New Jersey Department of Transportation
2005
RESEARCH IMPLEMENTATION REPORT

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in cooperation with NJDOT Bureau of Research

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2005 NJDOT RESEARCH IMPLEMENTATION REPORT

Executive Summary

The New Jersey Department of Transportation (NJDOT), Bureau of Research, annually funds about 20 research projects that support the transportation industry. Requested by industry customers, many of these projects solve important transportation problems, but limited information is known about the long-term effects of the studies. The Bureau is frequently approached by sponsors to justify the value of these projects to a much broader audience; therefore, the intent of this implementation study is to identify the quantitative and qualitative benefits of NJDOT research projects that were completed in 2005.

The scope of this study included measuring technology transfer benefits on four levels: knowledge transfer, marketing efforts, adoption of policy changes, and demonstration of technology to new audiences. Benefits were defined as enhancements, cost savings and economic impact; improvement of safety, and reduction of labor time for the customers, known as champions.

Principal Investigators from universities were interviewed by email, telephone, or in person on the outcomes of their research projects. It was expected that investigators would report on additional studies and projects that had been generated as a consequence of this initial work. Since the information was not always available, the NJDOT customers were identified by investigators for each project. Interviews were arranged with the customers to establish, not only benefits, but follow up activities that happened as a result of the research.

Nearly 90% of the projects involved the development and piloting of computer simulation and decision-making models to increase safety on New Jersey roadways. Over $8.5 million was realized from the research conducted during this period, and the potential exists for the NJDOT to regain an additional $834 million over time through the reduction of fatal and injury roadway crashes, recycling of pavement instead of using virgin asphalt, the development of customized bridge designs based on coring data, application of geopolymer coating to protect much of our vulnerable infrastructure, and the future installation of energy efficient LED lighting on New Jersey roadways.

![2005 NJDOT Research Studies Investment](image)


NJDOT Realized Savings

Safety and environmental projects provided the greatest financial benefit due to the strong economic relationship between reduction of crashes and congestion. In one study, a statewide safety network was established to support local transportation agencies. This network facilitated the contribution of $3,000,000 to the MPOs for the purpose of supporting local safety programs. Later, a series of focus groups were organized to develop the first statewide Comprehensive Strategic Highway Safety Plan (CSHSP). Since the Plan has been officially adopted in New Jersey, there was a 20 percent reduction of roadway crashes, estimated at over $823,000,000 in saving of lives.

Computer Modeling and Simulation of New Jersey Signalized Highways Volume I and II

Another cost savings for the NJDOT has been realized through the systematic improvement of traffic operations along the State’s signalized highway corridors. NJ Route 23 and NJ Route 42/322 were selected as study areas with the potential to reduce congestion and improve air quality through signal timing optimization. Optimal signal timings were developed using traffic volume data and existing signal timing. New timing directives were reviewed and approved by NJDOT Bureau of Traffic Engineering and Safety Programs to ensure compliance with the NJDOT standards and format. Significant improvement in level of service was achieved by optimizing the signals, reducing by half the average vehicle delays during peak morning hours.

The initial project was managing traffic flows associated with Route 23 and Route 42/322 to demonstrate the benefits of signal timing improvement. Total costs for both routes were roughly $101,388 while the combined net benefits came to $3.8 million per year, yielding a cost/benefit ratio of 1:21 overall (1:24 for Route 23 and 1:20 for Route 42/322). The ratio for future years will dramatically increase as costs are fixed. The study team also found optimized signal timing plans for Route 23 and Route 42/322 to be economically justified and recommended a yearly review of traffic signal and system performance to maintain efficiency and effectiveness. They suggested future studies incorporate New Jersey specific parameters such as vehicle occupancy, pollutant unit cost, and New Jersey specific crash data.

The findings confirmed that the total costs incurred, including engineering and network modeling costs, were balanced against estimated dollar benefits of the improved signalization. These benefits were reduced travel time, less fuel consumption, and lower environmental impacts during AM, Noon, and PM time periods for yearly weekdays. Additional benefits, not included in the study were savings from reduced crashes and customer satisfaction.

The capital program is now in its fourth year and has grown from an initial $1,000,000 budget item to $1,700,000 with additional change orders of $1,000,000 for a closed loop traffic operation. An additional $10,000,000 over the next 5 years is possible for optimization of routes in conjunction with Congestion Management Systems. This has allowed NJDOT to satisfy the optimization requirements in the Federal Performance Plan. The results were posted on the NJDOT website. Savings were realized through the reduction of labor, while safety benefits still need to be identified, along with travel time savings.

Environmental Savings

Additional environmental savings were realized through dredging of the New York/New Jersey navigational channels. In order to accommodate the newest generation of container ships, dredging of these navigational channels to a depth of 50 feet had to be done. There is a future potential to generate millions of cubic yards of red clay. This pilot study was undertaken to provide NJDOT with useful information on how this clay can be used most effectively.

Initially, 4000 cubic yards of red clay dredged from Newark Bay was transported to the Bayshore Recycling Corporation and placed in varying thicknesses and compacted to evaluate its behavior and workability. Both laboratory and field testing was done at different moisture and compaction conditions. Half of the clay was then removed and used in an
actual capping project. Researchers concluded that dredged red clay from Newark Bay and surrounding bodies of water was beneficially used as a low conductivity cap with similar performance to mined clay without the environmental impacts associated with mining. Conventional equipment and trucks could be used without the added expense of modification.

Scott Douglas, the NJDOT customer, confirmed that the purpose of this study was to help identify the most cost effective uses of dredged clay materials. The application was expected to produce a considerable cost savings due to being recycled. New York City had expressed interest in using the clay as a liner for the Fresh Kills Landfill. It was found that all costs were comparable or lower than costs of competing products. The estimated potential market use of red clay is approximately 22 million cubic yards over the next ten years. In addition to use in containment barriers for landfill capping and site remediation projects, other markets exist for the use of clay in pond liners and wetland restoration, as well as for the ceramic manufacturing industry if the red clay material is amended.

The technology was proven effective as a substitute for mined clay substitute. Also, the environmental benefits of this product include reduction of ongoing contaminants, stopping of leche, and acting as a contaminant absorbent at the nearby brown fields. The associated cost for transportation, unloading, moisture conditioning and placement was estimated to be $13.60 per cubic yard. The market price of mined clay from upland sites is $15 per cubic yard, and $2.30 in placement costs that total $17.30 per cubic yard of mined clay. It was cost effective to use dredged red clay instead of mined clay. Since 4,000 cubic yards of red dredged clay was processed and used instead of mined clay at the landfill, the realized savings amounted to $14,800.
Introduction

The New Jersey Department of Transportation (NJDOT), Bureau of Research annually funds about 20 research projects that support the transportation industry. Requested by industry customers, many of these projects solve important transportation problems, but limited information is known about the long-term effects of the studies. The Bureau is frequently approached by sponsors to justify the value of these projects to a much broader audience; therefore, the intent of this implementation study is to identify the quantitative and qualitative benefits of NJDOT research projects that were completed in 2005.

About the New Jersey Department of Transportation Bureau of Research

The Bureau of Research is responsible for delivering quality research and technology transfer solutions through a customer-focused program. This research is dedicated to identifying new products, improving existing processes, and refining systems that support the transportation infrastructure, enhance public safety, improve mobility, reduce congestion, protect the environment, and introduce innovative technologies to New Jersey based customers. The Bureau serves every unit within the Department of Transportation, Motor Vehicle Commission, and New Jersey Transit (NJDOT, 2007).

Surveys and literature searches, demonstration projects, and research studies are conducted by University partners and consultants. Most research studies are conducted by, but not limited to the following universities:

### Academic Research Partners

- New Jersey Institute of Technology
- Princeton University
- Rowan University
- Rutgers, The State University of New Jersey
- Stevens Institute of Technology
- The College of New Jersey
- University Transportation Research Center Consortium

### Members of the UTRC Consortium

- City University of New York (CUNY)*
- Columbia University (Columbia)
- Cornell University (Cornell)
- New Jersey Institute of Technology
- New York University (NYU)
- Polytechnic University (Polytechnic)
- Rensselaer Polytechnic Institute (RPI)
- Rowan University (Rowan)
- Rutgers University. The State University of New Jersey*
- State University of New York (SUNY)
- Stevens Institute of Technology (Stevens)
- University of Puerto Rico - Mayagüez (UPRM)

*USDOT University Transportation Centers

Methodology

The purpose of this follow-up study was to track and quantify the outcomes of funded research that had been completed in 2005. Technology transfer benefits were measured on four levels: knowledge transfer, marketing efforts, adoption of policy changes, and demonstration of technology to new audiences. Benefits were defined as enhancements, cost
Project Investigators were interviewed by email, telephone, or in person on the outcomes of their research projects. It was expected that investigators would report on additional studies and projects that had been generated as a consequence of this initial work. Since the information was not always available, NJDOT customers were identified by Investigators for each project. Interviews were arranged with the customers to establish, not only benefits, but follow up activities that happened as a result of the research. When required, the NJDOT project managers were also used as technical resources on projects.

2005 NJDOT Research Project Review

In 2005, a majority of the twenty-four research projects were evaluation studies of specifications, guides for bridge designs, simulation models, incident management strategies, transportation modeling, pricing of toll roads, LED lighting, and the ride quality of pavement. These projects differed from implementation and applied research because they addressed the assessment of the preexisting technologies in the focus areas of Intelligent Transportation Systems (ITS), Infrastructure, Safety and Human Factors, and the Environment. Over 70% of the studies addressed ITS or Infrastructure issues; while 20% involved roadway safety and 10% the environment. Half of the studies included the examination of existing resources/products for further use in current NJDOT specifications/guides. The following section examines each of the projects that were completed during this period.

**FHWA-NJ-2005-001: Congestion, Safety, and Security Initiative - Dr. Claudia Knezek, Rutgers University**

**Cost:** $366,444 (Year 2).

**Summary**

Based on prior federal reviews, the FHWA New Jersey Division determined the need to establish a statewide planning process to address congestion mitigation, public safety, and disaster relief. A literature review was conducted to determine the most effective approach for addressing congestion, emergency management, and safety. Several models were evaluated to establish that safety impacted all of the areas. Safety Conscious Planning was selected as the most
comprehensive approach to be used for establishing a statewide transportation safety network that included state, regional, and local representation. A statewide survey was conducted to determine regional and local safety needs of public agencies. A total of 302 local representatives responded and confirmed that funding was the major barrier to promoting roadway safety. The NJDOT Division of Traffic Engineering and Safety took action to support the locals by contributing $1,000,000 per region to fund local safety projects that met the established criteria. Afterward, a series of statewide and regional forums were held to promote the integration of safety into the MPO planning process.

Since the North Jersey Transportation Planning Authority (NJTPA) and the South Jersey Transportation Planning Organization (SJTPO) had already formalized safety programs, the SCP model was piloted by the Delaware Valley Regional Planning Commission (DVRPC) and incorporated into their regional planning goals that governed intrastate projects. Afterward, a public awareness campaign for elected officials was launched during the 2004 New Jersey League of Municipalities Conference, while a Safety Conscious Planning “starter kit” was developed and distributed to 566 local municipalities throughout New Jersey. The Safety Conscious Planning regional networks were then incorporated into one statewide Safety Management Task Force, which is currently led by Patricia Ott, NJDOT Director of Traffic Safety.

Implementation

The FHWA-NJ Division had requested the establishment of a statewide safety network, so the Safety Conscious Planning Model was implemented by the Metropolitan Planning Organizations. Since the NJTPA and the SJTPO were already involved in safety programs in their jurisdictions, the model was piloted with the DVRPC. Safety Conscious Planning was approved by their advisory commission and a series of regional forums were conducted in Mercer and Burlington, plus Camden and Gloucester Counties. A report of the results was provided to the DVRPC representative and used to establish their regional safety committee.

In addition to the NJDOT Research Showcase, the findings of this study were presented and published as part of the 2005 Proceedings of the Mid-Continent Transportation Research Symposium, sponsored by CTRE of Iowa State University. Knowledge transfer occurred during a series of forums and workshops that were held to establish a statewide safety network between the MPOs, NJDOT, and safety professionals. The cost savings were related to reducing crashes on New Jersey roadways.
Post Project Implementation Findings

According to Rosemarie Anderson of the Delaware Valley Regional Planning Commission (DVRPC), prior to this research project, safety was an integral part of all of their projects, but was not focused on specifically. The focus on safety began in 2003 with federally mandated safety workshops and there was a need to define what Safety Conscious Planning actually meant. This project, through its forums and meetings, brought together many aspects of transportation planning and safety and forged a strong coalition of members from the three regional Municipal Planning Organizations (MPOs), NJ Transit, and NJ State Police, as well as NJDOT, NJ Division of Highway Traffic Safety (NJDHTS) and AAA as well as other organizations.

