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MŰSZAKI
KATONAI
KÖZLÖNY

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Structures of the Árpád Line

Between the two world wars both victorious and defeated countries started to build fortifications on new principles. Hungary started to build up its defence system after the return of the high and medium height mountain areas. The defence developed under the leadership of Teofil Hárosy was built up from small size, in-ground, widely dispersed and well-camouflaged units. Most of the fortifications ensured defence and technical support. The open firing positions, spatially separated from the buildings, provided effective defence and possibility of counterattacks.

Keywords: *fortification theories, Árpád Line, reinforced concrete structures, firing positions, camouflage*

Introduction

After the end of World War I, from the end of the 1920s a new wave of fortress building has begun. Both significant development of weaponry and increase in firepower triggered changes in defence systems. The French Minister of War at the time, André Maginot, played a leading role in the development of the new theory. The reinforced concrete fortifications, built based on the "Maginot principle", up to several kilometres long and partially buried underground, were expected to hold back the attacking enemy.

The Little Entente countries surrounding Hungary (Czechoslovakia, Romania and Yugoslavia) also built fortresses along their borders from the second half of the 1930s. The effectiveness of these defence systems in combat conditions is unknown, since as a result of the first and second Vienna Awards, they were taken over by the Hungarians without a fight. These played no further role in the war afterwards.

The borders of Hungary as defined by the Treaty of Trianon – except for a short section of the Zemplén Mountains – was hilly and lowland. As a result of the Vienna Awards, the borders of some of the territories that were returned (Transcarpathia, Northern Transylvania) had a medium height and high mountainous character, which led to the development of a new border defence plan.

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The Hungarian fortress design

In 1939, with Transcarpathia returned, the practical implementation of the fortification of borders in the Eastern Carpathians was on the agenda. In the autumn of 1938, the Hungarian Defence Forces General Staff already formed a fortification department within the framework of the Institute of Military Technology, which did not have permanent staff yet, but only an ever-expanding range of tasks in the implementation of which civilian companies and specialists could be involved in addition to the staff of the Institute of Military Technology.[2]

Already in the autumn of 1939, the Fortification Command started to draw up plans for the Hungarian defence line. Of course, there was neither will nor financial resource for building a fortification system like the Maginot Line. The Árpád Line was a network of open firing positions and reinforced concrete defensive installations, shelters and observation posts that served them, taking advantage of the opportunities offered by the terrain. Its construction lasted practically until the beginning of the Red Army's Carpathian campaign in 1944.

The preparation of technical plans and the development of professional concepts for the construction of the fortress had already begun at the Institute of Military Technology earlier. The Hungarian Royal Defence Fortification Command deals with the general requirements, design and construction of concrete fortifications in its technical documentation. Some of the tables are labelled with the date "Month IV 1938".[3]

From the 1st of November 1939, Lieutenant Colonel Teofil Hárosy was appointed head of the planning department of the newly created Fortification Command. He visited Germany several times between 1937 and 1940 to study fortifications. On the 1st of November 1941, he was appointed Colonel of the Technical Staff and at the same time Commander of the Fortification Command.[4]

At that time, lacking combat experience, the French Maginot Line was considered the most modern facility. Therefore, similar anti-tank gun emplacements with long, winding tunnels and large shelters for personnel were planned. In the autumn of 1939, construction of this type of fortification system began under the Verecke Pass, in the area of Lower Verecke and the Latorca River (Figure 1).

