

Export:

Allows you to *export* a child object or data values. dTIMS™ CT will display a dialogue window where you have to supply the name and the path for the external file to send the exported data values to. Also, you can choose a file type for the external file. You can choose from the following file types: Microsoft Excel™, dBASE™, Text, Microsoft Access™, and HTML.

Find and Replace:

If you want to find and/or replace values in a specific column of a browse table. This selection is only enabled when a Data Sheet View is open. You can define what you want to *find,* what you want it replaced with, and how close match you want to look for. Additionally you may refine your search by column, whole table or selection.

Select All:

Will highlight all objects in corresponding workspace window

View

Navigate To:

Navigate to any object in dTIMS CT exactly as you would by selecting the object from the Navigation Pane. This menu item will launch three sub menus: *Database Structure*, *Work with Data* and *Analysis Reports*. Each of these menus further calls the level which will select the library of its group such as *Perspectives*, *Attributes* and *Data Views* for the *Database Structure* group.

Navigation Pane:

If you closed the *Navigation Pane*, this menu item will restore the *Navigation Pane* to its default position; otherwise it is already open and will be highlighted.

Properties:

If you closed the *Properties Pane*, this menu item will restore the *Properties Pane* to its default position; otherwise it is already open and will be highlighted.

Task Pane:

If you closed the *Task Pane*, this menu item will restore the *Task Pane* to its default position; otherwise it is already open and will be highlighted.

Toolbar:

If you closed the *Toolbar*, this menu item will restore the *Toolbar* to its default position; otherwise it is already open and will be highlighted.

Small Icons:

This menu selection is only enabled when you are displaying objects in a workspace window. Selecting *Small Icons* will change the object icons in the workspace window to small icons.

Large Icons:

This menu selection is only enabled when you are displaying objects in a workspace window. Selecting *Large Icons* will change all the object icons in the workspace window to large icons.

List View:

This menu selection is only enabled when you are displaying objects in a workspace window. Selecting *List View* will arrange all the object icons in alphabetical order.

Details:

This menu selection is only enabled when you are displaying objects in a workspace window. Selecting *Details* will arrange all the object icons in alphabetical order similar to *List View*; however, you may view more detailed information on each object, such as: *modified on*, *modified by* and *description*. In *Detail View* you may also sort objects by clicking on the individual column headers.

Design View:

Will only appear when you have selected specific objects from the workspace window. *Design View* will display the parent-child relationship for the selected object.

Data Sheet View:

Will only appear when you have selected specific objects from the workspace window (for example, *Data Views*). *Data Sheet View* will display the corresponding data table.

Tools

Security:

Contains one sub menu: *Users*.

Users:

Add and remove *users* and corresponding passwords of the dTIMS CT system.

Options and Preferences:
Displays the dTIMS™ CT System *Options* window that allows you to set the various system-wide parameters, including:

System Options:

• **Number of digits to right of decimal for length numbers (e.g., offsets):** The number of decimal places you want dTIMS CT to use for numbers representing length. You may supply a number from 0 to 6 in this field. All length related numbers are stored in dTIMS CT as double precision numbers. This mean that internally dTIMS CT interprets 3.40 as 3.3999999999. Therefore, when dTIMS CT compares two length related numbers, it considers them as equal, if their difference is less then 0.0000001.

• **Units used for measuring and reporting lengths:**

Supply the unit you are using for length measurement. The most common units are "km" or "mi". This is only a label dTIMS CT uses when displaying length. dTIMS CT does not convert the length measurements when you change this parameters.

• **Prefix all DRP descriptions with name of perspective the description came from:**

Check this box, if you want dTIMS CT to show the perspective name as a prefix of the DRP description.

User Options:

• Enable Warning Messages:

Check this box, if you want dTIMS CT to ask for confirmation before aborting (by pressing the Cancel button) the changes you made after entering a window and to close that window.

• Do not modify base elements:

Check this box, if you want dTIMS CT to notify you when a location in your import file is not on an existing base perspective element. If you check this box, dTIMS CT verifies that all locations in your import file are on existing base perspective elements. If you uncheck this box, dTIMS CT will automatically create the missing base perspective element. This is a convenient way to create base perspective elements while creating elements in another perspective by importing. However, this can damage your database, if the base perspective element ID is misspelled, for example. In this case dTIMS CT will add a section or point to the misspelled perspective.

• Ensure ElementIDs are unique (do not add pieces/instances):

Check this box, if you want dTIMS CT to notify you when an element ID in your import file already exists in the target perspective. If you check this box, dTIMS CT verifies that all element IDs in your import file do not exist in the target perspective. If you uncheck this box, dTIMS CT will automatically create another piece for section perspectives or another instance for point perspectives for the existing element ID. Unchecking this box is the only way to import multiple pieces or instances. However, this can damage your database, if the element ID is misspelled, for example. In this case dTIMS CT will add another piece or instance to the element ID matching this misspelling.

Budget Categories:

Use the budget categories tab to add and delete *Budget Categories*.

Descriptions:

All perspectives of the point designation (point, repeating point, exclusive point) will be listed. Use the Up, Down buttons to order the perspectives which will be used to populate the *descriptions* fields.

Execute:

If the selected object can be executed, this menu item will be active and you can execute the object (*analysis sets* can be executed (optimized)); otherwise this menu item will be inactive (eg. *attributes* can't be executed).

Cross Section Options:

Use this option to set Cross Section preferences to be used when executing the Cross Section query.

Database Reports:

Provides *Missing Pieces Reporting* for all non-contiguous lengths. The report is made up of *Perspective, Road, From* and *To*.

Stripmap Options:

Set these options as basic options for all database Stripmaps. For each Section, Lane, Historic, or Point perspective, you can preset the graphic you want to use to display in the Stripmap. From this point forward, each time you include the perspective which has been set will automatically lookup and find the graphic you want to use for the display. You can always change it at run time, should you need to.

Help

Contents:

Will display the contents of the dTIMS CT Help system in the Integrated Help Window. By default this window will appear above the default position of the Property Window

Index:

Will display the contents of the dTIMS CT Help system in the Integrated Help Window with Index tab active.

Search:

Will display the contents of the dTIMS CT Help system in the Integrated Help Window with Search tab active.

About dTIMS CT:

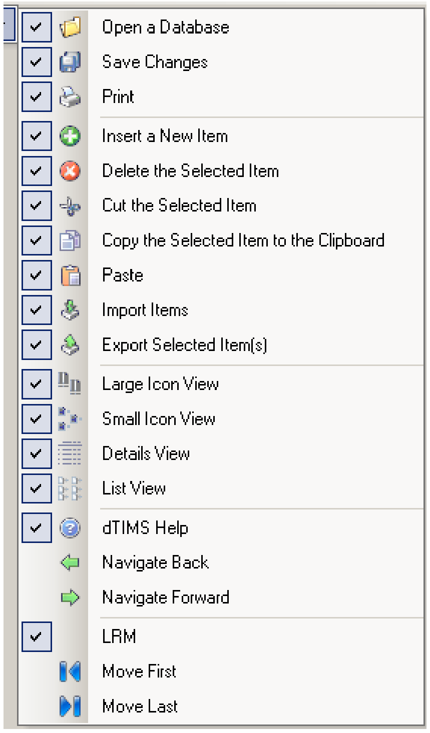
Will display the *Product Information Window* which contains the following information:

- Currently Installed Version
- Current Database
  - the name of currently open database (.dtims for Desktop application; .udl for the Enterprise application)
- Current User
- Security Key ID
- Modules active in your system

Context Sensitive Help

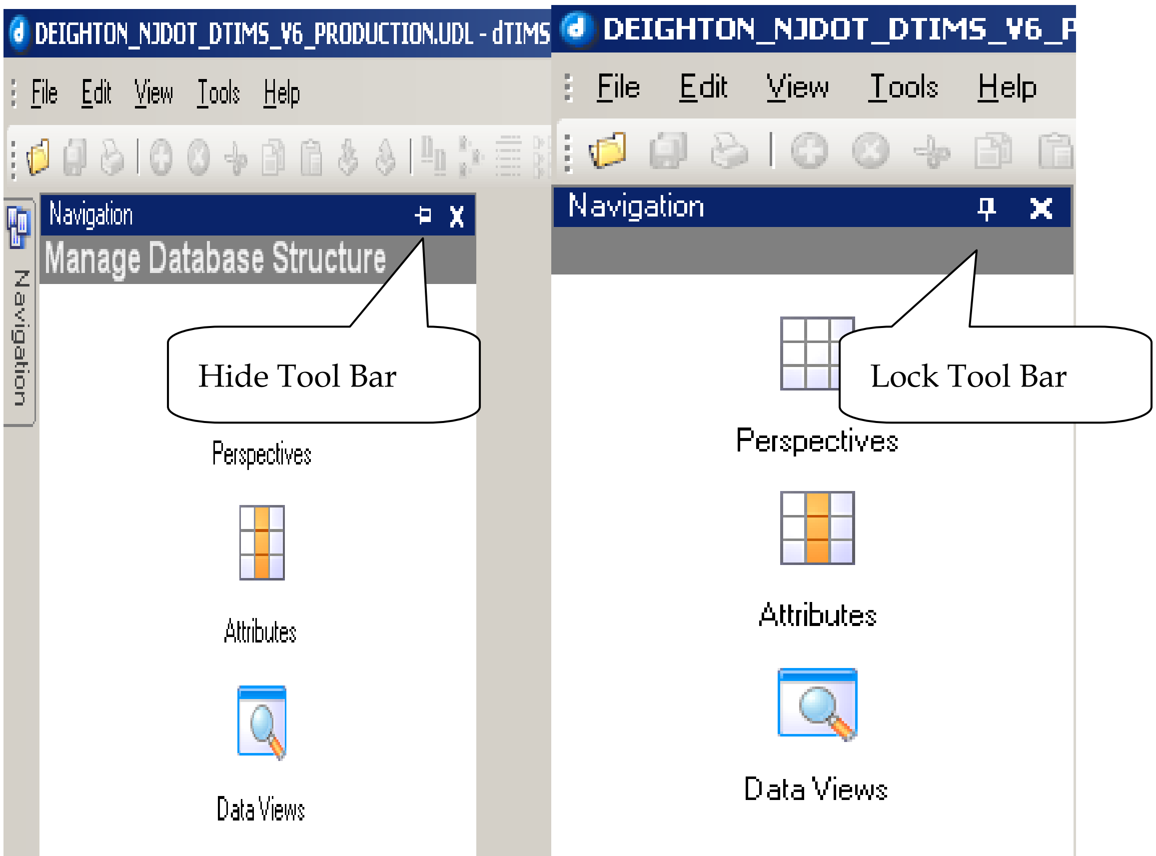
Users can access context sensitive help by pressing **{F1}** at any time during a task.

Tool Bar



All windows can be Pinned, Float, Docked, and Resized.

- **Pinning:** Refers to tacking a window to the side of the *Workspace Window*.
- **Floating:** Allows you to create a modular version of a window that will float above all other windows.
- **Docking:** Allows you to lock the position of a window to the top, bottom, left or right of the screen..
- **Resizing:** Allows you to customize any window in dTIMS CT by dragging a *window handle* to the desired shape.



Element Locations Location Reference Method (LRM) Base

The fundamental property that all your assets have in common is that the network around which they are described is linear. For example, roads, tracks and pipe lines start at some location and proceed in a linear fashion until they end at another location. In addition, signs, bridges and accidents are also related to some location on a road.

Typical elements for which dTIMS CT must store and relate location information are illustrated above. ***dTIMS CT*** stores this information (referred to as Internal fields in the database) through Element Location properties, as defined below:

Element Location Properties
Element ID
Base Perspective Element ID
From and To Address
From and To Descriptions
Length

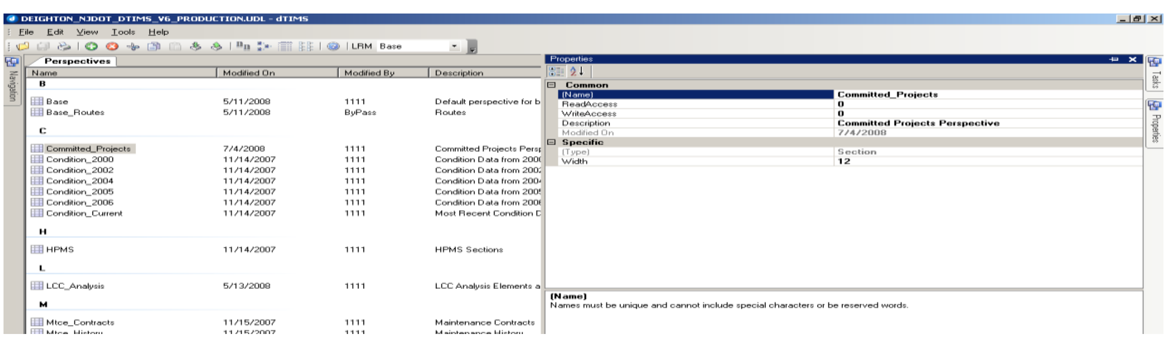
When an element location is added in any perspective and is outside the current bounds of the Base perspective element, the Base perspective element will be increased to include the new length. Removing elements will never decrease the length of the Base element.

Using LRM changes:

- LRM must be Base if Base elements are to be edited.
- Edits cannot occur on the elements of the perspective which is the current LRM
- If the perspective which is the current LRM contains multiple pieces, the reference will skip the missing pieces.
- If negative referencing occurs the same rules apply to multiple pieces.

Properties Window

Properties of the objects in dTIMS are entered or modified in the properties window. They are dependent on the object selected in the Work space.



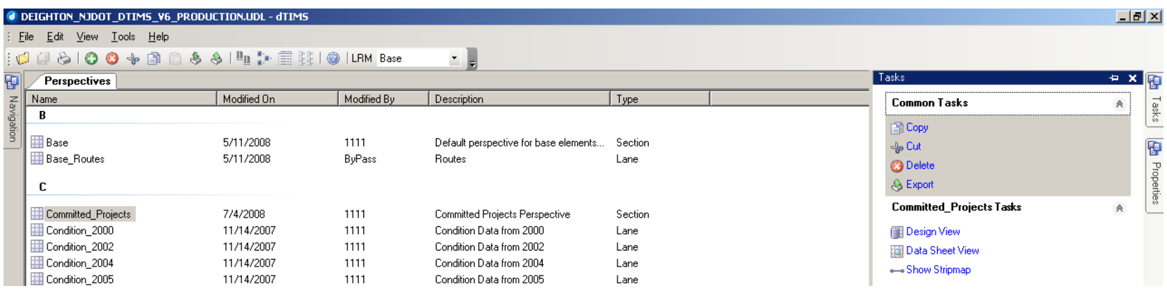
Perspectives Properties

Name	• Perspective names must be unique and avoid *reserved names* or *special characters*
Read Access	Shows the minimum access level required to view the properties of the current object. • Values are 0 through 9, where 0 represents no security is currently set, 9 is a system reserved security level and 8 is considered System Administrator level. • Default value is 0.
Write Access	Shows the minimum access level required to create or edit the properties of the current object. • Values are 0 through 9, where 0 represents no security is currently set, 9 is a system reserved security level and 8 is considered System Administrator level. • Default value is 0.
Description	General description of the Perspective (for example, what makes the perspective unique from other perspectives)
Modified on	Date the last modification was made
Modified by	User who made last modification to corresponding object
Type	Once you specify a Type you cannot modify it later.
Connect String	String of parameters required to connect to an ODBC data source. **Note:** **If an error occurs in display and database data, and an ODBC data source exists, check first to ensure that the path is correct**

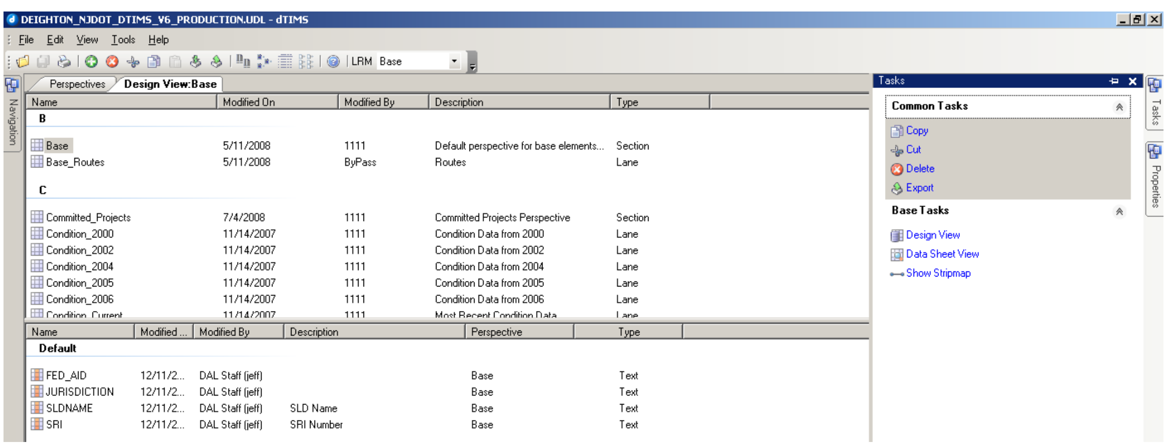
	and that the file exists.
ForeignKeyAttribute	If the current perspective has an external relationship, i.e., it is either a *one to many* (used for describing many entities that are related to one element in the source perspective) or *many to one* (used for describing entities that are common among many elements in a source perspective) type perspective.
Width	Specify the width you want dTIMS™ CT to use for the *element ID*.

Task Window

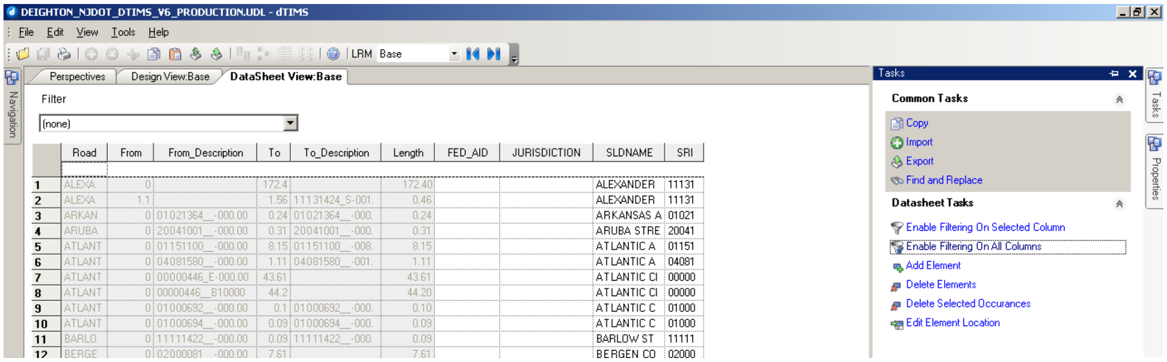
Tasks in the task window are dependent on the object selected in the Workspace.window.



Design view of a perspective shows the attributes of the perspective.



The Data sheet view shows the actual data in the perspective.



Perspectives Tasks

Add	*Adding* a perspective can be accomplished in many ways: through the *menu strip*, the *toolbar*, the *tasks pane*, the right click menu or pressing the insert key on your keyboard. All these operations will allow you to manually create one perspective. To add multiple perspectives refer to *Import*. dTIMS CT will also automatically create several *Default Attributes* for your perspective, depending on the Perspective Type you are creating.
Edit	Edit the properties of one or multiple perspectives.
Delete	Delete a perspective from the Perspective Workspace Window.
Copy	Make a new perspective by copying and editing the copied version.
Export	Will copy perspective properties to a file of your choice (*Access - mdl*, *Excel - xls*, *XML - xml*, *HMTL - html*, *dBASE - dbf and TEXT - txt*). Export is a useful feature when you use it in conjunction with the *Import* operation. For example, you export a perspective to a file, then using the same file you add the perspectives you want in your database. Next, you import the same file into dTIMS CT. This works well since you are assured the file format of the file you are importing is what dTIMS CT expects.
Import	Importing perspectives is a quick way to add multiple perspectives to your dTIMS CT database. By importing from a file you eliminate many of the steps required to add the same perspectives manually. Refer to the *Perspective Import File Format* to ensure the file you intend to import matches the format dTIMS CT expects.
Design View	Unique method of viewing the *parent - child* relationship that exists between *perspective* and *attribute* objects.
Data Sheet View	Formerly known as '*Browse*' in dTIMS CT, *Data Sheet* is used when you want to browse certain data or update data values from one perspective. If you want to browse data from

	data from multiple perspectives you would create a View.
Show Stripmap	Display graphical representation of the Perspective's elements.
Print	Two report types, Summary and Detail formats are available to print to screen (preview) or print to printer unit.

2. The dTIMS CT Database

2.1 Perspectives

Perspectives can be thought of as tables in your dTIMS CT Database Perspectives act as the holders for the data required or produced by dTIMS CT. The perspectives contains column called attributes or fields that describes the name for the type of data and rows called elements that contains the actual data. Attribute objects allow you to define the characteristics you want to store in each Perspective. The name 'perspective' is derived from the fact that perspectives represent a different way of looking at your network. The name 'perspective' is derived from the fact that perspectives represent a different way of looking at your network.

The Perspective Types in dTIMS CT are:

- **Section** (*S*)
- **Lane** (*L*)
- **Historic** (*H*)
- **Point** (*P*)
- **Exclusive Point** (*E*)
- **Repeating Point** (*R*)
- **One to Many** (*O*)
- **Many to One** (*M*)

Once the Perspective Type has been selected for a perspective, it can not be changed.

Perspectives • Section (S) Type

Defines a set of mutually exclusive elements. This means the elements cannot overlap one another. This is the most popular perspective type used in dTIMS CT. The following diagram illustrates how a section perspective relates to locations along the road, elements and how to conceptualize the data in the perspective table.

Perspectives • Lane Type

Defines a set of elements which can overlap. Any time two or more elements overlap, the system assumes there are that many lanes at that location. This perspective allows an agency to

describe each lane on a road. The following diagram illustrates how a lane perspective relates to locations along the road, elements and how to conceptualize the data in the perspective table.

Once defined, the road name cannot be edited.

Perspectives • Historic Type

Similar to a Section perspective, only the elements can overlap one another. This is typically used to store old contract limits or condition data which is continually coming into the database and will overlap the previous data. Using a Historic perspective and contract information a user can find the year of the most recent work performed on an element to calculate its age or extract the most recent condition data to use in an analysis. In addition, dTIMS CT uses Historic perspectives as the foundation for Cross Section Graphics. The following diagram illustrates how a section perspective relates to locations along the road, elements and how to conceptualize the data in the perspective table. Once defined, the road name cannot be edited.

Perspectives • Point Type

Defines a set of point elements, such as bridges, where only one element can exist at one particular location. Integrity checks prevent a user from defining two elements at the same

location, for example. The following diagram illustrates how a point perspective relates to locations along the road, elements and how to conceptualize the data in the perspective table.

Perspectives • Exclusive Point Type

Defines a set of point elements such as mile posts where only one element can exist at the same location but two elements in the network can have the same identifier as long as they are on different roads. Since each element in a perspective must have a unique identifier, dTIMS CT provides this perspective type to account for the fact that sometimes asset identifiers are only unique on a road. The following diagram illustrates how a section perspective relates to locations along the road elements and how to conceptualize the data in the perspective table.

Perspectives • Repeating Point Type

Defines a set of point elements where more than one element can exist at any particular location. This perspective allows agencies to store things such as accidents or signs. The following diagram illustrates how a repeating point perspective relates to locations along the road, elements and how to conceptualize the data in the perspective table.

Perspectives • One to Many Type

Defines a set of elements such as maintenance activities, where one element in a source perspective relates to many elements in this perspective. The following diagram illustrates how a section perspective relates to locations along the road, elements and how to conceptualize the data in the perspective table.

In a one-to-many relationship, the connecting ***text only*** attribute must contain only unique values. A record in Perspective A can have many matching records in Perspective B, but a record in Perspective B has only one matching record in Perspective A.

An Example: one vendor could supply more than one product, but each product has only one vendor.

This type of perspective is not available to Stripmaps.

Perspectives • Many to One Type

A many-to-one relationship is where one entity (typically a column or set of columns) contains values that refer to another entity (a column or set of columns) that has unique values.

In relational databases, these many-to-one relationships are often enforced by foreign key/primary key relationships, and the relationships typically are between fact and dimension tables and between levels in a hierarchy.

Foreign key is the link between two tables. Given a value from a row in one table you can access another table to find the row with related data.

The relationship is often used to describe classifications or groupings. For example, in a geography schema having tables Region, State, and City, there are many states that are in a given region, but no states are in two regions. Similarly for cities, a city is in only one state (cities that have the same name but are in more than one state must be handled slightly differently). The key point is that each city exists in exactly one state, but a state may have many cities, hence the term “many-to-one.”

Another example defines a set of elements, such as contractor names, where many elements in the source perspective relate to one element in this perspective.

This type of perspective is similar to a 'look-up' table.

The **Foreign Key assignment can only be a Table attribute**.

Maintenance of the table is only available through the Table attributes collection function.

This type of perspective is not available to Stripmaps.

The following diagram illustrates how a section perspective relates to locations along the road, elements and how to conceptualize the data in the perspective table.

There are a total of 30 perspectives created by Deighton, Rutgers and NJDOT staff during the dTIMS CT implementation process. Table 1 summarizes the perspectives created with respect to the perspective name, description and type.

Aside from the Base perspective, dTIMS CT allows you to create eight different Perspective Types. The single most important property when you create a perspective is its 'type'. Deciding which perspective type to use requires you to understand certain characteristics about the information which is destined to be stored in that perspective. For example, does the data being described have a start and end point? Should the data overlap? Does the data describe a point? Perspective Type represents the fundamental behavior of the perspective with respect to relationships to other perspectives. A key feature of dTIMS CT is its ability to integrate data between different perspectives. This is the key to being able to gather data from different sources, integrate the data, process it and provide outputs needed to make key decisions.

The reader is referred to the dTIMS CT Help system or the document called dTIMS CT V8 User Guide, available for download from the Client Area on the Deighton Website (http://www.deighton.com) for a description of the different types of perspectives listed in Table 1. Specific properties for each perspective can be accessed by right clicking the perspective name in the perspective library window and selecting "Properties" from the list.

Perspective Name	Description	Type
Base	Default perspective for base elements in network	Section
Base_Route	Routes	Lane
Committed_Projects	Committed Projects Perspective	Section
Condition_2000	Condition data from 2000	Lane
Condition_2002	Condition data from 2002	Lane
Condition_2004	Condition data from 2004	Lane
Condition_2005	Condition data from 2005	Lane
Condition_2006	Condition data from 2006	Lane
Condition_2007	Condition data from 2007	Lane
Condition_Current	Most Recent Condition Data	Lane
HPMS	Highway Performance Monitoring Section Sections	Lane
LCC_Analysis	LCC Analysis Element data	Section
Mtce_Contracts	Maintenance Contracts	Historic
Mtce_History	Maintenance History	Historic
Project_History	Project History	Historic
Project_History_Most Recent	Most Recent Project History Sections	Section
Project_IRI_Acceptance	Historic Perspective containing the IRI Acceptance Values	Historic
Ramps	Ramps	Repeating Point
SLD_Fed_Aid	Federal Aid Designation	Section
SLD_Func_Class	Functional Class	Section
SLD_Intersections	Intersections	Repeating Point
SLD_Jurisdictions	Jurisdiction Information	Section
SLD_Lanes	Lanes	Lane
SLD_Leg_District	Legislative District	Lane
SLD_Municipality	Municipality	Lane
SLD_Shoulder_Inside	Inside Shoulder Width	Lane
SLD_Shouder_Outside	Outside Shoulder Width	Lane
SLD_Speed_Limit	Speed Limit	Lane
SLD_Width	Pavement Width	Lane
Traffic	Traffic AADT and VMT Information	Lane
Traffic_ESAL_Factors	ESAL Factors	Lane

Table 1: Perspective Summary Table

2.2 *Attributes*

In the previous section Perspectives were described as objects that are used to contain groups of assets with similar characteristics. The next step in a database design is to define the characteristics you want to describe within each Perspective. These characteristics are called Attribute objects in dTIMS CT.

Attribute objects allow you to define the asset characteristics you want to store in each Perspective. In the analogy where Perspectives are thought of as tables, Attributes can represent the columns (fields) in each of the tables.

Table 12 to Table 42 in Appendix "A" list the attributes defined in each perspective listed in Table 1.

Each Attribute table in Appendix "A" lists the Perspective to which the Attributes belong to, the Attribute Name, a short description of the Attribute (as it appears in dTIMS CT) and the Attribute Type.

Attributes • *Attribute Type*

Every attribute you create is assigned a specific data type, which determines the kind of data values that can be entered into an attribute's cell. Attribute Type is important when designing your database because once you create an attribute in **dTIMS CT** you cannot change its type. It is important to note that **dTIMS CT** displays data values for attribute types in the format that you have specified in your **Windows | Regional Settings**. When you create an attribute, you will need to specify one of the following data types:

Data Type	Characteristics	Benefit
Integer	• Referred to as the Short Integer. • Whole numbers positive and negative and	• Space saving • Good for storing small values

	0 from -32,720 to +32,720	
Long (Integer)	• A variable that can hold a positive or negative whole number whose range is greater or equal to that of a standard integer on the same machine. • Whole numbers from -2 billion to +2 billion	• Good for storing large values
Single (Precision)	• Real numbers • stored in one computer word used for calculations	• Returns whole numbers rounded
Double (Precision)	• Real numbers • stored in two computer words used for calculations • requires decimal position 1 through 6	• Returns whole numbers rounded • stores largest number value • **must be** the data type used to hold an expression of the numeric type.
Boolean	• Yes/No • True/False	• Efficient • Space saving • Used in Filters
Date	• Calendar dates for years 100 through 9999 • Clock times in 12 or 24 hour formats	• Sort and calculate dates chronologically. • Allows use of dates mathematically • Uses defaults as set in the Windows Regional settings.

Text (String)	• Holds characters, numbers, special characters • 255 characters • Reference data enclosed in quotes.	• Though maximum is 255 characters, only the actual characters will be stored in the database.
Table	• Holds a user-defined list of entries • A *table* is made up of a code and decode • Entry selection is made from a drop down list. • Entry of the code only acts as a valid entry list.	• Data entry saving • Disk space saving • Allows optional display of the code or decode value in the data view. • Default value displayed is<<**a A**>>, be sure to remove the last entry before saving.
Hyper Link	• A predefined linkage between one object or resource to another object or resource • Attribute holds a hyperlink address to another object such as a visual. • If a link is followed using the Ctrl | click from a datasheet view, the windows explorer session will open but outside of the dTIMS CT application. • The path to the image is entered into the value of the attribute.	• Allows linking to another file type (document, web page, picture, etc) • Opens a file within a file • Simulates a viewer allowing playback mode. • During the *Stripmap* operation, the visual can show a picture of the road or point in that section.

Attributes Properties The attribute properties are dependent on the attribute types. The following are a description of all attribute properties.

Name	Attribute names must be unique and avoid *reserved names* or *special characters*
Read Access	Shows the minimum access level required to view the properties of the current object. • Values are 0 through 9, where 0 represents no security is currently set, 9 is a system reserved security level and 8 is considered System Administrator level. • Default value is 0.
Write Access	Shows the minimum access level required to create or edit the properties of the current object. • Values are 0 through 9, where 0 represents no security is currently set, 9 is a system reserved security level and 8 is considered System Administrator level • Default value is 0.
Description	General description of the Attribute (for example, what makes the attribute unique from other attributes)
Modified by	• Read only field • Updated by the system when the changes are saved. • Shown only if more than one user shares access to the database
Modified on	• Read only field • Updated by the system when the changes are saved.
Type see *Defaults* for more information	Every attribute is assigned a specific data type, which determines the kind of data values that can be entered into an attribute's cell. • There are nine available attribute types

CalcExp	Is the attribute you are creating going to be populated by a dTIMS CT function analysis? If it is, enter a calculated expression, otherwise ignore this cell and dTIMS CT will assume the attribute will be stored in the database and entered via data entry or transformation. • the expression must exist • if it is not available in the list, it could be because you have not saved the expression or because you have not yet selected the perspective from which the expression called the attribute. **Notes: Once the Attribute is saved without an expression attached, it cannot ever be added or updated to include an expression.** **- Change from keyed attribute to calculated attribute or vice versa can only be accomplished by delete and recreate.** **- Entry cannot be a typed expression, it must be a stored expression object.**
Number of Decimals	• This property is for *Single* or *Double* Attribute Types only. • Determine on numeric fields how many decimal positions (1-6) are required. • Enter the number of decimals you want to use when displaying the values of the current attribute. (The value in this cell does not affect the precision of any calculation including the attribute, it is used for display purposes only).
Numeric Default	• This property is for *Single*, *Double*, *Integer*, or *Long Integer* Attribute Types only. • Enter the value you want to use to signify that the attribute has not yet received a value.

Numeric Max	• This property is for *Single*, *Double*, *Integer*, or *Long Integer* Attribute Types only. • Enter the maximum value you want for the value range of the current attribute. The maximum value must be greater than the minimum value. If it is not, dTIMS™ CT will issue an error message when you try to save the parameters of the current attribute. See rules and values in *Type*. • To ensure data integrity, once the attribute has been saved, you are not allowed to change the numeric maximum value. • If a numeric attribute requires changes to Maximum (or Minimum), you will be required to create another attribute with the new ranges. • To populate the new attribute with the existing values, you can use two methods: 1• open a datasheet view with the old and the new attributes, copy the old values and paste to the new attribute and then delete the old attribute. 2• export the data from the old attribute, import to the new attribute and then delete the old attribute.
Numeric Min	• This property is for *Single*, *Double*, *Integer*, or *Long Integer* Attribute Types only. • Enter the minimum value you want for the value range of the current attribute. The minimum value must be less than the maximum value. If it is not, dTIMS™ CT will issue an error message when you try to save the parameters of the current attribute. See rules and values in *Type.* • To ensure data integrity, once the attribute has been saved, you are not allowed to change the numeric minimum value. • If a numeric attribute requires changes to Minimum (or Maximum), you will be required to create another attribute with the new ranges. • To populate the new attribute with the existing values, you can use two methods: 1• open a datasheet view with the old and the new attributes, copy the old values and paste to the new attribute and then delete the old attribute.

	2• export the data from the old attribute, import to the new attribute and then delete the old attribute.
Date Default	• This property is for *Table* Attribute Types only. • Enter the value you want to use to signify that the element in the perspective has not received a value for this attribute. • The default values at creation time are Date Default: 1/1/1900, Date Maximum: 1/1/2100 and Date Minimum: 1/2/1900 • The default cannot fall between the range set in the Maximum and Minimum • **Note: Enter the Date Minimum first to avoid a conflict where the default is greater than the minimum.**
Date Maximum	• This property is for *Table* Attribute Types only. Enter the maximum value you want for the value range of the current attribute. The maximum date value must be greater than the minimum date value. If it is not, dTIMS™ CT will issue an error message when you try to save the parameters of the current attribute. See rules and values in *Type.* • To ensure data integrity, once the attribute has been saved, you are not allowed to change the date maximum value. • If a Date attribute requires changes to Maximum (or Minimum), you will be required to create another attribute with the new ranges. • To populate the new attribute with the existing values, you can use two methods: 1• open a datasheet view with the old and the new attributes, copy the old values and paste to the new attribute and then delete the old attribute. 2• export the data from the old attribute, import to the new attribute and then delete the old attribute.

Date Minimum	• This property is for *Table* Attribute Types only Enter the minimum date value you want for the value range of the current attribute. The minimum date value must be less than the maximum date value. If it is not, dTIMS™ CT will issue an error message when you try to save the parameters of the current attribute. See rules and values in *Type.* • To ensure data integrity, once the attribute has been saved, you are not allowed to change the date minimum value. • If a Date attribute requires changes to Minimum (or Maximum), you will be required to create another attribute with the new ranges. • To populate the new attribute with the existing values, you can use two methods: 1• open a datasheet view with the old and the new attributes, copy the old values and paste to the new attribute and then delete the old attribute. 2• export the data from the old attribute, import to the new attribute and then delete the old attribute.
Perspective	• This property is common to all attribute types. • Select the perspective from the list to which you want the new attribute to belong.
Width	• Enter the width (number of characters) you want for your *Text* or *Table* type data in this attribute. • Default value of empty text attribute is *null.*
Table Decodes	• For *Table* Attribute Types only. • The ***(Collection)*** entry is used to supply a set of code values corresponding to the description of what the code means.

	• Default value if attribute is empty is ????. • Once the Collection form has been closed, move to another property field to ensure the values have been stored. • Updates on table entries can be done and saved at any time without affecting the current values.

Attributes • *Default Value*

When you create an attribute, you must supply a default value; unless an attribute has a data type of: *Table*, *Boolean*, *Text* or *Hyperlink*. Default values allow you to instruct dTIMS CT to place a value in all attribute cells that would otherwise have null values, or be somehow marked as missing. When you add a new element to a perspective or when you add an attribute to a perspective already containing elements you will need default values. Default values remain in place until you supply a value for every element in a perspective. See also an attribute's value range defined by an attribute's *minimum and maximum values*. A default value cannot fall inside an attribute's value range.

For *Text* and *Hyperlink* Attributes the default value dTIMS CT will automatically supply is "***null***". For ***Table*** Type Attributes the default value will be "***?????????***". For *numeric types* the default value will be **-1**.

Attributes • *Minimum/Maximum Values*

When you create certain types of attributes, you must also supply a *minimum value* and a *maximum value* defining what is referred to as an attribute's value range. All four numeric data type attributes, as well as the date attribute require you to supply a value range. dTIMS CT uses an attributes value range in other places throughout the system. An attribute's value range becomes very important when setting scales for plotting graphs or values for *strip maps*. Take the time to enter the most accurate values possible or you may find yourself returning to revise these values after viewing how small plots really are on *graphical strip maps* when an attribute's value range is too large.

Displaying Attribute Values	Single or multiple (from the same Perspective) can be displayed by requesting a datasheet view. Also included will be Internal System Attributes. To select multiple attributes, use the Ctrl key and click to select.
Calculated	A Calculated Attribute includes an expression from which the values are

Attributes	calculated. • a Calculated Attribute's values cannot be keyed • selection of the expression will determine the datatype • selection of the perspective will determine which expressions call objects from this perspective and are therefore valid for this object. • generic expressions not calling perspective specific objects will also be included.
Calculated Attributes and missing (default) values	In **Calculated Attributes** using expressions; should if any one of the fields contains the default value, then the default value of the target attribute will be returned. ***[Field1 + Field2 + Field3]*** Where default value of all fields is -1:

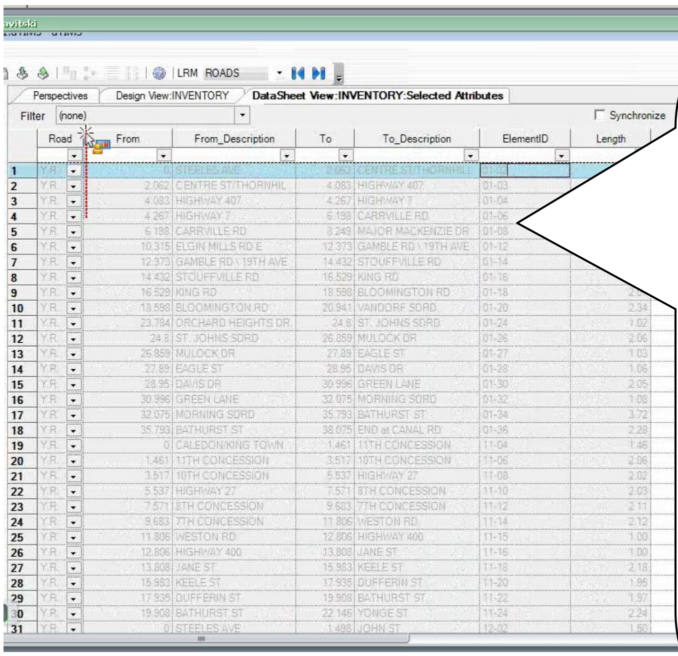
Attribute Tasks The following provides a description of the tasks associated with all attributes.

Add	*Adding* an attribute can be accomplished in many ways: through the *menu strip*, the *toolbar*, the *tasks pane* the right-click menu, or pressing the insert key on your keyboard. All these operations will allow you to manually create one attribute whether or not in *design mode*. To add multiple attributes refer to *Import.*
Edit	Edit the properties of one or multiple attributes.
Delete	Delete an attribute from the Attribute Workspace Window.
Copy	Make a new attribute by copying and editing the copied version.
Export	Will copy attribute properties to a file of your choice (*Access - mdl, Excel - xls, XML - xml, HMTL - html, dBASE - dbf and TEXT - txt*). Export is a useful feature when you use it in conjunction with the *Import* operation. For example, you export an attribute or attributes to a file, then using the same file you add the attributes you want in your database. Next, you import the same file into dTIMS CT. This works well since you are

	assured the file format of the file you are importing is what dTIMS CT expects.
Import	Importing attributes is a quick way to add multiple attributes to your dTIMS CT database. By importing from a file you eliminate many of the steps required to add the same attributes manually. Refer to the *Attribute Import File Format* to ensure the file you intend to import matches the format dTIMS CT expects.
Data Sheet View	Formerly known as '*Browse*' in dTIMS CT, *Data Sheet* is used when you want to browse certain data or update data values from **one perspective**. If you want to browse data from data from multiple perspectives you would create a View.
Show Stripmap	Display graphical representation of the Attribute's Perspective, its elements and a textual display of the Attribute's values for each of the elements.
Print	Two report types, Summary and Detail formats are available to print to screen (preview) or print to printer unit.

Design View

By selecting a design view of a perspective, all the attributes of the perspective are listed. Selecting attributes from this list develops a custom design sheet view with those attributes.



The seven attributes that are in grey, are called the internal attributes in CT, based on the base perspective, that are used to store the locations of each element in the perspective.

The attribute names are reserved and cannot be use in other perspectives.

Length and year are also reserved words.

To make changes, use the change element location option on the task bar.

Importing data into dTIMS CT

The easiest way to format a file for import of data into dTIMS CT is to export the data sheet view to an access table. The access database table has the field needed to import the data back into dTIMS CT to populate the elements (rows) in the perspective.

Data View allows the custom ***selection*** of the attributes and the ***building*** of a view from one or more perspectives and one or more attributes from those perspectives.

The Data sheet view in Perspectives allows the automatic visualization of all attributes of the selected perspective.

Data Views vs Data Sheet View	• Data Sheet View allows view of attributes from a single Perspective only • Data Views allows individual views of attributes from multiple Perspectives • A Data View is visualized using the Data Sheet View. • A Data View allows you to ***order your attributes*** so that you can customize your view and retain that order.

Other than visualization, what else can Data Views be used for?	• The Data Views opened with the Data Sheet view is used to **add, edit and delete** rows in the database. • A data view is also advantageous when using queries and transformations. • dTIMS CT's data entry tool. • Allows the export of the raw data into another application for mass updates.
Editing data in a Data Sheet View or Data View	The data / datasheet view is the method of choice for editing or adding individual elements into your network. This is accomplished using some tasks and operating from the Data sheet view **Note:** When editing your Data View, be sure to refresh the workspace by closing and reopening. This will ensure that you are working with the latest changes. Failure to do so will result in your collection data not being updated.
Automatic Data View creation by the Analysis Set	When a new Analysis Set is created, upon save of the object, a data view is constructed using the name of the Analysis Set concatenated by the characters **" _ELEM"**. This data view will contain all attributes of the Master Perspective cited in the Analysis Set. The attributes will include the current attributes. New attributes created after the analysis set will not be updated to the Data View. Access level will be set to 0.

3. The dTIMS CT Analysis

3.1 Pavement Distresses and Indices

Pavement condition data [pavement profile – IRI, Surface Distress, Rutting and Skid Resistance] is collected by Pavement Profiler and Skid Trailer. In NJ DOT, this condition data is processed outside of dTIMS CT and input into Condition perspectives for use in PMS analyses.

Each year of data condition data collection is stored within its own perspective within the dTIMS CT database. There are currently condition data perspectives for the years; 2000, 2002, 2004, 2005, 2006, 2007and 2008. The lattest perspective being called Condition_Current is updated on an annual basis with the existing dataset being archived in its own condition perspective named for the year that the data was collected.

The dTIMS CT analysis is based on the data found in the Condition_Current perspective that has been transformed from its stored 528 ft (0.1 mile) sections to a set of fixed homogeneous analysis sections based on past projects and pavement distress values found in the LCC_Analysis perspective.

The pavement distresses collected under the data collection phase of this project are listed in Table 2.

Data Code	**Description**
General	
RTE	Route Number
RTE_NAME	Route Name
DIR	Direction
BRIDGE	Bridge located in 0.1 mile section
CNTYCODE	County Code
CTRLSECT	Control Section
FWY	Freeway Functional Class
HPMS	HPMS Section
INTERST	Intersection located in 0.1 mile section
LANES	Number of Lanes
MED	Median located in 0.1 mile section
NHS	National Highway section
PAVETYPE	Pavement Type
RR	Bridge located in 0.1 mile section
SHOUT	Outside shoulder located in 0.1 mile section
SHRP	Bridge located in 0.1 mile section
SHS	Part of State Highway System
SIGNAL	Bridge located in 0.1 mile section
SPDLIM	Speed Limit
SRI	SRI of the section
STRAHNET	Part of STRA NET

Ride Quality Attributes		Units
LIRI	Left IRI	in/mile
RIRI	Right IRI	in/mile
AIRI	Average IRI	in/mile
PROFILERDATE	Date Profiler Tested	

Pavement Distress Attributes		
Non-Load Associated Distresses		Extent
ACLNGSL	AC Longitudinal Crack Slight	% Length
ACLNGMOD	AC Longitudinal Crack Moderate	% Length
ACLNGSEV	AC Longitudinal Crack Severe	% Length
ACTRSL	AC Transverse Crack Slight	% Length
ACTRMOD	AC Transverse Crack Moderate	% Length
ACTRSEV	AC Transverse Crack Severe	% Length
ACMULSL	AC Multiple Crack Slight	% Length
ACMULMOD	AC Multiple Crack Moderate	% Length

ACMULSEV	AC Multiple Crack Severe	% Length
PATCHSL	Patch Condition Slight	% Length
PATCHMOD	Patch Condition Moderate	% Length
PATCHSEV	Patch Condition Severe	% Length
SHDETSL	Shoulder Condition Slight	% Length
SHDETMOD	Shoulder Condition Moderate	% Length
SHDETSEV	Shoulder Condition Severe	% Length
RCLNGJTDETSL	RC Longitudinal Crack Slight	% Length
RCLNGJTDETMOD	RC Longitudinal Crack Moderate	% Length
RCLNGJTDETSEV	RC Longitudinal Crack Severe	% Length
RCTRJTDETSL	RC Transverse Crack Slight	% Length
RCTRJTDETMOD	RC Transverse Crack Moderate	% Length
RCTRJTDETSEV	RC Transverse Crack Severe	% Length
RCCRSL	RC Cracking Slight	% Length
RCCRMOD	RC Cracking Moderate	% Length
RCCRSEV	RC Cracking Severe	% Length
Load-Associated Distresses		
ACLDMULSL	AC Load-Associated Multiple Crack Slight	% Length
ACLDMULMOD	AC Load-Associated Multiple Crack Moderate	% Length
ACLDMULlSEV	AC Load-Associated Multiple Crack Severe	% Length
MAXLRUT	Max Left Rut	inch
MAXRRUT	Max Right Rut	inch
AVGRUT	Average Rut	inch
Distress Indices		
NDI	Non-Load Associated Distress Index	
LDI	Load Associated Distress Index	
SDI	Overall Surface Distress Index	
SDIOVRD	SDI over ridden by video review	
Others		
SKIDDATE		
SKIDVAL		

Table 2: Distress Data Collection Attributes

In general, a pavement management system requires pavement condition indexes for three reasons.

1. Pavement condition indices help determine when to apply a treatment.

For example, some indices, like transverse cracking, are sometimes used initially to help determine when to seal cracks, a maintenance type action. Others, like fatigue cracking and patch deterioration, are used to help determine when to resurface the pavement, a programmed construction type action. When used individually pavement condition indices are an indicator for the timing of actions. They are not necessarily a measure of the structural quality of a pavement, nor should they represent the relative value of that specific condition to the structural quality of the pavement.

2. Pavement condition indices help calculate the cost of a treatment.

   For example, cracking indices can be used to calculate the amount of cracks that need filling. This helps calculate the cost of a crack filling treatment. Other indices, such as rutting, can be used to determine whether a resurface treatment needs a levelling course or not.

3. Pavement condition indices help monitor the overall health of the network.

   Whereas the above two uses for pavement condition indices necessitated indices that described individual deficiencies, this use requires an overall or composite index. A composite index combines a number of condition indices into one overall number which when comparing one road section against another gives an overall idea of which one is in better condition. Composite indices, in some cases, can also be used to trigger treatments or calculate costs.

Pavement condition indices in New Jersey are reported on scales which range from 0 to 5. Typically, the 5 indicate the best condition and the 0's represent a very poor condition.

In the case of the NJDOT implementation of dTIMS CT, not all pavement condition information that is collected and stored within dTIMS CT is transformed into pavement condition indexes within dTIMS CT. The majority of the pavement condition data used by NJDOT is reduced by the data collection analysis into several pavement condition indices aggregated into tenth mile sections.

3.2 Condition Indices for dTIMS

The list of indices used in the dTIMS CT analysis is summarized in Table 3.

Index	Description
NDI	Non Load Associated Cracking
LDI	Load Associated Cracking
IRI	Roughness (in/mile)
FPR	Final Pavement Rating
SDIm	Surface Distress Index (Modified)

Table 3: Analysis Indices used in dTIMS CT

These index values are calculated prior to being loaded into dTIMS CT. The calculation of the values is described and documented in several documents including the following:

Modified Surface Distress Index (SDIm)
Received at the Parameter Development Meeting and documents the calculation of all indexes.

CalcSDIm Software User Manual Version 1 (Updated 2/12/2008)
Received at the Parameter Development Meeting and documents the calculation of all indexes in the PMS database.

Model Development.DOC (Created 10/31/2007)
Received at the Parameter Development Meeting and documents various methods that were investigated to calculate LDI, NDI and SDIm.

3.3 Performance Curves

During the implementation of the PMS, Deighton and NJDOT developed several iterations of the performance curves to be used within the PMS. In the end, Deighton and NJDOT decided to use sigmoid (S – shaped) curves to represent pavement deterioration within the State. This section will present the pavement families developed during the project and the default pavement performance curves implemented within dTIMS CT.

3.3.1 Pavement Families

Like the performance curves themselves, the pavement families went through several iterations during the PMS development. Originally the pavement performance families included the following characteristics:

- Pavement Type;
- Truck Traffic;
- Initial Construction Quality;
- Last Major Treatment Type;

Unfortunately the lack of data for the Last Major Treatment Type and the Initial Construction Quality led to those characteristics being removed from the pavement families.

Deighton and NJDOT then decided on the following pavement families:

Family	Pavement Type	Traffic
1	BC	Light *
2	**BC**	**Heavy**
3	CO	Light *
4	**CO**	**Heavy**
5	**RC**	**All**

* Light traffic family options were eliminated for current version.

Table 4: Pavement Families Currently only the Heavy pavement families

3.3.2 Performance Curves

The following pages of the report will detail the equation and the performance curve that was developed for each pavement family based on local expert opinion and work originating from Rutgers University in a document entitled <u>Development of Enhanced</u>

<u>Pavement Index Prediction Models;</u> Center for Advance Infrastructure and Transportation, March 27, 2008.

