# Annual Implementation Report
# Research Completed in Years 2015 and 2016

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In cooperation with

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## Executive Summary

The **New Jersey Department of Transportation (NJDOT), Bureau of Research**, supports transportation research necessary in order to provide relevant information, analysis and value-added solutions to transportation agencies and professionals. The results enhance the quality and cost-effectiveness of the policies, practices, standards and specifications required when planning, designing, building and maintaining the State's transportation infrastructure. The funded research results in the discovery of new materials, improvement of processes, refinement of systems, and the generation of innovative ideas that improve the durability and efficiency of infrastructure and the mobility, accessibility and safety of the State's residents, workers and visitors. However, the long-term effects, or the next necessary steps required to achieve full-scale implementation, as well as the benefits of research, are not always known. The Bureau is often approached by sponsors to justify the value of these projects to a much broader audience.

The purpose of the Annual Implementation Report is to review these effects. Where applicable, and where the results were reported or could be obtained, examples of the return on investment or other economic benefit to the State of New Jersey have been noted.

The Annual Implementation Report is also a means to screen for opportunities and document the strategies that have been used for technology transfer of research findings to the State's transportation community, including its transportation agencies, workforce and the broader community of transportation practitioners.

## Introduction

The project team collected information for this report through review of technical briefs, final research reports, and interviews with principal investigators and NJDOT research managers and customers. A summary of each funded project completed in 2015 and 2016 was developed.

The role and importance of technology transfer within the State transportation research program function has been the subject of continuing study. Several useful definitions for considering the role of technology transfer that were provided in a U.S. DOT Volpe Center study (Cuddy et. at, 2016) help frame and inform the process of considering effects and are shown below:

- Research and Development (R&D): Any activity that aims to create or improve a technology.
- Technology: Any knowledge, process, system, or other tangible or intangible thing that could be used to create benefits. Examples of new technologies include a survey, hiring process, a piece of software or "app", a traffic model, a new road construction technique or an unmanned aircraft.
- Technology Transfer (T2) Activities: All activities designed to help ensure that technologies created or improved through R&D are widely adopted for use outside or within the research-producing organization.
- Adoption: The decision to make a technology available for use in ordinary operational situations. This may or may not involve commercialization.
- Implementation Activities: Activities led by an adopter to make a technology available for ordinary operational use. These activities are generally preceded by adoption, and they often draw on research organizations for technology information and support.

## Research Approach

In 2015 and 2016, the Bureau of Research closed out 25 final research reports for work undertaken in previous years. The contract value of the completed research projects was approximately $8.8 million. As shown in Tables 1 and 2, most of the completed research reports were in the Design and Construction and Multi-Modal System Components & Users categories in terms of contract value and number of projects.

**Table 1**
**Number and Value of Completed Research Reports by Broad Research Category, 2015**

| Broad Research Category | Number of Reports Completed | Total Contract Value Completed |
|---|---|---|
| Design and Construction | 5 | $1,259,577 |
| Multi-Modal System Components and Users | 7 | $1,284,765 |
| Operations and Preservation | 1 | $224,081 |
| Traffic and Safety | 1 | $200,000 |
| Policy and Organization | 2 | $109,070 |
| Planning and Environment | 0 | $ - |
| Total | 16 | $3,077,493 |

**Table 2**
**Number and Value of Completed Research Reports by Broad Research Category, 2016**

| Broad Research Category | Number of Reports Completed | Total Contract Value Completed |
|---|---|---|
| Design and Construction | 4 | $4,645,067 |
| Multi-Modal System Components and Users | 1 | $175,003 |
| Operations and Preservation | 2 | $518,760 |
| Traffic and Safety | 2 | $371,819 |
| Policy and Organization | 0 | $ - |
| Planning and Environment | 0 | $ - |
| Total | 9 | $5,710,649 |

**Source: NJDOT Bureau of Research, Database of Final Reports**
**http://www.state.nj.us/transportation/refdata/research/ReportsDB.shtm**

As shown in Table 3, the completed research reports for 2015 and 2016 address implementation-related themes in various ways that can be organized into four sometimes overlapping categories (see Table 3):

- Some of the funded research were primarily analytical or evaluative studies which resulted in the development of report findings to satisfy the stated research question(s) with no discussion of technology transfer activities or implementation steps.
- Some studies made recommendations for future research to further refine investigated technologies or to advance research questions to a next stage.
- Some of the research studies made recommendations for implementation activities that could be taken in the future.
- Another segment of studies made implementation or technology transfer activities a central element or task of the completed research study.

This report provides the results of an investigation into the implementation steps taken, if any, since the conclusion of the research efforts. Research faculty, consultants, and NJDOT staff (current and former) responsible for the completed research reports were interviewed by telephone, by email or in person.

The review of implementation activities that have followed from the research shows that some efforts resulted in research papers and/or presentations at conferences to disseminate key findings. In other cases, implementation may have been realized through specific policy or procedural changes, the institutionalization of new standards for materials or design, the piloting of a demonstration project, or the development of new or improved tools for performing analyses or doing business. Where available or discovered, potential benefits related to the research study topic were noted. None of these studies would have been possible without public support.

**Table 3: 2015 and 2016 Research Reports by Type of Research and Treatment of Implementation Theme**

| ID | Title | Recommendations for Future Research | Implementation Activities | Implementation-Minded Recommendations | No Discussion of T2 | Research Type | Broad Research Category |
|---|---|---|---|---|---|---|---|
| FHWA-NJ-2015-001 | State Channel Maintenance Capacity | | X | | | Tool Development | Multi-Modal System Components and Users |
| NJ-2015-001 | Title VI Agency Policy Examination and Best Practices Review | X | | X | | Policy Research | Policy and Organization |
| FHWA-NJ-2015-002 | Impact of the Rail Grants Program | X | | X | | Policy Research | Multi-Modal System Components and Users |
| NJ-2015-002 | Channel Usage Research and Analysis | X | | X | | Statistical Analysis | Multi-Modal System Components and Users |
| FHWA-NJ-2015-003 | My Tix: NJ TRANSIT's Mobile Ticketing Application | | | | X | Technology Testing | Multi-Modal System Components and Users |
| NJ-2015-003 | NJDOT Analysis of Maintenance Titles | | | X | | Policy Research | Policy and Organization |
| FHWA-NJ-2015-004 | Video Cameras in Access Link Paratransit Vehicles | | X | X | | Policy Research | Multi-Modal System Components and Users |
| FHWA-NJ-2015-005 | Evaluation of Surface Resistivity Indication of Ability of Concrete to Resist Chloride Penetration | X | | | | Materials Testing | Design and Construction |
| NJ-2015-005 | Oversize/Overweight Public Documentation Benchmarking and Effectiveness Study | X | | X | | Policy Research | Multi-Modal System Components and Users |
| FHWA-NJ-2015-006 | Restricted-Use Licenses for Suspended NJ Drivers | | | | X | Policy Research | Traffic and Safety |
| FHWA-NJ-2015-007 | HMA Pay Adjustment | X | | X | | Standards Evaluation/ Design | Design and Construction |
| FHWA-NJ-2015-008 | Rejuvenating Agents with Rap in Hot Mix Asphalt (HMA) | | | X | | Materials Testing | Design and Construction |
| FHWA-NJ-2015-009 | The Effect of WMA on RAP in Hot Mix Asphalt | | X | | | Standards Evaluation/ Design | Design and Construction |
| FHWA-NJ-2015-010 | Performance Testing for HMA Quality Assurance | | X | | | Standards Evaluation/ Design | Design and Construction |
| FHWA-NJ-2015-011-I and FHWA-NJ-2015-011-II | Appropriate Implementation of Pavement Preservation Techniques | | X | | | Standards Evaluation/ Design | Operations and Preservation |
| FHWA-NJ-2015-012 | ADA Paratransit Facility Alternatives | | | X | | Project Feasibility Study | Multi-Modal System Components and Users |

