FLOAT hide and see

Final Long Operative Army proTection

A3 Graduation Report - Final

Study: MSc. Architecture track
Student name/author: M. V. V.
Student number: 5059984
Graduation Studio: Extreme

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1. Abstract

In 2022, Russia invaded Ukraine. Besides, the Baltic States are preparing for a possible attack from Russia. NATO wants to show its presence in Lithuania in order to scare off Russia. A Dutch NATO base will be placed and the Dutch Military of Defense asked TU Delft Architecture students to come up with a design proposal. Since attacks in Lithuania are very likely, the overall aim of this literature research tested by design is to provide a suggestion for a permanent military base in Lithuania – a design that provides a defensive resilient base for the soldiers. In times of war, soldiers need to be able to work from and return to a defensive resilient base. In times of peace, the base needs to protect soldiers against surprise attacks and provide direct visual connection to the outer world. Otherwise, NATO will easily lose strength. A literature research is done via selecting and combining literature. The literature discussed the basis of bunker design, building-configurations in relation to ground level, partial blast-resistant elements and compact and dispersed spatial configurations. Case-studies are added to enrich and provide more ideas.

Defensive resilience can be created by either a centralized or decentralized base. The deception of the attacker is important to make it harder for them to destroy the military base. In addition, a combination of buildings, that function as shelters, that are entirely underground, or above ground contributes to the resilience of the base. This combination contributes to the element of misleading. Besides, adding surrounding structures with sand make the base more blast-wave-resistant. The shelters themselves have several characteristics in order to be resilient and therefore contribute to a resilient base.

A few functions of the military base are developed with the main focus on the sleep facility. The functions to be developed are determined during the design phase, namely the area in the masterplan where sleep and eating come together. The design phase determined which materials are needed for the structure, with the building being made in a way to provide time for the soldiers to escape in case of bombing. It is important to use as many natural/local materials as possible to lower CO2-emissions. The Ministry of Defense is invited to take inspiration from *FLOAT hide and see*, a design that moves via water.

2. Part 1 - Introduction

2.1. Problem Statement

War destroys many lives. But it keeps happening.
In 2022, Russia invaded Ukraine. Besides, the Baltic States are preparing for a possible attack from Russia. The border from Lithuania to Poland could be closed-off, which would weaken NATO protection, and this needs to be prevented (Kirby, 2025). Therefore, NATO countries need to show their presence in Lithuania. One way to do this, is to create permanent military settlements close to the borders. In times of war, soldiers need to be able to work from and return to a defensive resilience base. In times of peace, the base needs to protect soldiers against surprise attacks and provide direct visual connection to the outer world. Otherwise, NATO will easily lose strength.

Besides, the climate is warming up. The carbon dioxide emissions contribute to this phenomenon (Rijksoverheid, n.d.). The world needs to prevent the warming up from getting worse and one way to do this, is by building with local materials and re-using buildings as much as possible.

2.2. Relevance

The Dutch Military of Defense asked TU Delft Architecture students to come up with a design proposal for a military base in Lithuania, since they are curious to our view. An important aspect is to build locally. The more one can build with local materials, the less transport costs and less carbon dioxide emissions. Besides, creating a permanent design that can be repurposed becomes more circular relatively to a temporary design (H. Dijkers & T. Dodson, personal communication, December 19, 2025).

Moreover, one needs to think about how this base can become defensive resilient for its soldiers. A building could be an easy target. Shock waves are dangerous. Creating a subterranean building could be expensive, but creating an attack-proof building above ground could be expensive as well. However, the use of sand/soil contributes to safety and resilience and building with timber is possible in shock-wave environments, but the latter is still underresearched (H. Dijkers & T. Dodson, personal communication, December 19, 2025). Therefore, literature and design research is done to understand which way of designing in the Lithuanian context would be most efficient.

2.3. Objective and Motivation

2.3.1. Objective

The main technical and architectural ambitions are the creation of a design that provides defensive resilience for its soldiers while implementing architectural quality and natural materials where feasible. The design provides protection in times of war (defensive resilience + architectural quality) and direct visual contact with the outer world in times of peace in spring and summer (architectural quality).

