Laboratory Information Management System

FINAL REPORT
April 2008

Submitted by

Dr. Jay N. Meegoda
Civil & Environmental Engineering Department
New Jersey Institute of Technology
Newark, NJ 07102

Dr. Chi Tang
National Center for Transportation and Industrial Productivity
New Jersey Institute of Technology
Newark, NJ 07102

NJDOT Research Project Manager
Mr. Robert Sasor

In cooperation with

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

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the New Jersey Department of Transportation or the Federal Highway Administration.

This report does not constitute a standard, specification, or regulation.
Currently, most state DOT material test results are reported on a micro scale and paper-filed. Each material lot is assessed separately for compliance, penalties, etc. All the test result reports are manually generated, distributed, and filed away individually. The filing processes of approving projects, preparing reports of material test results, and searching relevant closeout paper-documents are quite labor intensive and time-consuming. An intranet-based electronic filing system was developed (Laboratory Information Management System abbreviated as LIMS) to replace the current paper-based filing system. In order for proper implementation a mission statement was first developed, based on which the Laboratory Information Management System was formulated. This system consists of three major components; namely the database (MS SQL based), administrative management interface, and database-driven web application. The input to the database is through either the administrative management interface or the database-driven web application. The administrative management interface provides access to the following program functions: general project information, personnel information, material information, and other administrative tasks such as edit/review lab reports. The pilot scale database-driven web application of LIMS currently contains all the necessary forms for three major construction materials; namely, concrete, soils, and asphalt plus the closeout forms required by FHWA. LIMS will be evaluated by NJDOT as a pilot version for possible future implementation.

User’s manuals for the administrative management interface and the database-driven web application are available on request.
ACKNOWLEDGEMENTS

The New Jersey Department of Transportation (NJDOT) and the National Center for Transportation and Industrial Productivity (NCTIP) jointly sponsored this research. The program manager at NJDOT is Robert Saso; and at NCTIP, Dr. Lazar Spasovic. The authors would also like to acknowledge the NJDOT task force headed by Eileen Sheehy and John Zim, and NJDOT IT contact Marc Dorsch. Significant contributions from NJDOT task force members Mike McDonald and Tracy Boucher are highly appreciated. The authors also would like to acknowledge the contributions of J. Gerbino, N. Alfano, P. Sopronyi, and J. Merlo of NJDOT, as well as NJIT graduate students, Y. Zhang, S. Pinto, and A. Tang.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUMMARY</td>
<td>1</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>2</td>
</tr>
<tr>
<td>MS SQL DATABASE</td>
<td>4</td>
</tr>
<tr>
<td>ACCESS 2000 ADMINISTRATIVE MANAGEMENT INTERFACE</td>
<td>4</td>
</tr>
<tr>
<td>DATABASE-DRIVEN WEB APPLICATION</td>
<td>7</td>
</tr>
<tr>
<td>Construction Materials</td>
<td>9</td>
</tr>
<tr>
<td>Concrete</td>
<td>9</td>
</tr>
<tr>
<td>Soils</td>
<td>15</td>
</tr>
<tr>
<td>Asphalt Concrete</td>
<td>18</td>
</tr>
<tr>
<td>Close Out Forms</td>
<td>21</td>
</tr>
<tr>
<td>CONCLUSIONS</td>
<td>23</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1. Network Configuration for LIMS .............................................................. 3
Figure 2. The Main Menu for LIMS Administration Interface ............................... 5
Figure 3. Entrance to NJDOT Intranet LIMS ...................................................... 9
Figure 4. Flow Chart for Concrete Cylinder Tests ............................................. 10
Figure 5. LB201-CY General Information Form ............................................. 11
Figure 6. LB201-CY Field Office Form ............................................................. 12
Figure 7. LB201-CY Region Lab Form ............................................................... 13
Figure 8. LB201-CY Trenton Lab Form .............................................................. 13
Figure 9. LB201-CY Full Report Form ............................................................... 14
Figure 10. LB-269 General Information Form .................................................. 15
Figure 11. LB-269 Field Office/Region Lab Form ............................................. 16
Figure 12. LB-269 Full Report Form ................................................................. 17
Figure 13. LB-135 Summary Report Example .................................................... 18
Figure 14. LB-68 General Information Form .................................................... 19
Figure 15. LB-68 Trenton Lab Form ................................................................. 20
Figure 16. LB-68 Summary Sheet ................................................................. 20
Figure 17. LB-23 Close Out Form ................................................................. 21
Figure 18. LB-96 Close Out Letter to FHWA ................................................... 22
Figure 19. LB-96 - Exceptions or Failures Report ............................................. 22
Figure 20. Sample of Closeout Letter .............................................................. 23