3.3.2.1 BC Pavements Light Truck Traffic

Equations:

Family	Index	a	b	p	Equation for Index
BC/CO	NDI	15	0.35	55	5 -15* exp(-((55/nAAV_AGE_NDI) **0.35))
BC/CO	LDI	14	1	30	5 -14* exp(-((30/nAAV_AGE_NDI) **1.0))

Curves:

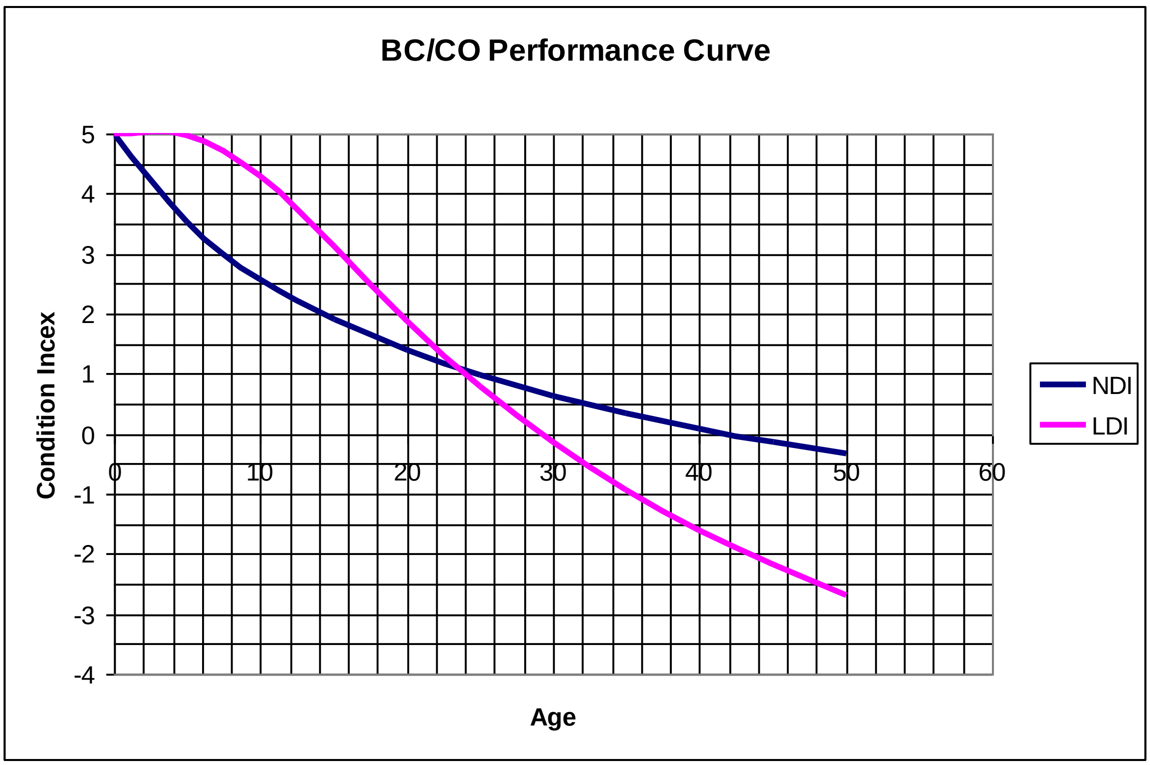


Figure 1: BC/CO NDI and LDI

RC Pavements

Equations:

Family	Index	a	b	p	Equation for Index
RC_ALL	NDI	13.59141	1.45	45	5 -13.59140915* exp(-((45/nAAV_AGE_NDI) **1.45))

Curves:

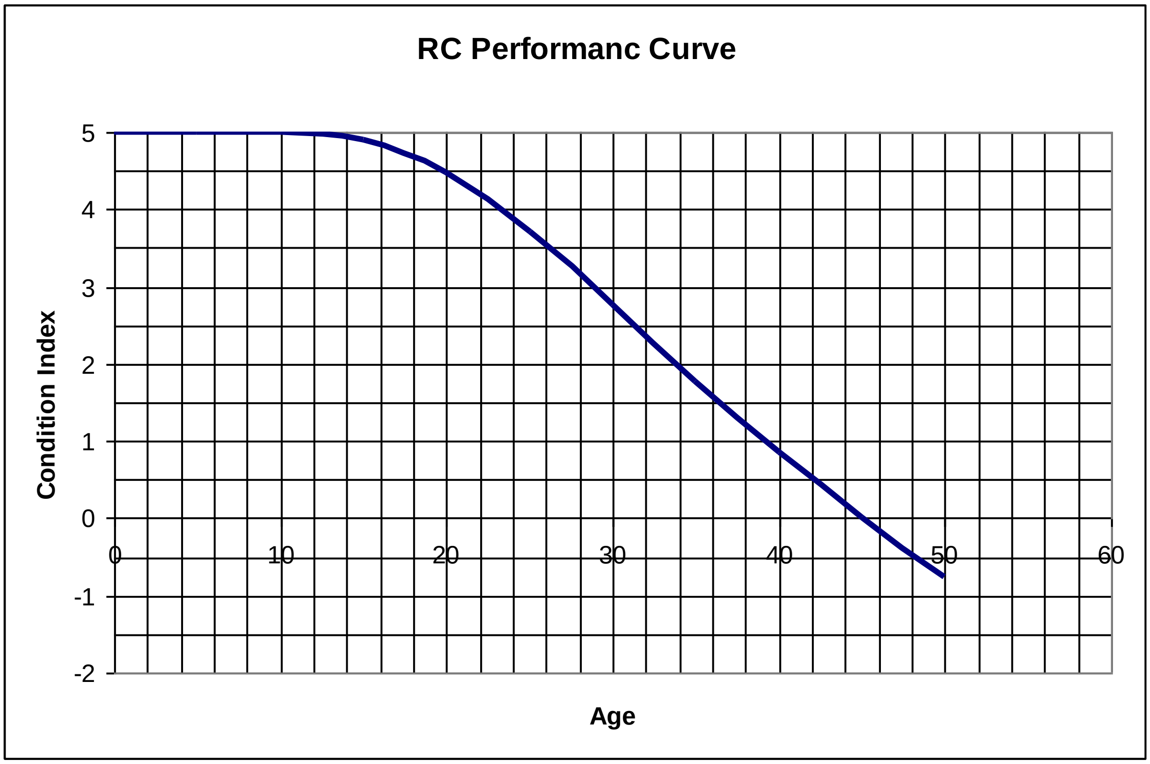


Figure 2:RC_ALL NDI

3.3.2.2 IRI Deterioration – All Pavements

Equations:

Family	Index	a	b	p	Equation for Index
IRI_ALL	IRI	13.59141	1.45	45	5 -13.59140915* exp(-((45/nAAV_AGE_NDI) **1.45))

Curves:

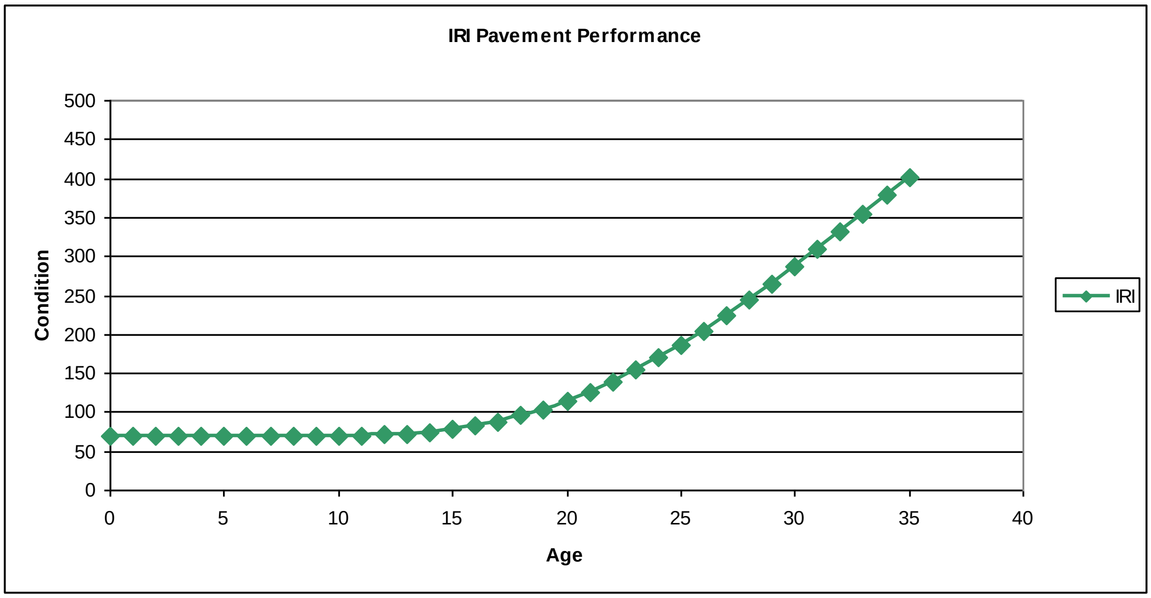


Figure 3:IRI All Pavements

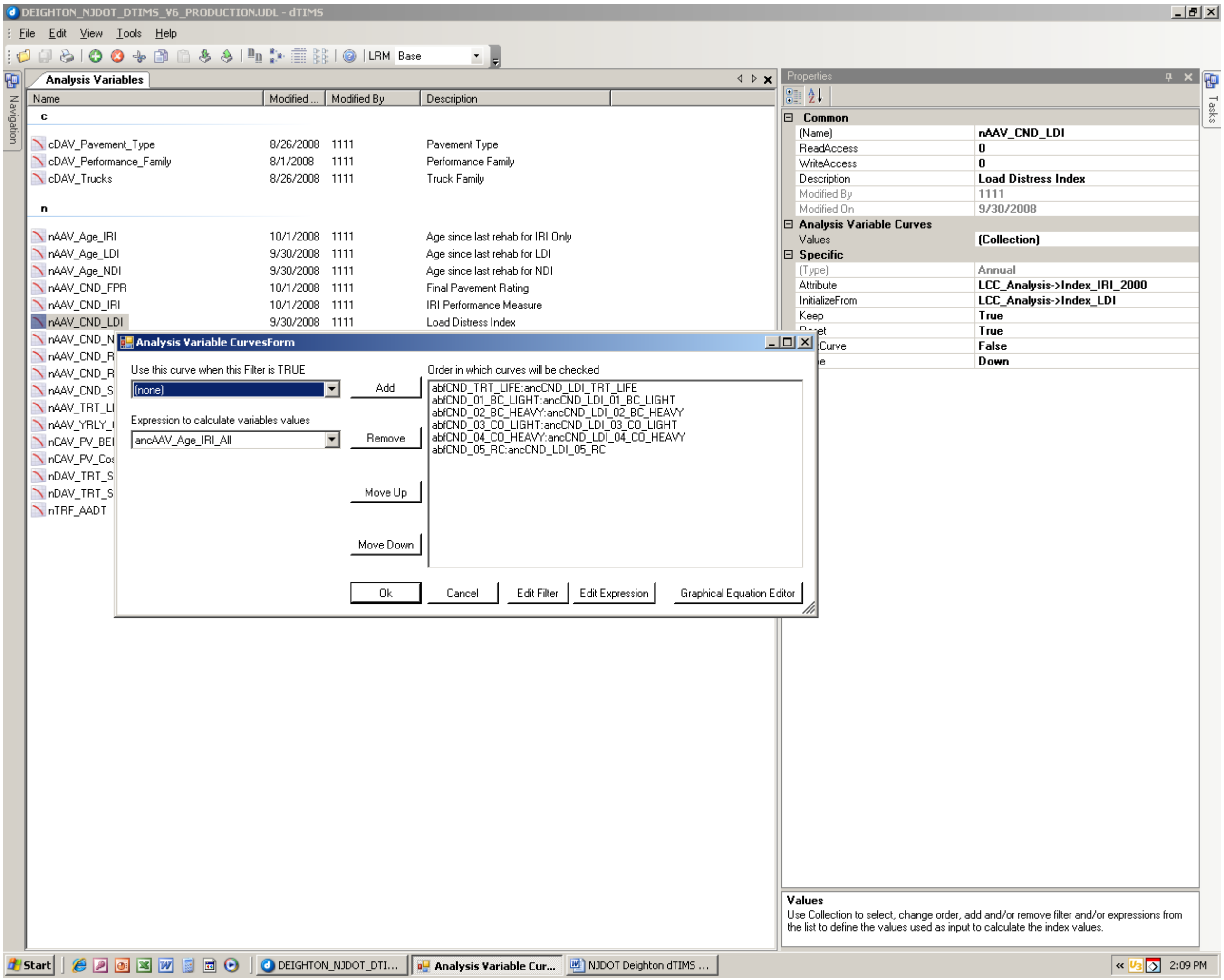
Performance Models in dTIMS

The performance model equations a stored as analysis expressions listed in table _____ below

Name	Performance Models
ancCND_**IRI**_01_**BC_LIGHT**	70.0+2718.28183* EXP(-((65.0/nAAV_Age_IRI) **1.2))
ancCND_**IRI**_02_**BC_HEAVY**	70.0+2718.28183* EXP(-((65.0/nAAV_Age_IRI) **1.2))
ancCND_**IRI**_03_**CO_LIGHT**	70.0+2718.28183* EXP(-((65.0/nAAV_Age_IRI) **1.2))
ancCND_**IRI**_04_**CO_HEAVY**	70.0+2718.28183* EXP(-((65.0/nAAV_Age_IRI) **1.2))
ancCND_**IRI**_05_**RC**	70.0+2718.28183* EXP(-((65.0/nAAV_Age_IRI) **1.2))
ancCND_**LDI**_01_**BC_LIGHT**	5.0 -10.87312732* EXP(-((30.0/nAAV_Age_LDI) **1.05))
ancCND_**LDI**_02_**BC_HEAVY**	5.0 -13.59140915* EXP(-((30.0/nAAV_Age_LDI) **0.75))
ancCND_**LDI**_03_**CO_LIGHT**	5.0 -13.59140915* EXP(-((30.0/nAAV_Age_LDI) **0.8))
ancCND_**LDI**_04_**CO_HEAVY**	5.0 -13.59140915* EXP(-((30.0/nAAV_Age_LDI) **0.79))
ancCND_**LDI**_05_**RC**	
ancCND_**NDI**_01_**BC_LIGHT**	5.0 -13.59140915* EXP(-((30.0/nAAV_Age_NDI) **0.85))
ancCND_**NDI**_02_**BC_HEAVY**	5.0 -13.59140915* EXP(-((30.0/nAAV_Age_NDI) **1.0))
ancCND_**NDI**_03_**CO_LIGHT**	5.0 -13.59140915* EXP(-((25.0/nAAV_Age_NDI) **0.72))
ancCND_**NDI**_04_**CO_HEAVY**	5.0 -13.59140915* EXP(-((20.0/nAAV_Age_NDI) **0.55))
ancCND_**NDI**_05_**RC**	5.0 -13.59140915* EXP(-((45.0/nAAV_Age_NDI) **1.45))

Table _______________ Performance model analysis expressions

The analysis variable nAAV_CND_LDI shown below illustrates the load associated LDI index used for BC and C0 pavements. The **Analysis Variable Curves** option in the property window provides the mechanism to select and order the analysis of the performance models for the various pavement families. The analysis expression **abfCND_01_BC_Light** identifies the pavement family **cDAV_Performance_Family = 'BC_LIGHT'.** The **cDAV_Pavement_Type** analysis variable is used to store the pavement family type for the analysis. The analysis variable, **ancCND_LDI_01_BC_LIGHT** provides the actual performance curve expression, **5.0 -10.87312732* EXP(-((30.0/nAAV_Age_LDI) **1.05)).**



Treatment Types, Triggers, Resets and Costs

3.4 The Treatments

Treatments are actions an agency takes on a network element either to slow the deterioration of a road (preservation) or to repair the effects of deterioration (rehabilitation). A treatment can be considered as a response to the certain condition or a policy based on condition and time.

One or more treatments applied over time constitute a Strategy. dTIMS CT has three types of Treatments: Major Treatments which are applied at most once per year in any Strategy, Minor Treatments which can be applied in every year with many types being applied in the same year, and Ancillary Treatments which can be applied only in conjunction with another treatment. All treatments defined in the NJDOT dTIMS CT setup are defined as Major treatments.

Table 5 summarizes the preventive maintenance, minor and major treatments defined in the NJDOT dTIMS CT. The summary indicates the treatment name, description, budget category and cost that funds the treatment.

Treatment Name	Description	Type	Budget Category	Cost Expression Name
Major_Rehab_Asphalt	Major Rehab Asphalt	Major	Resurfacing	ancCST_Major_Rehab_Asphalt
Major_Rehab_Composite	Major Rehab Composite	Major	Resurfacing	ancCST_Major_Rehab_Composite
Major_Rehab_Concrete	Major Rehab Concrete	Major	Resurfacing	ancCST_Major_Rehab_Concrete
Minor_Rehab_Asphalt	Minor Rehab Asphalt	Major	Resurfacing	ancCST_Major_Rehab_Asphalt
Minor_Rehab_Composite	Minor Rehab Composite	Major	Resurfacing	ancCST_Major_Rehab_Composite
Minor_Rehab_Concrete	Minor Rehab Concrete	Major	Resurfacing	ancCST_Major_Rehab_Concrete
PM_Chip_Seal	Chip Seal	Major	Maintenance	ancCST_PM_Chip_Seal
PM_Crack_Seal	Crack Seal	Major	Maintenance	ancCST_PM_Crack_Seal
PM_Diamond_Grinding	Diamond Grinding	Major	Maintenance	ancCST_PM Diamond_Grinding
PM_Micro_Milling	Micro Milling	Major	Maintenance	ancCST_PM_Micro_Milling
PM_Microsurfacing	Microsurfacing	Major	Maintenance	ancCST_PM_Microsurfacing
PM_Minor_Seal	Minor Seal	Major	Maintenance	ancCST_PM_Minor_Seal
PM_Ultra_Thin_Overlay	Ultra Thin Overlay	Major	Maintenance	ancCST_PM_Ultra_Thin_Overlay
Reconstruction	Reconstruction OF BC	Major	Maintenance	ancCST_Reconstruction

Table 5: Treatment Type and Funding Category.

3.4.1 Treatment Costs

The costs of treatments are defined in dTIMS CT using expressions. Details regarding the cost expressions are shown in Table 6. All of the treatment cost objects can be found by navigating to Analysis Expressions from the Analyze and Report navigation pane and then searching for the expressions that are named with "ancCST" (Analysis Numeric Calculator CoSTs) as a prefix to the name.

Name	TheExpression
ancCST_Major_Rehab_Asphalt	(GET_LENGTH(LCC_Analysis) * 5280.0 * (LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0)))/ 9.0 * 21.89 * 2.0 * ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_Major_Rehab_Composite	(GET_LENGTH(LCC_Analysis) * 5280.0 *(LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0)) 9.0 * 16.88 * 3.1 * ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_Major_Rehab_Concrete	(GET_LENGTH(LCC_Analysis) * 5280.0 * (LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0))) /9.0 * 22.3 * 3.1 * ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_Minor_Rehab_Asphalt	(GET_LENGTH(LCC_Analysis) * 5280.0 *(LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0)))/ 9.0 * 15.26 * 2.0 * ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_Minor_Rehab_Composite	(GET_LENGTH(LCC_Analysis) * 5280.0 *(LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0)))/ 9.0 * 10.37 * 3.1 * ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_Minor_Rehab_Concrete	(GET_LENGTH(LCC_Analysis) * 5280.0 *(LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0)))/ 9.0 * 17.2 * 3.1 * ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_PM_Chip_Seal	(GET_LENGTH(LCC_Analysis) * 5280.0 *(LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0)))/ 9.0 * 4.0 * 2.0 * ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_PM_Crack_Seal	(GET_LENGTH(LCC_Analysis) * 5280.0 * LCC_Analysis->Inventory_Pave_Width) / 9.0 * 2.5 * 2.0* ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_PM_Diamond_Grinding	(GET_LENGTH(LCC_Analysis) * 5280.0 * LCC_Analysis->Inventory_Pave_Width) / 9.0 * 7.0 * 2.0* ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_PM_Micro_Milling	(GET_LENGTH(LCC_Analysis) * 5280.0 * LCC_Analysis->Inventory_Pave_Width) / 9.0 * 3.0 * 2.0 * ((1.0 + GINFLATION) ** (YR - 1.0))

ancCST_PM_Microsurface	(GET_LENGTH(LCC_Analysis) * 5280.0 *(LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0)))/ 9.0 * 2.53 * 2.0 * ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_PM_Minor_Seal	(GET_LENGTH(LCC_Analysis) * 5280.0 *(LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0)))/ 9.0 * 2.0 * 2.0 * ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_PM_Ultra_Thin_Overlay	(GET_LENGTH(LCC_Analysis) * 5280.0 *(LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0)))/ 9.0 * 6.5 * 2.0 * ((1.0 + GINFLATION) ** (YR - 1.0))
ancCST_Reconstruction	(GET_LENGTH(LCC_Analysis) * 5280.0 *(LCC_Analysis->Inventory_Pave_Width + MAX(LCC_Analysis->Inventory_Shld_Width_Inside,0.0) + MAX(LCC_Analysis->Inventory_Shld_Width_Outside,0.0)))/ 9.0 * 98.45 * 3.1 * ((1.0 + GINFLATION) ** (YR - 1.0))

Table 6: Treatment Cost Expression Summary.

Further insight into the each of the cost expressions can be obtained by accessing the properties of the relevant Attributes, Expressions and Cross Tab Transformations within the NJDOT dTIMS CT.

3.5 The Trigger Limits

During the analysis, dTIMS CT uses Triggers to determine when to apply a Treatment to a network Element. Because dTIMS CT examines the effects of applying Treatments over a period of time, we often refer to these Triggers as trigger zones as opposed to trigger points. A trigger zone defines a range in condition or time over which a specific Treatment is applicable on an Element. A trigger point says, "apply the Treatment on the Element when the condition reaches this point." Trigger zones allow for the possibility of dTIMS CT testing various years for applying the same Treatment and letting economics decide which year gives the best return. There is an upper and a lower limit for each trigger zone; these are referred to as trigger limits.

Treatment Name	Analysiis Variable Triggers								
	nAAV_CND_LDI	nAAV_CND_NDI	nAAV_CND_SDIm	nAAV_CND_IRI	nAAV_Age_NDI	nTRAF_AADT	Index_Avg_Rut	Index_Skid_Value	cDAV_Pavement_Type
Major_Rehab_Asphalt	<= 2.4								BC
Major_Rehab_Composite	<= 2.4								CO
Major_Rehab_Concrete			<= 2.5						RC
Minor_Rehab_Asphalt	>=3.0	<= 2.5							BC
	<= 2.4								BC
Minor_Rehab_Composite	>=3.0	<= 2.5							CO
	<= 2.4		>= 2.5 AND <= 4.0						CO
Minor_Rehab_Concrete									RC
PM_Chip_Seal	>= 3.0	>= 2.5 AND <= 3.5	>= 2.5			<= 5000			BC OR CO
PM_Crack_Seal	>= 3.0	>= 3.2 AND <= 4.2	>= 2.5						BC OR CO
PM_Diamond_Grinding			> 3.5	> 170	> 5			<= Index_Skid_Trigger	RC
PM_Micro_Milling	> 4.7	> 4.7						<= Index_Skid_Trigger	BC OR CO
	> 4.7	> 4.7					>= 0.25 AND <= 0.5		BC OR CO
PM_Microsurface	>= 3.0	>= 2.5 AND <= 3.5	>= 2.5						BC OR CO
			>= 2.5					<= Index_Skid_Trigger	BC OR CO
			>= 2.5				>= 0.5 AND <= 1.0		BC OR CO
PM_Minor_Seal	>= 3.0	>= 3.0 AND <= 4.0	>= 2.5						BC OR CO
PM_Ultra_Thin_Overlay	>= 3.0	>= 2.0 AND <= 3.0	>= 2.5						
	>= 2.5 AND <= 3.0		>= 2.5						
			>= 2.5				>= 0.75 AND <= 1.5		
Reconstruction			< 1.0						

Table 7: Treatment Trigger Summary

Table 7 summarizes the treatment trigger limits, with respect to the noted annual analysis variables. The reader should assume that "AND" operators exist between all columns in the table. Where multiple rows exist for a given treatment it should be interpreted as having an "OR" between the rows.

From the point of view of expressions that have been implemented within dTIMS CT, Table 8 shows the expressions that are represented by the trigger matrix in Table 7.

Treatment Name	The dTIMS CT Expression
Major_Rehab_Asphalt	cDAV_Pavement_Type = 'BC' and nAAV_CND_LDI <= 2.4
Major_Rehab_Composite	cDAV_Pavement_Type = 'CO' and nAAV_CND_LDI <=2.4
Major_Rehab_Concrete	cDAV_Pavement_Type = 'RC' and nAAV_CND_SDIm <=2.5
Minor_Rehab_Asphalt	cDAV_Pavement_Type = 'BC' and ((nAAV_CND_NDI <= 2.5 And nAAV_CND_LDI >= 3.0) or nAAV_CND_LDI =2.4)
Minor_Rehab_Composite	cDAV_Pavement_Type = 'CO' and ((nAAV_CND_NDI <= 2.5 And nAAV_CND_LDI >= 3.0) or nAAV_CND_LDI<=2.4)
Minor_Rehab_Concrete	cDAV_Pavement_Type = 'RC' and nAAV_CND_SDIm >=2.5 and nAAV_CND_SDIm <=4.0
PM_Chip_Seal	(cDAV_Pavement_Type = 'BC' or cDAV_Pavement_Type = 'CO') and nTRF_AADT <= 5000.0 And nAAV_CND_NDI >= 2.5 And nAAV_CND_NDI <= 3.5 And nAAV_CND_LDI >= 3.0 and nAAV_CND_SDIm >= 2.5
PM_Crack_Seal	(cDAV_Pavement_Type = 'BC' or cDAV_Pavement_Type = 'CO') And nAAV_CND_NDI >= 3.2 and nAAV_CND_NDI <= 4.2 And nAAV_CND_LDI >= 3.0 and nAAV_CND_SDIm >= 2.5
PM_Diamond_Grinding	cDAV_Pavement_Type = 'RC' and nAAV_Age_NDI > 5.0 and nAAV_CND_SDIm > 3.5 and nAAV_CND_IRI > 170.0 and LCC_Analysis->Index_Skid_Value <= LCC_Analysis->Index_Skid_Trigger
PM_Micro_Milling	(cDAV_Pavement_Type = 'BC' or cDAV_Pavement_Type = 'CO') and nAAV_CND_LDI > 4.7 and nAAV_CND_NDI > 4.7 And ((LCC_Analysis->Index_Skid_Value <= LCC_Analysis->Index_Skid_Trigger) or (LCC_Analysis->Index_Avg_Rut>= 0.25 And LCC_Analysis->Index_Avg_Rut <= 0.5))
PM_Microsurface	(cDAV_Pavement_Type = 'BC' or cDAV_Pavement_Type = 'CO') and ((nAAV_CND_NDI >= 2.5 And nAAV_CND_NDI <= 3.5 And nAAV_CND_LDI >= 3.0) or (LCC_Analysis->Index_Skid_Value <= LCC_Analysis->Index_Skid_Trigger) or (LCC_Analysis->Index_Avg_Rut>= 0.5 And LCC_Analysis->Index_Avg_Rut <= 1.0)) and nAAV_CND_SDIm >= 2.5
PM_Minor_Seal	(cDAV_Pavement_Type = 'BC' or cDAV_Pavement_Type = 'CO') And (nAAV_CND_NDI >= 3.0 And nAAV_CND_NDI <= 4.0 And nAAV_CND_LDI >= 3.0) and nAAV_CND_SDIm >= 2.5
PM_Ultra_Thin_Overlay	((nAAV_CND_NDI >= 2.0 And nAAV_CND_NDI <= 3.0 And nAAV_CND_LDI >= 3.0) or (nAAV_CND_LDI >= 2.5 And nAAV_CND_LDI <= 3.0) or (LCC_Analysis->Index_Avg_Rut>= 0.75 And LCC_Analysis->Index_Avg_Rut <= 1.5)) and nAAV_CND_SDIm >= 2.5
Reconstruction	nAAV_CND_SDIm < 1.0

Table 8: Treatment Trigger Expressions

The treatment trigger are stored in Analysis Expressions shown in table ___________.

Name	Desc	TheExpression
abfTRG_Major_Rehab_Asphalt	Treatment Trigger Major Rehab Asphalt	cDAV_Pavement_Type = 'BC' and nAAV_CND_LDI <= 2.4
abfTRG_Major_Rehab_Composite	Treatment Trigger Major Rehab Composite	cDAV_Pavement_Type = 'CO' and nAAV_CND_LDI <=2.4
abfTRG_Major_Rehab_Concrete	Treatment Trigger Major Rehab Concrete	cDAV_Pavement_Type = 'RC' and nAAV_CND_SDIm <=2.5
abfTRG_Minor_Rehab_Asphalt	Treatment Trigger Minor Rehab Asphalt	cDAV_Pavement_Type = 'BC' and ((nAAV_CND_NDI <= 2.5 And nAAV_CND_LDI >= 3.0) or nAAV_CND_LDI <=2.4)
abfTRG_Minor_Rehab_Composite	Treatment Trigger Minor Rehab Composite	cDAV_Pavement_Type = 'CO' and ((nAAV_CND_NDI <= 2.5 And nAAV_CND_LDI >= 3.0) or nAAV_CND_LDI <=2.4)
abfTRG_Minor_Rehab_Concrete	Treatment Trigger Minor Rehab Concrete	cDAV_Pavement_Type = 'RC' and nAAV_CND_SDIm >=2.5 and nAAV_CND_SDIm <=4.0
abfTRG_PM_Chip_Seal	Treatment Trigger PM Chip Seal	(cDAV_Pavement_Type = 'BC' or cDAV_Pavement_Type = 'CO') and nTRF_AADT <= 5000.0 And nAAV_CND_NDI >= 2.5 And nAAV_CND_NDI <= 3.5 And nAAV_CND_LDI >= 3.0 and nAAV_CND_SDIm >= 2.5
abfTRG_PM_Crack_Seal	Treatment Trigger PM Crack Seal	(cDAV_Pavement_Type = 'BC' or cDAV_Pavement_Type = 'CO') And nAAV_CND_NDI >= 3.2 and nAAV_CND_NDI <= 4.2 And nAAV_CND_LDI >= 3.0 and nAAV_CND_SDIm >= 2.5
abfTRG_PM_Diamond_Grinding	Treatment Trigger Diamond Grinding	cDAV_Pavement_Type = 'RC' and nAAV_Age_NDI > 5.0 and nAAV_CND_SDIm > 3.5 and nAAV_CND_IRI > 170.0 and LCC_Analysis->Index_Skid_Value <= LCC_Analysis->Index_Skid_Trigger
abfTRG_PM_Micro_Milling	Treatment Trigger PM Micro Milling	(cDAV_Pavement_Type = 'BC' or cDAV_Pavement_Type = 'CO') and nAAV_CND_LDI > 4.7 and nAAV_CND_NDI > 4.7 And ((LCC_Analysis->Index_Skid_Value <= LCC_Analysis->Index_Skid_Trigger) or (LCC_Analysis->Index_Avg_Rut>= 0.25 And LCC_Analysis->Index_Avg_Rut <= 0.5))
abfTRG_PM_Microsurface	Treatment Trigger PM Microsurface	(cDAV_Pavement_Type = 'BC' or cDAV_Pavement_Type = 'CO') and ((nAAV_CND_NDI >= 2.5 And nAAV_CND_NDI <= 3.5 And nAAV_CND_LDI >= 3.0) or (LCC_Analysis->Index_Skid_Value <= LCC_Analysis->Index_Skid_Trigger) or (LCC_Analysis->Index_Avg_Rut>= 0.5 And LCC_Analysis->Index_Avg_Rut <= 1.0)) and nAAV_CND_SDIm >= 2.5

abfTRG_PM_Minor_Seal	Treatment Trigger PM Minor Seal	(cDAV_Pavement_Type = 'BC' or cDAV_Pavement_Type = 'CO') And (nAAV_CND_NDI >= 3.0 And nAAV_CND_NDI <= 4.0 And nAAV_CND_LDI >= 3.0) and nAAV_CND_SDIm >= 2.5
abfTRG_PM_Ultra_Thin_Overlay	Treatment Trigger PM Ultra Thin Overlay	((nAAV_CND_NDI >= 2.0 And nAAV_CND_NDI <= 3.0 And nAAV_CND_LDI >= 3.0) or (nAAV_CND_LDI >= 2.5 And nAAV_CND_LDI <= 3.0) or (LCC_Analysis->Index_Avg_Rut>= 0.75 And LCC_Analysis->Index_Avg_Rut <= 1.5)) and nAAV_CND_SDIm >= 2.5
abfTRG_Reconstruction	Treatment Trigger Reconstruction	nAAV_CND_SDIm < 1.0

3.5.1 Treatment Index Resets

For each treatment in Table 5, dTIMS CT allows the user to define a reset value for any of the annual analysis variables that are maintained in dTIMS CT. That is, a value that indicates an amount the condition indices within the dTIMS CT database would be changed by if the treatment was applied.

Table 9 presents the list of treatment reset expressions used in dTIMS CT to reset the condition Analysis Variables.

Treatment Name	Condition Analysis Variables					
	nAAV_CND_RDL	nAAV_CND_RSL	nAAV_CND_IRI	nAAV_CND_LDI	nAAV_CND_NDI	nAAV_CND_SDIm
Major_Rehab_Asphalt	ancRES_25	ancRES_25	ancRES_60	ancRES_5	ancRES_5	ancRES_5
Major_Rehab_Composite	ancRES_25	ancRES_25	ancRES_60	ancRES_5	ancRES_5	ancRES_5
Major_Rehab_Concrete	ancRES_25	ancRES_25	ancRES_75	ancRES_5	ancRES_5	ancRES_5
Minor_Rehab_Asphalt	ancRES_20	ancRES_20	ancRES_70	ancRES_5	ancRES_5	ancRES_5
Minor_Rehab_Composite	ancRES_20	ancRES_20	ancRES_70	ancRES_5	ancRES_5	ancRES_5
Minor_Rehab_Concrete	ancRES_20	ancRES_20	ancRES_75	ancRES_5	ancRES_5	ancRES_5
PM_Chip_Seal	ancRES_7	ancRES_RSL_7		ancRES_5	ancRES_5	ancRES_5
PM_Crack_Seal				ancRES_LDI_Crack_Seal	ancRES_NDI_Crack_Seal	ancCND_SDI_All
PM_Diamond_Grinding	ancRES_10	ancRES_RSL_10	ancRES_75			
PM_Micro_Milling	ancRES_7	ancRES_RSL_7	ancRES_75			
PM_Microsurface	ancRES_7	ancRES_RSL_7		ancRES_5	ancRES_5	ancRES_5
PM_Minor_Seal	ancRES_7	ancRES_RSL_5		ancRES_5	ancRES_5	ancRES_5
PM_Ultra_Thin_Overlay	ancRES_10	ancRES_RSL_10	ancRES_75	ancRES_5	ancRES_5	ancRES_5
Reconstruction	ancRES_25	ancRES_25	ancRES_60	ancRES_5	ancRES_5	ancRES_5

Table 9: Treatment reset expressions.

Resets, like many other objects within dTIMS CT, are controlled by expressions. Details regarding the treatment reset expressions can be obtained by accessing the properties of the Analysis Expressions noted in Table 9.

Name	Desc	The Expression
ancRES_0	0	0.0
ancRES_1	1	1.0
ancRES_10	10	10.0
ancRES_15	15	15.0
ancRES_2	2	2.0
ancRES_20	20	20.0
ancRES_25	25	25.0
ancRES_5	5	5.0
ancRES_60	60	60.0
ancRES_7	7	7.0
ancRES_70	70	70.0
ancRES_75	75	75.0
ancRES_Age	Reset to Age following a treatment	1.0
ancRES_Age_LDI_Chip_Seal	Reset Age Following a Chip Seal	nAAV_Age_LDI - 7.0
ancRES_Age_LDI_Crack_Seal	Reset Age Following a Crack Seal	nAAV_Age_LDI - 4.0
ancRES_Age_LDI_Microsurface	Reset Age Following a Microsurfac e	nAAV_Age_LDI - 7.0
ancRES_Age_LDI_Minor_Seal	Reset Age Following a Minor Seal	nAAV_Age_LDI - 5.0
ancRES_Age_LDI_Thin_Overlay	Reset Age Following a Thin Overlay	nAAV_Age_LDI - 10.0
ancRES_Age_NDI_Chip_Seal	Reset Age Following a Chip Seal	nAAV_Age_NDI - 7.0
ancRES_Age_NDI_Crack_Seal	Reset Age Following a Crack Seal	nAAV_Age_NDI - 4.0
ancRES_Age_NDI_Microsurface	Reset Age Following a Microsurfac e	nAAV_Age_NDI - 7.0
ancRES_Age_NDI_Minor_Seal	Reset Age Following a Minor Seal	nAAV_Age_NDI - 5.0

ancRES_Age_NDI_Thin_Overlay	Reset Age Following a Thin Overlay	nAAV_Age_NDI - 10.0
ancRES_GOOD	Reset Inital IRI to Good	'GOOD'
ancRES_Last_Treatment_Major	Set last treatment to Major	'MAJOR'
ancRES_Last_Treatment_Minor	Set last treatment to Minor	'MINOR'
ancRES_Last_Treatment_PM	Set last treatment to PM	'PM'
ancRES_LDI_Crack_Seal		MIN(nAAV_CND_LDI * 1.15,5.0)
ancRES_NDI_Crack_Seal		MIN(nAAV_CND_NDI * 1.15,5.0)
ancRES_Pavement_Type_BC	BC	'BC'
ancRES_Pavement_Type_BC_CO	Reset Pavement Type to BC or CO	IF(cDAV_Pavement_Type = 'BC','BC','CO')
ancRES_RSL_10	Reset RSL + 10	nAAV_CND_RSL + 10.0
ancRES_RSL_5	Reset RSL + 5	nAAV_CND_RSL + 5.0
ancRES_RSL_7	Reset RSL + 7	nAAV_CND_RSL + 7.0
ancRES_TRT_LIFE_CHIP_SEAL	Treatment Life for Chip Seal	7.0 + 1.0
ancRES_TRT_LIFE_CRACK_SEAL	Treatment Life for Crack Seal	4.0 + 1.0
ancRES_TRT_LIFE_MICROSURFACE	Treatment Life for Microsurfac e	7.0 + 1.0
ancRES_TRT_LIFE_MINOR_SEAL	Treatment Life for Minor Seal	5.0 + 1.0
ancRES_TRT_LIFE_THIN_OVERLAY	Treatment Life for Thin Overlay	10.0 + 1.0
ancRES_TRT_SLOPE_CRACK_SEAL_LDI	Crack Seal Treatment Slope	(MIN(nAAV_CND_LDI * 1.15,5.0) - nAAV_CND_LDI) / 4.0
ancRES_TRT_SLOPE_CRACK_SEAL_NDI	Crack Seal Treatment Slope	(MIN(nAAV_CND_NDI * 1.15,5.0) - nAAV_CND_NDI) / 4.0
ancRES_TRT_SLOPE_LDI	Crack Seal Treatment Slope	(5.0 - nAAV_CND_LDI) / (nAAV_TRT_LIFE -1.0)
ancRES_TRT_SLOPE_NDI	Crack Seal Treatment Slope	(5.0 - nAAV_CND_NDI) / (nAAV_TRT_LIFE -1.0)

3.6 *Analysis Sets*

The analysis set object is the center of dTIMS CT life cycle cost (LCC) analysis and contains all instructions dTIMS CT will follow when executing the strategy generation and optimization components of the analysis. An analysis set object contains directives like:

(a) how long the analysis will go into the future,
(b) what elements are being analyzed,
(c) which list of treatments are involved,
(d) which attribute values represent asset condition,
(e) where the results are to be placed and
(f) what objective function optimization will use.

There are no restrictions on the number of different LCC Analysis Sets that users can create in the system. Each time a user wants a different type of analysis, a user would create a different analysis set. For instance, a user could have an analysis set for the bridges in her network, and a different one for her roads. The user could also create another analysis set for roads, making this one look at minimizing the costs instead of maximizing the benefits. To do this, the user would simply reuse most of the objects created for the first road analysis set, and only change the objective function instruction. Therefore, when designing LCC Analyses Sets, the user should keep in mind certain analysis objects can be reused.

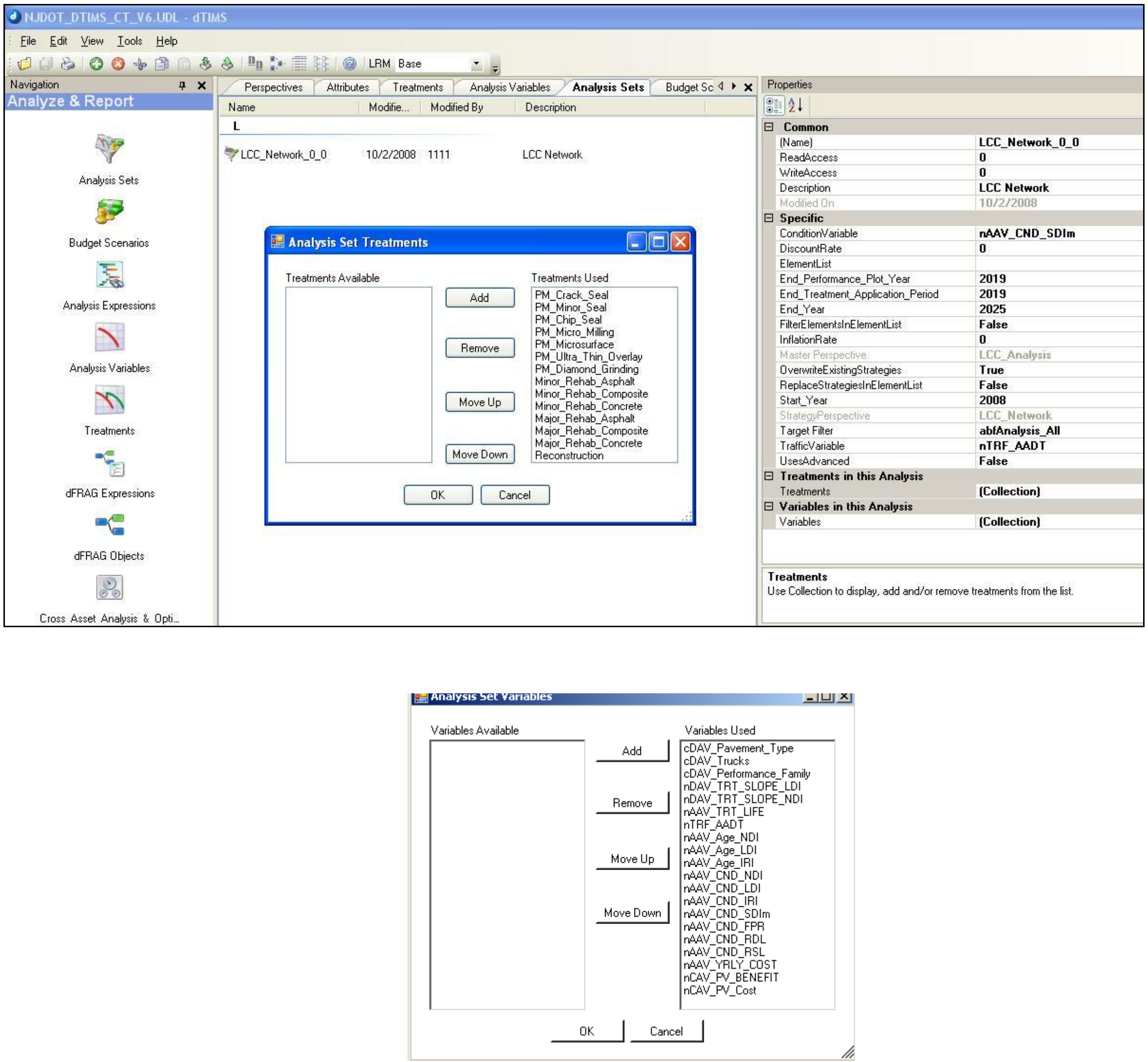


Figure 4: Example of dTIMS CT Analysis Set Properties (treatments and analysis variables)

An example Analysis Set properties window is illustrated in Figure 4. The Treatments included in this analysis set are displayed in the Analysis Set Treatments window that was opened via the Treatments collection button in the Property pane on the right-hand side of Figure 4.

From this general description, it is plain to see the role of the analysis set object is to contain the description of an LCC analysis. The analysis set's behaviour is to execute the analysis. It is important to keep in mind that dTIMS CT is generic and flexible. In other words, not only can the analysis be performed on any group of elements (of the same type), but also the user is required to define every aspect of it. Unlike its predecessor dTIMS 6, dTIMS CT Ver. 8 does not have any built-in 'knowledge' of the LCC analysis. For instance, dTIMS 6 had built-in vehicle operating cost, traffic volume growth and benefit calculations. None of these relationships are "hard coded" in a dTIMS CT Ver. 8 analysis; if required for a particular analysis, Deighton and the user must define these features during implementation. The user, as always, can review and edit the properties of an Analysis Set at any time following the initial implementation.

The NJDOT implementation of dTIMS CT has one analysis set defined called, LCC_Network_0_0. This single analysis set covers the entire New Jersey pavement network.

3.7 The Traffic Growth Rate

In pavement management time or age is used as the independent variables of Performance Curves. The traffic Annual Average Daily Traffic (AADT) and/or cumulative ESALs can be used as the weighting factor for area-under-the-curve benefits or in the calculation of Vehicle Operation Cost. The growth of the AADT values is facilitated through supplying an AADT growth rate. An annual growth rate of 1.92 has been applied to the sections within the PMS for analysis. The traffic growth rate can be adjusted in the analysis expression, ancTRF_AADT

3.8 The Analysis and Economic Parameters

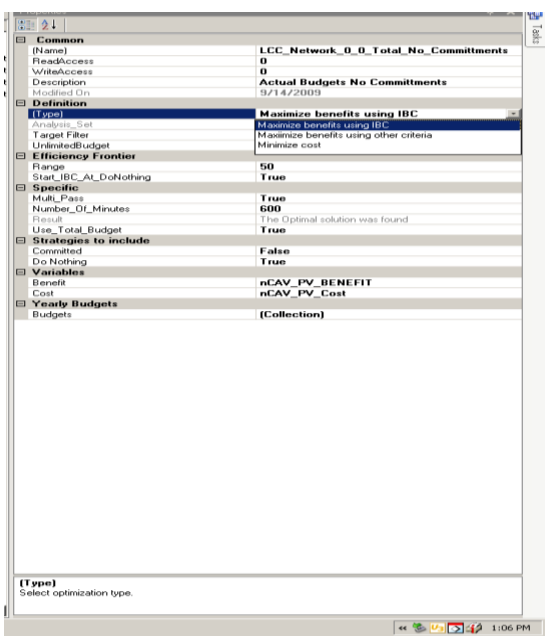
3.8.1 Discount and Inflation Rate

The economic parameters defined in dTIMS CT include the discount rate and the inflation rate. The discount rate is a factor used to reduce future costs or benefits to a present day value. The discount rate can have a major influence on the results of an economic analysis. In pavement management systems, discount rates between 4 and 10 % are used. Currently, the discount rate is set at 0% for the NJDOT dTIMS CT setup. The inflation rate is used to inflate the unit cost of a Treatment for each year in the Analysis Period. Currently, the inflation rate is set to 0%. The discount and inflation rates can be adjusted in the property table of the analysis set, LCC_Network_0_0.

3.8.2 Budget Scenarios

Budget scenarios allow you to examine and compare the effects of spending different amounts of money on the overall network condition. A Budget Scenario works in conjunction with an Analysis Set and cannot be added without first designing and entering an Analysis Set.

There is no limit on the number of budget scenarios assigned to each analysis set.



Each budget scenario has a different target budget (constraint) and the optimization routine may recommend a different construction program for each target budget. Optimization examines one scenario at a time using the amounts of money provided for each budget category.

The properties window of the budget scenario allows the user to specify the type of analysis – maximize benefit using incremental benefit cost or other criteria, or minimize costs and to specify the budget for each year of the analysis period. The annual budget can be broken down between capital and maintenance costs or between preventive maintenance and rehabilitation costs.

Common:	
Name	Budget Scenario names must be unique and avoid *reserved names* or *special characters* • Name length = 255 char. • Cannot contain special characters including spaces. • Try using a code to identify the field type and style such as bs_Identifying_name
Read Access	Shows the minimum access level required to view the properties of the current object. • values are 0 through 9, where 0 represents no security is currently set, 9 is a system reserved security level and 8 is considered System Administrator level.
Write Access	Shows the minimum access level required to edit the properties of the current object. • values are 0 through 9, where 0 represents no security is currently set, 9 is a system reserved security level and 8 is considered System Administrator level.
Description	Brief description of this Budget Scenario. • 255 characters maximum of your Budget Scenario identification and explanation • indication of what makes the budget scenario unique from other budget scenarios
Modified by	User who made last modification to corresponding object. • Read-only field • Updated by the system when the changes are saved. • Shown only if more than one user has access to the database.
Modified on	Date the last modification was made. • Updated by the system when the changes are saved.
Definition:	
Type	Use the drop-down list for the display of optimization types. Click to select • Maximize benefits using *IBC* • Maximize benefits using other criteria (cost/benefit graph is not created, all analysis variables holding other criteria must be of the compilation type variable) • Minimize costs (finds minimum cost to maintain condition level but cost/benefit graph is not created)

	Efficiency Frontier (cost/benefit) graphic is only created for ***Maximize benefits using IBC.*** Other types graphic will contain graph points only.

Analysis Set	Use the drop-down list for the display of analysis sets available
	• On edit, displays the name of selected Analysis Set for this scenario
	• The pre-selected Analysis Set must:
	  • have been selected,
	  • must be valid,
	  • must have met the criteria of containing at least two analysis variables.

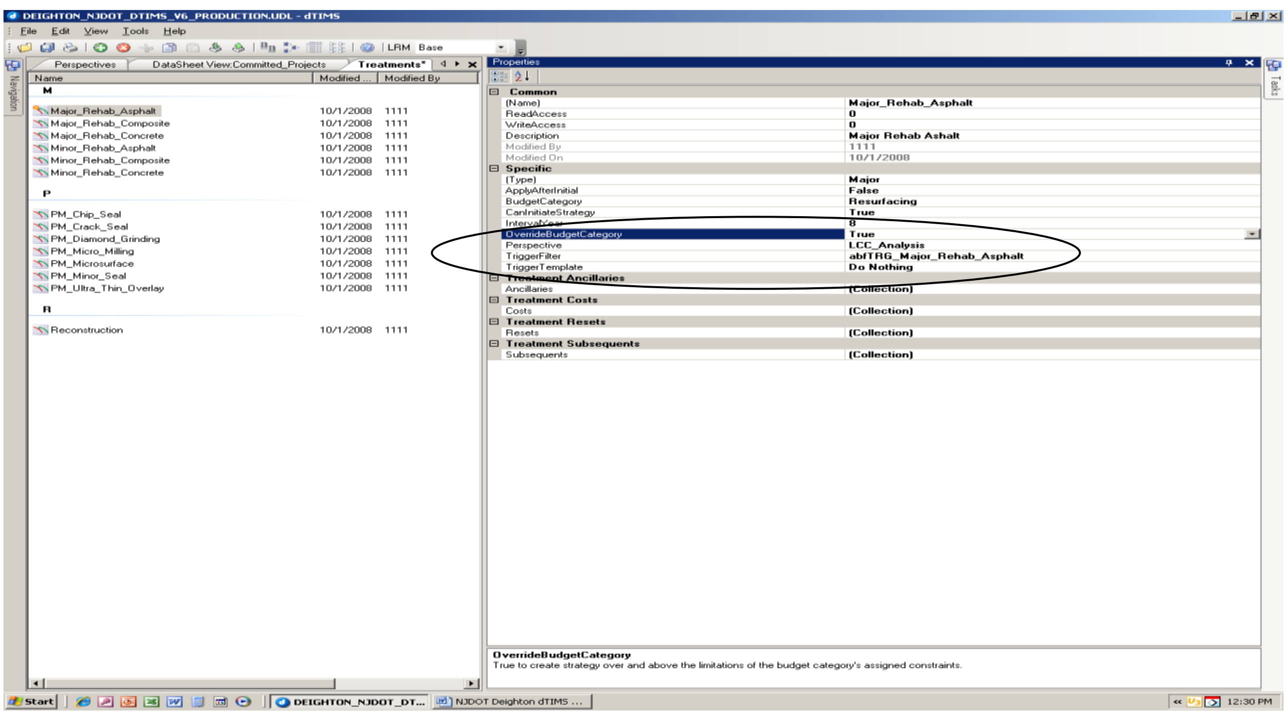
Target Filter	Use the drop-down list for the display of currently available filters.
Unlimited Budget	Use this option when you want to generate and view strategies without the concern of budget constraints. • Available only when the Type selection is ***Maximize Benefits using IBC*** • True/False • Once selected, removes the *Budgets* property from the *Yearly Costs:*
Efficiency Frontier:	
Range	IBC range (%) (Incremental Benefit Cost) • Enter the range you want dTIMS™ CT to consider for the IBC during the optimization process. • The range is used to target the optimization to the top percentage range.
Start_IBC_ At_Do Nothing	True/False • When calculating the IBC, you can indicate the start of calculation at Do-Nothing or 0 dollars.
Specific:	
Multi Pass	Multiple pass causes ***dTIMS™ CT*** to traverse the strategy list many times • True/False • Multi – Pass optimization reruns/does not run again from the top each time a solution is found • if there is little budget or unlimited budget, the same results will be found over more time • if time is an issue, it is best not to use this feature.
Number of Minutes	Number of Minutes for multi - pass • Enter the length of time you want to **limit** dTIMS™ CT to spend on executing the multiple pass optimization.
Result	The result of the optimization will be posted to this field: • *"An optimal solution was not found: There is not a selected strategy for each section"*

	• *"An optimal solution was not found: Allotted amount of time exhausted"* • *"An optimal solution was found.*
Use Total Budget	True/False • True = Total budget for all categories • False = Each budget category separately
Strategies to include:	
Committed	True/False • True = use committed ($ committed) treatments • False = ignore committed treatments
Do Nothing	The ***Do Nothing*** strategy is a strategy that has no treatments applied in any year. • True/False to include the do nothing strategy or not.
Variables:	
Benefit	Use the drop-down list for the display of compilation analysis variables for **present value benefit**
Cost	Use the drop-down list for the display of compilation analysis variables for **present value cost** Pre-defined Benefit and Cost variables:
Yearly Costs:	
Budgets	Use the *Collection* to invoke the Budget Categories table. • This table allows data entry of capital amounts for each time interval for calculations during optimization. • Once the Collection form has been closed, move to another property to ensure that the values have been stored. • Add a *budget category* .