2.3.2. Motivation

Via this research and research by design, the author wants to share her view on resilience in military base design. By creating a defensive resilient base in Rūdninkai, the author wants to contribute to the well-being of the soldiers, so that they too have the chance to survive the war and build a good life afterwards. What the author finds most distressing is that soldiers are risking their lives for those they want to protect. And the better the soldiers are, the better they can protect the people. After the war, the military base will be brought to life with a different function, namely farming by hydroponics. In this way, the military base serves the community in two meaningful ways.

2.4. Research and Design Questions

In order to create a certain base, a combination of research by literature and research by design is done. A main-question and sub-questions are formed to reach this goal:

Research- and design-based main question:

How can spatial strategies contribute to defensive resilience in military base design for its soldiers, using natural materials where feasible?

Sub-questions:

1. Which bunker design elements contribute to resilience?
2. How does the spatial configuration of earth and building influence safety, environmental comfort, and user perception?
3. How can soil and timber contribute to a blast resistance base?
4. How do compact and dispersed spatial configurations contribute to resilience?

2.5. Scope

2.5.1. Location

In order to create a military base, a strategically located terrain is necessary, which would be close to the Belarus Border: Rūdninkai Training Area. Therefore, this location forms the case-study in this Graduation Project.

2.5.2. Design Brief – *FLOAT hide and see*

Core principle

Float hide and see provides a defensive resilient base for the soldiers through deception. In times of war, the configuration of the base contributes to the safety of soldiers working there. In times of peace, the base contributes to the safety of soldiers against surprise attacks and allows direct visual contact with the outside world. After the possible departure of the military, the *FLOAT hide and see* will be repurposed to a facility for farming by hydroponics.

Design strategy

The masterplan is a distributed plan designed for 800 people, to contribute to defensive resilience. The focus is put on the sleeping facility, with a side-focus on the cafetaria. Sand and concrete is used to create the protective side of the design, namely the hangar. The facilities themselves are mainly designed with timber, since this is a well-used local material.

The basis of the base-configuration is to mislead the attacker, giving the soldiers a better chance of continuing to operate. The attacker will be misled by spreading buildings across the location.

The masterplan consists of buildings entirely underground and buildings above ground that can move by water and therefore find protection under the protective hangar with sand on top. Therefore, in times of peace, the base consists partially of buildings that allow natural daylight and direct visual contact with the outside world. In times of peace and spring/summer, the area within the hangar has the function of training area. The buildings entirely underground are used for other vital functions, such as water and food storage, electricity, depots, and medical facilities.

