JERSEY DOT'S
"Turning Problems into Solutions"
Tech Brief

Need a solution?
Think Jersey DOT

Analytical Modeling and Instrumentation Planning of The Doremus Avenue Bridge

FHWA/NJ-2002-008 September 2002

SO, HERE'S THE PROBLEM…

In 2007, the American Association of State Highway Transportation Officials (AASHTO) will adopt the Load and Resistance Factored Design (LRFD) Bridge Design Specifications as the mandatory standard by which all future bridge structures will be designed.

- Therefore, it is believed that there is a need to validate these new design procedures and models as well as the integrity of LRFD designed bridge structures.
- The Doremus Avenue bridge structure, located in Newark, NJ, is New Jersey's initial LRFD design.

AND, HERE'S OUR SOLUTION

The study identifies the procedure(s) and parameters used in bridge instrumentation and develops alternatives for analyzing, testing, and monitoring the new structure. The identification process will be implemented in two phases:

1) Development of a detailed Finite Element Model (FEM) that incorporates the nonlinear behavior of concrete material and
2) The planning and optimization of instrumentation schemes and the sensor location.

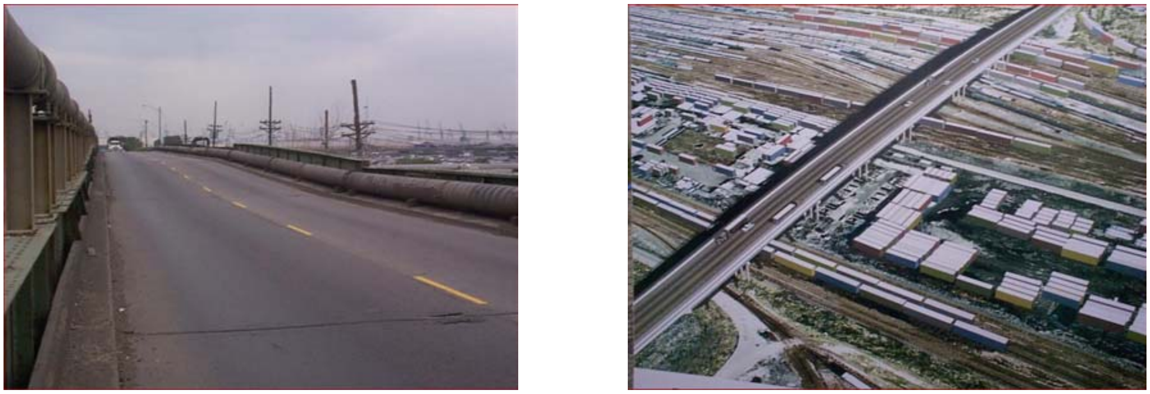
It is expected that the study will continue to allow instrumentation, field-testing, and long term monitoring over a 5-year period that will consist of three Phases:

1. Phase I: Bridge Modeling, Instrumentation Planning, and Coordination of Tasks.
2. Phase II: Bridge Instrumentation, Testing, and Verification prior to Traffic Opening.
3. Phase III: Bridge Testing and Long-Term Monitoring after Traffic Opening.

HERE'S WHAT WE DID…

This study covers Phase I of the project only and identified the method(s), procedure(s), and parameters considered in the analysis and instrumentation of the Doremus Avenue Bridge. The following tasks were employed to successfully complete the project:

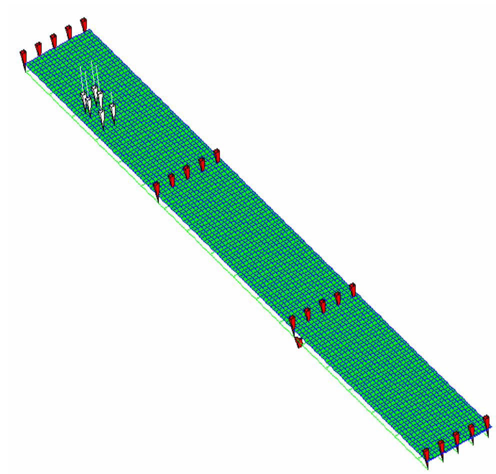
1. Conducted a literature review and a statistical evaluation of different parameters influencing bridge design and analysis.
2. Developed a technical specification described all equipment used in the instrumentation of the Doremus Avenue Bridge and the procedures to be followed by the contractor for the implementation of this instrumentation plan.



