European Military Heritage: Henri Alexis Brialmont From Belgium to Romania

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ABSTRACT

H.A. Brialmont a key military architect, instrumental in shaping the military architecture in Belgium and Romania, had notably influenced the sovereignty of both countries through his military designs and defense advisory roles.

This internship targets the study of Brialmont's military fortifications, emphasizing their role in the narrative of European heritage.

Why Brialmont?

His work symbolizes the emergence of a unified European concept, marked by significant military and technological advancements. The research, conducted in Belgium, compares Brialmont's fortifications with those in Romania to identify sustainable conservation practices. This analysis aims at integrating these historical sites back into the community, highlighting their importance in contemporary Europe.

A key initiative of this internship is the development of a new methodology for the remote detection of military fortifications, utilizing open-access data to bridge the gap between scientific research and practical application. This innovative approach offers a scalable, cost-effective tool for heritage conservation, moving towards a community-centric model of preservation.

The focus extends beyond historical analysis to practical conservation efforts. Research conducted in Belgium on Brialmont's and early 20th-century fortifications aims to uncover construction techniques and deterioration factors, with an eye towards sustainable preservation methods. Comparing these with Romanian counterparts, the goal is to identify adaptive reuse strategies that can reintegrate these sites into modern communities, emphasizing their relevance in today's Europe.

Ultimately, the internship seeks to shift from traditional, expensive conservation methods to a community-driven model that fosters widespread engagement and preserves the shared heritage of European history.

This effort aligns with the broader goal of redefining conservation practices, fostering a collective approach to safeguarding Europe's shared historical legacy.

Keywords: H.A.Brialmont, fortifications, military heritage, European heritage

INTRODUCTION

Henri Alexis Brialmont was one of the key figures of the Belgian military modernization and reform in the mid-19th century, being a strong advocate for the "Belgian Redoubt" defensive doctrine as well as a promoter of international Belgian power projection. Brialmont created and oversaw the construction projects of the Antwerp, Liege and Namur defensive lines, and the Bucharest defensive lines in the Kingdom of Romania, a task that was initially given to the German Armed Forces but cancelled to potential political repercussions from the Austro-Hungarian Empire.

Despite a strong opposition by the political scene in Belgium and it's preference for neutrality, Brialmont undertook this daring offer and became a private commissioned military advisor the crown of Romania. This move, subsequently influenced the Balkan Geopolitics by solidifying the Kingdom of Romania – dwarfed between three Super Powers – as a local emerging Powerhouse which would later come to be the mediator between the belligerents of the Balkan Wars.

His work played a key role in the defense of the Kingdom of Belgium during World War 1 and World War 2, as well as providing Romania with the necessary tools to project it's own presence in the global scene.

The power projection culminating in 1911 with the Japanese delegation visit at the Fortified Belt of Bucharest led by General Maresuke Noghi the Admiral of the Battle of Port Arthur.

1.1 The Fortified Belt of Bucharest

Nonetheless, with the start of the 1st world war, the "Bucharest Redoubt" proved to be instrumental for the fast re-deployment of the Romanian troops through the country serving as a logistic hub between fronts. But ultimately, with the overwhelming odds staked against the Kingdom of Romania and the news of the aftermath of the Siege at Liege and Namur, the Romanian forces abandoned the Bucharest fortifications before they could be besieged by the German forces.

The Fortified line never saw active service in combat throughout the rest of the war. During the inter-war period, the forts have been deemed unsuitable as fortifications and the decision was made to convert them into garrison and supply hubs. During the 2nd World War, the Fortifications have been used exclusively as military storage depots and Anti-Air Defense Emplacements. Throughout the Cold War these sites would fall into obscurity with half of them being decommissioned and abandoned. Although the Forts never saw combat, their implication and influence over the statute of the Kingdom of Romania played an undeniable role in the history of the country, the Balkans and ultimately the history of Europe.

1.2 Present Day Situation

In present day, half of the Romanian Fortifications oversaw by Brialmont are in a dilapidated state, with advanced traces of deterioration. The question is:

If these are truly a dead monument of a by-gone era or if they are very much alive, and if so, how can we reintegrate them into the local communities and into the modern-day social and political context?

As such we shall look and compare these Romanian forts with their Belgian counterparts. Understanding how Belgium dealt with their Military Heritage, could help at establishing plans for the reintegration of the Romanian military heritage in the present day community and relevance. Moreover, a comparative look at the evolution and deterioration of both Romanian and Belgian military sites can prove beneficial for both parties, from a heritage safeguarding point of view.

RESEARCH AND METHOD:

In this article we will discuss the survey campaign conducted at Fort 7 Wilrijk (part of the Antwerp defensive line) and Fort Breendonk (not part of Brialmont's designs, but is part of the same defence doctrine), for drawing parallels and identifying factors in the deterioration of the forts. After which, a comparison between some similar conservation issues will be made between the Belgian and the Romanian forts.