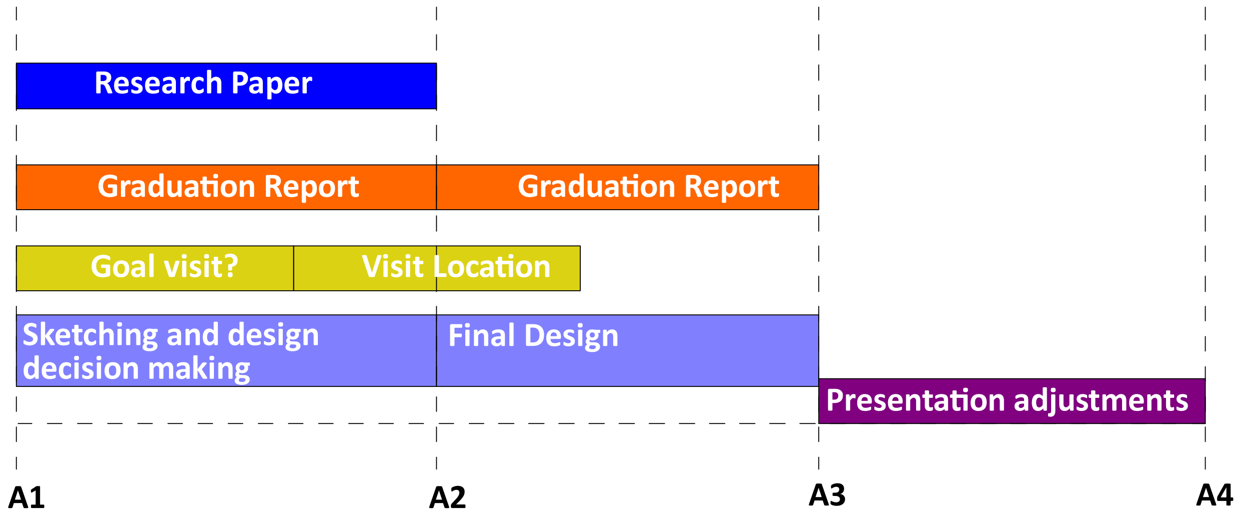
Resilience characteristics of a shelter

The main characteristics of the shelter that are implemented, are sand, reinforced concrete hangar, hermetic protection, ventilation, basic sanitary needs, waterproof structure and the connection to water, electricity, sewage and light.

3. Part 2 - Approach

3.1. Methods

The planning of this Graduation Project can be seen in Figure 1 and Table 1. A literature research is done. The current research is done via selecting and combining literature. Parts of the literature are translated into schematic diagrams to make the information more tangible. Case-studies are added to enrich the literature review in order to implement more possibilities for the design-phase. Analysis of local Lithuanian conditions are added to provide context to the design-assignment. Important here is the mapping of open areas at the chosen location and defining how to use those open areas. The design project tested and elaborated on the results of the research. This is done by creating different drawings to test ideas, and by the creation of sketch-models. The overall aim of this literature research tested by design is to provide a suggestion for a permanent military base in Lithuania, a design that provides a defensive resilient base for the soldiers. Meant for after the possible departure of the military, *FLOAT hide and see* will be repurposed by design exploration with the implementation of hydroponics as the main idea.



Notes:
- Research Paper at A1=80%
- Research Paper at A2=100%
- before A2, more case-studies have been implemented than at A1
- Graduation Report at A1=Draft
- Graduation Report at A2=Elaboration
- Graduation Report at A3=Final
- Before visit, goal of visit will be determined
- Visit to location will happen either before or after A2
- hopefully, do material testing with TNO/Ministery of Defense
- Lots of sketchmodels will be made during the sketching phase

Figure 1. *Planning made from A1 onwards – made by author (2026)*

Table 1. *Planning made from A2 Try-out onwards – made by author (2026)*

Table 1. *Planning made from A2 Try-out onwards – made by author (2026)*

Week number	The main Task
16	Improving design + Detailing
17	Detailing + improving design
18	Detailing + improving design
19	Physical model making + improving design
20	Physical model making + improving design
21	Physical model making + improving design
22	Creating Presentation + handing in doc.

3.2. Theoretical Framework

3.2.1. Site Analysis

The main natural materials that can be found in Lithuania, are wood (the most common species are birch, pine and spruce), peat, grain, hemp, limestone, dolomite stone, sand and gravel. The latter two dominate the Lithuanian superficial land (Federal Research Division of the Library of Congress, 1995, p. 167-241). Give or take, 9,5% of the ground underneath the superficial land exists of peat and +- 90% of this land has the function of farmland (Slepentiene et al., 2018).

Figure 2 shows the location with left Lithuania, the border to Poland and the location of the Rūdninkai Training Area. Top right shows how close the site is to Belarus and down right shows the Rūdninkai Training Area and within the location of FLOAT hide and see. Figure 3 shows the general analysis of the district Vilnius.

