ABSTRACT

Bruhl, Jakob C. Ph.D., Purdue University, May 2015. Behavior and Design of Steel-Plate Composite (SC) Walls for Blast Loads. Major Professor: Amit H. Varma.

Reinforced concrete (RC) structures have historically been the preferred choice for blast resistant structures because of their mass and the ductility provided by steel reinforcement. Steel-plate composite (SC) walls are a viable alternative to RC for protecting the infrastructure against explosive threats. SC structures consist of two steel faceplates with plain concrete infill sandwiched in between them. The steel faceplates are anchored to the concrete infill using stud anchors and connected to each other using tie bars. SC structures provide mass from the concrete infill and ductility from the continuous external steel faceplates. This dissertation presents findings and recommendations from experimental and analytical investigations of the performance of SC walls subjected to far-field blast loads.

Twelve SC panels were tested in the U.S. Army Corps of Engineers (USACE) Engineering Research and Development Center (ERDC) Blast Load Simulator (BLS). These panels varied flexure and shear reinforcement ratios, tie bar spacing, and steel faceplate strength. Results from the physical experiments were used to benchmark numerical models which were then used to expand the experimental database and perform a series of parametric studies investigating the influence of blast load, geometric, material, and analysis parameters.

Two benchmarked models were developed: (1) detailed finite element (FE) models using the non-linear FE code LS-DYNA, and (2) idealized single-degree-of-freedom (SDOF) models using experimentally validated bilinear strain hardening static resistance functions and exponential decay or triangular load pulse forcing functions. The idealized static resistance functions were developed from static tests of eight configu-

rations of SC walls which were also used to benchmark the FE modeling method. The results from the static experimental tests and benchmarked models are also provided in this dissertation.

Results from the physical experiments and analytical parametric studies were used to develop design recommendations. A rational method for designing SC walls to resist specific blast loads is presented along with pressure-impulse diagrams for use as design tools or aids.