**Table 3: 2015 and 2016 Research Reports by Type of Research and Treatment of Implementation Theme**

| ID | Title | Recommendations for Future Research | Implementation Activities | Implementation-Minded Recommendations | No Discussion of T2 | Research Type | Broad Research Category |
|---|---|---|---|---|---|---|---|
| FHWA-NJ-2016-001 | Integration of Bus Stop Counts Data with Census Data for Improving Bus Service | X | X | | | Tool Development | Multi-Modal System Components and Users |
| NJ-2016-002-NJ-2016-002-7 | Design and Fabrication of Orthotropic Deck Details | | X | | | Standards Evaluation/ Design | Design and Construction |
| FHWA-NJ-2016-002 | Highway Repair Consolidation Feasibility | | X | X | | Tool Development | Traffic and Safety |
| FHWA-NJ-2016-003 | Alternatives to Nuclear Density Testing | X | X | | | Standards Evaluation/ Design | Design and Construction |
| NJ-2016-003 | Cost of Roadway Construction Operations and Maintenance in NJ: Phase 1 Final Report | X | | | | Policy Research | Operations and Preservation |
| FHWA-NJ-2016-004 | Impact of Freight on Highway Infrastructure in New Jersey | X | X | | | Tool Development | Operations and Preservation |
| NJ-2016-004 | Optimizing Work Zone Lighting | | X | | | Manual Development | Traffic and Safety |
| FHWA-NJ-2016-005-I and FHWA-NJ-2016-005-II | Heavy Vehicle Load Simulator for Bridge Deck Testing Application, Volume I and Volume 2 | | X | | | Materials Testing | Design and Construction |
| FHWA-NJ-2016-006 | Laser Scanning Aggregates for Real Time Property Identification | | X | | | Technology Testing | Design and Construction |

**FHWA-NJ-2015-001**

## State Channel Maintenance Capacity

| | |
|---|---|
| Research Category: | Multi-Modal System Components and Users |
| Project Budgeted Cost: | $138,236 |
| Project Customer: | NJDOT Office of Maritime Resources |
| Organization: | Stockton University |

### Background

Currently, conventional placement areas for sediments dredged from New Jersey's waterways are in upland placement sites known as Confined Disposal Facilities (CDF). There is a great need for dredged material placement sites as their designated CDFs are nearing capacity. One solution for addressing the need for dredged material placement is to utilize the former subaqueous borrow pits or "dredged holes" that are found throughout the New Jersey bay-wide system. The New Jersey Department of Transportation/Office of Maritime Resources (NJDOT-OMR), Richard Stockton College of New Jersey Coastal Research Center (CRC), and Ocean and Coastal Consultants (OCC) investigated the utilization of dredged holes in New Jersey's coastal bays for the dual benefit of restoring degraded habitat and alleviating shoaling of nearby navigation channels through the beneficial use of dredged material.

### Implementation

This study created a geodatabase containing a total number of 122 dredged hole features that were identified and delineated from aerial photography, navigation charts, and previous investigations. After consultation with the study partners, priority dredged holes were identified from the candidate dataset as those that provide the greatest opportunities for the placement of dredged material to improve degraded marine habitat while continuing to maintain navigation channels to support commercial and recreational economies. The methodologies used help develop and enhance the Dredged Materials Management System (DMMS), the purpose of which is to enhance use of dredged materials throughout the state.

*A cuspate boundary created by a dredge can be seen on the northern and eastern limits of Dredged Hole 25 in 2012 aerial photograph.*

The findings were disseminated in multiple publications, including the Report of Findings and Recommendations of The Dredging Working Group and cited in Stockton University Coastal Research Centers' 30 year Analysis of Sand Redistribution and Shoreline Changes in New Jersey's Four Coastal Counties.

**NJ-2015-001**

## Title VI Agency Policy Examination and Best Practices Review

| | |
|---|---|
| Research Category: | Policy and Organization |
| Project Budgeted Cost: | $59,620 |
| Project Customer: | NJDOT Civil Rights |
| Organization: | Cambridge Systematics |

### Background


In order to meet Moving Ahead for Progress in the 21st Century Act (MAP-21) guidelines and remain in compliance with the Federal Highway Administration's Title VI requirements, NJDOT's Title VI Unit was instructed to re-examine the agency's existing Title VI policies and regulations. Through this process, they were charged with identifying the strengths and weaknesses of the Department's existing Title VI practices, in addition to the strengths and weakness of Title VI practices when coordinating with sub-recipients. Since each recipient of federal funds is charged with developing their own plans, policies, and requirements that assist in achieving Title VI compliance, no specific consistent instructional guidance or best practices were reported as available as a resource.

### Implementation

The research team found that a comprehensive Title VI Plan should include the following elements: Introduction/Overview, Organization and Staff Responsibilities, Procedures for Ensuring Compliance, Program for Conducting Title VI Reviews, Compliance Monitoring, and a Glossary of Terms/Definitions. Recommendations were made for strengthening internal partnerships, formulating training programs for a variety of audiences, and updating data collection methods and sources. NJDOT's most recently submitted Title VI Implementation Plan meets the FHWA guidelines.

NJDOT Civil Rights has also made the determination to advance a round of training for NJDOT staff and sub-recipients to encourage greater adoption of a data-driven process to ensure nondiscrimination in program, plans and activities.

**FHWA-NJ-2015-002**

## Impact of the Rail Grants Program

| | |
|---|---|
| Research Category: | Multi-Modal System Components and Users |
| Project Budgeted Cost: | $268,365 |
| Customer: | NJDOT Multimodal Services |
| Organization: | Rutgers University RIME |

### Background


CSX freight moving south on the River Line

The New Jersey Rail Freight Assistance Program awards approximately $10 million annually in grants to freight rail operators for construction and improvement projects. The purpose of the rail investments is to promote and sustain economic development and maintain a balanced transportation system where rail is more economically viable than other transportation systems. However, the New Jersey Rail Freight Assistance Program (hereinafter the "rail grants program") does not currently evaluate the impact of the grants after they have been awarded. No study had been conducted to evaluate the long-term impact of the program on the state's transportation goals. NJDOT also sought to study the past performance of the program to learn its effects on the New Jersey economy and transportation system and help inform any potential modification of its rail grants program.

### Implementation

Several recommendations were made to NJDOT, including the adoption of a systematic scoring technique to standardize and streamline its analyses. Ultimately, however, it was concluded that NJDOT should consider finding a way to incorporate financial analysis into its management of this program as well as to redefine the program's purpose.

NJ-2015-002

## Channel Usage Research and Analysis

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|---|---|
| Research Category: | Multi-Modal System Components and Users |
| Project Budgeted Cost: | $139,500 |
| Project Customer: | NJDOT Multimodal Services |
| Organization: | Cambridge Systematics |

### Background

The NJDOT Office of Maritime Resources (OMR) sought to develop an asset management system to more efficiently manage New Jersey's Marine Transportation System. The first step was to assess the economic value of New Jersey's channels and establish a count of vessels utilizing these channels. Vessel usage was determined by compiling available data on waterway services like slips per marina per channel, residential docks per channel, and boat ramps per channel. However, channel usage varies depending on factors such as weather, time of year, origin/destination, size, tides, type of vessel, and the availability of alternative routes. To satisfactorily assess channel usage, actual vessel count data needed to be checked against previously collected data, and a viable method of gathering vessel counts and classification data needed to be established. This study developed recommendations for how NJDOT can establish one or more methodologies for collecting vessel counts and classification data. By reviewing current methodologies used worldwide, and conducting their own pilot, the research team developed recommendations for how NJDOT can establish their own data-gathering system.

### Implementation

Several methods of vessel counting were compared that yielded similar results (within 3.2%). The location and selection of suitable vantage points must be considered to accurately determine volume and classification. Upon completion of the project, the team made the following policy recommendations to NJDOT:

- Adopt and implement formalized count procedures and classification systems;
- Institute data-driven decision making from additional counts (i.e., use regression analysis of different variables such as weather, channel width, channel depth, vertical clearance, population demographics, temporal, tides) with year-over-year trends;
- Develop formalized marine asset management system;
- Develop pre-survey field guide and checklist to match suitable count methodologies to known field conditions at each channel (including the weather forecasted for the survey day), and to inform logistical preparations; and
- Support post-processing through coordination with NJDOT and the New Jersey State Motor Vehicle Commission to match vessel registration data collected in the field to attributes associated with that registration number, including vessel classification, age, and place of registry

The project was presented at the 2018 NJDOT Annual Research Showcase

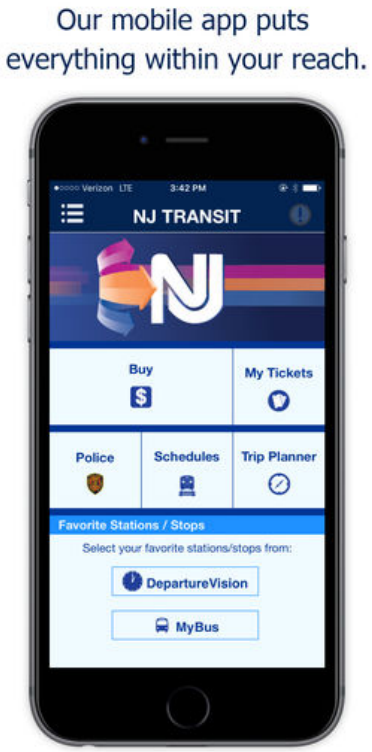
**FHWA-NJ-2015-003**

## My Tix: NJ TRANSIT's Mobile Tracking Application

Research Category: Multi-Modal System Components and Users
Project Budgeted Cost: $310,195
Project Customer: NJ TRANSIT
Organization: Rutgers University RIME

### Background

NJ TRANSIT's 3- to 7-year strategic plan emphasizes modernizing its daily operations. Mobile phone-based ticketing is the focus of this new plan. Mobile ticketing allows NJ TRANSIT to serve their customers quickly while reducing bottlenecks in ticketing areas. While other payment methods were also considered, mobile ticketing became the choice due to a recent NJ TRANSIT customer satisfaction survey that found that 99 percent of rail and bus customers use cell phones and more than 50 percent own smart phones. Therefore, it was important to determine if crew members could sufficiently adopt the new technology while also monitoring customers' reactions to the new system.




