FHWA Unveils New Bridge Security Design Manual

by Steve Ernst, Federal Highway Administration

The Federal Highway Administration (FHWA) recently completed the first edition of its *Bridge Security Design Manual*.[1] The manual was developed through an FHWA indefinite delivery, indefinite quantity contract with HDR Engineering and written by subcontractor PEC Engineering. It is available on the FHWA website.

The manual provides information for structural engineers, planners, owners, and others to incorporate effective strategies in bridge projects and make highway systems resilient against terrorist threats. These threats have been a growing concern in the United States since the September 11, 2001, attacks, and it has been shown by the Mineta Institute[2] and others that transportation structures are among the most popular targets for terrorist organizations. While previous infrastructure security research and practice have focused primarily on buildings, the limited bridge-specific design guidance suggests that bridges may not be well protected against the common loadings these terrorist threats can impart to bridge components. "The primary objective of this bridge security design manual is to present state-of-the-art guidance on bridge-specific security planning, extreme loading phenomenology and characterization, and protective design strategies to be used by the highway bridge community in terrorist threat vulnerability assessments of existing bridges, resilient design of new bridge construction, and emergency planning efforts."[1]

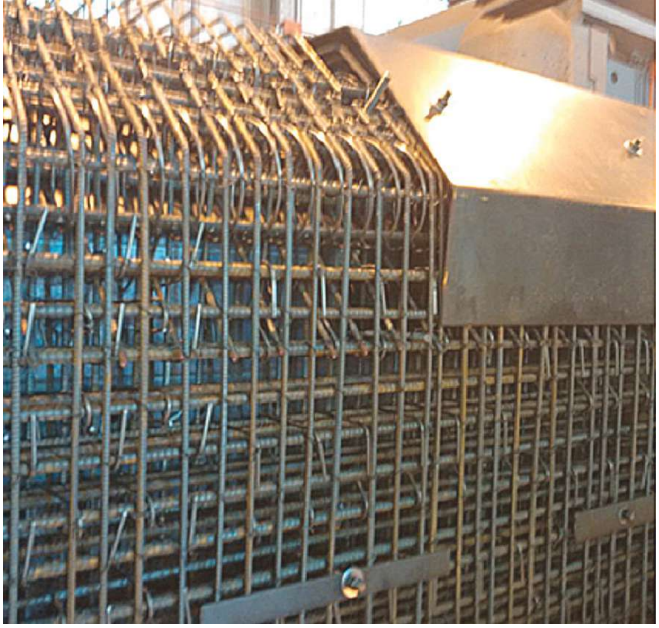
Table of Contents

Table of contents from the *Bridge Security Design Manual*. All Figures and Photos: Federal Highway Administration.

The manual covers a broad range of topics, including security planning, material performance, blast phenomenology, mechanics of structural elements, dynamic response of structures, protective design guidance, example designs for several component types (such as concrete towers), and the use of the software tool, Anti-terrorism Planner for Bridges (ATP-Bridge). The chapters covering these topics are fairly well self-contained. For example, the reader who is interested in understanding protective design for a concrete tower can use that chapter and relevant sections on loading, materials, mechanics, and response to gain a reasonable understanding of how to design a resilient tower.

Of particular interest to those who are new to this topic may be the chapters on planning, materials, and blast phenomenology. This information explores these topics from the bridge designer's point of view and provides background and fundamental principles that are carried forward into specific examples of protective design.

The chapter on ATP-Bridge stands alone to describe the use of the software design tool developed by the U.S. Department of Homeland Security and the authors of the manual. ATP-Bridge is a practical, engineering-level software program capable of predicting the response and anticipated damage of critical bridge components subjected to a variety of threat scenarios. ATP-Bridge features flexible software architecture designed to be continuously updated with state-of-the-art research and intuitive, user-friendly functionality that aligns with practice. The protective measures described in the manual use



Reinforcement cage for a hollow concrete tower designed to resist blast loading.

Detail of reinforcing steel cage for hollow concrete tower designed to resist blast loading.

the same state-of-art information from research and practice already incorporated in ATP-Bridge, so users of this manual can expect consistent alignment of design calculations and results. While ATP-Bridge might not be sufficient for all evaluations (for example, dynamic response), it is a very good predictor of damage from spall and breach, and the manual clearly describes supplemental design processes and tools to guide planners and designers to other resources.