This coalition heightened awareness within the MPO organizations regarding what additional work needs to be done to enhance roadway safety. Communication among members of the coalition increased significantly, sharing successes and pointing out the effects of unsafe practices. It spurred DVRPC to participate in a peer exchange with planners from other states. DVRPC subsequently held two county workshops, one for Burlington and Gloucester County, and the other for Mercer and Camden Counties.

In 2006, DVRPC established the Office of Safety & Security Planning and began doing safety specific projects. These projects included establishing a Regional Safety Task Force (a bi-state initiative) that brought together officials from five Pennsylvania counties and four New Jersey counties, officials from FHWA and NJDOT as well as other safety agencies and non-technical professionals from Children’s Hospital of Philadelphia, Burlington County’s SafeKids, NJ State Police, municipal police, Fire, EMS, and Virtua Hospital. A Pennsylvania Safety Plan was created as well as a Regional Safety Action Plan for pedestrians. Since 2006, DVRPC has conducted ten Road Safety Audits (RSAs) within ten Pennsylvania corridors and RSAs at five New Jersey intersections.

DVRPC organized an educational campaign for “Put the Brakes on Fatalities Day”, sponsored the NHI course “ITS & Safety”, offered an Older Driver Design Course, and participates in the “Alive at 25” program. They have also included a safety page on their website with links to publications and other resources. The momentum continues to grow. In retrospect, the research project served as a foundation for the NJ Comprehensive Strategic Highway Safety Plan, bringing agencies together and holding statewide forums to share concerns and ideas. One thing that could have enhanced the success of this project would have been a greater participation by local elected officials, planners, and engineers.

Further Recommendations

Although it is believed that policy and process changes, as well as sponsored educational initiatives, have had a positive impact on lives saved throughout the region, no data analysis has occurred. This type of study would be valuable to identify areas where there has been a decrease in the severity and types of crashes and link these decreases to specific initiatives. Also, such a study could identify areas that still need work so that available resources could be applied most
effectively. Assistance in tapping into available funding for more safety programs would also be beneficial, as would a study or nationwide survey on how to effectively reach elected officials who must be recruited as safety champions.

Projected Cost Benefit/Economic Impact

The most important outcome of this project was the establishment of a statewide safety network that teamed with the NJDOT Safety Management Task Force on the development of the first New Jersey Comprehensive Strategic Highway Safety Plan (NJCSHSP), a data driven document that was nationally adopted by FHWA in 2007. The members of the Safety Conscious Planning network organized 12 focus groups for the NJDOT that represented all levels government and the private sector, in order to draft the first statewide roadway safety plan. As a result of this effort, the number of roadway fatal and injury crashes in New Jersey have declined significantly between 2005 and 2007.

Michael Meyer (2008) conducted recent research on the cost of crashes and congestion to society. Using data from the 2005 Urban Mobility Report, he found that improving safety may also improve congestion, since 40 to 50% of all nonrecurring congestion is associated with traffic incidents. In 2005, the per person cost of a fatality is $3,246,192 and the cost for an injury is $68,170. According to the NJDOT Crash Data System Report, a reduction of 33 fatal crashes and 10,504 injury crashes had occurred after the Safety Plan was in place. Based on Meyer’s estimates, a total of $107,124,336 had been saved on fatal crash costs and $716,057,680 on the reduction of injury crashes. Most importantly, 33 fewer people died and over 10,500 fewer people were injured while traveling on New Jersey roadways.

FHWA-NJ-2005-002: Seismic Analysis of Retaining Walls, Buried Structures, Embankments, and Integral Abutments - Dr. Husan Najim, Rutgers University

Cost: $173,017.

Summary

Several major bridges have recently collapsed during earthquakes so newly recommended seismic design guidelines for the AASHTO Load and Resistance Factor Design (LRFD) were proposed in 2003, based on the NCHRP 12-49 Report. The guidelines included changes in the seismic design, which caused an increase in the seismic hazard levels in the eastern United States that resulted in higher design earthquake accelerations and soil factors. This increase in earthquake level (proposed 2500 year event versus the current 500 year event) will impact the seismic design of bridges in New Jersey. The following questions needed to be addressed:

- Is the 2500 years event justified for New Jersey?
- What is the impact on the seismic design, cost, retrofit, etc.?

The current LRFD specifications do not address seismic design of integral abutments, retaining walls, buried structures, and embankments.

A comprehensive review of newly recommended seismic design guidelines from the NCHRP 12-49 report was compared to the current guidelines of AASHTO LRFD specifications. Two examples of typical bridges were then compared to the two specifications, while the impact of soil site factors was examined in Central and South Jersey. It was found that small earthquake accelerations in the regions increased significantly in soft soils.
Implementation

This research project confirmed the importance of standardization in bridge design by evaluating the impact of the new seismic design guidelines from NCHRP 12-49 on seismic design of bridges in New Jersey and to provide seismic design criteria and guidelines based on this information. Two papers were presented in 2004 and 2006 by the researcher. The NJDOT Bridge Office was identified as the champion for implementing this seismic design guide, once it was verified for applicability as the new guideline for bridges in New Jersey.

The developed guidelines for seismic design of bridges in New Jersey are based on the design criteria from NCHRP 12-49 and are consistent with guidelines from other eastern states: New York and South Carolina. Two examples were included that showed transverse reinforcement requirements for large-diameter columns with heavy reinforcement in plastic hinge zones, which are higher in the new provisions compared to current AASHTO LRFD design. Also, the absent seismic design criteria and guidelines for abutments, retaining walls, embankments, and buried structure in New Jersey had been included in the report.

The NCRP 12-49 specified the 2 percent in 50 years (MCE) as the design event nationwide, but the Northeast region does not have enough justification due to the absence of rare large historic earthquakes in the area. Furthermore, the soil site factors adopted in NCHRP 12-49 were primarily based on earthquake and soil data from California. The soil site factors are higher than the small ground motions common to the Northeast region.

Further Recommendations

Although the customers have retired from the Bridge Department, Richard Dunne maintains that a very strong relationship continues to exist with the Bureau of Research. This project was important because the NCHRP 12-49 and other research had been reviewed, in order for recommendations to be made on seismic forces found in New Jersey. Now, only one document is used as a design manual and guidance for work being done on New Jersey bridges.
Projected Cost Benefit/Economic Impact

This project was also contributed to the geotechnical data management system of collected boring data that will have the ability to be analyzed by county and zip code. This decision-making tool will be used to establish customized design criteria on all projects. The expected outcome will be improved efficiency and cost savings for both retrofitted and new projects. Although not available at the present time, the cost benefits of enhanced efficiency and cost savings will be better able to be identified over time.

FHWA-NJ-2005-003: Development of a Performance Specification for Granular Base and Subbase Material – Thomas Bennert, Rutgers University, CAIT

Cost: $286,041.

Summary

Increasing emphasis has been placed on the long term performance of pavements due to the importance of New Jersey’s transportation infrastructure. Currently there is no performance specification in use in New Jersey when selecting materials for pavement construction. There is, however, a correlation between the gradation of aggregate materials and how well the pavement performs. As New Jersey moves toward the use of recycled asphalt pavement (RAP) and recycled concrete aggregate (RCA) because of diminishing supplies of virgin aggregate, it is important to know how use of these recycled materials will perform.

Samples were obtained from aggregate suppliers in three regions of the state for NJDOT I-3 and DGABC as well as RAP and RCA from a local supplier. Performance of various blends of these materials was evaluated through a series of 470 tests that measured drainage, bearing capacity, stress-dependent stiffness, static strength/stability, and cyclic strength/permanent deformation susceptibility. Testing resulted in recommendations not only for the use of RAP and RCA, but for NJDOT I-3 Aggregate as well as NJDOT DGABC.

- **NJDOT I-3 Aggregates** – Gradation specification should be tightened to represent more of the middle of the gradation band to avoid problems present at both the high and low ends.
- **NJDOT DGABC** – Gradation specification should become coarser to avoid several problems encountered at the low end of the gradation band.
- **RAP** – Limit to 50% the total weight of RAP blended with DGABC. Shear strength and CBR properties of 100% RAP samples were found to be similar to NJDOT I-3. Recommendation is to include RAP in limited amounts to the base course aggregate layer.
RCA – Up to 75% of total weight is acceptable for an RCA/DGABC blend. Permeability is decreased, but is still greater than NJDOT I-3 at its respective natural gradation.

Implementation

The main purpose of the study was to provide guidance on the potential modification of NJDOT specifications for base and subbase aggregates used in the construction of pavements. The customer for this research project was the NJDOT Pavement Group, which had not been using any type of performance specification when selecting materials for pavement construction. The selection of granular base and subbase aggregates was based on materials passing a gradation specification. Unavailable virgin aggregates had required NJDOT to consider using larger percentages of recycled aggregate materials, but limited information was available on pavement-related performance.

Product testing enabled the research team to develop guidelines for the selection of materials that are based on performance. Realized savings were attributed to the development of performance based recommendations that provided cost savings and increased the availability of supplies.

Further Recommendations

This was a very good study that yielded valuable information according to Eileen Sheehy, NJDOT Bureau of Materials Manager. The goal of the study was to answer several questions on the use of recycled pavement materials. The pavement industry had asked for specific changes, and a determination needed to be made as to whether those changes would work. Specification standards were in effect, but the adequacy of those standards had not been determined. The study effectively established a baseline for existing standards and resulted in specification changes in the 2007 Specification Manual. Specifically, RAP is no longer allowed in the subbase. It has more value in other applications. There were also new gradation requirements for the use of DGA. In addition, the study resulted in some materials procedures changes for testing and analysis. The cost of changing procedures and specifications was negligible.

The information obtained from the study was shared at a yearly meeting of Regional Materials Engineers. This meeting was held at Rutgers University where the Principal Investigator, Tom Bennert, discussed his research and testing results. “Marketing” occurred as a result of communication with the industry, particularly the New Jersey Asphalt Paving Association and Association of General Contractors (AGC) of New Jersey. These groups normally meet twice a year during which they are made aware of pending changes and are able to raise concerns for consideration prior to publishing specification changes.
Development of a Performance Specification for Granular Base and Subbase Material Results

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<th>T/2 Measures</th>
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<td>Policy/Process Change</td>
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Projected Cost Benefits/Economic Impact

This study confirmed that implementation had a positive effect on the environment in terms of using recycled materials. This is especially important in South Jersey where there is no virgin aggregate. Allowing the use of RCA lowers the cost since it is a less expensive material and does not need to be trucked in from other areas of the state. In the future, revised standards are expected to increase the longevity of paving projects, thus saving construction dollars over time. Research results have been fully implemented and a follow-up study on low permeability of RCA has been initiated through the Bureau of Research.


Cost: $127,633.

Summary

Since cross median crashes often result in collisions with ongoing traffic, they are considered one of the most dangerous types of crashes. The AASHTO Roadside Design Guide recommends barriers when median widths are less than 50 feet. Many states, including New Jersey, are considering more stringent guidelines for installing median barriers; therefore, NJDOT instituted a pilot program with a thrie beam barrier installed along Route I-80 in Morris County, and a three strand cable barrier installed along I-78 in Hunterdon County. The study team investigated ten impacts to the cable barrier and two impacts of the thrie beam barrier over a 12 month period. No collision resulted in penetration of the barrier and only one of the 12 collisions was severe enough to be reported to the police.

Based on the field investigation and experience of other state DOTs, both types of barriers were found to be effective, although installation of the cable barriers seemed to result in an increase in the total number of crashes. Also, the number of thrie beam crashes was insufficient to give conclusive results. The study team recommended ongoing monitoring of the pilot sites and an examination of pre and post installation data.
Implementation

The study results were presented by Dr. Gabler during a regional FHWA research conference. Two students participated in this project, while earning their Masters Degree in Engineering. Also, many papers were presented at TRB that analyzed national trends on using guide rail to prevent crashes. The NJDOT customers were Karen Manchin and Dave Buzuka, who responded to two median crashes that occurred in 2002 on state roadways. An ongoing study was expected to track the success of this design application in the future.

This project was initiated by the NJDOT Department of Civil Engineering, Roadway Design Group in response to several major cross-median crashes that occurred over the 2002 Memorial Day weekend. The crashes all involved trucks and resulted in fatalities, effectively shutting down one third of the state for a period of time. A Federal Highway/DOT Task Force was formed to look at cross-median standards, even though New Jersey was in full compliance with AASHTO standards which required guide rail protection for medians up to 30 feet in width. A national survey showed that many states protected medians greater than 30 feet wide, including California, which protects medians up to 75 feet in places. The standard in New Jersey is 60 feet.