### Implementation

The main research objectives of the project were to assist NJ TRANSIT in the selection and demonstration of a commuter rail electronic fare technology; and conduct an independent assessment of the selected technology in terms of its effectiveness. The existing technologies and lessons learned from other agencies were reviewed and summarized. Then a demonstration and evaluation plan was developed.

The use of the selected technology was assessed in laboratory as well as along a number of rail lines by the research team. The user experience and feedback were collected and analyzed. The research project provided evaluation of the mobile ticketing application (MyTix) for NJ TRANSIT. The application's effectiveness was measured, and over the time of the study the adoption rate for the MyTix app sharply increased.

The app has been considered a great success, and saves commuters time and money as it helps them avoid surcharges resulting from on-board ticket purchases.

## NJ-2015-003

## NJDOT Analysis of Maintenance Titles

Research Category: Policy and Organization
Project Budgeted Cost: $49,450
Project Customer: NJDOT Human Resources
Organization: Cambridge Systematics

### Background

NJDOT commissioned a study to conduct a review of various state highway maintenance crews to ensure that its highway safety crews are following best practices in the field and to assess whether NJDOT is currently organizing and staffing its field operations in accordance with modern crew structures. By comparing its crews to other highway maintenance crews, NJDOT sought to identify how to best structure its crews and positions to meet today's needs. This is especially relevant as many highway maintenance crew positions were created in the 1930s and their job descriptions may warrant revision to keep pace with changes in demand and technology; in some cases, positions may no longer be required or can be consolidated to maximize a crew's utility.

The primary objective of the research was to examine the structure of State Departments of Transportations' highway maintenance crews and report upon issues, trends, and other information relevant to organizing and staffing highway maintenance crews and worker title consolidation. The research methods consisted of literature review, survey and peer agency interviews.

### Implementation

The research team concluded that NJDOT should consider consolidating highway maintenance worker titles because the current titles are antiquated and restrict worker and crew efficiency by limiting the scope of their duties. The research team noted several beneficial objectives from addressing how highway maintenance crews' function and their titles. For example, making crews more flexible and efficient will increase productivity and reduce costs; improving recruitment and hiring techniques will reduce the resources spent on this process; increasing employee retention will reduce resources spent on the hiring and recruitment process and increase worker productivity by keeping their skills and knowledge in the highway maintenance crews; streamlining trainings and evaluations will reduce the time spent on these endeavors; standardizing trainings and evaluations will ensure that all workers are receiving the same information across the state; increasing advancement transparency will improve worker satisfaction and motivation.

The research team recommended that NJDOT assess and amend relevant policies and procedures in tandem with worker title consolidation, such as: trainings and evaluations, career path and advancement, recruitment and hiring. Maximizing crew efficiency and flexibility would require additional attention to fostering flexibility in work and supervisory duties and placement of specialty crews within the highway maintenance series. The research team found that prioritizing seniority and rank over skills and knowledge tended to reduce worker motivation to exceed expectations.

NJDOT subsequently adopted several recommendations put forward in the research including making advancement and training processes more transparent and implementing proficiency-based assessments for promotion.

## FHWA-NJ-2015-004

## Video Cameras in Access Link Paratransit Vehicles

Research Category: Multi-Modal System Components and Users
Project Budgeted Cost: $61,917
Project Customer: NJ TRANSIT
Organization: Rutgers University, CAIT and VTC

### Background

Access Link operates a fleet of approximately 350 vehicles to provide mobility to individuals who are unable to use local bus service as a result of their disability. The Access Link Paratransit vehicle fleets had been using a video clip monitoring system in part of their fleet for some time. In 2011, Access Link made a decision to begin installing video monitoring across their entire fleet. Since the installation of this type of system (DriveCam), many changes have occurred to available technology and corresponding costs.

NJ TRANSIT and NJDOT initiated this study to evaluate currently available video equipment options. This research involved a national survey of transportation providers to determine whether short segment systems or continuous recording systems were preferred and to collect cost-benefit information comparisons between short segment and continuous systems.

### Implementation

The project provided the sponsor with results from a Request for Information for the cost of installation of 5-10 cameras per fleet vehicle for paratransit cameras. The report findings were used to decide whether or not to implement continuous recording cameras both inside and outside the Access Link fleet vehicles. The decision was made to transition to cameras that show both interaction among people within the vehicle and interaction of the vehicle with the environment and infrastructure outside.

Access Link was made aware of the availability, cost, and potentially beneficial impacts that could result from improved technology use in the vehicle fleet. The switch from a short segment to a continuous recording system would provide a safety improvement for vehicle drivers and passengers alike. Furthermore, the video capture both inside and outside the vehicle would be an additional safety enhancement. The continuous video recording enhances the driver's ability to focus on moving the vehicle from point to point and increases safety and efficiency. It was also found to help resolve disputes, reduce driver harassment and provide indisputable evidence relevant to onboard incidents.

In addition, adoption of the continuous video equipment could yield cost savings attributable to a potential reduction in litigation avoided through review of recorded video footage and fewer fraudulent claims filed. The study team conclude that the cost for the new system would be easily recouped from the savings from fewer insurance claim payout expenditures.

**FHWA-NJ-2015-005**

## Evaluation of Surface Resistivity Indication of Ability of Concrete to Resist Chloride Ion Penetration

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|---|---|
| Research Category: | Design and Construction |
| Project Budgeted Cost: | $220,000 |
| Project Customer: | NJDOT Bureau of Materials |
| Organization: | Rutgers University |

### Background

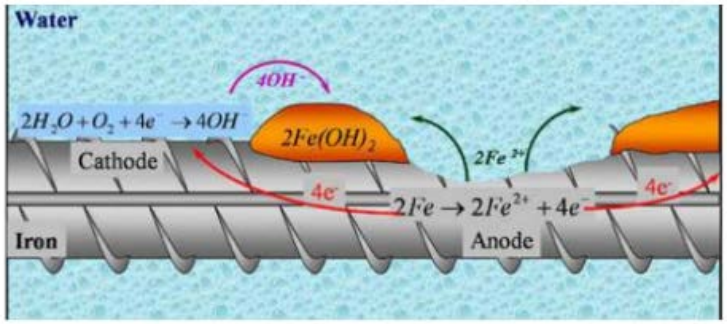



Figure 1. Corrosion Process [1]

Concrete's ability to resist chloride penetration is a determining factor when evaluating durability performance. The Rapid Chloride Permeability (RCP) test is ineffective in assessing the chloride resistance of concrete and has many drawbacks; it is a laborious destructive test that provides an indication of chloride ion movement but with high variances. In contrast, the Surface Resistivity (SR) test is non-destructive, requires less training, and provides higher accuracy with less single-operator and multi-laboratory variation in results, thus reducing construction disputes and litigation efforts. Implementation.

### Implementation

The project showed that the SR test can be an indicator of the chloride permeability of concrete. The SR as well as RCP tests were conducted on the same HPC specimens from laboratory and field mixes to develop a correlation through which an SR threshold is deduced. A parametric study was performed to study the effect of supplementary cementitious materials (SCMs) such as fly ash (Class F) and slag (Grade 100) and chemical admixtures such as accelerator and retarder on SR and RCP measurement for the concrete specimens cured in several conditions.

The research project provided the validation of the surface resistivity (SR) test as an alternative of the rapid chloride permeability (RCP) test requirement for high performance concrete used in New Jersey. The SR threshold proposed in lieu of chloride permeability threshold would be more economical and effective requirement in enhancing quality of construction.

To fully assess the surface resistivity test evaluation limits relative to the rapid chloride permeability test, the researchers recommended that future research focus on obtaining additional data from testing field samples based on mixtures composed of local resources and cementitious contents, noting the need for an additional number of field mixes that are used on NJDOT contracts especially those that would be failing the RCP test threshold.

