Paolo Bortot

Eigth Forts. Traces of the Modern in Austro-Hungarian Permanent Fortified Works among the Mountainous South-West Borders of The Empire. 1833-1913

Military architecture, Mountain fort, Modern fort, Armored fort, Brutalism

/Abstract

The nineteenth century was a century characterized by numerous wars and geopolitical changes that in fact resulted, by their being politically and geographically unfinished, in the Great War. It characterized the second decade of the twentieth century.

The military action, understood, recalling Carl von Clausewitz, as a continuation of politics by other means, led European states to bloody actions of offense and defense predominantly in the plains spaces. This is absolutely evident.

In the same period, new considerations of strategy and tactics lead to the consideration of mountainous territory as a place that offers strong positions, in which, as classical history reminds us, a handful of men can stop many: the case of Thermopylae a very famous example.

This essay therefore is devoted to eight forts built in the mountainous environment within the Austro-Hungarian Empire with the sole exception of Fort Airolo. These are eight forts that, according to the author, represent milestones in defense in the mountains. These forts, at the same time and in some way, are the works that best represent the attempt to address, according to the logic of their time, the resolution of the problem of modern fortification for the defense of the Empire.

The design and practical efforts of the officers of the Austro-Hungarian Genie Corps would eventually lead, in the early 1900s, to the construction of forts made entirely of concrete. Fort Garda was the first. In them we find experimentation with theoretical principles and thoroughly modern construction techniques and materials, making them de facto forerunners of the avant-gardes of modern architecture and in particular of functionalism and brutalism.

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"They say that in war, thought is of great importance. That's true, but only for the general, as long as it's about strategy which has nothing to do with philosophy. Indeed, such a glorious feat it is carried out by parasites, exploiters, thieves, hitmen, farmers. idiots, losers, all the dregs of society,..." [1]

ERASMUS OF ROTTERDAM, *Praise of Folly*, 1511

Introduction

In the second half of 1800 after the progresses in steel manufacturing techniques, European metallurgic industry started producing increasingly heavier weapons, which were more and more precise and destructive in their effects.

The first practical consequence was the restructuring of the *tracé* and of the profile of the permanent fortification by eliminating the bulwarks. New forms of building single forts were adopted and studied with the use of building materials such as cement concrete, and within the fortifications brand new heavy armored elements were introduced.

A second theoretical consequence was the development of a fortifying theory, which had the purpose to detect some "strong spots" - "Feste Stellungen" distinguishing between plains and mountains.

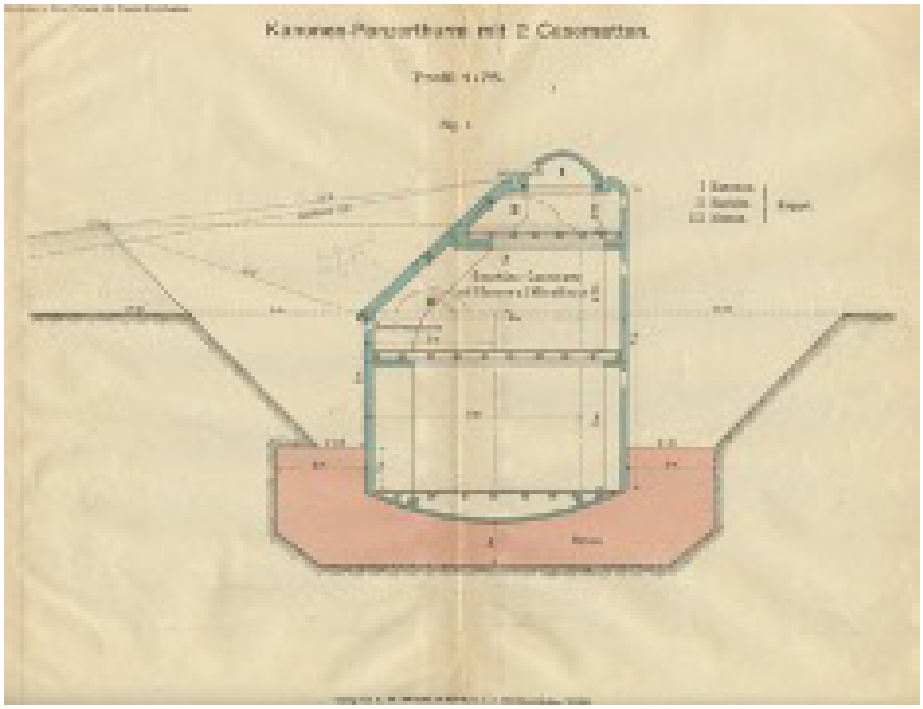
When choosing the strong spots, it was difficult to find the best position where to build the single defensive fort, which was aimed at being harmonized with the physical conformation of the terrain.

Forts were built either as isolated buildings, or in pairs, or in small groups, and from a morphological point of view they express, in the layout and construction technique, the state of the art of the various periods in which they were built.

The studies carried out in Austria-Hungary, military ally of the Kingdom of Italy since 1874, regarding the best geometric shape to give to modern fortification, lead to the development of various projects, even with completely new and original ideas [2] **[Fig.1]**, which were also partly adopted. In the second half of the 19th century, in addition to the tracé and the most proper position to choose, a new problem came out, that is to say the installation, within the permanent

1 *"Dicono che in guerra il pensiero abbia una grande importanza. É vero, ma solamente per il generale, in quanto si tratta di strategia che non ha nulla a che fare con la filosofia. Oltre a questo una impresa così gloriosa é realizzata con l'opera di parassiti, profittatori, ladroni, contadini, idioti, falliti, tutta la feccia della societá, ..."* Erasmo da Rotterdam, Elogio della follia. 1511 (Torino: Einaudi, 1966): 53-54.

2 See moreover the original proposal for an earthen fort by the Austrian officer Viktor Tilschkert who proposed forts with heavy armoured towers totally made of steel - "Panzerthürme"- placed at the top of the trapezoidal layout of the plan. Viktor Tilschkert, *Neue Formen der Panzer Fortification* (Wien: L.W.Seidel e Sohn, K.u.K. Hof-Buchändler, 1902).



fortification, of new armoured elements which production actually started in the first years of the 1860s.

The resistance of some heavy armoured casemate was tested also in some shooting ranges and in the end, by way of the empirical method, it was possible to determine the fittest shape to employ in the buildings. The result was the introduction of fixed armoured plates for frontal reinforcement with minimal cannon-embrasure - minimalscharten - , as well as of dome-style elements. In this way a result, "revolving heavy armoured casematte" started being studied and (of course) produced, or, it is better said, this type of casematte is, under a morphological perspective, revolving heavy armoured dome - "drehbare Panzer Kuppel ", which may be more lowered or less lowered, with a diameter that may be variable according to several Schools of Fortification.

This article briefly addresses the evolution of the modern fort on the south-west border of Austro-Hungarian Empire by analyzing some paradigmatic cases , according to the autor.

As a result of geopolitical changes following territorial losses, in rapid succession, of Lombardia (1859) and Veneto (1866) , the Austrian-Hungarian military *Genie* is forced to reinforce the new borders. Hence, a series of forts has been constructed, along the mountainous border of the South-Tyrolean salient. These first constructions would later be joined by others with new constructional and morphological characteristics, dictated by the need to modernize and adapt their endurance to the increased firepower..

The identified location for the construction of these forts were chosen to accentuate the function of a blockage - *Sperre* - in order to directly and physically to block the access ways to the region.

In this regard, De Paula observes: *"The barriers were mostly set up at narrow*

Fig. 1
Revolving heavy armoured dome for kannons - Kanonen Panzerthurm.
Source: Tilschkert 1902

points (valley barrages -Talsperren) or at dominant points (Mountain Pass barrages - Paßsperren), which had to block the road to be secured directly." [3] Furthermore, regarding their morphology, he notes: "Mainly bar-shaped constructions were built with the main facade on the enemy side." [4] In fact, the constructions built on the South Tyrolean territory at the beginning of the second half of the 19th century, presented in some cases a bar-shaped core with semicylindrical morphological elements (Forts Gomagoi, S.Nicoló), but also L-shaped plans inscribed in a square that have the edges of the vertical masonry rounded on the enemy side (Forts Strino, Larino). There are also cardioid-shape plan (Fort Nago). The South-Tyrolean permanent fortifications which were initially constructed in the traditional way, would gradually go on to present their own and innovative features both in terms of armament, but especially in terms of morphology.

They reflect the debate concerning the adoption of heavy armament and of heavy armor in the permanent defense works of the time, we recall here Fort Airolo of the St. Gotthard Pass barrage in the Swiss Confederation, surely the most modern heavy armored work - Panzerwerk - of the mountains in the second half of the 19th century. The Austrian school, through slow and continuous reflection accompanied by field experimentation, applied to the specific geographic context of mountains, respecting the requirements of economy and effectiveness typical of the Austrian military *Genie* school produced, along the border with the Kingdom of Italy, a numerous series of permanent defense works. They represent the proposed solution to the fortification problem in the various periods of construction. This process, which came to maturity in the early twentieth century, would eventually lead to the invention and use of novel and in some cases absolutely modern and original construction solutions.

This was made possible by the advances in steelmaking of the imperial heavy industry, particularly the Skoda company, which in the years immediately preceding the conflict reached a very high level of quality in the production of heavy weapons and armored elements.

Elements of periodization

We recall here briefly the various periods of construction as proposed by the author[5]:

1. First period (1833-1840). Construction of Nauders and Franzenfeste fortified works. They represent the two extremes of the small and large permanent

3 *"Die Sperren waren meist an Engstellen (Talsperren) oder an beherschenden Punkten (Paßsperren, welche den zu sichernden Verksweg unmittelbar zu sperren hatten, angelegt."* Kurt Mörz De Paula, *Der Österreichisch-Ungarische Befestigungbau 1820-1914* (Wien, Buchhandlung Stöhr, 1995): 73.

4 *"Die meist riegelförmiger Werke wurden in der Riegel mit Front zur Feindseite errichtet."* De Paula, Der Österreichisch-Ungarische Befestigungbau 1820-1914, 73.

5 Paolo Bortot, "Technical evolution and modernity of the Austrian South-Tyrolean imperial Forts on the italian borders", in *HERITAGE 2016*, eds. R. Amoeda, S. Lira, C. Pinheiro (Barcelona: Green Lines Institute, 2016): 1201-1211.

mountain fortification. Of the two, the lesser known is Fort Nauders also known as Fort Finstermünz, named after the homonymous pass.