For this, we will employ a mix of in-situ and remote (remote sensing/satellite) data acquisition. For the in-situ we will primarily be interested in environmental data such as:

- Measurements of humidity inside the Fort buildings
- Measurements of humidity outside the Fort buildings
- Correlation of data with Satellite information.
- Assessment of Water damage – Moisture inside the materials (such as salt deposition)

The scope is to document the construction materials and their integrity. By documenting the materials use for the building of the structure, a comparison between the satellite data and the in-situ data can be made, as such the information can serve as a template for future projects. As well as a good indicator of deterioration causes for other military heritage sites.

While the scope of this research may encompass broader applications, its primary focus lies on Military Heritage sites, specifically bunkers and fortifications. The decision was taken with consideration towards the historical context of Two World Wars and the Cold War, during which military installations became alienated from local communities and subsequently abandoned upon decommissioning. These alienated decommissioned military heritage sites often suffer from neglect and obscurity in the public domain. Their status remains ambiguous at best and poses potential hazards at worst, especially when these sites undergo advanced deterioration or inadequate demilitarization procedures post-decommissioning.

Furthermore a note shall be made that during the survey campaign the weather tended to be cold and rainy, as such we can only appreciate the data In relation to the rainy seasons of Belgium.a tellus. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas.

FORT 7 WILRIJK CAMPAIGN:

Fort 7 Wilrijk – Part of Brialmont's Antwerp Line. The site contains a series the original Brialmont designed fort as well as modifications realised by the Germans During WW2 and by the Belgian Army during the Interwar period. Today the fort site is a natural habitat for bats, providing suitable hibernation conditions due to it's suitable microclimate.

The survey campaign of this site revolves around collecting environmental data, respectively humidity and moisture data.

Two approaches have been used for this:

- Passive data logging of humidity and temperature inside the fortress.
- Active moisture measurement inside the fortress.

The idea behind this campaign was to observe the impact of humidity/moisture on the deterioration of the construction materials, the effects on the fortress microclimate as well as the suitable spots for bat hibernation.

3.1 On Site Documentation & Observations

The first observations that must be made regarding this site is the fact that there are 3 main historical layers that need to be taken in consideration.

The 1st layer is the original construction. A massive fortress build by stone, mortal and red-brick, All oft this servers as an utilitarian emplacement keeping simple and efficient, yet one of the marks of the signature styles for Brialmont. Is the addition of certain types of "Royal" decorations and accents.

While this isn't a necessary piece of information relevant to the article, it is a subtle "nice touch" that has been noted.

This site is surrounded by defence ditch filled with water (Fig.1). By this combination of water and a very extensive and heavy fortification secluded like an island, we can already speculate the presence of an extremely wet environment.

Fig.1. (Google Earth)Satellite view of the Fortification and surrounding ditch.

The second historical layer is the WW2 German additions brought to the Fort, such as the reinforcement with concrete of key defensive positions, the addition of a barrack and officer quarters vis-à-vis rom the fort's main entrance and many more alterations of different areas (but we won't go into details as it is beyond the scope of the study).

The third historical layer is the post-WW2 military designation of the fort, most of this period would see the addition of more modern elements to the fort, but it is unclear to what extent the fort was modified in that period, as it would be almost indistinguishable from the modernisations brought by the Germans during WW2.

Logging Summary

Highest :	17.3 °C / 82.2 %	**Start Time :**	2024/01/26 08:57:47
Lowest :	5.2 °C / 65.8 %	**Stop Time :**	2024/01/29 14:12:47(temporary)
Average :	6.3 °C / 72.8 %	**Elapsed Time :**	3d 5h 15m
MKT :	6.4 °C	**Data Points :**	310
Alarm At(Te):	N/A	**Alarm At(Hu):**	N/A