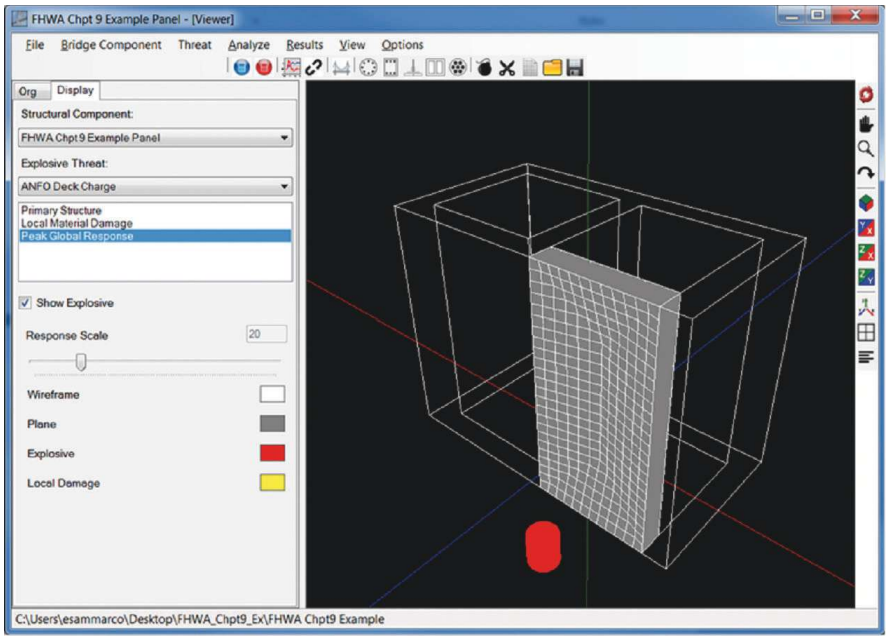
One topic covered in the manual is protective design guidance for reinforced concrete towers; an excerpt from this chapter is included here:

The chief protective design objective for blast-loaded RC [reinforced concrete] towers is to mitigate extensive local damage to individual RC tower panels such that gross loss in gravity-load carrying capacity and consequent collapse of the bridge is prevented. To achieve this chief objective, a recommended design procedure consisting of the following steps should be carried out:

- *Blast load characterization*
- *Component-level analysis and design of most severely loaded RC tower panel(s)*
- *System-level analysis to evaluate potential for collapse of bridge*

The example goes on to describe each of these steps in detail, including an analysis approach that first makes use of ATP-Bridge, then describes a potential alternative component-level dynamic analysis tool for preliminary design, and recommends that a high-fidelity finite element model be developed for the final nonlinear dynamic analysis. Though the use of specialized finite element software is not part of the manual, the steps and modeling techniques that a designer should employ are outlined to provide useful design guidance. Preliminary design using ATP-Bridge may also prove useful in planning or preliminary project development to establish good cost estimates and refined contract performance criteria.

The *Bridge Security Design Manual* is intended to be both a resource for broad audiences to better understand bridge security and a reference tool to design protection into bridges and to enable the highway systems they connect to function at a high level under a variety of threats. It makes use of the latest technology and research, including the ATP-Bridge tool. It is expected that the manual and the analysis software will be routinely updated to incorporate future research and state-of-the-practice for security design. The manual is available on the FHWA website: https://www.fhwa.dot.gov/bridge/security/hif17032.pdf. ATP-Bridge is available, with restrictions, from the U.S. Army Corps of Engineers Protective Design Center: https://pdc.usace.army.mil/software/atp4bridges.



ATP-Bridge three-dimensional graphics window showing blast source and response of panel of a two-cell reinforced-concrete tower.

References

1. Federal Highway Administration (FHWA) and PEC Engineering. 2017. *Bridge Security Design Manual*. https://www.fhwa.dot.gov/bridge/security/hif17032.pdf.
2. Jenkins, B. M., and L. N. Gersten. 2001. *Protecting Public Surface Transportation against Terrorism and Serious Crime: Continuing Research on Best Security Practices*. MTI Report 01-07. San Jose, CA: Mineta Transportation Institute (MTI).
3. Sammarco, E. L. 2014. "Development of Simplified Dynamic Response Models for Blast-Loaded Bridge Components." PhD diss., University of Texas at Austin.