2 Szabó 2002: 82–83.
3 Fortification Regulation s. a.: 47, 63.
4 Balla–Padányi 2023: 45.

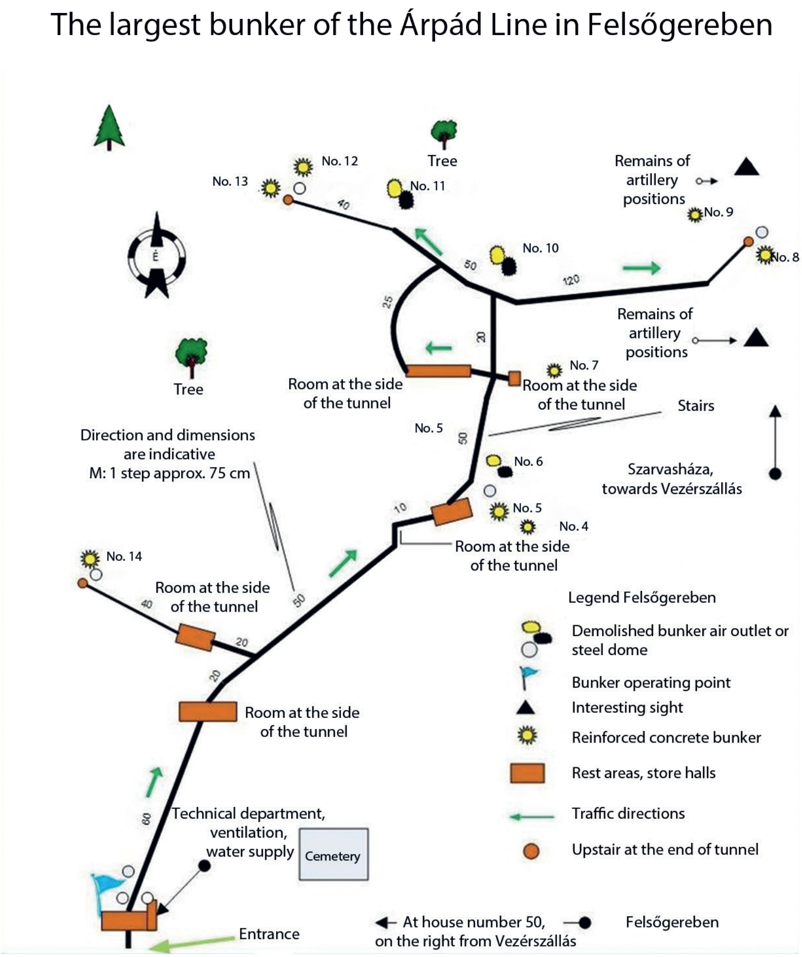

Figure 1: Maginot-type bunker at Felsőgereben
Source: Rakaczky–Rusz 2009: 129

In May 1940, the German army, in its campaign against France, did not bypass the Maginot Line, but embraced it vertically with airborne troops and then, attacking the entrances, formed a gap relatively easy.

In the autumn of 1940, a Hungarian military inspection committee also studied the Maginot Line occupied by the Germans and the Belgian fortifications. The Maginot Line, which was thought to be impregnable, was quickly overcome by the Germans with unexpected manoeuvres. However, Hungarian technical officers recognised that the small defence positions between the concrete monstrosities could withstand overwhelming force for a long time. Taking this experience into account, the designers of the Hungarian fortification system planned to build a small, well-camouflaged system with the basic cell of defence in the valley closures being the perimeter defensible swarm position.[5]

Defenders can be protected from the effects of aircraft bombs by oversizing the structural elements, scattered placement, preferably by building small structures and hiding them perfectly. These rules also protect against artillery fire.[6]

Geographical opportunities define where the fortifications should and should not be built. The advantages in combat are only proportional to the monetary investment if the defensive potential has been significantly increased. Against fortifications built in the high and medium height mountains – which are more defensible because of the circumstances – the enemy can only use as much force as the terrain allows him to deploy and move during the attack.

Hence, only areas of a closed valley should be blocked by permanent fortifications, because this is where we can provide the most advantageous defensive capability.[7]

In the autumn–winter of 1940, under the leadership of Teofil Hárosy, a plan for a coherent line of defence was drawn up, incorporating the defence of the Transcarpathian and Northern Transylvanian passages into one system. The name "Árpád Line" appeared at the same time. The system was not based on passive defence, but on a series of counterattacks and unexpected manoeuvres by the defenders.

In the new concept of fortress construction, the protection of personnel and armament, and the use of firing positions were separated. The two systems operated separately in space. Weapons were used in open firing positions (Figure 2), so that well-camouflaged shelters were hidden from the enemy. When enemy reconnaissance or artillery located the emplacements, the defenders would retreat to the shelters and then continue the fight from the alternate positions after the enemy fire ceased.

Figure 2: Open machine gun position with camouflage net (October 1944)
Source: Филоненко 2017: 82

5 Balla–Padányi 2023: 45–46.
6 Varró 1942: 69–70.
7 Varró 1942: 68.

Fortification instructions

In 1939–1940, some of the reinforced concrete structures still had an embrasure (Figure 3). This had been abandoned by the "redesign" using the German experience. The new bunkers were deliberately not equipped with an embrasure, and were primarily intended to protect the integrity of personnel and armament. The structures were built with 60–100 cm thick slabs. The bunkers were connected by trenches leading to open firing positions. For all the main weapons, several alternate positions were constructed.[8]

Figure 3: Embrasure detail from a blown-up bunker in Ung Valley
Source: Photograph taken by the author, 2014

This is reflected in the 1941 Fortification Regulation on the use of the embrasures. "Only rarely should embrasures be used. It is advantageous to position a single, rigid closing fire weapon, typically lateral machine guns, in a firing slit fortification, if they can provide the time necessary to counterattack the bulk of the defenders by sweeping obstacles with their huge fires. Otherwise, there are only disadvantages of the embrasures. Never set up a fortified position under an artillery barrage, as it will be vulnerable to the open fire of modern weapons. Such a fortification can be overcome even by a weapon of disproportionately inferior effect, which, without embrasures, the fortification would certainly resist."[9]

Reinforced concrete shelters were usually buried underground for good hiding. One person was usually calculated to use 4 cubic metres of air, which is enough for about 4 hours for a resting man. A so-called "battle plan" was first drawn up of the planned fortification, a valley block, which served as the basis for the later technical design. Standard reinforced concrete structures were used in the technical design and then in the construction, with only rare deviations from the plans. The detailed technical design of the fort consisted of the following:

[8] Kacsó 2003: 111–112.
[9] Fortification Regulation 1941: 4. §, 27.