2. Second period (1860-1862). Construction of forts with French casemate construction technique following the example of Napoleonic lunettes in Palmanova. His type had the task of barring roads, which is why they took the name "Strassensperren."

3. Third period (1880-83). Mixed-elements fort construction. Built with vertical external and internal walls of stone and lime surmounted by brick vaults. Open casemates in the internal part, covered with an earth layer of 2 or 3 meters. This particular construction method was carefully studied for the territory surrounding Trient and was thus named "Trentiner Stil", or "Trient style."

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4. Fourth period (1884-1900). The Austrian officer Julius Vogl invented a new type of barrage bombproof mountain fort that can be found only in the South-Tyrol region. This fort is characterized by aligned and inclined front casemates, normally 4, internally with cast iron shields to protect cannons. From the point of view of their shape, South-Tyrolean forts are unique all over Europe.

5. Fifth period (1904-1915). This is the period of modern heavy-armored Forts. The first work of this type was Fort Garda, completed in 1907. Here a new construction technique was experimented with the only use of concrete. It was built in a unique bolck of concrete with internal and perimetral walls with a thickness of 1.5 meters. The thickness of the covering was between 2.5 and 3.0 meters and it rested on a plane of 30cm double T beams. It was equipped with 4 heavy-armored rotating domes - *drehbare panzer Kuppeln* - and a revolving heavy-armored observatory - *drehbare gepanzerter Beobachtunssgstand* - for the commander.

As far as construction materials and morphology are concerned, Fort Garda represented the first example of South-Tyrolean modern mountain heavy-armored fort.

Let us now look at some paradigmatic cases of fortified monumental heritage in *Süd-Tirol*: they are representative of the entire Austrian mountain fortification.

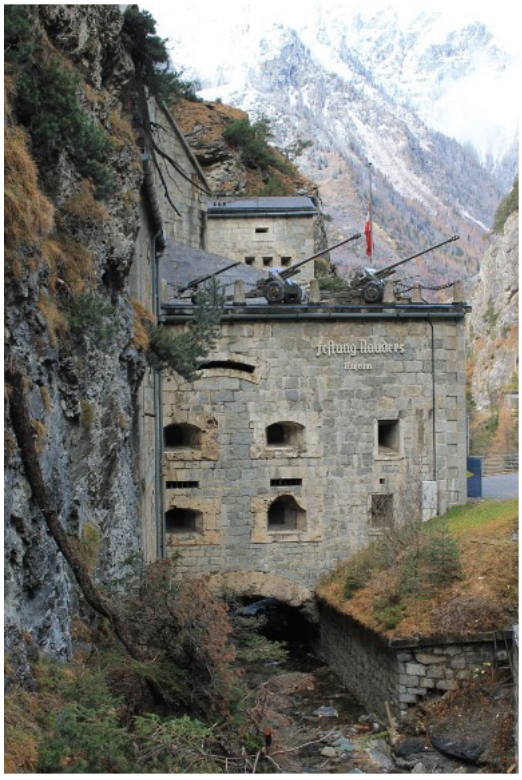
Fort Nauders

After the Napoleonic Wars and the Congress of Vienna, following the incursions of the French army into the Tyrolean valleys, it was recognized that the fortresses placed in the Po Valley were no longer enough to block enemy armies. Following long years of extensive field observations by Austrian officer Franz

Fig. 2
Fort Nauders.
Sud-East wiew.
Photo by the Author

von Scholl and Archduke John of Habsburg [6] in 1832, it was decided to build two works whose function was to block access to the Inn Valley.

The first work, the small Fort Nauders [Fig.2] (*Nord-Tirol-Oesterreich*), at the Finstermünz pass (1186m asl) just after the Reschen pass (1507 asl) blocked the ancient Roman Claudia-Augusta road, wich was of great strategic and commercial importance. The second work, the mighty fortress of Franzenfeste, was built on the right margin of the Eisack River north of the city Brixen. It had the dual function of barring the route leading to the Brenner Pass (1370m asl), but also to control the passage into the Pustertal valley that led to the Drava Valley.[7]



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Fort Nauders is practically unknown: it was also called Fort Finstermünz taking the name of the small pass (1186m asl) where it was built between the years 1834 and 1840.

This building had the function of blocking the road from South Tyrol to North Tyrol and was located, north of the village of Nauders, on the road from Reschen Pass into the Inn Valley. It constitutes a unique case, mainly for three orders of reasons.

First: the choice of construction site. The building is perfectly positioned in a fold of the terrain adhering to the steep rock face of the mountain. For this reason, it is completely out of sight and appears to those traveling north - the most likely direction of enemy arrival - only at a close distance of 70-80m after a bend in the road descending to the Inn Valley.

The small Stille stream laps at the base of the main facade of Fort, flowing into the artificial ditch and passing under the Caponier. [Fig.3]

This Caponier, shaped like a projecting bulwark with a polygonal plan, houses two overlapping pairs of artillery casemates. A few meters to the north there is also a deep ravine where the Stille stream forms a waterfall to reach the Inn valley below. The site exhibits the characteristics, according to military theory, of the "strong position"-"*Feste Stellung*": here nature and art shake hands.

The protection from view due to the morphology of the mountain, the presence of the natural obstacle on the north side, and also the small frontal stream that laps against the facade by flowing at the bottom of the dich, make it difficult to attack by live force and practically impossible to destroy with artillery.

The arrangement of the armament for close defense and the coverage by direct artillery fire of the possible main lines of attack - actually two namely south and north following the road - making it an impregnable building.

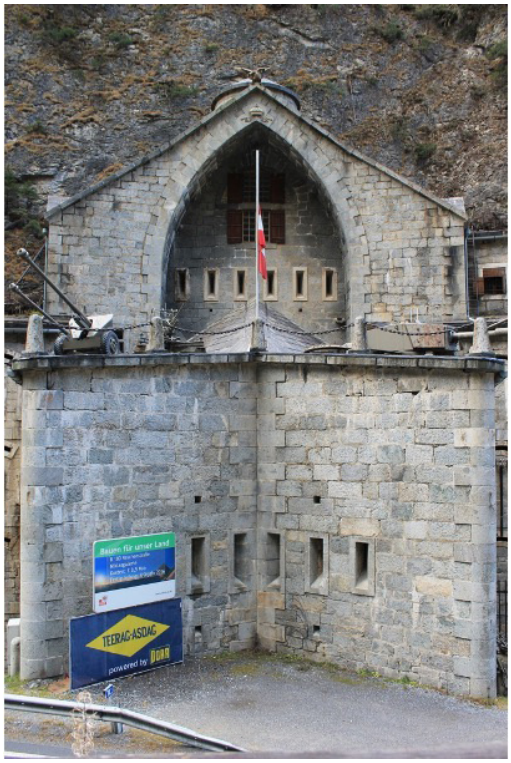
Fig. 3

Fort Nauders. South side of the caponier-bulwark with pairs of overlapping cannon-embrasures.

Photo by the Author

6 See the biographical notes on Franz von Scholl in Lino Vittorio Bozzetto, *Verona. La cinta magistrale asburgica* (Verona: Cassa Risparmio Verona Vicenza Belluno e Ancona, 1993): 162.

7 Dario Massimo, *La Fortezza* (Bressanone: Weger, 2010): 45.



Second: the refined artifice in the composition of the plan. The fort is formed by a symmetrical main body, consisting of the caponnier-bastion with plan of salient ended in a shape of a swallowtail. The fronts of the caponier-bastion in which the pairs of superimposed cannon-embrasures open, form a right angle with the two symmetrical side fronts of equal height: three superimposed levels of vertical embrasures open in the latter. In the final swallowtail element, six rifle-embrasures - three on each side - open to cover the dead angle.

This special conformation of the caponiera-bastion allowed a dual function of artillery defense through the open cannon-embrasures in the facades: the flanking action of the fort's elevations work with the vertical embrasures and at the same time direct firing against the advancing enemy on the road. To the side of the caponier, facing north, is the entrance to the fort, connected to the road by a small bridge over the front artificial dictch. The facade of the fort ends northward with a sloping front recessed by 30 degrees from the section adjacent to the caponier-bulwark. This final section of the work has a greater height: in it are four levels of vertical rifle-embrasures with direct action on the road rising from the Inn Valley.

All facade sections **[Fig.4]** are characterized by the arc-shaped ventilation elements placed above each pair of vertical embrasures: these allow internal ventilation and the removal of smoke from small arms during combat.

On the axis of the caponier-bulwark **[Fig.5]** there is the rearmost and tallest body of the building - placed above the roof of the main structure - that adheres posteriorly to the rock and has on its sides two small facades with rifle-embrasures providing action on the roof. It is characterized by the large pointed arch that would seem to recall the debate around the contemporary Gothic revival. In

Fig. 4
Fort Nauders. Detail of the north facade to the side of the entrance. Minimal ornamental elements.
Photo by the Author

Fig. 5
Fort Nauders. Front of caponier-bulwark.
Photo by the Author

fact, here the Gothic arch protects the recessed facade that houses the rifle-embrasures for frontal defense. At the same time, the arch functions as a strong structural element that supports the two-pitch gabled roof, which has an accentuated slope in order to promote snow sliding in the winter months.[8]

Laterally, this upper body, presents two asymmetrical facades, with two small gables on the south side and one on the north side, at which there are a different number of rifle-embrasure with the function of protecting the single-pitch roofing of the two lower south and north sections of the fort flanking the caponier-bulwark.

The volumetric composition of Fort Nauders ends at the highest point, at the center of the two-pitch roof of the volume characterized by the Gothic arch, with a small cylindrical tower with a conical roof: along the curvilinear walls of the cylinder open the rifle-embrasures that allowed a circular action with an "umbrella" protection.

The building is constructed of rough-hewn stones on site and lime. The facades are made of stones placed in irregular courses, almost with characteristics of rustic work. There are minimal concessions to ornamentation: string-course bands highlight the interior levels, regular stone blocks at the corners, and simple rectangular cornices surround the arched ventilation holes and rifle-embrasures.