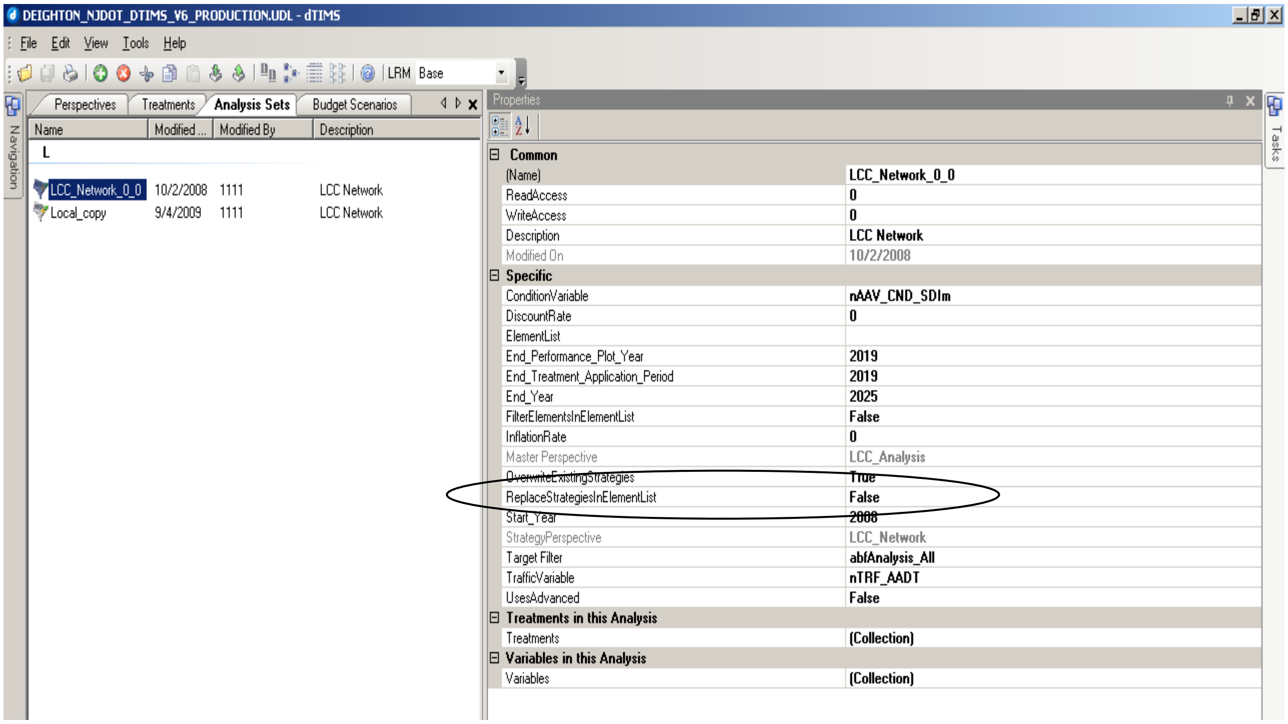
Committed projects identified in the future can be indicated in the property window.

Treatments Committed Overrides

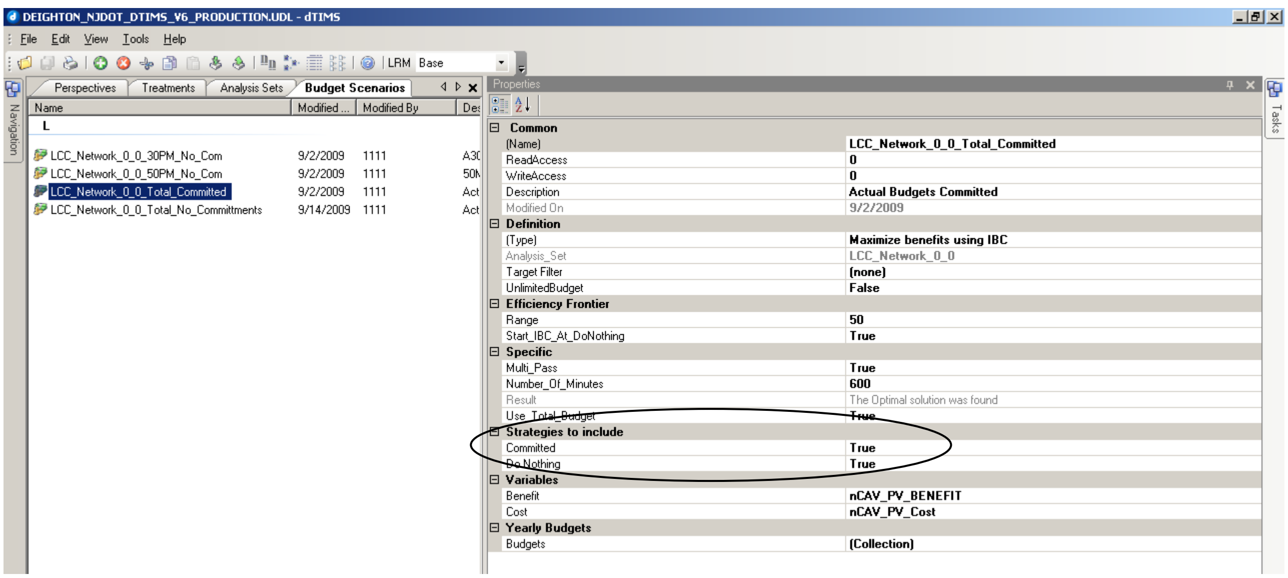
In the Treatment object properties there is a boolean field named ***OverrideBudgetCategory.*** Setting this field to TRUE will set a series of checks in motion to automatically generate two lists of strategies for every committed element, a committed list and a not committed list. Then, depending upon the values in the specialized attributes, it will use the proper list when selecting strategies during optimization. This allows the user to contrast the network impacts for the committed and not committed in the very same analysis, without having to re-generate the strategies. And, the two positions are distinguished using the name of his respective budget scenario.



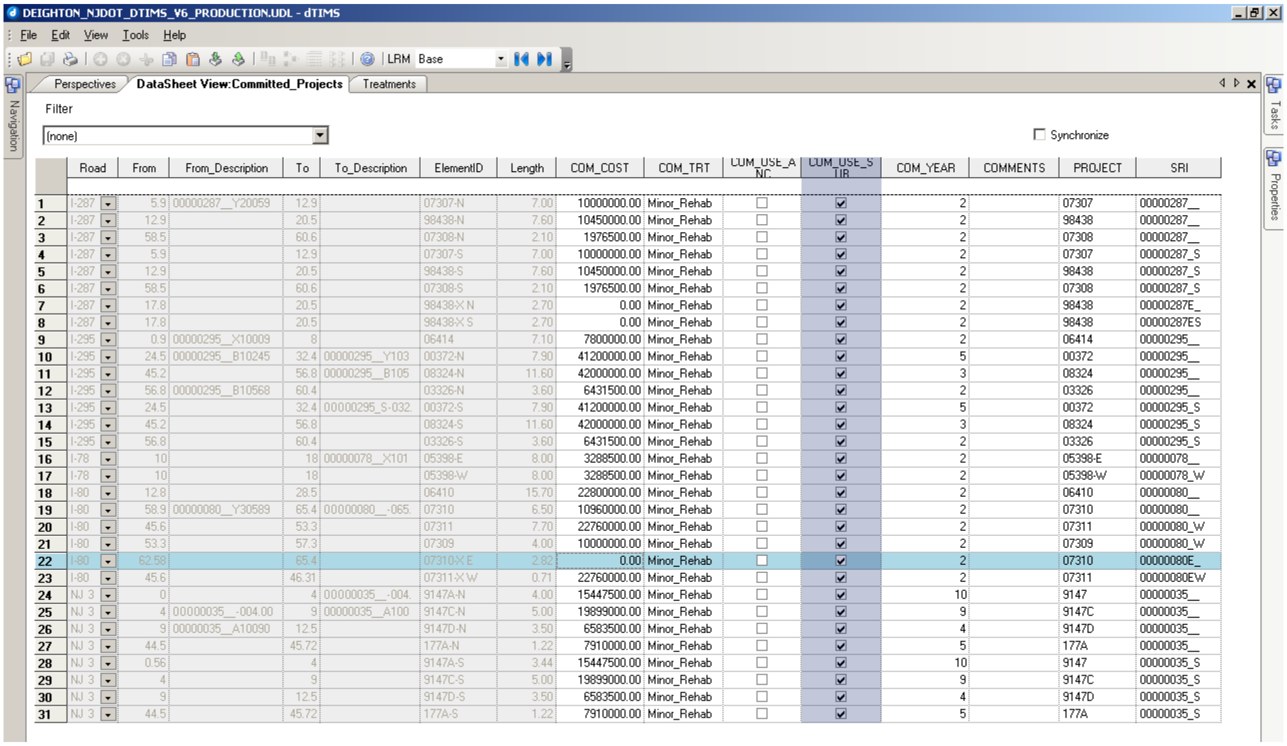
In the Analysis Set, OverwriteExistingStrategies is set to True.



And in the Budget Scenarios property window, **Strategies to include**, Committed is set to True.



The list of committed project are specified in the Committed_Projects perspective.



	Road	From	From_Description	To	To_Description	ElementID	Length	COM_COST	COM_TRT	COM_USE_ANC	COM_USE_SUB	COM_YEAR	COMMENTS	PROJECT	SRI
1	I-287	5.9	00000287__Y20059	12.9		07307-N	7.00	10000000.00	Minor_Rehab	☐	☑	2		07307	00000287__
2	I-287	12.9		20.5		98438-N	7.60	10450000.00	Minor_Rehab	☐	☑	2		98438	00000287__
3	I-287	58.5		60.6		07308-N	2.10	1976500.00	Minor_Rehab	☐	☑	2		07308	00000287__
4	I-287	5.9		12.9		07307-S	7.00	10000000.00	Minor_Rehab	☐	☑	2		07307	00000287_S
5	I-287	12.9		20.5		98438-S	7.60	10450000.00	Minor_Rehab	☐	☑	2		98438	00000287_S
6	I-287	58.5		60.6		07308-S	2.10	1976500.00	Minor_Rehab	☐	☑	2		07308	00000287_S
7	I-287	17.8		20.5		98438-X N	2.70	0.00	Minor_Rehab	☐	☑	2		98438	00000287E_
8	I-287	17.8		20.5		98438-X S	2.70	0.00	Minor_Rehab	☐	☑	2		98438	00000287ES
9	I-295	0.9	00000295__X10009	8		06414	7.10	7800000.00	Minor_Rehab	☐	☑	2		06414	00000295__
10	I-295	24.5	00000295__B10245	32.4	00000295__Y103	00372-N	7.90	41200000.00	Minor_Rehab	☐	☑	5		00372	00000295__
11	I-295	45.2		56.8	00000295__B105	08324-N	11.60	42000000.00	Minor_Rehab	☐	☑	3		08324	00000295__
12	I-295	56.8	00000295__B10568	60.4		03326-N	3.60	6431500.00	Minor_Rehab	☐	☑	2		03326	00000295__
13	I-295	24.5		32.4	00000295_S-032.	00372-S	7.90	41200000.00	Minor_Rehab	☐	☑	5		00372	00000295_S
14	I-295	45.2		56.8		08324-S	11.60	42000000.00	Minor_Rehab	☐	☑	3		08324	00000295_S
15	I-295	56.8		60.4		03326-S	3.60	6431500.00	Minor_Rehab	☐	☑	2		03326	00000295_S
16	I-78	10		18	00000078__X101	05398-E	8.00	3288500.00	Minor_Rehab	☐	☑	2		05398-E	00000078__
17	I-78	10		18		05398-W	8.00	3288500.00	Minor_Rehab	☐	☑	2		05398-W	00000078_W
18	I-80	12.8		28.5		06410	15.70	22800000.00	Minor_Rehab	☐	☑	2		06410	00000080__
19	I-80	58.9	00000080__Y30589	65.4	00000080__-065.	07310	6.50	10960000.00	Minor_Rehab	☐	☑	2		07310	00000080__
20	I-80	45.6		53.3		07311	7.70	22760000.00	Minor_Rehab	☐	☑	2		07311	00000080_W
21	I-80	53.3		57.3		07309	4.00	10000000.00	Minor_Rehab	☐	☑	2		07309	00000080_W
22	I-80	62.58		65.4		07310-X E	2.82	0.00	Minor_Rehab	☐	☑	2		07310	00000080E_
23	I-80	45.6		46.31		07311-X W	0.71	22760000.00	Minor_Rehab	☐	☑	2		07311	00000080EW
24	NJ 3	0		4	00000035__-004.	9147A-N	4.00	15447500.00	Minor_Rehab	☐	☑	10		9147	00000035__
25	NJ 3	4	00000035__-004.00	9	00000035__A100	9147C-N	5.00	19899000.00	Minor_Rehab	☐	☑	9		9147C	00000035__
26	NJ 3	9	00000035__A10090	12.5		9147D-N	3.50	6583500.00	Minor_Rehab	☐	☑	4		9147D	00000035__
27	NJ 3	44.5		45.72		177A-N	1.22	7910000.00	Minor_Rehab	☐	☑	5		177A	00000035__
28	NJ 3	0.56		4		9147A-S	3.44	15447500.00	Minor_Rehab	☐	☑	10		9147	00000035_S
29	NJ 3	4		9		9147C-S	5.00	19899000.00	Minor_Rehab	☐	☑	9		9147C	00000035_S
30	NJ 3	9		12.5		9147D-S	3.50	6583500.00	Minor_Rehab	☐	☑	4		9147D	00000035_S
31	NJ 3	44.5		45.72		177A-S	1.22	7910000.00	Minor_Rehab	☐	☑	5		177A	00000035_S

The COM_TRT Attribute **TIP:** Use **DNTG** when the perspective has elements that are not yet part of the network or when the decision has been made to ignore repair and maintenance on this element.	This is the name of the treatment to be committed within the strategy. • string attribute • when a valid treatment is named in this attribute, the element is considered to be committed • ***Minor*** treatments cannot be committed, any identified will be ignored during the Generate function. • when blank, the element is not committed • the treatment named in this attribute signals the system to ensure that the only strategies available for selection for this element during optimization are those that have this major treatment applied as their first treatment in the strategy. • entry of DNTG in this attribute for any element signals the system to commit the 'Do Nothing' strategy as the only strategy eligible for selection for this element during optimization.

The COM_YEAR Attribute	In order to commit this treatment, a valid entry is required when the COM_TRT attribute has been entered. • numeric attribute

<table>
<tr><td></td><td>enter the sequential year in which the named treatment is be to applied
an example is, year 5 of analysis.</td></tr>
<tr><td>The COM_COST Attribute</td><td>numeric attribute
enter the cost to be used for this treatment
valid entries are:
<table>
<tr><td>-1</td><td>use the cost expression for both financial and economic costs for the treatment when calculating the cost for applying this treatment</td></tr>
<tr><td>0</td><td>use zero costs for both financial and economic costs for this treatment</td></tr>
<tr><td>nnnn</td><td>any other value is the actual cost to be used for the economic and financial costs when this treatment is applied.
this value must be entered in the same monetary units other costs.
this value will be ignored if the element is not committed.</td></tr>
</table></td></tr>
<tr><td>The COM_USE_SUB Attribute</td><td>a boolean attribute indicating whether there is more than one treatment to be added to the strategy.
<table>
<tr><td>TRUE</td><td>indicates that dTIMS should follow the subsequent treatment list for the committed treatment which means that the committed treatment in COM_TRT becomes the first Major Treatment and will generate all strategy patterns associated with that by following the chain of subsequent treatments.

the element, therefore, could have a list with many committed strategies in it depending on how many major treatments have their "CanInitiate" flag set.</td></tr>
<tr><td>FALSE</td><td>apply only the listed major treatment and finish the strategy without applying any other major treatments and without initiating any other strategies.</td></tr>
</table></td></tr>
</table>

		• elements with a FALSE will only have one committed strategy generated. • examines each element and adds the minimum amount of money required to cover the cost of all the committed strategy thus creating a minimum required budget figure.
The COM_USE_ANC Attribute		• a boolean attribute indicating whether or not to check the triggers for the ancillary treatments associated with the committed Major Treatment.
	TRUE	• check the triggers for, and apply, all the ancillary treatments associated with the committed major treatment. • no additional cost will be added to the major treatment if a cost has been entered in the COM_COST attribute. The only way to include the cost for these ancillaries is, if the COM_COST attribute contains a value of -1 for this element.
	FALSE	• causes the ancillary treatments for the committed major treatment listed to be ignored.

There are four Budget Scenarios defined in the current NJDOT dTIMS CT setup. Each Budget Scenario is summarized in Table 10.

				Budget Category	
Budget Scenario Name	**Description**	**Year**	**Total Budget**	**Maintenance**	**Resurfacing**
LCC_Network_0_0_30PM_No_Com	30M Preventative Maintenance Budget with Balance for Resurfacing - No Committed Treatments	2008	$0	$0	$0
		2009	$167,600,000	$30,000,000	$137,600,000
		2010	$175,800,000	$30,000,000	$145,800,000
		2011	$30,000,000	$30,000,000	$0
		2012	$163,220,000	$30,000,000	$133,220,000
		2013	$143,100,000	$30,000,000	$113,100,000
		2014	$184,200,000	$30,000,000	$154,200,000
		2015	$143,602,000	$30,000,000	$113,602,000
		2016	$200,798,000	$30,000,000	$170,798,000
		2017	$194,300,000	$30,000,000	$164,300,000
		2018	$186,200,000	$30,000,000	$156,200,000
LCC_Network_0_0_50PM_No_Com	50M Preventative Maintenance Budget with Balance for Resurfacing - No Committed Treatments	2008	$0	$0	$0
		2009	$167,600,000	$50,000,000	$117,600,000
		2010	$175,800,000	$50,000,000	$125,800,000
		2011	$50,000,000	$50,000,000	$0
		2012	$163,220,000	$50,000,000	$113,220,000
		2013	$143,100,000	$50,000,000	$93,100,000
		2014	$184,200,000	$50,000,000	$134,200,000
		2015	$143,602,000	$50,000,000	$93,602,000
		2016	$200,798,000	$50,000,000	$150,798,000
		2017	$194,300,000	$50,000,000	$144,300,000
		2018	$186,200,000	$50,000,000	$136,200,000
LCC_Network_0_0_Total_Committed	Actual Budgets with Committed Treatments - No Budget Categories	2008	$0	$0	$0
		2009	$167,600,000	$0	$0
		2010	$175,800,000	$0	$0
		2011	$24,880,000	$0	$0
		2012	$163,220,000	$0	$0
		2013	$143,100,000	$0	$0
		2014	$184,200,000	$0	$0
		2015	$143,602,000	$0	$0
		2016	$200,798,000	$0	$0
		2017	$194,300,000	$0	$0
		2018	$186,200,000	$0	$0
LCC_Network_0_0_Total_No_Committments	Actual Budgets without Committed Treatments - No Budget Categories	2008	$0	$0	$0
		2009	$167,600,000	$0	$0
		2010	$175,800,000	$0	$0
		2011	$24,880,000	$0	$0
		2012	$163,220,000	$0	$0
		2013	$143,100,000	$0	$0
		2014	$184,200,000	$0	$0
		2015	$143,602,000	$0	$0
		2016	$200,798,000	$0	$0
		2017	$194,300,000	$0	$0
		2018	$186,200,000	$0	$0

Table 10: Budget Scenario Summary

3.8.3 Budget Categories

Budget Categories allow the user of dTIMS CT to dedicate budget funding to various, logical groups of treatments. For example, consider an agency having two cost centers, one for maintenance and one for capital costs. If each of these cost centers had different budget constraints and if the agency wanted to include both maintenance and capital treatments in the dTIMS CT analysis, that agency would define two budget categories. Once the agency did this they would associate all maintenance treatments to the maintenance budget category, and all capital treatments to the capital budget category. Then, they would enter different budget constraints for each budget category. After doing this, dTIMS CT would perform optimization in such a way to choose a mix of treatment types which still maximized the benefit, while not exceeding the budgets for either budget category.

Each treatment type defined in the NJDOT dTIMS CT can be supported with funds allocated to one of the two budget categories. The Budget Categories split the funding available in each Budget Scenario into Maintenance or Resurfacing dedicated funding. Note that two of the Budget Scenarios in Table 10 do not have funds defined in the two Budget Categories. This is because these two Budget Scenarios are designed to ignore the Budget Category properties for each treatment type and draw funding from the Total budget.

The use of specific Budget Categories in dTIMS CT allows the user to evaluate the influence of shifting funding between Budget Categories while maintaining the overall budget amount constant.

3.9 Preparing for the Analysis

In preparation for the analysis the dTIMS CT user executes two Batch Operations that execute individual transformations that take committed work and condition data from various perspectives and transforms that data to the Analysis perspective. Once the data has been transformed into the Analysis perspective, RSL is calculated. The Batch

Operations are called LCC_TRANSFER and LCC_RSL. The individual transformations that comprise the batch operations are summarized in

Batch Operation	Order	Operation Type	Operation Name
LCC_TRANSFORM	0	Perspective Transformations	LCC_00_CT_Direction
LCC_TRANSFORM	1	Perspective Transformations	LCC_01_AADT_N_E
LCC_TRANSFORM	2	Perspective Transformations	LCC_02_AADT_S_W
LCC_TRANSFORM	3	Perspective Transformations	LCC_03_PAVE_TYPE
LCC_TRANSFORM	4	Perspective Transformations	LCC_04_Average_IRI
LCC_TRANSFORM	5	Perspective Transformations	LCC_05_Average_Rut
LCC_TRANSFORM	6	Perspective Transformations	LCC_06_Max_L_Rut
LCC_TRANSFORM	7	Perspective Transformations	LCC_07_Max_R_Rut
LCC_TRANSFORM	8	Perspective Transformations	LCC_08_SDI
LCC_TRANSFORM	9	Perspective Transformations	LCC_09_Skid_Value
LCC_TRANSFORM	10	Perspective Transformations	LCC_10_Avg_Rut_2000
LCC_TRANSFORM	11	Perspective Transformations	LCC_11_Avg_Rut_2002
LCC_TRANSFORM	12	Perspective Transformations	LCC_12_Avg_Rut_2004
LCC_TRANSFORM	13	Perspective Transformations	LCC_13_Avg_Rut_2005
LCC_TRANSFORM	14	Perspective Transformations	LCC_14_Avg_Rut_2006
LCC_TRANSFORM	15	Perspective Transformations	LCC_15_Data_Date
LCC_TRANSFORM	16	Perspective Transformations	LCC_16_Data_Date_2000
LCC_TRANSFORM	17	Perspective Transformations	LCC_17_Data_Date_2002
LCC_TRANSFORM	18	Perspective Transformations	LCC_18_Data_Date_2004
LCC_TRANSFORM	19	Perspective Transformations	LCC_19_Data_Date_2005
LCC_TRANSFORM	20	Perspective Transformations	LCC_20_Data_Date_2006
LCC_TRANSFORM	21	Perspective Transformations	LCC_21_IRI_2000
LCC_TRANSFORM	22	Perspective Transformations	LCC_22_IRI_2002
LCC_TRANSFORM	23	Perspective Transformations	LCC_23_IRI_2004
LCC_TRANSFORM	24	Perspective Transformations	LCC_24_IRI_2005
LCC_TRANSFORM	25	Perspective Transformations	LCC_25_IRI_2006
LCC_TRANSFORM	26	Perspective Transformations	LCC_26_Max_LRUT_2000
LCC_TRANSFORM	27	Perspective Transformations	LCC_27_Max_LRUT_2002
LCC_TRANSFORM	28	Perspective Transformations	LCC_28_Max_LRUT_2004
LCC_TRANSFORM	29	Perspective Transformations	LCC_29_Max_LRUT_2005
LCC_TRANSFORM	30	Perspective Transformations	LCC_30_Max_LRUT_2006
LCC_TRANSFORM	31	Perspective Transformations	LCC_31_Max_RRUT_2000
LCC_TRANSFORM	32	Perspective Transformations	LCC_32_Max_RRUT_2002
LCC_TRANSFORM	33	Perspective Transformations	LCC_33_Max_RRUT_2004
LCC_TRANSFORM	34	Perspective Transformations	LCC_34_Max_RRUT_2005
LCC_TRANSFORM	35	Perspective Transformations	LCC_35_Max_RRUT_2006
LCC_TRANSFORM	36	Perspective Transformations	LCC_36_SDI_2000
LCC_TRANSFORM	37	Perspective Transformations	LCC_37_SDI_2002
LCC_TRANSFORM	38	Perspective Transformations	LCC_38_SDI_2004
LCC_TRANSFORM	39	Perspective Transformations	LCC_39_SDI_2005
LCC_TRANSFORM	40	Perspective Transformations	LCC_40_SDI_2006
LCC_TRANSFORM	41	Perspective Transformations	LCC_41_SKIDVAL_2000
LCC_TRANSFORM	42	Perspective Transformations	LCC_42_SKIDVAL_2002
LCC_TRANSFORM	43	Perspective Transformations	LCC_43_SKIDVAL_2004
LCC_TRANSFORM	44	Perspective Transformations	LCC_62_Number_of_Lanes
LCC_TRANSFORM	45	Perspective Transformations	LCC_44_SKIDVAL_2005
LCC_TRANSFORM	46	Perspective Transformations	LCC_45_SKIDVAL_2006
LCC_TRANSFORM	47	Perspective Transformations	LCC_47_Project_IRI
LCC_TRANSFORM	48	Perspective Transformations	LCC_48_Project_Activity
LCC_TRANSFORM	49	Perspective Transformations	LCC_49_Project_Date
LCC_TRANSFORM	50	Perspective Transformations	LCC_50_Project_Year
LCC_TRANSFORM	51	Perspective Transformations	LCC_51_Traffic_HF
LCC_TRANSFORM	52	Perspective Transformations	LCC_52_Truck_HR
LCC_TRANSFORM	53	Perspective Transformations	LCC_53_Truck_LF
LCC_TRANSFORM	54	Perspective Transformations	LCC_54_Truck_LR
LCC_TRANSFORM	55	Perspective Transformations	LCC_55_Traffic_Percent_Trucks

LCC_TRANSFORM	56	Perspective Transformations	LCC_58_LDI
LCC_TRANSFORM	57	Perspective Transformations	LCC_59_NDI
LCC_TRANSFORM	58	Formula Transformations	LCC_56_ESALS
LCC_TRANSFORM	59	Formula Transformations	LCC_57_Family_Trucks
LCC_TRANSFORM	60	Formula Transformations	LCC_61_Age
LCC_TRANSFORM	61	Perspective Transformations	LCC_62_Number_of_Lanes
LCC_TRANSFORM	62	Perspective Transformations	LCC_63_Jurisdiction
LCC_TRANSFORM	63	Formula Transformations	LCC_64_Family_Final_Family
LCC_TRANSFORM	64	Perspective Transformations	LCC_65_SRI
LCC_TRANSFORM	65	Perspective Transformations	LCC_66_Pave_Width
LCC_TRANSFORM	66	Perspective Transformations	LCC_67_Speed_Limit
LCC_TRANSFORM	67	Crosstab Transformations	LCC_68_Skid_Trigger
LCC_TRANSFORM	68	Crosstab Transformations	LCC_69_Design_Life
LCC_TRANSFORM	69	Formula Transformations	LCC_69_RDL
LCC_TRANSFORM	70	Perspective Transformations	LCC_71_COM_TRT
LCC_TRANSFORM	71	Perspective Transformations	LCC_72_COM_YEAR
LCC_TRANSFORM	72	Perspective Transformations	LCC_73_COM_COST
LCC_TRANSFORM	73	Perspective Transformations	LCC_74_COM_COMMENTS
LCC_TRANSFORM	74	Perspective Transformations	LCC_75_COM_PROJECT
LCC_TRANSFORM	75	Perspective Transformations	LCC_76_COM_USE_ANC
LCC_TRANSFORM	76	Perspective Transformations	LCC_77_COM_USE_SUB
LCC_TRANSFORM	77	Perspective Transformations	LCC_78_CT_DESIGNATION
LCC_TRANSFORM	78	Perspective Transformations	LCC_79_AADT
LCC_TRANSFORM	79	Perspective Transformations	LCC_80_Shld_Width_Inside
LCC_TRANSFORM	80	Perspective Transformations	LCC_81_Shld_Width_Outside
LCC_RSL	0	Formula Transformations	RSL_01_NDI_BC_LIGHT
LCC_RSL	1	Formula Transformations	RSL_02_NDI_BC_HEAVY
LCC_RSL	2	Formula Transformations	RSL_03_NDI_CO_LIGHT
LCC_RSL	3	Formula Transformations	RSL_04_NDI_CO_HEAVY
LCC_RSL	4	Formula Transformations	RSL_05_NDI_RC
LCC_RSL	5	Formula Transformations	RSL_06_LDI_BC_LIGHT
LCC_RSL	6	Formula Transformations	RSL_07_LDI_BC_HEAVY
LCC_RSL	7	Formula Transformations	RSL_08_LDI_CO_LIGHT
LCC_RSL	8	Formula Transformations	RSL_09_LDI_CO_HEAVY
LCC_RSL	9	Formula Transformations	RSL_10_LDI_RC
LCC_RSL	10	Formula Transformations	RSL_11_IRI_BC_LIGHT
LCC_RSL	11	Formula Transformations	RSL_12_IRI_BC_HEAVY
LCC_RSL	12	Formula Transformations	RSL_13_IRI_CO_LIGHT
LCC_RSL	13	Formula Transformations	RSL_14_IRI_CO_HEAVY
LCC_RSL	14	Formula Transformations	RSL_15_IRI_RC
LCC_RSL	15	Formula Transformations	RSL_16_Final_RSL

Table 11.

Batch Operation	Order	Operation Type	Operation Name
LCC_TRANSFORM	0	Perspective Transformations	LCC_00_CT_Direction
LCC_TRANSFORM	1	Perspective Transformations	LCC_01_AADT_N_E
LCC_TRANSFORM	2	Perspective Transformations	LCC_02_AADT_S_W
LCC_TRANSFORM	3	Perspective Transformations	LCC_03_PAVE_TYPE
LCC_TRANSFORM	4	Perspective Transformations	LCC_04_Average_IRI
LCC_TRANSFORM	5	Perspective Transformations	LCC_05_Average_Rut
LCC_TRANSFORM	6	Perspective Transformations	LCC_06_Max_L_Rut
LCC_TRANSFORM	7	Perspective Transformations	LCC_07_Max_R_Rut
LCC_TRANSFORM	8	Perspective Transformations	LCC_08_SDI
LCC_TRANSFORM	9	Perspective Transformations	LCC_09_Skid_Value
LCC_TRANSFORM	10	Perspective Transformations	LCC_10_Avg_Rut_2000
LCC_TRANSFORM	11	Perspective Transformations	LCC_11_Avg_Rut_2002
LCC_TRANSFORM	12	Perspective Transformations	LCC_12_Avg_Rut_2004
LCC_TRANSFORM	13	Perspective Transformations	LCC_13_Avg_Rut_2005
LCC_TRANSFORM	14	Perspective Transformations	LCC_14_Avg_Rut_2006

LCC_TRANSFORM	15	Perspective Transformations	LCC_15_Data_Date
LCC_TRANSFORM	16	Perspective Transformations	LCC_16_Data_Date_2000
LCC_TRANSFORM	17	Perspective Transformations	LCC_17_Data_Date_2002
LCC_TRANSFORM	18	Perspective Transformations	LCC_18_Data_Date_2004
LCC_TRANSFORM	19	Perspective Transformations	LCC_19_Data_Date_2005
LCC_TRANSFORM	20	Perspective Transformations	LCC_20_Data_Date_2006
LCC_TRANSFORM	21	Perspective Transformations	LCC_21_IRI_2000
LCC_TRANSFORM	22	Perspective Transformations	LCC_22_IRI_2002
LCC_TRANSFORM	23	Perspective Transformations	LCC_23_IRI_2004
LCC_TRANSFORM	24	Perspective Transformations	LCC_24_IRI_2005
LCC_TRANSFORM	25	Perspective Transformations	LCC_25_IRI_2006
LCC_TRANSFORM	26	Perspective Transformations	LCC_26_Max_LRUT_2000
LCC_TRANSFORM	27	Perspective Transformations	LCC_27_Max_LRUT_2002
LCC_TRANSFORM	28	Perspective Transformations	LCC_28_Max_LRUT_2004
LCC_TRANSFORM	29	Perspective Transformations	LCC_29_Max_LRUT_2005
LCC_TRANSFORM	30	Perspective Transformations	LCC_30_Max_LRUT_2006
LCC_TRANSFORM	31	Perspective Transformations	LCC_31_Max_RRUT_2000
LCC_TRANSFORM	32	Perspective Transformations	LCC_32_Max_RRUT_2002
LCC_TRANSFORM	33	Perspective Transformations	LCC_33_Max_RRUT_2004
LCC_TRANSFORM	34	Perspective Transformations	LCC_34_Max_RRUT_2005
LCC_TRANSFORM	35	Perspective Transformations	LCC_35_Max_RRUT_2006
LCC_TRANSFORM	36	Perspective Transformations	LCC_36_SDI_2000
LCC_TRANSFORM	37	Perspective Transformations	LCC_37_SDI_2002
LCC_TRANSFORM	38	Perspective Transformations	LCC_38_SDI_2004
LCC_TRANSFORM	39	Perspective Transformations	LCC_39_SDI_2005
LCC_TRANSFORM	40	Perspective Transformations	LCC_40_SDI_2006
LCC_TRANSFORM	41	Perspective Transformations	LCC_41_SKIDVAL_2000
LCC_TRANSFORM	42	Perspective Transformations	LCC_42_SKIDVAL_2002
LCC_TRANSFORM	43	Perspective Transformations	LCC_43_SKIDVAL_2004
LCC_TRANSFORM	44	Perspective Transformations	LCC_62_Number_of_Lanes
LCC_TRANSFORM	45	Perspective Transformations	LCC_44_SKIDVAL_2005
LCC_TRANSFORM	46	Perspective Transformations	LCC_45_SKIDVAL_2006
LCC_TRANSFORM	47	Perspective Transformations	LCC_47_Project_IRI
LCC_TRANSFORM	48	Perspective Transformations	LCC_48_Project_Activity
LCC_TRANSFORM	49	Perspective Transformations	LCC_49_Project_Date
LCC_TRANSFORM	50	Perspective Transformations	LCC_50_Project_Year
LCC_TRANSFORM	51	Perspective Transformations	LCC_51_Traffic_HF
LCC_TRANSFORM	52	Perspective Transformations	LCC_52_Truck_HR
LCC_TRANSFORM	53	Perspective Transformations	LCC_53_Truck_LF
LCC_TRANSFORM	54	Perspective Transformations	LCC_54_Truck_LR
LCC_TRANSFORM	55	Perspective Transformations	LCC_55_Traffic_Percent_Trucks
LCC_TRANSFORM	56	Perspective Transformations	LCC_58_LDI
LCC_TRANSFORM	57	Perspective Transformations	LCC_59_NDI
LCC_TRANSFORM	58	Formula Transformations	LCC_56_ESALS
LCC_TRANSFORM	59	Formula Transformations	LCC_57_Family_Trucks
LCC_TRANSFORM	60	Formula Transformations	LCC_61_Age
LCC_TRANSFORM	61	Perspective Transformations	LCC_62_Number_of_Lanes
LCC_TRANSFORM	62	Perspective Transformations	LCC_63_Jurisdiction
LCC_TRANSFORM	63	Formula Transformations	LCC_64_Family_Final_Family
LCC_TRANSFORM	64	Perspective Transformations	LCC_65_SRI
LCC_TRANSFORM	65	Perspective Transformations	LCC_66_Pave_Width
LCC_TRANSFORM	66	Perspective Transformations	LCC_67_Speed_Limit
LCC_TRANSFORM	67	Crosstab Transformations	LCC_68_Skid_Trigger
LCC_TRANSFORM	68	Crosstab Transformations	LCC_69_Design_Life
LCC_TRANSFORM	69	Formula Transformations	LCC_69_RDL
LCC_TRANSFORM	70	Perspective Transformations	LCC_71_COM_TRT
LCC_TRANSFORM	71	Perspective Transformations	LCC_72_COM_YEAR
LCC_TRANSFORM	72	Perspective Transformations	LCC_73_COM_COST

LCC_TRANSFORM	73	Perspective Transformations	LCC_74_COM_COMMENTS
LCC_TRANSFORM	74	Perspective Transformations	LCC_75_COM_PROJECT
LCC_TRANSFORM	75	Perspective Transformations	LCC_76_COM_USE_ANC
LCC_TRANSFORM	76	Perspective Transformations	LCC_77_COM_USE_SUB
LCC_TRANSFORM	77	Perspective Transformations	LCC_78_CT_DESIGNATION
LCC_TRANSFORM	78	Perspective Transformations	LCC_79_AADT
LCC_TRANSFORM	79	Perspective Transformations	LCC_80_Shld_Width_Inside
LCC_TRANSFORM	80	Perspective Transformations	LCC_81_Shld_Width_Outside
LCC_RSL	0	Formula Transformations	RSL_01_NDI_BC_LIGHT
LCC_RSL	1	Formula Transformations	RSL_02_NDI_BC_HEAVY
LCC_RSL	2	Formula Transformations	RSL_03_NDI_CO_LIGHT
LCC_RSL	3	Formula Transformations	RSL_04_NDI_CO_HEAVY
LCC_RSL	4	Formula Transformations	RSL_05_NDI_RC
LCC_RSL	5	Formula Transformations	RSL_06_LDI_BC_LIGHT
LCC_RSL	6	Formula Transformations	RSL_07_LDI_BC_HEAVY
LCC_RSL	7	Formula Transformations	RSL_08_LDI_CO_LIGHT
LCC_RSL	8	Formula Transformations	RSL_09_LDI_CO_HEAVY
LCC_RSL	9	Formula Transformations	RSL_10_LDI_RC
LCC_RSL	10	Formula Transformations	RSL_11_IRI_BC_LIGHT
LCC_RSL	11	Formula Transformations	RSL_12_IRI_BC_HEAVY
LCC_RSL	12	Formula Transformations	RSL_13_IRI_CO_LIGHT
LCC_RSL	13	Formula Transformations	RSL_14_IRI_CO_HEAVY
LCC_RSL	14	Formula Transformations	RSL_15_IRI_RC
LCC_RSL	15	Formula Transformations	RSL_16_Final_RSL

Table 11: Analysis Preparation Batch Transformation Summary

It is important to note that the order in which the transformations are placed in the batch transformation is vital to it proper execution. There are transformations later in the batch that the results of transformations that are placed earlier in the batch transformation.

4. The Results of the dTIMS CT Analysis

This section gives a brief summary of the results of the dTIMS CT analysis. The results are based on the "LCC_Network_0_0" Analysis Set defined in the NJDOT dTIMS CT. Charts, where required, are based on the "LCC_Network_0_0_Total_Committed" Budget Scenario.

4.1 Condition and Travel Distribution Summary

The following graphs give a pictorial representation of the overall network condition resulting from the recommended construction program generated using the above noted budget scenario.

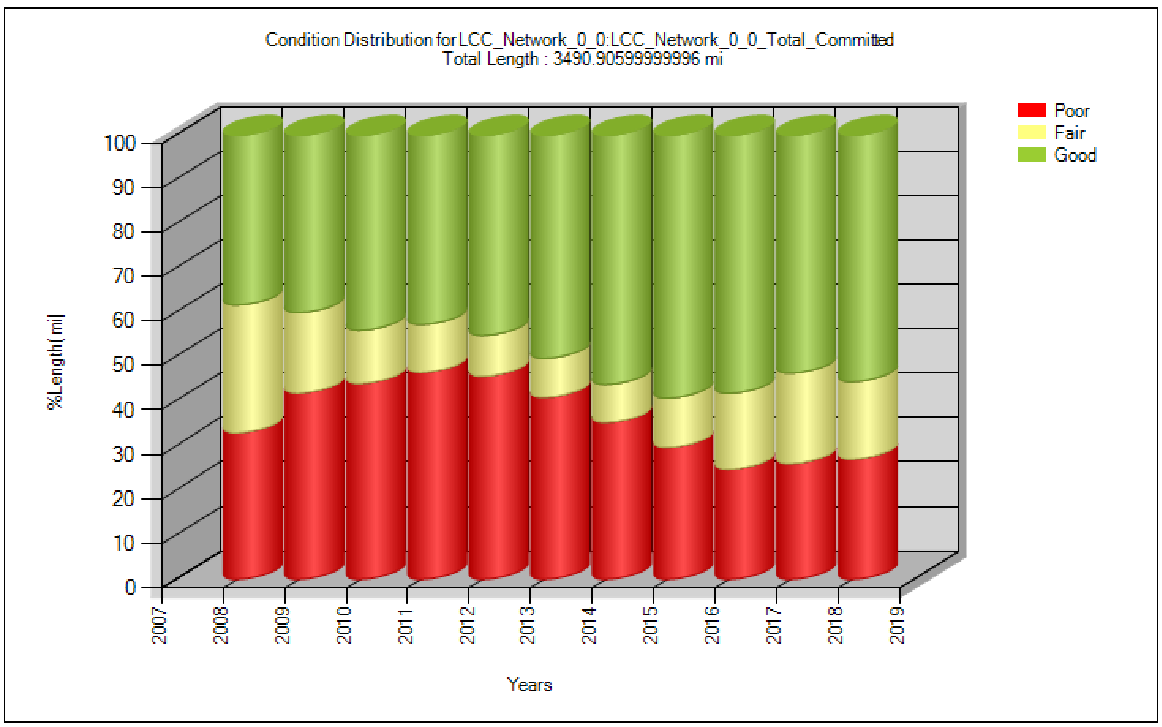


Figure 5: Condition Distribution Graph.

The condition distribution graph indicates the percent length of the network that will exist in each user defined condition categories (Good / Fair / Poor), in each of the analysis years, for a given budget scenario. For example, in 2008 the predicted condition distribution of NJDOT roads is as shown in Figure 6.

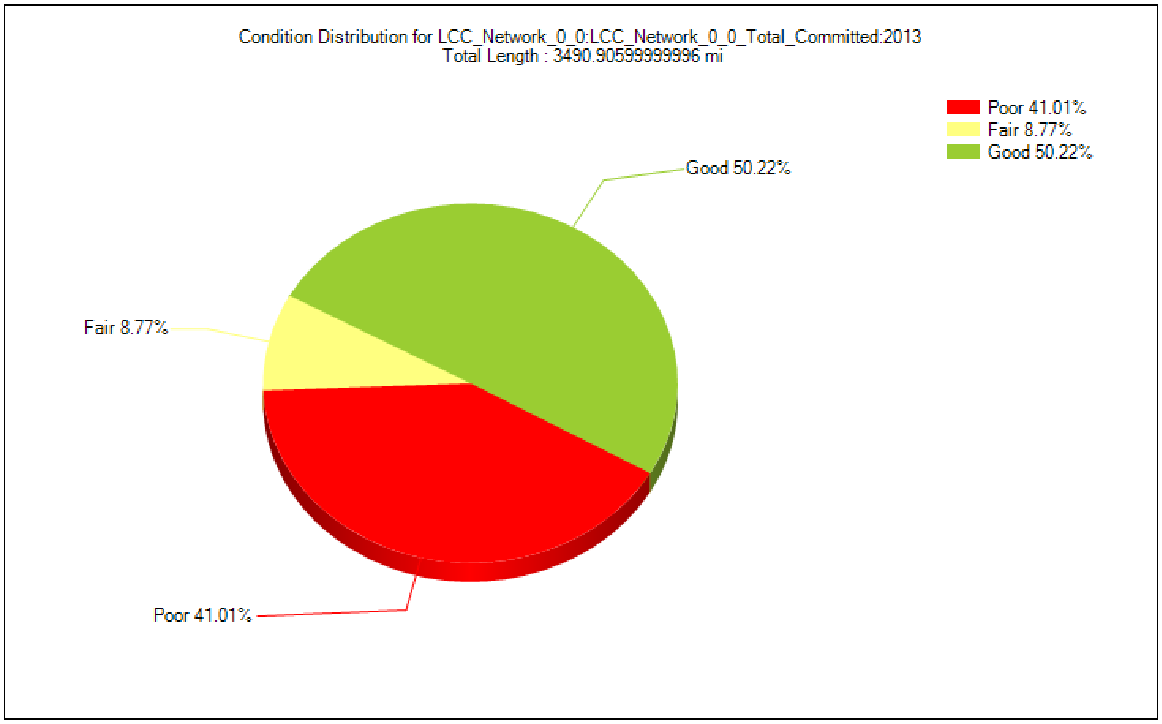


Figure 6: 2013 Condition Distributions

The condition categories are defined in the chart property window from the dTIMS CT software. Figure 7 shows the properties for the Condition Distributions graphs in Figure 5 and Figure 6.

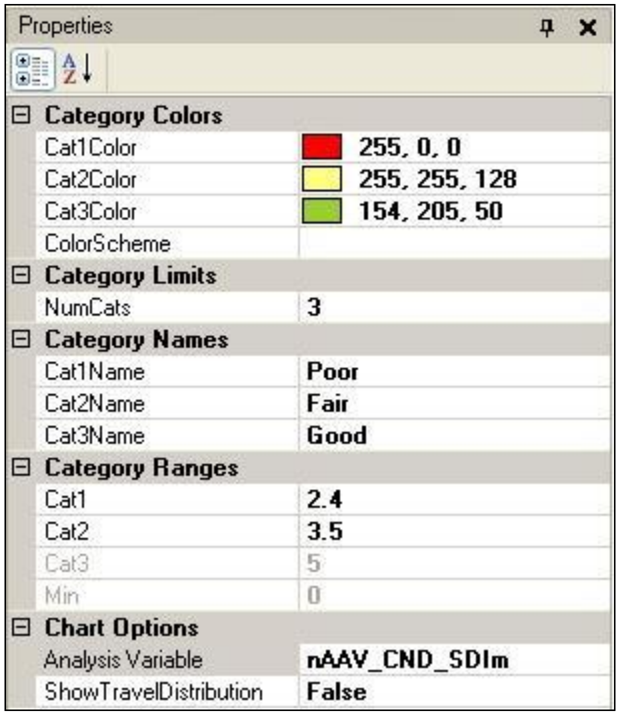


Figure 7: Network Condition Category Window

The user can select the Analysis Variable to be used as the condition variable; in this setup "SDIm" is used, the number of categories to split the results into; in this setup 3 are used, the names of the categories (Good, Fair and Poor), the ranges for each category and the chart colors from this property window.

The travel distribution graph is slightly different than the condition distribution graph in that it includes traffic information. The travel distribution graph indicates the percent vehicle miles that are driven on the NJDOT road network in each user defined condition categories (Good / Fair / Poor), in each of the analysis years, for a given budget scenario.

The condition categories for the travel distribution graph are the same as indicated in Figure 7.

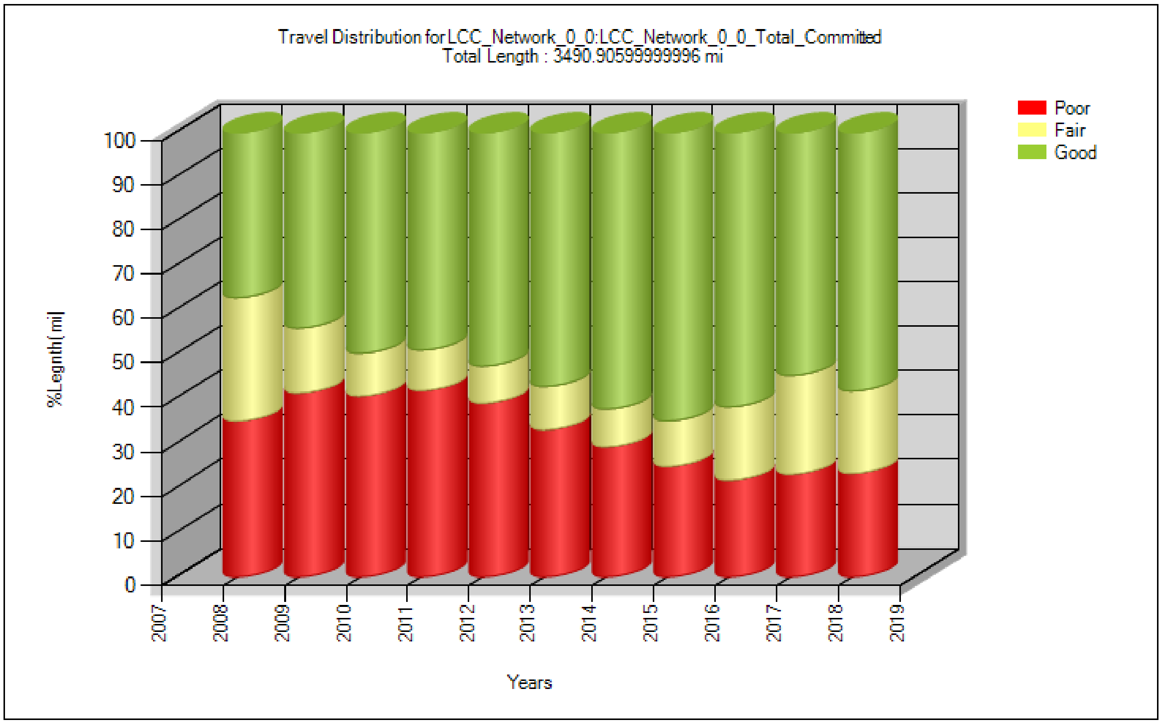


Figure 8: Travel Distribution Graph.

