A Review of The 1983 Revision of TM 5-855-1 "Fundamentals of Protective Design" (Nonnuclear)

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The current version of the Army TM 5-855-1 dated July 1965 is a reprint of former EM 1110-345-405 dated 1946, and has not been updated since 1946. Because of the large amount of data on such things as penetration, ground shock, and structural response from conventional weapons effects collected since World War II, the manual has become so outdated it is of limited usefulness. A revised version of the manual is needed so that contractors can be furnished specific guidelines for the design of protective structures.

The Structural Mechanics Division of the Structures Laboratory at the Waterways Experiment Station (WES) has been tasked by the Office, Chief of Engineers (OCE) to revise the manual. Dr. Jimmy P. Balsara, WES, is the Project Officer in charge of the revision, and Mr. Dick White, OCE, is the Program Monitor. Writing the revised manual has been a joint effort among the WES, the Army Chemical and Nuclear Agency (CNA) (Chapter 7), and the USAE Division, Huntsville, (HND) (Chapter 12).

The purpose of this paper is to make potential users of the manual aware of the revision, aware of its scope, and indicate how and when it can be obtained. Because of space limitations only a few selected graphs from the manual will be presented as an indication of its content.

Comparison of the Table of Contents in Table 1 with the contents of the original shows that the revised manual is completely new with very little material retained from the original version. For example, the revised manual places a great deal more emphasis on structural response

Table 1. Table of Contents

calculations, structural design, and includes a chapter on calculating instructure shock levels.

The chapters on weapon characteristics and penetration have been updated to include modern weapons with high slenderness ratios, about 8, while retaining some of the older weapons with slenderness ratios of about 3 (see Table 2).

Table 2. Characteristics of Typical Bombs

Class	W(lb)	D(in.)	L(in.)	C/W%	(L/D)	$\frac{4W}{\pi D^2}$
GP 250	260	11	36	48	3.3	2.7
*GP 250	280	9	75	35	8.3	4.4
GP 500	520	14	45	51	3.2	3.4
*GP 500	550	11	90	35	8.2	5.8
*GP 750	830	16	85	44	5.3	4.1
GP 1000	1020	19	53	54	2.8	3.6
*GP 1000	1000	14	120	42	8.6	6.5
GP 2000	2090	23	70	53	3.0	5.0
*GP 2000	2000	18	150	48	8.3	7.9
*GP 3000	3000	24	180	63	7.5	6.6
SAP 500	510	12	49	30	3.9	4.5
SAP 1000	1000	15	57	31	3.8	5.6
SAP 2000	2040	19	66	27	3.5	7.2
AP 1000	1080	12	58	5	4.8	9.5
AP 1600	1590	14	67	15	4.8	10.3

Figure 1 summarizes the available data, and gives a best estimate, on projectile penetration into rock. This type of presentation provides the user with both a best estimate of a bomb penetration, from which ground shock calculations can be made, and an indication of the uncertainty associated with the penetration estimate.

A summary of data on penetration of mild steel fragments into massive concrete is presented in Figure 2. Like much of the material in this revision, the curves in Figure 2 were obtained from another Government publication, in this case from Picatinny Arsenal Technical Report 4903, dated December 1975.

To calculate loads on a buried structure protected by a concrete burster layer, the depth of penetration and a coupling factor must be known. The coupling factor, for an airburst or penetrations up to fully contained in soil or concrete, can be obtained from Figure 3. This coupling