- layouts and sections of the proposed structures at a scale of 1:20, 1:25 or 1:50
- detailed plan of the pit and other earthworks
- formwork plan
- reinforcement plan

Special care was taken to reinforce the slabs. Projectiles hitting the slab may have caused fragments to detach from its inner surface and endanger the lives of the defenders. The internal reinforcement of the slab could be made of 14 or 20 (cm) I-beams or railway rails. To protect against concrete detachment from impacting projectiles, the internal formwork was left in place or iron plates were placed between the internal reinforcement. Because of the internal detachment caused by the shots, it was forbidden to smooth the wall surfaces and repair any defects.[10]

The instructions for fortifications deal with the quality of the construction materials that are allowed to be used in detail.

Cement: only high strength Portland cement can be used. The use of bauxite cement must be avoided.

Sand and gravel: preferably clean, sandy gravel from a "recognised site" should be used. Instead of gravel, hard crushed stone (e.g. basalt, granite, limestone) is preferable. The grain size should be such that the smaller grains perfectly fill the voids between the larger ones.

Water: free from components harmful to concrete (acid ions, sulphates, organic compounds, etc.), odourless, clean, neutral in chemistry.

Steel material: centrally tested and approved commercial product.[11]

The purpose of steel reinforcement is to limit the destructive effect of the projectile to as small as possible, i.e. to reduce the size of the cracks and the funnel cut.[12]

In addition to using the right quality materials, it is essential to carry out the concrete work in parallel. This ensures a monolithic concrete block of exceptional strength, which is the most resistant to the explosion of projectiles hitting the concrete.[13]

The cubic strength of the concrete shall be at least 400 kg/cm^2 for hand-compacted concrete and 500 kg/cm^2 for machine-compacted concrete.[14]

During our field survey, we carried out a Schmidt hammer concrete test on the blasted armoured cannon emplacement at Utcási Valley Block (now Slovakia) in 2023. This is a non-destructive concrete testing method that provides hardness information from the surface of the concrete and its vicinity. The Schmidt hammer test is generally used when it can be assumed that there is no significant discrepancy between the surface and the internal mass of the concrete. According to the Fortification Instructions, it is a basic requirement to produce monolithic concrete, therefore the average value of 374 kg/cm^2 obtained for concrete produced about 80 years ago is realistic and approximates the value given in the Fortification Regulation (Figures 4 and 5).

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[10] Szabó 2002: 127–130.
[11] Fortification Regulation 1941: 14–16.
[12] Fortification Regulation 1941: 10–11.
[13] Fortification Regulation 1941: 17.
[14] Fortification Regulation 1941: 29.

Figure 4: Reinforcement of structure
Source: Photographed by the author

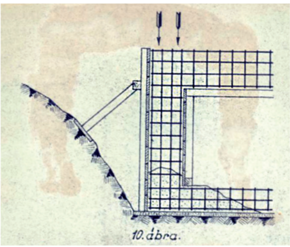

Figure 5: Reinforcement and concreting
Source: Fortification Regulation 1941: 59

The reinforced concrete structures of the Árpád Line

In all defence systems, a large number of single-person reinforced concrete firing positions were used for the use of light machine gun and machine guns (DOT – долговременная огневая точка). Because of their small size, they could be perfectly camouflaged. Two types were encountered during our research: hexagonal and rectangular structures. The hexagonal version (Figure 6) was the most common. This was due to the fact that it was easier and better to camouflage, had greater resistance and had no unused corners.

Figure 6: Hexagonal DOT
Source: Photograph taken by the author at the valley block of Utcás

The typical internal dimensions of the DOT are: length 1.75 m, width 1.6 m, height 1.9 m. The funnel-shaped embrasure on the outside and inside ensured efficient firing (Figure 7). Entrance was from a passage trench in the rear area, which provided protection from enemy artillery fire. The DOT had a wall thickness of 0.8 m and a slab thickness of 1.1 m, with four reinforcements of 10 and 20 mm quality reinforcing bars to provide improved resistance. Protection against splintering was provided by a 3 mm thick iron plate placed between the I-beams of the ceiling. The floor and the sidewalls were protected by boarding. The structure was covered with 0.3–0.4 m of humus soil, which improved camouflage and also protected against projectiles.[15]

[15] Игнатов–Кузнецов 1945: 2–3.