List of Abbreviations and Symbols

BDC Backup domain controller
DSL Digital subscriber lines
FHWA Federal Highway Administration
LIMS Laboratory Information Management System
NJDOT New Jersey Department of Transportation
PDC Primary domain controller
PMS Pavement Management System
SUMMARY
Currently, most state DOT material test results are applied on a micro scale and paper-filed. Each lot is assessed separately for compliance, penalties, etc. All the test result reports are manually generated, distributed, and paper-filed individually. The filing processes of approving projects, preparing material test result reports, and searching relevant closeout paper-documents are quite labor intensive and time-consuming. An intranet-based electronic filing system was developed (Laboratory Information Management System abbreviated as LIMS) to replace the current paper-based filing system.

In order for proper implementation a mission statement was developed, based on which the LIMS was formulated. It is given below.

“To provide a system to create and gather material related business and test information on NJDOT Bureau of Materials’ contractors, suppliers, producers and plants; product mix designs; production quality control; field sampling operations; and laboratory test results via NJDOT Intranet. Also this system should be able to analyze and generate reports based on their collected information and maintain all relevant data documents in a server database. Ideally, this system should facilitate the management of material testing and the project close out process via secured, user-friendly WebPages and graphical interfaces.”

This system consists of three major components: an MS SQL database, an MS Access 2000 administrative management interface, and a database-driven web application. The input to the SQL database is through either the administrative management interface or the database-driven web application. The administrative management interface provides access to and the ability to update information for the following program functions: general project information, personnel information, material information, and other administrative tasks such as edit/review lab reports. The pilot scale database-driven web application of LIMS currently contains all the forms for three major construction materials (i.e., concrete, soils, and asphalt) plus the closeout forms required by FHWA. LIMS has been installed on the NJDOT network, will be evaluated by NJDOT as a pilot version for possible future implementation.
INTRODUCTION
The New Jersey Department of Transportation (NJDOT) took a leadership role in developing research needs for a computerized information management system for material testing results. The NJDOT recognized that the need exists to reduce paperwork; expedite the material approval process; shorten the time between project completion and final closeout, and analyze the functional relationships between material testing data and material performances in order to identify significant trends over time.

Currently, most material test results are reported on a micro scale and paper-filed. There are more than 110 NJDOT forms, reports, memos, labels, and cards in use for material testing. Many of these forms have the same usage with different layouts. Each one of them has to be filed manually. Hence it is a time consuming and labor intensive process. Also, the transfer of these documents among related units of NJDOT causes delays in decision making.

To integrate the operational functionality of material data filing, processing, and transfer, a computerized local/remote Intranet network with an information management system for material testing results is needed. This system should standardize the data entry procedures, define performance evaluation measures, certify material test data, analyze the relationships between testing data and actual material performance, expedite contractor payments including penalties and bonuses, streamline the project closeout process, and generate summary reports. With proper modifications it will also be able to communicate with other NJDOT information systems, such as the Pavement Management System (PMS).