Prior to this study, the cross median protection used in New Jersey was the Dual Face Beam Guide Rail. A modified Thrie Beam Guide Rail (AASHTO designed) and a 3-Strand Cable (wire rope) Guide Rail system were gaining in popularity throughout the nation. Neither had been previously used in New Jersey. The design for the study was completed in late 2002. Construction of two pilot test areas began early in 2003, with modified Thrie Beam installed for .91 miles on Route 80, and 3-Strand Cable installed on Route 78 for a distance of 1.18 miles. The pilot was expected to last for one year, but the lack of a sufficient number of crashes to study during the first 12 months required an extended period of observation before the Final Report could be written.

| Evaluation of Cross Median Crashes Results |
|--------------------------|-------------|-------------|
| T/2 Measures             | Researcher  | Customer    |
| Knowledge Transfer       | ✓           | ✓           |
| Marketing/Website        |             |             |
| Policy/Process Change    | ✓           |             |
| Demonstrations           | ✓           | ✓           |
| Implementation Benefits  |             |             |
| Enhancement              | ✓           | ✓           |
| Cost Savings/Economic Impact |         | ✓           |
The findings confirmed that both of the pilot projects yielded positive results in preventing vehicles from crossing the median into opposing traffic. The low amount of crashes on Route 80 where the Thrie Beam was installed was especially surprising since it was located close to an interchange, a common place for cross-median crashes. It has been surmised that the high visibility of that barrier may account for the driver’s ability to avoid hitting it.

Implementation on New Jersey roadways began before the final report was released. Thirteen “hot spots” were identified for immediate installation of 3-Strand Cable Barrier. Median Crossover Protection Contract 1 was awarded on June 24, 2004 and installation took place on Routes 24, 80, 280, and 78. The 3-Strand Cable Barrier was selected over the Thrie-Beam because of the lower initial cost and its increasing use nationwide. Actual use of this barrier proved to be problematical from the start. The lower visibility caused more “hits”. While not serious or even reportable, these minor “hits” damaged and weakened the barrier, compromising its ability to prevent crossover crashes. Even while the cable was being installed, vehicles would stray off the roadway and knock the poles out of the ground. The 3-Strand Cable Barrier sustained more than one impact each month, causing a maintenance headache.

Further Recommendations

The Roadway Design Group subsequently did a life cycle analysis which proved that the dual face beam guide rail previously used was more cost effective on wider medians. Median Crossover Protection Contract 2 was then revised to use dual face beam guide rail instead of the 3-Strand Cable for the remaining “hot spots” that had initially been identified. No further use of the 3-Strand Cable is being made in New Jersey. Median Crossover Protection Contract 8 was awarded in January of 2008 in order to convert 3-Strand Cable to Dual Face Beam Guide Rail.

Projected Cost Benefit/Economic Impact

The project outcomes were related to knowledge transfer through research reports. There were no marketing or media events. Policy/Procedure changes included a shift to the newer 3-Strand Cable barrier initially, with an eventual reversal to the older type of barrier. In spite of a higher initial cost, the Thrie Beam Barrier was found to be beneficial to use in areas where there is a higher percentage of truck traffic or when the roadway has a split profile (lanes in one direction sit on higher ground than lanes in the opposite direction). Both the old style Dual Face Beam Guide Rail and the modified Thrie Beam Guide Rail are now being used in New Jersey. It is believed that implementation of the study findings has resulted in increased safety on New Jersey roadways although crash data studies have not been done for those areas with new guide rail installations. No additional help from the NJDOT Research Bureau is required for research implementation.


Cost: $477,468.

Summary

After the PANYNJ approved and put into place in 2001 a new pricing structure with tolls that varied according to time of day and type of payment, the Federal Highway Administration’s Value Pricing Program funded this study to assess the impacts on driver behavior, traffic and transit use, and public reaction. Research showed some change in driver behavior, but not a significant shift to public transit or non-peak hours. Overall, drivers appeared to be unaware or unclear about the time of day pricing program, especially those who used E-Z Pass. Truck dispatchers were not motivated to travel during non peak hours since they passed toll increases along to their clients.
Survey analysis revealed that 7.4% of passenger car drivers changed their behavior. They did this by shifting to public transportation, reducing frequency of travel, increased car pooling, shifting to E-Z Pass, and decreasing the number of stops per trip. They did not shift to off-peak periods. A larger percentage of truckers changed behavior (20.2%). The changes included increasing the use of E-Z Pass, increasing shipment charges, reducing truck trips, and changing their routes to avoid tolls altogether. Like passenger car drivers, they did not shift to off-peak periods, according to dispatcher surveys. Conflicting information was gathered from another project that indicated 6.1% of the carriers shifted to off peak hours once they realized the combined cost savings by using E-Z Pass and off peak travel. Time of day pricing did not appear to have an effect on transit ridership.

Public opinion supported discounts to E-Z Pass users as well as frequent users traveling during peak hours. More than half of people surveyed were in favor of toll revenues being used to support public transit and they felt it was a good idea to vary toll rates to help improve traffic congestion, but most did not think it fair to charge higher tolls during peak travel periods. Also, the study highlighted a critical need for political support at the State level and within the PANYNJ leadership. It is also important to include stakeholders at the beginning stage of the process, educate the public and media, find value for users, and conduct ongoing follow-up discussions.

**Implementation**

The technical staff of the Port Authority of New York and New Jersey, New Jersey Department of Transportation, the Federal Highway Administration’s Value Pricing Program and its consultants, provided the project team with support to enhance the quality of the value pricing system. Many press articles were generated on the impact of toll hikes, which should be put in place incrementally over time to lessen opposition. The stakeholders supported the research results, but were skeptical about the new toll schedule of varying toll charges affecting traveler behavior in positive ways. If agencies sought behavioral changes, travelers needed to see that they were saving or spending more money on tolls at
different times during the day. Overall, there was still internal and external opposition to implementing a value pricing initiative in the region. The E-Z Pass System also helped to reduce congestion.

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<tr>
<th>Evaluation of Port Authority of New York and New Jersey’s Time of Day Pricing Initiative Results</th>
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Further Recommendations

According to Mark Muriello (2008), from the Port Authority of New York and New Jersey, value toll pricing was introduced to six tunnels and bridges that connect New Jersey with New York City in 2001. The program has generated incremental revenues to support intermodal capital investment programs and has helped to reduce congestion. This program is one of the most aggressive applications in the country and has potential for use in further reducing congestion in the region. Opportunities exist for coordinated customer services at E-Z Pass Customer Service Centers in the region to encourage behavioral change to achieve congestion benefits.

Cost Benefit/Economic Impact

The PANY&NJ did express an interest in having similar projects adopted elsewhere in the region to support intermodal capital investment programs. However, the purpose of this study was to evaluate the success of time of day pricing, which Muriello acknowledged in his publication. The results of this federally funded project were to be used to evaluate and communicate the benefits and lessons learned from value pricing and to suggest program refinements. They also appear in the Transportation Research Record: Finance, Economics, and Economic Development (2006) publication on studies of international transportation finance reform.

FHWA-NJ-2005-007: Effectiveness of Certain Design Solutions on Reducing Vehicle Speeds – Dr. Janice Daniel, New Jersey Institute of Technology

Cost: $119,127.

Summary

This study was conducted in order to comply with a USDOT mandate on increasing bicycle use and walking among citizens, while reducing the number of associated injuries and fatalities by ten percent. The research included evaluating traffic calming techniques in residential areas where speed limits are below 35mph. After analyzing crash records, five locations were selected for the study. These locations were state roadways in Cranford, Westfield, New Brunswick, and Princeton where the speed limit was 25mph. A literature review of field studies was implemented to determine effective traffic calming methods that were then presented in a community survey to assess preferences and acceptability. Use of
a median with breakpoints received the most positive feedback, while speed humps and speed tables ranked the lowest. The study also produced an Evaluation and Implementation Plan for each of the five areas. The plan provided an assessment on traffic calming measures being used to reduce speeds and improve safety.

Implementation

The focus of this research is to explore various design solutions that may reduce vehicle speeds, especially in business and residential areas. Research had shown that one prevalent factor associated with motor vehicle crashes is speeding. The use of traffic calming measures to reduce speeds and volumes to acceptable levels held potential. A literature review was performed covering: (1) the state-of-the-practice of traffic calming in the United States and abroad; (2) experience of local and state Departments of Transportation that used various traffic calming measures; and (3) the legal and political concerns governing the installation of traffic calming measures on New Jersey roadways. New Jersey is cited as one of the first locations where traffic calming was implemented in the United States.

Locations in New Jersey where traffic calming treatments may be beneficial to motorists, bicyclists and pedestrians were identified. Field visits to state roadways with a posted speed limit of 25 mph were conducted to determine suitability for traffic calming applications. Five locations were identified for further study including: Route 28 (Westfield and Cranford), Route 67 (Fort Lee), Route 172 (New Brunswick) and Route 27 (Princeton). A visual preference survey was performed at these locations to determine the effectiveness, suitability and potential of the traffic calming treatments to reduce speeds.

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Further Recommendations

Although no champion was identified by the researcher, Douglas R. Bartlett, Manager, NJDOT Traffic Engineering & Investigations, did verify that no median dividers with breakpoints for pedestrians have been constructed at the locations recommended in the Final Report. There appears to be no formal process through which recommendations are reviewed and acted upon. However, once a change is made, a Traffic Regulation Order (TRO) must be filed in order to establish the legal status of a mid-block crossing which would enable enforcement to occur. There is no TRO for any of these locations.

Frequently requests are received to add traffic calming devices and crosswalks, but upon investigation, it may be determined that the low amount of pedestrian traffic does not warrant the negative effects of slowing the vehicular traffic. Any discussion of roadway design brings many different perspectives into conflict and balance must be achieved. Often a change in the driving culture is needed instead of over designing pedestrian crossings.

Projected Cost Benefit/Economic Impact

The purpose of this study was to determine design solutions for reducing vehicle speeds. Since traffic calming devices were not installed at the designated locations, there were no realized cost savings or economic impacts attributed to this project, except for knowledge gained by the municipalities, from residents participating in the survey. The results of this study will be helpful in the future if action is taken by the municipalities to address traffic calming issues.

FHWA-NJ-2005-008: Computer Modeling and Simulation of New Jersey Signalized Highways (Volume I – OPTIMIZATION) – Dr. Steven I. Chien, New Jersey Institute of Technology

Cost: $22,523.

Summary

In accordance with the NJDOT initiative to systematically improve traffic operations along the state’s signalized highway corridors, NJ Route 23 and NJ Route 42/322 were selected as study areas with potential to reduce congestion and improve air quality through signal timing optimization. Optimal signal timings were developed using traffic volume data and existing signal timing. New timing directives were reviewed and approved by NJDOT Bureau of Traffic Engineering and Safety Programs to ensure compliance with the NJDOT standards and format. Significant improvement in level of service was achieved by optimizing the signals, reducing by half the average vehicle delays during peak morning hours.

The study team concluded that programmatic updating of existing traffic signal timing plans would provide an effective means to respond to changes in traffic patterns. Although improvements would not be as dramatic as adding new roadway capacity, the cost to implement would be significantly less. Recommendations included development of a network portioning process which would control queue management at troublesome intersections without causing backups in adjacent areas as well as routine updating to ensure ongoing system optimization.

Implementation

Michael Asson, from NJDOT Traffic Operations, had requested this signal optimization project. The findings were presented at both TRB and the NJDOT Showcase. The major gain from the study was the distribution of knowledge to
improve traffic operations along the state’s signalized highway corridors. Findings from the companion study are reported in the following section.

FHWA-NJ-2005-009: Computer Modeling and Simulation of New Jersey Signalized Highways (Volume II – Cost and Benefit Analysis) –Dr. Steven I. Chien, New Jersey Institute of Technology

Cost: $80,283.

Summary

Prior research initiatives for managing traffic flows associated with Route 23 and Route 42/322 demonstrated the benefits of signal timing improvement. This phase of the project was a cost/benefit analysis for the optimal signal timing plans developed for those routes. An Excel based Benefit Analysis Tool (BAT) was developed for this initiative, but it has the capabilities to be revised and reused on other signal optimization projects.

Total costs for both routes were roughly $101,388 while the combined net benefits came to $3.8 million per year, yielding a cost/benefit ratio of 1:21 overall (1:24 for Route 23 and 1:20 for Route 42/322). The ratio for future years will dramatically increase as costs are fixed. The study team also found optimized signal timing plans for Route 23 and Route 42/322 to be economically justified and recommended a yearly review of traffic signal and system performance to maintain efficiency and effectiveness. They suggested future studies incorporate New Jersey specific parameters such as vehicle occupancy, pollutant unit cost, and New Jersey specific crash data.

The findings confirmed that the total costs incurred, including engineering and network modeling costs, were balanced against estimated dollar benefits of the improved signalization. These benefits were reduced travel time, less fuel consumption, and lower environmental impacts during AM, Noon, and PM time periods for yearly weekdays. Additional benefits, not included in the study were savings from reduced crashes and customer satisfaction.

Implementation

The Optimization portion of this study was conducted over a 24 month period. The Cost & Benefit analysis took 6-12 months. Due to aging traffic signal equipment, and the cost of maintaining it, NJDOT found that there was a need to take a proactive approach and optimize signal corridors on a regular basis. Mike Asson, NJDOT Traffic Operations, was the champion of this project. After his retirement, Pat Ott, Director of the NJDOT Division of Traffic Engineering and
Safety, found the study to be extremely successful in proving the benefits of optimization. It provided the basis for a capital line item for a statewide optimization program.