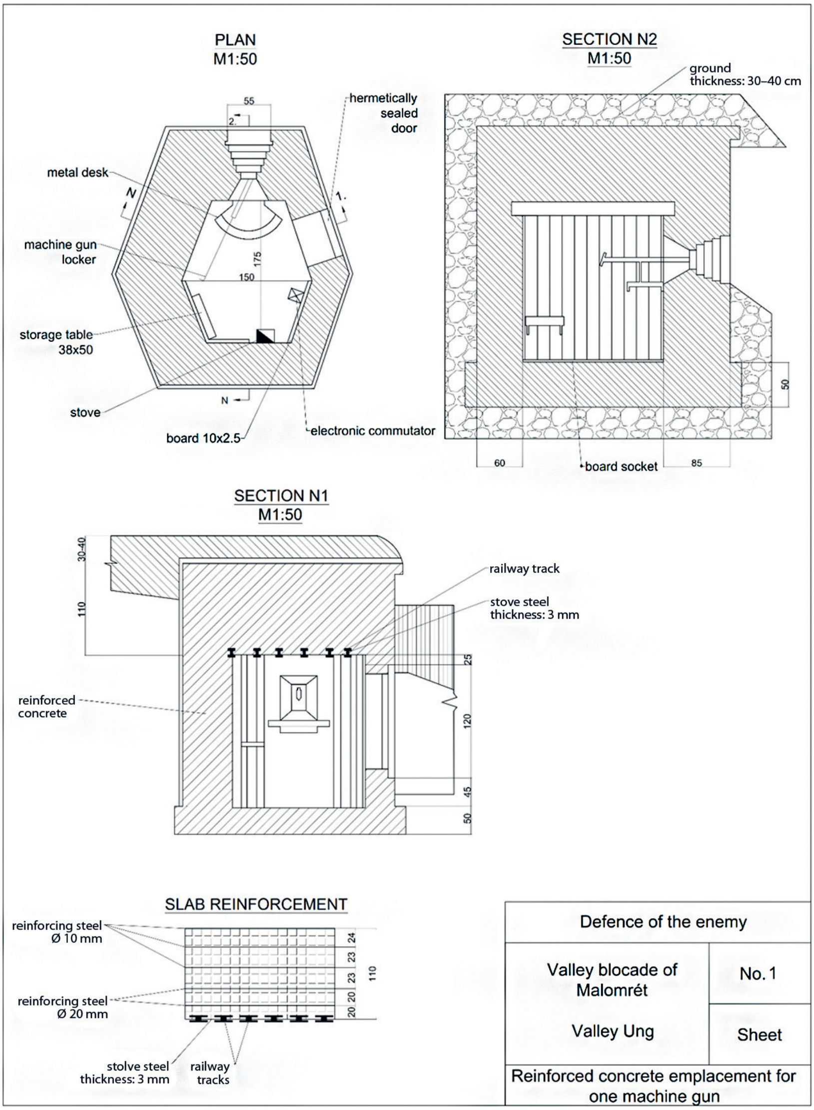

Figure 7: Technical drawing of single-person reinforced concrete firing position (DOT)
Source: Prepared by Bálint Papp and István Rakaczki based on ЦАМО РФ. Ф. 4 УФ (244). Оп. 3000. Д. 635. Л. 2.

The valley blocks were subdivided into section points and those are subdivided into swarm positions. The protection of personnel was an important consideration in the design of the valley blocks. To ensure this, reinforced concrete shelters were built: half-swarm bunkers (6 men), swarm bunkers (12 men) and officer shelters. The internal dimensions of the officers' bunker were 1.7 × 2.3 m. The half-swarm bunkers (Figure 10) consisted of one room, while the swarm shelters usually consisted of two units separated by a wall (Figure 8). The slab could be flat or arched. The protection of the interior from falling concrete splinters depended on the shape of the slab. In the case of the flat slab, a boiler iron was installed between the I-beam reinforcement, and wooden cladding was used. For the arched slab, a special corrugated sheet covering was used (Figure 9).[16]

