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SHOCKWAVE ARRESTED

Harold Warner

Dynamic Air Shelters' newest model completely defeats the shock wave, eliminating the transmission of shock into the interior space. This first ever innovation results in more safe habitat, the ability to protect equipment and the ability to protect non blast resistant buildings by placing a protective shock resistant sheath over the existing structure.

Introduction

Conventional metal framed soft sided fabric structures are frequently used as temporary shelters within blast zones of petrochemical facilities. They offer convenient setup and cost savings over permanent structures or heavy and more expensive portable blast resistant modules. However, their performance in an actual blast can be unsatisfactory and can place occupants in danger. Currently the company manufactures blast resistant (BR) low pressure inflatable air beam shelters that offer the convenience and cost advantages of a soft sided temporary shelter but much improved performance under blast load.

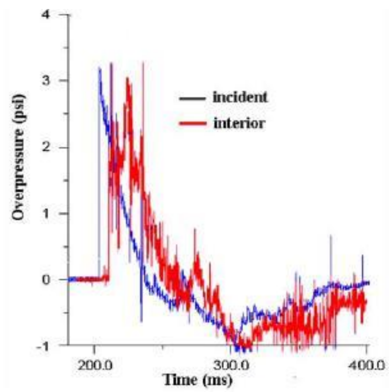
The recently developed breakthrough improves the already superior performance of the blast resistant shelters. This innovation, described in the paragraphs that follow, increases the load carrying capacity of the roof arch system and more significantly, allows the walls of the shelter to completely mitigate the shock front of a blast wave and reduce the peak pressure and impulse by 85 percent or more.

Background

Figure 1 illustrates the behavior of rigid framed tent structure under blast loading. In this case, the rigid frame undergoes severe deformation exceeding the yield strength of the metal material. The potential for significant injury is evident, both from the motion of the rigid frame and from loose debris (including fragments of structural components). This behavior is not peculiar to framed tents but virtually any structure with rigid components or hardened walls.

NOTE: video insert
Figure 1: Conventional rigid-framed tent under blast loading

In addition to the significant potential for injury caused by the high speed deformation of the metal frame, the soft fabric sides will be accelerated to supersonic speed by the blast wave causing a shock wave to be transmitted to the inside of the shelter. This shock wave can be just as strong or even stronger than the incident shock. Figure 2 illustrates the transmitted shock recorded inside a metal framed soft sided shelter during blast exposure. In this instance the wave on the interior actualizes a total of eight times, twice at a peak greater than the incident wave.



Conventional shelter with Hesco Barrier
Peak overpressure, impulse and rise time largely unaffected

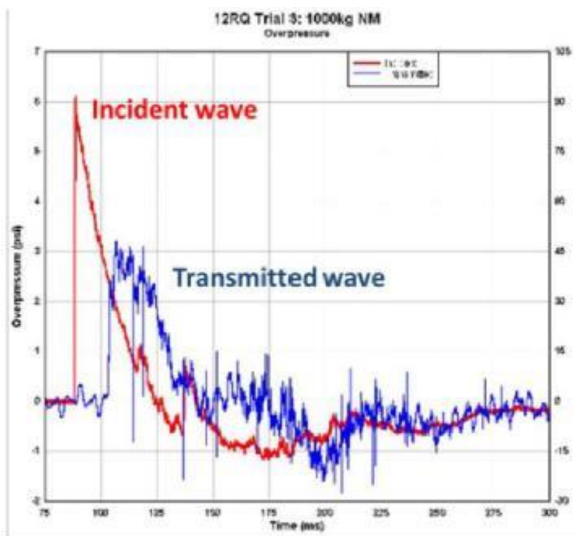
Figure 2: Transmitted shock inside metal framed soft sided shelter

In the inflatable blast resistant shelter, the fabric sides are supported by low pressure inflated columns eliminating any need for the internal metal framework, which results in the removal of one of the most significant potential causes of injury. The large internal columns also provide extensive support for the fabric sides mitigating the supersonic "snap" of the fabric reducing the magnitude of the transmitted shock. Figure 3 illustrates this mitigating effect. The actions on the restrained columns result in part, in a vertical compression of the columns rather than a horizontal displacement.