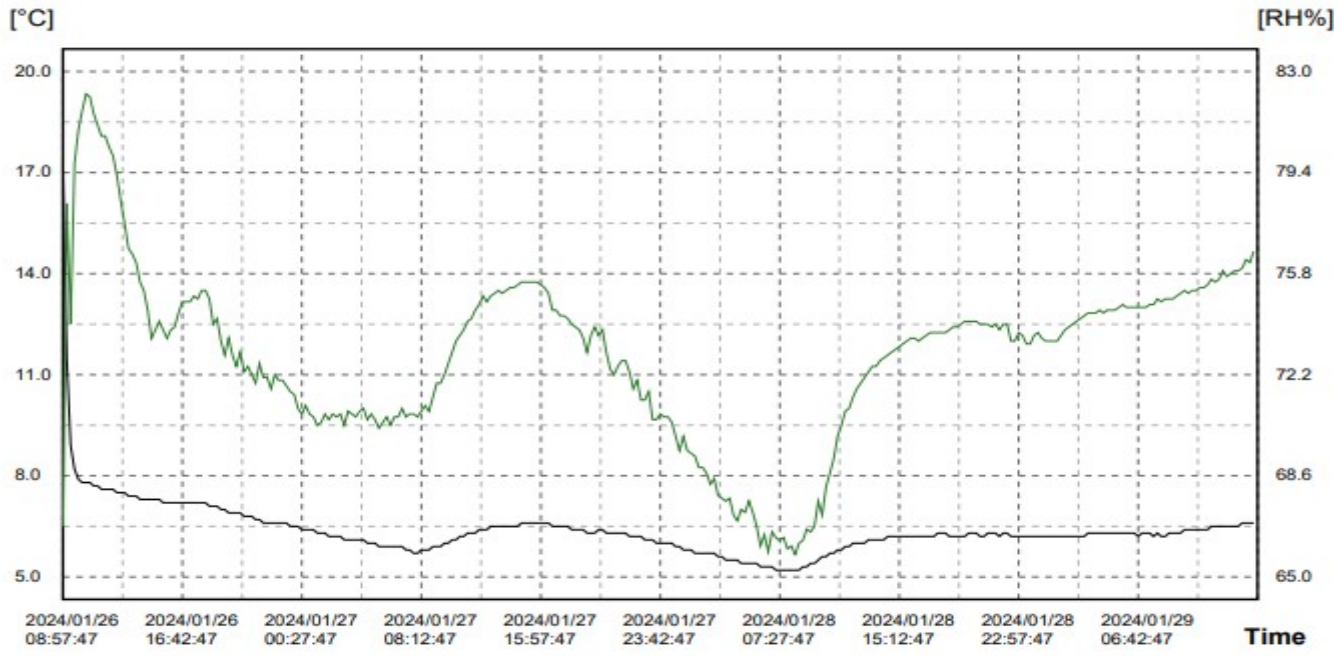


Fig. 2.Recorded Humidity and Temperature data over the period of 4 days.

During the campaign the campaign 2 data loggers have been used to record the Relative Humidity (RH) and the Temperature (ºC), the First data logger has been placed in the interior, ground floor of the fortress and left to monitor the data over a period of 4 days. The second data logger was moved throughout the fortress in order to register the Relative Humidity. Additionally a Resistance Meters (Pin Type Moisture Meter) has been used to record the Moisture inside the Fort. A soil pH, Temperature and Moisture measure was also planned directly next to the walls of the fort, but this was cancelled due to the lack of relevance of the data, the pH of the rainwater is generally mildly acidic, and the Soil acidity of Antwerp is known to be on average below 5.5, based on the European Commission's Institute of Environment and Sustainability, as such an acidic environment is expected. The only relevant data would have been the moisture content in the soil but due to the weather conditions it would have made little sense to collect soil moisture data.

Stationary Logger			Mobile Logger		
Hours	Temperature	Relative Humidity	Hours	Temperature	Relative Humidity
09:12:47	11.5 °C	78.3 %	09:12:47	15.2 °C	63.2 %
09:27:47	8.9 °C	74.0 %	09:27:47	13.8 °C	67.6 %
09:42:47	8.2 °C	79.7 %	09:42:47	13.8 °C	66.5 %
09:57:47	7.9 °C	80.9 %	09:57:47	13.5 °C	64.9 %
10:12:47	7.8 °C	81.6 %	10:12:47	13.4 °C	65.2 %
10:27:47	7.8 °C	82.2 %	10:27:47	13.1 °C	64.1 %
10:42:47	7.8 °C	82.1 %	10:42:47	12.8 °C	61.2 %
10:57:47	7.7 °C	81.5 %	10:57:47	14.2 °C	67.1 %
11:12:47	7.7 °C	81.1 %	11:12:47	15.4 °C	66.4 %
11:27:47	7.6 °C	80.7 %	11:27:47	15.9 °C	63.8 %
11:42:47	7.6 °C	80.7 %	11:42:47	16.4 °C	61.4 %
11:57:47	7.6 °C	80.3 %	11:57:47	16.8 °C	56.1 %
12:12:47	7.6 °C	80.0 %	12:12:47	17.1 °C	52.1 %
12:27:47	7.5 °C	79.3 %	12:27:47	17.2 °C	48.9 %
12:42:47	7.5 °C	78.4 %	12:42:47	17.2 °C	51.6 %
12:57:47	7.5 °C	77.6 %	12:57:47	15.1 °C	44.5 %
13:12:47	7.4 °C	76.7 %	13:12:47	15.3 °C	41.7 %
13:27:47	7.4 °C	76.5 %	13:27:47	16.3 °C	44.5 %
13:42:47	7.4 °C	76.2 %	13:42:47	16.5 °C	47.1 %
13:57:47	7.3 °C	75.5 %	13:57:47	17.0 °C	48.8 %
14:12:47	7.3 °C	75.2 %	14:12:47	17.7 °C	48.8 %