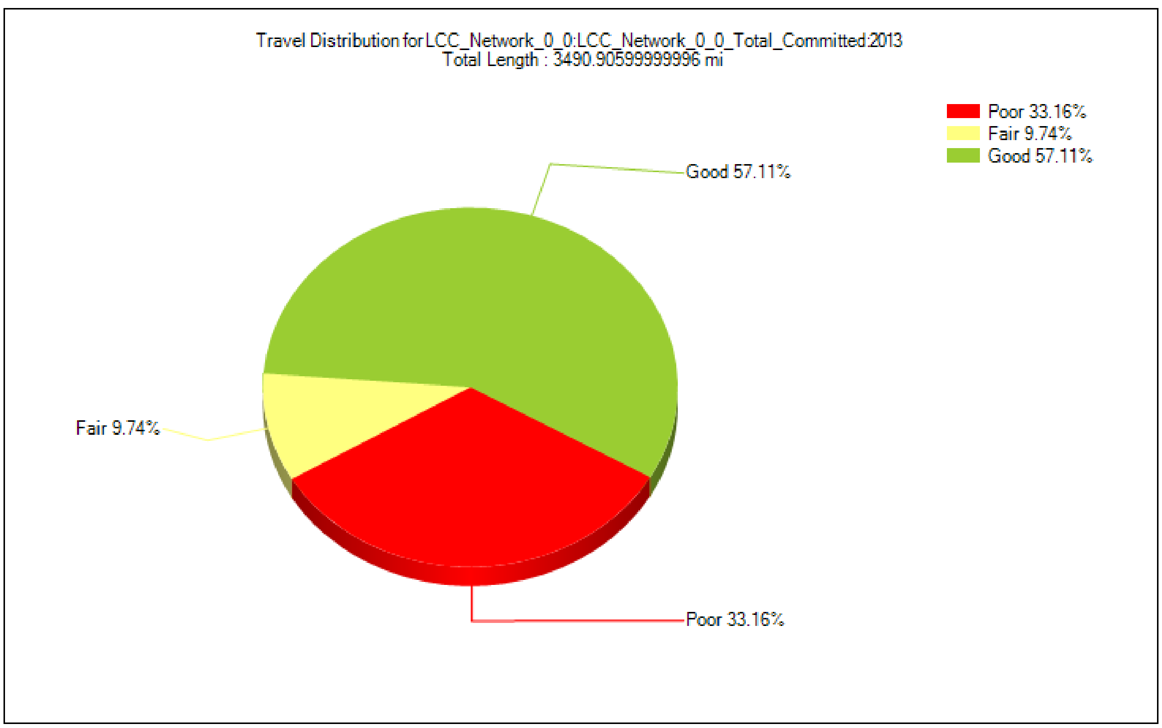


Figure 9: 2013 Travel Distributions

The comparison of the Condition Distribution Graph and the Travel Distribution Graph can give an overall impression of the degree to which the recommended pavement program is being effective in allocating funding to where it is needed in the network. Upon reviewing Figure 5 and Figure 8 for the year 2013 it can be seen that 50.2% of all roads in the NJDOT network fall into the Good category. At the same time, 57.1% of the vehicle-miles are driven on roads in that same category range. This shows that the roads that are more heavily traveled are the ones that are being maintained.

4.2 Return on Investment

The Return on Investment (ROI) graph generated by dTIMS CT allows the user to compile the results of two or more Budget Scenarios to predict the funding required to achieve a specific average network condition rating. Figure 10 shows the ROI graph for the analysis carried out in the NJDOT dTIMS CT setup.

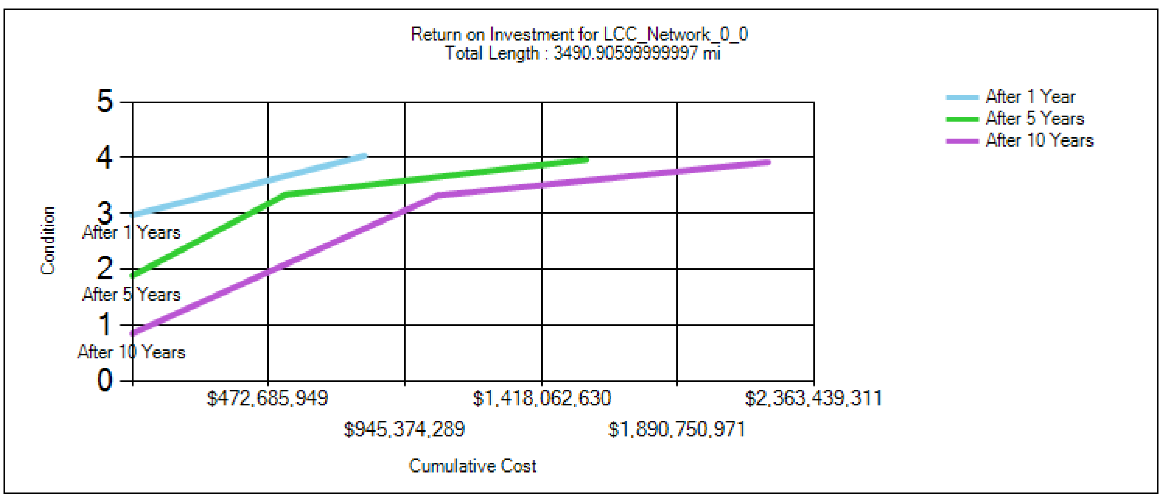


Figure 10: Return On Investment

The condition index used in the chart is SDIm and the Budget Scenarios are; Do_Nothing, LCC_Network_0_0_Total_No_Com and No_Limit. Although more budget scenarios were optimized in dTIMS CT it is important to note that, when selecting Budget Scenarios for the creation of a ROI graph, the Budget Scenarios be similar in properties. That is, only the Yearly Budgets collection should vary between the scenarios used to produce the RIO graph.

The ROI graph is a two dimensional graph produced by slicing a three dimensional graph along it Z-axis, which is time in years. Three slices are made at Year 1, Year 5 and Year 10 resulting in the three lines on the ROI graph.

The current average network condition is indicated in Figure 10 where the “After 1 Year” line crosses the Y-axis. In this case that is at condition rating 2.97. The graph can then be used to determine the approximate funding required to maintain that condition over the next 5 or 10 years. To do this the users projects a horizontal line from the current condition (2.97) to intersect the appropriate time line. For example the current condition intersects the “After 10 Year” line at approximately the $940,000,000.00 mark. This represents the cumulative funding needed to achieve the objective of maintaining the current condition over the next 10 years. The user would then convert the cumulative number into an annual budget ($94,000,000.00) and optimize the network to generate the supporting program recommendations. Similarly, the cost and program for to maintain any average network condition over time can be determined by entering the ROI graph on the Y-axis at the desired network condition.

The ROI graph is sometimes used in reverse to determine the probable average network condition that would result from a projected funding scenario. For example, suppose you were asked what impact a $75,000,000.00 per year budget projection would have on the average network condition after 10 years. This budget would be converted into a cumulative amount of $750,000,000.00 and used as a entry point to the ROI graph along the X-axis. Moving vertically to the

"After 10 Year" line we would see that the intersection of the two lines would be at about a SDIm condition rating of about 2.50 . The proposed budget would therefore impact the current average network condition by approximately 0.5 SDIm condition points. An informed decision to reduce the budget can then be made.

4.3 Recommended Construction Program

The recommended construction program generated by dTIMS CT for the "LCC_Network_0_0_Total_Committed" Budget Scenario is contained in Appendix "B". The recommendations have been summarized by year and reproduce in this report for the first five years of the analysis.

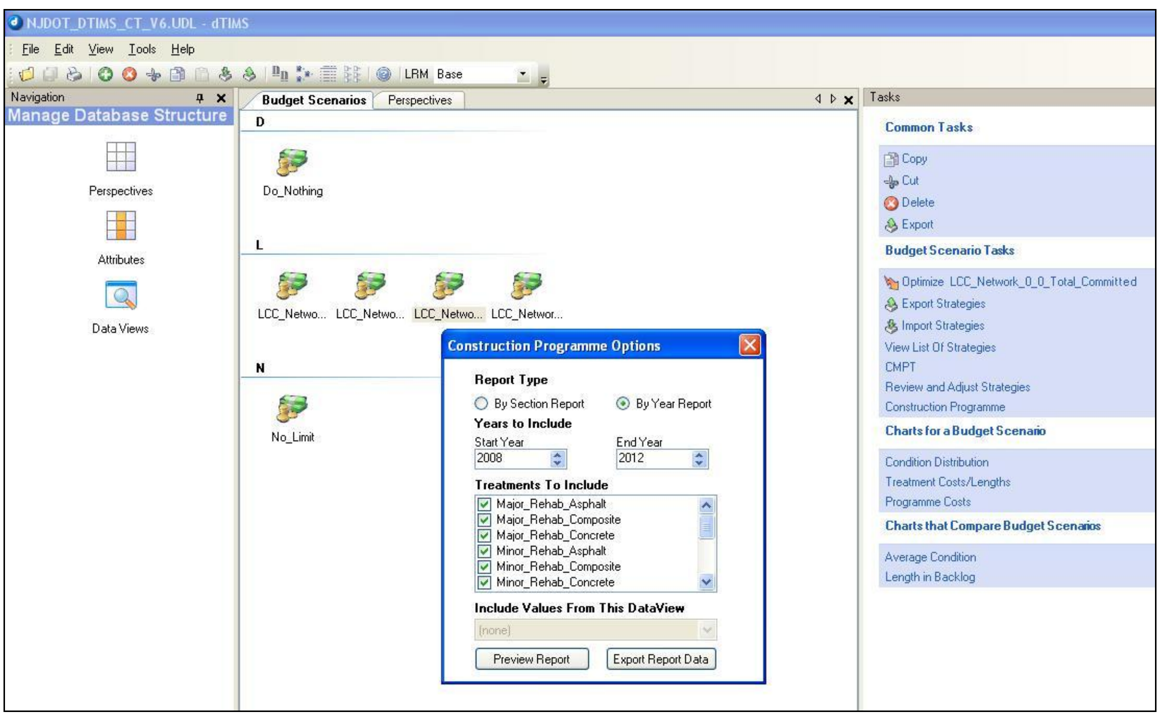


Figure 11: Producing a Construction Report

Figure 11 shows the window used to produce the appended construction program. The window is accessed by selecting a Budget Scenario and then selecting the Construction Programme control from the Common Task pane. The window allows the user to select the type of report; by section or by year, the length of the report in years, the treatments to include and a preview or export of the report. In this case the report was exported to MS Excel for custom formatting.

4.4 Average Network Condition

The current resulting average condition (CCI) based on the collected data is approximately 2.97 (out of 5) for the entire network. NJDOT must be cautioned that the average condition and the annual expenditure are both based solely on the current data collection and analysis. If the data and/or the analysis change in the future, this will have an impact on these predictions.

A comparison of the resulting average network conditions for the Budget Scenarios defined in the NJDOT dTIMS is shown in Figure 12. Two additional Budget Scenarios were defined to produce this figure; Do_Nothing ($0 available) and No_Limit (unlimited funding in each year with committed treatments).

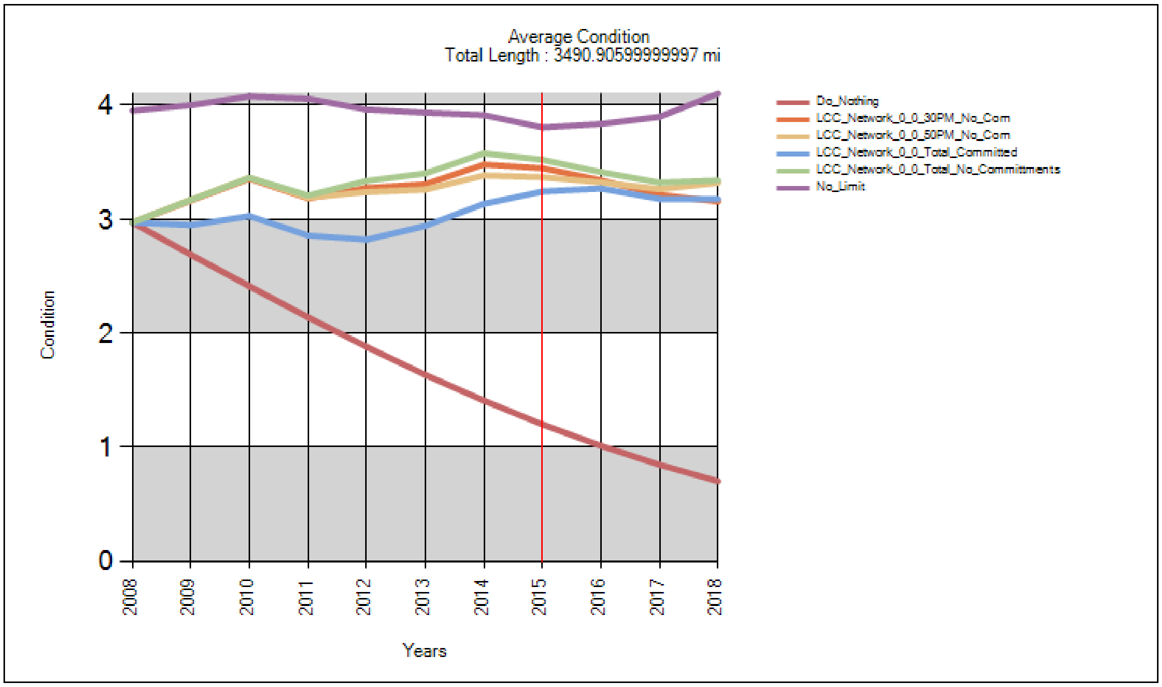


Figure 12: Average Network Condition (SDIm)

It is interesting to note how quickly the condition drops off when no funding is available but that unlimited funding seems to only maintain the network condition at about 4.0. The reason for this will be seen in Section 4.5, when we look at the amount of funding that is spent for each Budget Scenario with respect to the funding available.

4.5 Program Cost Versus Budget Available

5. Conclusions and Recommendations

To follow the training and final configuration.

Appendix “A” – Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Base	FED_AID		Text
	JURISDICTION		Text
	SLDNAME	SLD Name	Text
	SRI	SRI Number	Text

Table 12: Base Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Base_Routes	CT_Designation		Text
	CT_Direction		Text
	direction		Text
	mp_end		Double
	mp_start		Double
	parent_mp_end		Double
	parent_mp_start		Double
	parent_sri		Text
	route_type_code		Integer
	segment_type		Integer
	sldname		Text
	sri		Text

Table 13: Base_Routes Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Committed_Projects	COM_COST	Cost of the committed treatment	Double
	COM_TRT	Committed treatment name	Text
	COM_USE_ANC	Use ancillary treatments with the committed treatment	Boolean
	COM_USE_SUB	Use subsequent treatments with committed treatment	Boolean
	COM_YEAR	Year of the committed treatment	Integer
	COMMENTS		Text
	PROJECT		Text
	SRI	SRI Number	Text

Table 14: Committed_Projects Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Condition_1998	BEG_MP		Double
	BRSLBTR_H		Double
	BRSLBTR_L		Double
	BRSLBTR_M		Double
	BRSLBTRL_H		Double
	BRSLBTRL_L		Double
	BRSLBTRL_M		Double
	COMP_COND		Double
	COUNTY		Text
	CSI		Double
	Direction		Text
	DUALPAVE		Text
	ECI		Double
	END_MP		Double
	FALLIG_H		Double
	FALLIG_L		Double
	FALLIG_M		Double
	FBLOCK_H		Double
	FBLOCK_L		Double
	FBLOCK_M		Double
	FBRIDGE		Text
	FCD		Text
	FCONSTR		Text
	FDIR		Text
	FFAULT_CNT		Double
	FFRAME		Double
	FILENAME		Text
	FIRI_FLAG		Text
	FIRI_MEAN		Double
	FIRIL		Double
	FIRIR		Double
	FIRISD		Double
	FJFAULT_H		Double
	FJFAULT_L		Double
	FJFAULT_M		Double
	FKEY		Long
	FLANEDEV		Text
	FLONG_H		Double
	FLONG_L		Double
	FLONG_M		Double
	FRUT_MAX		Double
	FRUT_MEAN		Double
	FRUTSD		Double
	FSECTION		Text
	FSLAB		Double
	FSPEED		Double
	FTAPE		Text
	FTEXMTD		Double
	FTEXRMS		Double
	FTRANS_H		Double
	FTRANS_L		Double
	FTRANS_M		Double
	JCI		Double
	JNT_COUNT		Double
	NODISTRESS		Text
	PSI		Double
	RDI		Double
	Sub_Route		Text
	Supplement		Text
	Surf_type		Text
	VISI_DIR		Text
	VISI_DIRECTION		Text
	Visi_From		Long
	VISI_MILE		Text
	VISI_ROUTE		Text
	JNT_DISTR		Double
	NCI		Double
	Route		Text
	SCI		Double
	Sign		Text
	Visi_To		Long

Table 15: Condition_1998 Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Condition_2000	AADT	Average Annual Daily Traffic	Long
	ACLDLNGMOD	AC Load Related Longitudinal Cracking - Moderate (% Area)	Integer
	ACLDLNGSEV	AC Load Related Longitudinal Cracking - Severe (% Area)	Integer
	ACLDLNGSL	AC Load Related Longitudinal Cracking - Slight (% Area)	Integer
	ACLDMULISEV	AC Load Related Multiple Cracking - Severe (% Area)	Integer
	ACLDMULMOD	AC Load Related Multiple Cracking - Moderate (% Area)	Integer
	ACLDMULSL	AC Load Related Multiple Cracking - Slight (% Area)	Integer
	ACLNGMOD	AC Longitudinal Cracking - Moderate (% Area)	Integer
	ACLNGSEV	AC Longitudinal Cracking - Severe (% Area)	Integer
	ACLNGSL	AC Longitudinal Cracking - Slight (% Area)	Integer
	ACMULMOD	AC Multiple Cracking - Moderate (% Area)	Integer
	ACMULSEV	AC Multiple Cracking - Severe (% Area)	Integer
	ACMULSL	AC Multiple Cracking - Slight (% Area)	Integer
	ACTRMOD	AC Transverse Cracking - Moderate (% Area)	Integer
	ACTRSEV		Integer
	ACTRSL	AC Transverse Cracking - Slight (% Area)	Integer
	AIRI	Average IRI	Single
	AVGRUT	Average Rut	Single
	BRIDGE	Bridge	Text
	CNTYCODE	County Code	Text
	CTRLSECT	Control Section	Text
	DIR	Direction	Text
	FWY	Freeway	Text
	HPMS	HMPS	Integer
	INTERST	Interstate	Text
	LANES	Number of Lanes	Integer
	LIRI	Left IRI	Single
	MAXLRUT	Maximum Left Rut	Single
	MAXRRUT	Maximum Right Rut	Single
	MED	Median	Text
	NHS	NHS Designation	Text
	PATCHMOD	AC or RC Patching - Moderate (% Area)	Integer
	PATCHSEV	AC or RC Patching - Severe (% Area)	Integer
	PATCHSL	AC or RC Patching - Slight (% Area)	Integer
	PAVETYPE		Table
	PROFILERDATE	Profiler Test Date	Date
	RCCRMOD	RC Cracking - Moderate (% Area)	Integer
	RCCRSEV	RC Cracking - Severe (% Area)	Integer
	RCCRSL	RC Cracking - Slight (% Area)	Integer
	RCFLTMOD	RC Faulting - Moderate (% Area)	Integer
	RCFLTSEV	RC Faulting - Severe (% Area)	Integer
	RCFLTSL	RC Faulting - Slight (% Area)	Integer
	RCLNGJTDETMOD	RC Longitudinal Joint Deterioration - Moderate (% Area)	Integer
	RCLNGJTDETSEV	RC Longitudinal Joint Deterioration - Severe (% Area)	Integer
	RCLNGJTDETSL	RC Longitudinal Joint Deterioration - Slight (% Area)	Integer
	RCTRJTDETMOD	RC Transverse Joint Deterioration - Moderate (% Area)	Integer
	RCTRJTDETSEV	RC Transverse Joint Deterioration - Severe (% Area)	Integer
	RCTRJTDETSL	RC Transverse Joint Deterioration - Slight (% Area)	Integer
	RIRI	Right IRI	Single
	RR	Rail Crossing	Text
	RTE	Route	Text
	RTE_NAME	Route Name	Text
	SDI	Surface Distress Index	Single
	SDIOVRD	SDI Overridden by Video Rating	Text
	SHDETMOD	Shoulder Deterioration - Moderate (% Area)	Integer
	SHDETSEV	Shoulder Deterioration - Severe (% Area)	Integer
	SHDETSL	Shoulder Deterioration - Slight (% Area)	Integer
	SHDROPMOD	Shoulder Drop - Moderate (% Area)	Integer
	SHDROPSEV	Shoulder Drop - Severe (% Area)	Integer
	SHDROPSL	Shoulder Drop - Slight (% Area)	Integer
	SHOUT	Shoulders Outside	Text
	SHRP	SHRP Section	Text
	SHS	SHS Designation	Text
	SIGNAL	Signal	Text
	SKIDDATE	Skid Testing Date	Date
	SKIDVAL	Skid Value	Single
	SPDLIM	Speed Limit	Integer
	SRI	SRI	Text
	STRAHNET	Strah net	Text

Table 16: Condition_2000 Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Condition_2002	AADT	Average Annual Daily Traffic	Long
	ACLDLNGMOD	AC Load Related Longitudinal Cracking - Moderate (% Area)	Integer
	ACLDLNGSEV	AC Load Related Longitudinal Cracking - Severe (% Area)	Integer
	ACLDLNGSL	AC Load Related Longitudinal Cracking - Slight (% Area)	Integer
	ACLDMULISEV	AC Load Related Multiple Cracking - Severe (% Area)	Integer
	ACLDMULMOD	AC Load Related Multiple Cracking - Moderate (% Area)	Integer
	ACLDMULSL	AC Load Related Multiple Cracking - Slight (% Area)	Integer
	ACLNGMOD	AC Longitudinal Cracking - Moderate (% Area)	Integer
	ACLNGSEV	AC Longitudinal Cracking - Severe (% Area)	Integer
	ACLNGSL	AC Longitudinal Cracking - Slight (% Area)	Integer
	ACMULMOD	AC Multiple Cracking - Moderate (% Area)	Integer
	ACMULSEV	AC Multiple Cracking - Severe (% Area)	Integer
	ACMULSL	AC Multiple Cracking - Slight (% Area)	Integer
	ACTRMOD	AC Transverse Cracking - Moderate (% Area)	Integer
	ACTRSEV		Integer
	ACTRSL	AC Transverse Cracking - Slight (% Area)	Integer
	AIRI	Average IRI	Single
	AVGRUT	Average Rut	Single
	BRIDGE	Bridge	Text
	CNTYCODE	County Code	Text
	CTRLSECT	Control Section	Text
	DIR	Direction	Text
	FWY	Freeway	Text
	HPMS	HMPS	Integer
	INTERST	Interstate	Text
	LANES	Number of Lanes	Integer
	LIRI	Left IRI	Single
	MAXLRUT	Maximum Left Rut	Single
	MAXRRUT	Maximum Right Rut	Single
	MED	Median	Text
	NHS	NHS Designation	Text
	PATCHMOD	AC or RC Patching - Moderate (% Area)	Integer
	PATCHSEV	AC or RC Patching - Severe (% Area)	Integer
	PATCHSL	AC or RC Patching - Slight (% Area)	Integer
	PAVETYPE		Table
	PROFILERDATE	Profiler Test Date	Date
	RCCRMOD	RC Cracking - Moderate (% Area)	Integer
	RCCRSEV	RC Cracking - Severe (% Area)	Integer
	RCCRSL	RC Cracking - Slight (% Area)	Integer
	RCFLTMOD	RC Faulting - Moderate (% Area)	Integer
	RCFLTSEV	RC Faulting - Severe (% Area)	Integer
	RCFLTSL	RC Faulting - Slight (% Area)	Integer
	RCLNGJTDETMOD	RC Longitudinal Joint Deterioration - Moderate (% Area)	Integer
	RCLNGJTDETSEV	RC Longitudinal Joint Deterioration - Severe (% Area)	Integer
	RCLNGJTDETSL	RC Longitudinal Joint Deterioration - Slight (% Area)	Integer
	RCTRJTDETMOD	RC Transverse Joint Deterioration - Moderate (% Area)	Integer
	RCTRJTDETSEV	RC Transverse Joint Deterioration - Severe (% Area)	Integer
	RCTRJTDETSL	RC Transverse Joint Deterioration - Slight (% Area)	Integer
	RIRI	Right IRI	Single
	RR	Rail Crossing	Text
	RTE	Route	Text
	RTE_NAME	Route Name	Text
	SDI	Surface Distress Index	Single
	SDIOVRD	SDI Overridden by Video Rating	Text
	SHDETMOD	Shoulder Deterioration - Moderate (% Area)	Integer
	SHDETSEV	Shoulder Deterioration - Severe (% Area)	Integer
	SHDETSL	Shoulder Deterioration - Slight (% Area)	Integer
	SHDROPMOD	Shoulder Drop - Moderate (% Area)	Integer
	SHDROPSEV	Shoulder Drop - Severe (% Area)	Integer
	SHDROPSL	Shoulder Drop - Slight (% Area)	Integer
	SHOUT	Shoulders Outside	Text
	SHRP	SHRP Section	Text
	SHS	SHS Designation	Text
	SIGNAL	Signal	Text
	SKIDDATE	Skid Testing Date	Date
	SKIDVAL	Skid Value	Single
	SPDLIM	Speed Limit	Integer
	SRI	SRI	Text
	STRAHNET	Strah net	Text

Table 17: Condition_2002 Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Condition_2004	AADT	Average Annual Daily Traffic	Long
	ACLDLNGMOD	AC Load Related Longitudinal Cracking - Moderate (% Area)	Integer
	ACLDLNGSEV	AC Load Related Longitudinal Cracking - Severe (% Area)	Integer
	ACLDLNGSL	AC Load Related Longitudinal Cracking - Slight (% Area)	Integer
	ACLDMULISEV	AC Load Related Multiple Cracking - Severe (% Area)	Integer
	ACLDMULMOD	AC Load Related Multiple Cracking - Moderate (% Area)	Integer
	ACLDMULSL	AC Load Related Multiple Cracking - Slight (% Area)	Integer
	ACLNGMOD	AC Longitudinal Cracking - Moderate (% Area)	Integer
	ACLNGSEV	AC Longitudinal Cracking - Severe (% Area)	Integer
	ACLNGSL	AC Longitudinal Cracking - Slight (% Area)	Integer
	ACMULMOD	AC Multiple Cracking - Moderate (% Area)	Integer
	ACMULSEV	AC Multiple Cracking - Severe (% Area)	Integer
	ACMULSL	AC Multiple Cracking - Slight (% Area)	Integer
	ACTRMOD	AC Transverse Cracking - Moderate (% Area)	Integer
	ACTRSEV		Integer
	ACTRSL	AC Transverse Cracking - Slight (% Area)	Integer
	AIRI	Average IRI	Single
	AVGRUT	Average Rut	Single
	BRIDGE	Bridge	Text
	CNTYCODE	County Code	Text
	CTRLSECT	Control Section	Text
	DIR	Direction	Text
	FWY	Freeway	Text
	HPMS	HMPS	Integer
	INTERST	Interstate	Text
	LANES	Number of Lanes	Integer
	LIRI	Left IRI	Single
	MAXLRUT	Maximum Left Rut	Single
	MAXRRUT	Maximum Right Rut	Single
	MED	Median	Text
	NHS	NHS Designation	Text
	PATCHMOD	AC or RC Patching - Moderate (% Area)	Integer
	PATCHSEV	AC or RC Patching - Severe (% Area)	Integer
	PATCHSL	AC or RC Patching - Slight (% Area)	Integer
	PAVETYPE		Table
	PROFILERDATE	Profiler Test Date	Date
	RCCRMOD	RC Cracking - Moderate (% Area)	Integer
	RCCRSEV	RC Cracking - Severe (% Area)	Integer
	RCCRSL	RC Cracking - Slight (% Area)	Integer
	RCFLTMOD	RC Faulting - Moderate (% Area)	Integer
	RCFLTSEV	RC Faulting - Severe (% Area)	Integer
	RCFLTSL	RC Faulting - Slight (% Area)	Integer
	RCLNGJTDETMOD	RC Longitudinal Joint Deterioration - Moderate (% Area)	Integer
	RCLNGJTDETSEV	RC Longitudinal Joint Deterioration - Severe (% Area)	Integer
	RCLNGJTDETSL	RC Longitudinal Joint Deterioration - Slight (% Area)	Integer
	RCTRJTDETMOD	RC Transverse Joint Deterioration - Moderate (% Area)	Integer
	RCTRJTDETSEV	RC Transverse Joint Deterioration - Severe (% Area)	Integer
	RCTRJTDETSL	RC Transverse Joint Deterioration - Slight (% Area)	Integer
	RIRI	Right IRI	Single
	RR	Rail Crossing	Text
	RTE	Route	Text
	RTE_NAME	Route Name	Text
	SDI	Surface Distress Index	Single
	SDIOVRD	SDI Overridden by Video Rating	Text
	SHDETMOD	Shoulder Deterioration - Moderate (% Area)	Integer
	SHDETSEV	Shoulder Deterioration - Severe (% Area)	Integer
	SHDETSL	Shoulder Deterioration - Slight (% Area)	Integer
	SHDROPMOD	Shoulder Drop - Moderate (% Area)	Integer
	SHDROPSEV	Shoulder Drop - Severe (% Area)	Integer
	SHDROPSL	Shoulder Drop - Slight (% Area)	Integer
	SHOUT	Shoulders Outside	Text
	SHRP	SHRP Section	Text
	SHS	SHS Designation	Text
	SIGNAL	Signal	Text
	SKIDDATE	Skid Testing Date	Date
	SKIDVAL	Skid Value	Single
	SPDLIM	Speed Limit	Integer
	SRI	SRI	Text
	STRAHNET	Strah net	Text

Table 18: Condition_2004 Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Condition_2005	AADT	Average Annual Daily Traffic	Long
	ACLDLNGMOD	AC Load Related Longitudinal Cracking - Moderate (% Area)	Integer
	ACLDLNGSEV	AC Load Related Longitudinal Cracking - Severe (% Area)	Integer
	ACLDLNGSL	AC Load Related Longitudinal Cracking - Slight (% Area)	Integer
	ACLDMULISEV	AC Load Related Multiple Cracking - Severe (% Area)	Integer
	ACLDMULMOD	AC Load Related Multiple Cracking - Moderate (% Area)	Integer
	ACLDMULSL	AC Load Related Multiple Cracking - Slight (% Area)	Integer
	ACLNGMOD	AC Longitudinal Cracking - Moderate (% Area)	Integer
	ACLNGSEV	AC Longitudinal Cracking - Severe (% Area)	Integer
	ACLNGSL	AC Longitudinal Cracking - Slight (% Area)	Integer
	ACMULMOD	AC Multiple Cracking - Moderate (% Area)	Integer
	ACMULSEV	AC Multiple Cracking - Severe (% Area)	Integer
	ACMULSL	AC Multiple Cracking - Slight (% Area)	Integer
	ACTRMOD	AC Transverse Cracking - Moderate (% Area)	Integer
	ACTRSEV		Integer
	ACTRSL	AC Transverse Cracking - Slight (% Area)	Integer
	AIRI	Average IRI	Single
	AVGRUT	Average Rut	Single
	BRIDGE	Bridge	Text
	CNTYCODE	County Code	Text
	CTRLSECT	Control Section	Text
	DIR	Direction	Text
	FWY	Freeway	Text
	HPMS	HMPS	Integer
	INTERST	Interstate	Text
	LANES	Number of Lanes	Integer
	LIRI	Left IRI	Single
	MAXLRUT	Maximum Left Rut	Single
	MAXRRUT	Maximum Right Rut	Single
	MED	Median	Text
	NHS	NHS Designation	Text
	PATCHMOD	AC or RC Patching - Moderate (% Area)	Integer
	PATCHSEV	AC or RC Patching - Severe (% Area)	Integer
	PATCHSL	AC or RC Patching - Slight (% Area)	Integer
	PAVETYPE		Table
	PROFILERDATE	Profiler Test Date	Date
	RCCRMOD	RC Cracking - Moderate (% Area)	Integer
	RCCRSEV	RC Cracking - Severe (% Area)	Integer
	RCCRSL	RC Cracking - Slight (% Area)	Integer
	RCFLTMOD	RC Faulting - Moderate (% Area)	Integer
	RCFLTSEV	RC Faulting - Severe (% Area)	Integer
	RCFLTSL	RC Faulting - Slight (% Area)	Integer
	RCLNGJTDETMOD	RC Longitudinal Joint Deterioration - Moderate (% Area)	Integer
	RCLNGJTDETSEV	RC Longitudinal Joint Deterioration - Severe (% Area)	Integer
	RCLNGJTDETSL	RC Longitudinal Joint Deterioration - Slight (% Area)	Integer
	RCTRJTDETMOD	RC Transverse Joint Deterioration - Moderate (% Area)	Integer
	RCTRJTDETSEV	RC Transverse Joint Deterioration - Severe (% Area)	Integer
	RCTRJTDETSL	RC Transverse Joint Deterioration - Slight (% Area)	Integer
	RIRI	Right IRI	Single
	RR	Rail Crossing	Text
	RTE	Route	Text
	RTE_NAME	Route Name	Text
	SDI	Surface Distress Index	Single
	SDIOVRD	SDI Overridden by Video Rating	Text
	SHDETMOD	Shoulder Deterioration - Moderate (% Area)	Integer
	SHDETSEV	Shoulder Deterioration - Severe (% Area)	Integer
	SHDETSL	Shoulder Deterioration - Slight (% Area)	Integer
	SHDROPMOD	Shoulder Drop - Moderate (% Area)	Integer
	SHDROPSEV	Shoulder Drop - Severe (% Area)	Integer
	SHDROPSL	Shoulder Drop - Slight (% Area)	Integer
	SHOUT	Shoulders Outside	Text
	SHRP	SHRP Section	Text
	SHS	SHS Designation	Text
	SIGNAL	Signal	Text
	SKIDDATE	Skid Testing Date	Date
	SKIDVAL	Skid Value	Single
	SPDLIM	Speed Limit	Integer
	SRI	SRI	Text
	STRAHNET	Strah net	Text

Table 19: Condition_2005 Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Condition_2006	AADT	Average Annual Daily Traffic	Long
	ACLDLNGMOD	AC Load Related Longitudinal Cracking - Moderate (% Area)	Integer
	ACLDLNGSEV	AC Load Related Longitudinal Cracking - Severe (% Area)	Integer
	ACLDLNGSL	AC Load Related Longitudinal Cracking - Slight (% Area)	Integer
	ACLDMULISEV	AC Load Related Multiple Cracking - Severe (% Area)	Integer
	ACLDMULMOD	AC Load Related Multiple Cracking - Moderate (% Area)	Integer
	ACLDMULSL	AC Load Related Multiple Cracking - Slight (% Area)	Integer
	ACLNGMOD	AC Longitudinal Cracking - Moderate (% Area)	Integer
	ACLNGSEV	AC Longitudinal Cracking - Severe (% Area)	Integer
	ACLNGSL	AC Longitudinal Cracking - Slight (% Area)	Integer
	ACMULMOD	AC Multiple Cracking - Moderate (% Area)	Integer
	ACMULSEV	AC Multiple Cracking - Severe (% Area)	Integer
	ACMULSL	AC Multiple Cracking - Slight (% Area)	Integer
	ACTRMOD	AC Transverse Cracking - Moderate (% Area)	Integer
	ACTRSEV		Integer
	ACTRSL	AC Transverse Cracking - Slight (% Area)	Integer
	AIRI	Average IRI	Single
	AVGRUT	Average Rut	Single
	BRIDGE	Bridge	Text
	CNTYCODE	County Code	Text
	CTRLSECT	Control Section	Text
	DIR	Direction	Text
	FWY	Freeway	Text
	HPMS	HMPS	Integer
	INTERST	Interstate	Text
	LANES	Number of Lanes	Integer
	LIRI	Left IRI	Single
	MAXLRUT	Maximum Left Rut	Single
	MAXRRUT	Maximum Right Rut	Single
	MED	Median	Text
	NHS	NHS Designation	Text
	PATCHMOD	AC or RC Patching - Moderate (% Area)	Integer
	PATCHSEV	AC or RC Patching - Severe (% Area)	Integer
	PATCHSL	AC or RC Patching - Slight (% Area)	Integer
	PAVETYPE		Table
	PROFILERDATE	Profiler Test Date	Date
	RCCRMOD	RC Cracking - Moderate (% Area)	Integer
	RCCRSEV	RC Cracking - Severe (% Area)	Integer
	RCCRSL	RC Cracking - Slight (% Area)	Integer
	RCFLTMOD	RC Faulting - Moderate (% Area)	Integer
	RCFLTSEV	RC Faulting - Severe (% Area)	Integer
	RCFLTSL	RC Faulting - Slight (% Area)	Integer
	RCLNGJTDETMOD	RC Longitudinal Joint Deterioration - Moderate (% Area)	Integer
	RCLNGJTDETSEV	RC Longitudinal Joint Deterioration - Severe (% Area)	Integer
	RCLNGJTDETSL	RC Longitudinal Joint Deterioration - Slight (% Area)	Integer
	RCTRJTDETMOD	RC Transverse Joint Deterioration - Moderate (% Area)	Integer
	RCTRJTDETSEV	RC Transverse Joint Deterioration - Severe (% Area)	Integer
	RCTRJTDETSL	RC Transverse Joint Deterioration - Slight (% Area)	Integer
	RIRI	Right IRI	Single
	RR	Rail Crossing	Text
	RTE	Route	Text
	RTE_NAME	Route Name	Text
	SDI	Surface Distress Index	Single
	SDIOVRD	SDI Overridden by Video Rating	Text
	SHDETMOD	Shoulder Deterioration - Moderate (% Area)	Integer
	SHDETSEV	Shoulder Deterioration - Severe (% Area)	Integer
	SHDETSL	Shoulder Deterioration - Slight (% Area)	Integer
	SHDROPMOD	Shoulder Drop - Moderate (% Area)	Integer
	SHDROPSEV	Shoulder Drop - Severe (% Area)	Integer
	SHDROPSL	Shoulder Drop - Slight (% Area)	Integer
	SHOUT	Shoulders Outside	Text
	SHRP	SHRP Section	Text
	SHS	SHS Designation	Text
	SIGNAL	Signal	Text
	SKIDDATE	Skid Testing Date	Date
	SKIDVAL	Skid Value	Single
	SPDLIM	Speed Limit	Integer
	SRI	SRI	Text
	STRAHNET	Strah net	Text

Table 20: Condition_2006 Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Condition_Current	AADT	Average Annual Daily Traffic	Long
	ACLDLNGMOD	AC Load Related Longitudinal Cracking - Moderate (% Area)	Integer
	ACLDLNGSEV	AC Load Related Longitudinal Cracking - Severe (% Area)	Integer
	ACLDLNGSL	AC Load Related Longitudinal Cracking - Slight (% Area)	Integer
	ACLDMULISEV	AC Load Related Multiple Cracking - Severe (% Area)	Integer
	ACLDMULMOD	AC Load Related Multiple Cracking - Moderate (% Area)	Integer
	ACLDMULSL	AC Load Related Multiple Cracking - Slight (% Area)	Integer
	ACLNGMOD	AC Longitudinal Cracking - Moderate (% Area)	Integer
	ACLNGSEV	AC Longitudinal Cracking - Severe (% Area)	Integer
	ACLNGSL	AC Longitudinal Cracking - Slight (% Area)	Integer
	ACMULMOD	AC Multiple Cracking - Moderate (% Area)	Integer
	ACMULSEV	AC Multiple Cracking - Severe (% Area)	Integer
	ACMULSL	AC Multiple Cracking - Slight (% Area)	Integer
	ACTRMOD	AC Transverse Cracking - Moderate (% Area)	Integer
	ACTRSEV		Integer
	ACTRSL	AC Transverse Cracking - Slight (% Area)	Integer
	AIRI	Average IRI	Single
	AVGRUT	Average Rut	Single
	BRIDGE	Bridge	Text
	CNTYCODE	County Code	Text
	CTRLSECT	Control Section	Text
	DIR	Direction	Text
	FWY	Freeway	Text
	HPMS	HMPS	Integer
	INTERST	Interstate	Text
	LANES	Number of Lanes	Integer
	LDI	Load Distress Index	Double
	LIRI	Left IRI	Single
	MAXLRUT	Maximum Left Rut	Single
	MAXRRUT	Maximum Right Rut	Single
	MED	Median	Text
	NDI	Non Load Distress Index	Double
	NHS	NHS Designation	Text
	PATCHMOD	AC or RC Patching - Moderate (% Area)	Integer
	PATCHSEV	AC or RC Patching - Severe (% Area)	Integer
	PATCHSL	AC or RC Patching - Slight (% Area)	Integer
	PAVETYPE		Table
	PROFILERDATE	Profiler Test Date	Date
	RCCRMOD	RC Cracking - Moderate (% Area)	Integer
	RCCRSEV	RC Cracking - Severe (% Area)	Integer
	RCCRSL	RC Cracking - Slight (% Area)	Integer
	RCFLTMOD	RC Faulting - Moderate (% Area)	Integer
	RCFLTSEV	RC Faulting - Severe (% Area)	Integer
	RCFLTSL	RC Faulting - Slight (% Area)	Integer
	RCLNGJTDETMOD	RC Longitudinal Joint Deterioration - Moderate (% Area)	Integer
	RCLNGJTDETSEV	RC Longitudinal Joint Deterioration - Severe (% Area)	Integer
	RCLNGJTDETSL	RC Longitudinal Joint Deterioration - Slight (% Area)	Integer
	RCTRJTDETMOD	RC Transverse Joint Deterioration - Moderate (% Area)	Integer
	RCTRJTDETSEV	RC Transverse Joint Deterioration - Severe (% Area)	Integer
	RCTRJTDETSL	RC Transverse Joint Deterioration - Slight (% Area)	Integer
	RIRI	Right IRI	Single
	RR	Rail Crossing	Text
	RTE	Route	Text
	RTE_NAME	Route Name	Text
	SDI	Surface Distress Index	Single
	SDIOVRD	SDI Overridden by Video Rating	Text
	SHDETMOD	Shoulder Deterioration - Moderate (% Area)	Integer
	SHDETSEV	Shoulder Deterioration - Severe (% Area)	Integer
	SHDETSL	Shoulder Deterioration - Slight (% Area)	Integer
	SHDROPMOD	Shoulder Drop - Moderate (% Area)	Integer
	SHDROPSEV	Shoulder Drop - Severe (% Area)	Integer
	SHDROPSL	Shoulder Drop - Slight (% Area)	Integer
	SHOUT	Shoulders Outside	Text
	SHRP	SHRP Section	Text
	SHS	SHS Designation	Text
	SIGNAL	Signal	Text
	SKIDDATE	Skid Testing Date	Date
	SKIDVAL	Skid Value	Single
	SPDLIM	Speed Limit	Integer
	SRI	SRI	Text
	STRAHNET	Strah net	Text

Table 21: Condition_Current Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
HPMS	SRI	SRI	Text

Table 22: HPMS Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
LCC_Analysis	COM_COST	Cost of the committed treatment	Double
	COM_TRT	Committed treatment name	Text
	COM_USE_ANC	Use ancillary treatments with the committed treatment	Boolean
	COM_USE_SUB	Use subsequent treatments with committed treatment	Boolean
	COM_YEAR	Year of the committed treatment	Integer
	COMMENTS		Text
	Family_Initial_IRI	Initial IRI Pavement Family Clasification	Text
	Family_Last_Treatment	Last Treatment Pavement Family	Text
	Family_Performance_Family	Performance Curve Family	Text
	Family_Trucks	Truck Traffic Pavement Family Classification	Text
	Index_Age	Age of the segment	Integer
	Index_Avg_Rut	Average Rut	Single
	Index_Avg_Rut_2000	Average Rut in year 2000	Single
	Index_Avg_Rut_2002	Average Rut in year 2002	Single
	Index_Avg_Rut_2004	Average Rut in year 2004	Single
	Index_Avg_Rut_2005	Average Rut in year 2005	Single
	Index_Avg_Rut_2006	Average Rut in year 2006	Single
	Index_Data_Date	Data year that the data was collected	Date
	Index_Data_Date_2000	Data year that the data was collected	Date
	Index_Data_Date_2002	Data year that the data was collected	Date
	Index_Data_Date_2004	Data year that the data was collected	Date
	Index_Data_Date_2005	Data year that the data was collected	Date
	Index_Data_Date_2006	Data year that the data was collected	Date
	Index_Design_Life	Design Life	Double
	Index_FPR	Final Pavement Rating	Single
	Index_IRI	Average IRI	Single
	Index_IRI_2000	Average IRI	Single
	Index_IRI_2002	Average IRI	Single
	Index_IRI_2004	Average IRI	Single
	Index_IRI_2005	Average IRI	Single
	Index_IRI_2006	Average IRI	Single
	Index_LDI	Non Load Related Distress Index	Single
	Index_Max_LRUT	Maximum Left Rut	Single
	Index_Max_LRUT_2000	Maximum Left Rut	Single
	Index_Max_LRUT_2002	Maximum Left Rut	Single
	Index_Max_LRUT_2004	Maximum Left Rut	Single
	Index_Max_LRUT_2005	Maximum Left Rut	Single
	Index_Max_LRUT_2006	Maximum Left Rut	Single
	Index_Max_RRUT	Maximum Right Rut	Single
	Index_Max_RRUT_2000	Maximum Right Rut	Single
	Index_Max_RRUT_2002	Maximum Right Rut	Single
	Index_Max_RRUT_2004	Maximum Right Rut	Single
	Index_Max_RRUT_2005	Maximum Right Rut	Single
	Index_Max_RRUT_2006	Maximum Right Rut	Single
	Index_NDI	Non Load Related Distress Index	Single
	Index_RDL	Remaining Design Life	Double
	Index_RSL	Remaining Service Life	Double
	Index_RSL_IRI	RSL IRI	Double
	Index_RSL_LDI	RSL LDI	Double
	Index_RSL_NDI	RSL NDI	Double
	Index_RSL_SDI	RSL SDI	Double
	Index_RSL_Threshold_IRI	IRI RSL Threshold	Double
	Index_RSL_Threshold_LDI	LDI RSL Threshold	Double
	Index_RSL_Threshold_NDI	NDI RSL Threshold	Double
	Index_RSL_Threshold_SDI	SDI RSL Threshold	Double
	Index_SDI	Surface Distress Index	Single
	Index_SDI_2000	Surface Distress Index	Single
	Index_SDI_2002	Surface Distress Index	Single
	Index_SDI_2004	Surface Distress Index	Single
	Index_SDI_2005	Surface Distress Index	Single
	Index_SDI_2006	Surface Distress Index	Single
	Index_Skid_Trigger	Skid Trigger Value	Integer
	Index_Skid_Value	Skid Value	Single
	Index_Skid_Value_2000	Skid Value	Single
	Index_Skid_Value_2002	Skid Value	Single
	Index_Skid_Value_2004	Skid Value	Single
	Index_Skid_Value_2005	Skid Value	Single
	Index_Skid_Value_2006	Skid Value	Single
	Index_zDefault_Double	Default Double	Double
	Inventory_Bridge	Bridge	Text
	Inventory_CT_Designation	CT Designation	Text
	Inventory_CT_Direction	CT Direction	Text
	Inventory_Direction	Direction	Text
	Inventory_Jurisdiction	JURISDICTION	Text
	Inventory_Lanes	Number of Lanes	Integer
	Inventory_Pave_Type	Pavement Type	Table
	Inventory_Pave_Width	Pavement Width	Integer
	Inventory_Project_Date	Project Date	Date
	Inventory_Project_IRI	Initial IRI following the most recent project	Double
	Inventory_Project_Type	Type of the last treatment	Text
	Inventory_Project_Year	Year of Last Work	Integer
	Inventory_Route_Type	Route Type	Integer
	Inventory_Segment_Type	Segment Type	Integer
	Inventory_SLD_Name	SLD Name	Text
	Inventory_Speed_Limit	Speed Limit	Integer
	Inventory_SRI	SRI	Text
	PROJECT		Text
	Traffic_AADT	Average Annual Daily Traffic	Long
	Traffic_Esals	Design Esals	Long
	Traffic_Heavy_Flexible		Double
	Traffic_Heavy_Rigid		Double
	Traffic_Light_Flexible		Double
	Traffic_Light_Rigid		Double
	Traffic_Percent_Trucks	Percent_Trucks	Double

Table 23: LCC_Analysis Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Mtce_Contracts	Completion_Date		Date
	County1		Text
	County2		Text
	County3		Text
	Direction		Text
	From_Milepost		Double
	Lane_Miles		Double
	Munciipality_4		Text
	Municipality_1		Text
	Municipality_2		Text
	Municipality_3		Text
	Route		Long
	Shoulder_Miles		Double
	SRI		Text
	To_Milepost		Double

Table 24: Mtce_Contracts Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Mtce_History	Mtce_Action	Maintenance Action	Text
	Mtce_Date	Completion Date	Date

Table 25: Mtce_History Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Project_History	ACT_BUILT	Act Built	Text
	ACTIVITY	Project Activity	Table
	AGG_TYPE	Aggregate Type	Text
	ASPHALT_TYPE	Asphalt Type	Text
	BEG_MILE	Begin Mile	Double
	BNDR_CNT	Binder Count	Text
	DATA_YEAR	Data Year	Integer
	END_MILE	End Mile	Double
	HWY_ID	Highway ID	Text
	LANE_ID	Lane ID	Text
	PAVE_BUILT	Pave Built	Text
	PAVE_TYPE	Pavement Type	Text
	PROJ_DATE	Project Date	Date
	PROJ_ID	Project ID	Text
	PROJ_NUM	Project Number	Double
	PROJ_SEG	Project Segment	Double
	ROUTE_AUX	Route Aux Code	Text
	ROUTE_CODE	Route Code	Text
	ROUTE_DIR	Route Direction	Text
	ROUTE_NUM	Route Number	Text
	ROUTE_TYPE	Route Type	Text
	SEG_NUM	Seg Number	Double
	SN_TOTAL	SN Total	Double
	SRI	SRI	Text
	STR_NUM	Structural Number	Double
	SURF_THICK	Surface Thickness	Double

Table 26 Project_History Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Project_History_Most_Recent	ACT_BUILT	Act Built	Text
	ACTIVITY	Project Activity	Table
	AGG_TYPE	Aggregate Type	Text
	ASPHALT_TYPE	Asphalt Type	Text
	BEG_MILE	Begin Mile	Double
	BNDR_CNT	Binder Count	Text
	DATA_YEAR	Data Year	Integer
	END_MILE	End Mile	Double
	HWY_ID	Highway ID	Text
	LANE_ID	Lane ID	Text
	PAVE_BUILT	Pave Built	Text
	PAVE_TYPE	Pavement Type	Text
	PROJ_DATE	Project Date	Date
	PROJ_ID	Project ID	Text
	PROJ_NUM	Project Number	Double
	PROJ_SEG	Project Segment	Double
	PROJ_YEAR	Project Year	Integer
	ROUTE_AUX	Route Aux Code	Text
	ROUTE_CODE	Route Code	Text
	ROUTE_DIR	Route Direction	Text
	ROUTE_NUM	Route Number	Text
	ROUTE_TYPE	Route Type	Text
	SEG_NUM	Seg Number	Double
	SN_TOTAL	SN Total	Double
	SRI	SRI	Text
	STR_NUM	Structural Number	Double
	SURF_THICK	Surface Thickness	Double

Table 27: Project_History_Most_Recent Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Project_IRI_Acceptance	AVG_IRI		Double
	SRI		Text
	TEST_DATE		Text

Table 28: Project_IRI_Accepanct Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Ramps	direction		Text
	mp_end		Double
	mp_start		Double
	parent_mp_end		Double
	parent_mp_start		Double
	parent_sri		Text
	route_type_code		Integer
	segment_type		Integer
	sldname		Text
	sri		Text

Table 29: Ramps Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SLD_Fed_Aid	FED_AID		Text
	SRI	SRI	Text

Table 30: SLD_Fed_Aid Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SLD_Func_Class	Func_Class		Text
	Parent_SRI		Text
	SRI		Text

Table 31: SLD_Func_Class Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SLD_Intersections	Angle	Angle	Integer
	Dir	Direction	Text
	Just	Just	Text
	Leg_Label	Legal Label	Text
	Road_Name	Road Name	Text
	RT_ID	Route ID	Text
	RT_SYM	RT_SYM	Text
	Single	Single	Integer
	Type	Intersection Type	Table

Table 32: SLD_Intersections Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SLD_Jurisdiction	JURISDICTION	JURISDICTION	Text
	SRI	SRI	Text

Table 33: SLD_Jurisdiction Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SLD_Lanes	Lanes		Integer
	Parent_SRI		Text
	SRI	SRI	Text

Table 34: SLD_Lanes Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SLD_Leg_District	Leg_District	Leg District	Table
	Parent_SRI		Text
	SRI		Text

Table 35: SLD_Leg_District Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SDL_Inside_Shoulder	Shoulder_Width_Inside	Inside Shoulder Width	Double

Table 36: SDL_Inside_Shoulder Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SDL_Outside_Shoulder	Shoulder_Width_Outside	Outside Shoulder Width	Double

Table 37: SDL_Outside_Shoulder Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SLD_Municipality	Municipality	Leg District	Table
	Parent_SRI	Parent SRI	Text
	SRI	SRI	Text

Table 38: SLD_Municipality Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SLD_Speed_Limit	Speed_Limit	Speed Limit	Integer
	SRI	SRI	Text

Table 39: SLD_Speed_Limit Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
SLD_Width	Parent_SRI	Parent SRI	Text
	Pave_Width	Pavement Width	Integer
	SRI	SRI	Text

Table 40: SLD_Width Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Traffic	AADT		Double
	AADT_2006		Double
	AVC_STA		Text
	DVMT		Double
	HVY_TRK_PCT		Double
	LIMIT_END		Text
	LIMIT_START		Text
	MED_TRK_PCT		Double
	MP_END		Double
	MP_START		Double
	MUC_PCT		Double
	NB_OR_EB		Double
	PCT_3S2		Double
	PCV_MP		Double
	PCV_STATION		Text
	PEAK_DIR		Double
	PEAK_HOUR		Double
	REMARKS		Text
	ROUTE		Text
	SB_OR_WB		Double
	SRI		Text
	SUC_PCT		Double
	SUFFIX		Text
	TRK_PCT		Double
	Truck_DVMT		Double

Table 41: Traffic Perspective Attributes

Perspective Name	Attribute Name	Description	Attribute Type
Traffic_ESAL_Factors	Heavy_Flexible		Double
	Heavy_Rigid		Double
	Light_Flexible		Double
	Light_Rigid		Double
	MP_END		Double
	MP_START		Double
	ORIG_SRI		Text
	SRI		Text

Table 42: Traffic_ESAL_Factors Perspective Attributes

Appendix “B”

2008-2012 dTIMS CT

Recommended Program

Rutgers The State University of New Jersey

Center for Advanced Infrastructure and Transportation -CAIT

2010 Pavement Profiler Certification

For:

State of New Jersey
Department of Transportation

Pavement and Drainage Management Systems and Technology

Prepared by:

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June 7, 2010

Table of Content

Introduction

This report outlines the work performed for certifying the NJDOT walking, portable and high speed pavement profilers. The work was performed in accordance with the NJDOT Pavement Profiler Operation and Certification Manual and the AASHTO and ASTM Test Specifications:

AASHTO PP 49-07 Certification of Inertial Profiling Systems
ASTM E2133 Using a Rolling Inclinometer to Measure Longitudinal and Transverse Profiles of a Traveled Surface
AASHTO PP 17-07 Certification of Inertial Profiling Systems
AASHTO MP 17-08 Pavement Ride Quality When Measured Using Inertial Profiling Systems
AASHTO PP 50-07 Operating Inertial Profilers and Evaluation Pavement Profiles

Profiler Subsystem Calibration

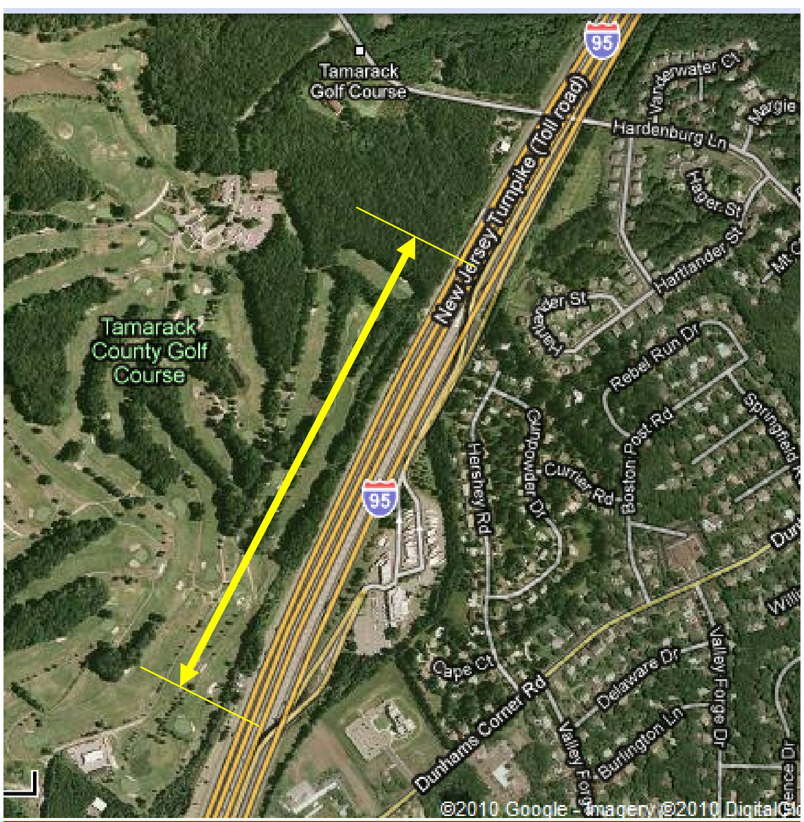
Before any field data was collected, the NJDOT staff performed laser height measurement tests to verify operation of the height sensor, bounce test to verify the operation of the accelerometers and distance measurements to validate the operation of the distance measurement instruments (DMI). These test verified the calibration of the profiler subsystems on the portable, and high speed inertial profilers.