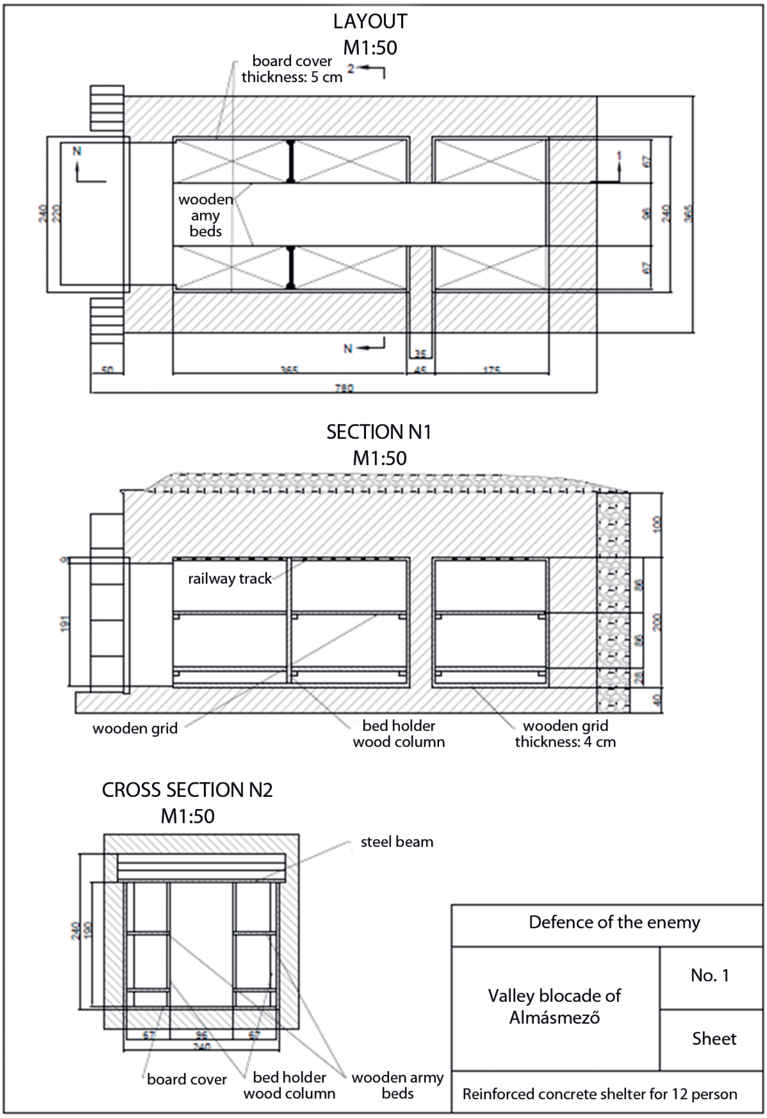

Figure 8: Technical drawing of a swarm shelter
Source: Prepared by Bálint Papp and István Rakaczki based on ЦАМО РФ. Ф. 4 УФ (244). Оп. 3000. Д. 635. Л. 22.

16 Филоненко 2017: 97–98.

Figure 9: Corrugated sheet covering used for bunker interiors (valley block of Kőrösmező)
Source: Photograph taken by the author

Figure 10: Half-swarm bunker: The place of corrugated sheet covering can be seen inside (valley block of Kőrösmező)
Source: Photograph taken by the author

In addition to the personnel, they also protected the armoury of the valley blocks from enemy fire. Reinforced concrete bunkers were also built for artillery weapons and anti-tank guns (Figures 11 and 12). Most of the valley fortifications had structures of the same size and layout. The use of the gun was spatially separated from the bunker. There was usually a ramp leading from the firing position to the shelter (Figures 13 and 14). The cannon rolled in through a 2.2 m wide door. The gun room measures 4.7 × 2.4 m, separated by a wall, followed by a 1.8 × 2.4 m shelter for the operating crew.