Further Recommendations

The project proved to be a catalyst in opening up discussions within the DOT regarding main line versus side road flow of traffic. Traditionally, mainline traffic flow has been favored. As a result of discussions prompted by the study, more balance between the primary and intersecting roads has been achieved. Timing changes have been implemented on half a dozen corridors since the end of the study. Existing controllers were used, so no new equipment resulted in any increase in cost. A potential savings in labor cost is anticipated since fewer service calls are required when a corridor is optimized, eliminating the need for individual timing changes.

The economic impact for the public is positive with optimization resulting in a reduction of delay per vehicle, increasing the motorist's productivity. Ancillary crash reduction results in lower societal costs, insurance costs, and costs involved in crash investigation. (Estimates of crash related costs in New Jersey total $9,300,000,000 yearly, or $1,100 per person.)

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<th>T/2 Measures</th>
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<td>Cost Savings/Economic Impact</td>
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Projected Cost Benefit/Economic Impact

The capital program is now in its fourth year and has grown from an initial $1,000,000 budget item to $1,700,000 with additional change orders of $1,000,000 for a closed loop traffic operation. An additional $10,000,000 over the next 5 years is possible for optimization of routes in conjunction with Congestion
Management Systems. This has allowed NJDOT to satisfy the optimization requirements in the Federal Performance Plan. The results had been posted on the NJDOT website. Savings were realized through the reduction of labor, while safety benefits need to be identified in the future, along with travel time savings.

Implementation has quantifiable benefits, but there is currently no ability to do “delay studies”. The Bureau of Research could be of assistance by sponsoring a post implementation study to quantify the changes that have been implemented, perhaps by conducting anecdotal surveys of drivers and local traffic agencies.

FHWA-NJ-2005-010: Intelligent Transportation Systems (ITS) Operational Support Contracts Implementation Plan – Dr. Raman Patel, Polytechnic University, UTRC

Cost: $64,357.

Summary

The goal of this project was to review the current operations and maintenance practices of New Jersey’s Traffic Operations Centers (TOCs) and best practices of other states, in order to develop recommendations for the Research Project Selection and Implementation Panel (RPSIP) to produce a better maintenance plan for ITS systems and devices. The expected benefit was to reduce downtime and enable the TOCs to achieve peak efficiency. The project confirmed the need to provide TOC managers with operational support in three critical areas to improve the system’s technical performance and overall operational efficiency. Additionally, operation plans, manuals, and an integrated statewide policy on fiber optics/wireless technologies would benefit this operation.

Implementation

This project was sponsored by the New Jersey Department of Transportation (NJDOT) with Lynne Gash, Michael Pilsbury, Mark Smith, Ron Stewart, and Gary Zayas providing technical support for the project. Additionally, Transportation Operation Center (TOC) supervisor, Mark Smith (TOC South) and manager Michael Pilsbury (TOC North) served as the champions for the TOCs. The major conclusion of this project is that the ITS deployment in the State is still evolving and by providing additional operational support at this juncture in the life-cycle process will significantly improve operational efficiency and return on ITS investment. Equipped with proper skills and support mechanism the technical response teams will be able to ensure proper functioning of ITS systems and field devices, and management of ITS contracts. These actions will generate a wider ITS knowledge-base and allow NJDOT to develop integrated statewide ITS applications with capabilities to further enhance regional coordination and information exchange.

![Annual Maintenance Costs chart](image-url)
Further Recommendations

In January 2005, a summary of the study was placed on the Research and Innovative Technology Administration website. The article highlighted lessons learned on establishing performance measures, stocking spare parts for equipment, standardizing statewide operations, and implementing a tracking system. Michael Pilsbury confirmed that a statewide operation was recently established in Woodbridge, at the former Turnpike Authority Headquarters. Therefore, the potential to support regional capabilities has increased significantly since completion of the study.

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<th>Intelligent Transportation Systems (ITS) Operational Support Contracts Implementation Plan Results</th>
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Project Cost Benefit/Economic Impact

The outcome of this evaluation study was to support Transportation Operations Centers (TOCs) in operating as a statewide unit, in order to realize enhanced efficiency and cost savings. Michael Pilsbury confirmed the operation has recently relocated to a central location, it is important to document the realized operational benefits over time.
Summary

The objective of this study was to develop a prototype dynamic traffic simulation and assignment tool to assist NJDOT engineers, planners, and policy makers in decision making and effective design. The project included a literature search of ITS priority corridor applications, data collected for the I-80 corridor, and the development of NJDOT-VISTA for the NJDOT I-80 corridor study. Data for the project would be obtained from NJDOT, NJTPA, TRANSCOM, PANYNJ, NJIT, and the NJ Turnpike Authority.

Using the model known as VISTA, core capabilities were developed for NJDOT planners and engineers to evaluate basic ITS technologies being considered for use on New Jersey roadways. This customized application was completed and demonstrated to NJDOT engineers and administrators in June 2003. The project concluded with recommendations for the NJDOT to do the following:

- Establish a comprehensive Universal Data Model for NJDOT to fully integrate all databases and the statewide GIS system,
- Enhance the incident management VMS and work zone modules for NJDOT corridors,
- Develop a DTA-based traffic forecasting system by integrating the VISTA system to the NJDOT’s traffic surveillance system and all other related databases,
- Replace the Static Traffic Assignment (STA) currently used for NJDOT North and South transportation planning models with one DTA model for the entire state,
- Integrate into the NJDOT-VISTA model bus and train operations, park & ride facilities, and detailed truck operations to develop an intermodal NJDOT-VISTA DTA model,
- With a comprehensive NJDOT-VISTA DTA model established, NJDOT should require all developers and consultants to use this model, and
- Develop a statewide offline and online response/emergency model based on NJDOT-VISTA DTA.

The offline model was to be used to conduct analysis of various emergency scenarios and potential response strategies and for training personnel. The online model was to be used as a traffic forecasting tool and a tool to evaluate various strategies based on the current and predicted status of the transportation network under a state of emergency.
Implementation

There was much statewide and external interest in the simulation model. Knowledge transfer included the presentation of findings at the University of Alabama sponsored Simulation Conference, TRB, and during the NJDOT sponsored Research Showcase. The New Jersey Department of Transportation, Transcom, and the National Center for Transportation and Industrial Productivity had served as research partners for this project.

| Development of a Simulation/Assignment Model for the NJDOT I-80 ITS Priority Corridor Results |
|-------------------------------------------------|-------------------------------------|-------------------------------------|
| T/2 Measures                                    | Researcher | Customer |
| Knowledge Transfer (Findings/Dissemination)     | ✓          |          |
| Marketing/Media (website)                      |            |          |
| Policy/Process Change                          |            |          |
| Demonstrations                                 |            |          |
| Implementation Benefits                        |            |          |
| Enhancement (Efficiency, Environment, Safety)  | ✓          |          |
| Cost Savings/Economic Impact                   | ✓          |          |

Further Recommendations

James Paral (now with Wilbur Smith and Associates) and Thomas Fucca (NJDOT) served as champions of the project. Although the model wasn’t adopted, there is great potential for local use in the future. The major benefit of this research project was the development of an “easy to use” data system model that supported the improvement of efficiency and safety of the road system. Also, there were distinct advantages to the software being web-based, instead of being PC based.

Projected Cost Benefit/Economic Impact

Knowledge transfer was realized through the presentation of findings at the University of Alabama sponsored Simulation Conference and during the TRB annual conference. Since the model was not adopted by the NJDOT, no immediate cost savings were realized. The potential may exist for the system to be adopted on a regional or local level.

FHWA-NJ-2005-012: Evaluation Study of New Jersey Turnpike Authority’s Time of Day Pricing Initiative – Dr. Kaan Ozbay, Rutgers University, CAIT

Cost: $559,618.

Summary

The New Jersey Turnpike Authority (NJTA) introduced the EZ Pass and time of day pricing to their customers during the same time period. The time of day pricing was considered an incentive to help reduce peak hour congestion. In 2003, toll charges were increased again, along with fees assessed to vehicle type. The Federal Highway Administration’s Value Pricing Program funded this study to assess the impacts produced by the time of day pricing. The study included measuring traffic impacts, behavioral impacts, and the media and decision-maker responses. Researchers from Rutgers University and Rensselaer Polytechnic Institute conducted the study with vehicle counts, disaggregate vehicle-by-vehicle traffic, and travel time information being used to quantify the impacts of the time of day pricing during two phases of the project. Next, a simulation model of the Turnpike was developed that included a toll
plaza for recording weaving and lane change behavior of vehicles. Rutgers Eagleton Institute conducted computer-aided telephone interviews on the impacts of time of day pricing on traveler’s behavior. Also, media and stakeholders’ responses to the implementation strategy were documented.

**Implementation**

Average daily traffic appeared to increase from 2000 to 2003 in spite of the introduction of time of day pricing. There was no evidence of a shift to other modes of transportation. After the first phase of time of day pricing, there was a slight shift in aggregate level traffic (1.7% AM peak and 3.7% PM peak). Off peak traffic had increased minimally by about 1.1%. During the second phase of the project, peak traffic actually increased (17% for AM peak and 14% for PM peak) while off peak traffic decreased by 6%. Reduction of travel time appeared to be a greater motivator than toll increases.

Results from micro-simulation modeling indicated that the simultaneous introduction of EZ Pass and the first phase of time of day pricing reduced average trip delay by about 3-18% and toll plaza delays by 44-74% between 2000 and 2001. Reduction of vehicle emission levels were calculated to be about 10.7% for that period. Also, there appeared to be minimal opposition from the public, possibly due to toll increases and EZ Pass introduction having occurred at the same time. Behavioral changes were restricted due to lack of flexibility of work hours of drivers.

| Evaluation Study of New Jersey Turnpike Authority’s Time of Day Pricing Initiative Results |
|-----------------------------------------------|----------|----------|
| T/2 Measures                             |          |          |
| Knowledge Transfer (Findings/Dissemination) | ✓        | ✓        |
| Marketing/Media (website)                 | ✓        | ✓        |
| Policy/Process Change                     |          |          |
| Demonstrations                           | ✓        |          |
| Implementation Benefits                   |          |          |
| Enhancement (Efficiency, Environment, Safety) | ✓        | ✓        |
| Cost Savings/Economic Impact              | ✓        | ✓        |

**Post Project Economic Impact**

Sean Hill of the New Jersey Turnpike Authority, confirmed the importance of the value pricing program. Staff members from the Turnpike Authority, the New Jersey Department of Transportation, the Federal Highway Administration’s
Value Pricing Program team, and consultants, provided the project team worked together to enhance the quality of the product. Most survey respondents, reporting behavioral changes because of time of day pricing, indicated multiple changes to adjust for the pricing differences. The frequently cited reduction combinations of changes were the following:

- frequency on Turnpike and increased trips along alternate routes (4.5 percent of entire sample),
- number of trips driving totally alone and increased trips along alternate routes (1.8 percent),
- frequency on the Turnpike,
- number of trips driving totally alone (1.7 percent),
- frequency on Turnpike and decreased weekday peak trips (1.7 percent), and
- weekday peak trips and increased trips along alternate routes (1.6 percent).

The results of this study also appeared in the Transportation Research Record: Finance, Economics, and Economic Development 2006 publication that include studies on international transportation finance reform.

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**FHWA-NJ-2005-015: Beneficial Use of Dredged Clay from Newark Bay and Environs – Dr. Ali Maher, Rutgers University**

**Cost:** Funded by other sources.

**Summary**

In order to accommodate the newest generation of container ships, dredging of the New York/New Jersey navigational channels to a depth of 50 feet must be done. This will generate millions of cubic yards of red clay. This pilot study was undertaken to provide NJDOT with useful information on how this clay can be used most effectively.

Initially, 4000 cubic yards of red clay dredged from Newark Bay was transported to the Bayshore Recycling Corporation and placed in varying thicknesses and compacted to evaluate its behavior and workability. Both laboratory and field testing was done at different moisture and compaction conditions. Half of the clay was then removed and used in an actual capping project. Researchers concluded that dredged red clay from Newark Bay and surrounding bodies of water was beneficially used as a low conductivity cap with similar performance to mined clay without the environmental impacts associated with mining. Conventional equipment and trucks could be used without the added expense of modification.

**Implementation**

Scott Douglas, the NJDOT customer, confirmed that the purpose of this study was to help identify the most cost effective uses of dredged clay materials. The application was expected to produce a considerable cost savings due to being recycled. New York City had expressed interest in using the clay as a liner for the Fresh Kills Landfill. It was found that all costs were comparable or lower than costs of competing products. The estimated potential market use of
red clay is approximately 22 million cubic yards over the next ten years. In addition to use in containment barriers for landfill capping and site remediation projects, other markets exist for the use of clay in pond liners and wetland restoration, as well as for the ceramic manufacturing industry if the red clay material is amended.