NJDOT LIMS is an integrated materials laboratory test results reporting system. A pilot scale intranet-based information management system was developed, installed, and tested by NJDOT. If fully implemented, a production version of LIMS will connect 20 field offices, 3 regional offices, and the central office in Trenton to transfer information, trail material samples, and periodically replicate the materials database. During an evaluation period, both the current paper-based filing system and the electronic intranet-
based LIMS will work side-by-side as co-existing systems. Eventually, LIMS can replace the current system.

The system was installed at NJDOT on a primary domain controller (PDC) running Windows NT with Microsoft SQL server. The production version of LIMS is expected to connect to three backup domain controllers (BDC) located at three regional offices. Computers running Windows 2000 in field offices were connected to the PDC via a 56K.V90 modem pool and digital subscriber lines (DSL). Figure 1 shows the computer configuration when the system is fully implemented.

![Network Configuration for LIMS](image)

**Figure 1. Network Configuration for LIMS**

The NJDOT Bureau of Materials will use LIMS. This system consists of three major components (a) database; (b) administrative management interface; and (c) database-driven web application. These three parts compose an NJDOT Intranet network application with which users can create reports; store testing results; and retrieve, display, and transfer information among NJDOT Bureau of Materials staff in Trenton, regional offices, and field offices.
MS SQL DATABASE
The SQL database stores all administrative information about projects, contractors, suppliers, material mix designs, personnel, laboratories, and field offices. The system administrator of NJDOT LIMS uses the Administrative Management Interface to input all administrative information. The Administrative Management Interface is an Access 2000 application, named 'Lims_2000_Admin.mdb'. This application has functional data entry/retrieval forms linked to the SQL database. Using these forms at the supervisor level, the system administrator can initialize specific records on projects, contractors, and suppliers; enter material mix design data, and enter User ID for authorized users. The SQL database also stores test results for concrete, soils, and asphalt samples.

ACCESS 2000 ADMINISTRATIVE MANAGEMENT INTERFACE
The Main Menu of the Access 2000 Administrative Management Interface provides access to the administrative program functions that allow updating of system information. Figure 2 shows the main menu of this interface. Clicking on any of the option buttons will take the user to the corresponding function. The functions included in this application are:

Edit/Review Project General Information: The project general information menu has three sub-options, namely Projects, Contractors, and Suppliers/Producers. The Projects screen is the default screen when entering into the Project General Information section. By clicking on the function buttons the screen will display information on Projects, Contractors, Suppliers/Producers, or exit the Project General Information section.

Projects - The Projects information screen allows administrators to enter general project information into corresponding data fields, which include project title, DP number, UPC number, project federal ID, and project start date and close out date. Administrators can also select the Data Units (English or Metric scale) to be used for this project, and the region, contractor, and resident engineer from the Region ID, Contractor ID, and names of resident engineers lists.
**Contractors** - The Contractors information screen allows administrators to view contractor specific information, add a new contractor, delete a contractor, or edit current contractor information. The contractor information saved here will be available on a Contractor Title selection list on the Projects information screen, in order to select a specific contractor for a project.

**Suppliers/Producers** - The Suppliers/Producers information screen allows administrators to view supplier/producer specific information, add a new supplier/producer, delete a supplier/producer, or edit current supplier/producer information. The supplier/producer information saved here will be available on a Concrete Supplier selection list on the Mix Design information screen, in order to select a specific supplier/producer for mix design materials. The “Add/Edit Plant Location” button on the screen allows the administrator to add or edit plant locations for suppliers/producers with multiple plant locations.

![Figure 2. The Main Menu for LIMS Administration Interface](image)

**Edit/Review Personnel Information:** The Personnel Information section is for administrating LIMS user information. The five sub-options are Groups; Field Offices; Regions; Personnel; and Exit. The Groups screen is the default one when entering into
the Personnel Information section. By clicking the appropriate function button the computer will display information on Groups, Field Offices, Regions, and Personnel, or exit the Personnel Information section. The option will be highlighted in green when the information is displayed.