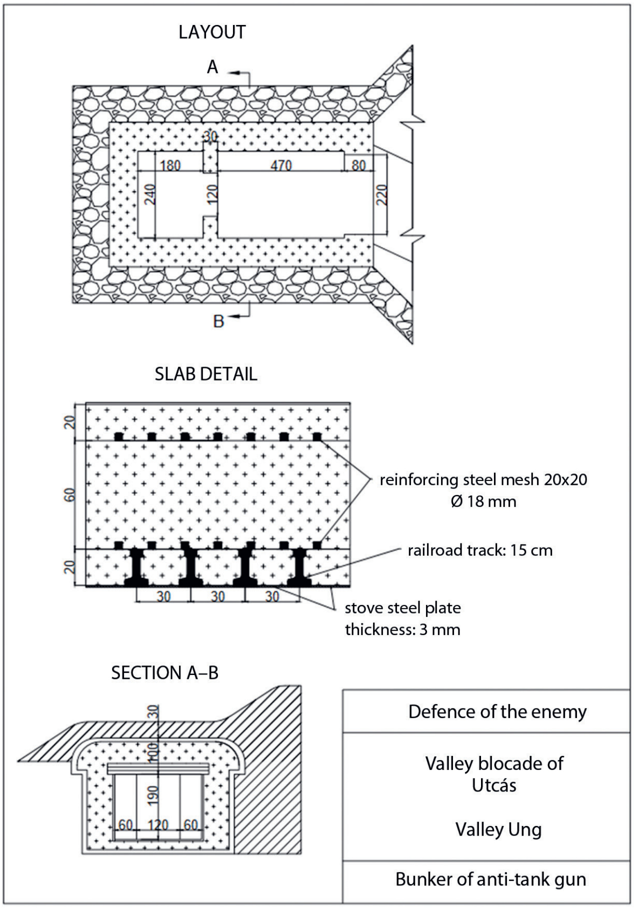

Figure 11: Technical drawing of an anti-tank gun bunker
Source: Prepared by Bálint Papp and István Rakaczki based on ЦАМО РФ. Ф. 4 УФ (244). Оп. 3000. Д. 635. Л. 27.

Figure 12: Anti-tank gun bunker near Oroszmokra
Source: Photograph taken by the author

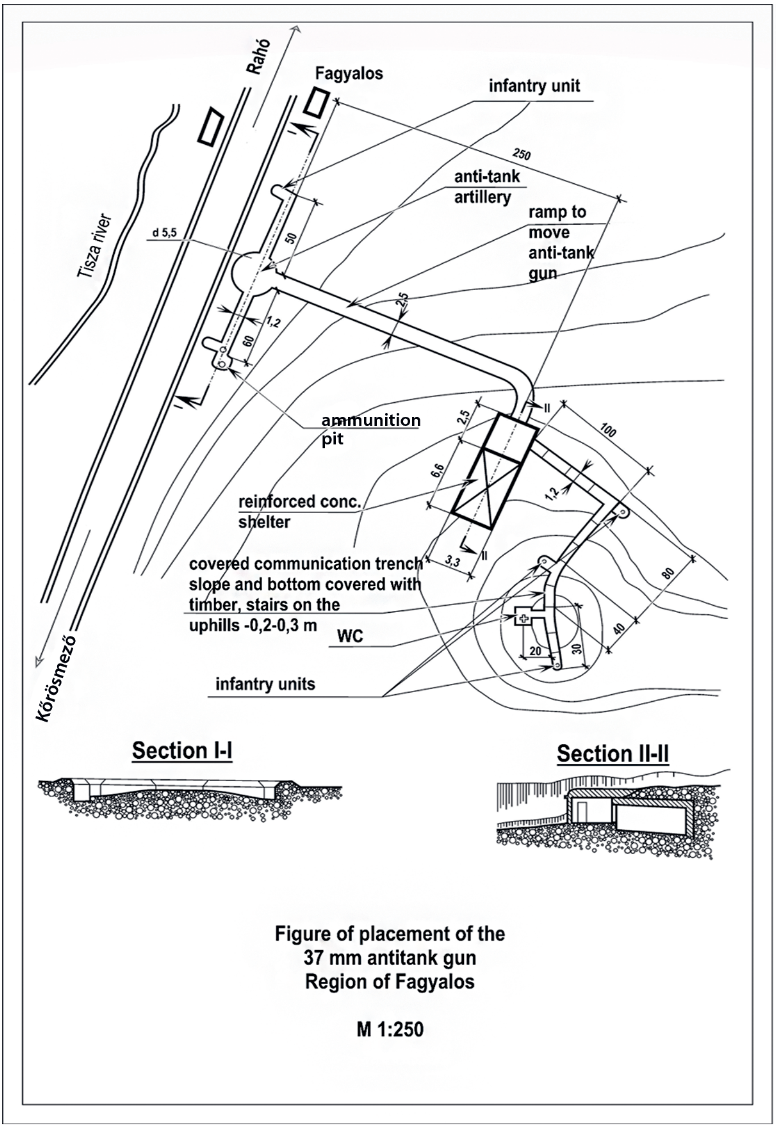

Figure 13: Anti-tank gun placement Fagyalos (valley block of Kőrösmező)
Source: Prepared by István Rakaczki and J. Miron Szalai based on ЦАМО РФ. Ф. 4 УФ (244). Оп. 3000. Д. 635. Л. 10.

Each valley block had several anti-tank units. They were mainly positioned after major bends in the road, alongside narrow roads where the armoured units could only move slowly and in single line. A barrier system in front of each gun emplacement ensured greater effectiveness. This could be a multi-row tank barrage, a tank ditch, an anti-tank minefield, or a combination of these.