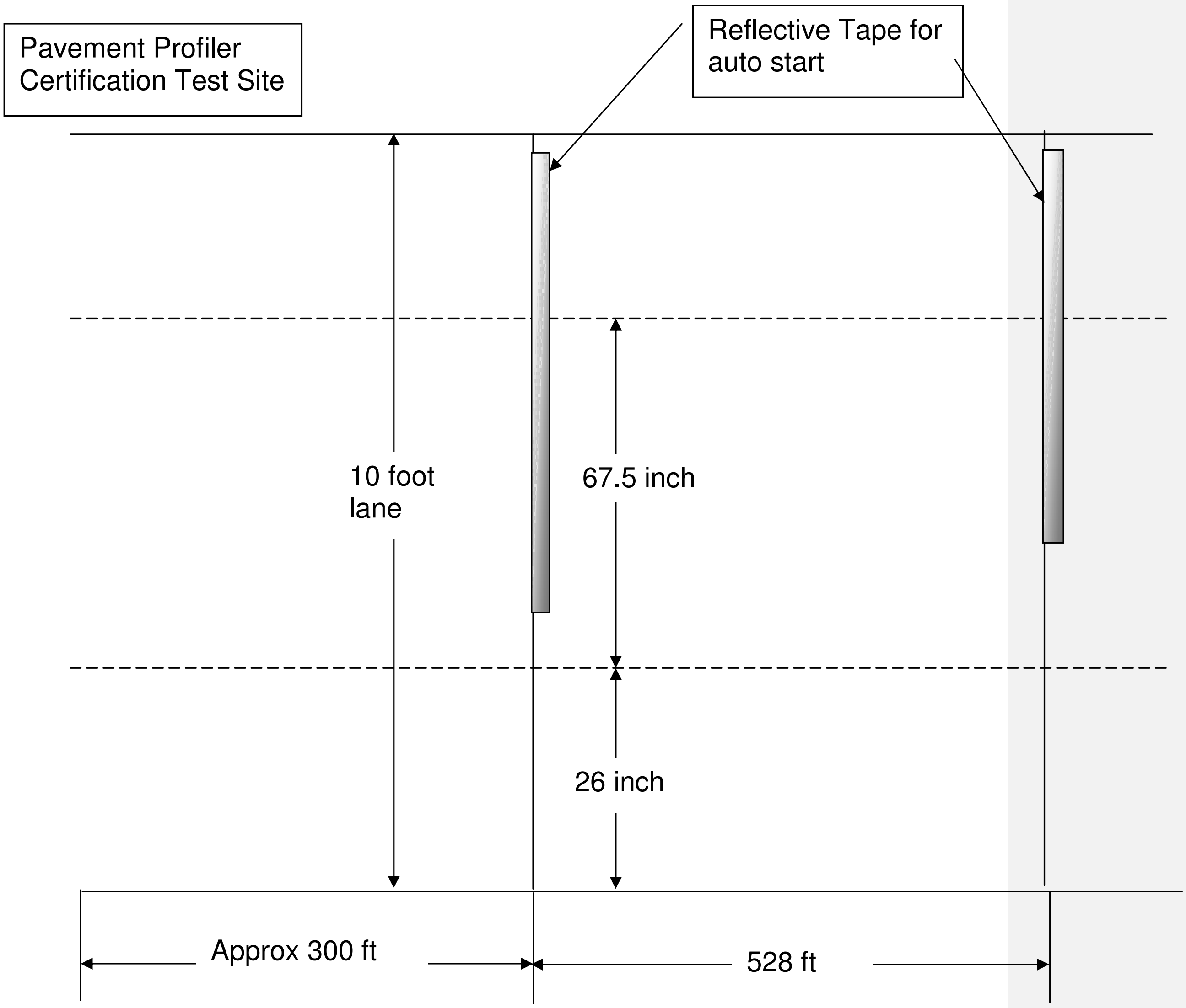
Pavement Profiler Certification Test Site

The test sites used for the field data collection were part of a non-traffic portion of the NJ Turnpike adjacent to the Molly Pitcher rest area north of exit 8A. Two test sections were identified in adjacent lanes. Test site S1 had an average IRI of 108.7 and test site S2 had average IRI of 94.1. These values fall within the smoothness criteria (95-135 inches per mile) for a moderate test site based on the ASSHTO PP49-07 specification Certification of Inertial Profiling Systems. Site 1 was located in lane 2 and Site 2 was located in lane 3.

Layout

Each test site was 528 feet with more than 300 foot lead-in. As required in the specification, the wheel paths were accurately measured with a steel tape and concrete nails were used to identify each 100 foot point. The wheel paths were spaced approximately 67.5 inches apart based on the distance between the profiler lasers on the ICC profiler as shown below. The laser spacing on the Dynatest Portable Profilers was adjusted to 67.5 inches to match the ICC profiler. Each wheel path was marked with yellow stripping paint and the start and ends points of each test site was marked with silver reflective tape used to autotrigger the profilers.





Pavement Profiler Certification Test Site
Reflective Tape for auto start
10 foot lane
67.5 inch
26 inch
Approx 300 ft
528 ft

DYNAMIC CERTIFICATION TESTING—

The certification of the profilers was conducted in two steps. The first step is to assess the repeatability of the Portable and High Speed Profilers, and the second step is to assess the accuracy of Portable and High Speed Profilers.

Repeatability refers to the assessment of a single profiler's ability to repeatedly measure the overall roughness as well as the spatial distribution of roughness along a single profile trace.

Accuracy refers to the assessment of the Portable or High Speed Profiler's ability to reproduce the profile trace measured by the Reference profiler **which is deemed to be correct**.

In addition to the certification procedure – an additional analysis was performed to verify the repeatability and accuracy of the IRI ride statistic.

Reference Profiler Data Collection

For this project, the ICC SurPRO 2000 was utilized as the reference profiler.

The SurPRO 2000 uses an inclinometer and accurate DMI to create a profile trace of each wheelpath.

The SurPRO 2000 was setup to collect data at a 1 inch sampling interval. The spacing between the wheels were set at 12 inches apart.

The SurPRO 2000 was pushed along the painted wheelpath markings to collect each pavement profile trace. The SurPRO 2000 profiler was pushed at a rate of 1 ± 0.2 mph due to the roughness of the site.

Prior to profile data collection, a closed loop profile was initially run to establish the Inclinometer Bias on the site.

The SurPRO profile data was collected eleven times on each wheelpath of each site.

Portable and High Speed Profiler Data Collection

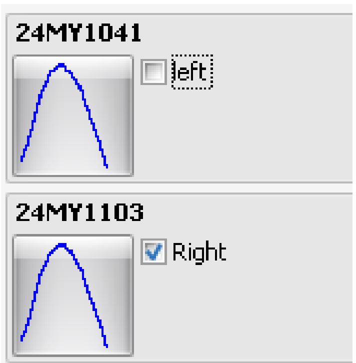
After verification of the profiler subsystems by the NJDOT staff, and DMI on the test site, the ICC Full Size Van and Dynatest Portable Profilers were operated to collect data on test sites S1 and S2. In accordance with the specifications, the profilers began their runs well before the 300 foot lead-in distance and aligned themselves on the wheel path markers 100 foot before the test site start points.

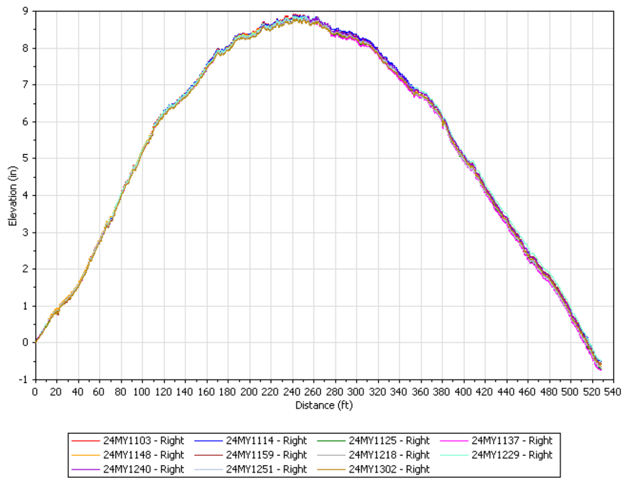
The ICC Size Van and Dynatest Portable Profilers were setup to collect data at approximately 2 inch sampling interval. The profile was operated at approximately 40 MPH due to the roughness of the site. Profile data from each vehicle was collected eleven times on each site.

Reference Profiler Analysis

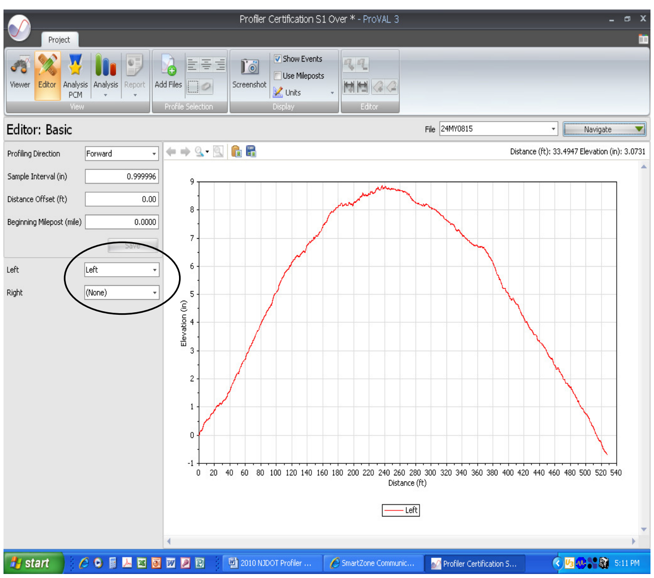
The profiler data from the SurPRO was downloaded using an Engineering Research Division (ERD) file format to a desktop computer for analysis. ProVAL 3 was used for the analyses.

Each profile name was modified to indicate whether it represented a left or right wheel path profile. All of the eleven profiles from each wheel path on both test sites were visually examined to verify that no visible anomalies were present.

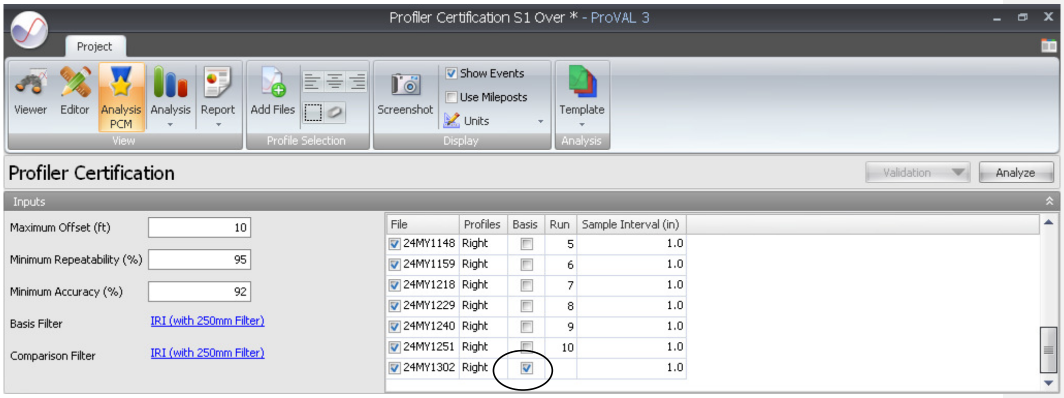




The ProVAL 3 Editor: Basic was used to modify the profile to left or right wheel path identification.



The ProVAL 3 Profiler Certification Analysis was then used to compare multiple runs of each profiler (i.e., repeatability test) and compare those repeats runs with a basis profile (i.e., accuracy test). The computation of cross-correlation was based on the guidelines in the **AASHTO PP49**. Standard Practice for Certification of Inertial Profiling Systems” is a standard for profiler operators and profiler equipment certification.



The left portion of the screen allows the user to set the Maximum Offset value and Minimum Repeatability and Accuracy percentage scores as well as set the Basis and Comparison Filters. For the reference profiler analysis, the Maximum Offset value was set to 10 feet. The Minimum Repeatability percentages was set to 95 percent and the Minimum Accuracy percentages was set to 92 percent, respectively. The **IRI with 250mm filter** was used for the Basis and Comparison Filters.

The right portion of the screen allows the user to select the profile files to use in the analysis for both the reference (basis) profile and the ten comparison profiles. Each of the eleven SurPRO profiles were used as the reference (basis) profile and the remaining ten were used as the comparison profiles for the repeatability and accuracy analyses.

For each profile, an analysis report was generated. The report includes the input parameters as well as the results of the cross correlations for repeatability and accuracy. The analyses are contained in the APPENDIX. The example below only contains the right repeatability and accuracy results since only the right side reference profiles were compared.

Analysis Report

Statistics

Statistic	Repeatability - Right	Accuracy - Right
Comparison Count	45	10
% Passing	87	100
Mean	96	97
Minimum	93	95
Maximum	98	98
Standard Deviation	1.3	1.2
Grade	Passed	Passed

Accuracy (%)

Run	Right
10	98
9	96
8	98
7	98
6	96
5	97
4	95
3	96
2	96
1	95

Repeatability - Right Correlations (%)

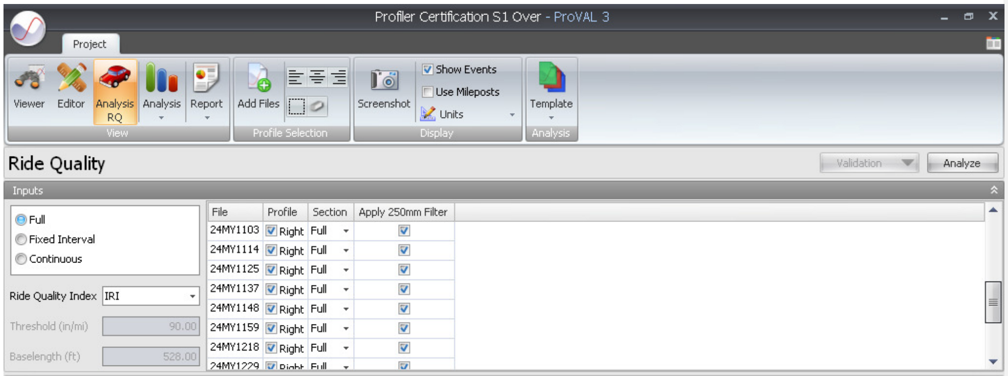
Run	2	3	4	5	6	7	8	9	10
1	97	98	98	97	98	96	96	96	97
2		97	95	98	97	95	94	94	97
3			98	96	98	96	97	96	96
4				96	97	97	97	97	95
5					96	95	95	94	96
6						96	96	95	96
7							96	95	94
8								97	94
9									93

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
2		0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
3			0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1
4				0.0	0.0	0.0	-0.1	-0.1	-0.1
5					0.0	0.0	-0.1	0.0	0.0
6						0.0	-0.1	0.0	0.0
7							-0.1	0.0	-0.1
8								0.0	0.0
9									0.0

All eleven reference profiler combinations passed the profiler certification analysis.

For verification of the IRI ride statistic, the IRI of each wheel path of the eleven runs on both site S1 and S2 were determined using the ProVAL 3 Ride Quality Analysis.



The screen allows the user to indicate which profiles and filter to apply. The results of the ride statistic analyses are provided in the APPENDIX. These results were used for verification of ride quality values.

The **repeatability** of the IRI statistic for each wheelpath was based on the Coefficient of Variation (COV) which is equal to the standard deviation of the IRI of the repeat runs of divided by the average of the repeat runs times 100. A percentage of 3% or less is acceptable.

The **accuracy** of the IRI statistic was based on the absolute difference between the individual IRI values from each run and the IRI from the "selected" profile. Since all the Mean repeatability scores were the same, the "selected" profile was chosen as the profile closest to the average profile. This analysis checks the percentage of the absolute differences between the runs and the reference profiler select profile IRI by dividing the average of the absolute differences by the IRI of the selected profile times 100. The percentage of 5% or less is acceptable.

All repeatability and accuracy verification of the IRI statistic for the reference profiler were acceptable as shown below.

SurPRO 2000

S1

Repeatability

File	Left	File	Profile	IRI (in/mi)	Mean Rep	File	Right	Profile	IRI (in/mi)	Mean Rep		MRI
24MY0815	1		Left	115.83	98	24MY1103	1	Right	102.51	96		109.17
24MY0827	2		Left	115.63	98	24MY1114	2	Right	100.59	96		108.11
24MY0839	3		Left	115.93	98	24MY1125	3	Right	101.57	96		108.75
24MY0850	4		Left	116.19	98	24MY1137	4	Right	102.81	96		109.50
24MY0902	5		Left	116.06	98	24MY1148	5	Right	101.45	96		108.76
24MY0912	6		Left	114.59	98	24MY1159	6	Right	101.11	96		107.85
24MY0934	7		Left	114.95	98	24MY1218	7	Right	103.35	96		109.15
24MY0945	8		Left	114.21	98	24MY1229	8	Right	102.60	96		108.41
24MY0958	9		Left	115.70	98	24MY1240	9	Right	102.67	96		109.19
24MY1019	10		Left	114.39	98	24MY11251	10	Right	100.35	96		107.37
24MY1041	11		Left	116.16	98	24MY1302	11	Right	101.85	96		109.01
			average	115.42					101.90			108.66
			STDEV	0.74					0.97			0.66
			COV	0.64				COV	0.95		COV	0.60

24MY0827 and 24MY1302 were selected as representative profiles for comparison with the high speed profilers.

SurPRO 2000
S1

Accuracy

<=5% Diff is the test

S1
SurPRO 2000

Left		ABS DIF		Right		ABS DIF
115.63	115.83	0.20		101.85	102.51	0.66
115.63	115.63	0.00		101.85	100.59	1.26
115.63	115.93	0.30		101.85	101.57	0.28
115.63	116.19	0.56		101.85	102.81	0.96
115.63	116.06	0.43		101.85	101.45	0.40
115.63	114.59	1.04		101.85	101.11	0.74
115.63	114.95	0.68		101.85	103.35	1.50
115.63	114.21	1.42		101.85	102.60	0.75
115.63	115.70	0.07		101.85	102.67	0.82
115.63	114.39	1.24		101.85	100.35	1.50
115.63	116.16	0.53		101.85	101.85	0.00
	Average	0.59			Average	0.81
	% Dif	0.51			% Dif	0.79

SurPRO 2000
S2

Repeatability

File	Left	Profile	IRI (in/mi)	Mean Rep	File	Right	Profile	IRI (in/mi)	Mean Rep		MRI
20MY0844	1	Left	79.25	96	20MY1108	1	Right	107.07	99		93.16
20MY0858	2	Left	83.44	96	20MY1119	2	Right	107.43	99		95.44
20MY0910	3	Left	79.79	96	20MY1130	3	Right	107.06	99		93.43
20MY0921	4	Left	81.87	96	20MY1140	4	Right	107.20	99		94.54
20MY0938	5	Left	78.55	96	20MY1151	5	Right	107.89	99		93.22
20MY0949	6	Left	80.53	96	20MY1201	6	Right	107.12	99		93.83
20MY1001	7	Left	80.14	96	20MY1212	7	Right	107.51	99		93.83
20MY1014	8	Left	83.22	96	20MY1222	8	Right	109.08	99		96.15
20MY1025	9	Left	79.00	96	20MY1233	9	Right	108.00	99		93.50
20MY1035	10	Left	80.11	96	20MY1243	10	Right	108.24	99		94.18
20MY1058	11	Left	80.44	96	20MY1254	11	Right	107.70	99		94.07
		average	80.58				average	107.66		average	94.12
		STDEV	1.62				STDEV	0.62		STDEV	0.94
		COV	2.01				COV	0.57		COV	1.00

20MY0949 and 20MY1254 were selected as representative profiles for comparison with the high speed profilers.

SurPRO 2000
S2

Accuracy

<=5% Diff is the test

S2
SurPRO 2000

Left		ABS DIF	Right		ABS DIF
80.53	79.25	1.28	107.70	107.07	0.63
80.53	83.44	2.91	107.70	107.43	0.27
80.53	79.79	0.74	107.70	107.06	0.64
80.53	81.87	1.34	107.70	107.2	0.50
80.53	78.55	1.98	107.70	107.89	0.19
80.53	80.53	0.00	107.70	107.12	0.58
80.53	80.14	0.39	107.70	107.51	0.19
80.53	83.22	2.69	107.70	109.08	1.38
80.53	79	1.53	107.70	108	0.30
80.53	80.11	0.42	107.70	108.24	0.54
80.53	80.44	0.09	107.70	107.7	0.00
	Average	1.22		Average	0.47
	% Dif	1.51		% Dif	0.44

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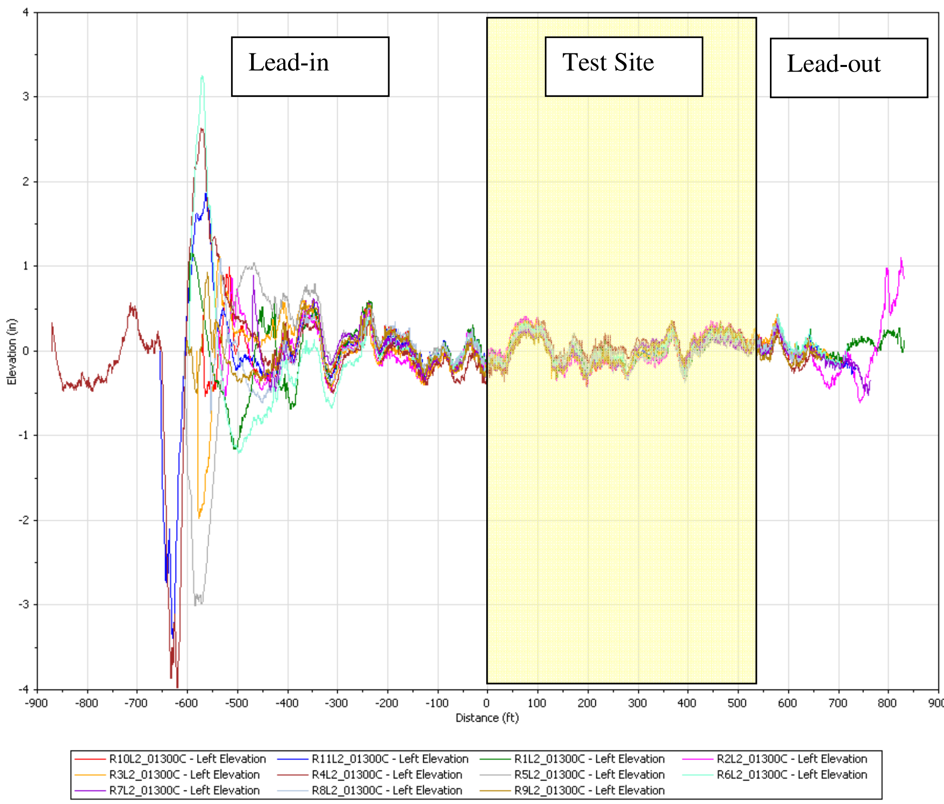
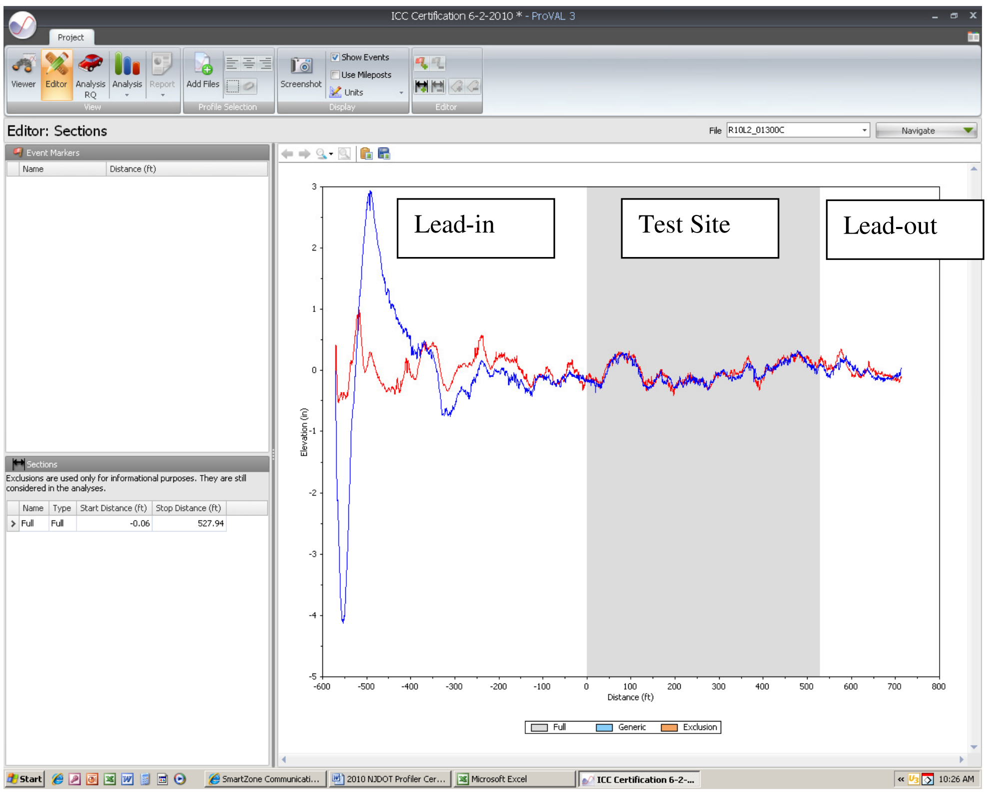
Portable and High Speed Profiler Analysis

The profiler data from the ICC and Dynatest Portable Profilers were downloaded using an Engineering Research Division (ERD) file format to a desktop computer for analysis. ProVAL 3 was used for analysis.

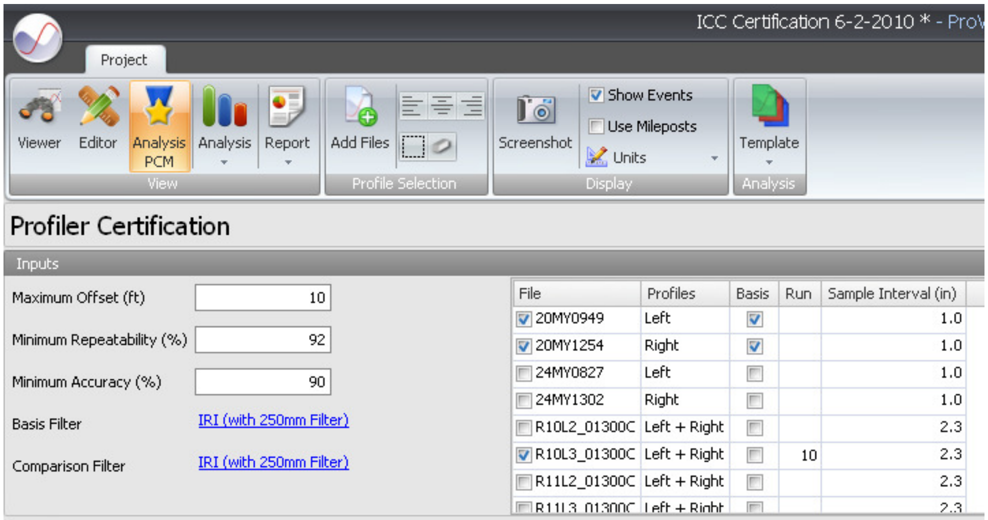
The profiles from each wheel path on both test sites were visually examined to verify that no visible anomalies were present. The profiles for each wheel path on site S1 and S2 for each profiler are provided in the APPENDIX.



The ProVAL 3 Editor: Sections was used to modify the test section limits of each profile to identify the start and end points of each 528 foot test section .



The ProVAL 3 Profiler Certification Analysis was then used to compare multiple runs of a profiler (i.e., repeatability test) and compare those repeat runs with a basis profile (i.e., accuracy test). The computation of cross-correlation is based on the guidelines in the **AASHTO PP49** “Standard Practice for Certification of Inertial Profiling Systems” is a standard for profiler operators and profiler equipment certification.



The left portion of the screen allows the user to set the Maximum Offset value and Minimum Repeatability and Accuracy percentages as well as set the Basis and Comparison Filters. For the high speed profiler analyses, the Maximum Offset value was set to 10 feet. The Minimum Repeatability percentages was set to 92 percent and the Minimum Accuracy percentages was set to 90 percent. The IRI with **IRI 250mm filter** was used for the Basis and Comparison Filters. The Maximum Offset value limits the amount of longitudinal shifting that ProVAL will use to align the profiles to maximize repeatability and accuracy cross correlation analysis. The Minimum Repeatability percentages and the Minimum Accuracy percentages provide a minimum allowable Mean score of the repeatability analysis cross correlation analyses. Mean values below these limit fail to produce an acceptable profiler certification.

The right portion of the screen allows the user to select the profile files to use for both the reference (basis) profile and the ten comparison profiles. The SurPRO profiles were used as the reference (basis) profile for the left and right profiles and the ten profiles from the high speed profilers were used as the comparison profiles on each test section.

Interpret the Analysis Results

The test results are summarized in tables for repeatability of cross correlations of each wheel path, repeatability of the offset adjustments used by the software to longitudinally adjust the profiles to maximize the correlations, accuracy of the high speed profiles against the reference profile, and a summary table.

• For the repeatability test, the left data of a comparison profile will automatically be compared against left data of the comparison profiles, and the same for the right data.
• For the accuracy test, left data of all comparison profiles will automatically be compared against the left data of the reference profile, and the same for the right data.

Repeatability - Left Correlations

Run	4	5	6	7	8	9	10
2	92	86	92	91	93	92	89
4		91	95	92	95	94	92
5			91	90	91	88	87
6				91	96	95	92
7					91	92	89
8						95	92
9							92

Repeatability - Right Correlations

Run	4	5	6	7	8	9	10
2	94	90	94	93	93	91	86
4		94	97	94	97	95	91
5			95	93	95	91	89
6				93	96	93	91
7					94	95	91
8						95	91
9							93

Repeatability - Left Offsets (ft)

Run	4	5	6	7	8	9	10
2	1.1	-2.9	-2.6	-2.2	-3.5	0.3	1.5
4		-3.9	-3.7	-3.3	-4.7	-0.8	0.3
5			0.1	0.5	-0.8	3.0	4.3
6				0.3	-1.0	2.8	3.9
7					-1.4	2.4	3.6
8						3.7	4.9
9							1.1

Repeatability - Right Offsets (ft)

Run	4	5	6	7	8	9	10
2	0.9	-2.9	-2.7	-2.4	-3.7	0.1	1.3
4		-3.9	-3.7	-3.3	-4.7	-0.8	0.3
5			0.1	0.7	-0.6	3.2	4.1
6				0.3	-1.0	2.8	3.9
7					-1.4	2.4	3.6
8						3.7	4.9
9							1.1

Accuracy

Run	Left	Right
8	77	84
6	81	90
9	86	93
10	81	91
5	82	87
2	80	91
7	80	87
4	79	88

Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	28	28	8	8
% Passing	57	68	0	50
Mean	92	93	81	89
Minimum	86	86	77	84
Maximum	96	97	86	93
Standard Deviation	2.4	2.5	2.6	2.9
Grade	Passed	Passed	Failed	Failed

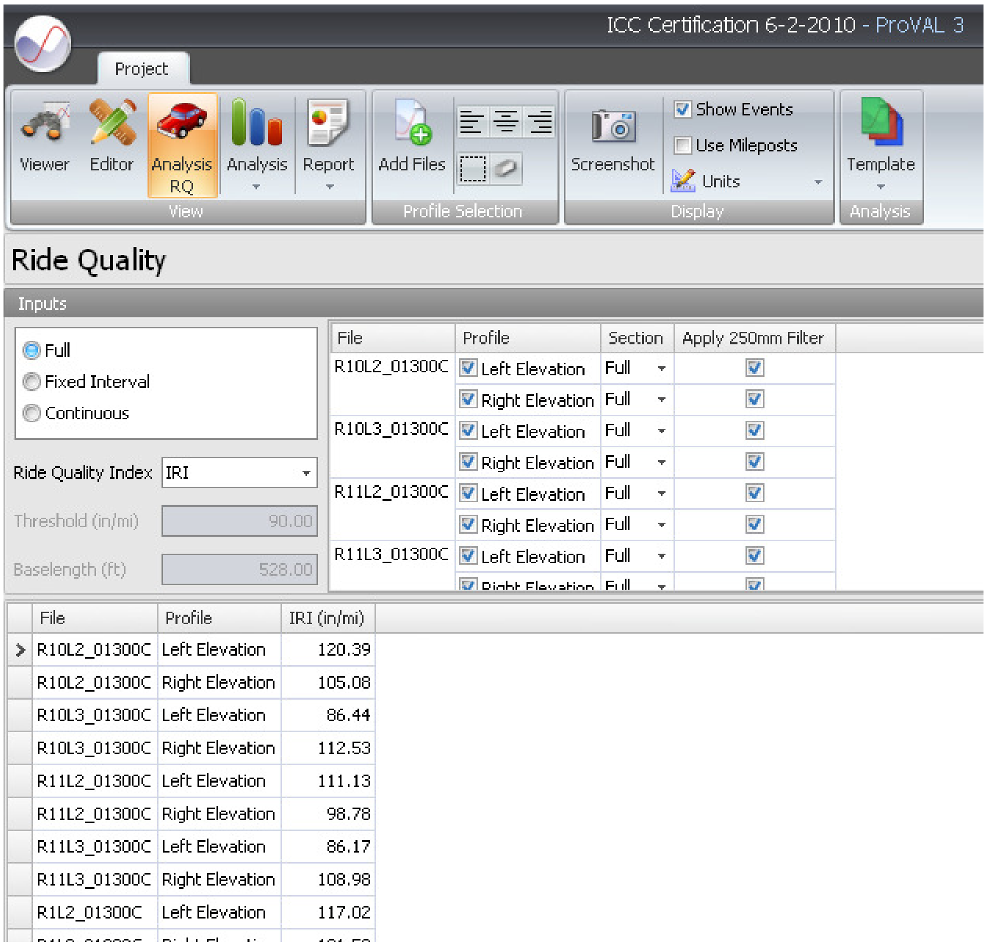
Minimum Repeatability percentage = 92%
Minimum Accuracy percentage = 90%

Statistics for the Repeatability and Accuracy test are grouped together in the Statistics table. One statistic in particular to note is the **Grade**. If the Mean score of the repeatability analysis is less than the Minimum Repeatability percentage or Mean score of the accuracy analysis is less the Minimum Accuracy percentage set in the input screen, the Grade will be "**Failed**", otherwise it will be "**Passed**".

For each profile, an analysis report was generated and is provided in the APPENDIX. The report includes the results of the cross correlations for repeatability and accuracy and the overall statistics.

Ride Statistics Analysis

After the Profiler Certification Analyses was performed on the profile traces, the IRI ride statistic was evaluated for repeatability and accuracy. The ride quality of each run for each wheel path on both site S1 and S2 were determined using the ProVAL 3 Ride Quality Analysis.



The screen allows the user to select each profiles and which filter to apply. The results of the ride statistic analyses are provided in the APPENDIX. These results were used for verification of ride quality values. The IRI results were downloaded to Excel for analyses.

The **repeatability** of the IRI statistic for each wheelpath was based on the Coefficient of Variation (COV) which is equal to the standard deviation of the IRI of the repeat runs divided by the average of the repeat runs times 100. The percentage of 3% or less is acceptable.

The **accuracy** of the IRI statistic for each wheelpath was based on the absolute difference between the individual IRI values from each run and the IRI from the "selected" profile. Since all the Mean repeatability scores for the reference profiler were the same, the "selected" profile was chosen as the profile IRI closest to the average profile IRI as shown in the reference profiler section.

The accuracy analysis checks the percentage of the absolute differences between the individual HSP runs and the reference profiler IRI by dividing the average of the absolute differences of the HSP IRI by the IRI of the selected profile times 100. The percentage of 5% or less is acceptable.

The ICC analysis tables are presented as an example below. The summary of the profile analyses are presented in the APPENDIX.

ICC

S1 Repeatability

File	Profile	IRI (in/mi)	File	Profile	IRI (in/mi)		MRI
R1L2_01300C	Left	117.02	R1L2_01300C	Right	101.59		109.31
R2L2_01300C	Left	124.85	R2L2_01300C	Right	114.06		119.46
R3L2_01300C	Left	130.14	R3L2_01300C	Right	111.93		121.04
R4L2_01300C	Left	123.49	R4L2_01300C	Right	111.48		117.49
R5L2_01300C	Left	97.86	R5L2_01300C	Right	99.47		98.67
R6L2_01300C	Left	109.49	R6L2_01300C	Right	98.27		103.88
R7L2_01300C	Left	113.68	R7L2_01300C	Right	99.69		106.69
R8L2_01300C	Left	108.52	R8L2_01300C	Right	97.70		103.11
R9L2_01300C	Left	116.75	R9L2_01300C	Right	102.59		109.67
R10L2_01300C	Left	120.39	R10L2_01300C	Right	105.08		112.74
R11L2_01300C	Left	111.13	R11L2_01300C	Right	98.78		104.96
	Average	115.76		Average	103.69		109.73
	STDEV	9.01		STDEV	6.06		7.24
	COV	7.78		COV	5.84	COV	6.60

S2

File	Profile	IRI (in/mi)	File	Profile	IRI (in/mi)		MRI
R1L3_01300C	Left	92.54	R1L3_01300C	Right	107.58		100.06
R2L3_01300C	Left	87.31	R2L3_01300C	Right	109.37		98.34
R3L3_01300C	Left	89.68	R3L3_01300C	Right	109.94		99.81
R4L3_01300C	Left	84.51	R4L3_01300C	Right	108.08		96.30
R5L3_01300C	Left	83.52	R5L3_01300C	Right	108.51		96.02
R6L3_01300C	Left	85.93	R6L3_01300C	Right	109.44		97.69
R7L3_01300C	Left	86.03	R7L3_01300C	Right	110.93		98.48
R8L3_01300C	Left	86.36	R8L3_01300C	Right	108.97		97.67
R9L3_01300C	Left	85.90	R9L3_01300C	Right	111.20		98.55
R10L3_01300C	Left	86.44	R10L3_01300C	Right	112.53		99.49
R11L3_01300C	Left	86.17	R11L3_01300C	Right	108.98		97.58
	Average	86.76		Average	109.59		98.18
	STDEV	2.46		STDEV	1.47		1.31
	COV	2.83		COV	1.34	COV	1.34

The repeatability of the IRI of the ICC on S1 was not acceptable. The repeatability of the IRI of the ICC on S2 was acceptable.

Accuracy

<=5% Diff is the test

S1 ICC

Left	ICC	ABS DIF	Right	ICC	ABS DIF
115.63	117.02	1.39	101.85	101.59	0.26
115.63	124.85	9.22	101.85	114.06	12.21
115.63	130.14	14.51	101.85	111.93	10.08
115.63	123.49	7.86	101.85	111.48	9.63
115.63	97.86	17.77	101.85	99.47	2.38
115.63	109.49	6.14	101.85	98.27	3.58
115.63	113.68	1.95	101.85	99.69	2.16
115.63	108.52	7.11	101.85	97.70	4.15
115.63	116.75	1.12	101.85	102.59	0.74
115.63	120.39	4.76	101.85	105.08	3.23
115.63	111.13	4.50	101.85	98.78	3.07
	Average	6.94		Average	4.68
	% Dif	6.00		% Dif	4.60

S2 ICC

Left	ICC	ABS DIF	Right	ICC	ABS DIF
80.53	92.54	12.01	107.70	107.58	0.12
80.53	87.31	6.78	107.70	109.37	1.67
80.53	89.68	9.15	107.70	109.94	2.24
80.53	84.51	3.98	107.70	108.08	0.38
80.53	83.52	2.99	107.70	108.51	0.81
80.53	85.93	5.40	107.70	109.44	1.74
80.53	86.03	5.50	107.70	110.93	3.23
80.53	86.36	5.83	107.70	108.97	1.27
80.53	85.90	5.37	107.70	111.20	3.50
80.53	86.44	5.91	107.70	112.53	4.83
80.53	86.17	5.64	107.70	108.98	1.28
	Average	6.23		Average	1.92
	% Dif	7.74		% Dif	1.78

The accuracy of the IRI of the ICC on left wheel path of S1 and S2 was not acceptable. The accuracy of the IRI of the ICC on right wheel path on S1 and S2 was acceptable.