Third. The significance of this work is underscored by the military historical sources that, upon careful analysis, can be observed in the construction. Certainly the placement of the casemates for the artillery in overlapping pairs recalls the same solution used for the Bulwark of the Magdalene built in Verona [Fig.6] in the Renaissance period according to the instructions of Francesco Maria della Rovere with the technical contribution of Michele Sanmicheli. Franz von Scholl was perfectly familiar with Verona's Renaissance walls. Recalling Bozzetto, "Scholl drew up the preliminary studies and the overall plan to turn Verona into a 'maneuver and storage stronghold' for the imperial army. In addition, by 1832 Scholl had defined plans for the Alpine barrages at Franzenfeste near Brixen and Nauders near the Reschen Pass. The works at Verona and Franzenfeste were started in the same year, 1833, those at Nauders in 1834."[9]

Scholl would therefore arrive at the strengthening of the Bastion as part of the project to transform the fortress of Verona while essentially maintaining its Renaissance layout. In fact, Francesco Maria della Rovere Duke of Urbino commander of the Venetian army argued that the cannon-embrasures should be in the flanks of the bastions, "li quali nuoceno più e sono più guardati." [10]

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8 The building is in fact built at 1290m asl, at those altitude the snowpack could reach 3-4 meters.

9 *"Scholl elaborò gli studi preliminari ed il progetto d'insieme per trasformare Verona in una 'piazzaforte di manovra e di deposito' per l'armata imperiale. Inoltre nel 1832 Scholl aveva definito i progetti per gli sbarramenti alpini di Franzenfeste presso Brixen e di Nauders, vicino al passo di Resia. I lavori di Verona e di Franzenfeste vennero avviati nello stesso anno, nel 1833, quelli di Nauders nel 1834."* Bozzetto, Verona. *La cinta magistrale asburgica*, 162.

10 Francesco Maria della Rovere, *Discorsi militari.* in Ennio Concina, *La macchina territoriale* (Roma-Bari: Laterza, 1983): 89.

Exactly the solution that is employed in Nauders building. In this mountain fort we also find military design principles already implemented by French officers in Italy during the Napoleonic campaigns: in fact, the umbrella defense of the fort's roofs directly recalls the same concept expressed and implemented by the French in the fortress of Rocca d'Anfo consisting on the cylindrical element[11] overhanging the summit lunette. The casemate facade of the Anfo summit lunette itself has arched elements [12], in this case of the lowered type protect the set-back masonry in which the rifle-embrasures open, in analogy to the back wall protected by the large Gothic arch.

The plan of the salient caponier-bulwark of Fort Nauders can also be considered an adaptation of the layout, on a smaller scale, of the second and third fortification modes of Carnot's System. This was characterized, at a much larger dimensional scale, by bulwarks for tanagled defense. Finally, another element recalling of French works is found in the masonry of the small barracks **[Fig.7]** built in front of the Nauders fort on the opposite side of the road. The design of de facade, with arched elements at the ground floor and the stringcourse frame of the first floor in fact take up stylistic elements from the barracks [13] of the gorge lunette of Rocca d'Anfo. Here at the Finstermünz pass, the decorative elements typical of urban culture introduced on the facades of the small barracks contrast with the spartan, rustic and essential construction of the fort.

6 - 7

Fort Nauders (or Finstermünz) is effectively the first modern Austrian imperial mountain fort. This structure embodies the functional needs dictated by defense, resulting from field reconnaissance and the application of fortification theory to a practical case. It conforms to the reality of the situation, according to the principles dear to Karl von Clausewitz, here applied to the art of defensive construction, in the act of fortification carried out in a context of peace and without haste.

This work is attributable, in terms of the layout of the plan, structure and conception, to Franz von Scholl. It stands in the field of functionalism, outside the didactic and academic schemes of the time. It can be considered among the innovative works from the point of view of modern fortification theory but, at the same time, well grounded in the tradition of building practice.

Fig. 6
Bulwark of Maddalene. Verona.
Photo by the Author

Fig. 7
Fort Nauders. Facade of the barracks adjacent to the fort.
Photo by the Author

11 The fortress of Rocca d'Anfo was designed by François-Joseph-Didier Liédot and approved by Chasseloup the designer of the Palmanova lunettes. See the design drawing of the cylindrical structure in the text by Philippe Prost, *La Fortezza incompiuta* (Milano: Electa, 1989), 56.

12 See the design drawing of the facade of the upper part of the lunette in the text by Philippe, *La Fortezza incompiuta*, 64.

13 See the design drawing of the facade of the upper part of the lunette in the text by Prost, *La Fortezza incompiuta*, 61.

The building, with its large Gothic pointed arch that characterizes the main facade, the serial elements of the rifle-embrasure, the presence of single-pitch, double-pitch, and cone-shaped roofs, with the invention of the caponier-bulwark housing the artillery casemates in overlapping pairs, certainly recalls on the one hand the contemporary revaluation of the Gothic while expressing a certain tendency toward eclecticism.

8 - 9

The Forts of San Nicolò, San Rocco and Gorazda

The Austrian Empire lost Lombardy in 1859. The new frontier thus comes to lie on the borders of South Tyrol. Urgent barrages in the western valleys and the northern edge of Lake Garda were necessary. These are forts [14] built immediately beside the road - "Strassensperren" - made all at the same time, as we mentioned, between 1860 and 1862, as the new border was completely undefended. These works, because of the technique with which they was built, are also called "French-style forts."

A pair of forts was built north of Lake Garda: Fort S.Nicoló and Fort Nago. Fort S. Nicoló, by shape and structure is the one that can make us understand, perhaps most directly, the French derivation. In fact, morphology and construction technique directly echo those of the polygonal lunettes built by the French "Genie" in an external radial position to modernize the Venetian Fortress of Palmanova. These were works designed by General Chasseloup, built between 1806 and 1809, and well known to Austrian "Genie" officers. These lunettes consisted of a salient-shaped embankment lined with stone along the outer perimeter of the scarp. Inside the lunettes, on the axis, is a rectangular-mixtilinear casemate ending in a semi-cylinder shape **[Fig.8]** on the enemy side: here on the upper floor there are cannons-embrasures.

The exterior walls were built of cut stone blocks laid in regular courses. The work has internally lowered vaults on the ground floor and a round-vaulted roof on the first floor that ends externally with a roof made of brick.

The plan of the Napoleonic casemate of Palmanova, with its semi-cylinder terminating shape, thus presents, on a smaller scale, exactly the pattern of the plan of the Austrian fort built at the entrance to Riva 26 years later.

Fort S.Nicoló, **[Fig.9]** built between 1860 and 1861, had a dual function. Direct barrage of the 'road access to the town - Strassensperre - blocking those coming from Torbole along the route at the edge of the lake at the base of Mount Brione.

Fig. 8

French lunette Fort of Palmanova. Flank and semi-cylindrical element on the enemy side with cannon-embrasures.

Photo by the Author

Fig. 9

Fort San Nicoló. Semi-cylindrical element of the north facade.

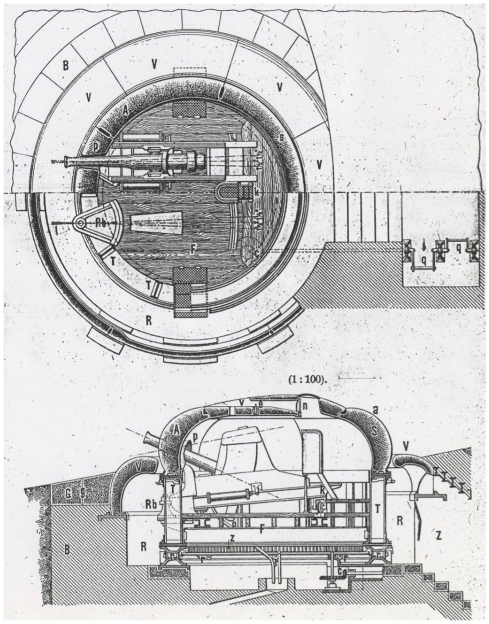
Photo by the Author

14 Fort Gomagoi is built at the beginning of the Trafoi Valley that ends in altitude with Passo dello Stelvio. In the Vermigliana Valley ending west with Passo del Tonale Fort Strino. In the upper Chiese Valley, forts Larino, Revleger, and Danzolino close access to the Tione basin.

Control of the stretch of water in front of Riva harbor and the flat stretch between Mt. Brione and the town in an anti-disembark function.

The building, with a mixtilinear plan, consists of a paralelepiped with a main body about 43 meters long and 12.5 meters wide ending northward with a semi-cylinder. Morphologically, as we have seen, it echoes, on a larger scale, the French type of Palmanova.

The facades are made of regular blocks of limestone in horizontal courses. In them open vertical rifle-embrasures in groups of three, surmounted at the top by elegant lunettes for the exit of smoke produced by small arms during the combat. A pair of cannon-embrasures, surmounted by lunettes, opens in the middle of the long façade oriented toward the city. The half-cylinder-shaped north side houses a cannon-embrasure at on the first floor and a series of equidistant single vertical rifle-embrasures. All of the rifle-embrasures are simply open in the walls without relief moldings on the outline.



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In contrast, the lunettes for smoke escape and cannon-embrasures are highlighted by elegant relief cornices with stone ashlars. The exterior walls are 1.3 meters thick all around, including the interior walls. The short wall, facing the lake, is 3.5 meters thick. On the ground floor, the fort has casemates for cannons, 2 ammunition depots, troop rooms, kitchen and food storage rooms in the semicircular space. On the upper level are the soldiers' dormitories with rifle-embrasures for rifles for short-distance combat. The roof is made of wooden structure with tile covering. The armament consisted of 3 Mod.61 15-cm smooth-barrel cannons in casemates: two towards the lake, and one, in the semi-cylinder part, towards the flat terrain on the north.

The works of this period thus look towards the past. These are academic exercises that have some defensive effect against possible troop attacks, but certainly not against modern artillery.

To find something truly innovative, at least from the building morphology point of view, we will have to reach the 1880s.

In the mid-1800s, new explosive artillery shells are produced.Experienced in major European firing ranges, torpedo grenades cause a real crisis in fortification. Forts with thick embankments covering service rooms and casemates, such as Fort Pannone,[15] suddenly become obsolete and dangerous.

The layer of earth placed over the casemates, warehouses and living quarters, increased the projectile destructive action. The weight of the earth above the penetracted projectile, increases the force of the explosion to be directed

Fig .10

Plan and section of the Gruson-Werke armored dome of the type installed on Fort San Rocco.

Source: Moriz Ritter von Brunner, Wien, Verlag von L.W. Seidel and Sohn, 1896, p.19

15 See Paolo Bortot, *Progetto e memoria: il forte scomparso di Pannone nell'ambito della fortezza di Riva del Garda., in Donato Riccadonna, I Forti austroungarici nell'Alto Garda: che farne? Atti del Convegno.* Forte superiore di Nago 27 febbraio-2 marzo 2002 (Riva: Museo Civico Riva del Garda, 2003): 39-43.

downward, causing masonry vaults to collapse. A first attempt to redress the balance in favor of defense was made by experimenting with an ultra-modern large armored dome of German manufacture .