1000 kg NM explosion; 5.9psi x 36ms incident blast

NOTE: video insert

Figure 3: The inflatable shelter response in Figure 4 illustrates the shock and blast mitigation for the shot of figure 3. The peak overpressure is reduced by 50%, the impulse reduced is by 28% and the rise time is extended by 4 ms.



DASL shelter: incident and transmitted blast waves
Peak overpressure reduced ≈ 50%
Impulse reduced ≈ 28%
Rise time extended ≈ 4ms

Figure 4: Mitigation of transmitted shock wave - <u>Multi column innovation</u>

A Large Span Structures Project was conceived as a response to the needs of existing and potential clients in the military, construction, sports facility and other markets, who require lightweight, rapidly-deployable buildings for temporary, semi-permanent and permanent applications with much larger spans than current product lines.

The project investigated four different technological approaches to achieve a large-span inflated structure:

- Multi-layer pneumatic construction;

- Systems to reduce snow accumulation and/or encourage shedding;
- Cable-based stabilization of structural arches; and
- Tensile membrane–based structural stabilization.

Within the multi-layer component of the project, various structural tubing configurations were evaluated. These are illustrated in Figure 5.

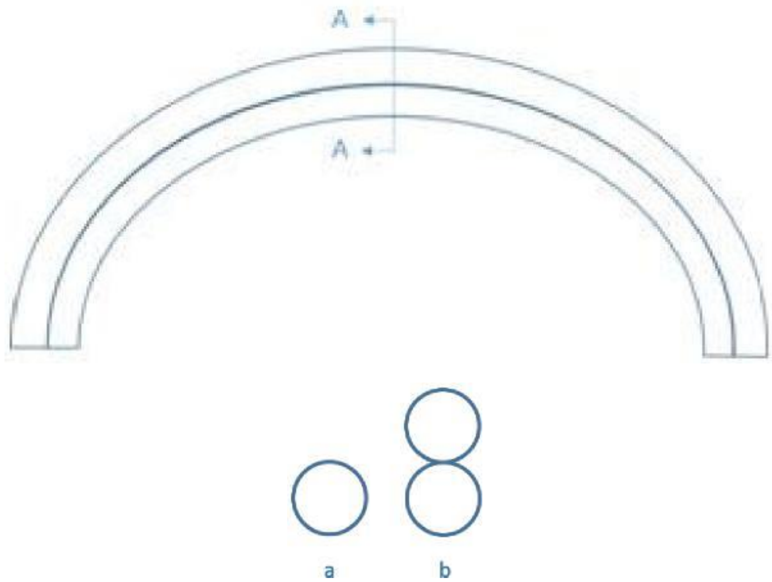


Figure 5 – Single- and dual-layer configurations

The configurations included in Figure 5 represent cross-sections of the major structural ribs in an inflated fabric air beam structure. They are described as follows:

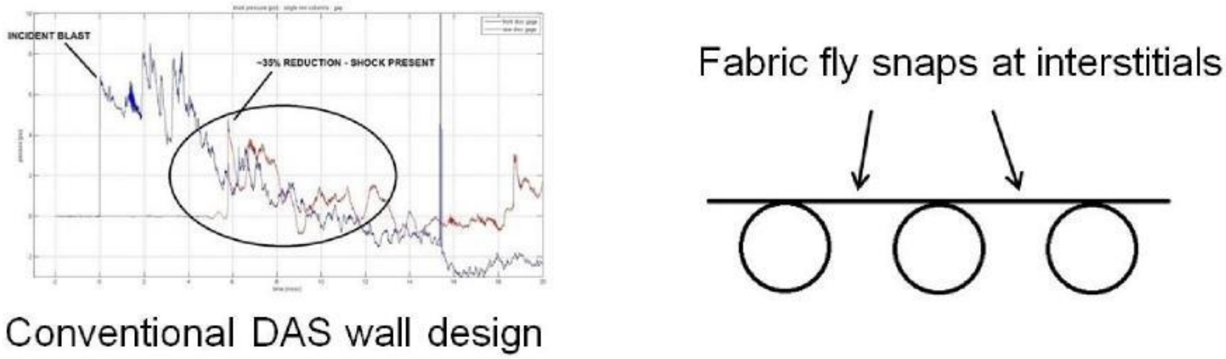
a. Single-layer arrangement. In this configuration the standard columns are arranged in close contact. This arrangement has no interstitial gap between columns therefore eliminating the mechanism of shock wave transmission into the shelter.
b. Dual-layer arrangement. In this configuration a double layer of columns are arranged in close contact, eliminating the interstitial gap between columns and also increasing the strength of the arch cross section. The columns in this configuration are one half the diameter of the comparable columns in a single layer arrangement. This results in increased strength, reduced intrusion into the shelter habitable space, and improved blast mitigation within the same overall wall thickness. This is considered to be the typical arrangement for a multilayer structure.

<u>Blast test method and results</u>
Blast testing of inflated fabric wall sections was conducted using a fuel-air driven detonation blast wave generator. The generator produces a free field blast wave consisting of a leading shock wave with a trailing exponentially decaying pressure (Friedlander wave). The test shots

were fired with incident side-on overpressure values just before the wall section of between 5.2 psig and 8.1 psig but with limited positive phase durations for all shots.
In the driver section of the generator, a fuel-air mixture is detonated, causing a blast wave to travel down the length of the generator test section. The wall section is located in the square test section. Horizontal pressure sensors, mounted on metal discs at the tube centerline, are located upstream and downstream of the test specimen.

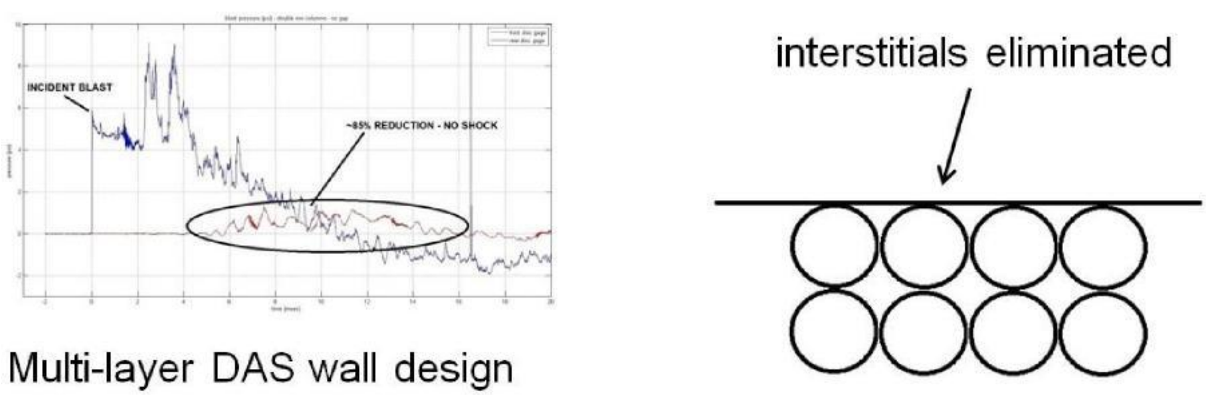
Tests were run on the regular shelter column configuration, single (close contact) column configuration, double (close contact) column configuration, and triple (close contact) column configuration.

The following figures are representative of the test results.



NOTE: Video insert

Figure 6: Transmitted shock, conventional DAS wall arrangement



Note that the relative shock mitigation is similar to the mitigation observed during the test illustrated in figures 3 and 4.

Figure 7: Transmitted pressure wave, double column arrangement

The multilayer design effectively eliminates the leading shock wave from the blast wave resulting in the transmission of an acoustic wave instead of a more damaging blast wave.