Summary

APPENDIX

<u>Profiles</u>

- **SurPRO 2000**
- **ICC**
- **Dynatest 146**
- **Dynatest 147**

<u>Certification Analysis Results</u>

- **SurPRO 2000**
- **ICC**
- **Dynatest 146**
- **Dynatest 147**

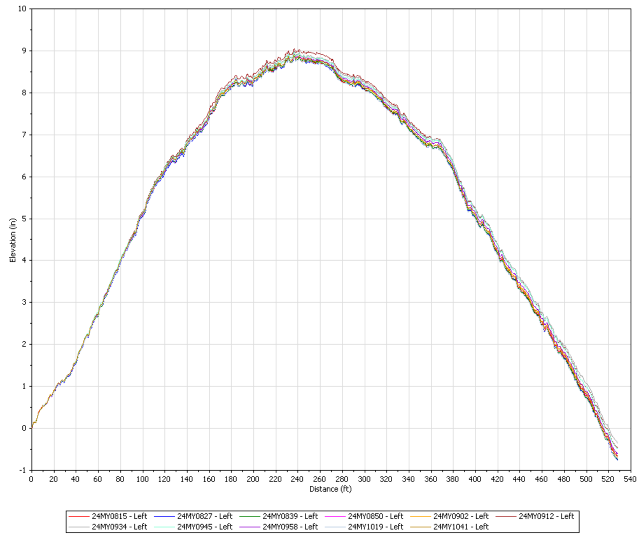
<u>IRI Verification</u>

- **SurPRO 2000**
- **ICC**
- **Dynatest 146**
- **Dynatest 147**

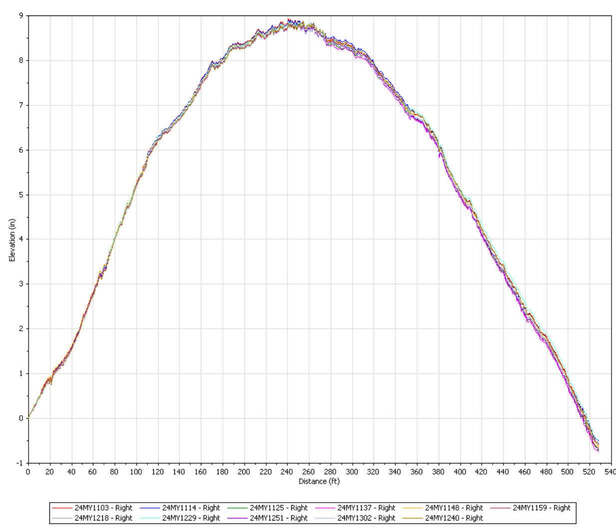
Profiles

Reference Profiler - SurPRO 2000

S1 Left

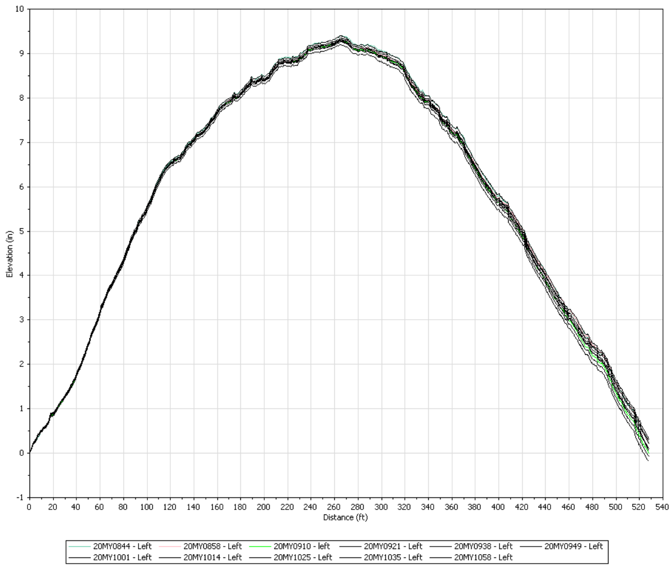


S1 Right

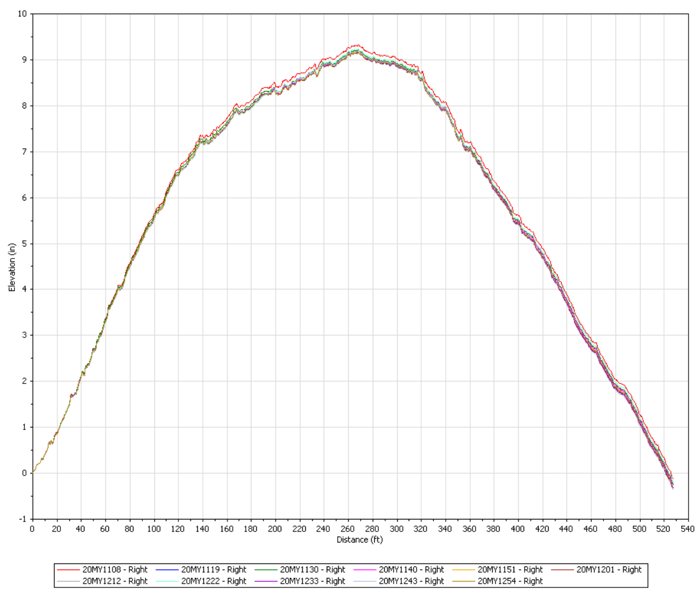


Reference Profiler - SurPRO 2000

S2 Left



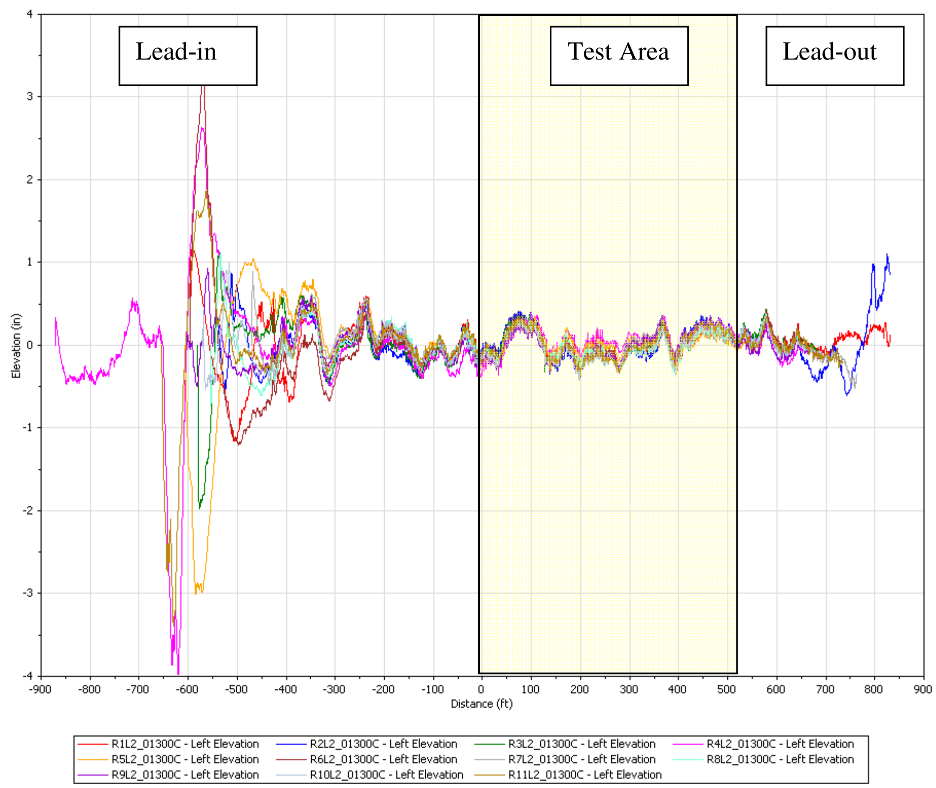
S2 Right



High Speed Profilers

ICC

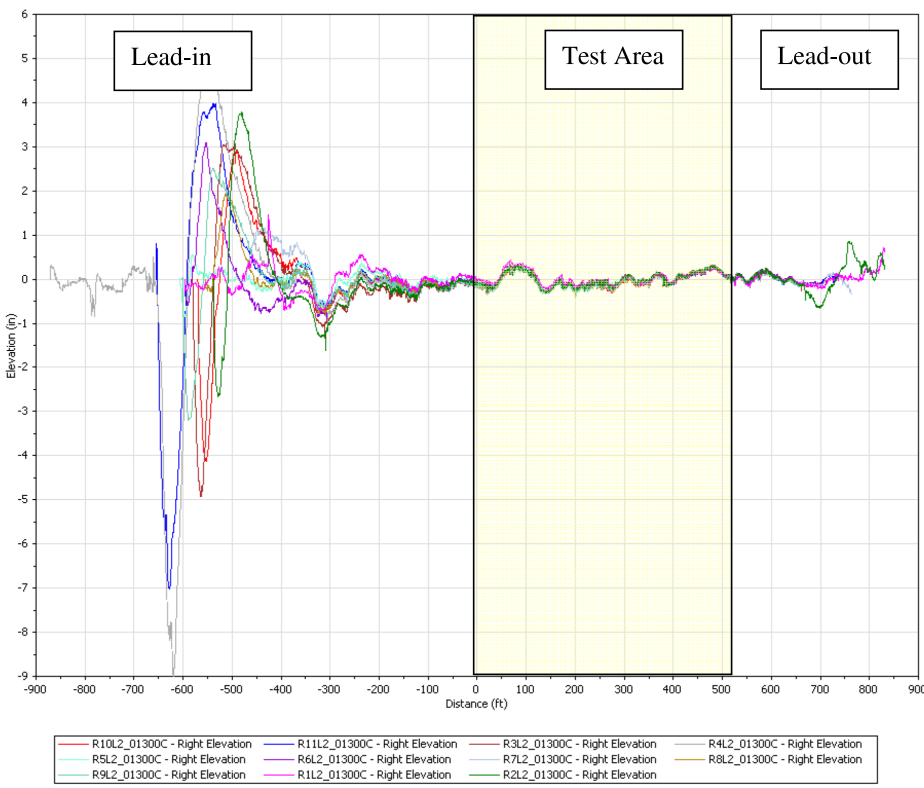
S1 Left



S1 ICC Left Wheelpath

ICC

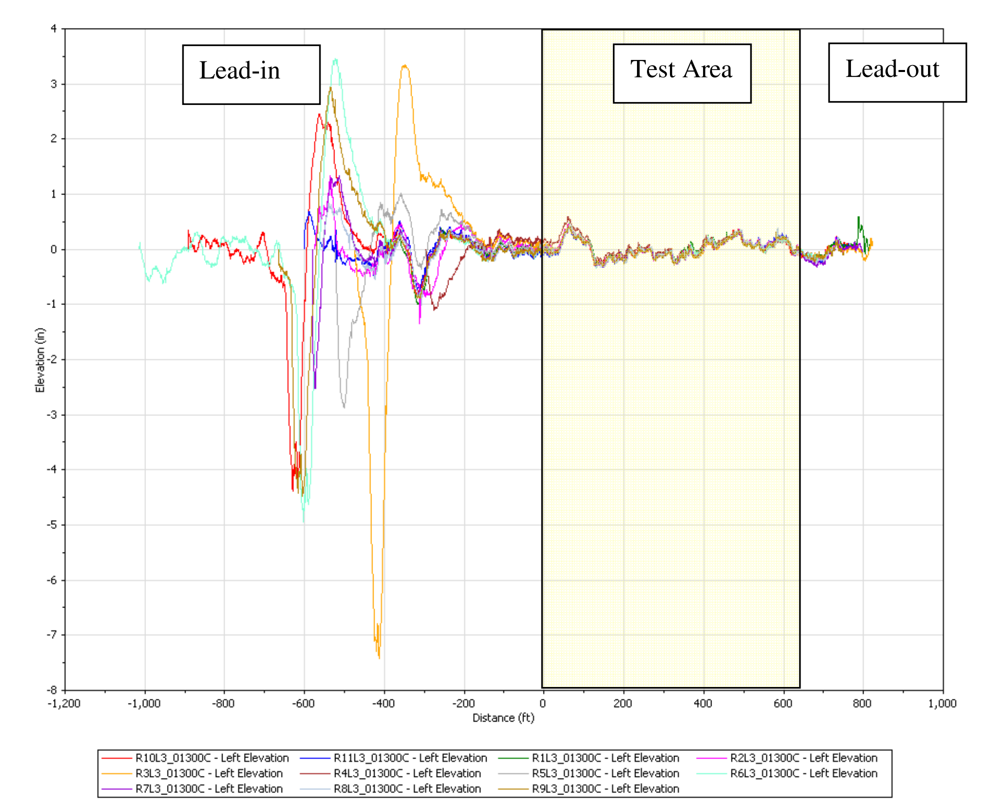
S1 Right



S1 ICC Right Wheelpath

ICC

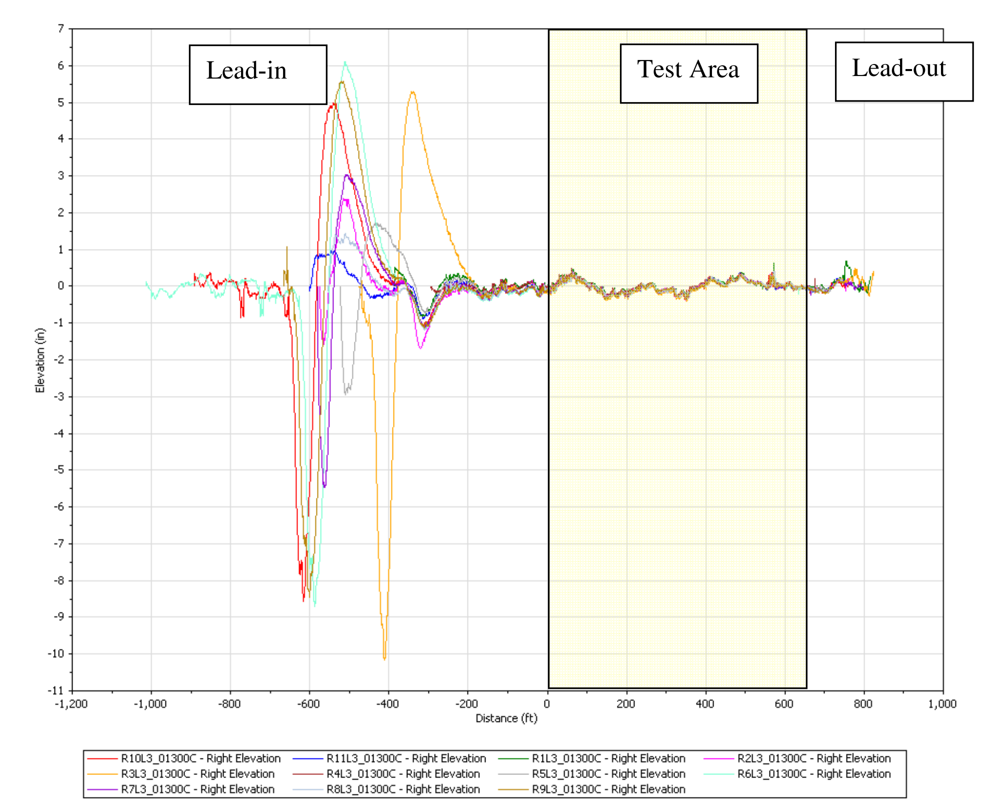
S2 Left



S2 ICC Left Wheelpath

ICC

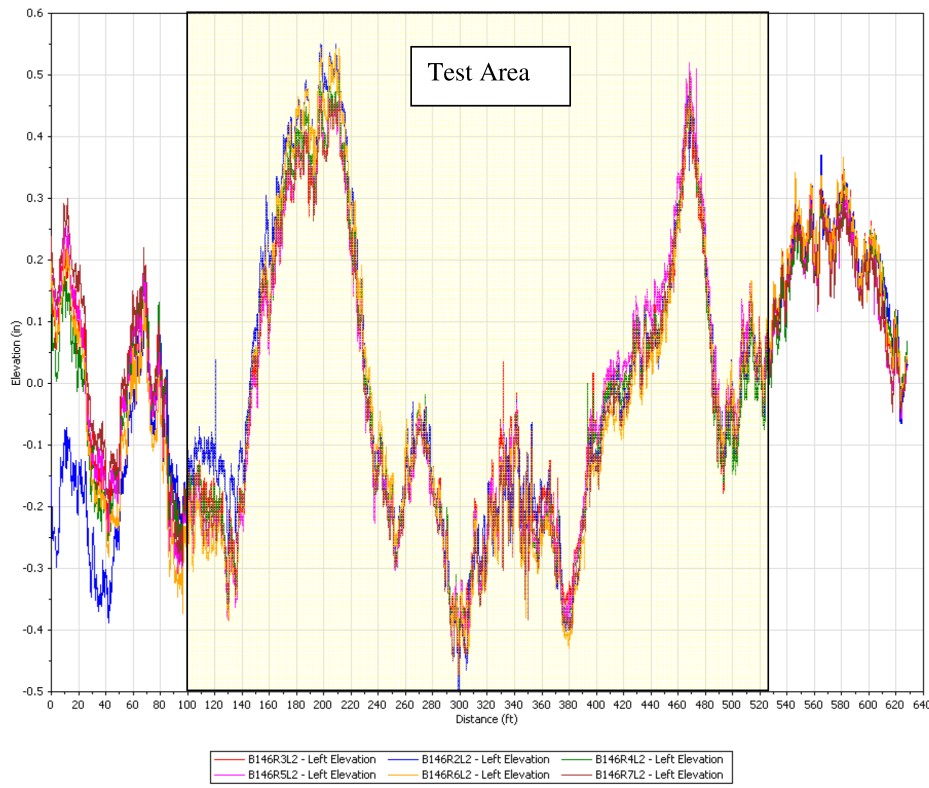
S2 Right



S2 ICC Right Wheelpath

Dynatest 146

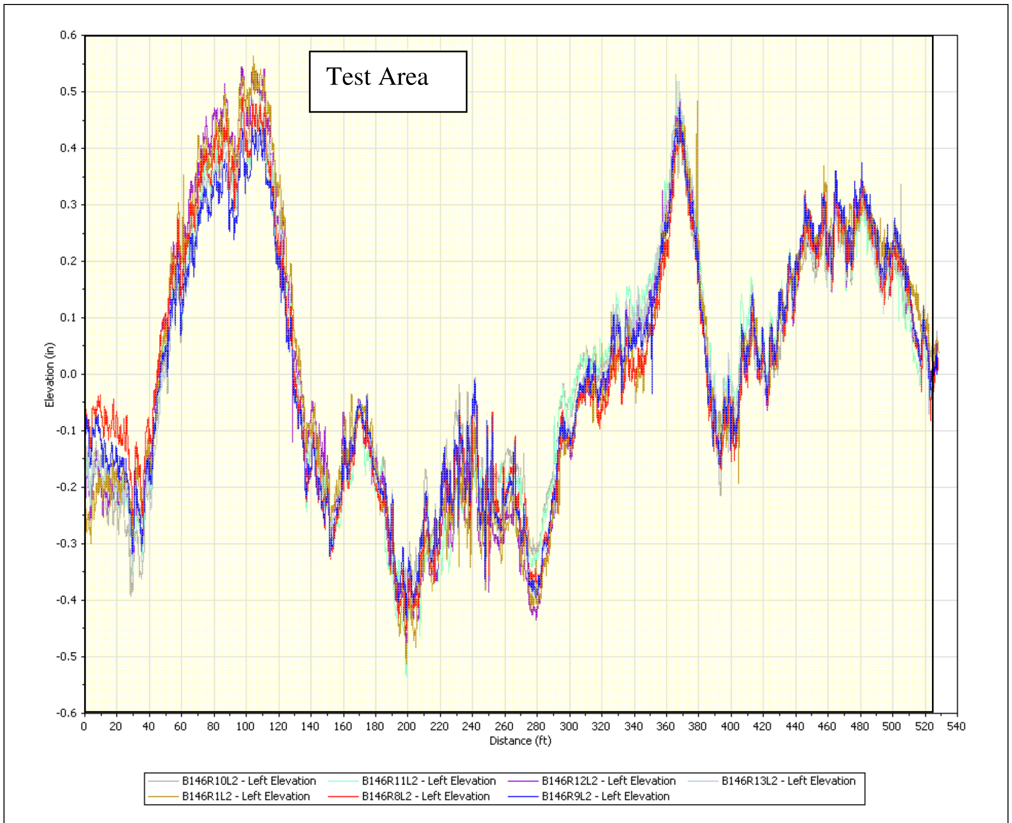
S1 Left



S1 Dynatest 146 Left Wheelpath (mistriggered 100 foot before the test site)
Profiles were adjusted in the editor

Dynatest 146

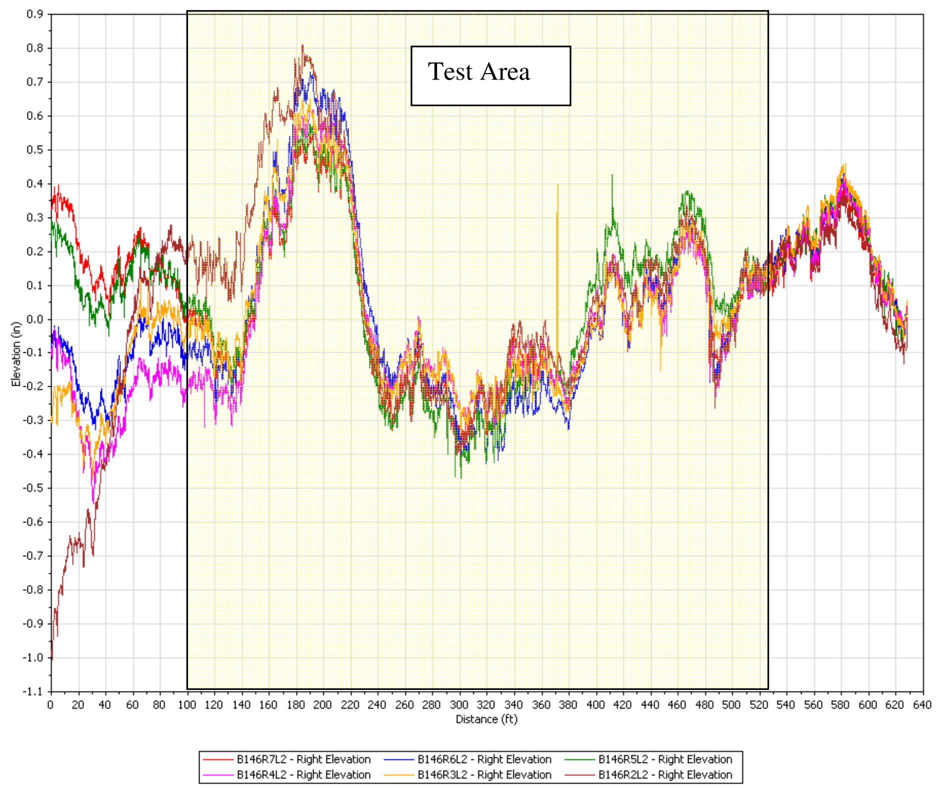
S1 Left



S1 Dynatest 146 Left Wheelpath (properly triggered a the zero location)

Dynatest 146

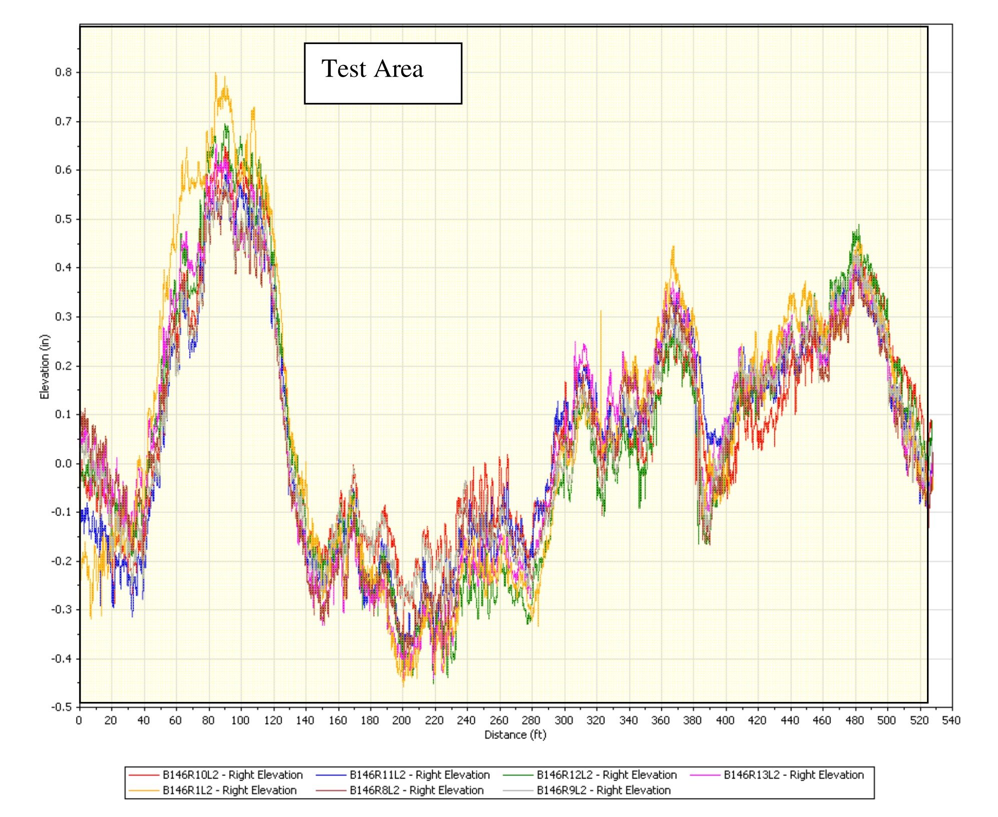
S1 Right



S1 Dynatest 146 Right Wheelpath (mistriggered 100 foot before the test site)
Profiles were adjusted in the editor

Dynatest 146

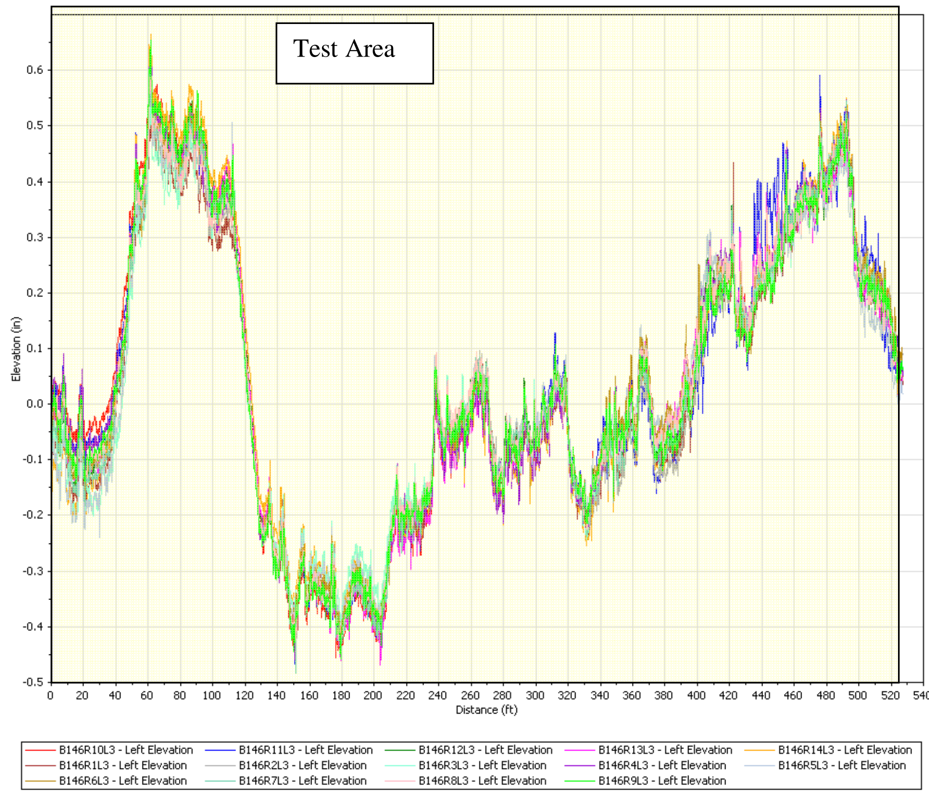
S1 Right



S1 Dynatest 146 Right Wheelpath (properly triggered a the zero location)

Dynatest 146

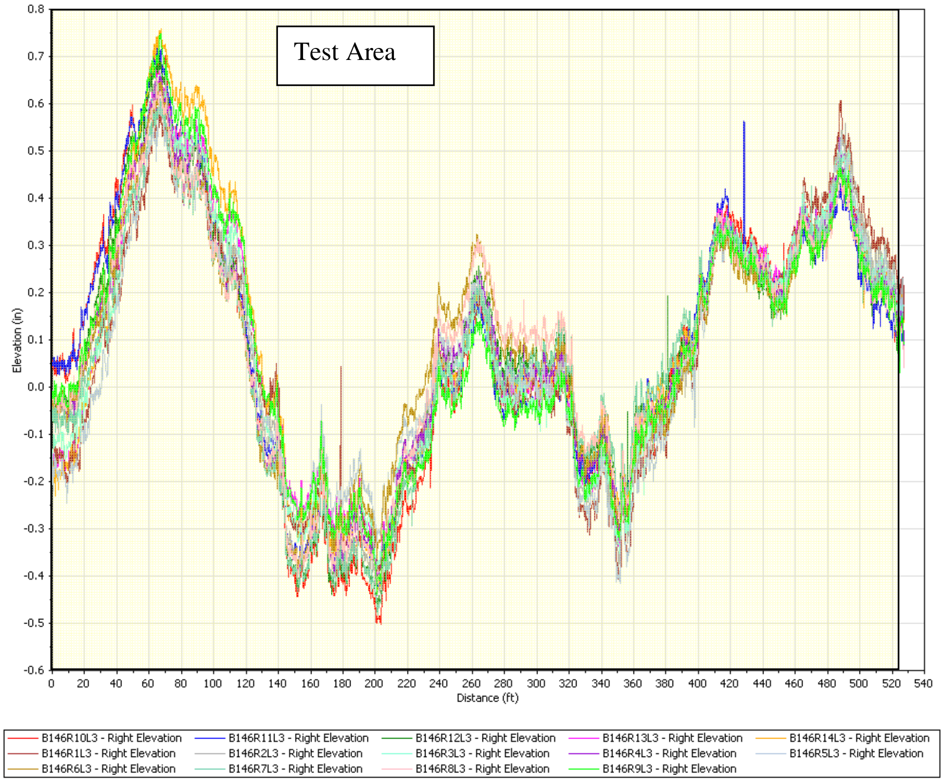
S2 Left



S2 Dynatest 146 Left Wheelpath

Dynatest 146

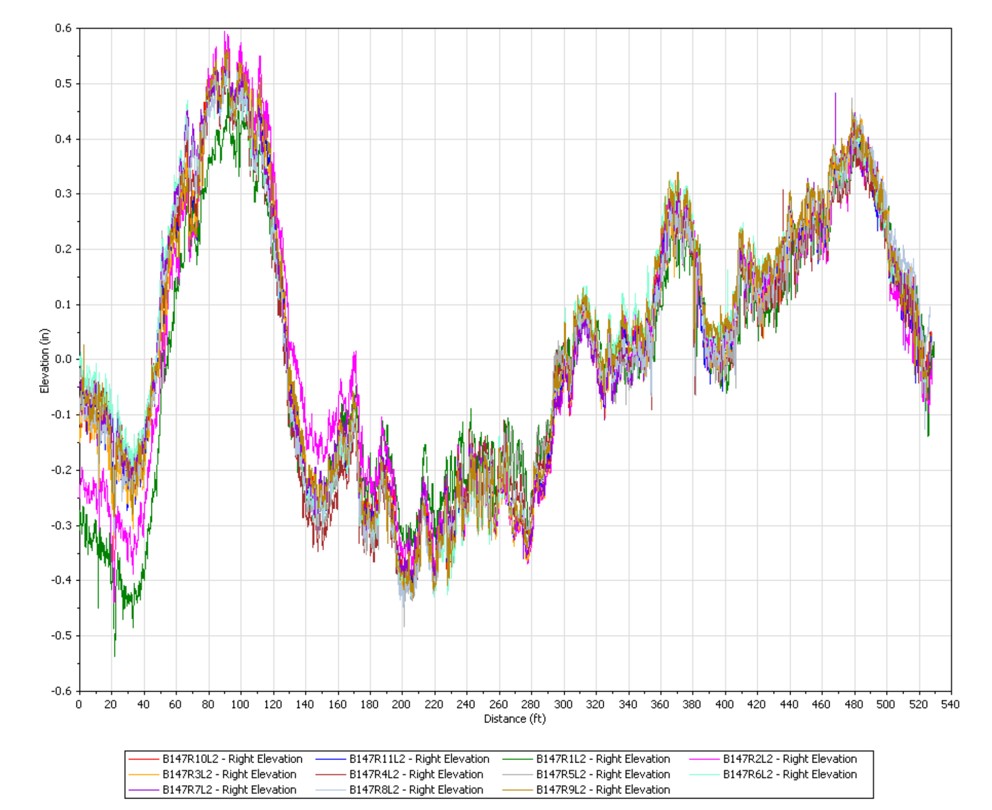
S2 Right



S2 Dynatest 146 Right Wheelpath

Dynatest 147

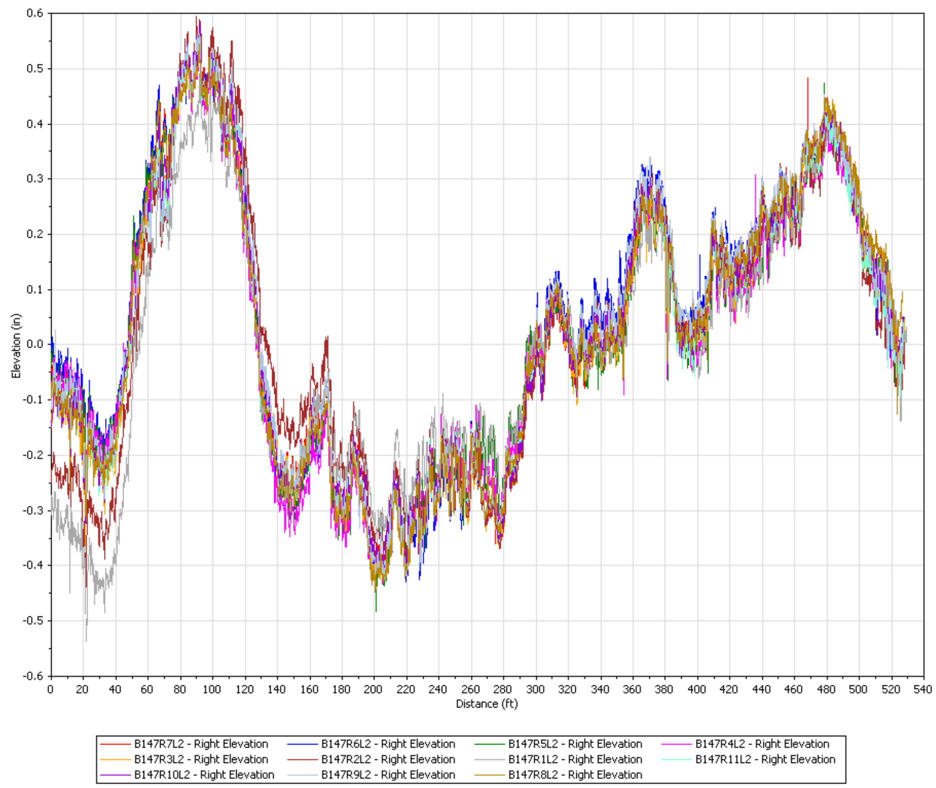
S1 Left



S1 Dynatest 147 Left Wheelpath

Dynatest 147

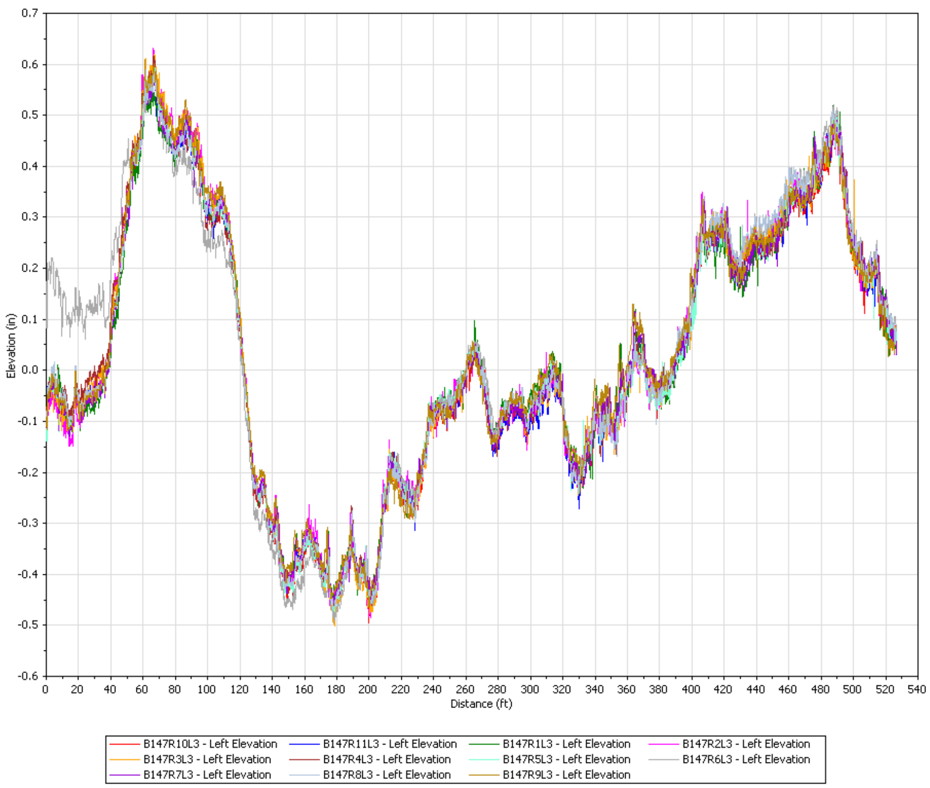
S1 Right



S1 Dynatest 147 Right Wheelpath

Dynatest 147

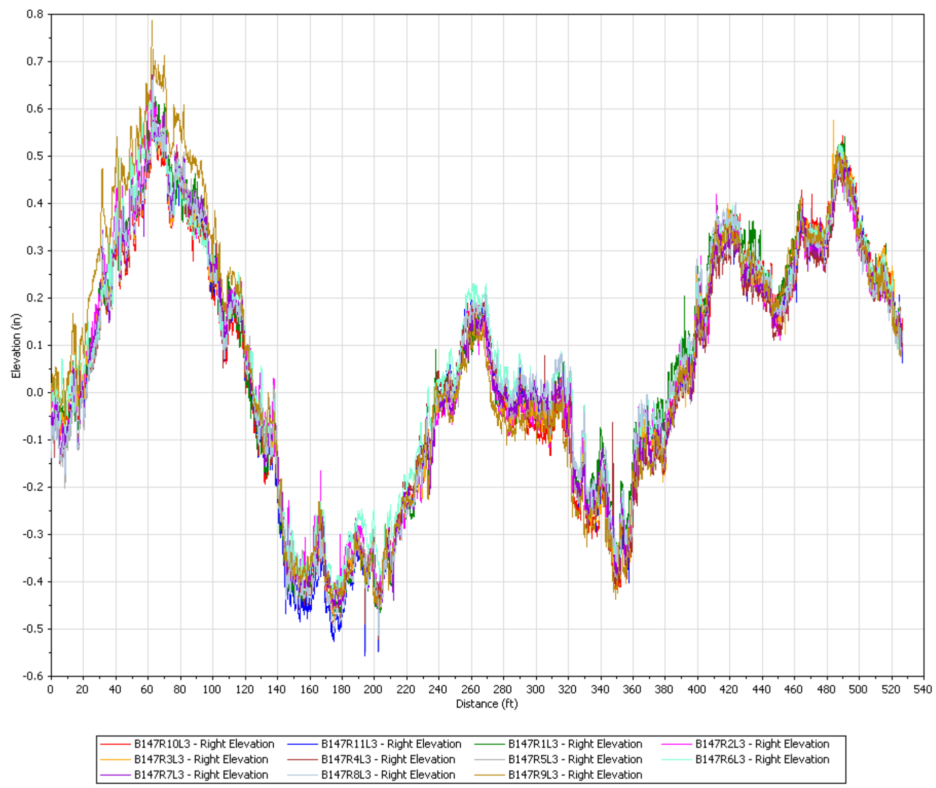
S2 Left



S2 Dynatest 147 Left Wheelpath

Dynatest 147

S2 Right



S2 Dynatest 147 Right Wheelpath

Profiler Certification Analysis Test Results

SurPRO 2000
S1 Left

Repeatability - Left Correlations

Run	2	3	4	5	6	7	8	9	10
1	99	99	99	98	98	98	99	98	99
2		99	99	98	98	97	98	97	99
3			99	98	98	98	98	97	99
4				98	97	97	98	97	99
5					99	99	99	98	98
6						99	99	98	98
7							99	99	98
8								98	98
9									97

Repeatability - Right Correlations

Run	2	3	4	5	6	7	8	9	10
1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3			n/a	n/a	n/a	n/a	n/a	n/a	n/a
4				n/a	n/a	n/a	n/a	n/a	n/a
5					n/a	n/a	n/a	n/a	n/a
6						n/a	n/a	n/a	n/a
7							n/a	n/a	n/a
8								n/a	n/a
9									n/a

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2		0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.2
3			0.0	0.0	0.0	0.0	0.0	0.0	0.1
4				0.0	0.0	0.0	-0.1	0.0	0.1
5					0.0	0.0	-0.1	0.0	0.1
6						0.0	0.0	0.0	0.1
7							-0.1	0.0	0.1
8								0.0	0.2
9									0.1

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3			n/a	n/a	n/a	n/a	n/a	n/a	n/a
4				n/a	n/a	n/a	n/a	n/a	n/a
5					n/a	n/a	n/a	n/a	n/a
6						n/a	n/a	n/a	n/a
7							n/a	n/a	n/a
8								n/a	n/a
9									n/a

Accuracy

Run	Left
8	99
7	99
6	99
5	99
4	98
10	98
3	98
2	99
1	98
9	99

Statistics

Statistic	Repeatability - Left	Accuracy - Left
Comparison Count	45	10
% Passing	100	100
Mean	98	99
Minimum	97	98
Maximum	99	99
Standard Deviation	0.7	0.5
Grade	Passed	Passed

SurPRO 2000
S1 Right

Repeatability - Left Correlations

Run	2	3	4	5	6	7	8	9	10
1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3			n/a	n/a	n/a	n/a	n/a	n/a	n/a
4				n/a	n/a	n/a	n/a	n/a	n/a
5					n/a	n/a	n/a	n/a	n/a
6						n/a	n/a	n/a	n/a
7							n/a	n/a	n/a
8								n/a	n/a
9									n/a

Repeatability - Right Correlations

Run	2	3	4	5	6	7	8	9	10
1	97	98	98	97	98	96	96	96	97
2		97	95	98	97	95	94	94	97
3			98	96	98	96	97	96	96
4				96	97	97	97	97	95
5					96	95	95	94	96
6						96	96	95	96
7							96	95	94
8								97	94
9									93

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3			n/a	n/a	n/a	n/a	n/a	n/a	n/a
4				n/a	n/a	n/a	n/a	n/a	n/a
5					n/a	n/a	n/a	n/a	n/a
6						n/a	n/a	n/a	n/a
7							n/a	n/a	n/a
8								n/a	n/a
9									n/a

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
2		0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
3			0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1
4				0.0	0.0	0.0	-0.1	-0.1	-0.1
5					0.0	0.0	-0.1	0.0	0.0
6						0.0	-0.1	0.0	0.0
7							-0.1	0.0	-0.1
8								0.0	0.0
9									0.0

Accuracy

Run	Right
10	98
9	96
8	98
7	98
6	96
5	97
4	95
3	96
2	96
1	95

Statistics

Statistic	Repeatability - Right	Accuracy - Right
Comparison Count	45	10
% Passing	87	100
Mean	96	97
Minimum	93	95
Maximum	98	98
Standard Deviation	1.3	1.2
Grade	Passed	Passed

SurPRO 2000
S2 Left

Repeatability - Left Correlations

Run	2	3	4	5	6	7	8	9	10
1	92	97	95	97	97	93	98	96	95
2		93	96	92	94	96	92	93	95
3			96	97	98	93	98	97	96
4				95	97	95	95	96	98
5					97	93	98	97	96
6						94	97	97	98
7							93	95	95
8								97	96
9									96

Repeatability - Right Correlations

Run	2	3	4	5	6	7	8	9	10
1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3			n/a	n/a	n/a	n/a	n/a	n/a	n/a
4				n/a	n/a	n/a	n/a	n/a	n/a
5					n/a	n/a	n/a	n/a	n/a
6						n/a	n/a	n/a	n/a
7							n/a	n/a	n/a
8								n/a	n/a
9									n/a

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.2	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.3
2		-0.1	0.1	-0.1	0.0	0.0	0.1	0.2	0.2
3			0.2	0.0	0.1	0.1	0.2	0.2	0.2
4				-0.1	-0.1	-0.1	0.1	0.1	0.1
5					0.0	0.1	0.2	0.2	0.2
6						0.0	0.2	0.2	0.2
7							0.1	0.2	0.2
8								0.0	0.1
9									0.0

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3			n/a	n/a	n/a	n/a	n/a	n/a	n/a
4				n/a	n/a	n/a	n/a	n/a	n/a
5					n/a	n/a	n/a	n/a	n/a
6						n/a	n/a	n/a	n/a
7							n/a	n/a	n/a
8								n/a	n/a
9									n/a

Accuracy

Run	Left
1	96
2	95
3	97
4	97
5	96
6	98
7	96
8	96
9	97
10	98

Statistics

Statistic	Repeatability - Left	Accuracy - Left
Comparison Count	45	10
% Passing	76	100
Mean	96	97
Minimum	92	95
Maximum	98	98
Standard Deviation	1.8	1.0
Grade	Passed	Passed

SurPRO 2000
S2 Right

Repeatability - Left Correlations

Run	2	3	4	5	6	7	8	9	10
1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3			n/a	n/a	n/a	n/a	n/a	n/a	n/a
4				n/a	n/a	n/a	n/a	n/a	n/a
5					n/a	n/a	n/a	n/a	n/a
6						n/a	n/a	n/a	n/a
7							n/a	n/a	n/a
8								n/a	n/a
9									n/a

Repeatability - Right Correlations

Run	2	3	4	5	6	7	8	9	10
1	99	99	99	99	99	99	97	99	99
2		99	99	99	100	99	97	99	99
3			99	99	99	99	97	99	99
4				99	99	99	97	99	99
5					99	99	97	99	99
6						99	97	99	99
7							97	99	99
8								97	98
9									99

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3			n/a	n/a	n/a	n/a	n/a	n/a	n/a
4				n/a	n/a	n/a	n/a	n/a	n/a
5					n/a	n/a	n/a	n/a	n/a
6						n/a	n/a	n/a	n/a
7							n/a	n/a	n/a
8								n/a	n/a
9									n/a

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.2
2		0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0
3			0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0
4				0.1	0.0	0.0	-0.1	0.1	0.1
5					-0.1	-0.1	-0.1	0.0	0.0
6						0.0	0.0	0.1	0.1
7							0.0	0.1	0.1
8								0.1	0.1
9									0.0

Accuracy

Run	Right
10	99
9	99
8	99
7	99
6	99
5	99
4	99
3	97
2	99
1	99

Statistics

Statistic	Repeatability - Right	Accuracy - Right
Comparison Count	45	10
% Passing	100	100
Mean	99	99
Minimum	97	97
Maximum	100	99
Standard Deviation	0.8	0.6
Grade	Passed	Passed

ICC S1

Repeatability - Left Correlations

Run	2	3	4	5	6	7	8	9	10
1	86	87	91	83	87	63	84	91	81
2		88	77	67	75	72	92	93	91
3			83	74	79	69	87	91	81
4				93	94	56	76	82	71
5					90	49	68	73	62
6						53	71	79	70
7							77	71	75
8								91	90
9									89

Repeatability - Right Correlations

Run	2	3	4	5	6	7	8	9	10
1	80	83	82	79	79	62	78	86	74
2		83	65	59	64	77	90	89	85
3			76	71	74	70	82	88	75
4				88	89	50	64	73	59
5					90	44	58	67	53
6						47	60	70	58
7							84	76	81
8								88	88
9									87

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	-3.1	-4.3	-2.2	-0.3	-4.8	-3.7	-2.7	-1.2	-2.0
2		-1.2	0.9	2.6	-2.0	-0.6	0.3	1.6	1.1
3			2.0	3.7	-0.8	0.5	1.5	2.8	2.2
4				1.6	-2.9	-1.6	-0.6	0.7	0.1
5					-4.7	-3.3	-2.4	-1.0	-1.6
6						1.1	2.0	3.6	3.0
7							0.9	2.2	1.6
8								1.3	0.7
9									-0.6

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	-2.9	-4.3	-2.2	-0.3	-4.8	-3.5	-2.6	-1.4	-2.0
2		-1.2	0.9	2.8	-1.8	-0.8	0.3	1.5	0.9
3			2.0	3.7	-0.6	0.5	1.5	2.8	2.2
4				1.6	-2.7	-1.6	-0.6	0.7	0.1
5					-4.7	-3.5	-2.4	-1.0	-1.6
6						1.1	2.0	3.4	2.8
7							0.9	2.2	1.6
8								1.3	0.5
9									-0.6

Accuracy

Run	Left	Right
2	10	16
4	12	18
1	11	20
8	8	19
5	9	21
7	11	24
3	15	23
6	12	20
9	11	15
10	12	19

Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	45	45	10	10
% Passing	9	0	0	0
Mean	79	74	11	20
Minimum	49	44	8	15
Maximum	94	90	15	24
Standard Deviation	11.4	12.7	1.9	2.8
Grade	Failed	Failed	Failed	Failed

ICC S2

Repeatability - Left Correlations

Run	2	3	4	5	6	7	8	9	10
1	91	80	89	89	92	87	92	89	92
2		80	88	89	90	88	89	93	89
3			82	87	80	76	82	79	80
4				93	92	86	92	91	93
5					89	85	92	90	91
6						91	95	92	95
7							91	90	91
8								91	96
9									91

Repeatability - Right Correlations

Run	2	3	4	5	6	7	8	9	10
1	89	83	86	90	91	89	91	91	91
2		90	86	93	89	88	88	93	89
3			89	92	88	88	88	90	86
4				94	94	90	94	93	93
5					93	91	94	95	93
6						94	97	94	97
7							95	93	95
8								93	96
9									94

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	-1.4	-5.0	-1.6	-4.1	-0.5	-4.5	-4.1	-3.7	-5.0
2		-3.7	-0.3	-2.7	0.9	-3.1	-2.9	-2.6	-3.9
3			3.2	0.7	4.3	0.5	0.7	1.1	-0.3
4				-2.6	1.1	-2.9	-2.6	-2.2	-3.5
5					3.6	-0.3	-0.1	0.3	-1.0
6						-3.9	-3.7	-3.3	-4.7
7							0.1	0.5	-0.8
8								0.3	-1.0
9									-1.4

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	-1.2	-4.8	-1.4	-3.9	-0.5	-4.3	-4.1	-3.7	-5.0
2		-3.5	-0.3	-2.7	0.7	-3.1	-2.9	-2.6	-3.7
3			3.4	0.7	4.3	0.3	0.7	1.1	-0.3
4				-2.7	0.9	-2.9	-2.7	-2.4	-3.7
5					3.4	-0.5	-0.3	0.3	-1.0
6						-3.9	-3.7	-3.3	-4.7
7							0.1	0.7	-0.6
8								0.3	-1.0
9									-1.4

Accuracy

Run	Left	Right
9	79	88
7	81	84
10	68	81
3	77	84
6	77	85
4	81	90
8	86	93
5	81	91
2	82	87
1	80	91

Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	45	45	10	10
% Passing	29	49	0	40
Mean	89	91	79	87
Minimum	76	83	68	81
Maximum	96	97	86	93
Standard Deviation	4.7	3.2	4.7	3.9
Grade	Failed	Failed	Failed	Failed

Dynatest 146
S1

Repeatability - Left Correlations

Run	2	3	4	5	6	7	8	9	10
1	84	89	77	59	64	92	92	95	93
2		83	71	53	58	80	75	78	76
3			84	61	68	93	93	94	96
4				77	88	86	87	84	86
5					92	68	68	67	66
6						73	76	71	74
7							96	95	95
8								95	97
9									97

Repeatability - Right Correlations

Run	2	3	4	5	6	7	8	9	10
1	78	81	55	30	38	78	82	88	80
2		74	49	28	37	67	68	77	66
3			73	38	52	85	94	87	94
4				66	85	81	78	69	76
5					84	46	47	40	46
6						63	63	51	62
7							86	84	83
8								89	96
9									87

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.0	0.2	0.2	-0.3	-0.3	0.0	-0.2	-0.2	-0.2
2		0.2	0.2	-0.7	-0.5	-0.2	-0.3	-0.2	-0.3
3			0.0	-0.7	-0.7	-0.2	-0.3	-0.3	-0.3
4				-0.7	-0.7	-0.2	-0.3	-0.3	-0.3
5					-0.2	0.3	0.2	0.2	0.2
6						0.3	0.2	0.3	0.2
7							-0.2	0.0	-0.2
8								0.2	0.0
9									-0.2

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.0	0.2	0.2	-0.2	-0.2	0.0	-0.2	-0.2	-0.2
2		0.2	0.2	0.2	0.0	0.0	-0.2	-0.2	-0.3
3			0.0	-0.5	-0.5	-0.2	-0.3	-0.3	-0.3
4				-0.5	-0.5	-0.2	-0.3	-0.3	-0.5
5					-0.2	0.3	0.2	0.2	0.2
6						0.5	0.3	0.3	0.2
7							-0.2	-0.2	-0.3
8								0.0	0.0
9									-0.2

Accuracy

Run	Left	Right
2	80	70
10	91	82
3	76	59
9	64	34
1	48	20
4	51	23
5	71	46
6	68	50
7	71	56
8	70	49

Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	45	45	10	10
% Passing	33	7	10	0
Mean	81	68	69	49
Minimum	53	28	48	20
Maximum	97	96	91	82
Standard Deviation	12.4	18.9	12.7	19.5
Grade	Failed	Failed	Failed	Failed

Dynatest 146
S2

Repeatability - Left Correlations

Run	2	3	4	5	6	7	8	9	10
1	69	90	87	84	86	88	78	85	84
2		73	81	82	56	59	79	79	64
3			90	89	76	84	84	91	92
4				92	73	75	87	95	82
5					70	74	92	96	79
6						92	64	72	73
7							69	76	81
8								92	82
9									85

Repeatability - Right Correlations

Run	2	3	4	5	6	7	8	9	10
1	72	91	85	84	82	90	70	85	85
2		74	81	83	55	64	72	78	59
3			86	88	72	87	73	90	85
4				92	69	76	81	93	75
5					66	76	80	95	73
6						87	58	68	73
7							64	78	85
8								83	71
9									79

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.2	0.2	0.2	-0.2	-0.3	-0.2	-0.2	-0.2	0.0
2		0.0	0.0	-0.2	-0.5	-0.2	-0.2	-0.2	0.0
3			0.0	-0.2	-0.5	-0.2	-0.2	-0.2	0.0
4				-0.3	-0.5	-0.3	-0.2	-0.2	-0.2
5					-0.2	0.0	0.0	0.0	0.2
6						0.2	0.3	0.3	0.3
7							0.0	0.0	0.2
8								0.0	0.2
9									0.2

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.0	0.2	0.2	-0.2	-0.3	-0.2	-0.2	-0.2	0.2
2		0.0	0.2	-0.2	-0.3	0.0	-0.2	-0.2	0.0
3			0.0	-0.2	-0.5	-0.2	-0.2	-0.2	0.0
4				-0.3	-0.5	-0.2	-0.2	-0.2	0.0
5					-0.2	0.0	0.0	0.0	0.2
6						0.2	0.3	0.3	0.5
7							0.0	0.0	0.2
8								0.0	0.2
9									0.2

Accuracy

Run	Left	Right
9	11	16
1	13	15
8	11	16
2	13	15
10	12	17
7	12	17
6	9	19
5	15	15
4	12	17
3	13	15

Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	45	45	10	10
% Passing	16	7	0	0
Mean	81	78	12	16
Minimum	56	55	9	15
Maximum	96	95	15	19
Standard Deviation	9.6	9.8	1.6	1.3
Grade	Failed	Failed	Failed	Failed

Dynatest 147
S1

Repeatability - Left Correlations

Run	2	3	4	5	6	7	8	9	10
1	98	68	93	91	87	76	91	87	83
2		68	94	89	86	77	90	87	82
3			73	81	84	94	72	78	85
4				91	86	79	85	83	79
5					94	87	89	90	88
6						92	88	92	93
7							81	86	92
8								95	89
9									94

Repeatability - Right Correlations

Run	2	3	4	5	6	7	8	9	10
1	96	69	88	90	90	76	90	82	83
2		66	90	87	86	73	88	81	81
3			64	81	83	92	69	78	81
4				84	81	69	79	71	71
5					94	86	86	86	88
6						88	88	86	89
7							78	85	88
8								89	89
9									94

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.0	-1.0	-0.5	-0.3	-0.2	-0.5	0.0	0.0	0.0
2		-1.0	-0.5	-0.2	-0.2	-0.5	0.0	0.0	0.0
3			0.5	0.8	0.8	0.5	0.8	1.0	1.0
4				0.2	0.3	0.0	0.5	0.5	0.5
5					0.0	-0.2	0.2	0.2	0.3
6						-0.3	0.2	0.2	0.2
7							0.3	0.5	0.5
8								0.0	0.2
9									0.0

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.0	-1.0	-0.5	-0.2	-0.2	-0.5	-0.2	-0.2	0.0
2		-1.0	-0.5	-0.2	-0.2	-0.5	-0.2	-0.2	0.0
3			0.7	0.8	0.8	0.5	0.8	0.8	1.0
4				0.2	0.3	0.0	0.3	0.3	0.5
5					0.2	-0.3	0.0	0.2	0.2
6						-0.3	0.0	0.0	0.2
7							0.3	0.3	0.5
8								0.0	0.2
9									0.2

Accuracy

Run	Left	Right
2	89	86
9	89	85
4	78	78
7	85	74
1	94	90
5	93	92
8	86	86
10	93	86
6	95	88
3	92	90

Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	45	45	10	10
% Passing	24	9	50	30
Mean	86	83	89	86
Minimum	68	64	78	74
Maximum	98	96	95	92
Standard Deviation	7.2	7.9	5.2	5.6
Grade	Failed	Failed	Failed	Failed

Dynatest 147
S2

Repeatability - Left Correlations

Run	2	3	4	5	6	7	8	9	10
1	87	69	75	93	83	89	84	78	96
2		78	78	83	93	97	86	88	87
3			75	64	78	78	68	86	70
4				76	80	77	77	73	74
5					81	84	84	72	93
6						92	84	89	82
7							85	87	89
8								75	84
9									77

Repeatability - Right Correlations

Run	2	3	4	5	6	7	8	9	10
1	94	73	84	94	89	90	73	84	93
2		78	86	91	96	95	75	90	92
3			64	67	79	80	59	89	72
4				90	85	86	87	74	85
5					89	87	82	77	92
6						93	75	90	88
7							75	91	89
8								62	74
9									82

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.2	0.2	0.5	0.0	0.0	0.2	-0.2	0.0	0.0
2		0.2	0.3	0.0	-0.2	0.0	-0.3	0.0	0.0
3			0.2	-0.2	-0.3	-0.2	-0.5	-0.3	-0.2
4				-0.3	-0.5	-0.3	-0.7	-0.5	-0.3
5					-0.2	0.0	-0.3	0.0	0.0
6						0.2	-0.2	0.2	0.2
7							-0.3	-0.2	0.0
8								0.3	0.3
9									0.0

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6	7	8	9	10
1	0.2	0.2	0.5	0.0	0.0	0.2	-0.2	0.0	0.2
2		0.2	0.3	0.0	-0.2	0.0	-0.3	0.0	0.0
3			0.3	-0.2	-0.2	-0.2	-0.5	-0.2	-0.2
4				-0.3	-0.5	-0.3	-0.7	-0.3	-0.3
5					0.0	0.0	-0.3	0.0	0.0
6						0.2	-0.3	0.0	0.0
7							-0.3	0.0	0.0
8								0.3	0.3
9									0.0

Accuracy

Run	Left	Right
9	73	80
7	85	87
2	83	87
5	70	72
10	68	74
3	86	89
6	84	88
8	69	61
4	93	96
1	72	79

Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	45	45	10	10
% Passing	13	18	10	10
Mean	82	83	78	81
Minimum	64	59	68	61
Maximum	97	96	93	96
Standard Deviation	7.7	9.4	8.8	10.2
Grade	Failed	Failed	Failed	Failed

Profiler IRI Verification Test Results

ICC

S1

File	Profile	IRI (in/mi)	File	Profile	IRI (in/mi)		MRI
R1L2_01300C	Left	117.02	R1L2_01300C	Right	101.59		109.31
R2L2_01300C	Left	124.85	R2L2_01300C	Right	114.06		119.46
R3L2_01300C	Left	130.14	R3L2_01300C	Right	111.93		121.04
R4L2_01300C	Left	123.49	R4L2_01300C	Right	111.48		117.49
R5L2_01300C	Left	97.86	R5L2_01300C	Right	99.47		98.67
R6L2_01300C	Left	109.49	R6L2_01300C	Right	98.27		103.88
R7L2_01300C	Left	113.68	R7L2_01300C	Right	99.69		106.69
R8L2_01300C	Left	108.52	R8L2_01300C	Right	97.70		103.11
R9L2_01300C	Left	116.75	R9L2_01300C	Right	102.59		109.67
R10L2_01300C	Left	120.39	R10L2_01300C	Right	105.08		112.74
R11L2_01300C	Left	111.13	R11L2_01300C	Right	98.78		104.96
	Average	115.76		Average	103.69		109.73
	STDEV	9.01		STDEV	6.06		7.24
	COV	7.78		COV	5.84	COV	6.60

S2

File	Profile	IRI (in/mi)	File	Profile	IRI (in/mi)		MRI
R1L3_01300C	Left	92.54	R1L3_01300C	Right	107.58		100.06
R2L3_01300C	Left	87.31	R2L3_01300C	Right	109.37		98.34
R3L3_01300C	Left	89.68	R3L3_01300C	Right	109.94		99.81
R4L3_01300C	Left	84.51	R4L3_01300C	Right	108.08		96.30
R5L3_01300C	Left	83.52	R5L3_01300C	Right	108.51		96.02
R6L3_01300C	Left	85.93	R6L3_01300C	Right	109.44		97.69
R7L3_01300C	Left	86.03	R7L3_01300C	Right	110.93		98.48
R8L3_01300C	Left	86.36	R8L3_01300C	Right	108.97		97.67
R9L3_01300C	Left	85.90	R9L3_01300C	Right	111.20		98.55
R10L3_01300C	Left	86.44	R10L3_01300C	Right	112.53		99.49
R11L3_01300C	Left	86.17	R11L3_01300C	Right	108.98		97.58
	Average	86.76		Average	109.59		98.18
	STDEV	2.46		STDEV	1.47		1.31
	COV	2.83		COV	1.34	COV	1.34

The repeatability of the IRI of the ICC on S1 was not acceptable. The repeatability of the IRI of the ICC on S2 was acceptable.
Repeatability of 3% is acceptable.