On a hill to the south of the city of Trento, at a dominant point on the left side of the Adige Valley, at an elevation of 445m above sea level, was thus built between 1881 and 1883, Fort San Rocco as a barrage to any attempt to take the city from the south.

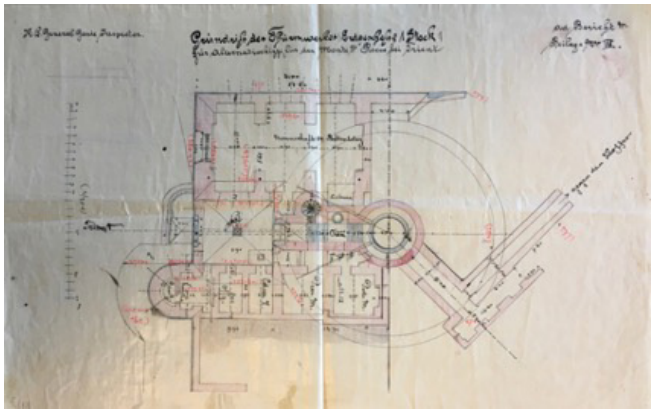
This 'work features the most modern technological-military defense element of the time: a revolving armored dome **[Fig.10]** by the German firm Gruson-Werke. The result is a fort with design layout where old and new stand side by side.

A lower part, oriented towards the Adige valley, consists of a salient of polygonal shape in isosceles trapeze **[Fig.11]** that houses above open-air barbette emplacements for 4 M61 cannons of 15 cm caliber. Along the perimeter of the embankment was a ditch that followed the trapezoidal layout. This part of the work was of an outdated type in that it echoed the form of the open earthen fort - Tunkler type - of the early entrenched camps. Here the artillerymen were directly exposed to shrapnel and the 'destructive effect of explosive projectiles.

The major base of the trapeze (North) measures about 150 meters, the minor base (South) about 60 meters and the oblique sides about 80 meters. Because of the rising ground, the ditch was interrupted at the throat side of the block that houses the armored dome. This was built of concrete and lined with stone. The near defense in the original project was carried out by means of caponiers

Fig. 11 Fort San Rocco. Plan of the fort. 1881

Source: Fondo K.u.k Geniedirektion Trient. Archivio di Stato Trento.



placed at the bottom of the ditch.[16] Two caponiers were located at the apexes of the short salient side, and a third caponier was placed at the end of the oblique, flanking section of the building with the dome.

The upper part [Fig.12], housing the dome, is differently structured. This consisted of a stone masonry work cut in regular courses. It presentes a rectangular, two-level plan containing a series of functional rooms. A caponier, orthogonal to the outer facade and terminating in a semi-cylinder, is placed at the side of the entrance door.

The entire upper work is rotated 45 degrees to the north side - the largest - of the trapezoid-shaped polygonal layout. In this way it aligned with the oblique side of the trapeze. The heavy rotating armored dome - weight 120 tons - manufactured in Germany by Gruson Werke Buckau-Mackleburg, was installed on the roof. The circular shaft of the tower, in plan, was positioned tangent to the walls of the rooms on the salient side.

The dome was constructed of hardened cast iron and is made of 5 sectors with a longitudinal section of varying thickness and a very distinctive shape. In fact, externally the dome appeared to have a toroidal morphology ending at the top with a very low cap. The thickness was greater at the front where there was more possibility of receiving a direct hit; it then gradually decreased to the top. A small circular hatch opened on the top for smoke to escape. The accompanying extract drawing from Brunner's text makes everything clear.

The dome rested on a ring-shaped front armor, also made of hardened cast iron, set into the roofing concrete. It was armed with a pair of 12cm "Minimalschartenkanone"- minimal cannon embrasure - with a barrel length of 3.2 meters. The cannons had a range of 8.0 km with both explosive and shrapnel projectiles. The diameter of the dome at the base was 4.00 meters.

Along the gorge side - the base of the isóscele trapeze - a casemate was build with garrison quarters - Wohnkasamatte - . In this work, the living part, is separated from the fighting elements of the fort. This is an extremely modern

Fig. 12

Fort San Rocco. Ground floor plan of the upper part in stone masonry.

Source: Fondo K.u.k Geniedirektion Trient. Archivio di Stato Trento.

Fig.13

Turmfort Gorazda. Gruson revolving armored dome made of hardened cast iron.

Photo by the Autor

16 See project drawing *K.K. General Genie Inspektor, Monte S.Rocco bei Trient. Wien am 23 Juni 1881, 1/500*", Fondo Genio A-U, Archivio di Stato Trento.

solution that appears here for the first time, anticipating project solutions that would appear in the first decade of the 20th century.

The garrison, *"...in the case of war with Italy consisted of 3 officers and 120 petty officers and soldiers, in the case of war against Russia the garrison would consist of 1 officer and 60 soldiers."*[17]

Ultimately, Fort San Rocco, although armed with a the most modern revolving armored dome, has some incongruences due to the inclusion and use of such advanced technology within a static and conservative cultural context. The lower part of the work with the artillery emplacements in open-air barbette, the wall structure on which the dome is installed, with its stone-clad exterior walls ending in horizontally laid stone slab covers, the small inner courtyard, appear anachronistic.

Another work, that was instead projected around the Gruson armored dome **[Fig.13],** in an attempt to integrate new technological elements more closely into the layout, was built in a mountainous environment on the Adriatic coast of Montenegro. Here again, as we shall see, the "classical" Austrian tradition that looked to the past appears with full force.

Between the years 1884 and 1886 the Turmfort Gorazda was built on the Montenegrin coast of the Adriatic Sea south of the ancient Venetian fortress-city of Kotor. The name of the fort emphasizes the presence of the modern armored tower.The "Tower Fort" - "Turmfort"- ensured the secure domination of the Budua-Cattaro road.

The fort is situated in a dominant position on the Gorazda mountain relief, from which it takes its name, at an elevation of 452 m above sea level, opposite Mount Lovcén. The elevated position offered an incomparable view of the Lustizza peninsula and the two branches of the Kotor "fjord" to the north, of the flat or shallowly sloping Gerbal territory stretching southward, encompassed between the hills by the Adriatic Sea to the west and the rocky slopes of Mount Lovcén to the east. The revolving armored dome allowed 360-degree action, thus also controlling possible enemy action from the Adriatic Sea.

The Gruson armored dome, the same as that of Fort S.Rocco, was armed with a pair of 12-cm cannons, in this case is the center of the plan composition and at the apex of the elevation volumes. The layout of the fortification is in

Fig.14

Turmfort Gorazda. View of the front ditch in the curvilinear tract at the apex of the salient. Note the two caponieres with oriented rifles-embrasures for close defense. The scarp and counter scarp walls lined with regular stone courses ending in a cover of horizontal stone slabs. On the left is the fort's sloping rampart in which opening the minimum cannon-embrasures with half-armored shield openings.

Photo by the Autor

17 *"...in caso di guerra con l'Italia era formata da 3 ufficiali e 120 sottoufficiali e soldati, nel caso di guerra contro la Russia la guarnigione sarebbe stata composta da 1 ufficiale e 60 soldati."* Stefano Pinotti, Festung Trient. Le Fortificazioni di Trento e il relativo periodo storico (Schio: Gino Rossato Editore, 2011): 155.

the form of a salient. The 'angle, between the two blocks of casemates, hinged around the curvilinear element formed by the dome, is of 105 degrees.

Same armored casemates with metal half-cap with minimal-embrasure are located at the front, below the rampart, allowing to beat the circular sector of land between the fort and the steep slopes of Mount Lovcén, in direction to the east. The apex of the salient layout is rounded. [Fig.14]

15

This element characterizes the shape of the ditch, which is about 7 meters wide and between 5 and 7 meters deep. At the bottom of the ditch are 4 stone-clad caponiers with vertical rifle-embrasures - with the usual rectangle plan ending in a semi-cylinder - for close defense in case of "*viva forza*" attacks.

In the gorge side, on the central axis, there is a section of cylindrical masonry placed in the center of the two wings living casemates [Fig.15] of the building forming a 105-degree angle between them. In the center of the curvilinear section is the portal of the fort. The two symmetrical casemates of the fort have, on the gorge side, holes for internal lighting with contours of level stone ashlars.

The interior floors are highlighted on the facade by a simple rectangular stringcourse band. On the top of the vertical masonry, throughout the work, is a stone cover.

The memory of the fortification tradition, in addition to the symmetry of the layout, is the low ravelin placed to protect the gorge side, which, along the entire perimeter, is bordered by stone walls. In the center of the ravelin is a recessed, sinuous open-air pathway, protected from view and direct fire, which allowed the entrance to the fort to be reached.

The work is organized on three levels. The lowest level has a corridor that follows the layout of the V-shaped salient fort with a rounded apex: from it there is access to the four caponieres for the close defense of the ditch. [18] The two heads of this corridor are open onto the side sections of the ditch to favor the ventilation of the interior.

The middle level (the main one) houses housing quarters for troop and officers , ammunition stores, 2 casemates in each side with traditional cannon-embrasures for cannons with traitor -*"traditor"* - function, and 5 minimum

Fig. 15.
Turmfort Gorazda. View of the right ditch (north side). In the left foreground, the pair of traitor cannon-embrasures at the end of the casemate block for the garrison. On the left of the photo, at the end of the gorge ditch, the curved masonry into which the entrance portal opens.
Photo by the Author

18 In fact, the two caponiers beating the two sections of the sides' ditch, although they have a symmetrical plan, have direct action only on the short sections of the ditch: in fact they are semi-caponiers. The two caponiers located on either side of the arc of the circle at the apex of the salient, have action on the two sides. Their function was to beat the straight frontal sections of the ditch and the circular arc section

cannon-embrasures casemates with frontal armored semi-cap shield [Fig.15] positioned internally. These latter housed the cannons - Minimalschartenkanone - 12cm M80 on pivoting support designed from Krupp. Barrel weight of cannons was 1700 kilograms, length 3.2 meters: pivoting support weight was 1120 kilograms. The useful range of 8 kilometer.

At the top level of the building was the revolving armored dome with the characteristic toroidal shape. From a technical point of view, this dome, represented the most advanced product of German steelmaking technology of the time. The process of casting hardened cast iron allowed the creation of domed shapes, which became the new morphological element here.