As observed in the Table, the Mobile Logger is on average 7.92°C warmer and has a relative humidity that is 22.58% lower that of the stationary one. The mobile logger has been use throughout the the Fort to map the micro-climate of the inner keep. Considering the new designation of the Fort as a Bat Hibernation Natural Reservation, it was important to observe under which conditions certain parts of the fort an offer suitable hibernation spots for the bats. Most of the readings from the mobile logger have been collected from the 1st floor of the main inner keep of the fort, which have been noted for hosting hibernating bats in the past years, although in recent times their number kept decreasing, this year, no Bat has been spotted on this floor.

Stationary Logger			Mobile Logger		
Hours	**Temp**	**RH**	**Hours**	**Temp**	**RH**
11:12:47	7.7 °C	81.1 %	**11:12:47**	15.4 °C	66.4 %
11:27:47	7.6 °C	80.7 %	**11:27:47**	15.9 °C	63.8 %
11:42:47	7.6 °C	80.7 %	**11:42:47**	16.4 °C	61.4 %
11:57:47	7.6 °C	80.3 %	**11:57:47**	16.8 °C	56.1 %

Considering these significant differences, we can expect a reading error of ±2-4 ºC (with an internal machine error of about 0.50-1.00 ºC).

Even so judging by the data collected and it's difference, it can be noted that the ground floor proves to be a much suitable environment for the bats, providing a low temperature as well as a generally high humidity. On the other hand, the 1st floor of the fort has significantly less RH, even in the scenario in which temperatures are actually lower and the average RH of the 1st floor has an error of -10%, which would still be lower by 10-20% than the Ground Floor. This difference in temperature can only be explained by the water infiltration into the structure, with the ground and upmost top levels of the fort providing the lowest temperatures with highest RH (due to the earthwork present on the roof of the fort), while the mid-point between these extremities (in our case the 1st floor) provides a more temperate micro climate with generally less humidity. The Moisture Meter data further supports this theory with a general reading of 14-23% moisture content in the walls of the main corridors of the 1st floor, an average of 20-26% moisture content in the walls of the rooms oriented to the outer side of the Fort, and lastly an average of 26-40% moisture content was in the area of the room's windows (most of the 30-40% reading have been detected in the higher parts of the walls, with some readings of 16-26% in the lower parts).

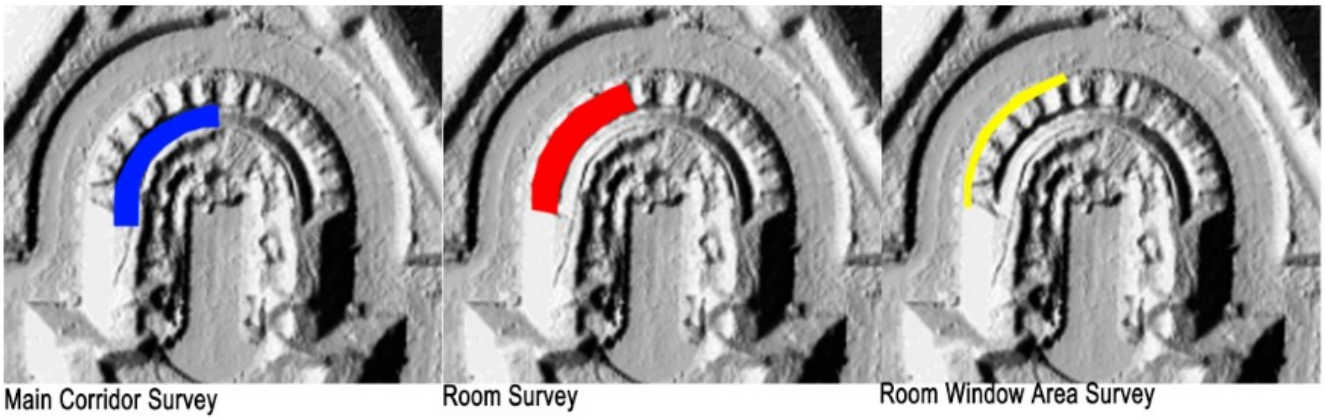


Fig. 3. Survey Areas for the Moisture Detection

By this observations we can establish that the 1st floor only contains relatively high RH due to the general climate trend but the micro climate itself is relatively low in moisture content and subsequently low in Relative Humidity. This does explain the lack of interest in the Bat's choice for hibernation, as the 1st floor would prove to be too unstable in term of Relative Humidity fluctuations.