	Accuracy		<=5% Diff is the test

ICC
S1

Left	ICC	ABS DIF	Right	ICC	ABS DIF
115.63	117.02	1.39	101.85	101.59	0.26
115.63	124.85	9.22	101.85	114.06	12.21
115.63	130.14	14.51	101.85	111.93	10.08
115.63	123.49	7.86	101.85	111.48	9.63
115.63	97.86	17.77	101.85	99.47	2.38
115.63	109.49	6.14	101.85	98.27	3.58
115.63	113.68	1.95	101.85	99.69	2.16
115.63	108.52	7.11	101.85	97.70	4.15
115.63	116.75	1.12	101.85	102.59	0.74
115.63	120.39	4.76	101.85	105.08	3.23
115.63	111.13	4.50	101.85	98.78	3.07
	Average	6.94		Average	4.68
	% Dif	6.00		% Dif	4.60

S2

Left	ICC	ABS DIF	Right	ICC	ABS DIF
80.53	92.54	12.01	107.70	107.58	0.12
80.53	87.31	6.78	107.70	109.37	1.67
80.53	89.68	9.15	107.70	109.94	2.24
80.53	84.51	3.98	107.70	108.08	0.38
80.53	83.52	2.99	107.70	108.51	0.81
80.53	85.93	5.40	107.70	109.44	1.74
80.53	86.03	5.50	107.70	110.93	3.23
80.53	86.36	5.83	107.70	108.97	1.27
80.53	85.90	5.37	107.70	111.20	3.50
80.53	86.44	5.91	107.70	112.53	4.83
80.53	86.17	5.64	107.70	108.98	1.28
	Average	6.23		Average	1.92
	% Dif	7.74		% Dif	1.78

The accuracy of the IRI of the ICC on left wheel path of S1 and S2 was not acceptable. The repeatability of the IRI of the ICC on left wheel path on S1 and S2 was acceptable.
Accuracy of 5% is acceptable

Dynatest S1 **146**

File	Profile	IRI (in/mi)	File	Profile	IRI (in/mi)		MRI
B146R1L2	Left	114.10	B146R1L2	Right	119.92		117.01
B146R2L2	Left	117.36	B146R2L2	Right	125.54		121.45
B146R3L2	Left	124.51	B146R3L2	Right	123.31		123.91
B146R4L2	Left	126.55	B146R4L2	Right	120.20		123.38
B146R5L2	Left	128.43	B146R5L2	Right	114.93		121.68
B146R6L2	Left	129.71	B146R6L2	Right	119.46		124.59
B146R7L2	Left	123.13	B146R7L2	Right	113.73		118.43
B146R8L2	Left	123.57	B146R8L2	Right	115.49		119.53
B146R9L2	Left	121.53	B146R9L2	Right	112.48		117.01
B146R10L2	Left	120.61	B146R10L2	Right	112.10		116.36
B146R11L2	Left	117.68	B146R11L2	Right	106.92		112.30
	Average	122.47		Average	116.73		119.60
	STDEV	4.84		STDEV	5.48		3.80
	COV	3.95		COV	4.69	COV	3.17

S2

File	Profile	IRI (in/mi)	File	Profile	IRI (in/mi)	MRI
B146R1L3	Left	92.19	B146R1L3	Right	102.71	92.19
B146R2L3	Left	92.86	B146R2L3	Right	95.90	92.86
B146R3L3	Left	115.54	B146R3L3	Right	80.72	115.54
B146R4L3	Left	111.24	B146R4L3	Right	87.30	111.24
B146R5L3	Left	102.63	B146R5L3	Right	90.01	102.63
B146R6L3	Left	116.24	B146R6L3	Right	84.01	116.24
B146R7L3	Left	104.03	B146R7L3	Right	92.96	104.03
B146R8L3	Left	111.88	B146R8L3	Right	88.53	111.88
B146R9L3	Left	112.32	B146R9L3	Right	83.39	112.32
B146R10L3	Left	100.35	B146R10L	Right	94.77	100.3

			3				5
B146R11L3	Left	123.42	B146R11L3	Right	80.44		123.42
	Average	107.52		Average	89.16		107.52
	STDEV	9.93		STDEV	6.98		9.93
	COV	9.24		COV	7.82	COV	9.24

The repeatability of the IRI of the Dynatest 146 on S1 and S2 was not acceptable. Repeatability of 3% is acceptable.

Accuracy <=5% Diff is the test

Dynatest 146

S1

Left	147	ABS DIF		Right	147	ABS DIF
115.63	114.1	1.53		101.85	119.92	18.07
115.63	117.36	1.73		101.85	125.54	23.69
115.63	124.51	8.88		101.85	123.31	21.46
115.63	126.55	10.92		101.85	120.2	18.35
115.63	128.43	12.8		101.85	114.93	13.08
115.63	129.71	14.08		101.85	119.46	17.61
115.63	123.13	7.5		101.85	113.73	11.88
115.63	123.57	7.94		101.85	115.49	13.64
115.63	121.53	5.9		101.85	112.48	10.63
115.63	120.61	4.98		101.85	112.1	10.25
115.63	117.68	2.05		101.85	106.92	5.07
	Average	7.12			Average	14.88
	% Dif	6.16			% Dif	14.61

S2

Left	147	ABS DIF		Right	147	ABS DIF
80.53	92.19	11.66		107.7	102.71	4.99
80.53	92.86	12.33		107.7	95.9	11.8
80.53	115.54	35.01		107.7	80.72	26.98
80.53	111.24	30.71		107.7	87.3	20.4
80.53	102.63	22.1		107.7	90.01	17.69
80.53	116.24	35.71		107.7	84.01	23.69
80.53	104.03	23.5		107.7	92.96	14.74
80.53	111.88	31.35		107.7	88.53	19.17
80.53	112.32	31.79		107.7	83.39	24.31
80.53	100.35	19.82		107.7	94.77	12.93
	123.42				80.44	
	Average	25.40			Average	17.67
	% Dif	31.54			% Dif	16.41

The accuracy of the IRI of the Dynatest 146 on S1 and S2 was not acceptable.
Accuracy of 5% is acceptable

Dynatest 147

S1

File	Profile	IRI (in/mi)	File	Profile	IRI (in/mi)		MRI
R1L2_01300C	Left	131.31	R1L2_01300C	Right	111.88		121.60
R2L2_01300C	Left	123.48	R2L2_01300C	Right	102.40		112.94
R3L2_01300C	Left	122.09	R3L2_01300C	Right	105.43		113.76
R4L2_01300C	Left	125.61	R4L2_01300C	Right	104.98		115.30
R5L2_01300C	Left	107.45	R5L2_01300C	Right	96.01		101.73
R6L2_01300C	Left	136.86	R6L2_01300C	Right	110.16		123.51
R7L2_01300C	Left	131.72	R7L2_01300C	Right	104.77		118.25
R8L2_01300C	Left	135.15	R8L2_01300C	Right	112.23		123.69
R9L2_01300C	Left	122.75	R9L2_01300C	Right	104.57		113.66
R10L2_01300C	Left	137.92	R10L2_01300C	Right	113.99		125.96
R11L2_01300C	Left	136.96	R11L2_01300C	Right	119.10		128.03
	Average	128.30		Average	107.77		118.04
	STDEV	9.18		STDEV	6.40		7.58
	COV	7.16		COV	5.94	COV	6.42

S2

File	Profile	IRI (in/mi)	File	Profile	IRI (in/mi)		MRI
R1L3_01300C	Left	88.43	R2L3_01300C	Right	108.72		98.58
R2L3_01300C	Left	88.42	R8L3_01300C	Right	100.92		94.67
R3L3_01300C	Left	92.05	R3L3_01300C	Right	103.11		97.58
R4L3_01300C	Left	87.17	R7L3_01300C	Right	110.33		98.75
R5L3_01300C	Left	85.59	R4L3_01300C	Right	108.34		96.97
R6L3_01300C	Left	89.43	R6L3_01300C	Right	106.57		98.00
R7L3_01300C	Left	87.29	R5L3_01300C	Right	111.15		99.22
R8L3_01300C	Left	87.36	R1L3_01300C	Right	109.92		98.64
R9L3_01300C	Left	86.78	R11L3_01300C	Right	108.55		97.67
R10L3_01300C	Left	86.58	R10L3_01300C	Right	112.45		99.52
R11L3_01300C	Left	87.43	R9L3_01300C	Right	111.48		99.46
	Average	87.87		Average	108.32		98.09
	STDEV	1.73		STDEV	3.56		1.40
	COV	1.97		COV	3.29	COV	1.43

The repeatability of the IRI of the on S2 left wheel path was acceptable. The repeatability of the IRI of the Dynatest 147 on the other wheel paths were not acceptable.
Repeatability of 3% is acceptable.

	Accuracy		<=5% Diff is the test

Dynatest 147

S1

Left	ICC	ABS DIF		Right	ICC	ABS DIF
115.63	131.72	16.09		101.85	110.16	8.31
115.63	131.31	15.68		101.85	111.88	10.03
115.63	136.86	21.23		101.85	96.01	5.84
115.63	123.48	7.85		101.85	102.40	0.55
115.63	107.45	8.18		101.85	104.98	3.13
115.63	122.09	6.46		101.85	105.43	3.58
115.63	125.61	9.98		101.85	104.77	2.92
115.63	135.15	19.52		101.85	112.23	10.38
115.63	122.75	7.12		101.85	104.57	2.72
115.63	137.92	22.29		101.85	113.99	12.14
115.63	136.96	21.33		101.85	119.10	17.25
	Average	14.16			Average	6.99
	% Dif	12.24			% Dif	6.86

S2

Left	ICC	ABS DIF		Right	ICC	ABS DIF
80.53	92.05	11.52		107.70	108.72	1.02
80.53	87.36	6.83		107.70	100.92	6.78
80.53	87.17	6.64		107.70	103.11	4.59
80.53	87.29	6.76		107.70	110.33	2.63
80.53	85.59	5.06		107.70	108.34	0.64
80.53	89.43	8.90		107.70	106.57	1.13
80.53	88.42	7.89		107.70	111.15	3.45
80.53	88.43	7.90		107.70	109.92	2.22
80.53	87.43	6.90		107.70	108.55	0.85
80.53	86.58	6.05		107.70	112.45	4.75
80.53	86.78	6.25		107.70	111.48	3.78
	Average	7.34			Average	2.89
	% Dif	9.11			% Dif	2.69

The accuracy of the IRI of the Dynatest 147 on right wheel path of S2 was acceptable. The repeatability of the IRI of the Dynatest 147 on the other wheel paths on S1 and S2 was not acceptable.
Accuracy of 5% is acceptable

2012 Pavement Progiler Certification Summary											
			Profile Repeatability and Accuaracy				IRI Index Repeatability and Accuracy				
	Passing	90%	90%	90%	90%				<=3%	<=5%	
High Speed Profiler											
ICC											
		Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right		Average	Stdev	COV	% DIF	
L2 Mean		93	91	95	93	Left	106.40	2.67	2.51	1.63	
						Right	93.66	1.61	1.72	0.93	
L3 Mean		91	90	93	93	Left	78.80	1.00	1.27	0.97	
						Right	106.33	2.16	2.03	1.16	
Portable Profiler											
146											
L2 Mean		90	86	90	87	Left	106.74	2.86	2.68	2.20	
						Right	96.12	1.64	1.71	1.20	
L3 Mean		92	92	91	93	Left	79.42	1.64	2.06	1.92	
						Right	106.23	0.90	0.85	0.68	
147											
L2 Mean		89	80	92	85	Left	124.14	3.92	3.16	2.44	
						Right	108.40	5.56	5.13	4.05	
L3 Mean		92	91	94	92	Left	96.12	3.50	3.64	2.52	
						Right	94.41	2.38	2.52	1.59	
Walking Profilers											
Rutgers											
L2 Mean		97.36	94.80	98.00	92.40	Left	113.98	1.36	1.19	0.87	
						Right	98.19	1.22	1.24	1.04	
L3 Mean		91.71	95.71	93.00	96.60	Left	82.99	2.12	2.55	2.08	
						Right	108.28	1.48	1.37	0.72	
Bureau of Materials											
Region - North											
L2 Mean		94.96	93.13	94.9	94.7	Left	115.27	1.62	1.41	1.08	
						Right	99.06	2.48	2.51	1.99	
L3 Mean		92.71	97.36	92.9	97.8	Left	82.73	1.52	1.84	1.51	
						Right	109.37	1.56	1.42	1.04	
Region - South											
L2 Mean		91.38	79.4	92.9	83.5	Left	121.86	3.16	2.59	2.16	
						Right	108.29	3.94	3.64	2.68	
L3 Mean		72.31	87.16	74.5	86.4	Left	88.95	4.14	4.65	3.83	
						Right	113.45	3.26	2.88	2.01	
Region - Central											
L2 Mean		95.09	93.69	96	94.6	Left	112.17	2.21	1.97	1.52	
						Right	95.85	1.89	1.97	1.37	
L3 Mean		95.89	98.69	96.33	98.7	Left	82.06	0.98	1.19	0.97	
						Right	107.02	0.69	0.64	0.44	
Trenton											
L2 Mean		94.6	89.92	93.6	91.67	Left	112.60	2.10	1.87	1.35	
						Right	99.56	2.44	2.45	2.93	
L3 Mean		92.96	94.7	92.7	95	Left	79.87	1.11	1.39	1.09	
						Right	107.28	2.23	2.08	1.58	
								Exclude Region South			
						SurPro					
						S1	115	114			
						S2	100	98			
						S3	83	82			
						S4	109	108			
						Portable					
						S1	115				
						S2	102				
						S3	88				
						S4	100				
						High Speed					
						S1	106				
						S2	94				
						S3	79				
						S4	106				

ON-BOARD SOUND INTENSITY (OBSI) EVALUATION OF QUIET PAVEMENTS UTILIZED IN NEW JERSEY

Technical Memorandum

Submitted by

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In cooperation with

New Jersey
Department of Transportation
Bureau of Research and Technology
and
U.S. Department of Transportation
Federal Highway Administration

DISCLAIMER STATEMENT

ABSTRACT

Quiet pavements have received much attention throughout the transportation related noise community, as a method of reducing highway related noise. This has spurred an interest to determine the noise related properties of current surface materials and surface modification techniques for asphalt and concrete pavement surfaces. Two methods, the close-proximity-method (CPX) and the on-board-sound-intensity method (OBSI), have gained success as practical methods of measuring sound properties of the tire/pavement interface, which is the largest contributing factor to highway noise from passenger vehicles moving over 30 mph (48.3 kph).

In New Jersey, concern over noise mitigation techniques and the exorbitant cost of implementing sound barriers has been steadily on the rise. The New Jersey Department of Transportation (NJDOT) became interested in noise mitigation via research completed by the Center for Advanced Infrastructure and Transportation (CAIT) and the National Center for Asphalt Technology (NCAT) utilizing the CPX method in 2005. The resultant research effort provided the NJDOT with valuable information allowing them to more appropriately select asphalt overlays that were not just durable and rut resistant, but also quieter.

In 2010, a research effort was initiated with the OBSI method (AASHTO TP76, *Method of Tire/Pavement Noise Using the On-Board Sound Intensity Method*) to measure new and old in-service pavements found in New Jersey. Data presented in this paper represent the OBSI noise measurements of typical pavement surfaces found in New Jersey. Attempts are also made to compare and evaluate the differences in noise and mixture properties of polymer modified and asphalt rubber Open Graded Friction Course mixes.

INTRODUCTION

As noise control becomes an overwhelming concern, Departments of Transportation (DOT) across the US and around the world are becoming increasingly interested at mitigating noise from the source (1,2). On highways, the controlling generation mechanism of noise is the tire/pavement interface (1). The On-Board-Sound-Intensity (OBSI) excels as a tire/pavement interface measurement technique, which has matured greatly over the last eight years, to quickly and efficiently evaluate in-service pavements (3).

The OBSI testing procedure is described in AASHTO TP 76-09 (4). As per the standard, all measurements were based on a 440 foot (134.1m) test section in a vehicle moving at 60 mph ±1mph (96.6kph ±1.6kph) with a 5 second measurement period, where one single A-weighted result is arithmetically averaged from the five second measurement period (4). Four microphones are utilized within this type of testing with two combined to create an intensity probe on the leading edge of the tire patch (the area that the tire contacts the pavement) and the remaining two microphones combined to make a second intensity probe, located on the trailing edge of the tire patch. Pulse, an acoustic engineering software program created by Brüel and Kjaer, is commonly used to do the aforementioned arithmetic averaging by utilizing the pressure difference between the microphones in each intensity probe, on the leading and trailing edge. This method utilizes sound intensity measurements near the tire pavement interface to single out the tire/pavement noise from the drive train, exhaust, and aerodynamic noise also produced by the vehicle. The close proximity of the microphones to the tire patch, the effective use of windscreens to ensure accurate measurements, and the ability to verify the quality of each measurement on the spot makes the OBSI method extremely useful.

Past research on pavement surface noise has shown that Portland cement concrete (PCC) typically produces higher noise levels from the tire pavement interface when compared to asphalt based surfaces (5). A significant amount of past pavement noise research has been focused on the possibility of mitigating highway traffic noise through pavement mix selection or surface treatment processes. Studies looking into the effectiveness of quiet pavements have compared typical dense graded hot mix asphalt (DGA) pavements to porous or semi-porous asphalts to find significant noise mitigating properties (6). In 2007, the National Center for Asphalt Technology (NCAT) completed a report comparing sound pressure level using the close proximity method (CPX) and sound intensity using the OBSI method for measurements of quiet pavements with open graded structures (7). Prior work on porous pavements has been conducted to measure the durability and effective design life of noise mitigating properties of open-graded and other functional overlays (8). To utilize open-graded friction courses (OGFC) for noise reduction at the tire/pavement interface, the structural properties of the mixes need to be analyzed for regionally specific needs (9). Such research has shown that OGFC overlays should be used cautiously in areas where the use of studded tires or snow chains during the winter season is prevalent, since it has been shown that studded tires significantly reduce the longevity of an OGFC life span (10). A significant amount of work has been completed in New Jersey on the use of functional thin lift overlays and their practicality as pavement surfaces in NJ, confirming that open graded asphalt pavements are a viable option for the NJDOT and can aid in noise mitigation (11).

Over the last five years, the New Jersey Department of Transportation (NJDOT) has received numerous noise complaints from residents who are located near several interstates and state highways. Many of these highways are aging and in need of future rehabilitation. However, after reviewing a federal highway administration (FHWA) Final Report regarding CPX tire/pavement interface noise measurements completed by The Center for Advanced Infrastructure and Transportation (CAIT) in 2005 (5), the NJDOT envisioned that the future rehabilitation of these pavement sections should address the possible functional components of the pavement as well as the required structural components. This would allow the NJDOT to address the pavement noise, possibly splash and spray, and other functional components while retaining rut resistance and durability. Therefore, if the NJDOT could quantify overall noise levels and spectral differences of pavement surface noise for in-service wearing courses in New Jersey, the NJDOT may be able to use the information in the pavement rehabilitation design process. If the NJDOT had a database of functional noise reducing pavements utilized in the state, information could be included during rehabilitation material selection to address pavement noise mitigation while retaining the other structural and functional needs during future rehabilitation.

To accomplish this, a pavement noise evaluation was conducted for the NJDOT in the spring of 2010 using the OBSI method to measure the tire/pavement interface noise of various asphalt pavement surfaces in-service in New Jersey. The pavements measured were chosen as representative samples of typical surface courses and functional thin lift overlays found in the state of New Jersey. The tested sections included two PCC pavements, three DGA pavements each paved in one year increments, two asphalt rubber open graded friction course (AROGFC) paved two years apart, and two polymer modified open graded friction courses (MOGFC), also paved two years apart.

OBJECTIVES

In the age of sustainability, an often forgotten aspect of environmental stewardship is reducing traffic noise generated at the tire/pavement interface. Pavement surfaces and materials can be selected by state agencies not just for structural reasons, but also for functional purposes, such as noise mitigation. The main objective of the research study was to develop a database of pavement noise measurements for various pavement surfaces in New Jersey, and to compare the noise mitigation properties of polymer-modified and asphalt rubber modified open graded friction course mixtures.

TESTING PROCEDURES

The test data presented in the paper was measured using a Chevy Malibu test vehicle. The test vehicle weighed 4,200 lbs with a full tank of fuel, all testing equipment, and two technicians. Before and after testing, the microphones were verified using a Larson Davis CAL200 94 dB signal generator. Before and after testing, the Standard Reference Test Tire (SRTT) was measured for hardness at every quadrant of the tire across each tread using a type A tire durometer (12). After the tire was mounted to the vehicle, the microphone spacing and placement was measured to ensure the distances were within the AASHTO TP76 specifications (4). Windscreens were always used while testing in New Jersey to ensure the least amount of wind generated interference. A picture of the final mounting arrangement is shown in Figure 1. The mounting, setup, and calibration of the equipment was done in the field, as close to the test site as possible, and if a second calibration was required, it was completed in the field. All of the

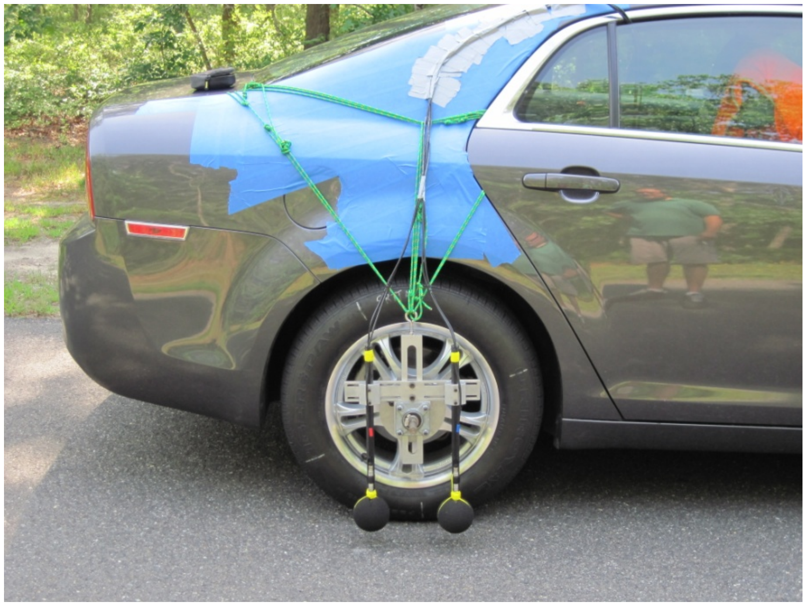

Figure 1 – On-Board Sound Intensity (OBSI) Mounting System

testing and results utilized for this paper were completed in the right lane, at 60 mph ± 1mph (96.6 ± 1.6kph). Any possible interference, such as a large truck passing by, a sound wall, or an overpass, was recorded by the technician during testing, and considered during post-analysis. The coherence between the two microphones on each intensity probe and PI spectrum were monitored during each test to ensure the validity of each measurement. A complete record of written data was compiled in conjunction with each measurement completed in the field.

TEST SECTIONS

Test locations (sites) are designated within this paper as the interstate or highway being tested, where a known material exists, typically designated by mile markers. Each test location was broken down into test sections by utilizing the mile marker signs as start points for measurements. Each test location was chosen either from a list of noise complaints provided by the NJDOT or because the pavement at that location was a functional overlay that could possibly provide noise reduction benefits. Each test section was a 440 ft (134.1 meters) long section where a 5 second noise measurement was completed. A test section was designated at each mile marker and sometimes at each half mile marker, based on the length of the test site. If the test site was less than 5 miles long, the half mile markers were usually used to gather more data about each pavement type. Using the mile marker signs ensured that the measurements were taken at the same start point during each consecutive measurement, required less time to set up test sections overall, and more easily allowed for pavement distinction based on pavement records provided by NJDOT that typically reference mile markers. The test sections evaluated in the study are described in the following sections.

NJ Rt. 202

The Rt. 202 location was paved in 2007 with a 12.5mm mix, with a PG76-22 asphalt binder (12.5H76). This test site was located from mileposts 14 to 18 southbound in Hunterdon County

NJ. Rt. 202 is a 2 lane, 55 mph state highway in Readington Township, NJ with a southbound annual average daily traffic of 18,790 (AADT) in 2008.

NJ Rt. 3

The Rt. 3 location was a 12.5mm PG76-22 (12.5H76) mix that was paved in 2008. The Rt. 3 test site was 3 miles long between mileposts 3 and 6 both northbound and southbound in Passaic County NJ. Rt. 3 is a 3 lane, 55 mph state highway used as a major thoroughfare between the George Washington Bridge and I-80 which had an average annual daily traffic of 124,050 (AADT) in 2008.

Garden State Parkway (GSP)

Three test locations were selected on the Garden State Parkway (GSP), all of which were 2 lane, 65 mph zones. A 12.5mm PG76-22 (12.5H76) mix which was paved in 2009 was tested between mileposts 38 to 48 northbound and southbound. The site connected Egg Harbor Township, NJ to Port Republic City, NJ. A polymer modified open graded friction course (MOGFC) that was paved in 2007 was tested between milepost 24 to 26 in Upper Cape May Township in Cape May County. A second MOGFC which was paved in 2009 was tested between mileposts 41 to 48 southbound, from Galloway Township NJ, to Port Republic City, NJ. The last available average annual daily traffic count suggests that in 2007, all three sites had 4712 AADT.

Interstate 95 (New Jersey)

The location tested on I-95 was an asphalt rubber open graded friction course (AROGFC) mix that was paved in 2007. The site stretched through Mercer County, between mileposts 4 and 8 both northbound and southbound from Ewing, NJ to the intersection of I-295 near Lawrenceville, NJ. The I-95 site was a 3 lane, 65 mph zone, with an average annual daily traffic of 84,079 (AADT) in 2008.

Interstate 280 (New Jersey)

On I-280 the test site was a roughly ground Portland cement concrete (PCC) in Essex County, NJ. The site ranged from milepost 6 -13 eastbound and westbound. This part of I-280 is a major connector between I-80 and I-95, which is a 4 lane, 65 mph zone with an average annual daily traffic of 102,482 (AADT), in 2008. The site was in the middle of a rehabilitation project when testing occurred. The PCC there was treated with a rough surface grind to reduce the bumps produced by joint heaving. The project will be receiving an AROGFC wearing course in the summer of 2010.

Interstate 295 (New Jersey)

On I-295, a 7 mile test site with a well worn PCC was tested. The I-295 location was in Burlington County, on a 3 lane, 65 mph zone, which ranged from Springfield Township to Bordentown Township from mile markers 49 to 56, northbound and southbound. This part of I-

295 is just south of the connection to Rt. 1, I-95, and the City of Trenton. The average annual daily traffic measured in 2007 for the test section was 65,000 vehicles.

Interstate 78 (New Jersey)

On I-78, an asphalt rubber open graded friction course (AROGFC), which had a PG64-22 binder modified with asphalt rubber, was paved in 2009. The tested site was a 6 miles long, 4 lane, 65 mph zone in Somerset County that ranged from mileposts 34 to 41 both westbound and eastbound, with an average annual daily traffic of 70,904 (AADT) in 2008. The section ranges from Bernards Township, NJ to Warren Township, NJ at the border of Somerset and Warren County.

ON-BOARD SOUND INTENSITY TEST RESULTS

The results displayed for the OBSI measurements were recorded in A-weighted decibels. The overall OBSI level is the arithmetic average of the recorded sound intensity levels at each one third octave band frequency. Each spectrum chart shows the recorded sound intensity level relative to a one third octave band spectrum. Table 1 shows the mix design information related to the I-78 AROGFC, the I-95 AROGFC, and the Garden State Parkway MOGFC mixes.

Results for the tire/pavement interface noise collected in the spring of 2010 are shown in Figure 2. Figure 2 shows the overall sound intensity levels in dBA of each test site from the highest on the left to the lowest on the right. Each site shown on Figure 2 is representative of a distinct pavement surface type. The overall sound intensity levels for each site were calculated by averaging each valid measurement from each 440 foot (134.1 meter) test section found within each test location. A single standard deviation for each material was included to show the accuracy of the averaging procedure for each material. This methodology was applied to ascertain an overall material characterization of each material. As seen with the standard deviation bars, the more test sections within each test site, the more variation that was found in the material, which represents the reality of materials due to variable states of disrepair, as well as the ability of testing the identical wheelpath area on repeat runs. As seen in Figure 2, at an overall level of 107.4 dBA, the rough ground PCC from I-280 was the loudest section tested, while the quietest section tested was the GSP 2009 MOGFC section which had an overall OBSI level measured at 96.8 dBA. The PCC pavements tested were over 4 dBA higher than the loudest DGA, the Rt. 3 12.5H76 site which was paved in 2008.

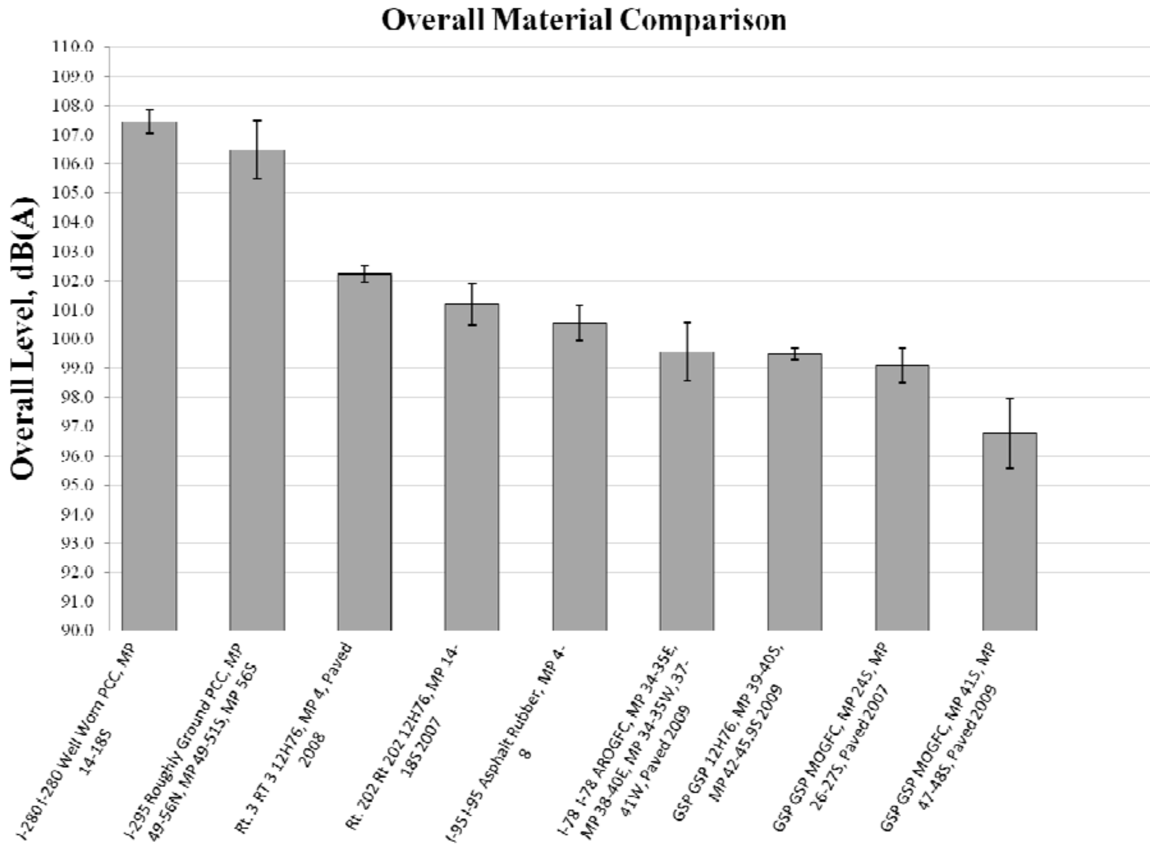

Figure 2 – On-Board Sound Intensity (OBSI) Measurement for Selected Test Sections

Figure 3 shows the spectrum analysis of the roughly ground PCC tested on I-280, and the aged PCC tested on I-295. The spectrum analysis shown in Figure 3 shows the difference between the sound intensity levels at one third octave band spectrum. The roughly ground PCC was almost 1 dBA louder overall, but the spectrum showed that it was louder from the 1600hz one third octave band and higher. The surface of the PCC on I-280 was 2 - 3 dBA louder than the I-295 PCC. The surface of the I-280 PCC was treated with a rough grind to alleviate any disparities in joint elevation, where joint heave had occurred due to improper undersealing procedures. This grinding appears to have reduced the peak seen in the I-295 PCC around 800hz, but it is suspected that the intense macro-texture led to an increase of the overall noise level. Overall, the PCC sections that were tested in the spring of 2010 were louder than every other pavement tested.

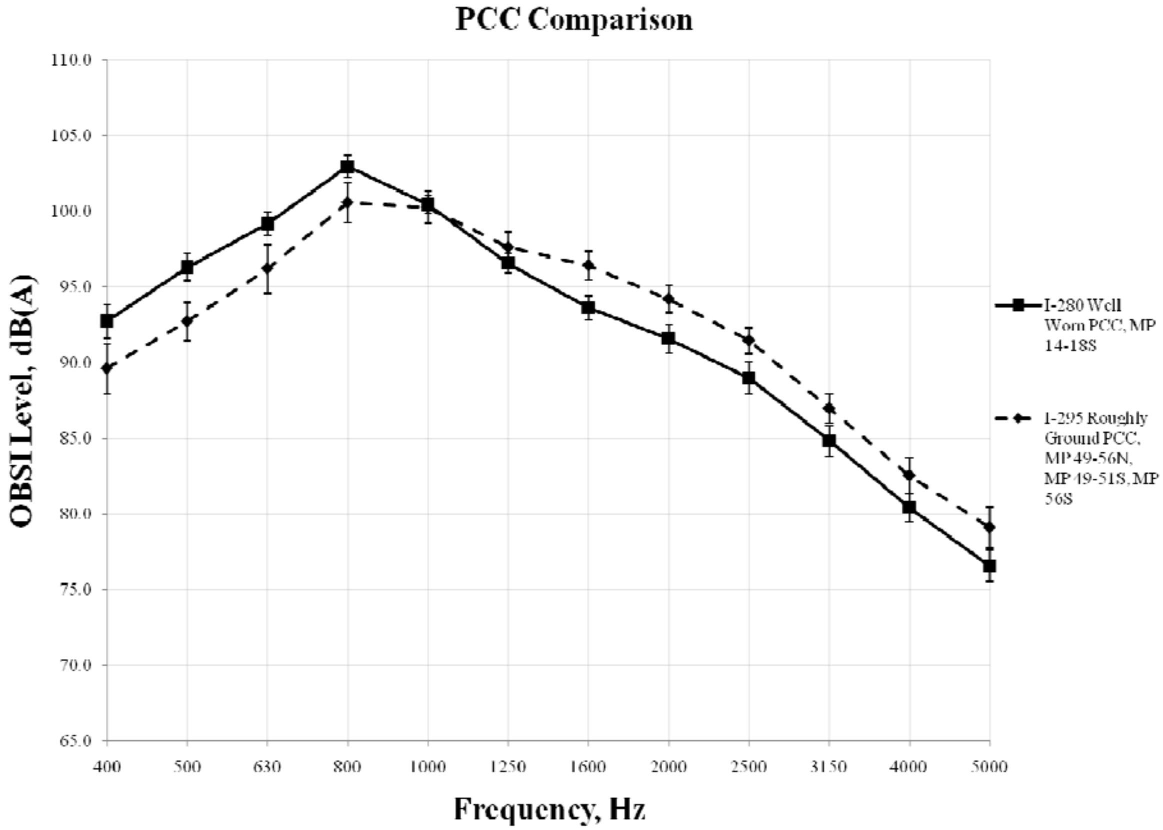

Figure 3 – Noise Spectrum Analysis for Concrete Test Sections

Figure 4 shows the spectrum analysis of the Rt. 3 12.5H76, the Rt. 202 12.5H76, and the GSP 12.5H76 materials. The DGA's measured in the Spring of 2010 all showed similar spectral trends. As shown in Figure 2, the Rt. 3 12.5H76 had an overall OBSI level of 102.2 dBA, the Rt. 202 12.5H76 had an overall OBSI level of 101.2 dBA, and the GSP 12.5H76 had an overall OBSI level of 99.5 dBA. Figure 4 shows that the pattern was similar for each surface, although the magnitude was different. It is hypothesized that even though the Rt. 3 DGA from 2008 was louder than the Rt. 202 DGA from 2007, the traffic load on the Rt. 3 DGA was over 6.5 times as much as the Rt. 202 section, possibly indicating that the additional traffic may have increased the exposure of aggregate in the wheelpath area on the Rt. 3 12.5H76 sections. The GSP 12.5H76 spectrum showed lower sound intensity levels between the 800hz to 1600hz one third octave band levels, which leads us to believe that the air voids have not seen the amount of traffic that the other two dense graded asphalts have seen, which is supported by the 4712 AADT.

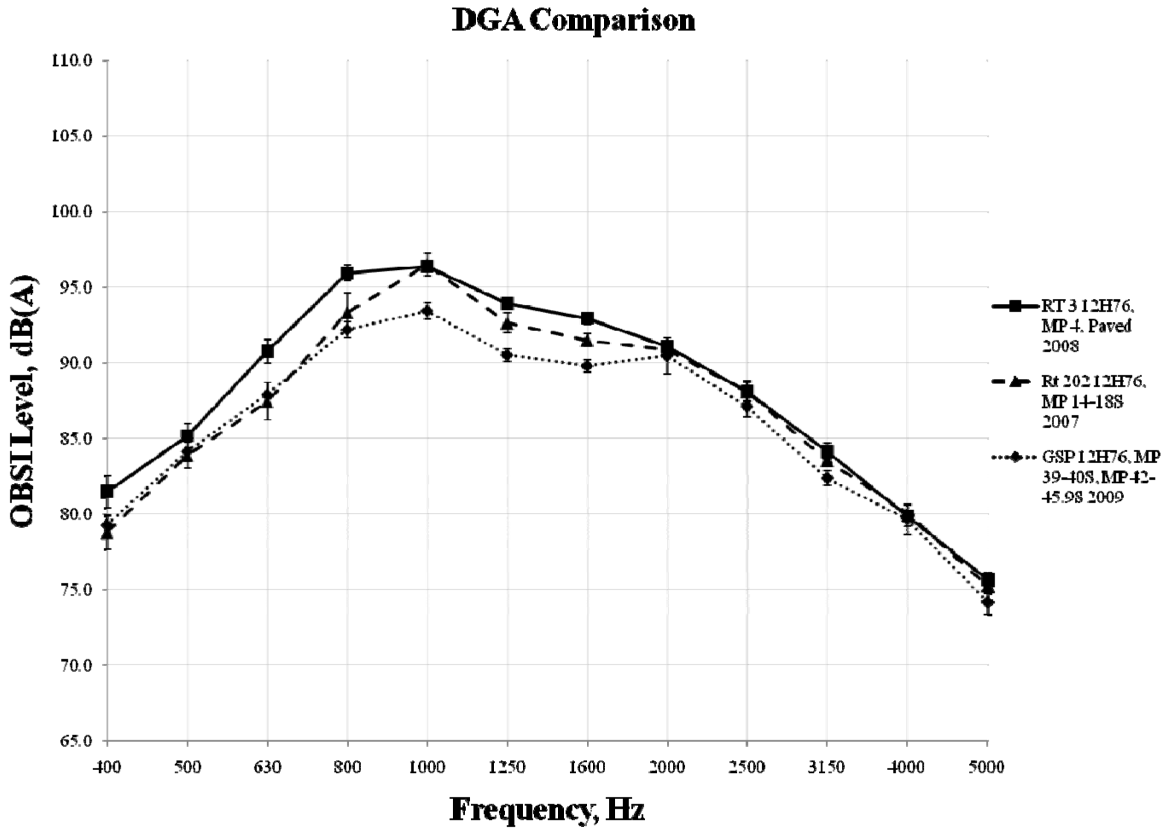

Figure 4 – Noise Spectrum Analysis for Dense-Graded Asphalt Mixture Sections

Figure 5 shows the spectrum analysis from the I-95 AROGFC and the I-78 AROGFC test sites. The I-95 AROGFC was paved in 2007 and the I-78 AROGFC was paved in 2009. The overall level of the I-95 AROGFC was 100.5 dBA and the overall level of the I-78 AROGFC was 99.6, as seen in Figure 2, which is not a large difference. Figure 5 on the other hand, shows the spectrum analysis of the two AROGFCs, which suggests that there are some differences between the 500hz to 1000hz frequencies and between the 2000hz to 3150hz frequencies on the one third octave band spectrum. Since both roads see a similar amount of annual daily traffic, it seems that the I-95 AROGFC which is two years older than the I-78 AROGFC, the mixture properties themselves were further reviewed. Table 1 lists the job mix formula (JMF) information for the OGFC test sections in the study. Table 1 clearly indicates a large difference in design air voids between two AROGFC mixes, with the I-78 AROGFC designed to accommodate almost 11% more air voids by volume. This disparity in volumetric design is most likely the reason for the differences in the one third octave band spectrum.

Regardless, the spectrum does suggest that although the two AROGFC pavements have had some time to age, they still retain the properties of a “quiet pavement”, which has reduced sound pressure levels in the 1000hz to 4000hz range on the one third octave band spectrum, where the average human range is more negatively affected.

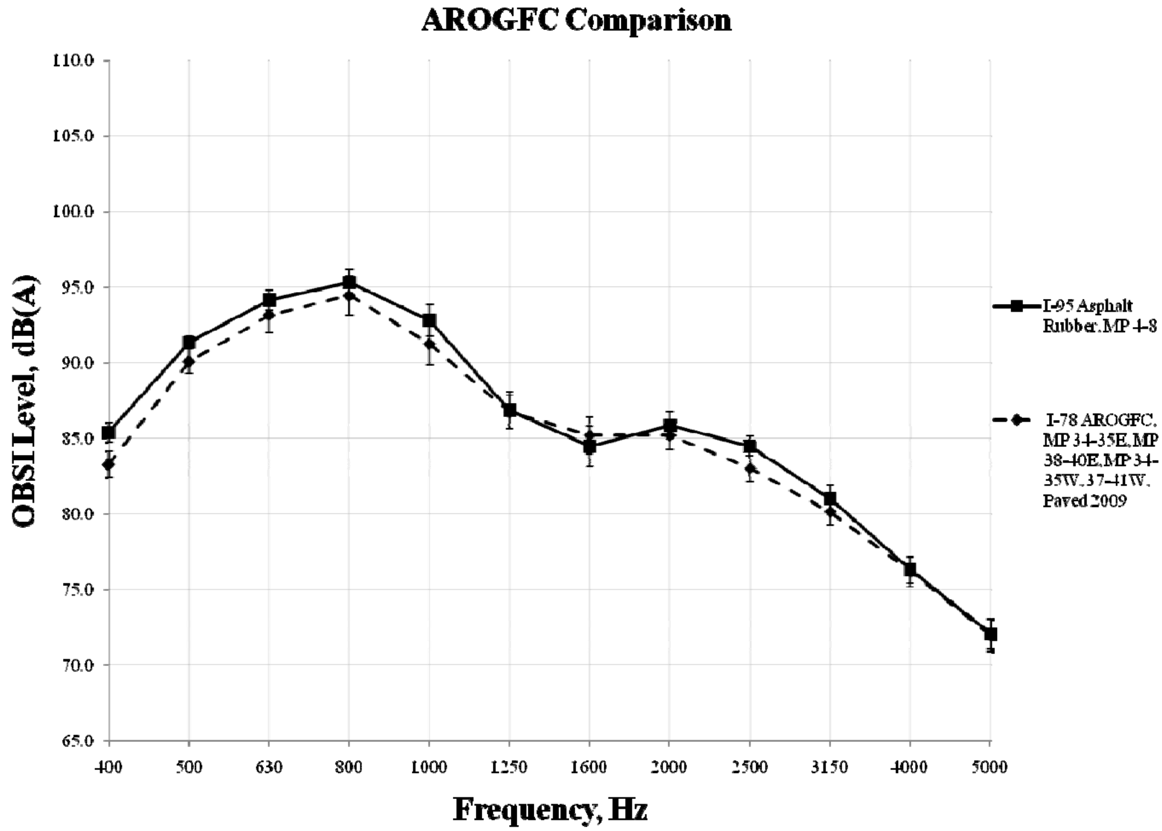

Figure 5 – Noise Spectrum Analysis for Asphalt Rubber Open Graded Friction Course (AROGFC) Sections

Table 1 - Mix Design Gradations for Polymer Modified Open Graded Friction Course and Asphalt Rubber Open Graded Friction Course Sections

Parameter	I-78 AROGFC	I-95 AROGFC	MOGFC (2007)	MOGFC (2009)
12.5mm	100	100	100	100
9.5mm	97.0	94.4	90.1	88.9
4.75mm	31.0	31.0	31.0	27.2
2.36mm	7.8	7.0	10.0	11.5
1.18mm	5.8	4.0	8.8	8.9
.600mm	4.0	4.0	7.2	7.0
.300mm	3.1	3.0	5.8	3.9
.150mm	2.0	2.0	4.6	3.3
.075mm	0.9	2.0	3.5	3.0
PG Grade	64-22	64-22	76-22	76-22
PB, %	8.5	8.6	5.7	5.7
Air Voids, %	25.5	14.1	19.7	21
VMA, %	39.4	31.1	N/A	N/A
Other	16% Crumb Rubber	19.5% Crumb Rubber	.3% Cellulose Fiber	.3% Cellulose Fibers + Anti Stripping Additive

Figure 6 shows the spectrum analysis for the MOGFC from the GSP, which was paved in 2009, and the MOGFC from the GSP which was paved in 2007. The MOGFC between mile marker 24S, 26-27S, was paved in 2007, while the MOGFC between mile marker 41S, 47-48S was paved in 2009. In Figure 2, the overall dBA level of the older 2007 MOGFC was 99.1 dBA, while the 2009 MOGFC, which was tested the following day and under identical environmental conditions, was 96.8 dBA. The MOGFC mix designs shown in Table 1 are similar in asphalt binder grade, design air void percentage, and gradation. Therefore, since the materials for both sections are extremely similar, the differences in the noise spectrum analysis is most likely a function of the aging (general stiffening) and minimal surface wearing due to accumulated vehicle passes.

