

SDSC – A STRUCTURE DESTROYING SHAPED CHARGE

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A shaped charge, designed to destroy large dimension structures, has been small scale tested showing promising characteristics. Its design is based on the principle that the energy of the formed jet gives rise to an effect that is equivalent to an internal explosion within the target. This effect is shown to be achieved when the shaped charge is fired into concrete and aluminum at a standoff of 1.5 C.D. When shot into spaced steel and aluminum targets, it also shows a promising destructive effect. At large standoffs, such as when a large gap exists between the first and the second target layers, the liner material behaves super-plastically, thus giving rise to deep penetrations. It is suggested that a weapon for infantry use, based on the tested shaped charge design and scaled up to 3.2 C.D. of the prototype be evaluated for use in urban combat applications.

INTRODUCTION

The shaped charge warhead operated by a simple crash switch has always been a preferred weapon by the infantry due to its high reliability. Its drawback is, however, its being much less effective when used in an urban engagement compared to its use against armored vehicles. The type of shaped charge presented herein may be a promising candidate for solving this problem. We discuss this point again after presenting the tests results.

THE CHARGE PROTOTYPE

The shaped charge prototype has a liner of one inch diameter inserted into a plastic tube of 30mm outside diameter. The charge contained 25 grams of C-4 explosive and was point initiated using a standard PIC and fuse. After filling by hand, the PIC, having a one inch outside diameter, was placed centrally and in contact with the free end of the explosive fill in the plastic tube. The assembled charge was then placed on the test stand at the desired standoff. The maximum time between filling and firing the charge was a few weeks. No metal parts were used in the charge design except for the metallic elements of the fuse.

TEST DESCRIPTION AND DESIGN CONSIDERATIONS

The eight shaped charges prepared were tested against four types of targets. The first five were shot into steel and aluminum spaced targets to get the feeling of the general characteristics of the standoff function (see Table I). Subsequently, three charges were fired against aluminum and concrete slabs at a standoff of 1.5 C.D. to verify the design expectations.

In designing the charge, the basic idea was to use a material for the liner that is highly compressible so that the energy absorbed as it is compressed during the penetration process creates an internal explosion effect when released. Such an effect cannot be observed if the formed jet is long, because the penetration process of such a jet is long as well and the energy accumulation by compression and its release is a continuous process. The liner was therefore designed to form a jet, shaped almost like a ball so that this process occurs practically in one step. The SCAN code [1] was found to be very effective in preparing this design.

The five experiments where the designed charge was shot against spaced targets (see Table I) revealed however that the jet elongated super-plastically with ongoing time. At a standoff of 20 C.D. (Test IV) it transformed into a very long thin jet that penetrated through the entire target of fourteen 3 mm aluminum plates spaced 10 mm apart. It was this observation along with additional calculations with the SCAN code that led us to predict that the jet characteristics would suit the design purpose best when applied at a standoff of 1.5 C.D. The subsequent three tests were performed at this standoff.

The target for Test VI was 102 mm thick aluminum and considered semi-infinite. For Test VIII, the aluminum slab was 51 mm thick. The penetration achieved in experiment VIII was half of the target thickness. The maximum hole diameter was also equal in size to the penetration depth. Thus, the observed bulging of the underside of the target was not negligible (Figure 1). When the same charge was fired against concrete 61 mm thick, it caused a total breakup of the target. Reconstructing the fractured pieces of concrete like a puzzle, we managed to estimate the diameter of the hole as being larger than 4 inches (see Figure 2).

PHYSICAL INTERPRETATION

When we look at the penetrated layers of the spaced targets we see round holes, reflecting the axial symmetry and coherent flow of the formed jet at all the standoff ranges tested (Figure 3).

When the same jet penetrates an aluminum block (Tests VI and VIII) a hole is formed having a circular entrance but its internal surface is not smooth. The sectioned target (Figure 1) shows a sudden widening of the hole just before the penetration stops. This effect is explained in Reference 2 as occurring when the penetration velocity is a bit larger than the minimum required for eroding the target material. If the jet material is not compressive, this effect either is absorbed by the material or a long shear band is formed. Due to the compressibility of the jet material, excessive compression energy is released at this final stage of the penetration process and the result is the much larger width of the hole created just above its bottom. This effect

improves the ability of the SDSC to destroy targets made of brittle materials such as concrete, shattering them like from an internal explosion.

This feature was observed in both tests VI and VIII. The internal surface shape reflects the exploding behavior of the jet when the penetration occurs in a semi-infinite target. There are two conditions under which such an effect is expected to happen. The material of the jet must have large compressibility and the target material must confine the penetrating short jet flow for a long enough time. Confinement is not imposed on the flow in a spaced target made of thin layers, as the penetration of each layer takes a time period too short for a build up of the explosion-like effect.