However, the moisture content detection indicate that the extremities of the exterior walls present a very high percentage of moisture content, and considering the acidic nature of the water in this region, a questing regarding the damage towards the integrity of the wall structure is raised. Most period accurate mortar recipes use a mix of Calcium Carbonate (CaCO3) with

sand and other additives of choice. On it's own this doesn't mean anything. But in the context of low pH water and salts carried by the water from the soil into the walls, the Calcium Carbonate can in fact transform into Gypsums and start to "leach out" causing loose of aggregation of the mortar as well as plastic deformation, which in time would mean that the bricks will start to detach from the walls. This case can be seen in the Fort in areas which had a draining system mounted.

Fig. 4. Detached Brick Layers caused by the leaching of mortar from the wall

And this degree of damage could be also seen in the German "modernized" additions brought to the fort. Although regarding these additions it must be noted that these fortifications were built in a rushed emergency regime, with little care for the long term conservation or integrity.

Fig. 5. Detached Brick Section and Moisture Saturated Area of the German Fortification

3.2 Conclusion of the Survey

All-in-all, the survey of the Fort 7 raises an interesitng question regarding the state and conservation of the fort.

On one hand, this is a Natural Reservation for Bats, which require a cold temperate areas as well as generally a highly humid envirorment in order to facilitate an ideal hibernation spot. On the other hand the humid envirorment is a product of the overall climate, with rainy seasons during late winter, but if we are to exclude the general trends we will see that the Forts's microclimate shows much more tamer humidity and moisture contntent levels, as well as advanced deterioration that affets the structure's integrity (due to the climate rainy season and relatively low pH of the soil and rianwater), which besides losing a potential valuble piece of historical heritage, it can also prove to be a life-threathning hazard for both humans and wildlife. Under this pretext, perhaps the best approch would be the beginnnign of an indepth and well documented analysis of the Fort's most suitable bat hibernation spots as well as the Fort's Structural Rehabilitation. Establishing which parts of the Fort can be safely habited by bats and which parts are only suitable due to advanced deterioration is key for the promotion of a healty and safe envirorment.

And considering the project and community involvement of the Fort 7, this can be a promising re-applyable project for other similar forts including the Romanian ones. Mixing Natural Habitats with Historical sites and involving local communites with pro-enviroment initiatives.

FORT BREENDONK CAMPAIGN:

Fort Breendonk – While this site is not part of Brialmont's designs or overview, the Fort is part of series of fortifications proposed by Brialmont during late 19th century. It relatively close to the construction period of the Romanian fortifications and employs many architectural elements as well as defensive architectural features that can be seen in at the Bucharest defence lines.

Today this fort is a historical museum commemorating the harsh conditions of WW2 prisoners of the Nazi regime. The site has the unique property of being the only fortress that has been "unearthed" and left naked in order to see "naked" fortifications.

The survey campaign focuses on observing technological features as well as creating a Digitalize Surface Models of the Fort (as well as comparing it with LiDAR Digitalized Surface Models). This can be used in the future for the detection of similar fortifications that had been buried or forgotten.

4.1 On Site Documentation & Observations

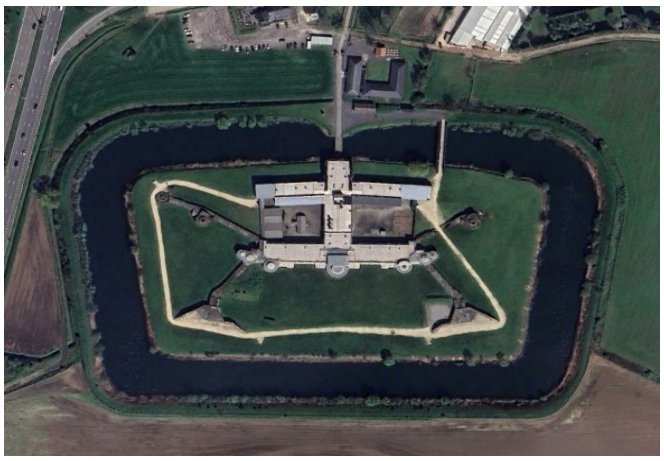
Fort Breendonk part of a later addition to the Antwerp line, the while the for itself isn't a Brialmont design, H.A. Brialmont pushed the idea of an additional defensive line for Antwerp in the 1880s-1890s (parallel to the contract in Romania). And many of the Romanian Forts and Batteries would see some similar degree of design approaches. Unlike the large bulky profile of older forts (Such as Fort 7), a lower and more discreet profile with a slightly "sunken" inner Fort has been favoured. This would come to be a very popular approach in the late 1890's and early 1900s.

One of the elements that did not change is the ditch.

Fig.6. (Google Earth)Satellite view of the late 1880s early 1900s Fortification and surrounding ditch.

But what truly makes Fort Breendonk a special example of this type of fortifications is the possibility to observe the structure under the earthwork.