In addition to the anti-tank gun, the defensive position consisted of several open firing positions, an ammunition store, a reinforced concrete shelter, open or covered trenches and a ramp for moving the gun, which together provided all-round protection. The anti-tank emplacements in each of the valley blocks made maximum use of the terrain conditions, and therefore the emplacements may have differed slightly.[17]

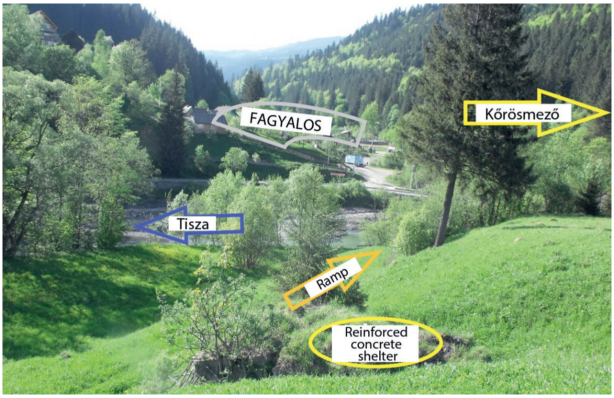

Figure 14: Detail of anti-tank emplacement at Fagyalos
Source: Photograph taken and edited by the author

If we compare the site plan of Fagyalos in Figure 13 with the photo (Figure 14), we can see that the site plan contains several misrepresentations. The Tisza flows on the other side of the road, the shelter and its entrance and the ramp are wrongly depicted. The bend of the road and the river is to the NNE of the shooting range (not shown in the figures).

The defence used reinforced concrete guns in front of all armoured units to force enemy tanks to stop (Figure 15). Its size and shape depended on the area of use. In land areas, regular triangular guns were deployed. They were cut horizontally below the top and an iron hook of minimum 10 mm diameter was installed. This was used to lift the wire barrier during loading and to attach the wire barrier during installation. To close rivers, swamps and wetlands, elongated deltoid gullies were used. The shorter side was against the flow of water, which was more resistant to the pressure of water and possible ice (Figure 16).

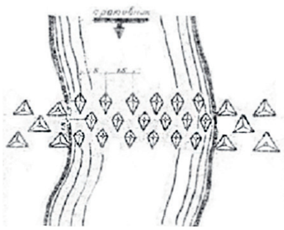

Figure 15: Application of tank blocking pyramid rows
Source: ЦАМО РФ. Ф. 4 УФ (244). Оп. 3000. Д. 635. Л. 33.

[17] Филоненко 2017: 79–83.

Figure 16: Remains of the tank blockades in creek Vecsa
Source: Photograph taken by Rusz Ferenc

Technical structures

One valley block was occupied by a fortress squadron. In the event of a sustained enemy attack, it could remain in combat for several days without support. Each fortress therefore had multiple doses of supply, which were deposited in secure earth and wood or reinforced concrete storage areas. Supply and first aid for the wounded worked in the same way. All valley bunkers had a kitchen. It was also built according to a type design (Figure 17).

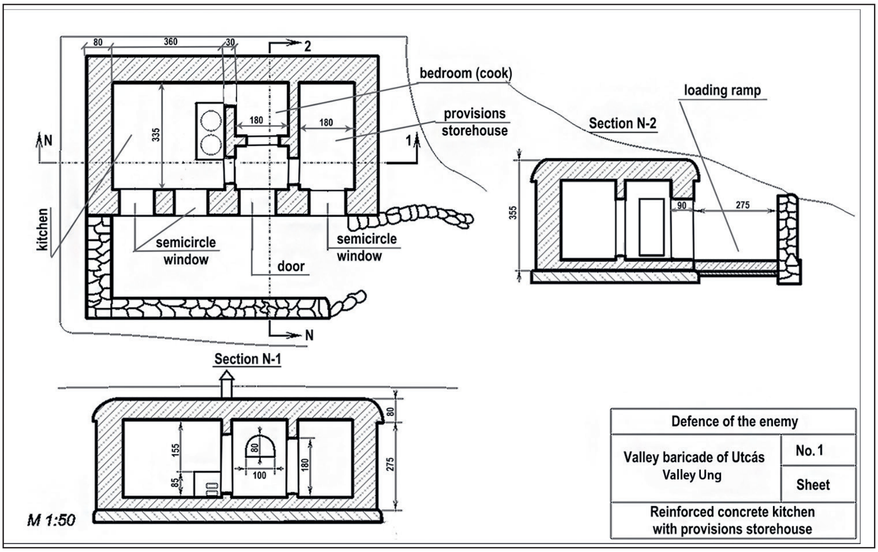

Figure 17: Technical drawing of kitchen
Source: Prepared by István Rakaczki and J. Miron Szalai based on ЦАМО РФ. Ф. 4 УФ (244). Оп. 3000. Д. 635. Л. 29.