## NJ-2015-005

## Oversize/Overweight Public Documentation Benchmarking and Effectiveness Study

Research Category: Multi-Modal System Components and Users
Project Budgeted Cost: $54,040
Project Customer: NJDOT Bureau of Freight Planning and Services
Organization: Cambridge Systematics

### Background

Operating a commercial vehicle in the United States requires an understanding of the many federal and state rules that govern the industry. Often, this information is provided to the commercial vehicle industry in the form of complex official codes and regulations, making it difficult for industry to clearly understand what is expected of them. New Jersey is an example of a state where commercial vehicle rules are provided to the industry in the form of code and regulatory documents. Of particular concern are the rules and regulations related to the size and weight limitations of commercial vehicles operating in the State.

### Implementation

The research identified national best practices for information dissemination on size and weight limits and recommended both methods and materials that can be employed by state departments of transportation (DOTs) to better educate operators, and thus increase compliance with regulations. Recommendations were made to provide in-depth, up-to-date and specific information through various handbooks, guidebooks, and manuals, making such documentation digital or accessible online at nj.gotpermits.com, and exploring the development of a smart-phone application.

The research was selected and submitted to AASHTO in 2016 as an example of High Value Research, and was presented at the 2017 TRB Annual Meeting.

**FHWA-NJ-2015-006**

## Restricted-Use Licenses for Suspended NJ Drivers

Research Category: Traffic and Safety
Project Budgeted Cost: $200,000
Project Customer: New Jersey Motor Vehicle Commission
Organization: Rowan University

### Background

In New Jersey, driver license suspension for traffic-related offenses was established as a way to remove “bad drivers” from the roads. However, in the early 1990s, this sanction was expanded to non-traffic-related offenses, such as failure to meet financial responsibilities or failure to acquire/maintain proper auto insurance. Over time, this has became a controversial issue with many asking why non-traffic-related offenses were being punished with a revocation of driver licenses. In some cases, loss of a driver’s license exacerbated the reasons why the license was revoked in the first place. For example, someone who was falling behind on their child support could be faced with a license suspension, which in turn made it more difficult to go to work and catch up on their child support.


Several states in the U.S. have countered this unintended impact by creating Restricted Use License programs, allowing drivers with suspended licenses to drive in specific scenarios such as driving to work. The primary objective for this study was to explore the possibility, the consequences, and the implications of implementing a Restricted Driver’s License (RDL) program in New Jersey.

The report conducted a literature review of current practices and experiences with restricted-use driver license programs; examined the characteristics of driver license suspensions in New Jersey; performed a national survey of State motor vehicle agencies; evaluated Restricted Use Licenses for drivers with commercial driver licenses; investigated crash and violation risk of drivers with non-driving suspensions; and performed a survey of the perceptions of NJ Police Chiefs regarding a Restricted Driver License.

### Implementation

The study was meant to evaluate the efficacy of a proposed new system. No presentations or publications were made about the compiled data and research. The findings were presented to NJ Motor Vehicle Commission and detailed the existence of programs in other states, as well as the perceptions of enforcement officers in New Jersey about a potential program. Police officers surveyed in New Jersey thought such a program could be beneficial, but to date no policy changes have been made.

## FHWA-NJ-2015-007

## HMA Pay Adjustment

Research Category: Design and Construction
Project Budgeted Cost: $236,310
Project Customer: NJDOT Bureau of Materials
Organization: Rutgers University CAIT

### Background

In the current NJDOT specifications, hot-mix asphalt (HMA) pavement is tested and price adjusted for in-place air voids, total thickness, and ride quality compliances. The current pay factors in the specifications are based on empirical field data and engineering experience. A number of states have begun to implement longitudinal joint specifications, and most are based on determinations of density. However, distress at the joint is caused by the ability of air and water to enter the pavement structure, which is also related to permeability.

The purpose of the study was to recommend the specification limits for air voids at the longitudinal joint based on density and permeability testing results and perform risk analysis for the proposed pay equations. The project sought to evaluate multiple quality characteristics of hot-mix asphalt (HMA) for pay adjustment in quality assurance (QA). Life-cycle cost analysis (LCCA) was used to develop performance-related pay adjustment for in-place air voids.

### Implementation

The project evaluated multiple quality characteristics of hot-mix asphalt (HMA) for pay adjustment in quality assurance (QA) and developed life-cycle cost analysis (LCCA) to measure performance-related pay adjustment. Draft specifications were developed and provided to NJDOT.

A follow-up study was completed within a year that provided refined specifications. A pilot project was reported to be in the planning stages. The project was presented at the TRB Annual Meeting in 2017 and 2018.

**FHWA-NJ-2015-008**

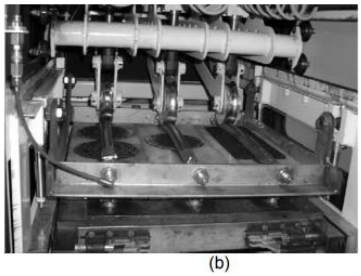
## Rejuvenating Agents with RAP in Hot Mix Asphalt (HMA)

Research Category: Design and Construction
Project Budgeted Cost: $203,162
Project Customer: NJDOT Bureau of Materials
Organization: Rutgers University CAIT

### Background

NJDOT had been investigating various options to utilize higher percentages of recycled asphalt pavement (RAP) in hot mix asphalt (HMA). Research efforts ranging from controlled laboratory studies to field pilot projects have clearly indicated that RAP mixtures are stiffer and more prone to cracking than virgin asphalt mixtures. These efforts have also suggested that one of the major causes of the higher stiffness and cracking potential is the lack of blending between the RAP and virgin asphalt binders. This project evaluated the potential use of rejuvenating agents for use with higher RAP asphalt mixtures. Various rejuvenating agents, pre-blended in the asphalt binder, were evaluated in asphalt mixtures with 25 percent and 40 percent RAP by weight of mix. Asphalt binder test procedures were developed to assess the degree of rejuvenating each rejuvenating agent provided. Asphalt mixture performance tests were used to ensure the final mixture performance balanced rutting and fatigue cracking performance under the NJDOT High RAP (HRAP) specification. Effectiveness of the rejuvenator types evaluated was provided.


(a)


(b)

### Implementation

The results of this study were used to validate some of the asphalt binder test methods not yet adopted by NJDOT. The barrier to implementation is that the testing process is fairly sophisticated to deploy. The higher additions of RAP clearly reduce performance, thus validating the high RAP specification that was being developed concurrently with this research. The research supported the need for mixture performance testing. The research study developed and introduced a new means for evaluating the maximum effectiveness of the rejuvenator on the RAP mixture using the shape of the master curve and determining the Rheological Index (R-value) and Cross-over Frequency that can be determined from extracted and recovered asphalt binders. In evaluating the two different sets of RAP mixtures using asphalt binder and mixture testing protocol, the testing indicated that the Paraffinic Oil rejuvenator provided the best rejuvenating properties for maximizing performance of RAP HMA.

Some of the findings generated during the course of the research study were already implemented and disseminated to other agencies and the asphalt industry by its completion. For example, the NJDOT HRAP specification began during the beginning of the study. Rejuvenators had been evaluated and utilized in the HRAP mix produced by an asphalt plant. Also, findings from the study had been presented at the Northeast Asphalt User Producer Group (NEAUPG), as well as the Association of Asphalt Paving Technologists (AAPT) regarding the use of rejuvenators and addressing their effectiveness.

## FHWA-NJ-2015-009

## The Effect of WMA on RAP in Hot Mix Asphalt

Research Category: Design and Construction
Project Budgeted Cost: $330,031
Project Customer: NJDOT Bureau of Materials
Organization: Rutgers University CAIT

### Background

Warm mix asphalt refers to asphalt concrete mixtures that are produced at temperatures approximately 40 to 70 degrees Fahrenheit cooler than typically used in the production of hot mix asphalt. The goal with warm mix asphalt is to produce mixtures with similar strength, durability, and performance characteristics as hot mix asphalt using substantially reduced production temperatures.

This project evaluated the performance of different WMA technologies when utilized in asphalt mixtures containing Recycled Asphalt Pavement and polymer-modified PG64E-22 (i.e. - PG76-22). In addition, the proposed WMA mixture design procedure, developed as part of NCHRP Project 9-43, A Mix Design Procedure for Warm Mix Asphalt, was evaluated using New Jersey materials.