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**Further Recommendations**

In 1996, dredging the harbor became a joint plan between New York and New Jersey to seek alternatives for disposal of red clay. This evaluation study reviewed the use of red clay from the Newark Bay, as a beneficial liner and capping clay. Typically, this material was used to cap the ocean disposal site at Sandy Hook but environmental concerns were raised about continuing with the procedure. Red clay underlies the bay and requires the movement of about 7-8,000,000 cubic yards. Stakeholders supported the pilot study that was conducted by Rutgers to determine the benefits of using red clay at upland sites. Also, geotechnical properties of the clay were evaluated for use at brownfields.

The technology was proven effective as a substitute for mined clay substitute. Also, the environmental benefits of this product include reduction of ongoing contaminants, stopping of leche, and acting as a contaminant absorbent at the nearby brown fields. Improvements in the State of New Jersey often translate into improvements for the country, especially in what has been accomplished with redevelopment and utilizing the University as a research incubator. Several presentations were given at Transportation Research Board, and before advisory boards representing the Chesapeake Bay region, New England, Pennsylvania, Maryland, and Virginia.

**Projected Cost Benefit/Economic Impact**

The associated cost for transportation, unloading, moisture conditioning and placement was estimated to be $13.60 per cubic yard. The market price of mined clay from upland sites is $15 per cubic yard, and $2.30 in placement costs that total $17.30 per cubic yard of mined clay. It was cost effective to use dredged red clay instead of mined clay. Since 4,000 cubic yards of red dredged clay was processed and used instead of mined clay at the landfill, the realized savings amounted to $14,800 in savings.
Summary

Modeling is the traditional way that transportation planners, engineers, and managers find solutions to complex problems. There are many software packages available to implement transportation models. This project was undertaken to identify the most widely used software packages along with their most important features.

The study team collected data from software developers and transportation professionals, sorted and organized the information into a database, then developed an application to facilitate browsing through the database. This application allowed users to find information and make comparisons between different software packages. It also provided information about interconnectivity, and ranked packages according to certain criteria, and allowed for updating information in the database. The expected outcome of this project was to assist transportation officials in determining which software tools are the most appropriate for particular applications and in the selection of tools to cover specific modeling needs.

Implementation

There was an increasing demand for sound graphical interface, GIS capabilities, integration with land-use packages, sound import-export functions, modeling of emissions, transit-forecasting capabilities and modeling of toll facilities. These capabilities were often incorporated in software packages like TransCAD, EMME/2 and CUBE. Simulation packages were required with sound graphical interface, ability to model ITS facilities, roundabouts, pedestrians, toll facilities, emissions and parking. Also, there was a need to add capabilities to model commercial vehicles and Highway Capacity Manual requirements.

Since there was an abundance of available transportation planning and traffic simulation packages, the selection criteria was for the package to be project based. However, other tools with a friendly user interface, network modification and creation structure, traffic generation / distribution, vehicle / driver classification, route selection / traffic assignment, ITS modeling capabilities, incident simulation / traffic control and measure of effectiveness were considered, too.

Emissions modeling packages like MOBILE, PPSUITE and CAL3QHC are among the most widely used emissions modeling software packages. MOBILE is the industry standard in emissions modeling. ITS modeling was mainly done using VISSIM, IDAS and INTEGRATION. There was a need to develop simulation packages that are capable of doing ITS modeling.

All 28 respondents felt that a new package would only be used if a client had been ready to accept it. Twelve of the respondents felt that any new software needed to be validated with real world data before it was accepted by the industry. Proper documentation and support to accept TRANSIMS was confirmed by sixteen of the respondents. The
The fact that TRANSIMS cannot run on a single PC was identified as one of its deficiencies by 11 of the respondents. The results confirmed that TRANSIMS was more oriented toward research, testing and documentation but was still required, since the industry may consider adopting it.

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**Further Recommendations**

The Advisory Board, consisting of state transportation and planning officials, served as the champions and helped to guide the project. The objective of the project survey was to determine the perspective on the overall use of software, as well as to identify specific features of transportation software packages. A survey confirmed that there were widely used transportation planning packages like Tranplan, MINUTP and TP+. Tradition seemed to be an important factor for the continued use of these packages, even when alternatives were available commercially that seemed to have increased capabilities. When tools were widely used, transportation professionals had been able to easily relate their analyses and results to other collaborators who were using the same modeling tools.

**Projected Cost Benefits/Economic Impact**

Knowledge transfer was an important outcome of this study. In the future, selection of the appropriate transportation model will enable planners and transportation professionals to do their job more efficiently and save money. Also, a student, participating in this study, was able to complete a master’s degree.

**FHWA-NJ-2005-017: Ride Quality Follow-Up - Dr. Nenad Gucunski, Rutgers University**

**Costs:** $554,668.

**Summary**

In addition to offering drivers and passengers a comfortable ride, smooth pavements last longer and are less costly over their lifespan. Newly constructed or rehabilitated pavements needed to be measured and conform to NJDOT specifications for smoothness. The objectives of this study included identifying an accurate and consistent device for measuring pavement smoothness that performed at highway speeds to eliminate lane closures and associated risks. This research included providing NJDOT with recommendations for a standard pavement profiler to be used to calibrate other profilers that determine pavement smoothness. Also, identification of ride quality parameters helped to describe both the true pavement roughness and the user’s opinion of required ride quality.

After field testing, the Walking Profiler was selected as the NJDOT Standard Pavement Profiler (SPP). The developed ride statistics could not be validated as a measure of user or rider discomfort. Therefore, it was recommended that a
panel study be conducted in which both the driver and a passenger measure the quality or comfort of the ride. The result needed to include a means of correlating the riders’ subjective opinion with an objective measure of the same ride.

Implementation

The NJDOT Pavement Group was the customer for this project. TRB and other journals published the research results that were also presented at the TRB Conference. According to the researcher, improved ride quality affected aesthetic enhancements, improved roadway safety, and offered the potential for cost savings over time.

There were two outcomes of this study, which included the use of profiling devices to assess the ride quality of pavements and to monitor the ride quality standard on new projects. The department conducted reviews on quality assurance standards and set penalties or bonuses, based on the determined ride quality value. Also, meetings were held with the construction community to gain a better understanding of expectations for bonuses. Ride quality was established by a profiler van, containing lasers on the wheel path, that records the quality of pavement at 32,000 times per second and created the internal roughness index (ITI) based on the value warranting a bonus.

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Further Recommendations

During the past several years, NJDOT projects require ride quality assessment on new pavement. A companion research project will include the use of a handheld profiler, to certify status the department’s profilers and those of other contractors. The department has one profiler, so it is important to assess the accuracy of this device along with other types of equipment that are available in the region. According to a FHWA sponsored study, the public values smoothness of pavements as the top roadway priority. The value of improved ride quality is that a pavement lasts longer which enhances efficiency and cost savings. Also, a smoother pavement is quieter for the drivers and residents of the community.
Proposed Cost Benefit/Economic Impact

Knowledge transfer was an important outcome of this project. Several presentations were given by the department representatives on ride quality at the request of the Society of Asphalt Technologists, New Jersey Paving Association, NJDOT Contractors and the Asphalt Technologist Program. In addition to state level presentations, several programs were presented to the Atlantic Alliance and municipal government.

According to Joseph Beke, the NJDOT customer, an incentive program was established for contractors. A total of 17 of the 24 pavement projects funded by NJDOT did warrant bonuses. The bonuses amounted to over $1,800,000 and the penalties were about $570,000. The total payment to contractors was $1,250,000, but the department expected to realize significant savings with long term durability, a smoother roadway system, and improved quality of the roadway. Although not applicable to this study, smooth roads last between six and ten years longer, so savings are expected to be realized in the future.

The department received an unexpected testimonial from a local official on the quality of the finished road project in his town. Also, it is important to identify in future studies, the reduction of vehicle repair costs because front ends would not be wearing out quickly. Smoother roads further reduce congestion since vehicles are not switching lanes as often to avoid potholes.


Cost: Funded by other sources.

Summary

This report addressed a new design concept for a Truck Mounted Attenuator (TMA) used in work zone safety. The project included redesigning the TMA to achieve a cost-effective and practical solution to current TMA problems. These problems were related to truck dump bed usage, extension length, behind the truck, and electrical connections subject to corrosion. In Phase I, a new TMA concept was proposed, which was based on the use of hydraulic shock absorbers (HSAs) to reduce the size and maintainability requirements as compared with existing systems, yet still meet NCHRP performance requirements.

Phase II of this project focused on the initial development of the HSA system, which included two large hydraulic shock absorber cylinders fixed to the truck chassis on one end, extending rearward to an impact strike plate on the other end, and supported laterally by utilizing the dump truck body for support and stiffening. In order to verify the feasibility of this proposed design, focus was placed on a quarter-scale HSA system. This scale TMA was designed, fabricated, and tested to a dynamically equivalent one-sixteenth energy absorption level. Vertical testing of the 2” bore x 24” long cylinder pair, with cylinder and chassis support structure, was performed with a 4,000 lb weight dropped at increasing heights up to 7 feet.
Implementation

The tests were successful, and the results proved that this system has the potential to be scaled up to full size, and be used as a truck mounted attenuator for work zone safety. This project was supported by two customers from the NJDOT, who were Richard Shaw (Operations Support) and Stephen Toth (Bureau of Equipment). The FEM simulation study of the scaled model TMA was performed to demonstrate that the system could absorb the impact energy prescribed by NCHRP 350 report. The result confirmed that there were no anticipated weak points or expected failure locations; therefore, the use would improve safety for the NJDOT employees when TMAs were used by the department.

Further Recommendations

The study identified a new design concept for Truck Mounted Attenuators (TMA) that included a hydraulic shock absorber (HSA) system. While implementation did not occur due to cost, the product has the potential for improving work zone safety. Building and use of a full scale model was to be the objective of Phase III, but the project was considered too costly to create a full working prototype. Retrofitting the trucks would have involved relocating major parts of the vehicle and was not deemed to be practical.

### Development of Advanced TMA Designs, Phase II Results

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Projected Cost Benefit/Economic Impact

The goal of this research was to create a shorter, lighter, less expensive TMA. Even though this goal was not achieved, Richard Shaw, Director, Operations Support, did not regard the project as a failure. It confirmed that NJDOT is currently using the best available system in its work zones. Knowledge transfer occurred as part of the reporting process. No other direct benefits can be attributed to this study. Further assistance in implementation is not required.


Cost: $64,274.

Summary

Railroad crossings in urban areas pose a potential hazard for drivers, especially where streets run parallel to the railroad tracks. Motorists, who make turns across the tracks to enter the parallel road, sometimes become entrapped on the tracks. The research approach consisted of data analysis of accident records, lab experiments for studying the effect of design solutions, and field validation studies. Results from the lab experiment suggested that driver confusion when attempting to make left-turns at railroad crossings had been reduced by highlighting the grade area, including pavement and center line marking and coloring the road-rail track intersection area with reflective paint. Field testing of three locations confirmed that significantly safer vehicular movements could be obtained with a combination of grade crossing area painting and pavement marking. Using either of these solutions alone yielded no significant difference. During the investigation, the research team noted that at each of the locations studied, there appeared to be a high rate of vehicle-to-
vehicle collisions or vehicle-to pedestrian collisions due to the mental workload of drivers approaching and crossing the grade crossing. The team recommended installation of traffic lights if the crossings could not be eliminated.

The New Jersey Department of Transportation and NJ TRANSIT Corporation cosponsored the project; while John Vogler (NJ Transit), Paul Schneider, and Todd Hirt of NJDOT Utility and Railroad Engineering championed this research effort. The project demonstrated useful human factors research methods were important to safety studies. Due to the low occurrence rate of unsafe left turn driving behavior or its surrogate measures, the results needed to be interpreted carefully without overstating the outcome. In addition to the potential risk of vehicles turning onto railroad tracks, the specific roadway/railroad configurations being investigated put a heavy mental workload on drivers of both roadway directions (perpendicular to the railroad tracks and parallel to the tracks). Drivers needed to make quick and accurate decisions upon approaching and crossing the grade crossing.

Further Recommendations

Although the problem of vehicle-to-vehicle collisions was not in the scope of this project, it is believed that there is a high incidence of vehicle-to-vehicle or vehicle-to-pedestrian collisions in these specific roadway/railroad configurations. This assessment was evidenced by near misses of collision and many failure-to-yield cases observed during the field study. The research team suggested the installation of traffic lights at those grade crossings. The traffic lights should be installed throughout the entire section in order to ensure consistency of traffic controls in similar roadway/railroad configurations.

| Human Factors Evaluation of Design Ideas for Prevention of Vehicle Entrapments of Railroad Tracks Due to Improper Left Turns Results |
| T/2 Measures | Researcher | Customer |
| Knowledge Transfer (Findings/Dissemination) | ✓ | ✓ |
| Marketing/Media (website) | | |
| Policy/Process Change | ✓ | ✓ |
| Demonstrations | | |
| Implementation Benefits | | |
| Enhancement (Efficiency, Environment, Safety) | ✓ | ✓ |
| Cost Savings/Economic Impact | ✓ | ✓ |

Todd Hirt, Diagnostic Team Leader, Railroad Engineering & Safety Unit and Greg Spiritosanto, Transportation Engineer, Division of Design Services & Diagnostic Team Leader, Railroad Engineering & Safety Unit were interviewed on the project outcomes. This study was initiated by Transit in response to incidents that had occurred at railroad crossing locations around the State where configurations included parallel traffic on both sides of the railroad.
track. Some drivers became confused and turned onto the railroad right of way instead of onto the street, stranding their vehicles on the track.