16

The Gruson rotating armored dome of toroidal shape, terminating in a lenticular dome, was protected externally at the base by a crown forepart formed of hardened cast iron elements cemented into the concrete cover. The dome also rested on an internal steel ring structure standing at the top of circular shaft made of stone and concrete block masonry. The latter housed the servants assigned to the rotational movement of the dome. Between the dome and the forepart was a gap that effectively let water go through, that is inpratically in mountainous environment. The rotation movement was manual, by means of cranks placed below the level of the pieces, which sent the movement to gears.

The total weight of all constituent elements of the dome, without cannons, is 120,000 kilograms. The management of such complexity required a certain number of men: 1 commander, 1 petty-officer and 4 artillerymen in charge of the pieces, 2 men in charge of the ammunition service, 4 men in charge of the winch (for lifting the shells, expolosive charges, and for rotating the dome). The total number of servants was thus 12 men. The Gruson armored dome, with manual movement could make a full rotation in 1 minute. The cannons could have a firing rate between 1 and 2 rounds per minute: it depended on the skill of servants.

Fort Gorazda armed with the modern twin rotating armored dome, thus represents at that time the most technologically advanced point in the planning of permanent fortification works in Austria-Hungary in the mid-1880s. Here, too, however, as in Fort San Rocco, some incongruities can be observed.

In plan, the fort presents a symmetrical layout of "classical" form. Close defense was implemented by means of caponiers in the ditch with vertically oriented rifle-embrasures of traditional form. The masonry structure of the work, inside and outside, with its square stone walls, externally ending "sharp-edged," with covers of stone slabs laid horizontally, appear anachronistic.

Fig. 16
Turmfort Gorazda. Casemate with an armoured semi-cap shield with minimum cannon-embrasure for cannon with on pivoting support.
Photo by the Author

Near and far defense were here concentrated. The thick earth rampart covering the fixed casemates could prove damaging in the event of bombardment with large caliber explosive shells.

The type of armored dome installed was very expensive, and its great weight made it difficult to transport - even fractionally - and to install. The solution adopted in the 'mountainous environment, will be to build permanent works, as we shall see, with a morphological repetitive scheme of the cannon sector. Thus, fixed casemates were built side by side - in varying numbers - with internal metal semi-cap shields and minimal opening cannon-embrasures, such as those at Fort Gorazda. Externally, the cannon-embrasures opened on an inclined plane: an idea of naval derivation. [19]

17

These types of forts, designed expressly for the mountain environment of Süd-Tirol and Carinthia, built of concrete or clad, depending on de case, also in granite, stone or porphyry, are called "Type Vogl" [20] after the Austrian officer who defined their role and form. They were also armed with a number of small-diameter armored dome mortars with a lowered lenticular cross-section. Nothing compared with the exceptional heaviness of the Gruson domes. The Vogl-type mountain forts are in fact still tied to forms that look toward the past. To encounter a more consistent use of concrete and, in fact, the modern Austrian armored dome type, we must go to the first decade of the twentieth century.

A first turning poin: Fort Airolo

The 1880s were of particular importance in the concept of permanent mountain fortifications. There is the particular case of Switzerland, which, as a small country situated between aggressive giants, had at that time the problem of modernising permanent fortifications. In fact, there was no school or officers with specific theoretical or practical training in the country. Precisely at the time of the construction of Fort Gorazda, between 27 March and 30 September 1885, several commissions working on fortifications were active in Switzerland, one of which presented "*... to the federal government, the project for a first nucleus of fortifications grouped around the Gotthard massif. Having taken the political decision to build fortifications, those responsible were faced with a number of*

Fig.17

Fort Airolo. View of the left side section of the ditch and the gorge front. Note the plastic forms of the cover and the caponieres for close defense. It's possible to see the rotating armoured dome on the top of the roof. At the middle of the rampart you can see the armored minimum cannon-embrasures.

Photo by the Author

19 See Paolo Bortot, *Morphology and Technology of the Austro-Ungarian Empire mountain forts on the Italian and German South-Tyrol in the 19th century: a path to modernity*, ed. Maria Rita Pais, Plan Barron. *A future for super-resistent structures* (Lisbon, 2024): 53-54.

20 The characteristics of Vogl-type forts are well described in Kurt Mörz De Paula, *Der Österreichisch-Ungarische Befestigungbau 1820-1914* (Wien: Buchhandlung Stöhr, 1995): 90-91.

practical difficulties, the first of which was "... the absence of Swiss specialists in contemporary fortifications." [21]

This fact resulted in emissaries being sent to all European countries with the task of studying *"the latest improvements in the Art of Fortification throughout Europe."* [22] The result was the construction of a first major work, Fort Airolo[**Fig.17**]. Three pre-projects were requested from three different planners, *"... from Captain Mougin, Major Schumman, and an opinion from Lieutenant Field-Marshal von Salis, a Swiss officer in the service of the Austro-Hungarian Empire."* [23]

In this competition, three of Europe's most important schools of fortification were thus compared: the French, the German and the Austrian.The latter was held in high esteem by the Swiss, imposing itself over the most modern that was then available on the fortification Market. Fort Airolo was built between the years 1887-1890, following the observations of von Salis-Soglio, [24] presenting at the same time, morphological and construction technique solutions derived from the European debate, but also, at the same time, solutions from the Austrian fortification school. This work testifies, at the same time, that modern construction solutions and materials from the European debate were known in Austria-Hungary. The result was the construction of a fort in the form of an enormous tortoise shell made of concrete covered in granite that housed the casemates with an inner shield and minimal cannon-embrasures, ammunition depots, technical rooms, and garrison quarters. At the top of the roof was a rotating armoured steel dome of the Schumann type with two 12cm cannons. In the sloping rampart front were the minimum cannon-embrasures for five 8.4cm cannons in casemates. At various points on the roof were four revolving retractable armoured turrets for 5.3cm rapid-fire cannon, and three revolving armoured observatories.

The set of solutions adopted completely realised the idea of a modern industrial fort. This work presents an irregular trapeze shape that adapts to the

21 *"... au gouvernement fédéral le projet d'un premier noyau de fortifications groupées autour du massif du Saint-Gothard. La décision politique de contruire des fortifications prise, les responsables furent confrontés à une série de difficultés pratiques. ...",* - la prima delle quali era n.d.A. - *"l' absence de spécialistes suisses en matière de fortification contemporaine."* Maurice Lovisa, "L'Exemple Suisse", in *Actes du colloque Séré de Rivières. Épinal 14-15-16 Septembre 1995* (Paris: Association Vauban, 1999): 249.

22 *"... les dernieres perfectionement dans le domaine de l'art de fortifier dans l'Europe entière."* In Lovisa, Actes du colloque Séré de Rivières, 251.

23 *"... au capitaine Mougin, au major Schumman et l'avis du lieutenant feld-maréchal von Salis, officier suisse au service de l'empire austro-hongrois."* Lovisa, *Actes du colloque Séré de Rivières,* 249-251.

24 Says Lovisa in this regard: *" ...les esquisses de von Salis furent en effet retenues."* Lovisa, *Actes du colloque Séré de Rivières*, 251.

Fig. 18
Fort Airolo. Detail of the sloping front section of the trapezoidal ditch. In the foreground, it's possible to see the semi-caponier and the caponier in the background.
Photo by the Author

morphology of the terrain. The defence of the front section of the ditch was entrusted to a caponier [Fig.18] protruding from the scarp wall located at the left corner between the minor (sloping) base and the oblique side of the trapeze. In front of the caponier is a semi-circular counter-scarp gallery with a rifle-embrasures The second inclined section of the trapeze, on the right side, was defended by a semi-caponier. Finally, a caponier - with a classical rectangular plan ending in a semi-cylinder - placed to the side of the entrance on the ravine side, with rifle-embrasures along the entire perimeter, implemented the flanking work of the residential casemate, and the path, embedded in the ground, for access to the fort.

19 - 20

Fort Airolo, is in fact the most modern armoured mountain fort in existence at the time. Although built in Switzerland, it can be considered a product of the Austrian 'Genie' school. There are in fact also typical traditional elements, already used, as we have already seen, in the fort for revolving armored tower, Turmfort Gorazda. The same to caponier in the ditch, with masonry of the arched scarp, the use of the semi-caponier, the introduction " in nuce " of the ditch flanking system with the construction of a semi-circular gallery with rifle-embrasures at the caponier, the use of masonry casemates with semi-caponier frontal shield with minimal gunnery (typically Austrian), the cladding of the articulated roof in very regular squared blocks of granite, the living quarters for the garrison on the gorge front and the defensive caponier on the side of the entrance.

The new is instead constituted by the abandonment of the symmetrical plan, by the introduction from the "tortoise shell" morphology of the fort, wich effectively build the idea of modern fort theorized by French Mougin. The new is also constituted from the roofing made with rounded joints between the various surfaces,but more importantly, from the installation of the twin-barrel rotating armored dome in steel **[Fig.19]** - no longer in cast iron - of lenticular shape. Finally, the ultra-modern technical equipment is completed with the inclusion, in the volumic mass of the fort, of the rotating retractable armored turrets for rapid-fire cannons and the rotating armored observers, also retractable. In summary, the fort is armed with the most advanced fortification armaments available in the European market at the time.

Fig. 19

Fort Airolo. Detail of the roof. Note: the aerators for air exchange, the revolving dome-observatory for the direction of fire, the modern twin revolving armoured dome.

Photo by the Author

Fig.20

Fort Mitterberg. View from the friendly side towards the mountain.

Photo by Author

The imperial Mountain Forts: Fort Mitterberg, Fort Garda, Fort Verle

As we mentioned earlier, the solution adopted among the mountains of the imperial territory between Tyrol and Carinthia was the "Vogl type." The forts built, although different in shape and size, were characterized by a typical morphological element, the presence of cannons placed in side-by-side casemates with a front armored cap shield placed internally, which presented on the outside a characteristic sloping plane protecting the battery. According to the author, of all of them, the most representative case, also because it still exists today and is embedded in a Dolomite territory of incomparable beauty is Fort Mitterberg. **[Fig.20]**

This was built between 1884 and 1889 at 1585m above sea level. Its function, combined with the purpose of Fort Heideck, was that of impeding the access to Sexten Valley from Fischlein Valley and from Monte Croce Comelico pass.

Fort Mitterberg, which still exists, has an irregular 5-sided plan, of which two sides form a 160-degree angle, salient toward the enemy **[Fig.21]**. In practice it consists of two functional blocks, which are then joined by two narrow corpses to form a single building with a small inner court.

One of the sides of the salient consists of the building body from the rectangular-plan armored battery with long side parallel to the mountain level lines. The external inclined plane of fair thickness is covered with granite blocks. Internally, there are 3 casemates with frontal armor formed by metal semi-cap shield with minimal cannon-embrasure. **[Fig.22]** There is then a second morphologically more articulated body, which housed on the cover a battery of 3 howitzers in 3 small revolving armored domes for indirect firing.