### Implementation

This study resulted in the full acceptance of WMA for use on NJDOT projects. The specifications now reflect that either WMA or HMA may be used. WMA has important environmental and health benefits associated with reduced production temperatures, including lower greenhouse gas emissions, lower fuel consumption, and reduced exposure of workers to asphalt fumes. Lower production temperatures can also potentially improve pavement performance by reducing binder aging, providing added time for mixture compaction, and allowing improved compaction during cold weather paving

This project was featured during one of the NJDOT Annual Research Showcase events to highlight the project to NJDOT research stakeholders.

## FHWA-NJ-2015-010

## Performance Testing for HMA Quality Assurance

Research Category: Design and Construction
Project Budgeted Cost: $270,074
Project Customer: NJDOT Bureau of Materials
Organization: Rutgers University CAIT

### Background

The objective of this project was to evaluate various HMA performance tests for potential implementation as an end-result Quality Assurance test for hot mix asphalt; and to provide recommendations upon its potential use for NJDOT. The scope of the project also included the procurement, set-up and training of the performance test equipment, as well as a round robin study to compare test results between NJDOT and Rutgers University.

### Implementation

During its initial implementation with NJDOT, the initial Superpave mixtures were found to be coarser, had less asphalt binder, and were harder to place and compact than the previous Marshal asphalt mixtures designed for the identical traffic level. What resulted were asphalt mixtures that were prone to poor longitudinal joint construction and asphalt pavements failing more quickly due to fatigue cracking-related distress.

Presentations on this work occurred at the Transportation Research Board (TRB) conference, Northeast Asphalt Users and Producers Group conference, and the Mid-Atlantic Quality Assurance Workshop.

Training was conducted for NJDOT staff so they could conduct their own in-house testing for all of their performance tests. Subsequent to the training, NJDOT conducted their own performance-related specifications testing and changed it operating procedures which eliminated the need to hire external labs to do this work. This in-house capability ensures that asphalt materials will meet the minimum level of performance required (quality control/quality assurance).

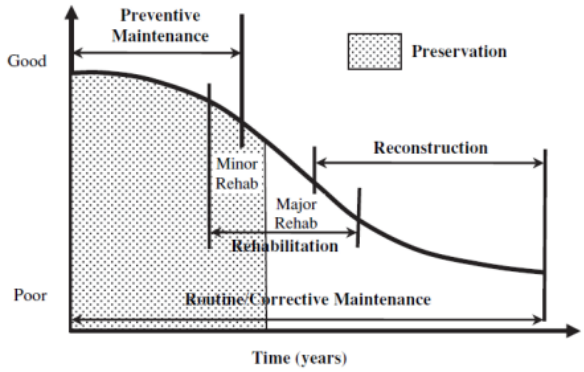
## FHWA-NJ-2015-011-I and FHWA-NJ-2015-011-II

## Appropriate Implementation of Pavement Preservation Treatments

Research Category: Operations and Preservation
Project Budgeted Cost: $224,081
Project Customer: New Jersey Department of Transportation
Organization: Rutgers University CAIT

### Background

The New Jersey Department of Transportation (NJDOT) recently formed a Pavement Preservation Task Force and added Pavement Preservation Treatments to the Department's Pavement Management System (dTIMS). The Department would like to expand its use of pavement preservation treatments and newer pavement rehabilitation and reconstruction treatments to extend pavement service life. The critical features of a pavement preservation program are choosing the right treatment on the right road at the right time. NJDOT sought assistance in identifying treatments that will have a high success rate on NJ's state-maintained roads, shoulders and ramps, taking into consideration the climate, pavement type and condition, traffic levels and loading, construction staging practices and constraints on local materials, suppliers and contractors. This research study examined the pavement preservation treatments that are appropriate on NJ's state-maintained roads, the means of selecting the right time and condition to apply the treatment, the treatment's effectiveness on the road's condition, and the extension of the service life and the cost of applying the treatment.



Source: Adapted from Peshkin et al. 2007.

### Implementation

The project utilized an extensive literature search of preservation centers, industry websites, and state DOT sites and surveys to identify appropriate pavement preservation, rehabilitation, and reconstruction treatments for use in NJ and the availability of contractors and suppliers in the surrounding states.

Based on the results of the project, NJDOT selected seven treatment types that could be used in New Jersey. Demonstration projects which included Cold Inplace Recycling (CIR), Full Depth Reclamation (FDR), Asphalt Rubber Chip Seal, Slurry Seal and Micro-surfacing treatments provided training opportunities for NJDOT staff. Outside of the training and internal documentation, the findings were not published in any brochure or publication.

The Route 83 Cold Inplace Recycling project utilized the mix design methodology, and CIR specifications and procedures and training developed by this project. The pilot project was used as a demonstration of this technology for other agencies throughout the state. The research expanded understanding of pavement preservation treatments in NJ and at NJDOT.

The research provided the NJDOT PMS and other agencies with an expanded toolbox of pavement treatment tools to more effectively and efficiently use the State's limited pavement budget.

In terms of economic benefits, the Pavement Preservation specifications developed for NJDOT are available for all other agencies (e.g., toll authorities, counties and municipal agencies). The Pavement Preservation treatments identified in the project are less expensive than the traditional rehabilitation treatments (mill 2 inch and overlay 2 inch). As an example, Pavement Preservation treatments have an average cost of $2.50/SY while the average Pavement Rehabilitation treatments cost approximately $25.00/SY. These treatments therefore allow a much greater percentage of an agency's miles to be treated using the same budget, which preserves the overall condition of the pavement network.

The work is summarized in LTAP training courses for municipal, county, state, and consultant staff. The research was cited in the report's recommendations to expand the pavement treatment toolbox for all agencies. Through its technology transfer program, NJDOT's Bureau of Research is currently working with the Pavement and Drainage Management and Technology unit to fund the development of a short video to promote awareness of pavement preservation treatments and why NJDOT is using them.

The Pavement Preservation treatments will be used as NJDOT construction project opportunities become available, making the implementation of these treatments a slow, but enduring process.

**FHWA-NJ-2015-012**

## ADA Paratransit Facility Alternatives

Research Category: Policy and Organization
Project Budgeted Cost: $312,512
Project Customer: NJ TRANSIT
Organization: Rutgers University, CAIT and VTC

### Background

The Access Link paratransit service is provided by NJ TRANSIT to persons with disabilities through private contractors, with facilities being leased during each contract period. Due to the short duration of the contracts and the high growth of ridership and vehicles, service providers have often moved from one facility location to another at the end of each contract. Due to the high costs of leasing and difficulties in frequently finding appropriate properties, NJ TRANSIT sought a study to assess the advantages and disadvantages of owing one or more of its Access Link facilities instead of continuing to lease.


### Implementation

The research study sought to assess the quantifiable advantages of NJ TRANSIT owning one or more of its Access Link facilities and determine the optimal locations for siting such facilities. A literature review was conducted and supplemented by site visits to Access Link facilities, interviews with Access Link facility managers, and structured interviews with ADA division offices from 11 other transit agencies nationwide. Cost models were developed that compared the costs of leasing versus owning for several existing and potential Access Link facilities. A GIS-based accessibility analysis was prepared to identify optimal locations with the region. Forecasted growth in ridership demand in sub-regions of the state over the next 25-year period was prepared.

Nationwide, the interviews showed a high degree of satisfaction among transit agency officials from the ownership of ADA paratransit facilities. The cost models showed that NJ TRANSIT could break even with leasing costs over a 12-15 year period by owning the facilities and by choosing those facilities with optimal locations. Furthermore, savings of $6 million to $13 million were projected over a 25-year period.

NJ TRANSIT viewed the research information as helpful in determining whether or not to begin facility acquisition projects in the future. Currently, no plans have been made to do so.

One paper was presented on this topic, “Practical Approaches for Making ADA Paratransit Facility Ownership and Location Decisions,” which was presented at the 96th Annual Meeting of TRB in 2017.

## FHWA-NJ-2016-001

## Integration of Bus Stop Counts Data with Census Data for Improving Bus Service

Research Category: Multi-Modal System Components and Users
Project Budgeted Cost: $175,003
Project Customer: NJ TRANSIT
Organization: University of Albany, New York

### Background

Providing a safe, efficient, and cost-effective bus network is a continuing challenge, requiring reliable data and high-quality planning tools. Recent products made available by the United States Census Bureau, including the American Community Survey (5-year series) and the 2010 Decennial Census, create a golden opportunity for planners and researchers to refine the empirical basis for their population-based decisions. By delving into the demographics and characteristics of each of its markets, NJDOT and NJ TRANSIT can better understand the demographic factors that influence transit ridership in various markets and improve the lives of its stakeholders.