**Groups** - There are three system defined user groups in LIMS – Administrators, Supervisors, and Owners (Technicians). Utilizing these three available user groups, the LIMS system will administer security by granting different levels of access to users.

**Field Offices** - The Field Offices screen allows the administrators to manage field office information by assigning each field office with a unique Office ID. An Office ID is a two-digit ID with the first digit representing region (0 – Trenton; 1 – North; 2 – Central; 3 – South) and the second digit representing office number. For example, Bureau of Materials, Trenton will be assigned Office ID of 00, and the 3rd field office in the northern region will be assigned an Office ID of 13.

**Regions** - The Regions screen allows the administrators to manage region information by assigning each region a unique Region ID. A Region ID is a one-digit ID representing area (0 – Trenton; 1 – North; 2 – Central; 3 – South).

**Personnel** - The Personnel information screen allows administrators to view employee specific information, add a new employee, delete an employee, or edit existing employee information. The employee information saved here will be available on a Resident Engineer selection list on the Projects information screen, in order to select a specific resident engineer for a project. Personnel information will also be used to determine access to information when logging onto the web based report system.

**Edit/Review Material Information:** The “Edit/Review Material Information” section displays the selection windows for the user to view Concrete and Soil material information, respectively. Once the SUPER PAVE mix design data are available, that information will also be added.

**Concrete** - The Concrete button on the page will open the “Mix Design Board” screen. The Mix Design Board screen allows administrators to enter additional information on concrete mix designs. The existing concrete mix designs database based on Microsoft FoxPro was imported to the SQL database in this project. Therefore, once the mix
design is selected based on the mix design ID, all the fields in the form used for the concrete cylinder test become available.

Soils - The Soil button on the page will open the "Soil_General" screen. This screen allows administrators to enter or modify information on soil type and soil gradation. Also, it allows specifying information on soil material supplier/producer from the Soil Suppliers sub-form in the same way as suppliers/producers were selected in the "Project_General" form.

**Edit/Preview Other Administrative Tasks:** The Other Administrative Tasks section allows administrators to manage additional information on the LIMS system including options of adding and editing forms, reports, and serial numbers.

*Edit/Review Form List* - This interface is for adding and editing Form ID, Approved Date, Form Title, Purpose, and corresponding ASP file name for the web application.

*Edit/Review Report List* - Report Number is either generated by the application or added by administrators from this interface. A Report Number is a combination of Form ID, DP Number, Report Date, and some other unique identifiers. For concrete cylinders, a report number consists of Form ID, DP Number, report date, lot number and class of concrete.

*Review Serial Number List* - A Serial Number is automatically generated for each test in the web application processing procedure. Each Serial Number is unique.

**Edit/Preview Lab Reports:** This interface is under development. It is the place for administrators to generate customized reports such as producer/contractor performance evaluation sheets and project quality control summary reports.

**Exit:** It allows users to exit the LIMS Administration Interface application.

**DATABASE-DRIVEN WEB APPLICATION**

LIMS data entry is central to all samples whether they are raw materials, in process, intermediate, or finished products. By LIMS design, the data entry can be done manually (basic information initialization), automatically (calculated and transferred
results), or be triggered (data downloading) by another device. Each sampling process has its own logical life from beginning to the end. All data entry forms in LIMS were created according to their sampling logic, and data fields and form layout were standardized. It is the integrated design of the sampling cycles that makes LIMS a flexible and reliable information management system.

Laboratory supervisors outline the tests to be completed and field engineers and sampling workers correspondingly generate specific worksheets and fill in the necessary information after samples are taken for testing. Each sample is uniquely coded for identification using a user defined sample ID number. Using this ID number, all relevant data about the sample can be retrieved at any stage of the sampling process from any location in the system provided the user has the required authority. The sampling process is initiated when the sample and worksheets are brought to the local laboratory for testing and the identification information has been entered into the LIMS database.