A small revolving armored observatory is placed on a conical structure built for purely functional reasons of bullet resistance. This was also originally covered with galvanized sheet metal. The building thus presents, from the enemy side, an articulated morphological structure.

Internally, the spaces are organized on three levels. A ground floor with warehouses, a second floor with rooms for the garrison and officers, and a third floor with fighting rooms.

21 - 22

Fig.21

View of the battle front with the two sides of the salient. A close-up of the linear battery block with the 3 minimum cannon-embrasures at the base of the inclined plane invented by Vogl for mountain forts. In second floor the articulated masses with the cone-shaped element at the top of which is installed the revolving armoured observatory.

Photo by the Author

Fig.22

Forte Mitterberg. Interior view of the armoured casemate with a semi-calotte with a minimal cannon- embrasure for a cannon Mod.80-12cm on pivoting support.

Photo by the Author

Externally, Fort Mitterberg looks like a very traditional building with facades clad in rustic "*opus incertum*" stone. The east elevation, in which the entrance door opens, has six large windows that give light to the garrison's living quarters. The north elevation, facing the mountain, features two levels of embrasures for close defense and ends in the east corner with a small tower that, at the top, houses an armored casemate for Belgian-made Montigny machine gun.

Two more machine gun casemates were located in the southeast (1 machine gun) and southwest (2 machine guns) corners of the works at the ditch level. Globally, the fort's armament consisted of 3 Mod.80 15cm howitzers in revolving armored domes, 3 12cm Mod.80 cannons with Mod.85 pivot-carriage, and 4 Montigny machine guns. The number of men in the plan garrison was 180 men of witch 3 officers, 17 petty officers and 82 artillerymen.

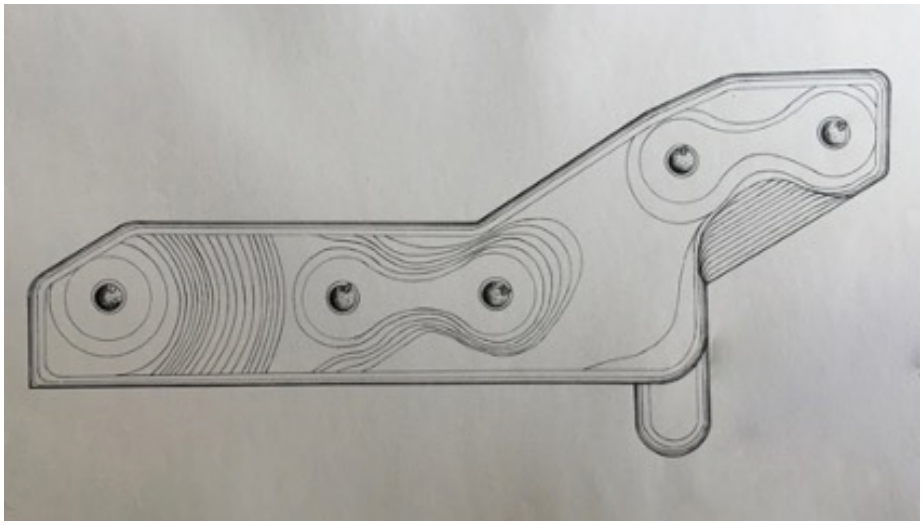
Fort Mittelberg, which outwardly looks like a classic fence, almost convent-like, presents the articulated volumetry of the fighting front determined by pure functional needs. It also presents the covering of the roof in galvanized sheet metal - one of the first cases at the European level. The plastic volume of the built work, integrated with the technical elements of heavy and light armament, the inclination of the combat front determined by the calculation of projectile penetration, and the complete absence of ornamental elements, make this building one of the most interesting examples of mountain military architecture of the second half of the 19th century. In addition, being installed in the casemate block of the cannons, the armored inner semi-cap shields with minimal cannon-embrasures, being still present the armored casemate of the Montigny machine gun in the turret and being still installed the armored observatory dome made of hardened cast iron, make this fort a unique case in the entire Süd-Tirol.

Fort Garda. The first expression of Brutalism.

The case that constitutes a turning point on the territory of the empire , is the construction of Fort Garda in fact the first truly modern armored fort built in Süd-Tirol. The construction technique adopted in some European countries was already part of the design and construction practice of the modern fort: building constructed entirely in concrete, basically a single inside excavated monolith, with integration of howitzers in revolving armored domes, cannons and machine guns protected by armored shields. Experiences made by the Austrians in the Kummersdorf polygon led to the discovery that concrete was stronger than granite. The shock of bullets exploded in it caused surface chipping but remained confined to the point of impact. Fort Garda was built for the purpose of experimentation in the use of concrete and steel.

The *Garda Werk* was constructed [25] between 1st September of 1904 and May 26th 1907 in the lower part of Monte Brione in the Riva Fortress. *"The*

25 *Rapportsplan über das Werk Garda*, Jahr 1907, KAW.



new building is characterized by a more rigorous application of the theory of the mountain forts and new techniques of construction.

It was built 153.50m above sea level on the southern side of Monte Brione on the edge of the vertical cliff that descends until the lake. The roof was built emulating the natural enviornment of the existing terrain, rendering it invisible from the enemy side. The roof had a thickness between 2.5 and 3.0 meters and lay on a continuos structure of steel IPE beams with a height of 35cm." [26]

The fort consists of a large building a formed by two sections, one larger, about 46 meters in length, and one smaller, about 24 meters. They are leaning against the mountain forming a 30-degree angle between them. Altogether they are about 70 meters long.

"The roof has an articulated and sinuous morphology. Its form, in correspondence of the howitzer battery, is made of two low pair of artificial small concrete hills with rounded volumes, at different levels, on wich the armored rotating domes were installed. [Fig.23]

At the end of the longest segment of the fort, that rose to the mountain following its profile towards north, was located the observatory of the commander, a small armored rotating dome. From here one can view the entire surrounding landscape.

Already during the project, the volumetry of the roof was designed with the level curves inherent to the topography. This highlights the concept of reconstruction nature." [27]

The main body of the building houses various technical rooms and garrison quarters with windows opening onto the narrow gorge ditch. [Fig.24], The rotated small body houses a combat gallery with oriented embrasures for small arms,

26 See Paolo Bortot, *Morphology and Technology of the Austro-Ungarian Empire mountain forts on the Italian and German South-Tyrol in the 19th century: a path to modernity. Pais, Plan Barron. A future for super-resistent structures*, 63.

27 Pais, *A future for super-resistent structures*, 63.

Fig. 23
Forte Garda. The roof. Drawing by Architect PhD Paolo Bortot

on the mezzanine floor, and two casemates for 8 cm M05 rapid-fire cannons[28] with traitor function on the upper floor. In this section, located to the south, a machine gun was added after the completion of the work.

On the ground floor, there were garrison rooms and stores for large-calibre ammunitions. To the right of the entrance was the machine engine room with a petrol generator for the production of electricity for the interior lighting - with petrol storage - and the operation of the optical telegraph, telephone and search-lights.

The staircase connecting the various floors is located in the west corner of the main building at the compositional pivot point of the plan.

On the first floor of the fort, there was the optical telegraph, rooms for the garrison with relatively large windows and, in the shorter part of the building, the traitor cannons.

At the final part of the main facade - a quarter of a cilinder - and at the end of the short facade, we find the oriented rifle-embrasures towards the direction of fire determined geometrically by the shape (in front by the slope and in plan by the orientation) of each opening - embrasure - for the rifles used in close defence.

The second floor, from a planimetric point of view, is not very different from the first, but it radically changes the visual relationship with the outside space: here we find only form-orientated rifle-embrasures, in the elevation and plan, obtained with 'concentric' mouldings. It's a space specifically for combat. In the building's angular quarter-circle, there is an electric spotlight - Scheinwerfer - for the illumination of the space close to the outside during night-time combat.

From a morphological point of view, the fort's roof is extremely interesting. In the project, it was shaped as an "artificial nature" that follows the contours of

Fig. 24
Fort Garda. Wiew of gorge side.
Photo by the Author

28 *Rapportsplan über das Wek Garda, Jahr 1907*, KAW.

the terrain. [Fig.25], The plastic form of the building's exterior volumes allows the rotating armoured domes - positioned in pairs - to be harmoniously integrated with the concrete architectural structure. From the enemy side, the lake side, the building is completely invisible, with only the rotating armoured domes and the commander's rotating armoured observatory visible. On the friendly side - north and north-west - the roof is connected to the façades with simple curved lines, at some points in triple curvature.

The morphology of the roof, but also the entire building, can be well defined in the words of Bruno Zevi about the work of Eric Mendelshon: his expressionism, *"exalts the material and dramatically moves it to create a univocal formal message."* [29] What's more, *"... the interior form was excavated and the exterior sculpted to create a poetic image of organic compactness."* [30] The entire roof, which recalls the formal contour of fort Airolo, was covered by galvanized metal sheets, which once again places it, with the use of this new material, among the first cases of the application of this roofing technique in Europe.

The fort is extremly modern, but the concept of the nearby defence is from the 1800s. The construction shows a fundamental contradiction, it's a hybrid. That's why it's so important. It allows us to understand in depth the process of development of the form, between tradition and innovation. During the construction of the fort, the Austrian Armoury perfected the machine gun. In the same year that the building was inaugurated (1907), the Schwarzlose machine-gun Mod.07 8mm was launched. In the months before the outbreak of war, as the author's survey and observations show, this technological 'lack' was corrected.

The caponiere to the right of the entrance was enlarged with the addition of another volume containing two embrasures for two machine guns, one on each side of the ditch.