Fig.7. (Google Earth)Satellite view of the Fort



In this case, we are not primarily interested in environmental data, as there's little use or reason to collect them, The Fort is in working condition and it is maintained by staff. The only data relevant to the climate/microclimate would be the moisture contented measurement, and for the purpose of this survey, we will conduct an analysis of the site's moisture content using Sentinel 2 multispectral imaging.

(look at Fig. 7. For a True Color Satellite Image)

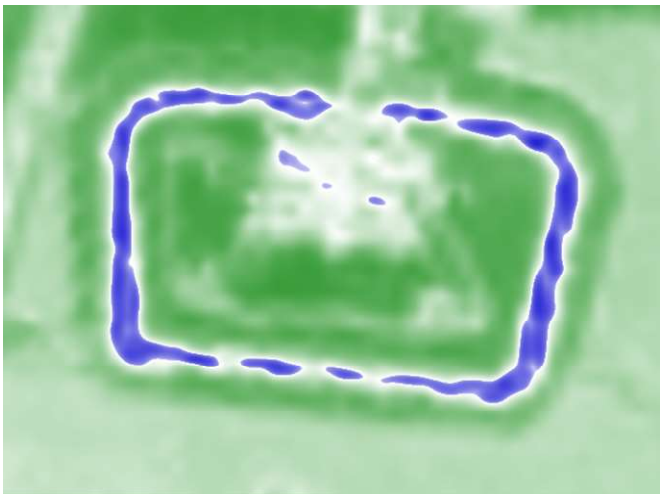


Fig.8. (Sentinel-2)NDWI view of the Fort Breendonk

Utilising the Normalised Difference Water Index (NDWI), a map of the relative distribution of water content can be created (blue areas are water bodies, green are vegetation and white areas are areas with a degree of moisture content (usually structures, but can be agricultural fields or streets as well).

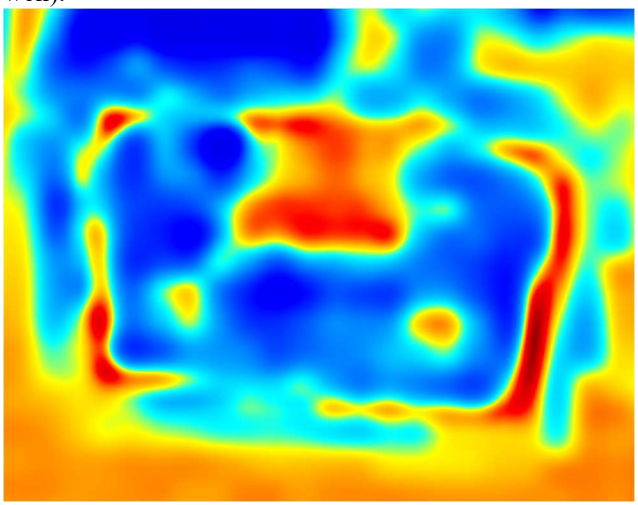


Fig.9 (Sentinel-2)NDMI view of the Fort Breendonk

The Normalised Difference Moisture Index (NDMI or Simply Moisture Index) highlights areas that contains "relaxed" and "stressed" water/moisture. This is helpful in discriminating constructions materials (since different types of materials react differently to moisture absorption), as well as establishing the heath of plants, relaxed spots appear blue and represent areas with high moisture and stability in environment. While stressed spots represent areas with generally low moisture that undergoes physical changes (water is absorbed or evaporated, thus creating stress).

This Moisture Index information combined with the Water Index can give us clues regarding the microclimate of the fort. The soil surrounding the fort is in a stable state providing a suitable environment for the vegetation, while the fort itself is under a lot of stress, which indicates a mix between suitable cycles for bio-colonisation and evaporation of water which diminish the suitability of bio-colonisation but promotes salt re-crystallisation. As such we can expect Salt depositions formations, especially inside the fort where RH changes constantly with the circulation of the tourists (large concentration of people can produce condensation which rises the RH).

This is confirmed by the in-situ documentation of the fort.

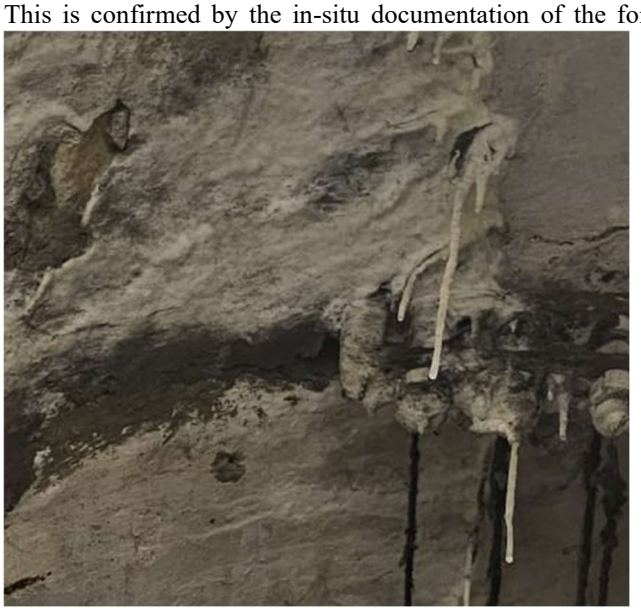


Fig.10. Salt deposition after re-crystallisation

This is a normal occurrence in areas that do not have a humid microclimate but the general climate of the area can be rainy or humid, it is also a normal occurrence in areas close to large bodies of water, and in our case, the fort acts like an island in the middle of an area that has shallow phreatic water level. This problem is slightly accentuated by the sunken profile of the fort, being in closer proximity to the