Projected Cost Benefit/Economic Impact

From the DOT perspective, the greatest benefit of the study was a heightened awareness of the situation. Any time there is a change at a railroad crossing, such as street widening or new construction, the Railroad Engineering & Safety team holds a diagnostic team meeting with local stakeholders. If the configuration matches that of the study, the diagnostic team realizes that additional safety measures must be taken and incorporates the study recommendations regarding enhanced delimiters as appropriate for the community. This outcome reflected an informal procedure change.

To date, implementation has occurred in approximately twelve locations. Results were difficult to quantify although there were no additional incidents at locations where the enhanced delineators have been added. It was also difficult to quantify the economic impact. Enhanced delineators are relatively low cost with lighting having been assessed as the most expensive enhancement. Painting and striping does not reflect additional cost except for the labor.

Cost savings were calculated based on the impact of a vehicle not getting stranded on the tracks. Police must call the train masters and the rail line must be shut down and possibly de-energized. One incident represents a major delay for NJ Transit as well as for traffic around the intersection. Also, the Railroad Engineering & Safety team found the NJDOT Research Bureau to be very responsive to requests for studies, which included their approval of a project on drivers’ perceptions at railroad crossings that was completed in 2004.

________________________


Cost: $66,911.

Summary

Incidents are events that reduce the roadway capacity and often lead to congestion. There is a critical need for quick detection, response, and removal of these incidents in order to maximize the efficiency of existing traffic networks. Many different incident management strategies are in use throughout the country. A literature review identified important procedures and technologies to be used, while New Jersey specific incident data was reviewed to identify common incident types and characteristics. Incident occurrence and duration models were developed for different incident types.

The team developed a microscopic simulation model of a network to capture the dynamic nature of traffic flow. The prototype software developed is called Rutgers Incident Management Systems (RIMS). This model provides users with a powerful tool to assess current settings of an IMS or predict the effects of any changes to the existing system. Cost-benefit of different incident management strategies was conducted. For example, along Route 295, analysis showed that using closed circuit television yielded a higher benefit ratio than using loop detectors.
Implementation

The benefit cost analysis for all the incident technologies had been done for a period of 20 years, thus taking into account the long-term benefits of their respective implementation. Results of the analyses showed that loop detectors and CCTVs were viable options for incident detection and hence these detection technologies had been worth implementing in the South Jersey corridor. In fact, loop detectors and CCTVs have proved to be useful in incident detection, as supported by several studies that were conducted in the past to analyze the effectiveness of these technologies.

| Evaluation of Incident Management Strategies Results |
|----------------------------------|--------|--------|
| T/2 Measures                     | Researcher | Customer |
| Knowledge Transfer (Findings/Dissemination) | ✓       | ✓       |
| Marketing/Media (website)        |          |         |
| Policy/Process Change            |          |         |
| Demonstrations                   |          |         |
| Implementation Benefits          |          |         |
| Enhancement (Efficiency, Environment, Safety) | ✓     |         |
| Cost Savings/Economic Impact     | ✓       |         |

Further Recommendations

The system reported a reduction in primary accidents by 35%, secondary accidents by 30%, inclement weather accidents by 40%, and overall accidents by 41% (22). A review of video surveillance/CCTV data collected in 1995 indicated an average reduction in response time of 20%. Using the accident frequency for freeways, the results showed an annual savings of $1.65 million. There would be a twenty year established benefit if adopted by NJDOT Traffic Operations.

Projected Cost Benefit/Economic Impact

The customer was not available to comment on the benefits of this study. However, knowledge transfer and the expansion of the application to other areas (e.g. traffic safety) were realized as a project outcome.
FHWA-NJ-2005-021: Geopolymer Coating Demonstration Project for Route I-295 Scenic Overlook – Dr. P. N. Balaguru, Rutgers University

Cost: $10,000.

Summary

Proper bridge maintenance has provided extended life and a good aesthetic appearance to the structure. The best way to protect bridge concrete substructures is through the prevention of liquid ingress that starts the deterioration. The goal of this project was to develop a durable, graffiti resistant, self cleaning coating that will allow vapor pressure release and is compatible with concrete.

The demonstration project evaluated Geopolymer, an inorganic coating developed at Rutgers. The test site was a parapet wall located at the Scenic Overlook along I-295 South, near Trenton, New Jersey. Results showed that the inorganic polymer provided an aesthetically pleasing appearance by easily being applied to large surfaces without requiring extensive surface preparation. Only power washing was done prior to the applications. Performance was being monitored for durability, aesthetics, self cleaning, and de-polluting properties as part of another research project.

Implementation

Members of the Bridge Group team were the customers for this project. Since the intent was to extend the life of a bridge, increased efficiency and safety were identified as the technology transfer benefit of this project. The potential benefits for widespread use of this coating on bridge surfaces are many. Aesthetically, the coating blends in with the existing bridge material. It is resistant to graffiti and very easy to clean, reducing maintenance costs to preserve an attractive appearance. Its effectiveness in preventing surface erosion could add many years to the life of the structures, possibly thirty years.

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Further Recommendations

Full scale implementation of the product used in this research had not yet occurred, but the potential for its use appeared promising. After observing the pilot project application for a three year period and finding very positive results, a second study was conducted at the Route 47 drawbridge in Wildwood, NJ. Application of the geopolymer coating was made inside the bridge house in order to stop water infiltration and deterioration. This occurred in April 2008. Work on the outside surfaces and parapet walls had been scheduled to begin shortly.

Widespread use of this coating would have an enhanced esthetic effect because of its resistance to paints used to apply graffiti and the easy removal of any graffiti that does occur. More time is needed to observe the durability and protective qualities of the material, in order to quantify the benefits of implementation. The NJDOT Bureau of Research was supportive of this effort as evidenced by its approval of the Wildwood, NJ project which will test the material under more extreme conditions. An additional study on performance-test skid properties of the geopolymer coating would be helpful in determining its applicability for use on bridge decks. If the long term advantages of this material could be quantified and published in scholarly journals, true technology transfer could occur with widespread use not just in New Jersey, but globally as well.

Projected Cost Benefit/Economic Impact

Cost savings based on widespread use of this coating had not been determined. The material itself was not more costly than other coatings, although using a higher percentage of carbon fiber may have driven up the cost. Changing the procedures or specifications would entail a cost increase for a new item of work, but the labor costs are difficult to predict especially if the work was to be done as part of a contract bid. Counterbalancing the additional costs to apply the geopolymer coating was required for significantly extending the life of the structure. Since the geopolymer coating had been easy to clean, maintenance time was reduced and this has a safety implication of reducing the time that maintenance workers were being exposed to potentially dangerous working conditions.

FHWA-NJ-2005-022: Analysis and Modeling of Cape May County Roadway Elevations and Evacuation Routes – Dr. Steven I-Jy Chien, New Jersey Institute of Technology

Cost: $246,384.

Summary

Disaster response in areas with high population density requires evacuating people quickly and efficiently. This study determined the evacuation times for varying populations, behavioral responses, hurricane levels, and the Routes 47/347 reversal lane operation scenarios for Cape May County, New Jersey. Roadway elevations throughout the Routes 47/347 corridor area were established using a GPS survey to verify whether the roadways were usable in the event of a hurricane.

Research included a literature review of previous studies, current practices, and model selection. An S-curve model was used in this study. First, GPS established roadway elevations to determine if roads were passable under various hurricane conditions. Twenty four evacuation scenarios were considered with different combinations of the following parameters:

- Traffic Operations – Lane Reversal/No Lane Reversal
- Area Population – Peak Season/Off Peak
- Hurricane Intensity – Category 1/Category 2 or Higher
Behavioral Response – Fast/Medium/Slow

Overall, two hundred and ten (210) simulation runs were conducted. Estimates of Cape May County evacuation times during a hurricane strike ranged from 16 to 25 hours after the order to evacuate was given. The variation in time was dependent on behavioral responses.

Results of the study showed that the current State Police reversal plan was ineffective due to the limited time savings. The reversal plan needed to be revised as the bottleneck during evacuation would exist south of Route 83, the initiation point of the current reversal plan. In addition, the Cape May HES map showed sections of NJ Route 47/347 having been ineffective as an evacuation route for a given hurricane level.

The consequences of lives being lost, due to an ineffective evacuation plan, required additional modeling of expanded evacuation plans, which included an addition of Route 9/GSP, extended lane reversal south of the current stating point, and north to assess the impact of an Atlantic City evacuation.

Implementation

The New Jersey State Police, NJDOT, and the DVRPC were involved in the project as customers. The research results were presented and published at TRB; while the County Freeholder Office was trained in the evacuation results. The NJDOT website also hosted the research report. Cape May County Engineer, Dale Foster, summarized his appreciation of this study by confirming that it was “an eye opener” that pointed out the deficiencies in the Routes 47/347 contra flow evacuation plan that the State put together. Cape May County did not initiate this study although there was always a concern as to the efficiency of the established evacuation plan. It has been many years since the area was tested by a level 2 or greater hurricane, but hurricane evacuations have become very important issues, especially after the devastation and loss of life in New Orleans with Hurricane Katrina.

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Further Recommendations

Recommendations for follow-up studies have resulted in the SJTPO conducting and funding an evacuation time study to identify a better starting point for the traffic reversal process to begin, looking at 4-5 feeder roads. Cape May County did a small study of all roads in the county, and there is currently an additional study underway under the auspices of the Office of Emergency Management (OEM) to determine appropriate changes that should be made along the Garden State Parkway in terms of contra flow. The OEM planned to present a table top exercise as proof of concept to the agencies involved in the evacuation process, such as the Garden State Parkway, NJ Turnpike Authority, SJTPO, NJDOT, local and State Police, and EMS. The county’s goal is to have policy changes and an improved evacuation plan in place before the 2008 East Coast hurricane season. The OEM consultant was assigned to produce a new Procedure Manual for the evacuation process.

Projected Cost Benefit/Economic Impact

In addition to the Final Report, the principal investigator, Kier Opie, presented information from his findings at the 2006 NJDOT Showcase and at the 2006 Cape May County Transportation Infrastructure Forum. Benefits of implementing recommendations from this follow-up study involved the potential for saving lives and reducing the amount of time required to evacuate the county through the evacuation plan. The greatest difficulty in executing any plan was determined to be notifying the population. The potential is there for NJDOT Research Bureau to sponsor research on effective methods of communication for both the permanent residents and transient populations, as well as examining the impacts of Nor’easter storms.

FHWA-NJ-2005-024: Material Characterization and Seasonal Variation in Material Properties – Dr. Nenad Gucunski, Rutgers University

Cost: $1,922,108.

Summary

Since pavement design and performance have been affected by environmental factors such as temperature and moisture that vary with time of day and seasonal conditions, the need existed to develop a standard regional model that adjusted for these variations. This study included twenty-four test sections (21 hot mix asphalt, 1 composite, and 2 Portland cement) that were instrumented to continuously measure environmental and climactic parameters over a two year period. A database was populated with information obtained to give a better understanding of moisture retention within a pavement system and its profound effect on the cost and service life of a highway network. The end result was successful investigation of the influences and seasonal fluctuation of environmental factors on pavement performance in New Jersey. The effect of these factors on long-term pavement performance was evaluated by studying the response of pavement structures with different thicknesses and material properties under different environmental conditions. Ultimately, new seasonal and temperature adjustment models were developed that are specific to New Jersey.

The study team recommended continued monitoring of the environmental parameters at the test sites to further refine the temperature and seasonal adjustment models. Future studies needed to include examining different combinations of environmental regions (north or south), and asphalt concrete thickness, development of better testing protocols for studying the effects of slab curling, and inclusion of additional composite sections since most rehabilitation activities on rigid pavements involve an asphalt concrete overlay.
Implementation

The AASHTO Pavement Design Guide published in 1993 was scheduled for a major revision in 2002. The intent of this revision was to supplement the empirically based procedures with mechanistic properties to better meet the design challenges of current pavement rehabilitation. To prepare for this revision, New Jersey, along with several other lead states undertook several studies for calibration purposes. This was one of those studies. The study enabled NJDOT to improve the quality of the new design guide, which included sample applications and recommendations. Financial constraints were also considered, when addressing long term and short term aspects of the process.