### Implementation

The research team developed a software tool suite called the Bus Transit Market Analyst (BMTA). BTMA uses technology to aid in transit planning by mapping and visualizing various datasets and by developing demand models. The BTMA integrates several data sources including the General Transit Feed Specifications (GTFS), the American Community Survey (ACS) Application Programming Interface (API), the Census Transportation Planning Products (CTPP) as well as the Longitudinal Employer-Household Dynamics (LEHD) Longitudinal Origin-Destination Employment Statistics (LODES) datasets. The BTMA has a set of open source tools for analyzing and visualizing machine-readable automatic farebox data and ridership survey data. The survey tools include a set of interactive graphs and maps that allow users to filter by route, demographics, and customer data. BTMA includes a transit demand modeling tool that uses Open Trip Planner as a microsimulation routing “engine.”

The final data visualization and informatics tool suite offers an enhanced perspective on NJ TRANSIT’s own transportation assets, identifies the key demographic factors that influence transit ridership, supports the development of solutions for NJ TRANSIT, and provides a data tool for agency use.

The research team developed an implementation and training plan to introduce the Transit Market Analyst software to NJ TRANSIT staff. As part of the implementation plan, two NJ TRANSIT employees working in demand modeling were identified as the shepherds, tasked with transferring the knowledge, deploying the technology, and trained as internal points of reference to support users of the software within the agency. The research team held weekly trainings with the NJ TRANSIT employees on understanding the software and the accompanying report and organized a hands-on training seminar for other NJ TRANSIT employees. Additionally, the software was hosted on servers located at the University at Albany for at least one year beyond the project end date.

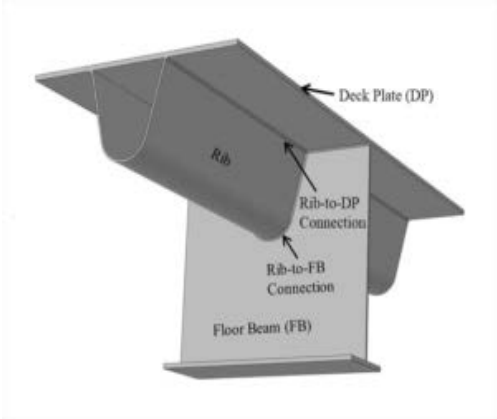
FHWA-NJ-2016-002 and NJ-2016-002-007

## Design and Fabrication of Orthotropic Deck Details

| | |
|---|---|
| Research Category: | Design and Construction |
| Project Budgeted Cost: | $940,000 |
| Project Customer: | NJDOT |
| Organization: | Lehigh University |

### Background

A steel orthotropic deck integrated with steel box girders is proposed by the designer for the replacement of the Route 7 Wittpenn lift bridge. Contrary to the more conventional design, this design incorporated a thicker deck plate stiffened by round bottom ribs passing continuously through matching cutouts in the floor beams. This research project investigated cost-effective design and fabrication of welded connection details for the proposed steel orthotropic deck for the replacement Wittpenn Bridge, and verified the infinite life fatigue performance of the details by testing a full-scale prototype of the part bridge deck under simulated maximum axle loading for fatigue design of orthotropic deck. Subsequently, infinite life fatigue performance of the connection details was evaluated by laboratory testing of a full-scale prototype of the part bridge comprising five ribs and three floor beams in a unique setup that adequately replicated the boundary conditions.




### Implementation

The research showed the advantages of using these bridge decks, emphasizing their light weight and structural efficiency, and their estimated life span of over 100 years. Orthotropic bridge decks are lighter due to the reduced need for concrete, which minimizes the total dead load carried by the rest of the structure. Estimates are that up to 25 percent of a bridge's total mass can be saved by reducing the deck weight, and those weight reductions can extend to cables, towers, piers, and so forth. Orthotropic decks are prefabricated and their modular form allows for accelerated bridge construction and higher quality control. The bridges can be erected more quickly, thus minimizing the impact on New Jersey's motorists. The maintenance requirements for orthotropic bridges are expected to be much lower as there would be no need to re-deck the bridges every few decades. Although there are high initial construction costs associated with orthotropic bridges due to the complex welds involved, such costs would be offset by the lower maintenance costs over the life of the bridge.

In July 2017, the Route 7 Wittpenn Bridge was the first bridge constructed in New Jersey using an orthotropic bridge deck. The research findings have been disseminated in many publications and presented internationally in many places including, but not limited to, the ASCE Structures Conference, the IABAC in Geneva, the Orthotropic Bridge Conference in China, as well as domestically for a Lunchtime Tech Talk given to NJDOT employees in Trenton.

## FHWA-NJ-2016-002

## Highway Repair Consolidation Feasibility

Research Category: Design and Construction
Project Budgeted Cost: $321,819
Project Customer: NJDOT
Organization: Rutgers University RIME

### Background

Faced with a growing number of work zones, the challenge for transportation agencies is to effectively manage the impacts of work zones to alleviate congestion and maintain the safety of motorists without disrupting project schedules. Coordinating work zone activities and improving communication among agencies is already in practice by various state departments of transportation (DOTs) and transportation agencies. The main objective of this study was to understand the types of projects that can be coordinated and to evaluate the effectiveness of coordinating short- and long-term projects using a cost-benefit analysis approach to measure the efficiency of various combinations of projects relative to each other and the status quo. The research team conducted an extensive literature review, determined the state of practice in other state DOTs, and conducted interviews with NJDOT staff to investigate the types of projects undertaken by NJDOT and if there was already a practice of work zone coordination on NJ roadways.

### Implementation

After consulting with the project panel and the NJDOT Mobility and Systems Engineering division, the research team devised a work zone coordination framework that utilizes one common work zone database, drawing upon OpenReach and Capital Program Management Project Reporting System databases. The Work Zone Coordination Spreadsheet (WCS) tool was developed to provide NJDOT with an easy-to-use tool to evaluate the feasibility and effectiveness of coordinating short- and long-term work zones, and to measure the benefits of various combinations of projects relative to each other and the status quo. The project resulted in the development of an online tool with web-based user interface that integrates all scheduled and active construction projects from the OpenReach database and planned CPM projects from the project reporting system database. The tool identifies conflicts between work zone projects and estimates benefits of mitigation of conflicts. The tool allows users to identify work zone conflicts, alert involved parties, and conduct a benefit-cost analysis of coordinating the conflicting work zones. Details on how to use the WCS tool are detailed in the Work Zone Coordination Spreadsheet Tool section of the final report.

At the time of the report's conclusion, the tool was operational. The research team noted its plan to provide technical support to the users of the tools, fix minor bugs and ensure that it remains available throughout its initial testing period. The report also identified the need for future work to continue the day-to-day maintenance and development of the tool based on the actual experiences of its users and to automate the use of different online and offline databases maintained by NJDOT.

## FHWA-NJ-2016-003

## Alternatives to Nuclear Density Testing

Research Category: Design and Construction
Project Budgeted Cost: $450,000
Project Customer: NJDOT Bureau of Materials
Organization: Rowan University

### Background

Highway agencies employ specifications that rely on selecting a specific aggregate type and a minimum density level. The density requirement is determined using the nuclear density gauge (NDG), which is currently considered the primary tool for assessing the quality of compacted base/subbase and subgrade layers. However, there are several concerns and safety risks associated with using this device. Strict regulations for using the NDG require specific transportation and storage methods/procedures only appropriate for nuclear devices. These regulations also require having trained licensed personnel to operate the NDG, making use of the NDG more onerous and expensive. The NDG also exposes the operator to harmful radiation, meaning there is a safety risk as well.

NJDOT would like to replace the nuclear density gauge with non-nuclear based devices/methods when assessing the quality of compacted unbound pavement layers. The overall goal of this study was to evaluate alternative non-nuclear methods for use during the acceptance of soil and quarry produced aggregate compaction through field evaluations of new technology and cost analysis comparisons between the new technology and the NDG.

### Implementation

Several non-nuclear devices were tested, with the dynamic cone penetrometer (DCP) emerging as the most efficient. Each device was evaluated for its sensitivity to moisture content, compaction effort applied, aggregate type, and testing time. Based on laboratory testing, a multiple linear regression model to predict DCP field measurements was developed. The model was then calibrated using field data.

Pilot testing was implemented on three separate sites, with results being as efficient as the NDG. Based on this study, the researchers recommended that NJDOT implement this procedure for specifying minimum DCP values for quality acceptance of unbound subgrade and base/subbase layers during the construction of roadway projects. Moving from the nuclear device to the non-nuclear base device yields significant benefits, including the elimination of the need for costly nuclear recertification for operators, special storage requirements, and safety concerns stemming from hazardous radiation.