Next to the armoured casemates of the rapid-fire cannons, on the first floor, a embrasure was drilled for a third machine gun. [Fig.26] The heavy armament was installed on the roof that was full coverd with metal sheet finished

Fig. 25
Fort Garda. Main part from the gorge side. The contours of the roof follow the terrain.
Photo by the Author

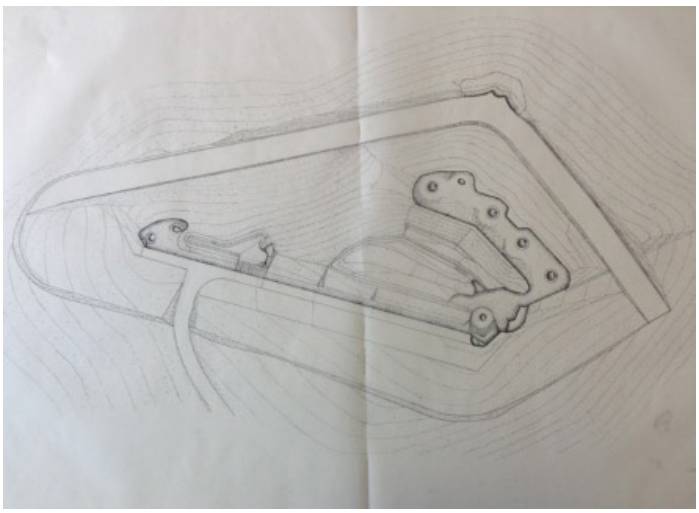
Fig. 26
Fort Garda. Front of the shortest side. The fort is built on a rocky base. The texture of the surface of the facade left rough after casting is evident, showing the patterns and joints impressed by the wooden boards. The morphology of the façade is determined by the interior spaces. The lower part houses the defensive tunnel for light weapons with oriented embrasures. On the upper level one can see the two holes that housed the cannon armoured plates with minimal embrasures for the "traitor" cannons. At the end of the facade one can see the MG Mod.07 machine-gun embrasure added later.
Photo by the Author

29 *"...esalta la materia e drammaticamente la muove per creare una scattante immagine in un univoco messaggio formale."* In Bruno Zevi, Storia dell'Architettura moderna (Torino: Einaudi, 1950): 154

30 *"...la forma interna veniva scavata e quella esterna scolpita per realizzare un'immagine poetica di organica compattezza."* Zevi, Storia dell'Architettura moderna, 156.

with zinc. This was composed by 4-10cm Mod.1899 modern howitzers, with 43 degrees elevation and 10 degrees depression, in rotating armoured dome. The fire was directed by a small rotating armored dome of the commander located in the higher point of the construction. After the building of the fort, 3 8-mm machine guns Schwarzlose Type Mod.1907 were installed for the short range defense. The existing caponiere was extended for 2 machine guns. A third machine gun was installed at the end of the west façade. The garrison was made up of 114 men: 6 officiers, 15 petty-officeirs and 93 soldiers.

The size of the construction, made of a large monolithic and articulated mass of concrete, is imposing. The entire construction is the result of a set of avant-garde construction techniques integrated with the most modern products of the Austro-Hungarian Empire's military heavy industry, with the effect of constructing a building among the most modern in Europe at the time, and at the same time partially reducing the backwardness of the construction technique of the Empire's permanent fortified works.



27 - 28

By the way, it should be noted here which Austro-Hungarian military Genie did indeed build an exclusively functional building. Let's remember that the first to design and build this type of fort, all in concrete, was the Belgian Brialmont, which built in Belgium the first armoured forts in Europe in the 1880s.

At the time of its construction, Fort Garda looked like an austere building without any decorative element. The compact design came from the adaptation to the ground. The big natural cliff constituted pratically an insuperable obstacle. The planned weaponry on the gorge side, rifles and machine guns, turning the work paratically unconquerable. The facades surfaces showed the characteristic texture of the beton brut with the natural veins of the wood.

The modern shape of the sinuous roof, connected with the façades by a quarter of the circle, was stemmed by plastic properties of concrete, by structural calculation and insatlled technology. Then, the fort appeared as a powerful war machine that integrated the most advanced elements of the technologies and techniques of passive and active defense of the time. This coud be considered, by its architectural and morphology elements, the precursor of European expressionist architecture and of the brutalism.

Fig. 27
Fort Verle. General plan . Designed by Architect PhD Paolo Bortot

Fig. 28
Fort Verle. View of gorge side. Photo by the Author

Fort Verle. The stateof the art of the austrian aromoured mountain fort.

Fort Verle represents a concentration of values rarely found in the history of architecture. It was built immediately after the Great War, finally applying the most up-to-date theoretical and construction principles of the armoured mountain fort in practice. It was the one that resisted the overpowering Italian artillery and troops most strongly, in fact making itself the protagonist of one of the bloodiest battles in a single attack.

The Fort Verle[31] **[Fig.27]** was built at 1506m a.s.l., between 22 October 1908 and 30 April 1913, on the back of the meadows of the Vezzena pass near Malga Verle. It was a modern armoured fort. According to the author, it is the most important example, both of the mountain armoured fort type and for its historical value, being the theatre of well-documented cruel events for the Austrian officer Fritz Weber, but also for Luis Trenker, which graduated in architecture in Graz after the war. Let's remember here that historical value, as defined by Alois Riegel, deriving from the ability to recognise an architectural object that is in front of us.

The Fort Verle consisted of five main elements connected to each other: (1) the main casemate - Wohnkasamatte - **[Fig.28]**, consisting of two overlapping floors with a long rectangular plan; (2) the complex of armoured casemates and one coffre - placed at the eastern side of the fort - with the function of flanking the Luserna fort and for close combat; (3) the fixed armoured casemates installed for close combat on the opposite, western side; (4) the howitzer battery block; (5) the work for flanking the ditch situated in the counterscarp at the top of the salient.

The habitational casemate had a very long rectangular plan. The spaces for the troops were placed at three different levels to follow the contours of the terrain. The fort practically had an east-west orientation. On the east side, in the direction of the Vezzena meadows, the flanking armament, which in this case was particularly abundant, was placed in the first floor; two 8 cm Mod.05 rapid-fire cannons were placed in two casemates with armoured shields. Their action was in an easterly direction towards the road from the Asiago plateau. In the same position, at the south angle of the short side, was a one- floor coffre. On the first floor, immediately to the side of the rapid-fire cannons, in the rounded corner of the building, it was housed 4 machine guns in pairs behind armoured shields. In the opposite side (west), at the end of a long corridor, a close combat position was reached, characterised by two fixed armoured casemate, armed with four 8mm M07 MG machine guns. **[Fig.29]**, The habitational casemate - Wohnkasamatte - had a long corridor on the side close to the rock, opening onto the bedrooms and technical rooms. On the ground floor, starting from the west side, there was a real bathroom, two large garrison rooms, the

31 *K.u.k. Geniedirektion in Trient. Rapports Plan des Werk Verle. Übersichtsplan 1:400 Lit. A Trient, im Feber 1913 Planer und Erbauer Haupt. Lehmayer.* KAW.

accumulator room, the machine room, the workshop, the kitchen, the medical officers' room, the infirmary room and the entrance to the guard post. After the guard post we find combat spaces placed in the gorge coffer [Fig.30], and further inside we find the supply depot and two storerooms, one for the genie material and one for the artillery material. On the upper floor we found the same bathroom, large rooms for the garrison and rooms for the officers. Next to the staircase was the telephone room. A staircase led up to the block of fighting casemates armed with the forementioned 8 cm cannons and machine guns in pairs housed in the gorge coffer. On top of the armoured roof, the commander's rotating armoured observation dome was in a dominant position.

On the first floor was the entrance to the howitzer battery. This was made up of a monolithic block set into the rock, forming an angle of around 30 degrees with the main work of the fort. The same block then had a second rotation angle of 30 degrees.

29 - 30

The battery therefore consisted of three aligned armoured domes and a fourth armoured dome slightly further back from the others. Here, in a more forward position as the theory predicted, a second fixed armoured casemate with machine-guns was also installed with defensive and observation function. A strong flanking installation was present on the counter-scarp of the ditch. This was powerfully armed with two pairs of 6cm Mod.10 rapid-fire cannons behind an armoured shield for the use of signal guns.

At the start of the war, the fort had two officers, three petty officers and a medical officer. *"There are more than two hundred artillerymen and a hundred sappers from Genie... people from Upper Austria, Salzburg and Tyrol. …These important positions have been assigned to very loyal troops."*[32] The cost of the fort was 1.834.585 crowns, of which 33.708 was for the land, 1.735.421 for the construction, 17.742 for the furniture and 43.813 for the administration.

The building looks like the result of calculation, the application of concrete and the installation of chromium-hardened steel armour. To understand life in an Austrian fort at the beginning of the 20th century, we strongly recommend to read the text by Fritz Weber cited in the note. Here we find a detailed description of the fighting which brought the men close to exhaustion. Weber recalls the situation in the fighting, in which *"the concrete vibrates like bronze ...a man, at best the upper part of a human body, ...is on the ground.... Two, three men come*

Fig. 29

Forte Verle. Wiew of the gorge side of the fort. On the roof to the right is the rotating armoured commander's dome for the direction of fire. To the left of the photo the outlines of the howitzer battery domes emerge from the ground.

Source: KAW - Bortot (2005), p.156

Fig. 30

Fort Verle. View of the gorge coffre. On the first floor - in the centre of the photo - one sees the armoured shield with two embrasures for 8mm Mod.07 machine guns. On the ground floor - on the left of the photo - one can see the gorge coffre placed to protect the entrance.

Source: KAW - Bortot, (2005),p.157

32 *"Si tratta in gran parte di elementi giovani, sui quali si piú contare: gente dell'Austria superiore, del Salisburghese, e del Tirolo. … Si sono volute affidare queste importanti posizioni a truppe fedelissime."* Fritz Weber, Tappe della disfatta (Milano: Mursia, 1965): 8.

towards us, staggering, their faces black with smoke, their eyes wide open."[33] On the outside, another spectator who witnessed the battle, the Austrian writer Robert Musil, notes : *"War. At the top of the mountain. Behind the sentry barrage you walk like a tourist. Heavy artillery firing at the distance. At intervals of 20, 30 seconds and more, it reminds you of the boys which at a great distance are throwing stones at each other. ... Grenades explode in the back of Vezzena's collar. Bad black smoke from a house which has been burning for minutes. Too bad for Lavarone's poorly decorated landscape."*[34]

The observations of the Viennese Robert Musil, a young officer at the front of the Italian Süd-Tirol, remind us of the war situation in which the young men of yesterday found themselves. Another Viennese, Friz Weber, recalls how the limits of human suffering were reached: *"Every explosion has the effect of a powerful fist to the head. The ears whistle, the veins in the forehead harden, blood comes out of the ears. ... Six hours spent in the observatory serve to atone for all the sins which a man can make in the course of his life."*[35]

The extreme harshness of the fighting and the tragic efficiency of Fort Verle as a war machine are testified to by the plaque on the side of the Passo Vezzena road in memory of the assault of valiant force attempted by the Italian troops on one of the most heavily defended points of the Italian-Austrian front. The following is written on it: *"On the night of 25 - 8 - 1915, the infantrymen of the 115 Treviso, attempting with pertinacious impetus the road to Trento on this hill, devoted their lives and blood to the redeeming victory. Fallen: 43 officers, 1048 infantrymen."*

The fort was in fact heavily armed. The heavy armament consisted of 4 Skoda Mod.09 10cm howitzers in a revolving armoured dome, 2 Mod.05 8cm rapid fire cannons behind a fixed armoured shield, 4 Mod.10 6cm rapid fire cannons behind a fixed armoured shield, 1 machine gun in a revolving armoured dome - the commander's - and 14 machine guns in fixed armoured metal casemates or behind an armoured shield. The planned garrison consisted of 1 officer and 30 men of the Landesschutzen, 4 officers and 167 men of the fortress artillery, 3 sappers, 3 telephonists, 1 doctor and 1 nurse. On the date of entry into the war, the effective garrison of Fort Verle consisted of two officers, 3 petty-officers and 1 medical officer.