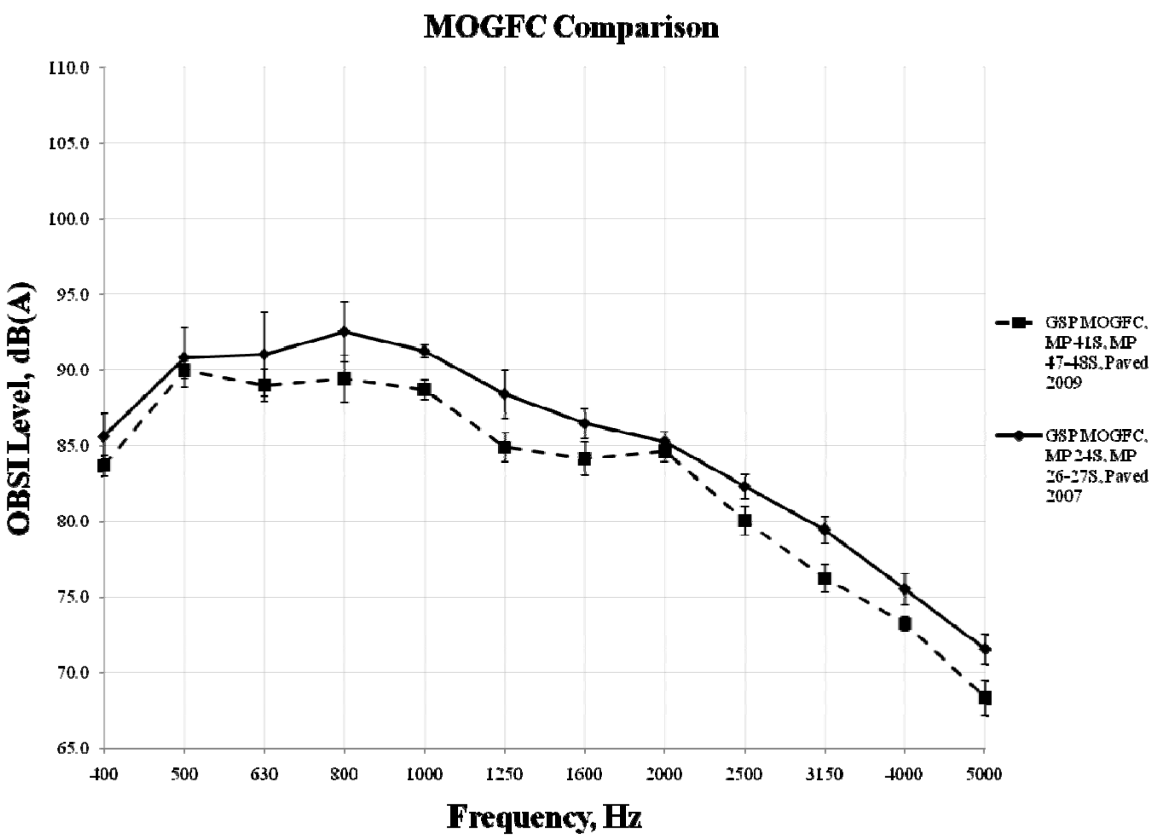

Figure 6 – Noise Spectrum Analysis for Polymer Modified Open Graded Friction Course (MOGFC) Sections

Dense Graded Asphalt (DGA) vs. Open-Graded Friction Course (OGFC)

When comparing the three DGA mixes with the OGFC mixes, it is easy to see that although the overall sound levels portrayed on Figure 2 suggest that the materials are somewhat similar, the spectrum analysis shows differently. Figure 7, which shows the OGFC mixes compared to the DGA mixes, begins to explain why OGFC materials in NJ are perceived as quieter. The DGA mixes, including the newest GSP 12.5H76, had noticeably higher measured sound intensity levels, from the 1250hz one third octave band frequency and higher. Even around 2500hz, where the older AROGFC had an average sound intensity 84.5 dBA, the newest DGA was almost 3 dBA higher at 87.1 dBA. At the low end of the measured spectrum, both the MOGFC and AROGFC mix types have higher recorded values. In the case of the GSP 12.5H76, the recorded intensity level at 500hz was 84.1 dBA, while the 2 year old AROGFC from I-95 was recorded at 91.4 dBA, which is a significant difference. Given this data, it is suspected that although the 500hz - 630hz one third octave band frequencies are higher for the New Jersey open graded mixes, the tone is less annoying to the receiver than the dense graded mixes which all have elevated A-weighted decibels from the 1250hz - 5000hz one third octave band center frequency range. It is hypothesized that the increased air void content of the OGFC surfaces are creating this attenuation of noise in the higher frequency range.

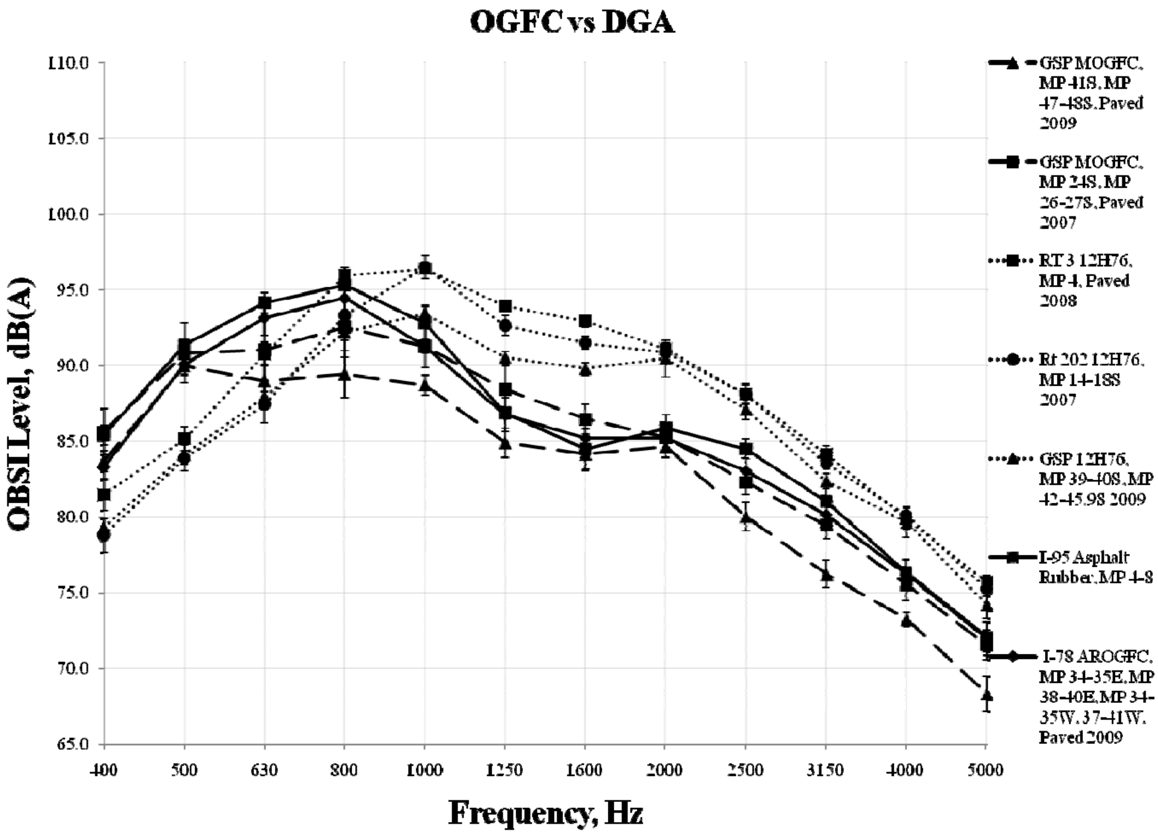

Figure 7 – Noise Spectrum Analysis for Open Graded Friction Course Mixes vs. Dense Graded Mixes

AROGFC vs. MOGFC

The comparison of the AROGFC to MOGFC results is interesting. As shown in Figure 2, the AROGFC sections were both louder overall. The 1997 AROGFC from the I-95 section overall OBSI level was measured at 100.5 dBA and the I-78 AROGFC overall OBSI level was measured at 99.6 dBA, while the 1997 MOGFC overall OBSI level was measured at 99.1 dBA and the 2009 MOGFC overall OBSI level was measured at 96.8 dBA. The important note to make about the difference between the AROGFC and MOGFC materials is the relative change in the noise spectrum properties over time. In comparing the test sections evaluated to date, it appears that the MOGFC became significantly louder over the three years of in-service life, while the AROGFC seems to have changed an insignificant amount over the 3 year in-service life. Given that the AADT on the AR sections were over 16 times higher, one would expect to see more of a change in the AROGFC, which is not apparent from the measurements. Continued testing of these sections over time is planned to continually monitor these trends.

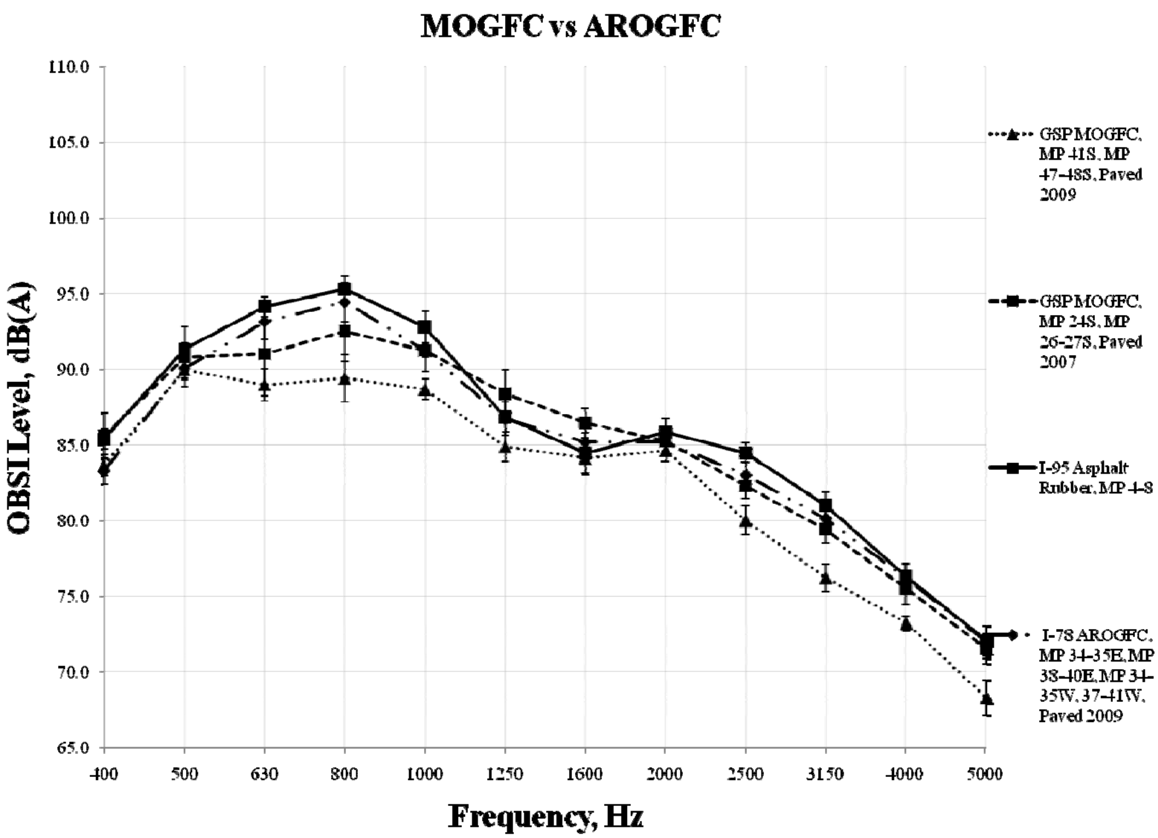

Figure 8 – Noise Spectrum Analysis for MOGFC vs. AROGFC

SUMMARY AND CONCLUSIONS

In conclusion, an OBSI testing program was initiated with the intention of creating a "quiet pavement" database for the state of New Jersey including the overall sound intensity measurements and the spectrum analyses for each material. To begin the program with help from the NJDOT, several pavement surfaces typically found in New Jersey were tested with the OBSI method. The pavement surfaces were chosen to gather a representation of the pavement types currently in-service within the state. Functional overlays that had been suspected of having properties of quiet pavements were included in this study. The materials tested and presented within this paper were primarily chosen in order to provide the NJDOT with additional information for material selections regarding noise properties, to be used in conjunction with other functional and structural information for rehabilitation projects in the future.

Initial findings show that based on the test sections evaluated in this study, in-service PCC pavements are considerably louder than the asphalt pavements in service in the state of New Jersey. It can also be seen that the dense graded asphalt sound intensity levels seem to be dependent on their location, which is presumed to be due to their respective traffic patterns, traffic volume, and age differences. As stated earlier, the initial hypothesis for the discrepancies in dBA levels with the DGA's ageing could possibly be due to general wearing in the wheelpath area, as well as the possible initiation of surface distress creating a higher ratio of macro-texture which negatively affects the sound intensity levels.

The analysis of the open-graded surface courses showed some promising results along the lines of possible aging affects with different open graded pavements. Of the pavement sections tested to date, the data suggests the MOGFC pavements in NJ have resulted in the lowest sound intensity levels, with the lowest overall sound level measured to date being 96.8 dBA on the Garden State Parkway MOGFC. However, when comparing the three year old MOGFC, there is a significant increase in noise level measured, possibly due to aging and wearing characteristics of this material. Therefore, based on the preliminary data, it would suggest that the AROGFC may be a better option over the MOGFC pavements. Even though the initial sound intensity level of the AROGFC was not as low as the MOGFC, it appears that the asphalt rubber additive may help to maintain the pavement for a longer service life by limiting the detrimental effects of asphalt age hardening, while retaining the noise mitigating properties over time.

ACKNOWLEDGEMENTS

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SBS vs Elvaloy Modified PG76-22: Evaluation of Asphalt Binder and Mixtures Properties

Submitted to:

New Jersey Department of Transportation (NJDOT)
Bureau of Materials

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SCOPE OF WORK

The scope of the project encompassed evaluating the asphalt binder and mixture performance of two PG76-22 asphalt binders modified with different polymers; 1) Styrene-Butadiene-Styrene (SBS) and Elvaloy. Asphalt binder samples were sampled from the asphalt supplier storage tanks during production. Hot mix asphalt samples (HMA) were sampled from the trucks prior to leaving the asphalt plant. The HMA supplied consisted of an NJDOT 12.5 mm Superpave mixture designed with 100 gyrations and using a PG76-22 (12.5H76) and containing 25% RAP. The mixture was placed as an intermediate layer on Rt.1 in New Jersey.

Laboratory testing consisted of both asphalt binder testing and mixture testing. For the asphalt binder testing, the continuous performance grade as well as the Multiple Stress Creep Recovery (MSCR) in accordance with AASHTO TP70 were conducted. Asphalt mixture testing consisted of:

- Dynamic Modulus (AASHTO TP79);
  - Short-term and long-term aged conditions
- Rutting Evaluation
  - Asphalt Pavement Analyzer (AASHTO TP63)
  - Asphalt Mixture Performance Tester (AASHTO TP79)
- Fatigue Cracking Evaluation
  - Flexural Beam Fatigue (AASHTO T321)
    - Short-term and long-term aged conditions
  - Overlay Tester (NJDOT B-10)
- Moisture Susceptibility (AASHTO T283)

Asphalt Binder Testing

Continuous performance grading (PG) was conducted on asphalt binders supplied to the Rutgers Asphalt Pavement Laboratory from Trap Rock Industries. The asphalt binders were sampled from the storage tanks at the asphalt supplier's facility. The continuous PG grading of the asphalt binders were conducted in accordance with AASHTO M320, *Performance-Graded Asphalt Binder*, AASHTO R28, *Accelerated Aging of Asphalt Binder Under a Pressurized Aging Vessel (PAV),* and AASHTO R29, *Grading or Verifying the Performance Grade (PG) of an Asphalt Binder*. The measured continuous PG grade of the asphalt binders were as follows:

- Elvaloy Modified Binder: 82.4-24.4 (22.8)
- SBS Modified Binder: 79.2-25.2 (24.1)

The above results compare favorably with the results determined by MTE (Reinke, 2010) shown below:

- Elvaloy Modified Binder: 81.8-24.7
- SBS Modified Binder: 78.9-25.0

Along with the continuous PG grading, the asphalt binders were evaluated using the Multiple Stress Creep Recovery (MSCR) test in accordance with AASHTO TP70, *Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer*. The non-recoverable creep compliance (J_{nr}) and % Recovery were measured and recorded at three temperatures; 64, 70, and 76°C. The results of the testing are shown in Table 1. The test results indicate that the Elvaloy modified asphalt binder achieves better J_{nr} and % Recovery parameters than the SBS Modified asphalt binder. The MSCR results compare favorably to the high temperature PG grade values shown previously.

Table 1 – Multiple Stress Creep Recovery (MSCR) Results

	SBS Modified	Elvaloy Modified
J_{nr} @ 64°C and 3.2 kPa	0.46	0.20
J_{nr} @ 70°C and 3.2 kPa	1.19	0.65
J_{nr} @ 76°C and 3.2 kPa	2.93	1.61
% Recovery @ 64°C and 3.2 kPa	24.79	46.5
% Recovery @ 70°C and 3.2 kPa	11.0	25.6
% Recovery @ 76°C and 3.2 kPa	1.59	10.0

Asphalt Mixture Testing

The asphalt mixture produced by Trap Rock Industries consisted of a 12.5mm, coarse-graded Superpave mix with 25% RAP and a PG76-22 asphalt binder (12.5H76). The 12.5H76 was placed as an intermediate course on U.S. Rt 1. During production, the asphalt mixtures were sampled and placed in 5-gallon containers. The containers were delivered to the Rutgers Asphalt Pavement Laboratory, where the sample containers were stored until sample fabrication and testing.

Prior to testing, the asphalt mixtures were reheated to compaction temperature and then compacted into the respective performance test specimens. For this study, test specimens were compacted to air void levels ranging between 6 and 7%, except for moisture damage susceptibility testing (AASHTO T283) where the samples were prepared to air voids ranging between 6.5 and 7.5%.

Dynamic Modulus (AASHTO TP79)

Dynamic modulus and phase angle data were measured and collected in uniaxial compression using the Simple Performance Tester (SPT) following the method outlined in AASHTO TP79, *Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester (AMPT)* (Figure 1). The data was collected at three temperatures; 4, 20, and 45°C using loading frequencies of 25, 10, 5, 1, 0.5, 0.1, and 0.01 Hz. Test specimens were evaluated under both short-term and long-term aged conditions. Since the mixtures evaluated in the study were plant


Figure 1 – Photo of the Asphalt Mixture Performance Tester (AMPT)

produced, it was assumed that these materials already represented short-term aged conditions. To simulate long-term aged conditions, additional compacted samples were produced and laboratory oven-aged in accordance with AASHTO R30, *Mixture Conditioning of Hot Mix Asphalt*.

The collected modulus values of the varying temperatures and loading frequencies were used to develop Dynamic Modulus master stiffness curves and temperature shift factors using numerical optimization of Equations 1 and 2. The reference temperature used for the generation of the master curves and the shift factors was 20^{o}C.

$$\log|E^*| = \delta + \frac{(Max - \delta)}{1 + e^{\beta + \gamma\left\{\log\omega + \frac{\Delta E_a}{19.14714}\left[\left(\frac{1}{T}\right) - \left(\frac{1}{T_r}\right)\right]\right\}}} \quad (1)$$

where:

$|E^*|$ = dynamic modulus, psi

ω_r = reduced frequency, Hz

Max = limiting maximum modulus, psi

δ, β, and γ = fitting parameters

$$\log[a(T)] = \frac{\Delta E_a}{19.14714}\left(\frac{1}{T} - \frac{1}{T_r}\right) \quad (2)$$

where:

a(T) = shift factor at temperature T

T_r = reference temperature, °K

T = test temperature, °K

ΔE_a = activation energy (treated as a fitting parameter)

Figures 1 and 2 show the master stiffness curves for the short-term and long-term aged mixtures, respectively. The test results show that both mixtures have very similar stiffness properties at both aging conditions.

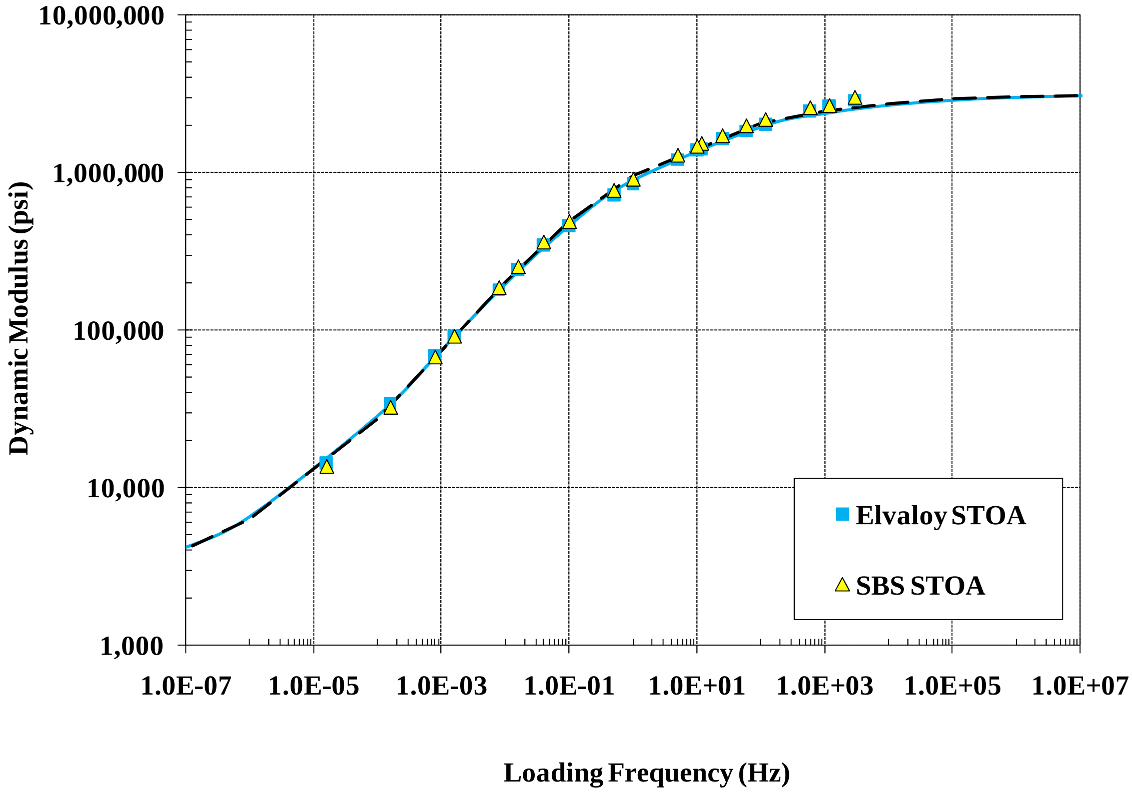

Figure 2 – Dynamic Modulus (E*) Master Stiffness Curves for Short-Term Aged (STOA) Conditions for Elvaloy and SBS Modified HMA

Additionally, the asphalt mixtures were evaluated to determine their potential of aging by evaluating the Aging Ratio between the dynamic modulus properties measured under long-term and short-term aged conditions. As the E* Aging Ratio goes above the value of 1.0, it represents an age hardening in the mixture's stiffness properties. The Aging Ratio results are shown in Figure 4. Figure 4 shows that both mixture have very similar aging characteristics when comparing the mixture stiffness properties.

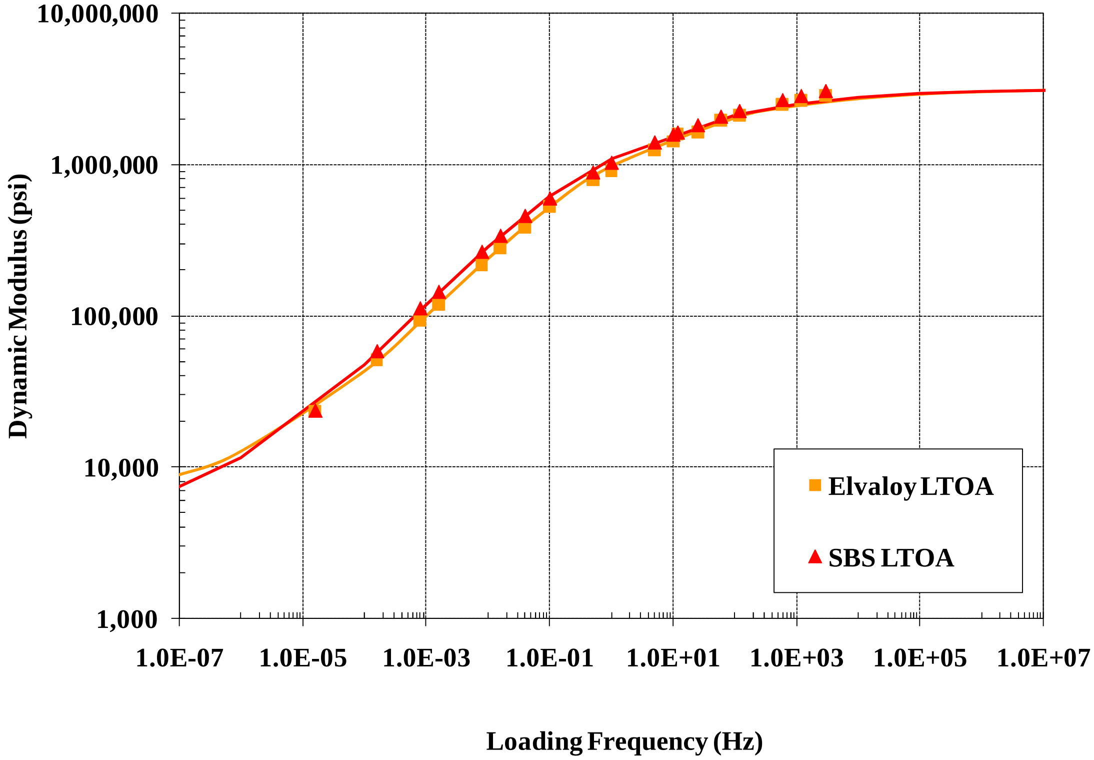

Figure 3 - Dynamic Modulus (E*) Master Stiffness Curves for Long-Term Aged (LTOA) Conditions for Elvaloy and SBS Modified HMA

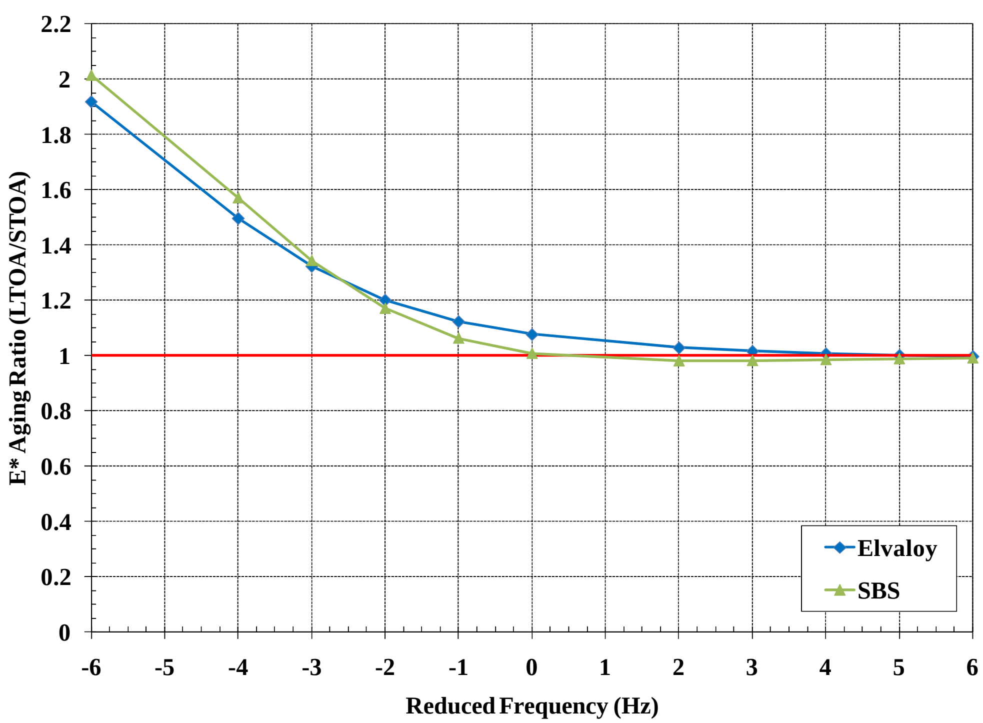

Figure 4 – Dynamic Modulus (E*) Aging Ratio for the Elvaloy and SBS Modified HMA

Rutting Evaluation

The rutting potential of the asphalt mixtures were evaluated in the study using two test procedures; 1) The Asphalt Pavement Analyzer (AASHTO TP63) and 2) The Repeated Load – Flow Number (AASHTO TP79).

Asphalt Pavement Analyzer (APA)

Compacted asphalt mixtures were testing were their rutting potential using the Asphalt Pavement Analyzer (APA) in accordance with AASHTO TP63, *Determining Rutting Susceptibility of Asphalt Paving Mixtures Using the Asphalt Pavement Analyzer (APA).* Prior to testing, the samples were conditioned for a minimum of 4 hours at the test temperature of 64°C. The samples are tested for a total of 8,000 cycles using a hose pressure of 100 psi and wheel load of 100 lbs.

The APA rutting results for the Elvaloy and SBS modified HMA are shown in Figure 5. The results indicate that the SBS modified HMA had a slightly lower rutting potential. However, the test data was comparable and from a statistical standpoint, the two mixture performed equally.

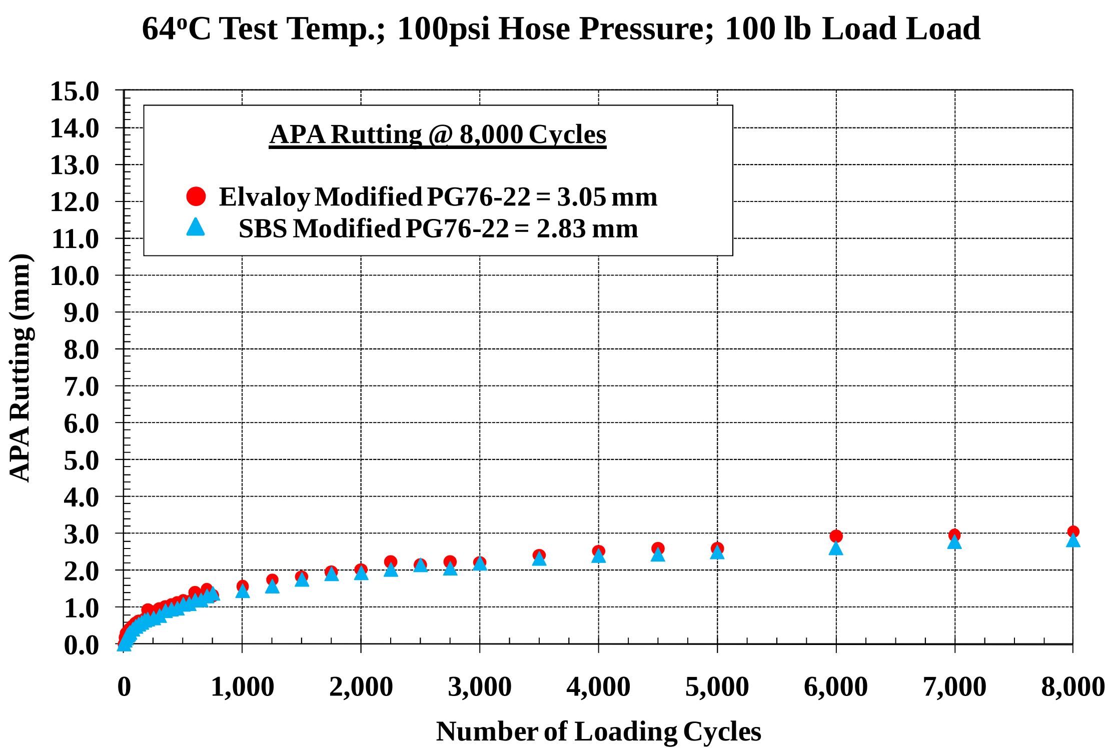

Figure 5 – Asphalt Pavement Analyzer (APA) Rutting Results

Repeated Load – Flow Number Test

Repeated Load permanent deformation testing was measured and collected in uniaxial compression using the Simple Performance Tester (SPT) following the method outlined in AASHTO TP79, *Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester (AMPT).* The unconfined repeated load tests were conducted with a deviatoric stress of 600 kPa and a test temperature of 54.4^{o}C, which corresponds to New Jersey's average 50% reliability high pavement temperature at a depth of 25 mm according the LTPPBind 3.1 software. These testing parameters (temperature and applied stress) conform to the recommendations currently proposed in NCHRP Project 9-33, *A Mix Design Manual for Hot Mix Asphalt*. Testing was conducted until a permanent vertical strain of 5% or 10,000 cycles was obtained.

The test results for the Elvaloy and SBS modified HMA is shown in Table 2. The Flow Number results indicate that on average, the Elvaloy mixture had a slightly better resistance to permanent deformation than the SBS modified mixture. However, when evaluating the data using the Student t-test, it was found that the permanent deformation results were statistically equal at a 95% confidence level.

Table 2 – Repeated Load – Flow Number Test Results

Mix Type	Sample ID	Flow Number (cycles)	Cycle to Achieve 5% Strain
Elvaloy Modified	1	859	2,343
	2	614	2,042
	3	760	2,402
	4	567	1,877
	Average	***700***	***2,166***
	Std Dev	***134***	***249***
	COV %	***19***	***11***
SBS Modified	1	499	1,522
	2	557	2,076
	3	813	3,331
	4	602	2,129
	Average	***618***	***2,265***
	Std Dev	***137***	***762***
	COV %	***22***	***34***

Fatigue Cracking Evaluation

The fatigue cracking properties of the mixtures were evaluated using two test procedures; 1) the Overlay Tester (NJDOT B-10) and 2) Flexural Beam Fatigue (AASHTO T321).

<u>Overlay Tester (NJDOT B-10)</u>

The Overlay Tester, described by Zhou and Scullion (2007), has shown to provide an excellent correlation to field cracking for both composite pavements (Zhou and Scullion, 2007; Bennert et al., 2009) as well as flexible pavements (Zhou et al., 2007). Figure 6 shows a picture of the Overlay Tester used in this study. Sample preparation and test parameters used in this study followed that of NJDOT B-10, *Overlay Test for Determining Crack Resistance of HMA*. These included:

- 25^{o}C (77^{o}F) test temperature;
- Opening width of 0.025 inches;
- Cycle time of 10 seconds (5 seconds loading, 5 seconds unloading); and
- Specimen failure defined as 93% reduction in Initial Load.

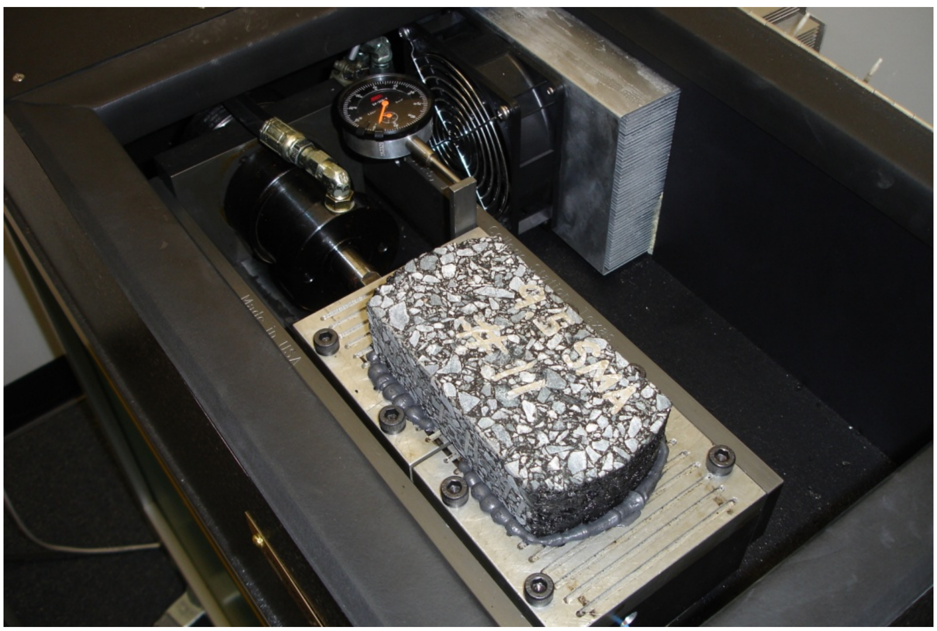

Figure 6 – Picture of the Overlay Tester (Chamber Door Open)

Table 3 indicates that on average the SBS modified HMA has a slightly better resistance to fatigue cracking than the Elvaloy modified HMA when evaluated in the Overlay Tester. However, similar to the rutting resistance, the test results are statistically equal at a 95% confidence level.

Table 3 – Overlay Tester Results of Elvaloy and SBS Modified HMA

12.5H76 with Elvaloy + 25% RAP				
Sample ID	**Air Voids (%)**	**Temp (F)**	**Displacement (inches)**	**Fatigue Life**
# 1	6.85	77 F	0.025"	25
# 2	6.72			6
# 3	6.36			12
# 4	6.92			40
# 5	6.78			6
Average =				**18**
Standard Deviation =				**15**
Coefficient of Variation =				**82**

12.5H76 with SBS + 25% RAP				
Sample ID	**Air Voids (%)**	**Temp (F)**	**Displacement (inches)**	**Fatigue Life**
# 1	6.51	77 F	0.025"	18
# 2	5.93			15
# 3	6.00			25
# 4	6.32			16
# 5	6.35			27
# 6	6.28			44
Average =				**25**
Standard Deviation =				**12**
Coefficient of Variation =				**46**

Flexural Beam Fatigue (AASHTO T321)

Fatigue testing was conducted using the Flexural Beam Fatigue test procedure outline in AASHTO T321, *Determining the Fatigue Life of Compacted Hot-Mix Asphalt (HMA) Subjected to Repeated Flexural Bending*. The applied tensile strain levels used for the fatigue evaluation were; 300, 500, 600, 700 and 900 micro-strains. Samples were tested at short-term and long-term aging conditions following the procedures outlined in AASHTO R30, *Mixture Conditioning of Hot-Mix Asphalt (HMA)*.

Samples used for the Flexural Beam Fatigue test were compacted using a vibratory compactor designed to compact brick samples of 400 mm in length, 150 mm in width, and 100 mm in height. After the compaction and aging was complete, the samples were trimmed to within the recommended dimensions and tolerances specified under AASHTO T321. The test conditions utilized were those recommended by AASHTO T321 and were as follows:

- Test temperature = 15°C;
- Haversine waveform;
- Strain-controlled mode of loading; and
- Loading frequency = 10 Hz;

The flexural beam fatigue test results for the Elvaloy and SBS modified mixes for the short-term and long-term aged conditions are shown in Figures 7 and 8. The figures indicate that the fatigue resistance of the mixtures is very similar at both aged conditions. Further comparisons on how the fatigue resistance changes with respect to the aging conditions are shown in Figures 9 and 10. The results show that both the Elvaloy modified and SBS modified mixtures were able to retain a majority of their respective fatigue resistance even after long-term aging.

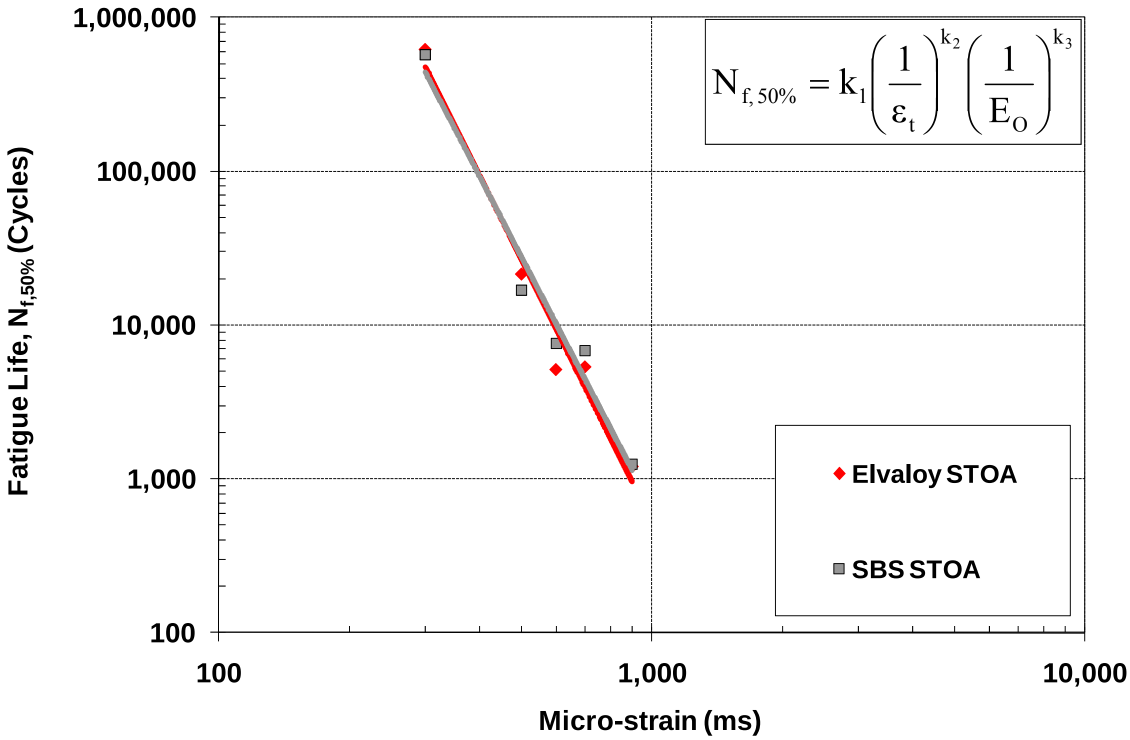

Figure 7 – Flexural Beam Fatigue Results of Elvaloy and SBS Modified HMA (Short-term Aged Condition)

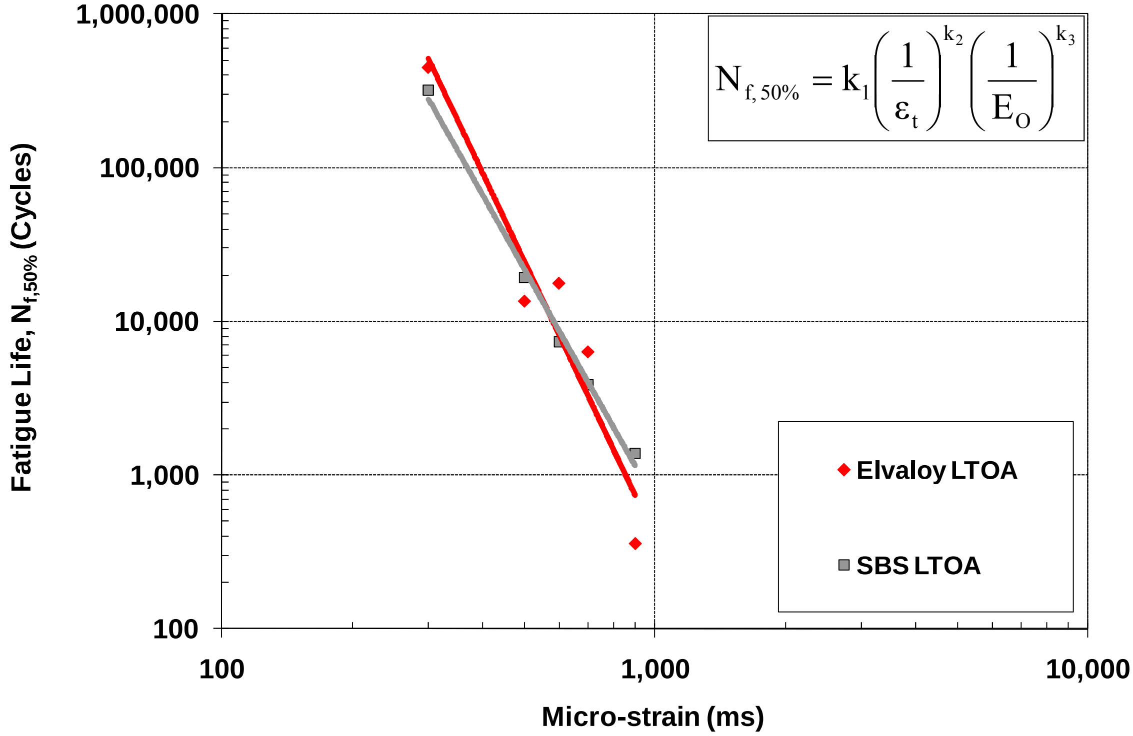

Figure 8 - Flexural Beam Fatigue Results of Elvaloy and SBS Modified HMA (Long-term Aged Condition)

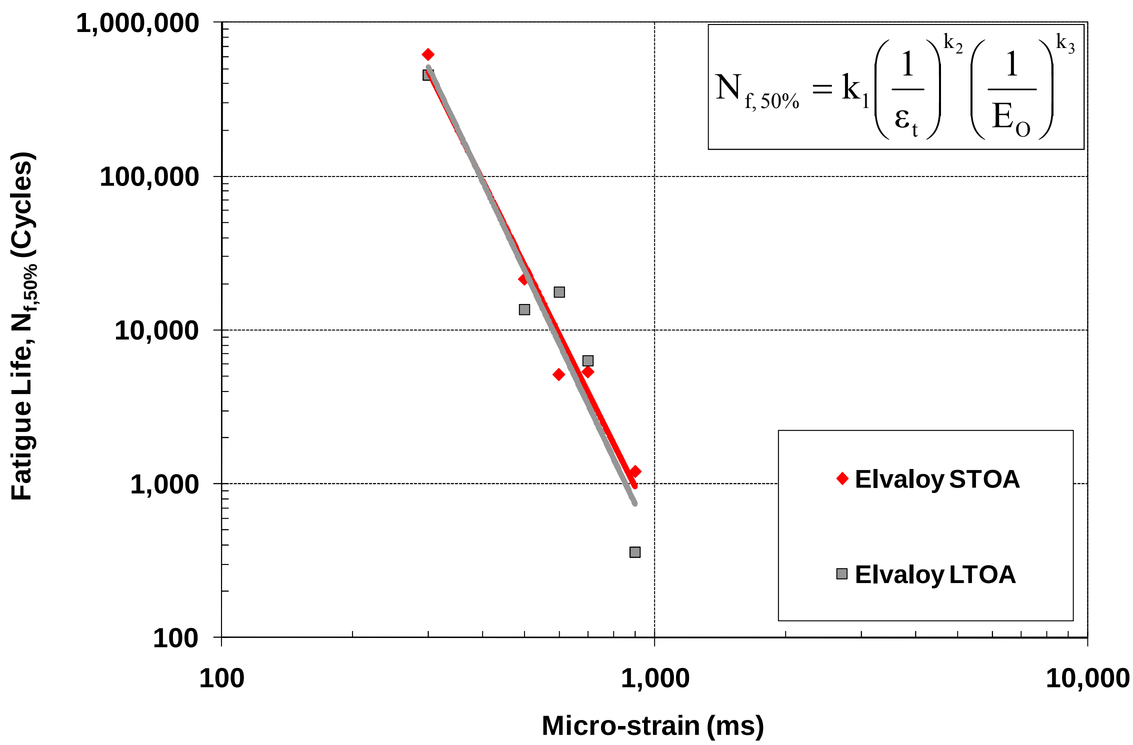

Figure 9 – Short and Long-term Aged Flexural Beam Fatigue Results of Elvaloy Modified HMA

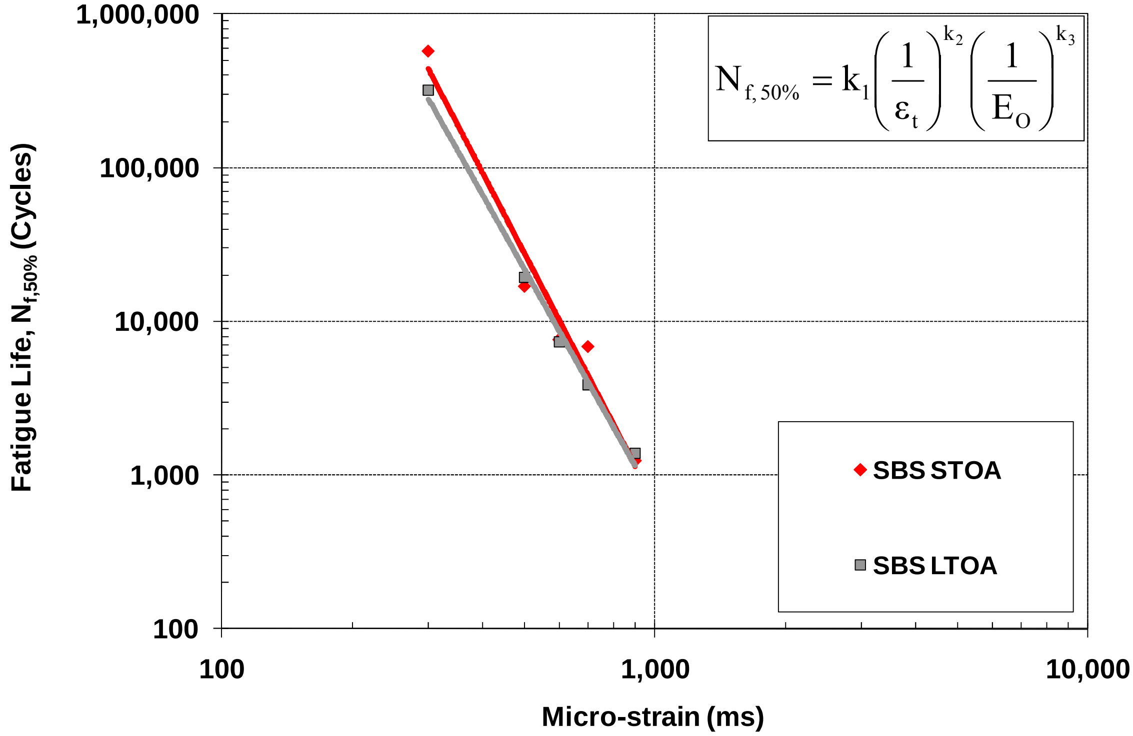

Figure 10 - Short and Long-term Aged Flexural Beam Fatigue Results of SBS Modified HMA

Resistance to Moisture-Induced Damage (Tensile Strength Ratio, TSR) – Test Results

Tensile strengths of dry and conditioned asphalt samples were measured in accordance with AASHTO T283, *Resistance of Compacted Asphalt Mixtures to Moisture Induced Damage*. The results of the testing are shown in Table 4. The test results showed that the Elvaloy and SBS modified HMA both met the 80% TSR requirement of the NJDOT. Although on average, the Elvaloy modified HMA mixture showed slightly better TSR results than the SBS modified HMA mixture.

Table 4 – Tensile Strength Ratio (TSR) Results of Elvaloy and SBS Modified HMA

Elvaloy PG76-22 + 25% RAP			
Specimen Type	Indirect Tensile Strength		Average TSR (%)
	Dry	Conditioned	
AASHTO T283 Conditioned	170.5	146.7	***85.0%***
	173.1	144.0	
	174.0	149.3	
	172.5	***146.7***	

SBS PG76-22 + 25% RAP			
Specimen Type	Indirect Tensile Strength		Average TSR (%)
	Dry	Conditioned	
AASHTO T283 Conditioned	183.0	142.8	***80.1%***
	178.1	145.4	
	183.1	147.7	
	181.4	***145.3***	

Conclusions

A research program was developed to compare the performance of asphalt binders and mixtures modified with Elvaloy and SBS polymer modifiers. Asphalt binder testing consisted of continuous performance grading and Multiple Stress Creep Recovery (MSCR), while the asphalt mixtures were tested to determine mixture stiffness, permanent deformation, fatigue cracking, and resistance to moisture damage properties at short and long-term aged conditions. The test results showed that:

- At the polymer dosage rates used for these materials, the Elvaloy modified asphalt binder showed slightly better high temperature properties (both from the continuous PG grading and MSCR testing) while the SBS modified asphalt binder exhibited slightly better low temperature properties.
- Both the Elvaloy and SBS modified asphalt mixtures had very similar asphalt mixture properties with respect to stiffness, permanent deformation, fatigue cracking, and resistance to moisture damage.
- Based on the test results, it would appear that both the Elvaloy and SBS polymer modification resulted in asphalt mixtures of statistically equal performance. However, it should be noted that these mixtures did contain 25% RAP which may have influenced some of the mixture properties.