Then samples are tested at a local laboratory or sent to the central laboratory in Trenton. Since all the sampling ID information has been input into the system, the labs can display the required test result form from a computer screen based on the sample ID, and update the test data. LIMS will automatically check the specific limits and calculate the required material data so as to generate Pass/Fail reports, and will calculate the pay factors. If all results pass specification, LIMS will recommend a sample completion status or compliance. Comments are entered in the event that a conditional approval status is assigned to a sample. Once a report is generated, the local and central labs as well as other units of NJDOT will be able to use them for further analysis. Finally, all the sampling data are secured with integrity in the relational SQL database for reliable and flexible retrieval and analysis.

Based on the employee information entered by the administrators, authorized users can log on to the NJDOT LIMS web application through the Intranet network. Figure 3 shows the entrance to NJDOT Intranet portion of LIMS.
Construction Materials
The pilot scale LIMS currently contains all the forms for following three major construction materials plus the closeout forms required by FHWA:

- Concrete (cylinders, cores and beams)
- Soils
- Asphalt Concrete

Concrete - Based on tonnage used, fresh concrete is the highest consumed material for NJDOT. Figure 4 is a schematic diagram showing the procedure adopted for testing Portland cement concrete (PCC) cylinders.
As part of the PCC acceptance procedure, Figure 4 shows pay factors for not achieving the specified concrete strength values. The other research issues incorporated in the database include the security of the system. Once an NJDOT employee logs into the LIMS system with their username (name, position and location of the user), the system will assign read, write, edit and delete privileges. For instance a technician entering raw data in a field office can only modify the data entered in that office. Once his or her supervisor approves the data no one is allowed to edit, modify or delete. LIMS essentially implemented the above flow chart in a logical manner and the following section provides the details.

Figure 4. Flow Chart for Concrete Cylinder Tests
Forms

The NJDOT LB201-CY form includes information on Portland Cement Concrete Cylinder inspection and testing results. The LB201-CY Report ID consists of Form ID (LB-201-CY), DP Number (project identification number), Report Date, Lot Number and Class, and Version Number. Hence the report ID for data shown in Figure 5 will appear as: Form(LB-201-CY)_DP(11111111)_RptDate(10/12/2000)_12A_R0.

Figure 5. LB201-CY General Information Form

There are four sub-forms for the LB201-CY report as described below:

- General Information Form – This is the default screen that displays when retrieving an existing or adding a new report. This form displays general information of a report including Report Unit (Metric or English), Report Version Number (Original or Revised), etc. (See Figure 5).

- Field Office Form – This form displays test results obtained at the field office. Here users need to identify either the Trenton Lab or Regional Lab where subsequent testing will take place. Based on their selection, A Regional Lab Form or Trenton Lab Form will be generated (See Figure 6).
- Region Lab or Trenton Lab Form – This form displays test results obtained at regional laboratories or at the Trenton lab. (See Figures 7 and 8).
- Full Report Review – This form displays all the information from the above three forms for review. A printer-friendly version is also available with the full report review (See Figure 9).

Figure 6. LB201-CY Field Office Form
**Figure 7. LB201-CY Region Lab Form**

**Figure 8. LB201-CY Trenton Lab Form**
Figure 9. LB201-CY Full Report Form
**Soils** - The LB-269 form includes information on Soils inspection and testing. It is used to generate the summary report for soils (LB-135). LB-269 Report ID consists of Form ID (LB-269), DP Number, Report Date, Soil Type and Sample Number. Hence a typical report ID will appear as:

Form (LB-269)_DP (88888888)_RptDate (4/2/2002)_AggType (I-3)_SampleNo (201)

**Forms**

There are three sub-forms of the LB-269 report as described below.

