RESEARCH AND TECHNOLOGY

REVIEW

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RESEARCH BULLETIN

Next Peer Exchange Planned

As required by federal regulation, NDOT will hold its next tri-ennial research-program peer exchange during the week of April 23, 2001.

As in the past, the peer-exchange team will consist of research professionals from other state DOTs and the Federal Highway Administration (FHWA). Research managers from Oregon, Montana and Colorado along with FHWA officials from Nevada and Oregon have agreed to be part of NDOT's peer-exchange teams.

The exercise will focus on an exchange of ideas/practices relative to research-management processes, e.g., project prioritization, project management, implementation, etc. As such, the team will meet with the constituencies of NDOT's research program including division heads, university researchers, and NDOT's top administrators.

A peer exchange presents a unique opportunity to compare notes, so to speak, with other research professionals to identify respective program strengths and also to identify opportunities for improvement. The findings of this year's exchange will serve to shape the future of NDOT's research program through the end of TEA-21.✪

In This Issue

NDOT Research

Seismic Retrofit of Flared Columns at the Airport Viaduct in Reno

As part of NDOT-sponsored research to evaluate the seismic performance of reinforced concrete bridge columns and to develop seismic retrofitting schemes, this study examined the ductility capacity of flared reinforced concrete bridge columns with substandard shear capacity and low confinement. The project was conducted at the University of Nevada, Reno and was directed by Professor M. Saiid Saiidi. The need for this study became apparent following the dramatic failure of the flared columns in the Mission Gothic Overpass in Southern California during the 1994 Northridge earthquake. A multi-phase study of flared

Typical columns with structural flares in Nevada bridges

columns in bridges in Northern Nevada was undertaken.

Analytical studies revealed that two types of flared columns are particularly vulnerable. Both have "structure flares" unlike those typically used in California which are architectural. The steel reinforcement in structural flares is the only source of flexural strength, while in architectural flares, the main steel is in the core and flare reinforcement is minimal. To retrofit architectural flares, the flares are cut around the column at the junction to the superstructure. This method cannot be used in structural flares because the column would lose its flexural capacity. Therefore, new retrofit methods had to be developed for Nevada bridges.

Cyclic tests of as-built column models showed that only columns with high vertical steel ratio are vulnerable. Tests also showed that the columns, despite their deficiency in shear and confinement, have an inherent advantage. Plastic hinges do not occur at the end of the column but are shifted to some distance away from the end. The shifted plastic hinges have the advantage of leaving the connections damage free and improve the overall stability of the structure. The retrofit methods that were investigated were developed so that the plastic-hinge location is maintained.

The most common method to retrofit bridge columns for shear and/or confinement is the installation of steel jackets. However, no past studies had been conducted on the use of steel jackets on flared columns. A series of cyclic tests and shake-table simulations were conducted on column models that were retrofitted with a steel jacket. A gap was left in the jacket in the plastic hinge area to avoid connection damage. The 1994 Northridge-Sylmar earthquake was simulated on the shake table. The tests showed that the steel jacket improved the shear capacity substantially and the ductility capacity was increased by approximately 40 percent. It became clear that a gapped steel jacket would be an effective seismic retrofit measure for the columns from a technical point of view. However, due to space limitations adjacent to the columns, an alternate retrofit strategy had to be found.

Fiber reinforced plastic fabrics are an alternative material for seismic retrofit of reinforced concrete structures. They require only a limited clearance around the column for installation. These fabrics, however, were not initially considered because they have been used only on circular bridge columns, and there was no research data on their performance. The next phase of the research was to investigate the shake-table response of flared columns with carbon and glass fiber composite jackets. A new method of installation of composite fabrics had to be developed for flared columns. A continuous wrap normally placed on circular columns would lead to a change of fiber angle that could adversely affect the column performance. The effect of reducing the height of the jackets was also investigated to determine if there were any problems in stopping the jackets above the ground level. The shake-table data showed that the carbon and glass fiber composites both performed as well as a steel jacket, and it is not necessary to excavate around the base of the columns to extend the jackets. A step-by-step design and installation procedure was prepared and used to implement the research results. The columns were retrofitted in spring 2000 using glass fiber composites. Glass was selected over carbon due to its lower cost.

The major benefits from the research were:

1) Many of the columns were found to have sufficient ductility and did not need retrofitting. This led to significant cost savings for the project.

2) Research showed that composite fabrics are effective retrofit measures. Because the fabrics are relatively easy to install in a tight working space, they were implemented in the actual retrofit plan.

3) Research results demonstrated that the parts of the columns that are embedded below grade did not need to be covered by jackets. As a result, no excavation around the base of the columns was necessary. This also led to considerable cost savings, less disruption to facilities under the bridges, and a reduction in traffic delays on adjacent streets.

Different phases of the study are documented in the following

reports that are available from the NDOT library. They are: 1) **"Dynamic Testing and Analysis of Non-Prismatic Reinforced Concrete Bridge Columns Retrofitted with FRP Jackets,"** 2) **"Shake Table Testing of Flared Bridge Columns with Steel Jacket Retrofit,"** and 3) **"Effects of Confinement and Flares on the Seismic Performance of Reinforced Concrete Bridge Columns."**✪

Library Services and Collection

The new NDOT library, located in room 110 C on the first floor of the NDOT headquarters building, is being developed to meet NDOT staff's needs for information. The library collection is being organized and will be indexed into a computer database using library automation software. The database, once it is completed, will be placed on the NDOT intranet with "search" capability so that every NDOT employee will have access to all the library information. The goal of the new library is to provide the following services:

- Circulation of library materials;
- Organization and maintenance of library collection;
- Notification of newly received materials;
- Literature searches; and
- Access to documents and databases via on-line, interlibrary loan or purchase.

The new library has a variety of publications *(continued on page 4)*

Product Evaluation Committee (PEC) Meeting Recap

Approved Field Test

Reflexite Endurance – Rigid High-Strength Sign Panel Material

A potential alternative to roll-up (flexible) construction signs will be evaluated. The Product Evaluation Committee approved a field test to determine the durability of rigid high-strength Reflexite Endurance Signs. Important consideration was given to the fact that no other rigid sign (aluminum blank) other than the Reflexite Endurance Sign, using a portable stand, has passed NCHRP Report-350 requirements.

The Endurance Sign is a combination of a high-performance thermoplastic sign substrate with reflective sheeting (film). This sheeting is composed of microprismatic retroreflective elements integrally bonded to a flexible, UV-stabilized polymeric film.

Although Reflexite's Endurance Sign panel was tested with portable sign stands under the TL-3 evaluation criteria set forth in the NCHRP Report 350, FHWA certification is limited to the crashworthiness characteristics of this device and does not cover its structural features or performance characteristics. A field test will be conducted to evaluate the in-service performance of the entire system, including Reflexite's sign substrate, reflective sheeting (film), and a portable sign stand. If this system performs well, the test findings can be implemented in the form of a new specification for a portable sign support with a rigid sign panel including reflective sheeting material.✪

Product Removal

Carsonite International

Due to product failure, the Maintenance Division requested that Carsonite's Driveable Survivor flexible guidepost be removed from the qualified product list pending re-evaluation. Maintenance personnel have reported rapid degradation of the sheeting backing used to affix reflective sheeting to the post. The committee's decision to remove the guide post from the QPL was based on the delineation problem.

As discussed at the last PEC meeting, the coming research-program annual cycle will include the development of a research problem statement to address the department's policy regarding the use of guideposts.✪

Specification Revision

Reflective Raised Pavement Markers

In an effort to ensure product and construction work quality, the committee approved a revision to the QPL for reflective pavement markers to include only

abrasion resistant models. Therefore, the QPL for raised, reflective, pavement markers was revised to include only abrasion resistant markers.✪

(Library continued from page 3)

from different sources. The five major categories are:

1) Research reports from government agencies and research organizations. They include the Transportation Research Board (TRB) reports, Transit Cooperative Research Program (TCRP) reports, National Cooperative Highway Research Program (NCHRP) reports, Strategic Highway Research Program (SHRP) reports, Federal Highway Administration (FHWA) research and development reports, and AASHTO specifications.

2) Federal regulations and laws including the "Code of Federal Regulations (CFR)," the "United States Code and Federal Register", etc.

3) NDOT publications including NDOT research reports, contract special provisions, NDOT newsletters, state planning and research work programs, and Nevada highway department biennials, etc.

4) Newsletters, journals and magazines such as the "AASHTO Journal," "ITE Journal," "ITS International," "Engineering News Report," "Better Roads," "Public Roads," "Roads and Bridges," etc.

5) Reference books and publication catalogs including design guides, engineering textbooks, dictionaries, and product catalogs. In addition, the library receives a number of information fliers, brochures and some documents in non-print formats such as CD-ROM, video, or audiotape.✪

The Research Division administers the department's research, development and technology transfer program and serves as the "clearing-house" for product evaluations.

Research and Technology Review is published quarterly by the NDOT Research Division. Its purpose is to provide the latest information on the NDOT research activities including product evaluation and other pertinent research topics.

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