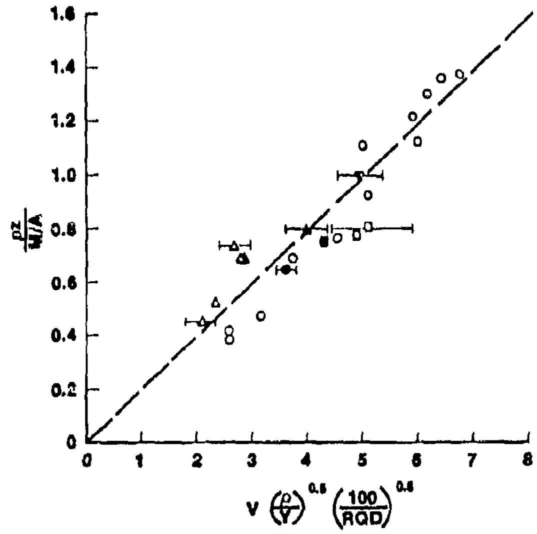

Figure 1. Empirical analysis of projectile penetration in rock

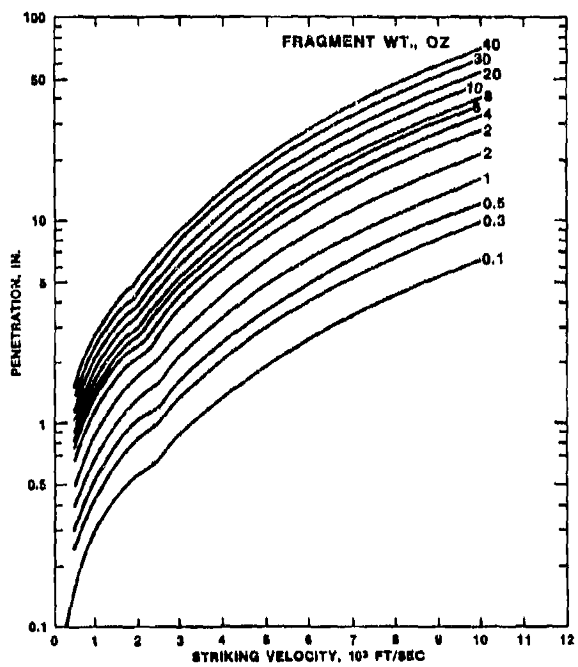

Figure 2. Penetration of mild steel fragments into massive concrete

factor can be used, along with equations presented in the manual to compute free-field stress, impulse, velocity, acceleration, or displacement. The free-field stress can then be used along with Figure 4 to estimate an "equivalent" uniform load on a buried structure. This equivalent load is

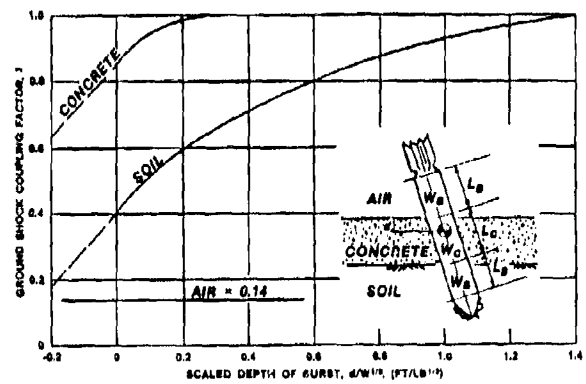

Figure 3. Ground shock coupling factor as a function of scaled depth of burst for air, soil and concrete

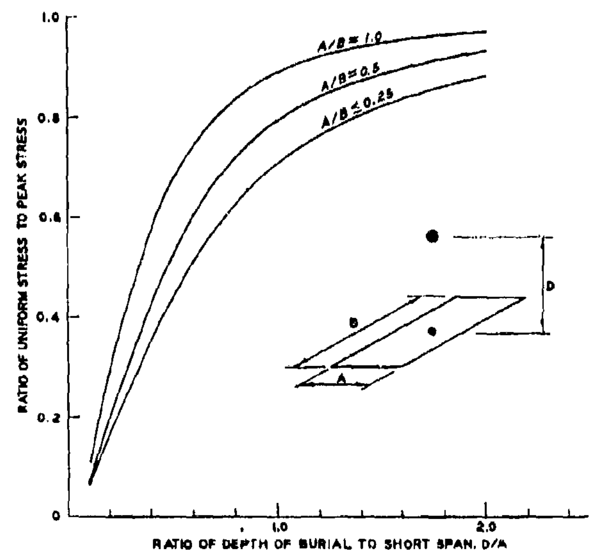

Figure 4. Equivalent uniform load in flexure

that uniform load that will produce the same structural deflection as a $P_o(R/r)^3$ load distribution; where P_o is the peak free-field stress, R is the perpendicular distance between the center of gravity (c.g.) of the bomb and center of the structure roof (or wall), and r is the slant distance between the bomb c.g. and a point on the structure roof. This concept of an equivalent load for use in simplified structural response calculations has been recently developed at WES and has been carefully checked against available data. It is very useful for design calculations since a worst case burst position, i.e. near the center of the roof or wall, is normally assumed.