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33 *"Il cemento armato vibra come bronzo. ... Un uomo o piú precisamente la parte superiore di un corpo umano, ...giace a terra...Due, tre uomini ci vengono incontro, barcollando, la faccia nera di fumo, gli occhi sbarrati."* Weber, *Tappe della disfatta*,14.

34 *"Guerra. Sulla vetta di una montagna. Dietro lo sbarramento di sentinelle si va come un turista. Duello lontano di artiglieria pesante. A intervalli di 20, 30 secondi e piú, rammenta ragazzi che a grandi distanze si buttano sassi addosso. … Granate scoppiano nella gola dietro Vezzena; brutto fumo nero come di una casa in fiamme incombe per minuti interi. Pena per il povero inghirlandato paesaggio di Lavarone."* Robert Musil , *Diari. 1899-1941* (Torino: Einaudi, 1980): 465.

35 *"Ogni scoppio ha su di noi l'effetto di un poderoso pugno alla testa. Le orecchie fischiano, le vene si inturgidiscono, il sangue esce dalle orecchie. ... Sei ore passate nell'osservatorio servono a espiare tutti i peccati che un uomo normale puó commettere durante tutta la sua vita."* Weber, *Tappe della disfatta*, 33.

Conclusions: Brutalism ad a necessity

This article, which deals with Austrian fortifications in Süd-Tirol, deals with eight forts which, according to the author, represent milestones in the construction of fortifications, particularly mountain fortifications, taking up some of the questions presented at the Lisbon Congress on 7 November 2023.

The objective is to show a path through which, in an empirical-practical way, people are drawn to the construction of fortifications that are placed high in the history of modern architecture. The theme, but also the territory descrived, proved to be extremely complex. This was due to the events in the region, which is situated at a truly strategic point, that has not a despicable historical density.

The forts described here therefore show us the long road of modernisation taken by Austrian officers, which culminated in the construction of efficient and modern armoured mountain forts that were invincible during the fighting of the Great War.

In particulary, the historical period between the end of the 19th century and the beginning of the 20th century, when modern armoured forts were built, was characterised by great technical development. We find inventions such as the electric light bulb, the radio, the telephone, the cinema, the internal combustion engine, the automobile, the dreadnought battleship and the aeroplane. In the industrial field, the first assembly lines led to a significant increase in production. At the same time, industrial processes ensured ever more perfect productions of the same objects in large series.

In the artistic field we find the birth of the isms: cubism, futurism, expressionism, among others. Cities were rapidly increasing in size and population. Life became chaotic and in continuous movement. Wrote Robert Musil - of whom, during the war, we will find testimonies of the fighting at the Austrian Fort Verle -: *"Air trains, overland trains, underland trains, pneumatic mail, automobile chairs, ...very fast lifts pump masses of men vertically from one traffic level to another..."*[36]

In the Austrian panzerwerke of the early 20th century, we find the use of the telephone, the telegraph, the optical telegraph, the internal combustion engine, the machine gun, howitzers in revolving domes, fixed armoured metal casemates, armoured metal shields, in a context of perfect integration of heavy weapons technology, steel technology and concrete construction technology.

The complete absence of decorative elements and the total integration of form, function and elements of technology place these buildings squarely in the dimension of modernity. Forte Garda was the first among them.

The tragic events of the Great War closed that parenthesis of apparent calm and serenity of the Belle Époque.

The time and world described by Stefan Zweig: *"was an orderly world, with*

36 *"Treni aerei, treni sulla terra, treni sotto terra, posta pneumatica, catene di automobili, ... , ascensori velocissimi pompano in senso verticale masse di uomini dall'uno all'altro piano di traffico..."* Musil, *Diari. 1899-1941*, 465.

clear stratifications and comfortable passages, it was a world without haste. Not only was haste considered inelegant, but it was a superfluous reality, because in that staid bourgeois world, with its innumerable cautions and precautions, things never happened suddenly..." [37] The Austro-Hungarian Empire, after hundreds of years, the place where everything happened without haste, ended.

The military buildings presented are certainly anticipators of modern architecture and, at the same time, bring up some typical urban planning issues such as the direct observations made to recognise the site - strong position - to be fortified: it is a question of analysing the territory on a large scale and the relationships between the various buildings which were linked by a communications network. The final point of this fortification activity, the construction of the fortifications entirely in concrete, beginning with Forte Garda, is strongly emphasised.

From an architectural point of view, the plastic forms extend organically into the terrain. The roof is plastically connected to the vertical elements with rounded elements. The same goes for the casemates: all edges are avoided as they are easily damaged by the projectiles and allow them to slide without damage.

The shape of the forts from the last period, particularly the Verle fort, is remember some of the sketches by Erich Mendelsohn, one of the founding fathers of Expressionist architecture. In his Einsteinturm he built exactly the plastic forms linked by curved elements which can be found in some Austrian forts, especially in the Garda and Verle forts. Even Rudol Steiner, in the first version of the Goetheanum, designed the element above the entrance, which appears frontally as a German helmet, but laterally is a practically exact quotation of the shape of a fixed armoured casemate which can be found in the Verle fort or also in the observatory at the top of Vezzena. In the second version of the Goetheanum, concrete appears as the leitmotif of the construction: it was the practical response to the fire in the first almost-finished building.

The modern Austrian armoured forts in Süd-Tirol have a concrete structure that is coherent with the function of the building, eliminating every temptation for ornament. The form is generated, as we have seen, to respond to the technical problem of installing the armoured steel and defence elements, which can make some constructions of the Modern Movement palid.

The aspirations of Futurist paper architecture are fully realised here in concrete and steel, using raw, bare material, without predetermined solutions, thus fully realising the aspirations of Antonio Sant' Elia expressed in his manifesto of Futurist architecture of 11 July 1914. Even Boccioni, in his manifesto for futurist architecture, wanted a radical renewal of architecture through a return to necessity. The Austrian armoured forts, with their elemental and pure materials, designed without decoration, represent exactly that, brutalism as necessity.

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37 *"era un mondo ordinato, con chiare stratificazioni e comodi passaggi, era una realtá supérflua, giacche in quel saldo mondo borghese, con le sue innumerevoli cautele e previdenze, non accadeva mai nulla all'improvviso..."* Stefan Zweig, *Il mondo di ieri. Ricordo di un europeo.* (Mondadori: Milano, 1947): 39.

Bibliography

Bortot Paolo. *Progetto e memoria: il forte scomparso di Pannone nell'ambito della fortezza di Riva del Garda*, in AA.VV. *I Forti austroungarici nell'Alto Garda: che farne? Atti del Convegno.* Forte superiore di Nago 27 febbraio-2 marzo 2002. Riva, Museo Civico Riva del Garda, 2003.

Bortot Paolo. *I Forti del Kaiser. Opere corazzate nel Sud-Tirolo italiano.* 1900-1915. Bassano del Grappa: Tassotti Editore, 2005.

Bortot Paolo , *Technical evolution and modernity of the Austrian South-Tyrolean imperial Forts on the italian borders*, in *HERITAGE 2016*, edited by R. Amoeda, S. Lira, C. Pinheiro. Barcelos Green Lines Institute , 2016.

Bortot Paolo, *Morphology and Technology of the Austro-Ungarian Empire mountain forts on the Italian and German South-Tyrol in the 19th century: a path to modernity. Plan Barron. A future for super-resistent structures*, edited by Maria Rita Pais. Lisbon: 2024.

Bozzetto Lino Vittorio. *Verona. La cinta magistrale asburgica.* Verona: Cassa Risparmio Verona Vicenza Belluno e Ancona, 1993.

Brunner von Moriz Ritter. *Leitfaden für den unterricht in der beständigen Befestigungen. Zum gebrauche in den k.und k. Militär-Bildungs-Austalten*. Wien: Verlag von L.W. Seidel and Sohn, 1896.

Concina Ennio. *La macchina territoriale*. Roma-Bari: Laterza, 1983.

De Paula Kurt Mörz. *Der Österreichisch-Ungarische Befestigungbau 1820-1914*. Wien: Buchhandlung Stöhr, 1995.

Lovisa Maurice. "L'Exemple Suisse". In *Actes du colloque Séré de Rivières. Épinal 14-15-16 Septembre 1995*. Paris: Association Vauban 1999.

Massimo Dario. *La Fortezza*. Bressanone: Weger, 2010.

Musil Robert. *Diari. 1899-1941*. Torino: Einaudi, 1980.

Prost Philippe, (Ed.). *La Fortezza incompiuta*. Milano, Electa, 1989.

Rotterdam da Erasmo. *Elogio della follia*. Milano: Mursia, (15111), 1966.

Stefano Pinotti. *Festung Trient. Le Fortificazioni di Trento e il relativo periodo storico*. Schio: Gino Rossato Editore, 2011.

Tilschkert Viktor. *Neue Formen der Panzer Fortification.* Wien: L.W.Seidel e Sohn, K.u.K. Hof-Buchändler, 1902.

Zevi Bruno. *Storia dell'Architettura moderna.* Torino: Einaudi, 1950.

Zweig Stefan. *Il mondo di ieri. Ricordo di un europeo*. Mondadori, Milano, 1947. Weber Fritz. Tappe della disfatta. Milano: Mursia, 1965.

Documents

Project drawing *"K.K. General Genie Inspektor, Monte S.Rocco bei Trient. Wien am 23 Juni 1881, 1/500"*, Fondo K.u.k. Geniedirektion Trient. Archivio di Stato Trento. Rapportsplan über das Werk Garda, Jahr 1907, KAW - Kriegsarchiv Wien.

K.u.k. Geniedirektion in Trient. Rapports Plan des Werk Verle. Übersichtsplan 1:400 Lit. A Trient, im Feber 1913 Planer und Erbauer Haupt. Lehmayer. KAW - Kriegsarchiv Wien