Reinforced concrete kitchens were installed at all protection nodes (Figure 17). They were usually built at the rear, behind a slope, in concealment, and located along a road suitable for food supplies. The layout of the kitchen was very simple. To the right of the entrance hall was the food store (3.35 × 1.8 m), which could be closed by a door, to the left was the kitchen, opposite which was the cook's room (1.8 × 1.8 m). Depending on the number of defenders, two or four cooking units were used.[18]

The kitchen was lit through semicircular windows. The windows and doors were hermetically sealed with metal doors and metal shutters. The structure of the walls and ceiling of the kitchen was similar to that of the reinforced concrete buildings, except that in several places the outer part of the front wall was made of stone (Figure 18).

Figure 18: Former kitchen building at the area of Vízköz
Source: Photograph taken by the author

The valley blockades had a first aid post. These reinforced concrete structures were the largest buildings. Their external dimensions were 9.95 m (11.0 m) long, 5.1 m wide and 3.5–4.0 m high. The slab was flat reinforced concrete resting on I-beams, with boiler iron plates between the I-beams to provide protection against concrete splinters. The walls and floor of the building were covered with boards. The health centre was divided into three rooms. The central part was internally accessible from both adjacent rooms, the right and left rooms having separate exits (Figure 19). The left room had benches for the wounded, the central room, lit by two windows, served as an examination room and even as an operating theatre for minor operations. All medical stations were built according to the same technical drawing.[19]

18 Игнатов–Кузнецов 1945: 12.
19 Игнатов–Кузнецов 1945: 11.

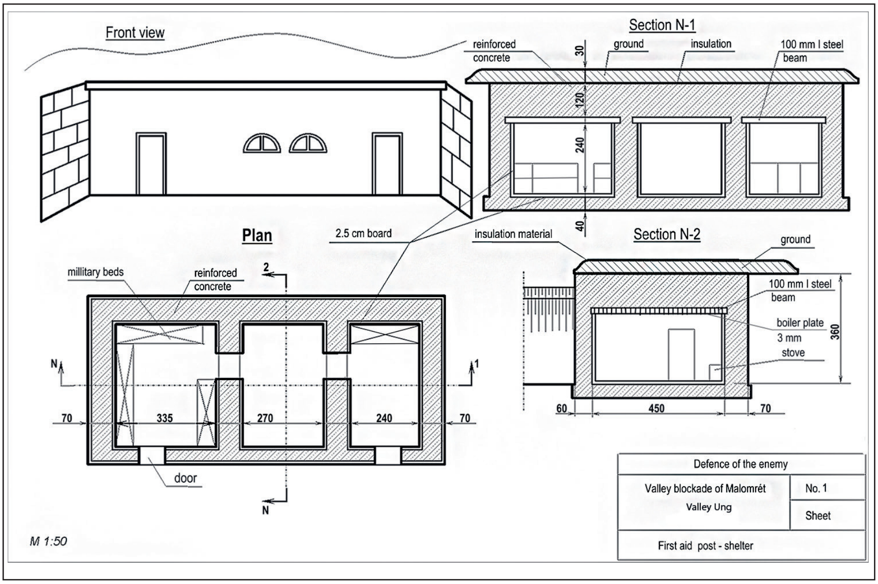

Figure 19: Technical drawing of first aid post
Source: Prepared by István Rakaczki and J. Miron Szalai based on ЦАМО РФ. Ф. 4 УФ (244). Оп. 3000. Д. 635. Л. 28.

The larger valley blocks had an electric power station, too. This provided lighting in shelters and other structures, and possibly power for small machinery. Another important role was to keep the wire barriers at the section points electrified to hold back the attacking enemy. The wire barriers were supplied with 3,000 Volts DC. A reference to this can be found in the war diary of the 17th Guards Corps attacking the valley barrier at Kőrösmező.

The power supply system was installed in two buildings, 200–300 metres apart, identical in plan and dimensions. The engine and dynamo were in one location, the transformer in the other, which was closer to the main defence line. In both buildings, a dividing wall separated the engine room from the work room. The reinforced concrete service buildings were structurally identical to the flat-roofed shelters.[20]

Summary

After the spectacular failure of the Maginot-type fortification systems, which were designed for defence only, a new type of defence was needed. The economic possibilities of Hungary did not allow the construction of large, expensive structures. The active defence system developed under the leadership of Colonel Teofil Hárosy provided the possibility of a counterattack. Small, well-camouflaged reinforced concrete structures, resistant to known artillery shells, provided protection for the personnel and armament. The Red Army's continuous attack for

[20] Игнатов–Кузнецов 1945: 12.

a month and a half only reached the Árpád Line in a few places (Uzhoki Pass, Tatar Pass). The Kőrösmező valley blockade held its ground, only falling into the hands of the attackers after the execution of the Hungarian withdrawal order.

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