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Further Recommendations

No implementation or formal change of policy or procedures had taken place since the study results were published because the revised Design Guide had not yet been released, five years after its target date. Recommendations for continued monitoring of the environmental parameters at the test sites and additional studies did not take place, with the exception of an additional six months of monitoring which ceased due to staff reductions. Likewise, no targeted pilot study was undertaken to develop better testing protocols for studying the effects of slab curling, which remains an area of great interest to the pavement industry. The study also promoted the establishment of the Pavement Resource Center at Rutgers University Center for Advanced Infrastructure and Transportation and provided valuable information regarding New Jersey specific effects.
Projected Cost Benefit/Economic Impact

The study has resulted in a significant amount of knowledge transfer. In addition to the final report, a paper was presented at the 2006 Annual TRB meeting, and Robert Sauber, NJDOT Chief Pavement Engineer, participated in an FHWA/USDOT workshop in Rocky Hill, Connecticut on September 19, 2006. His presentation was available nationwide via a webcast and was based on the findings of this study. The webcast is still available for viewing at the Connecticut DOT website [www.ct.gov/dot/CIW](http://www.ct.gov/dot/CIW) and discusses frankly the discrepancy between the study findings and the expected results, offering advice to other states that may be considering similar reviews as to what they should do differently. There had been no safety, environmental or cost savings benefits that were attributed to the project at this time.

FHWA-NJ-2005-025: Evaluation of Integral Abutments - Sophia Hassiotis, Stevens Institute of Technology

Cost: $316,266.

Summary

Integral abutment bridges were defined as bridges without expansion joints between the deck and the abutments. They have been in use for thousands of years. Recently, many new bridges have been constructed using complicated movement joints and siding bearings to accommodate calculated thermal effects and horizontal displacement, but these bridges have begun to show signs of deterioration resulting in costly repairs annually. This research evaluates integral abutments as a design alternative to the use of bearings in medium-length highway bridges.

The conclusion reached, after reviewing the collective knowledge from NJDOT and other Departments of Transportation throughout the country on the design and construction of integral abutment bridges, evidence gathered from measurements of the Scotch Road integral abutment bridge in Trenton, New Jersey, numerical calculations, and conducting an extensive literature search, was that integral abutments constitute a preferable design for new bridge construction. This primary recommendation was followed by twenty-one (21) additional recommendations that outline situations or factors to consider, when creating a successful integral abutment design.

![Diagram of integral abutment bridge](image)

Implementation

Jose Lopez, Deputy Manager of the NJDOT Bridge Bureau served as the project champion and provided technical support and guidance during the execution of this project. The parametric findings indicated that all four factors studied, significantly affected the magnitudes of the critical buckling load of the pile. The single-pile buckling model showed that the pile globally buckles at vertical load boundary conditions. However, embedding the pile into a 0.6 m galvanized steel...
sleeve filled with sand increased the pile capacity against buckling by 17 times. The results from this parametric study for the pile-bent model also emphasized that the group effect substantially increases the buckling capacity for each of the piles (2.53 times that of a single pile embedded in sand with fixed and sway-fixed boundary conditions). Application of combined axial and vertical loading has an adverse effect on the pile capacity for buckling, and the critical buckling load decreases significantly under this type of loading.

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<td>Demonstrations</td>
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**Implementation Benefits**

- Enhancement (Efficiency, Environment, Safety) ✓
- Cost Savings/Economic Impact ✓

**Further Recommendations**

Since the conclusion of this project, the LRFD method for the design of foundations has been in effect at the NJDOT Bridge Department. The design and method should not be affected, but the load factors, resistance factors, and limit analysis were not addressed for the piles in the presence of strong sand, which generates a need for further research on the subject matter.

**Project Cost Benefit/Economic Impact**

As a result of the knowledge transfer from this study, it is expected that enhancements will be realized in design efficiency and cost savings. However, no benefits reported at this time.

**Summary**

Retrofitting bridges with countermeasures to prevent or mitigate scour differed in New Jersey, depending on bridge ownership. Use of varying countermeasure standards often resulted in inefficient retrofit and a recurring problem. The goal of this project was to prepare a handbook of unified guidelines on design of scour countermeasures for both new and old bridges in New Jersey.

The handbook was created and can be used for planning and design of a new bridge, design of countermeasures for an existing bridge, and provides guidelines for in-depth scour study of a bridge site. All important considerations specific to scour conditions in New Jersey have been identified and recommendations made for effective countermeasures suitable to river conditions in New Jersey. Guidelines proposed for selected countermeasures are based on their effectiveness during past applications around the world, physical tests, and the best design practice for the area.
recommended that the handbook be updated as new countermeasures are developed, particularly for aspects of scour design addressing scour of embankments and tidal flow, which are not reviewed in the current manual.

Implementation

Over thirty six thousand bridges in the country are either scour critical or scour susceptible. There are 467 scour critical bridges in New Jersey. These bridges are susceptible to damage because of the erosion of streambed material during severe floods that could cause damage. Scour critical bridges in the State have been retrofitted using different standards for countermeasures, depending on the bridge ownership. This handbook has been developed based on the goal to provide a unified guideline to design scour countermeasures for both new and old bridges, which will be used by city, county and state engineers and bridge structural consultants.

All important aspects specific to scour conditions in New Jersey have been identified through an in-depth review of NJDOT Phase II inspection reports of scour critical bridges. A detailed review of all available resources on scour countermeasure design, including HEC 11, 18, 20 and 23, CIRIA Manual (2002), NCHRP 24-07 report, scour countermeasure drawings by Maryland State Highway Administration and numerous research articles on scour countermeasure design, has been carried out to recommend effective countermeasures suitable to river conditions in New Jersey. Guidelines, proposed for selected countermeasures, are based on their effectiveness during past applications throughout the world, physical tests, and the best design practice followed in the subject area. The handbook presents comprehensive guidelines on all aspects of various scour countermeasures, including constructability and environmental constraints specific to New Jersey.

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<th>Handbook of Scour Countermeasure Designs</th>
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Design guidelines, presented in the handbook, supplement the Hydraulic Engineering Circulars and have been developed with intent to provide the engineers all important aspects of scour countermeasure design for New Jersey conditions in a collective and systematic manner. The engineers still needed to refer to specific HEC for more detailed information on specific aspects of scour countermeasure designs.
Further Recommendations

According to Richard Dunne, NJDOT Bridge Department, the publication now has a New Jersey based approach. A literature review was conducted on scour countermeasures used in other States and their application in New Jersey. Most recommendations were adopted in the NJDOT design manual and the new treatment section for protecting bridges. Future considerations for review on scour include the low flow conditions and treatments. Also, new scour countermeasures for bridge abutments were to be completed and incorporated into the handbook in the future.

Projected Cost Benefit/Economic Impact

As a result of the knowledge transfer gained from this study, it is expected that cost savings will be realized in the future due to standardized use of countermeasures. At this time, no economic benefits have been attributed to the project.


Cost: Funded by other sources.

Summary

It is desirable to remove toxic sediments from the bottom of many NY and NJ waterways. These sediments have degraded the environment and caused loss of habitat. Dredging can remove these toxic sediments as well as restore navigational, commercial, and recreational uses. However, with dredging, there is the potential for dispersing contaminated sediments into the surrounding media. Cement Deep Soil Mining (CDSM) technology can be used to stabilize contaminated sediments before removal. This project was undertaken to evaluate CDSM results in the NY/NJ harbor and surrounding bodies of water as well as to determine the extent of sediment dispersion during the process.

Several samples of river sediments were mixed with various percentages of cement ranging from 7% - 14%. The samples were tested to determine the gain in strength over time. Total suspended solids were also monitored. Solidified sediments were dredged using conventional methods. Shear strength of the sediments was significantly increased using CDSM. Total suspended solids increased in the vicinity of the equipment in a radius of 75 feet and a depth of 15 feet.

The research team concluded that CDSM technology has potential for effectively stabilizing contaminated sediments, resulting in increased workability and improved material handling characteristics. These stabilized sediments do not impede dredging. They can remain in place indefinitely if properly capped. Dispersion of sediments during mixing was not detected beyond 125 feet from the mixing point.
Implementation

This study evaluated a technique that amends sediment, in situ, with a pozzolanic mixture, such as Portland cement, lime-kiln dust or fly ash. This technology has been used successfully throughout the New York/New Jersey Harbor to stabilize low-to-moderately-contaminated sediment dredged from navigation channels. Once the sediment is amended, it is transported easily and used as fill and capping material.

Restoration of the sediments of the Harbor will have a significant impact on the economy and quality of life in Northern New Jersey. As part of restoration of the Harbor, highly contaminated sediments in the Harbor and surrounding water bodies may need to be dredged and disposed of in order to minimize future migration of contaminants. However, dredging of the highly contaminated sediments must be done in an environmentally sound fashion, as that they are not dispersed beyond their existing location. In-situ solidification of sediments using CDSM could mitigate the potential risk of contaminant dispersion during dredging, transportation and processing.

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<th>Solidification Stabilization of Soft River Sediments Using Deep Soil Mixing Results</th>
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As part of a pilot project conducted at the mouth of the Passaic River, CDSM technology was successfully implemented for the stabilization/solidification of slightly contaminated sediments. The site was selected because the sediments had physical characteristics similar to those in known Harbor hot spots such as the Lower Passaic River. Cement was typically the preferred additive for solidification since it was capable of being mixed in slurry form and was consistent in its chemical and physical properties.

Further Recommendations

Scott Douglas, the NJDOT customer, identified the need to improve the Port economy through the reduction of ongoing contaminants. Once the contaminant sediments were exposed to in-situ stabilization through the application of Portland Cement, the dredged material had the ability to be used for construction purposes. The sediments were mixed with percentages of cement and tested to determine strength gain. It was confirmed that the strength gained increased the consistency of hard silt/clay. The sediments had the potential to remain in place indefinitely, be properly capped, or treated and used as increased strength materials.

Potential Cost Benefit/Economic Impact

In Situ solidification of sediments, using CDSM, was able to effectively reduce the risks of dispersing contaminants during dredging, transportation, and processing. The study was successful in stabilizing contaminated sediments to be dredged in a solid form and disposed of without causing further harm to the environment. There had been no cost savings realized during the study. Future applications may differ when the product is successfully used to cap landfills and restore brown fields.
Cost: $146,000.

Summary

NJDOT maintained a need to identify cutting-edge technology and quantify key issues of energy efficiency and associated costs in roadway lighting. There are an estimated 45,000 lamps on the NJ State roadways. All are the high pressure sodium (HPS) types with wattage that varies from 150W (50%), 250W (35%), and 400W (15%). Research for this project occurred in three phases. A literature search was conducted on the basic factors of vision and lighting issues as well as the features and construction of street lighting technology focused on HPS types of lighting and newer induction types. The second phase included evaluating visibility and color rendering of two light sources, sodium (yellow) and white light. The Decision Support phase included a life cycle cost analysis (LCCA) for seven types of lamps over a 20 year period.

During the study, 2000 HPS Restrike lamps were installed on Route 78. Initial cost and ongoing energy costs were found to be comparable to lamps traditionally used throughout the state, but it is anticipated that these lamps will save the State money in terms of safety resulting from higher quality lighting and labor costs related to relamping since the lamping cycle is expected to be twice as long. Another important consideration is the issue of worker safety. Replacing lamps on a busy highway such as Route 78 is dangerous and can sometimes be fatal.

Lamps were installed at the NJDOT Complex, located in Ewing/Trenton that allowed researchers to observe and compare the visual effects of yellow versus white light sources in terms of hazard identification and driver decision support. White light appeared to increase visibility. Also, QL lamps were installed at the War Memorial in Trenton. These lamps provided better lighting to enhance the safety of critical locations. They were rated with a mean life of about 100,000 hours, which was four times as long as the traditional HPS lamp. The Life Cycle Cost analysis showed that Induction, HPS restrike, and LED lighting technology all perform better than HPS. However, Induction and LED do not meet the NJDOT lighting requirements in terms of lumens per watt even though experimental results imply similar performance.

The conclusion of the study was that new NJDOT specifications be developed to accommodate new types of lighting technologies. Once LED light distribution improves, they were to be recommended for use in the state. The HPS Restrike met the current specifications and produces an equivalent quality light and energy use as traditional HPS with the benefit of increased life.
Implementation

Richard Shaw, NJDOT Maintenance, was identified as the customer for this research project. Several benefits would result from the replacement of standard overhead and sign lighting. In addition to energy savings, driver safety would improve due to hazard recognition. An estimated $3.5 million dollar savings would be realized over a 20 year period for restrikes. Roadside work would be reduced considerably for relamping. However, federal policies would need to be changed in order for the NJDOT to implement the change in lighting.

