Development and Testing of an Underground Protective Shelter Constructed of Hyperbolic Paraboloid Shell Elements

THOMAS F. MORIARTY UNIVERSITY OF TENNESSEE
PETER VON BUELOW 310 PERKINS HALL
                      KNOXVILLE TN 37996-2030

SEPTEMBER 1986

FINAL REPORT

OCTOBER 1984 - DECEMBER 1985

DISTRIBUTION IS LIMITED TO U.S. GOVERNMENT AGENCIES ONLY. THIS REPORT DOCUMENTS TEST AND EVALUATION. DISTRIBUTION LIMITATION APPLIED SEPTEMBER 1986 OTHER REQUESTS FOR THIS DOCUMENT MUST BE REFERRED TO THE AIR FORCE ENGINEERING AND SERVICES CENTER (AFESC/RDxi) TYNDALL AIR FORCE BASE, FLORIDA 32403-6001.

WARNING
INFORMATION SUBJECT TO EXPORT CONTROL LAWS
THIS DOCUMENT MAY CONTAIN INFORMATION SUBJECT TO THE INTERNATIONAL TRAFFIC IN ARMS REGULATION (ITAR) OR THE EXPORT ADMINISTRATION REGULATION (EAR) OF 1979 WHICH MAY NOT BE EXPORTED, RELEASED, OR DISCLOSED TO FOREIGN NATIONALS INSIDE OR OUTSIDE THE UNITED STATES WITHOUT FIRST OBTAINING AN EXPORT LICENSE. A VIOLATION OF THE ITAR OR EAR MAY BE SUBJECT TO A PENALTY OF UP TO 10 YEARS IMPRISONMENT AND A FINE OF $1,000,000 UNDER 22 U.S.C. 2778 OR SECTION 2410 OF THE EXPORT ADMINISTRATION ACT OF 1979. INCLUDE THIS NOTICE WITH ANY REPRODUCED PORTION OF THIS DOCUMENT.
NOTICE
Please do not request copies of this report from HQ AFESC/RD (Engineering and Services Laboratory).
Additional copies may be purchased from:

Defense Technical Information Center
Cameron Station
Alexandria, Virginia 22314
Development and testing of an underground protective shelter constructed of hyperbolic paraboloid shell elements.

This report documents the full-scale test of an underground shelter designed to resist near misses of conventional munitions. The structure was made of hyperbolic paraboloidal (HYPAR) panels and provided 750 square feet of usable floor space. The hyperbolic paraboloidal shape is an efficient means of carrying impulsive loads, characteristic of conventional munitions. The HYPARS derives its efficiency from its shape of two opposing curvatures. The HYPAR panels were approximately 6 inches thick composed of five layers. The layers were made up of two layers of reinforced concrete, two layers of unreinforced concrete and an asphalt reinforced with glass mat layer.

Two blast tests were conducted. Each test used a MK-83 bomb. In the first test, the bomb was 14 feet from the shell. In the second test, the bomb was 10 feet from the shell. In both tests, the structure survived the blast. The structure underwent large deformations and localized failure but did not collapse and no spalling occurred.