(a) (b)

Figure 3. (a) View of the existing Doremus Avenue Bridge. (b) A rendering of the proposed Doremus Avenue Bridge.

3. Developed detailed finite element models to simulate actual behavior under various types of truck loading.



(a) (b)

Figure 2. Three-dimensional finite element model for unit 1 in Doremus Avenue Bridge under an HS-20 truck loading.

4. Compared results from the FE model and preliminary calculations. The FE model need's to be validated experimentally in Phase II of the project and utilized henceforth more accurately. Information from bridge sensors will be used to update the FE model as soon as it becomes available. The information obtained from the model will be processed to update the instrumentation plans accordingly.
5. Perform preliminary structural analysis, soil characterization, instrumentation planning, seismic cross holes, and substructure testing.

6. Recommend modifications or additional field verifications during each phase of the study.

The following tasks are related to the substructure evaluation and monitoring:

- Site characterization with respect to dynamic soil properties
- Preparation for the substructure instrumentation
- Preparation for the drilled shaft testing

THE BOTTOM LINE…

The Rutgers University research team has provided all the instrumentation shscemes to the contractor who will be responsible for the installation of cables, sensors, and testing equipment.

Future Tasks
The following tasks will be implemented in coordination with the NJDOT resident Engineer, Consulting Engineer on Site, and Contractor:

1. Install vibrating wire strain transducers (VWST) in the concrete deck for spans 1, 2, and 3.
2. Install girder transducers to be used with the portable live load testing as well as dynamic strain measurements.
3. Install accelerometers and goephones for dynamic vibration measurements and to predict deflections of the girder as well as mode shapes and vibrations.
4. Develop and install a LVDT-Cable system to measure deflections of at least one girder in each stage. The LVDT-Cable system shall be accurate in detecting deflection to within $\pm$1/100 of an inch. Verify the deflection measurement from the LVDT-Cable system with a non-contact Laser system.
5. Install and run all cables needed to contact sensors to data acquisition systems placed in steel cabinets and located at Pier 2.
6. Install and operate a permanent bending plate weigh-in-motion system at the south abutment in Stage I and Stage II. The WIM system will be used to weigh trucks at highway speeds with an accuracy of $\pm$5% of gross vehicle weight.
7. Install a fatigue data logger system capable of recording peak stress ranges and rain flow analysis.
8. Perform calibration static testing using truck of known axle weights and configuration. Also perform dynamic tests using the same calibration trucks at speeds close to normal highway speeds.
9. Install a telephone line and establish the remote data collection routine and software needed to download data from various data acquisition systems.
10. Install electric power and/or solar panels, if needed.
11. Collect concrete samples from the deck slab to determine its mechanical properties, which will be used in the FE model.
12. Perform a comparison between analytical and experimental results.
13. Perform long-term monitoring for deflections, fatigue, and durability of the bridge structural elements. Compare results with the AASHTO-LRFD code provisions
14. Perform substructure testing to collect time histories for loading and response. The shaft impedance will be obtained and matched by theoretical models of the dynamic

response of the drilled shaft. A numerical model of the drilled shafts will be developed using the FEM and other software like Pilay 2. Shaft impedances will be used for the evaluation of soil-structure interaction effects on the dynamic response of the bridge due to vehicular and earthquake loading.

FOR MORE INFORMATION CONTACT:

NJDOT PROJECT MANAGER:	Nicholas Vitillo
PHONE NO.	**(609) 530-5966**
e-mail	**Nick.Vitillo@dot.state.nj.us**
UNIVERSITY PRINCIPAL INVESTIGATOR:	Hani H. Nassif, P.E., Ph.D.
UNIVERSITY:	**Rutgers University -CAIT**
PHONE NO.	**(732) 445-4414**
e-mail	**nassif@rci.rutgers.edu**

A final report is available online at
http://www.state.nj.us/transportation/research/research.html

If you would like a copy of the full report, please FAX the NJDOT, Bureau of Research, Technology Transfer Group at (609) 530-3722 or send an e-mail to Research.Bureau@dot.state.nj.us and ask for:

Analytical Modeling and Instrumentation Planning of The Doremus Avenue Bridge

NJDOT Research Report No: FHWA/NJ-2002-008