For aboveground or surface flush structures, cratering may be more of a threat than structural response. Crater dimensions in reinforced or unreinforced concrete can be estimated from Figure 5.

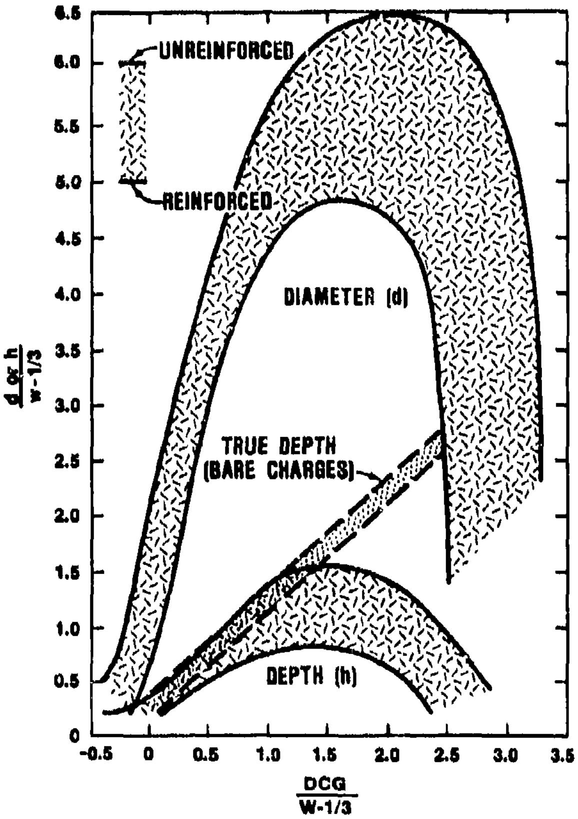

Figure 5. Estimated crater dimensions in massive concrete

As the final example, free-field acceleration, velocity, and displacement can be used along with the procedures given in Chapter 11 (Instructure Shock) to calculate instructure shock spectra. These shock spectra can be used in conjunction with the fragility curves shown in Figure 6 to design shock isolation devices for critical elements within the protective structure.

The examples shown in Figures 1 through 6 are a representative sampling from the revised manual. References that these figures were taken from, or data they were based on, are given in the manual. The intent here is to show that the manual attempts to present the most recent developments in the design of structures to resist conventional weapons effects. Also, the manual is complete in the sense that, given a conventional weapon threat, an aboveground or buried structure can be completed designed to defeat the threat using only the information contained in the manual.

The current status of the revised manual is that a first draft has been reviewed by a large sample of the technical community. Comments returned from this review have been incorporated into the manual and a final draft, reflecting the review comments, will be ready in May 1983. A

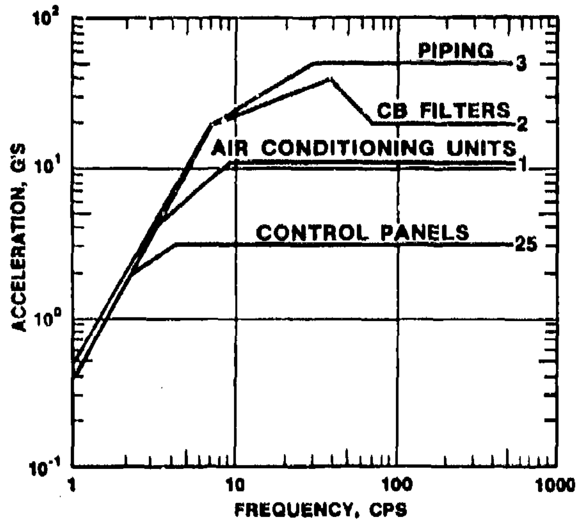

Figure 6. Equipment shock resistance

camera-ready copy will be furnished the HND in July 1983 for publication. Copies of the manual will be available from the Government Printing Office or through other standard channels for obtaining Department of the Army technical manuals.