The researchers also recommended testing on additional field sections constructed using different types of aggregates to enhance the implementation of the developed specifications. The researchers also recommended that the future research evaluate the ramifications of waiving the requirement for measuring field moisture content as it may affect the practicality of the developed DCP specifications and hinder implementation. Findings from this project were published in various NJDOT publications. A TRB conference paper was also developed, and a presentation was given to the New England State Materials Organization and Mid-Atlantic Quality Assurance Workshop.

## NJ-2016-003

## Cost of Roadway Construction, Operations and Maintenance in NJ

Research Category: Design and Construction
Project Budgeted Cost: $43,000 (Phase I)
Project Customer: NJDOT
Organization: Rutgers University VTC

### Background

New Jersey's transportation systems comprise a vast array of infrastructure, including more than 38,000 centerline miles of roadways and thousands of bridges under State and local jurisdiction; more than 3,000 buses operating on 262 bus routes; 12 commuter rail lines serving 165 stations in 117 municipalities; 3 light rail lines serving 62 station/stops; 350+ park-and-ride lots; 3 commercial airports, 46 general aviation airports; 225 miles of commercial navigation channels; the largest seaport on the east coast; two Class I rail freight carriers and 14 regional and shortline railroads. The costs of planning, constructing, operating and maintaining New Jersey's transportation infrastructure are significant. While some national research has estimated the average cost to maintain and operate state highway systems, no such research had been conducted in New Jersey. The primary Phase I research objective was to estimate the average costs to plan, construct, operate and maintain the roadways and bridges under NJDOT jurisdiction.

### Implementation

The results of Phase I provided a baseline estimate of the average aggregate costs of the roadways and bridges under NJDOT jurisdiction. Costs averaged around $1.5 billion annually. This equates to an average cost of $183,757 per lane mile to plan, construct, operate and maintain the roadways and bridges under NJDOT jurisdiction and increases to $212,927 per lane mile when interest payments on bonds is added.

Additional analysis was recommended for Phase II to understand more completely the factors that influence cost efficiency of specific NJDOT projects and programs, and the costs of planning, constructing, operating and maintaining roadways under the jurisdictions of its toll road authorities. The Phase II analysis was expected to yield average project cost and average cost per lane-mile estimates for a full range of project types and a full spectrum of project components. As with the Phase I programmatic cost analysis, the research team expected to conduct a qualitative assessment of the projects in the sample set to identify outlier project and differentiating factors that may help to explain variation in the cost estimate range.

The Phase I report was the subject of several media articles and blog posts, including articles posted on Equipment World's *Better Roads* website, the Engineers and Labor-Employer website, and the NJ Senate Republicans website as well as two articles posted on NJ.com. Report findings were also cited in testimony by NJDOT's Acting Commissioner before the New Jersey Legislature on the Transportation Trust Fund. Finally, lessons learned from the data compilation and analysis process for Phase I provided NJDOT's senior leadership with important insights regarding how the department's financial management system procedures might be refined to make it easier to track and report construction, operations and maintenance costs and expenditures.

**FHWA-NJ-2016-004**

## Impact of Freight on Highway Infrastructure in New Jersey

Research Category: Operations and Preservation
Project Budgeted Cost: $475,760
Project Customer: Bureau of Freight Planning and Services
Organization: Rutgers University RIME

### Background

Infrastructure systems (highway pavement, bridges, tunnels) are critical to mobility and economic prosperity. However, overweight vehicles hauling freight can deteriorate infrastructure at a higher rate relative to other exposure, and cause financial impacts that are not explicitly quantified. This study examined the impact overweight vehicles have on New Jersey infrastructure, specifically highway pavements and bridges. The research included Life Cycle Cost Analyses for proposed deterioration models to determine the damage cost caused by overweight vehicles.

### Implementation

The research developed both a decision-support tool based on the ASSISTME-WIM software and a unified database for the decision support tool that can be used by NJDOT personnel to assess and quantify the associated damage costs to the NJDOT infrastructure network due to overweight trucks. The end result provided a tool that enabled the NJDOT Bureau of Freight Planning and Intermodal Coordination to combine the agency's freight and overweight vehicles data with maintenance and traffic data, to estimate the actual damage cost on NJ highways due to overweight trucks. Using this tool, and based on the analysis of permit records, the estimated state-wide average cost of moving one ton of overweight load per one mile is about $0.33, in which about approximately 60 percent of the damage cost is attributed to pavement and 40 percent to bridges. The researchers found that NJDOT's weight-based fee structure does not fully recover the damage costs.

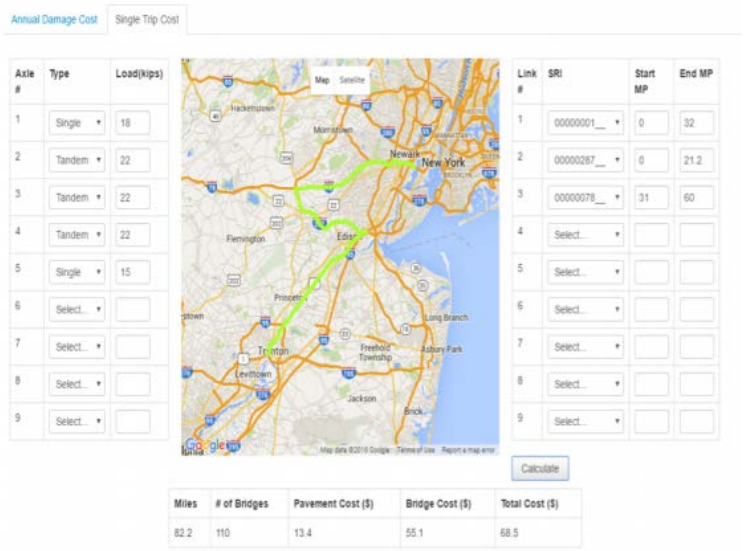



Figure 2. Module for calculating damage cost

The project yielded a unified database of all available data relating to the condition rating of PMS, bridge management system (BMS) and inventory, and Weigh-In-Motion (WIM) truck weight spectra.

The researchers identified the need for future research work to investigate the damage costs of prestressed concrete girders to improve the bridge deterioration models. Future research work was also recommended to account for the damage costs by developing a permit fee structure for overweight trucks based upon overweight ton per mile traveled.

**NJ-2016-004**

## Optimizing Work Zone Lighting

Research Category: Traffic and Safety
Project Budgeted Cost: $100,000 - $50,000 from NJDOT
Project Customer: NJDOT
Organization: Rensselaer Polytechnic Institute

### Background

Work zones are inherently complex and confusing visual environments, where the usual patterns of traffic flow are perturbed, and where lights used by workers for task visibility can create glare for workers and nearby drivers. In addition to warning lights that may be flashing, the use of delineation and signage can contribute to the "visual chaos." NJDOT commissioned this study to address work zone related issues. The study sought to identify the needs of workers and drivers in different work zone environments, and to review existing knowledge about ways in which lighting practices and technologies can be deployed to provide workers with sufficient illumination while minimizing glare and confusion to all individuals in and near the work zone.

### Implementation

The results of the technical analyses led to the development of several preliminary guidelines for illumination system selection/layout, application of sign and delineation devices and materials, and the use and control of warning lights to provide workers and nearby drivers with visual information in work zones. Implementation of the preliminary guidelines in the report can assist NJDOT in improving visual conditions in several different types of work zones through lighting that maintains visual performance while reducing glare and distraction from excessively bright lights.

Implementing the recommendations from the project could result in economic benefits through reductions in work zone-related crashes and subsequent injuries or fatalities to transportation workers along the road. These benefits are difficult to quantify, but based on project findings could be $3,700 per work zone incident.

The results of this project were presented at the 2018 NJDOT TRB Roundtable discussion and disseminated in the following publications:

- UTRC Winter 2018 Newsletter: http://files.constantcontact.com/08b78404201/f40ed8be-c942-481e-93e1-fca9269c1c24.pdf
- AASHTO 2017 Research Impacts (Better – Faster – Cheaper): https://research.transportation.org/wp-content/uploads/sites/31/2017/09/ResearchImpacts2017_Better-Faster-Cheaper.pdf

- AASHTO 2017 Maintenance Research: Innovations from State DOTs: https://research.transportation.org/wp-content/uploads/sites/31/2017/12/MaintenanceResearch2017Final-Web.pdf
- National Work Zone Safety Information Clearinghouse Summary: https://www.workzonesafety.org/publication/optimizing-work-zone-lighting/
- Guidelines for Work Zone Lighting Poster: https://www.lrc.rpi.edu/resources/newsroom/pdf/2016-2017/WorkZoneLighting_8511.pdf
- 2018 TRB Annual Meeting Poster Presentation (must be a registered TRB Annual Meeting participant to access): http://amonline.trb.org/2017trb-1.3983622/t020-1.3997695/384-1.4122300/p18-22040-1.4114691/p18-22040-1.4122303?qr=1

The project was also submitted to AASHTO by NJDOT as a “high value research project.”

