Bomb Shelter alternatives for challenging areas

The purpose of this document is to explore specific challenges in building safe, effective bomb shelters in the Hard and Harder to Reach areas in Ukraine.

Please note that the author is not an engineer, and has relied on the published and unpublished work of engineers and construction experts. Ultimate feasibility should be thoroughly vetted through technical experts. The purpose of this document is to outline the challenges and initiate the development of potential solutions.

Geographic and Logistic Challenges specific to Ukrainian 'Hard to Reach' and 'Harder to Reach' areas

Many of the front line areas in Ukraine happen to be in lower topographies and have a great deal of surface water in the form of rivers, lakes, etc. Therefore the water table in these areas will be closer to the surface. This will make 'digging in' a traditional bomb shelter, a more costly and possibly impractical solution as the structure would be prone to all the hazards related to water seepage.

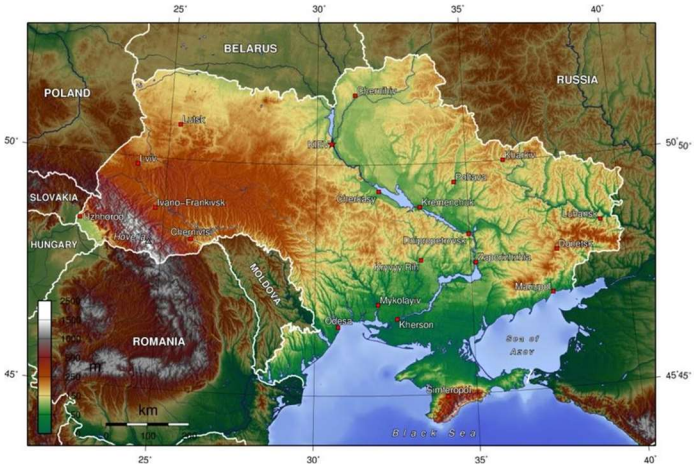


Figure 1: Ukraine Topographical Map

Figure 2: Topographical Map with overlay of LiveUA Data

Any shelter that requires the use of heavy equipment or material transport on large (semi) trucks, will encounter bombed out roads and bridges in these areas. Creating another challenge for installing 'traditional' bomb shelters.

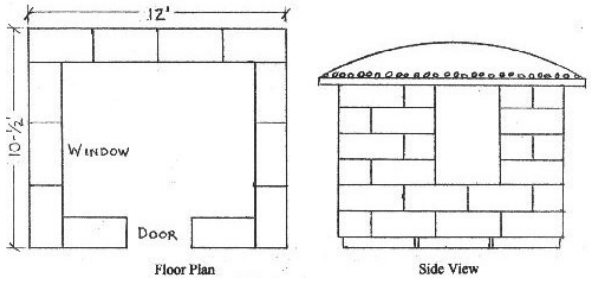
Table of Primary Constraints, based on local conditions:

Constraints	Work Arounds
Site cannot "dig in" shelters	Above ground shelters or Shelter within a Shelter solutions
Bad roads	'Right Sized' Materials for smaller transportation options Locally sourced Materials
Lack of local construction skills/capacity	"Kit" solutions that can be assembled onsite

Potential Complementary Technologies: Anderson Shelters + Straw Bale Construction Techniques

At this time, there do not appear to be any commercially available single solutions for 'above ground' or 'shelter within shelter' options. However, by combining some solutions that ARE available temporary shelters may be practical.

According to written sources, the effectiveness of the Anderson Shelters was due to the soil buffer around and over the corrugated steel structure. Therefore, a mount or layers of strawbales stacked around the structure could, theoretically provide an equivalent level of protection, if built above ground.



Building the safety shelter, within and APPROPRIATE existing structure could increase the efficacy.

All of the materials required for such a construction are transportable in smaller vehicles and, with the exception of the Anderson Shelter kit, available within the same or neighboring oblast. Straw Bales, Pallets and Tarps are readily available in most Oblasts and advertised on OLX. (Kherson/Straw Bale Filter: https://www.olx.ua/d/khe/q-%D1%81%D0%BE%D0%BB%D0%BE%D0%BC%D0%B0-%D0%B2-%D1%82%D1%8E%D0%BA%D0%B0%D1%85/)

Depending on the installation, protecting the bales from moisture would also need to be considered.

Appropriate 'anchoring foundation' options may also need to be explored. Anchoring to the pallet structure outlined in the "Emergency Straw Bale Shelter" instructions might be adequate, given the additional weight of the straw bales on the structure.

Primary Written Resources:

'Directions for the erection and sinking of the galvanised corrugated steel shelter' Home Office February 1939 https://andersonshelters.org.uk/wp-content/uploads/anderson_shelter_construction_instructions.pdf

"The Design of Bomb Shelters" by Paul Newman Gillett. Department of Civil Engineering, University of Michigan in 1943. https://d.lib.msu.edu/etd/9892

"Upgrading Basements for Combined Nuclear Weapons Effects: Expedient Options" Stanford Research Institute 1976 https://apps.dtic.mil/sti/pdfs/ADA030762.pdf

"Straw Bale Emergency Shelter" , Owen Geiger 2009 https://strawbaleplans.wordpress.com/2009/03/08/straw-bale-emergency-shelter/ ..

The following are some applicable clips from "The Design of Bomb Shelters" which might be especially helpful.

The family-type shelter in England was designed to meet the following requirements:

1. Protection from the blast and fragments of a 500 lb. high explosive bomb detonated at a distance of 50 feet.
2. Protection from a direct hit of a light incendiary bomb.
3. Sitting accomodations for 6 persons with cubic capacity of 35 cubic feet per person.

the location of a refuge room, as there is a possibility of being crushed or trapped by debris if the building should fall, if ready egress is not provided. In wooden frame houses, it is likely that any room in the house which is readily accessible and with quick means of reaching outdoors, is suitable. The value of the stud walls in providing protection against splinters is not great, but may be increased by sandbag revetments if the householder wants to go to this expense and inconvenience. In a brick house, the 12" exterior walls give a measure of protection but here there is danger of wall collapse that is not present in frame buildings. Basements have been suggested for shelters and are excellent from the standpoint of lateral protection from fragments and blast, but are open to several objections, the most serious of which is the danger of being trapped by fire or crushed by debris.

If the building in which the shelter is located is sound structurally and fairly resistant to bombardment, the shelter can be made relatively secure and will offer a high degree of protection. If the building is old, or of wall bearing masonry construction, it may be very unsafe and non-fireproof buildings should never be used for shelters.

A building of the skeleton frame type, of steel or reinforced concrete is generally very resistant to bombing and ordinarily suffers only local damage even from a direct hit.

The action of a bomb upon hitting a building is either to detonate on impact, causing extreme local damage to the roof and top story, or to penetrate several floors or to the basement before exploding, depending on the fuse setting. Weighing the probabilities of fuse timing and damage from penetration and/or explosion, it seems that the third or fourth floor down from the roof in a five to ten story building is the safest place for a shelter. Floors at these levels have the important advantage of being above the level of gases, and the effects of explosions on the ground (blast and fragments) are lessened. It is probable that such locations would be more accessible to all the occupants.

Shelters in buildings higher than ten stories might well be placed at a relatively lower level, say about halfway down from the top. Since bombs do not drop vertically but in a modified parabolic path, there is a possibility of bombs striking the sides as well as the roof of a building; the probability of this occurance is greater for tall, narrow buildings.