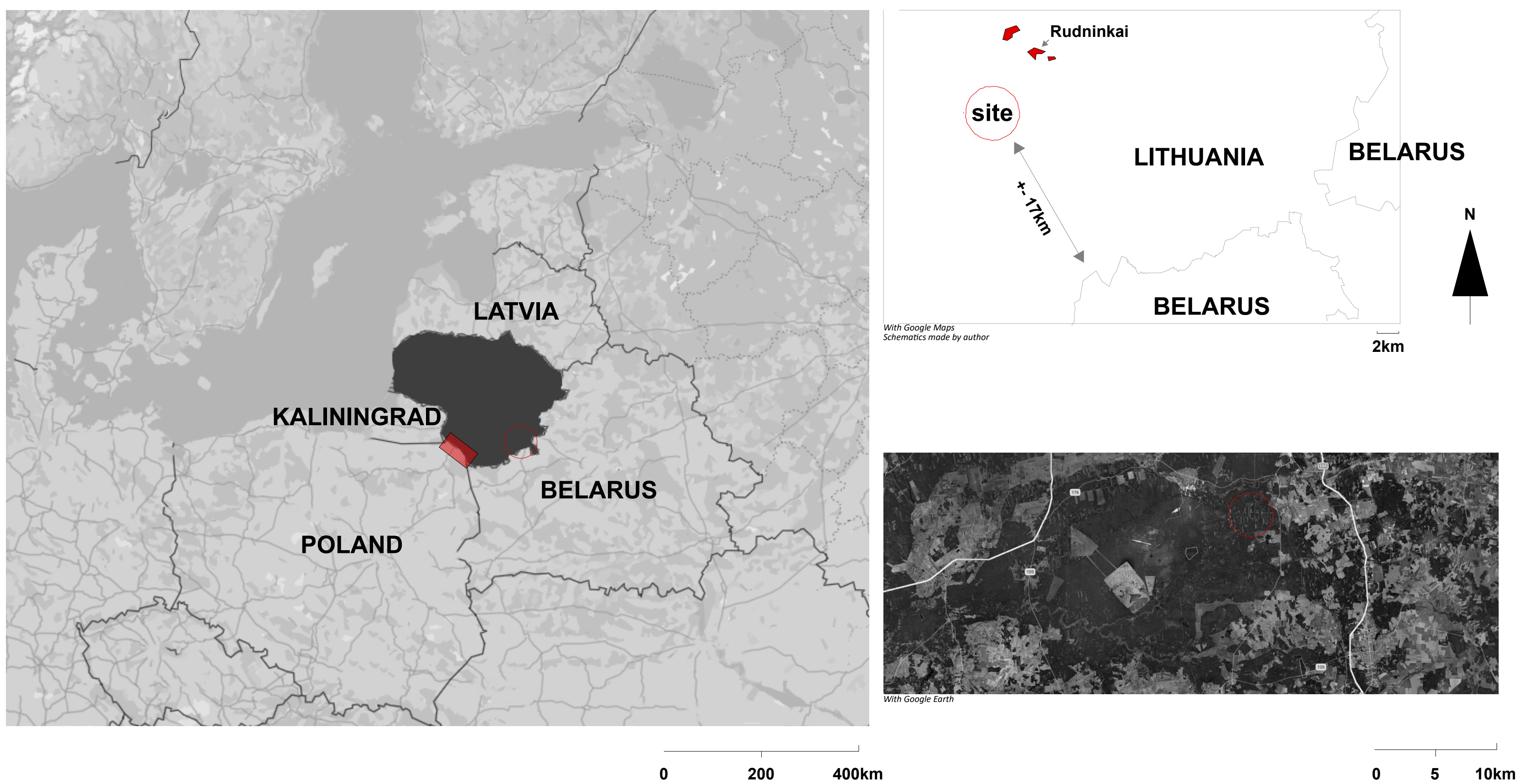


Figure 2. *Location – made by author (2026)*

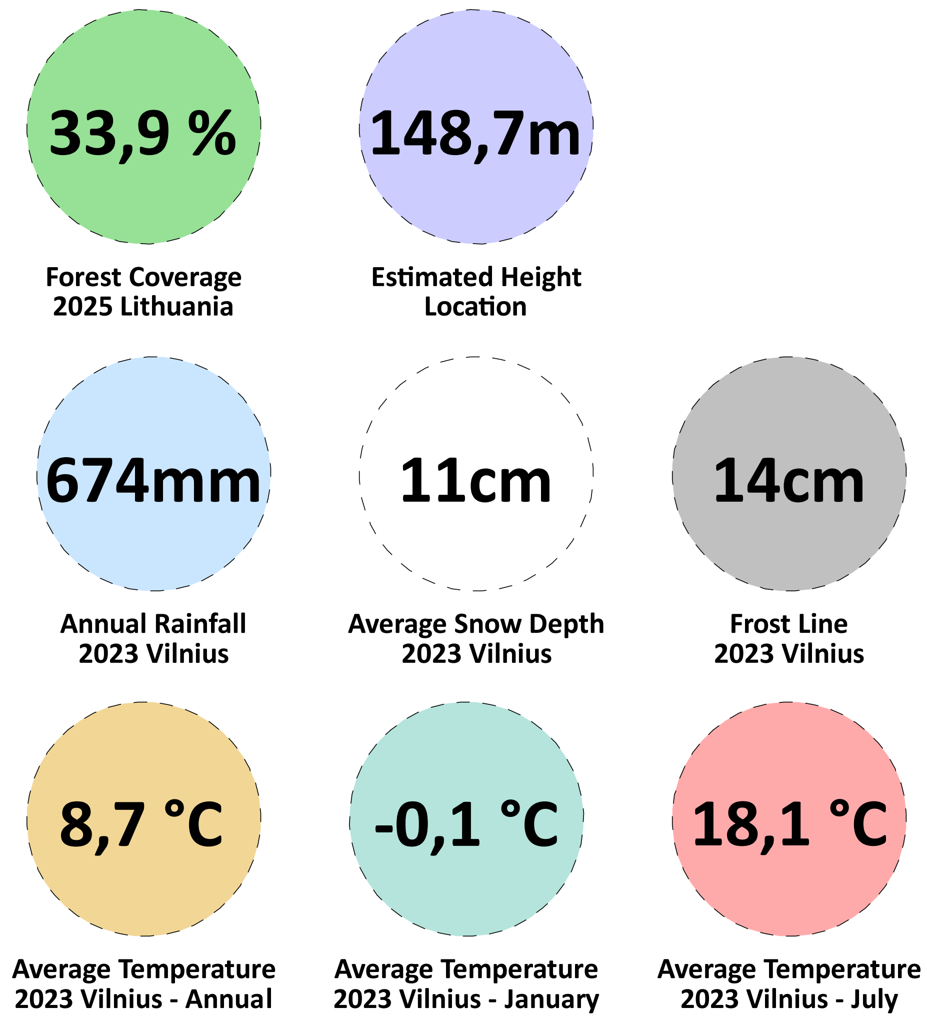


Figure 3. *Forest Coverage and climate information – made by author. (see sources at References)*

3.2.2. Bunker Design Elements

Perperi et al. (2023, p. 71-72) argues important requirements for bunker design, as can be seen in Figure 4. Gillett (1943, p. 3-24) argues important requirements for bunker design as well, as can be seen in Figure 5. Besides, Gillett (1943, p. 3-24) discusses differences with bunkers above ground level, as can be seen in Figure 6. Because this type is not entirely covered with soil, it needs bigger dimensions of the outer shell with a shorter roof span (Gillet, 1943, p. 3-24).