- **General Information** – This is the default screen that displays when retrieving an existing or adding a new report. This form displays general information and a portion of field soil tests. (See Figure 10).
- **Field Office/Region Lab Test Form** – This form displays results of tests performed by the field office or the regional office laboratory. The test results are shown automatically after all the required fields have been filled. (See Figure 11).
- **Full Report Review** – This form displays all the information from the above two forms for reviewing purposes. A printer-friendly version is also available with full report review. (See Figure 12).

![Figure 10. LB-269 General Information Form](image-url)
### Figure 11. LB-269 Field Office/Region Lab Form

#### Field Analysis of Soil Aggregate - (Region Lab)

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Accumulated Wt.</th>
<th>( % Retained x F ) + (D) = Total Acc. Wt. Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 8/2.36</td>
<td>214</td>
<td>(0.311 x 3072) + 2544 = 3499</td>
</tr>
<tr>
<td>No. 16/1.18</td>
<td>358</td>
<td>(0.52 x 3072) + 2544 = 4141</td>
</tr>
<tr>
<td>No. 50/009μ</td>
<td>490</td>
<td>(0.722 x 3072) + 2544 = 4705</td>
</tr>
<tr>
<td>No. 100/150μ</td>
<td>558</td>
<td>(0.81 x 3072) + 2544 = 5032</td>
</tr>
<tr>
<td>No. 200/75μ</td>
<td>670</td>
<td>(0.964 x 3072) + 2544 = 5567</td>
</tr>
<tr>
<td>Fan</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>689</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Accumulated Wt.</th>
<th>% Retained</th>
<th>% Passing</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 inch/160</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>Min</td>
</tr>
<tr>
<td>2 inch/60</td>
<td></td>
<td></td>
<td>130</td>
<td>100</td>
</tr>
<tr>
<td>1 1/2 inch/37.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 inch/25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4 inch/19</td>
<td>1584</td>
<td>28.1</td>
<td>72</td>
<td>60</td>
</tr>
<tr>
<td>1 inch/12.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/8 inch/9.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 44.75</td>
<td>2544</td>
<td>45.2</td>
<td>55</td>
<td>33</td>
</tr>
<tr>
<td>No. 8/2.36</td>
<td>3499</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 16/1.18</td>
<td>4141</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 50/009μ</td>
<td>4765</td>
<td>84.6</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>No. 100/150μ</td>
<td>5032</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 200/75μ</td>
<td>5567</td>
<td>93.85</td>
<td>1.2</td>
<td>0</td>
</tr>
</tbody>
</table>

**Sampled By:**

**Tested By:**

**Checked By:**

(Sign now)

**Title:**
**LE-269**

**FIELD ANALYSIS OF SOIL AGGREGATE**

- **Project**: Rt. 1 & 9 SEC. 2AL
- **Producer**: Pascack Crushed Stone, Pascack Lakes, NJ
- **DP Number**: D8888888
- **Type of Material**: I-3
- **Date Tested**: 4/2/2002
- **Sample No.**: 201
- **Date Sampled**: 3/29/2002
- **Propose Joe**: 0.07
- **Elevation/Depth**: 10
- **Quantity**: 525
- **Wt. Soil and Pan (gms)**: 5387
- **Dry Soil and Pan (gms)**: 5738
- **Moisture Loss (gms)**: 49
  - **Wt. Before Washing (Dry gms)**: 2558
  - **Wt. After Washing (Dry gms)**: 2548
  - **Wt. of Dry Soil (Dry gms)**: 5652
  - **Moisture Content %**: 0.07
  - **Wash Loss (gms)**: 10

**Sieve Analysis**

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Accumulated Wt.</th>
<th>Total Acc. Wt Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 6/25.6</td>
<td>214</td>
<td>214</td>
</tr>
<tr>
<td>No. 8/18.115</td>
<td>338</td>
<td>434</td>
</tr>
<tr>
<td>No. 10/20</td>
<td>498</td>
<td>4755</td>
</tr>
<tr>
<td>No. 10/10.0</td>
<td>558</td>
<td>5002</td>
</tr>
<tr>
<td>No. 10/10</td>
<td>678</td>
<td>5537</td>
</tr>
<tr>
<td>Pan</td>
<td></td>
<td>605</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>605</td>
</tr>
</tbody>
</table>