CONCLUSIONS

The results of Test VII against concrete indicate that if the same charge would be scaled up to 81.3 mm diameter (that of the standard BRL shaped charge: i.e. based on a 3.2 scale-up), we would have a warhead containing about 800 grams of explosive of the brisance of C-4, that can penetrate a concrete wall 200 mm thick and form a hole of about 13 inches diameter (about 330 mm). The liner, fuse and envelope do not add considerably to the total weight and the resulting weapon would be expected to be a useful and simple to operate ordnance system for urban combat.

REFERENCES

- [1] E. Hirsch, SCAN, Shaped Charge Analyzer Model. Computer Program User Manual, Drew Goodlin and T.R. Sharon, 1998. Southwest Research Inst. San Antonio Texas. USA.
- [2] E. Hirsch and G. Yossifon, Shear-band Enforcement on Flow Upon Stopping of Penetrating Projectiles by Metallic Targets. Fundamental Issues and Applications of Shock Wave and High Strain Rate Phenomena. Staudhamer Murr Meyers Edition, Proceedings of the EXPLOMET2000 conference, Albuquerque NM pp399-406 (2000).

Table I. SDSC TESTS OF SPACED TARGETS

TEST	I	II	III	IV	V
STANDOFF	3 C.D.	3 C.D.	1 C.D.	20 C.D.	1 C.D.
TARGET	STEEL	AL	AL	AL	STEEL
HOLE DIA	11.7	15.3	16.5	7-9	14.5
mm	14.4	24-28	24-23	6	22.8-23.8
	13.4	18	35-38	5.8	19.5
	10.2	12	35-36	5.5	no
	2.2 dent	12.5	31.5-35	5.5	
	no	11.8	20	4.9	
		12	no	5.5	
		12		5.2	
		12		4.3	
		12		4.4	
		No plate		4.5	
				4.3	
				4	
				4	

All plates 3 mm thick, 10 mm spacing. AL: 5052 Aluminum, STEEL: 1032



Figure 1. Sectioned aluminum target from Test VIII.
Standoff 1.5 C.D.

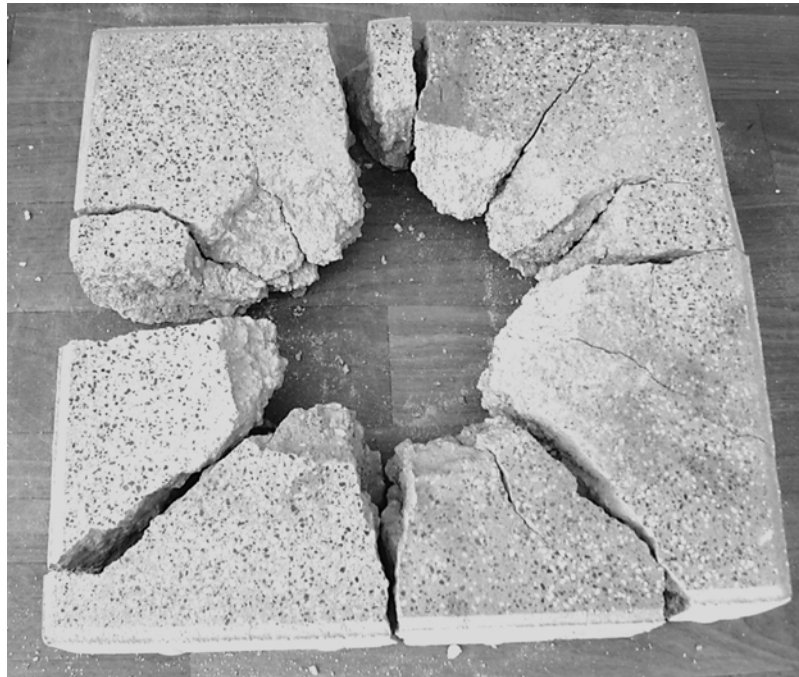


Figure 2. Concrete slab after Test VII, Standoff: 1.5 C.D.

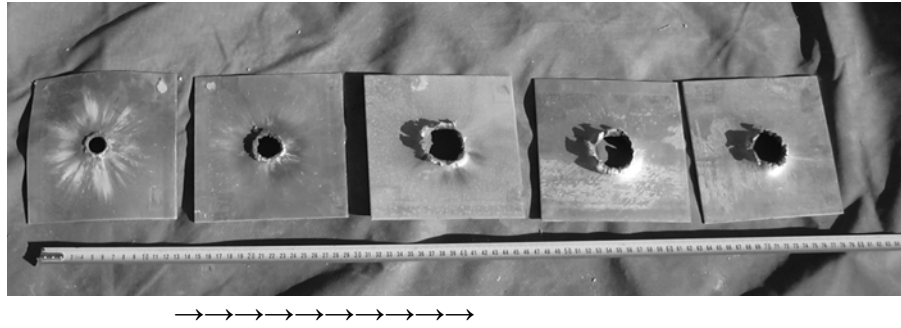


Figure 3. Aluminum plates (penetration exits) from Test III. Upper plate at left.