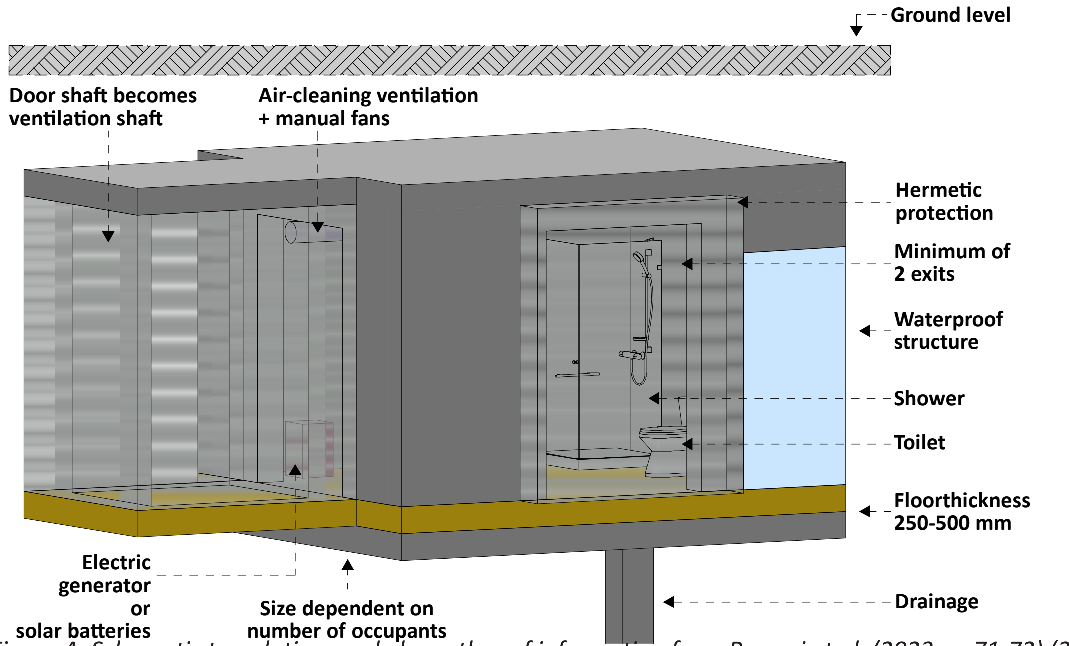


Figure 4. *Schematic translation made by author of information from Perperi et al. (2023, p. 71-72) (2026)*

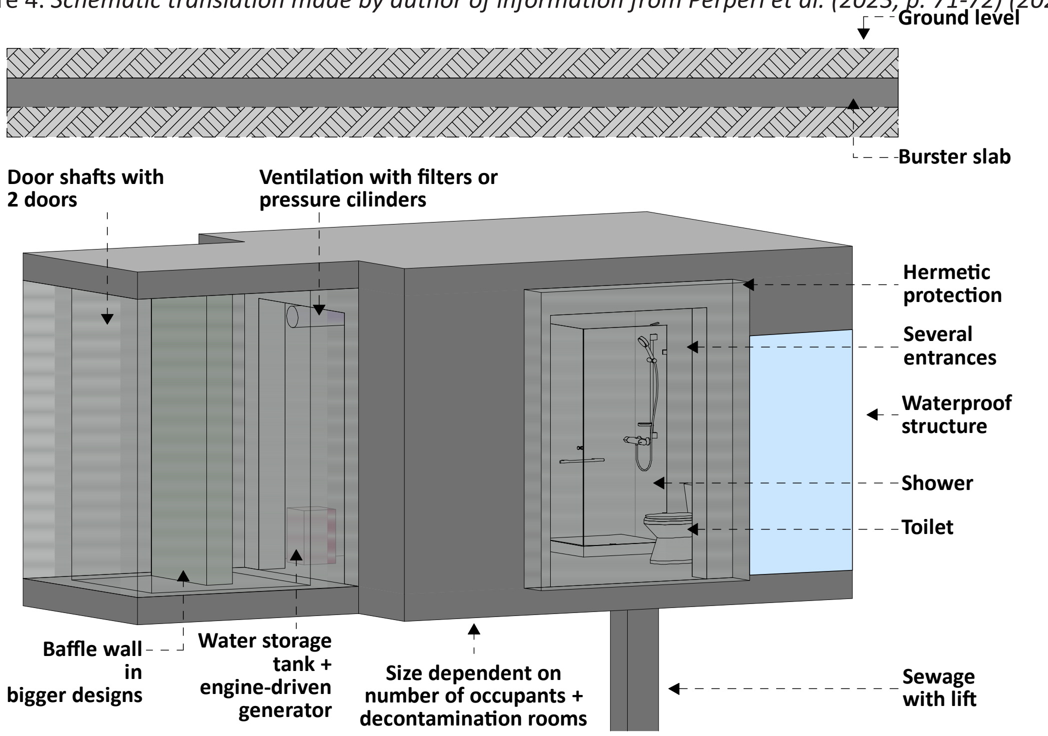


Figure 5. *Schematic translation made by author of information from Gillett (1943, p. 3-24) (2026)*