**Specifications**

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Accumulated Wt.</th>
<th>% Retained</th>
<th>% Passing</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 in/100</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>Max 100</td>
</tr>
<tr>
<td>3.0 in/9.5</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>Max 90</td>
</tr>
<tr>
<td>2 in/5</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>Max 150</td>
</tr>
<tr>
<td>1 1/2 in/37.5</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>Max 37.5</td>
</tr>
<tr>
<td>1 in/22</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>Max 100</td>
</tr>
</tbody>
</table>

**Legend for Test Compliance:**
- **C**: Complies
- **NC**: Non-complying
- **CS**: Complies but is subject to testing after compaction

**Figure 12. LB-269 Full Report Form**
Based on the LB-269 forms, the LB-135 summary report is generated at the end of each week for all soil types for a given project. The data for the report is retrieved from the LB-269 forms and summarized by the project (DP Number), Soil Type and the week ending date to generate the LB-135 report (See Figure 13).

Asphalt Concrete - The LB-68 form for asphalt includes information on layer thickness, specific gravity and void content of bituminous concrete cores. LB68 Report ID consists of Form ID (LB-68), DP Number, Report Date, Lot Number, Lift, Type, and the Revision Number. Hence a typical report ID will appear as: Form (LB-68)_DP(11111111)_RptDate(1/1/2000)_LotNo(10)_Lift(S)_Type(OS)_R2.
Forms
There are three sub-forms of the LB-68 report as shown below:

- General Information — This is the default screen that displays when retrieving an existing or adding a new report. This form displays general information including Report Units (Metric or English), Report Version (Original or Revised), etc. (See Figure 14.)
- Trenton Lab Form – This form displays test results performed by the Trenton lab. (See Figure 15.)
- Summary Sheet – This form displays summary information of a specific sample. It will highlight the specification that the sample fails to meet. A printer-friendly version is also available with full report review (See Figure 16).

Based on the LB-68 form, the LB-68 Summary Sheet is generated. The summary sheet consists of summarized information of a test sample, as well as the testing criteria for validating/accepting the sample.

Figure 14. LB-68 General Information Form
Figure 15. LB-68 Trenton Lab Form

Figure 16. LB-68 Summary Sheet
Close Out Forms

All the required close out forms have been incorporated into the LIMS System. This feature will help users to process closeout of projects effectively and efficiently. Only administrators are authorized to create closeout forms. However, supervisors are authorized to create the LB-23 form, which contains soil information. All other users may open, view, and print the closeout forms. The following Close Out Forms are currently available in the LIMS System: Form LB95-A, Form LB95-Electrical, Form LB95-Landscape, Form LB95-Soil, Form LB317, Form LB23 (see Figure 17), Form LB212, Form LB96 (see Figure 18, close out letter form).

The closeout procedure triggers a series of actions which include a list of material failures and action taken (see Figure 19, Exceptions or Failures Report). This list will be attached to a computer generated closeout letter, as shown in Figure 20, to be sent to the FHWA.

Figure 17. LB-23 Close Out Form
Figure 18. LB-96 Close Out Letter to FHWA

Figure 19. LB-96 - Exceptions or Failures Report

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Lot No.</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>15</td>
<td>wall (BM)</td>
<td>No More Records Exist! Penalized as per Spec.</td>
</tr>
</tbody>
</table>
CONCLUSIONS
The implementation of LIMS can significantly reduce paper-work loads and provides the capability to organize relevant materials data rapidly. It also shortens the time between project completion and the final closeout procedure mandated by the Federal Highway Administration (FHWA) for federally funded projects. LIMS and its concept have a great potential to be a showcase for the nation, and to be adopted by other transportation agencies for management of materials and laboratory test data.