## FHWA-NJ-2016-005-I and FHWA-NJ-2015-005-II

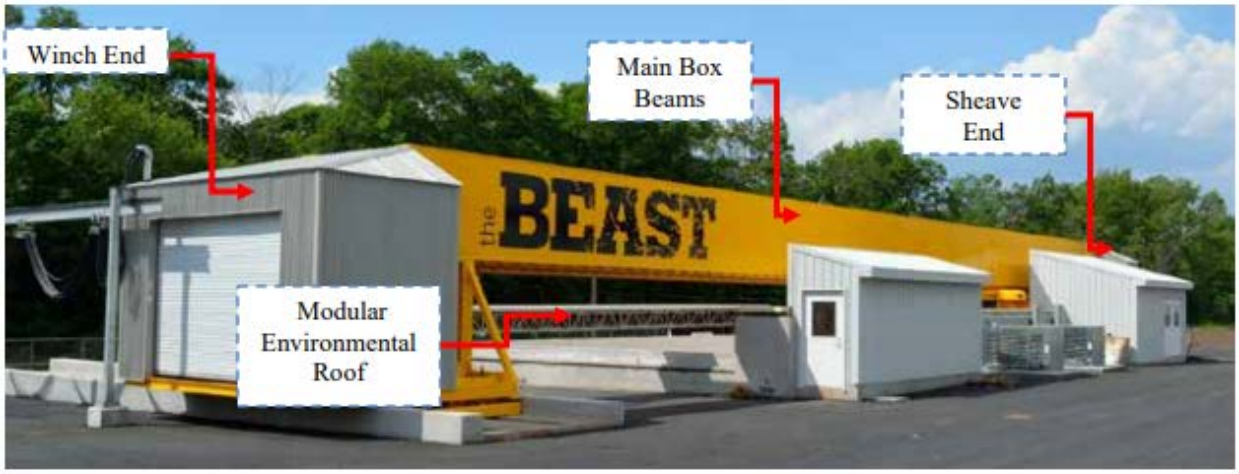
## Heavy Vehicle Load Simulator for Bridge Deck Testing Application: Volume I & Volume II

| | |
|---|---|
| Research Category: | Design and Construction |
| Project Budgeted Cost: | $3,000,000 |
| Project Customer: | NJDOT Bureau of Research |
| Organization: | Rutgers University CAIT |

### Background

This project created a full-scale load testing equipment facility to reliably study complex processes of bridge element deterioration over time due to impacts such as traffic and environmental loading conditions. It was necessary to identify a set of parameters that describe the primary drivers of bridge deterioration, and then to vary these parameters in a controlled sense while observing performance/deterioration over time. In this manner, the causal relationships between external inputs (e.g. repetitive live loads, temperature cycles, freeze-thaw, applications of deicing chemicals, etc.), bridge attributes (e.g. superstructure flexibility, cover thickness, rebar coating, girder spacing, etc.), and various performances (associated with durability, serviceability, strength, etc.) can be discerned.

The project developed specialized testing equipment that will permit the accelerated testing of complete bridge superstructures.




### Implementation

These capabilities have been disseminated through numerous venues, such as:

- National Bridge Preservation Partnership, Annual Meeting, April 2018, Orlando, FL
- AASHTO COBS Annual Meeting, June 2018, Burlington, VT
- American Society for Nondestructive Testing (ASNT) Annual Conference, September 2018, New Brunswick, NJ.

To disseminate the testing capabilities developed under this project, several publications were developed:

- Mini-documentary - https://www.youtube.com/watch?v=fsniSlZuvBc&feature=youtu.be
- ASCE **Civil Engineering** magazine, February 2016 issue: *Rutgers BEAST Designed to Accelerate Bridge Evaluations* - https://www.asce.org/cemagazine/
- ARTBA *Transportation Builder* Research & Education Division (RED) Spotlight, (Sept/October 2015)
- ConstructionEquipmentGuide.com (Nov 16, 2015): BEAST to Study Lifespan of Bridge Construction Materials - https://www.constructionequipmentguide.com/Rutgers-Unveils-the-BEAST-to-Study-Lifespan-of-Bridge-Construction-Materials/26641/
- DuBois & King online news (Nov 3, 2015): The BEAST is Revealed - http://www.dubois-king.com/the-beast-is-revealed/
- Equipment World, Better Roads News (Oct 20, 2015): The BEAST launched at Rutgers - https://news.rutgers.edu/research-news/rutgers-launches-world%E2%80%99s-first-accelerated-testing-facility-bridges/20151014#.XDdqCVVKiUm

In September of 2018, the Federal Highway Administration (FHWA) funded the first research study that will utilize the capabilities of the BEAST Lab. This project focuses primarily on establishing the effectiveness of common bridge deck overlays. To permit the performance of overlays to be examined, FHWA has elected to construct the overall specimen using techniques and materials that were common in the late 1980s. The following specific objectives were defined to guide the overall study:

(1) Establish the long-term performance of bare reinforced concrete bridge decks constructed from materials common in the late 1980s
(2) Establish the long-term performance and effectiveness of various common overlay systems applied to aging/deteriorated reinforced concrete bridges decks
(3) Determine and quantify the ability of various nondestructive evaluation, global sensing approaches, and their integration to identify and track deterioration within bare reinforced concrete bridges decks and decks protected with common overlay systems

Since the project in question was focused on the development of the BEAST lab's testing capabilities, the completion of this project did not directly yield results that could be implemented by NJDOT. However, as these testing capabilities are now utilized, it is expected that the results will permit the improvement of policies, procedures, material specifications, design details, assessment practices, and rehabilitation/repair strategies for bridges. These enhancements will focus primarily on improving bridge durability and extending bridge service life, which can translate into significant savings to NJDOT.

With the new capabilities, researchers are well-positioned to quantitatively examine the long-term performance and durability of complete superstructure systems. This capability is unique and does not exist at any other laboratory throughout the world.

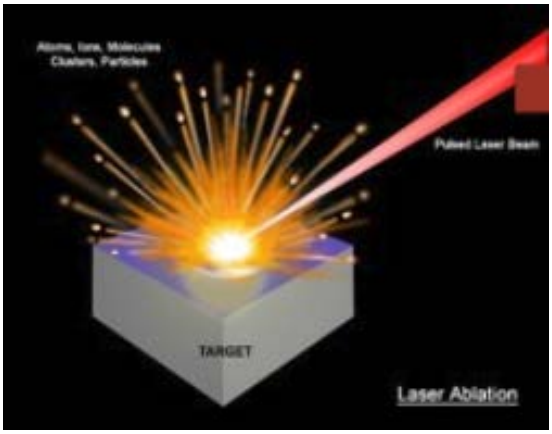
**FHWA-NJ-2016-006**

## Laser Scanning Aggregates for Real Time Property Identification

Research Category: Design and Construction
Project Budgeted Cost: $255,067
Project Customer: NJDOT Bureau of Materials
Organization: Rowan University

### Background

This research study utilizes laser technology for real-time property determination of an aggregate that can be performed in the field to yield relevant data quickly, so that aggregate quality control can be undertaken in a timely and cost-efficient manner. Currently, NJDOT uses X-Ray Fluorescence analysis (XRF) and petrographic examination to identify the minerals present in the aggregate. This process requires more time and careful sample preparation. Laser Induced Breakdown Spectroscopy (LIBS) technology is used to identify the mineral composition of aggregate used for road construction. This technology enables the user to know the quality of aggregates provided by various aggregate manufacturing companies which will affect the durability of the highways/roads.




### Implementation

The research showed that LIBS is feasible as a means to quantify chemical composition of aggregate. By dividing the training set into carbonate and non-carbonate stones, prediction accuracy and reliability improved considerably. Future testing will include further refinement of predictive models, building on the split training set strategy. This equipment was also tested with a low cost, temperature controlled, lower resolution spectrometer and was found to produce similar results with the same accuracy. Thus, the equipment can be made 50 percent more affordable in the future. A manual was developed for the end users that includes the safety precautions, and the operation and maintenance of the equipment. The manual was used to train NJDOT personnel in the use of the equipment.

The research resulted in a product that can generate millions in cost savings because of the shorter turnaround time required to analyze the mineralogy of aggregates. The approach can result in significant societal benefits by reducing the rate of deterioration of roadways due to use of poor-quality aggregates. The equipment used in the project was turned over to NJDOT. The project's Principal Investigator was awarded the Research Implementation Award from the New Jersey Department of Transportation for this project.