phreatic water level, thus transporting more salts into the structure of the fort.

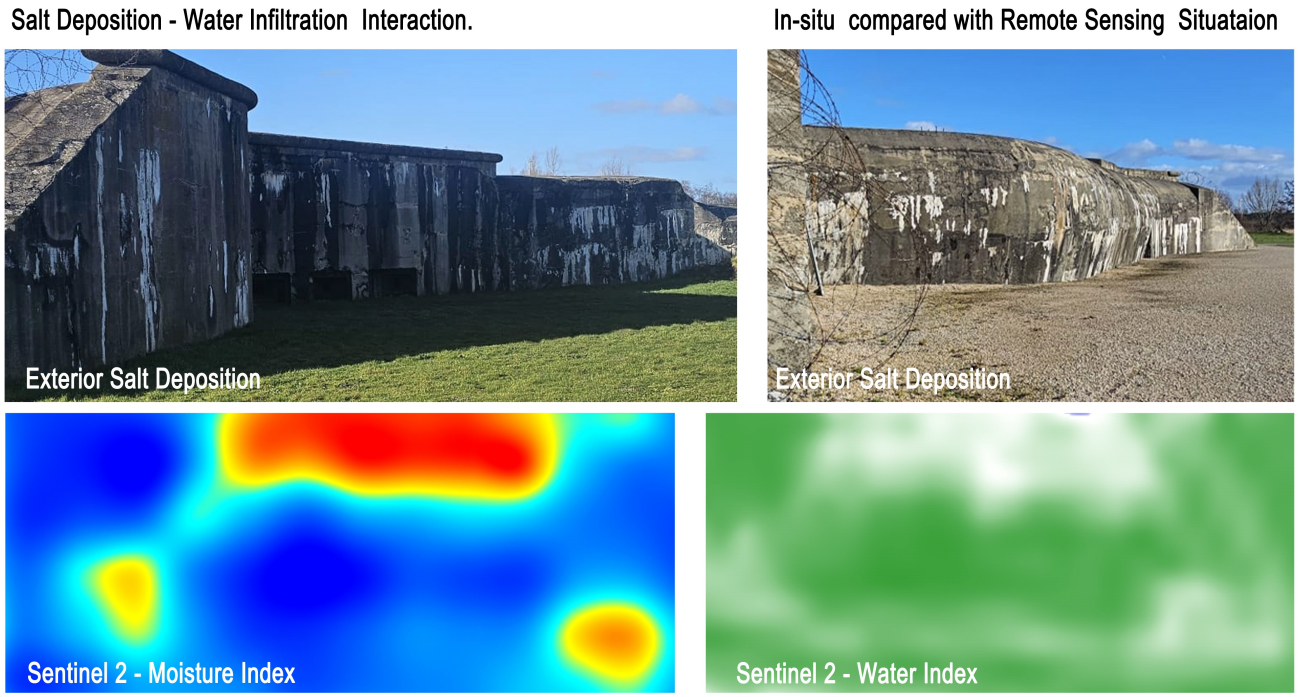


Fig.11. Salt blasting over long cycles of moisture content changes.

And by taking a look on the outer part of the for we can see a clear indication of both Salts and bio-colonisations. I should be noted that the salts varied from white to a yellow-ish colour, without a laboratory analysis we cannot say for sure what's the content of the salt, but it is most likely iron oxide precipitation transported from the inner reinforced concrete structure.

Fig.12. Salt blasting close-up.

Entering into a more in-depth analysis of the source and morphology of the salts would be beyond the scope of this article, but it is noted, that this exact type of deteriorations can be found in the Bucharest Fortifications. More than that, due to "sunken" profile of the main fortification, many of the Bucharest Fortifications suffer from flooding of the main structure, which makes them inaccessible and hazardous. Furthermore, due to flooding, a lot of salt solubilised salts are transported into the structure of the Forts.

By comparing Fort Breendonk with the fortifications around Bucharest, it is clear that this is a drawback of to the design.