For every 150 HPS bulb replacements with a restrike, there would be a $69/20 year present value savings ($1.5 million); while the 250 HPS bulb replacement with a restrike $94/20years present value savings that amount to $1.5 million.

| Use of LED or Other New Technology to Replace Standard Overhead and Sign Lighting Results |
|---------------------------------|-------|-------|
| T/2 Measures                    | Researcher | Customer |
| Knowledge Transfer (Findings/Dissemination) | ✓     | ✓     |
| Marketing/Media (website)      |         |       |
| Policy/Process Change          |         |       |
| Demonstrations                 | ✓     |       |
| Implementation Benefits        |         |       |
| Enhancement (Efficiency, Environment, Safety) | ✓     |       |
| Cost Savings/Economic Impact   | ✓     |       |

Further Recommendations

From an Operations Support perspective, the primary focus of this study was LED technology. The findings showed that the technology is not yet advanced enough to provide the floodlight pattern required for effective overhead lighting. Richard Shaw, Director of Operations Support, expects that it is “just a matter of time” before technology catches up. To assist in implementing the findings of the study, the NJDOT Bureau of Research could keep abreast of the technology improvements and share information from research periodicals.

Potential Cost Benefit/Economic Impact

This study produced knowledge transfer valuable for future applications but with no quantifiable benefits because implementation at this time is not possible. LED lighting is highly attractive because of its intensity and potential cost savings. Costs for electricity with widespread use of LED lighting are projected to be 10% lower than current electrical costs. Also, maintenance costs would be reduced because of the decreased frequency of relamping the roadways.

Summary

The purpose of this implementation follow-up study was to identify technology transfer measures that contribute to the enhancement and cost savings of transportation research. According to TRB (1999), the four stages of the technology transfer process include awareness (knowledge transfer), attitude formation, persuasion (marketing), trial and decision making (policy/procedure/process change), and confirmation (demonstration). These technology transfer measures and implementation benefits were described by both the researchers and customers.
Knowledge Transfer: A total of 18 graduate students were employed on the research projects during this period. After the studies were completed and accepted by NJDOT, these researchers and students conducted 49 presentations and wrote 26 publications that were nationally distributed. Several of the final research reports had been acquired for distribution by the Washington State DOT and Colorado DOT libraries. A total of 14 presentations and publications were conducted and published during the TRB Annual Meeting. NJDOT research studies were also presented at five national conferences (Midcontinent Transportation Research Symposium, National LTAP Conference, FHWA Pavement Conference, University of Alabama Simulation Research Conference, and the FHWA Safety Conscious Planning Meeting). Three Master’s thesis studies were produced in conjunction with the research projects. Also, the prestigious Transportation Research Record featured two articles on value pricing that were authored by Dr. Kaan Ozbay.

Marketing/Media: Marketing of products and safety strategies played an important role in 30% of the projects. The major focus of the Congestion, Safety, and Security Initiative was using the media to support the establishment of a
statewide safety network. Another project included educating the asphalt industry on changes in the NJDOT recycled pavement performance specifications. According to the researchers, media was involved in promoting value pricing for the NJ Turnpike Authority and the Port Authority of New York and New Jersey. The evaluation study on the NJDOT TOCs was nationally featured through RITA as an example of “lessons learned”. Also, the clay dredging project results were shared with environmental groups in the region.

**Policy and Procedures:** Several projects resulted in policy and procedural changes at NJDOT, which has contributed to the efficiency of the agency. Specifically, a statewide safety network was established to reduce roadway crashes, while enhancements of railroad crossings contributed to the reduction of crashes, and a new technology was tested to help reduce truck crashes on New Jersey roadways. A brief description of the outcomes has been provided below:

- **Statewide safety network:** The establishment of a statewide safety network was requested by FHWA – New Jersey Division to reduce crashes through data driven action efforts.

- **Safety enhancements at railroad crossings:** Any time there is a change at a railroad crossing, such as street widening or new construction, the Railroad Engineering & Safety team holds a diagnostic team meeting with local stakeholders. If the configuration matches that of the study, the diagnostic team realizes that additional safety measures must be taken and incorporates the study recommendations of enhanced delimiters as appropriate for the community.

- **Comprehensive design manual:** The Seismic Analysis study produced one comprehensive design manual used as guidance on the design of bridges in New Jersey. Specifications were also changed to address the use of recycled pavement on NJDOT roadways. Also, a handbook on scour countermeasures was developed as a standard for the industry.

- **New safety technology:** The Thrie Beam Median Barrier was tested and is now used in areas experiencing a high volume of truck crashes.

- **Revenue studies:** Time of day pricing was examined to identify revenue benefits.

- **Simulation and decision-making models:** The computer modeling and simulation of signalized highways program generated the most cost savings of all the studies that were conducted during this period. Specifically, the project opened discussions within NJDOT to achieve more balance between primary and intersecting roads through timing changes.

- **Saving lives through evaluation:** Analysis and modeling of the Cape May County Roadway Evacuation Route led to redeveloping the plan since it was proven to be ineffective.

**Demonstrations:** In addition to the projects that were identified in the previous section, demonstrations were used by researchers during the development phase for NJDOT. The geopolymer coating project required a series of demonstrations to determine whether or not this application was effective. The two dredging projects were based on demonstrations and tests to secure contaminants through the use of in situ applications and to promote alternative uses of dredged clay. Also, the use of LED to replace the lighting on NJDOT roadways was unable to be implemented, but there is great potential in the future when required technologies become available.

**Enhancement Benefits:** All of the respondents identified enhancement as a benefit of the research studies. (See the table below.) Aesthetics is an indirect benefit of some projects, such as improvement pavement, traffic calming, and the use of protective coating on bridges. A majority of the projects were directed toward improving the efficiency of operations at the department. The safety devices and applications were targeted toward the reduction of crashes and protection of highway workers. Nearly 70% of the equipment used the studies were simulation models that had been designed to either enhance safety or improve efficiency of transportation operations.
Cost Saving/Economic Impact Benefits: Two studies involved evaluating revenues generated from the time of day pricing on toll roads. Improvements in safety and the reduction of time were the two benefits most frequently realized from the projects. The computer simulation and decision-making models mostly influenced time savings for employees or the motorist, as well as the reduction of congestion and improvement of roadway safety. Specifically, modeling of New Jersey signalized highways improved travel time and reduced crashes. Other evaluation models focused on the testing of evacuation plans, simulation of incidents (e.g. Route I-80), and addressing incident management on NJDOT roadways. The projects, requested by the bridge department, were very practical and related to improving the efficiency of the bridge design process. Manuals and guides were updated and standardized to reflect designs that are applicable to conditions found in New Jersey. This focus on improved efficiency will show a positive benefit in the near future when the Department’s newly developed geotech data management system of collective boring data is launched. This decision-making tool will enable customized design criteria to be developed, by county and zip codes, for both new and maintenance bridge projects.

Nearly 90% of the projects, requested by the NJDOT customers, involved the development and piloting of computer simulation and decision-making models that were designed to increase the safety of New Jersey roadways. Over $8.5
million was realized from the research conducted during this period, and the potential existed for the NJDOT to regain an additional $834 million over time through the reduction of fatal and injury roadway crashes, recycling of pavement instead of using virgin asphalt, the development of customized bridge designs based on coring data, application of geopolymer coating to protect much of our vulnerable infrastructure, and the future installation of energy efficient LED lighting on New Jersey roadways.

NJDOT Realized Savings

Safety projects were reported as having the greatest financial return due to the reduction of crashes and congestion. For example, a statewide Safety Conscious Planning network was established in 2004 to offer safety support for local transportation agencies. A total of $3,000,000 was contributed to local agencies for local safety projects. Later, a series of focus groups were held to develop the first statewide Comprehensive Strategic Highway Safety Plan (CSHSP) that was adopted in 2007, which has resulted in nearly a 20 percent reduction of roadway crashes.

Computer Modeling and Simulation of New Jersey Signalized Highways Volume I and II

NJDOT customers had expressed the need to systematically improve traffic operations along the state’s signalized highway corridors. NJ Route 23 and NJ Route 42/322 were selected as study areas with potential to reduce congestion and improve air quality through signal timing optimization. Optimal signal timings were developed using traffic volume data and existing signal timing. New timing directives were reviewed and approved by NJDOT Bureau of Traffic Engineering and Safety Programs to ensure compliance with the NJDOT standards and format. Significant improvement in level of service was achieved by optimizing the signals, reducing by half the average vehicle delays during peak morning hours.

The initial project was managing traffic flows associated with Route 23 and Route 42/322 to demonstrate the benefits of signal timing improvement. Total costs for both routes were roughly $101,388 while the combined net benefits came to $3.8 million per year, yielding a cost/benefit ratio of 1:21 overall (1:24 for Route 23 and 1:20 for Route 42/322). The ratio for future years will dramatically increase as costs are fixed. The study team also found optimized signal timing plans for Route 23 and Route 42/322 to be economically justified and recommended a yearly review of traffic signal and system performance to maintain efficiency and effectiveness. They suggested future studies incorporate New Jersey specific parameters such as vehicle occupancy, pollutant unit cost, and New Jersey specific crash data.
The findings confirmed that the total costs incurred, including engineering and network modeling costs, were balanced against estimated dollar benefits of the improved signalization. These benefits were reduced travel time, less fuel consumption, and lower environmental impacts during AM, Noon, and PM time periods for yearly weekdays. Additional benefits, not included in the study were savings from reduced crashes and customer satisfaction.

The capital program is now in its fourth year and has grown from an initial $1,000,000 budget item to $1,700,000 with additional change orders of $1,000,000 for a closed loop traffic operation. An additional $10,000,000 over the next 5 years is possible for optimization of routes in conjunction with Congestion Management Systems. This has allowed NJDOT to satisfy the optimization requirements in the Federal Performance Plan. The results had been posted on the NJDOT website. Savings were realized through the reduction of labor, while safety benefits need to be identified in the future, along with travel time savings.

**Environmental Savings**

In order to accommodate the newest generation of container ships, dredging of the New York/New Jersey navigational channels to a depth of 50 feet must be done. This will generate millions of cubic yards of red clay. This pilot study was undertaken to provide NJDOT with useful information on how this clay can be used most effectively.

Initially, 4000 cubic yards of red clay dredged from Newark Bay was transported to the Bayshore Recycling Corporation and placed in varying thicknesses and compacted to evaluate its behavior and workability. Both laboratory and field testing was done at different moisture and compaction conditions. Half of the clay was then removed and used in an actual capping project. Researchers concluded that dredged red clay from Newark Bay and surrounding bodies of water was beneficially used as a low conductivity cap with similar performance to mined clay without the environmental impacts associated with mining. Conventional equipment and trucks could be used without the added expense of modification.

Scott Douglas, the NJDOT customer, confirmed that the purpose of this study was to help identify the most cost effective uses of dredged clay materials. The application was expected to produce a considerable cost savings due to being recycled. New York City had expressed interest in using the clay as a liner for the Fresh Kills Landfill. It was found that all costs were comparable or lower than costs of competing products. The estimated potential market use of red clay is approximately 22 million cubic yards over the next ten years. In addition to use in containment barriers for landfill capping and site remediation projects, other markets exist for the use of clay in pond liners and wetland restoration, as well as for the ceramic manufacturing industry if the red clay material is amended.

The technology was proven effective as a substitute for mined clay substitute. Also, the environmental benefits of this product include reduction of ongoing contaminants, stopping of leche, and acting as a contaminant absorbent at the nearby brown fields. The associated cost for transportation, unloading, moisture conditioning and placement was estimated to be $13.60 per cubic yard. The market price of mined clay from upland sites is $15 per cubic yard, and $2.30 in placement costs that total $17.30 per cubic yard of mined clay. It was cost effective to use dredged red clay instead of mined clay. Since 4,000 cubic yards of red dredged clay was processed and used instead of mined clay at the landfill, the realized savings amounted to $14,800.

**Conclusion**

Nearly 90% of the projects, requested by the NJDOT customers, involved computer simulation models or products designed to increase safety on New Jersey roadways. Over $2.3 million was realized by the NJDOT, when examining the difference between the investment and realized savings from the research projects. The potential exists for the NJDOT to gain over $853 million based on the reduction of fatal and injury roadway crashes, recycling of pavement instead of using virgin asphalt, the development of customized bridge designs based on coring data analysis, using the geopolymer coating to protect much of our vulnerable infrastructure, and the future installation of energy efficient LED lighting on New Jersey roadways.
References


Project Title:

FHWA Project Number_______________________________________ Start Date:__________ Completion Date:______________

Principal Investigator: _______________________________________ University/Consultant:______________________________

Bureau of Research Project Manager:___________________________ Customer/Unit:____________________________________

Implementation Follow Up: 1 year ___ 2 year___ 3 year ___

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Implementation Benefits

- Enhancement
  - Aesthetic
  - Efficiency/Effectiveness
  - Environmental
  - Safety

- Cost Savings/Economic Impact
  - Equipment
  - Labor
  - Materials
  - Revenue Increase
  - Safety
  - Time

  TOTAL

How useful were the research findings/products/outcome? The research study resulted in:

- implementable changes with quantifiable benefits. Please Specify:______________________________________________
- implementable changes with no quantifiable benefits. Please Specify:______________________________________________
- knowledge transfer with no quantifiable benefits. Please Specify:______________________________________________
- no implementation. Explanation:__________________________________________________________________________

Can the Bureau of Research or NJ LTAP provide further assistance in implementing the findings of the study? Yes No Comments: