Title:
Blast Testing of Full-Scale, Precast, Prestressed Concrete Girder Bridges

Background:
The terrorist attacks of September 11, 2001 on the World Trade Center and the Pentagon focused the attention of the transportation industry on the vulnerability of existing state owned facilities to similar attacks. Science Applications International Corporation (SAIC) was contracted by the American Association of State Highway and Transportation Officials (AASHTO) and the Transportation Research Board to create a Vulnerability Assessment process to be used by the states to identify their most vulnerable facilities. Each state is expected to identify 15 to 20 of the most vulnerable facilities and than develop mitigation procedures for each identified facility. The mitigation can be anywhere from access denial and/or increased standoff distance, to structural hardening. All these mitigations are meant to stop or, at the very least, minimize the damage due to a terrorism attack on the facility.

Most states DOT's, including the Washington State Department of Transportation (WSDOT), are not trained to make vulnerability assessments from attacks by terrorists. As a result, WSDOT enlisted the aid of FHWA to make these assessments. FHWA assembled a team of experts from New Jersey, Boston, and Washington DC as well as an explosives expert from the U.S. Army Corps of Engineers Engineer Research and Development Center (ERDC), Vicksburg, Mississippi and a faculty member from the University of New Mexico. The team spent an entire week discussing details of some of the bridges identified in Washington as vulnerable, field visiting a number of these bridges, and preparing an assessment presentation.

Nationally, research and analysis procedures need to be developed to help all states implement proven bridge details addressing terrorism concerns. During the recent AASHTO Subcommittee on Bridges and Structures Meeting, a research project was initiated to create "hazard standard details." This study is intended to produce standard minimum details to be used nationally and it appears these details will be very similar to the minimum details now used for seismic force mitigation such as, column confinement, large beam seat widths, and elimination of rebar splices in columns.

As a result of the vulnerability assessment exercise, we discovered that there has been very little research conducted on blast effects on bridges. During our discussions, it was identified that there was a need to conduct real life-size blast experiments on prestressed girder bridges. Based on past experience, the blast experts have a very good idea of what damage to expect from a blast originating on top of a prestressed girder bridge. It is assumed (note assumed, not known) that the deck will be blown out and it is most likely one of two girders would be damaged depending on the exact location of the detonated device. The big question is what will happen if the detonation occurs under the prestressed girder

bridge. It is very well understood by engineers that, if one exerts an upward force on a prestressed girder, it will self-destruct due to the extreme bottom fiber compression with the application of a relatively small load. Therefore, the big question is will the deck be blown out and relieve the upward blast pressure before the girders fail due to the blast uplift force.

Objectives:
The objective of this research is: (1) to assess the damage done to precast, prestressed girder bridges from a blast generated below the girders, (2) to compare this damage with a blast generated on top of the bridge deck, and (3) to develop recommendations for possible mitigation measures that would harden this type of bridge blast damage.

Scope of Work:
Two full-scale model bridges will be built to test blast effects. These bridges are similar to commonly constructed bridges in the United States. Both bridges will be four-girder bridges with one being 75 and the other being 150 feet long. The girders will be set on timber bunking and a trench dig under the bridges so the test will be reasonably close to actual highway conditions. A device will be detonated on top of the 75-foot bridge and below the 150-foot bridge to capture both source conditions. The test blasts will be fully instrumented and video taped. The collected data will be reduced and used to formulate mathematical reproductions of the experienced forces and pressures for use in terrorism hardening of future designs and possible existing bridge retrofit schemes.

The U.S. Army, Corps of Engineers, Engineer and Research Development Center (ERDC) will provide the expertise in sizing the appropriate detonation device and in analyzing the forces and pressures produced by the blast. The U.S. Army's Yakima Firing Range, located near Yakima, Washington, will be the test site. The test specimen structures will be built in the spring of 2005 and tested in the fall of 2005.

BENEFITS:

Precast, prestressed concrete girder bridge system designs are very commonly used by most states and many are located on the Interstate Highway System that is also known as the National Defense Highway System*. Our military is extremely dependent on this system for the movement of goods and vital personnel. The destruction of these bridges would restrict or prevent the desired military mobility.

This precast, prestressed concrete girder bridge blast test is a beginning of the process required to formulating the answers to the questions of what, if anything, the states can do to mitigate existing structures and/or design new structures that will prevent their destruction by terrorists attacks. This effort could lead to some very efficient and cost effective design solutions.

EXISTING PARTNERS:

Those involved in the development of this study include:

- U.S. Army, Corps of Engineers, Engineer Research and Development Center, Vicksburg, MS. The COE will provide development of the blast test plan, instrumentation and data collection.
- U.S. Army, Yakima Firing Range will provide the site for the test. Debris may be left from the blasts for future training exercises. They will also provide equipment for fire suppression.
- Washington State Department of Transportation will provide the bridge design, survey crew for site preparation, administrative functions (contracting, liaison between organizations), and construction oversight.
- Central Premix, Spokane, Washington and Morris Brothers, Clackamas, Oregon will each provide four prestressed girders for the bridges at no cost to the study.
- City of Seattle will provide approximately $215,000 to assist with the cost of the test.
- Washington State University will conduct analysis of the blast results as part of a project receiving federal discretionary funding from the Federal Highway Administration (up to $250,000).

BUDGET:

The estimated cost to for the complete project is $1,000,000, however, as noted above some of this funding has already been obtained. The amount this pooled fund is seeking from partners is $500,000. This funding will be used to actually construct the bridge test specimens at the test site and do the clean up work and other details as noted below.

Additional construction costs would include the following:

1. Surveying and elevation controls,
2. Site grading and excavation (can assume an approximate 20-foot deep excavation to provide the 16’-6” typical structure clearance),
3. Construction administration and item payments,
4. Site preparation for observation and necessary instrumentation,
5. Explosive ordinance and the placing of the ordinance,
6. Debris clean up and grading works to restore the test site (fill the excavation burying the debris).
7. Fire suppression equipment and personnel.

Comments:

This study is open to all states; however, a minimum contribution of $10,000 will be required to be a member of the Technical Advisory Committee (TAC). The TAC will provide guidance for the study and review and comment on all documents produced by the research team.

* The Dwight D. Eisenhower National System of Interstate and Defense Highways consists of limited access facilities of the highest importance to the nation and are built to uniform geometric standards. They connect, as directly as practicable, the principal metropolitan areas, cities and industrial centers and provide important routes to, through and around urban areas. They serve national defense purposes and connect at border points with Canada and Mexico along routes of continental importance.