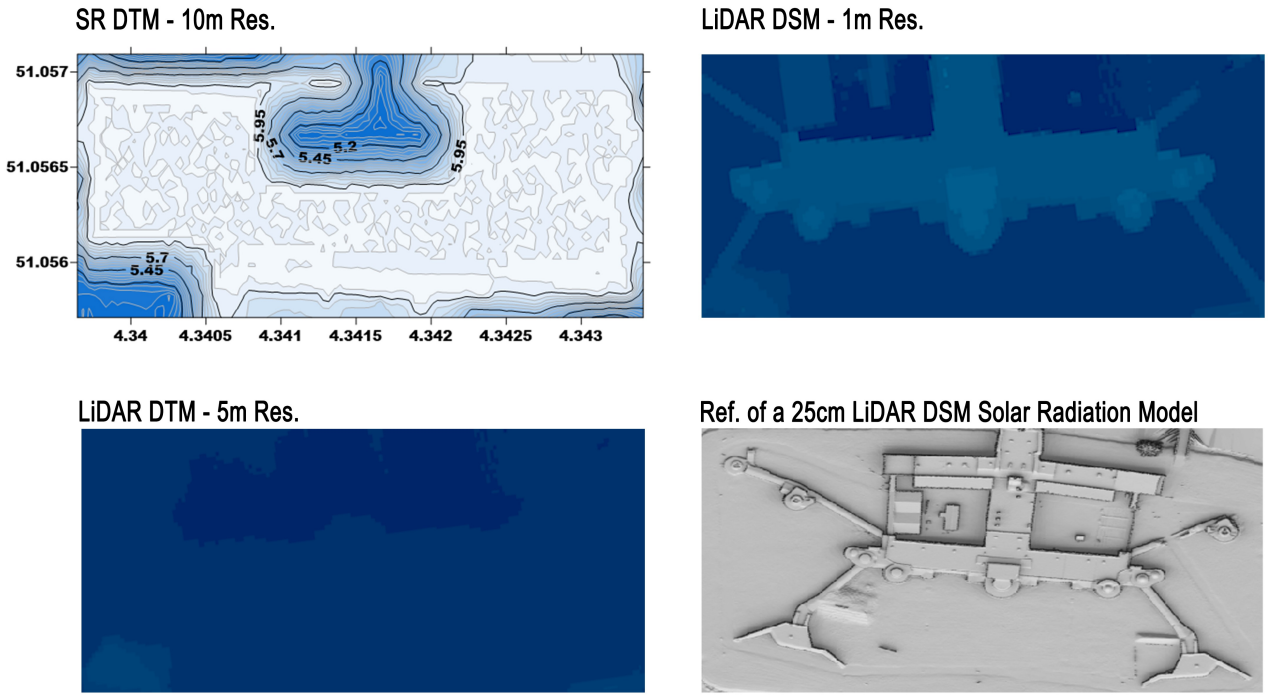


Fig.13. Comparison between DTM and DSM data.

Finally, for the remote detection, a look into the applicability and performances of open-access data has been made, for this reliability two types of approaches have been taken:

- DTM – use of the Digitalized Terrain Model, an algorithm that calculates the real height/elevation of the terrain (without structures and trees/canopy)

- DSM – use of the Digitalized Surface Model, an algorithm that calculates the real height/elevation of the surface (taking in consideration structures and trees/canopy)

As seen in Fig.13. the DSMs can replicate the exact shape of the structure to a fairly high degree, while the DTMs apparently fail at recognising the structure. Upon closer look, it can be seen that the DTMs actually managed to capture the "sunken" profile of the fort, which cannot be seen that well through the DSMs. With this considerations it can be said that the DSMs and DTMs are in fact complementary techniques. (although in this specific example, there is no tall vegetation that would normally pose a challenge in the detection of structures).

For this specific case, the use of LiDAR Digital Elevation Model data created by VITO and Digitaal Vlaanderen (EODaS) has been chosen as a test base. Since the model was created on behalf of the Flemish Energy and Climate Agency (VEKA). This data was compared with the Satellite DEM model used by Google in "Google Earth" to check the difference and establish the viability of Synthetic Aperture Radar in cases in which LiDAR data is not available. Although this study did not had any particual challenges in the detection, a simple comparison applied on a subject in this field of studies is more than enough.

4.2 Conclusion of the Survey

Fort Breendonk offers one of the more interesting cases as a fort. Having both the status of a pre WW1 military Fortification as well as a WW2 concentration camp and offering an interesting opportunity for the study of fortified positions. It's history can be to some decrees compared to the Fort "Jilava" in Romania, a Brialmont Fort converted into concentration camp in the service of the Communist regime post WW2. Although the "unearthed" property of Fort Breendonk makes it completely unique as both a monument for the studies of fortifications as well as a museum for the remembrance of the horrors of a dictatorial regime.

Many of the Forts conservation issues could be attributed to the general design of the fort, being commonly seen and acknowledged in similar designs.

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