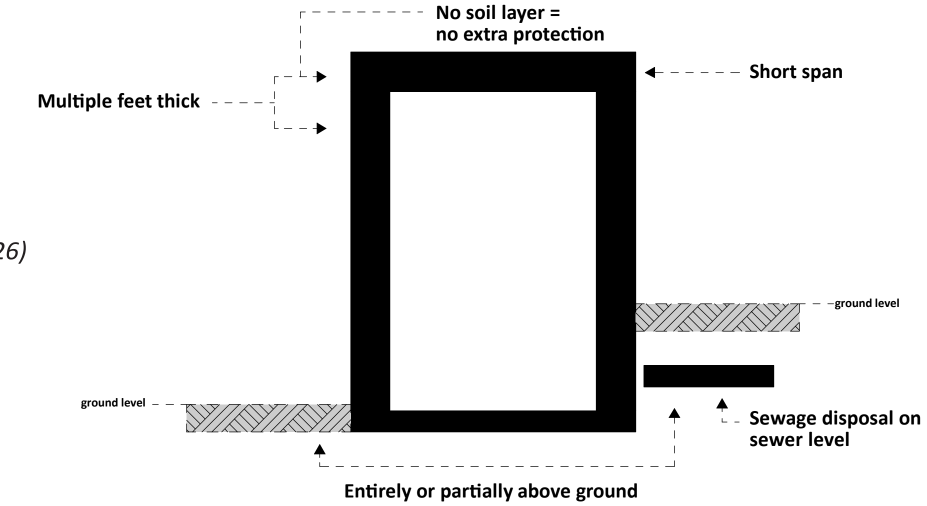


Figure 6. *Schematic translation made by author of information of shelters that are entirely or partially built above ground from Gillett (1943, p. 3-24) (2026)*

Case-study:
The bunker Van Ouwenlaan in The Hague is built from 1942 to 1945 and provides insight into thickness of the reinforced concrete structure (Figure 7). The entrance of the bunker was built above ground level, with a soil layer on top in order to protect and hide the building (Monumentenzorg Den Haag, 1997).

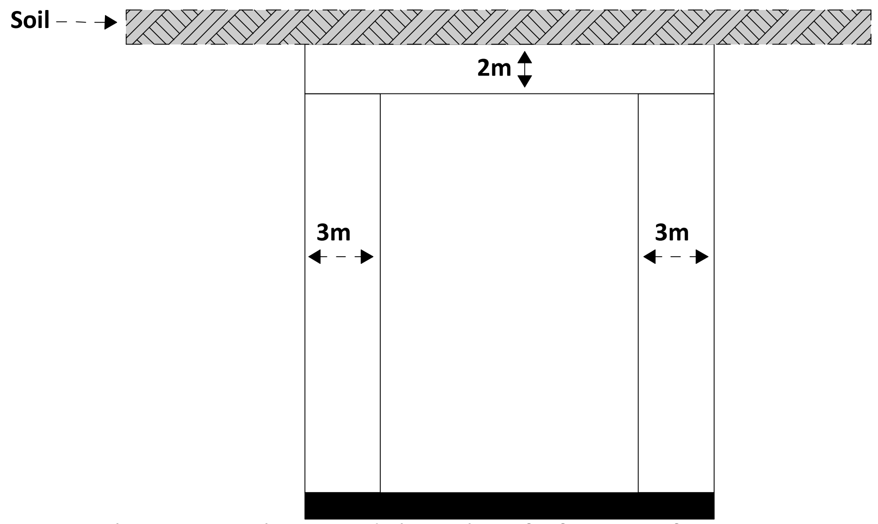


Figure 7. *Schematic translation made by author of information from Monumentenzorg Den Haag (1997) (2026)*

3.2.3. Building Configurations in Relation to Ground Level

In case of an emergency, there is a difference in escape possibilities with structures at ground level or higher and below ground level as can be seen in Figure 8. With the former case, one can escape and be directly on ground level. In the latter case, one must climb upward or flee to a different underground area. Moreover, in the latter case, humidity may arise as a concern, since the temperature of the interior is often higher than the largely constant temperature of the soil, allowing condensation to occur (Centrum Ondergronds Bouwen, COB, 2002, p. 17-31). Besides, one should consider that natural daylight is typically favored over artificial light. Polychromatic artificial light is important in case no daylight enters the structure, and direct visual and physical connection to the outer world are important (COB, 2002, p. 17-31) (Voorden, 1999, p. 1-58). Mechanical ventilation is the required way of ventilating in underground structures (Voorden, 1999, p. 1-58).

A building could also be partially surrounded by soil. In case daylight is able to enter the structure, more fluctuations in temperature occur in comparison to complete underground structures. Moreover, the interior has a risk of obtaining a higher temperature than above ground structures (National Renewable Energy Laboratory [NREL] & Information Services Program, 1997).

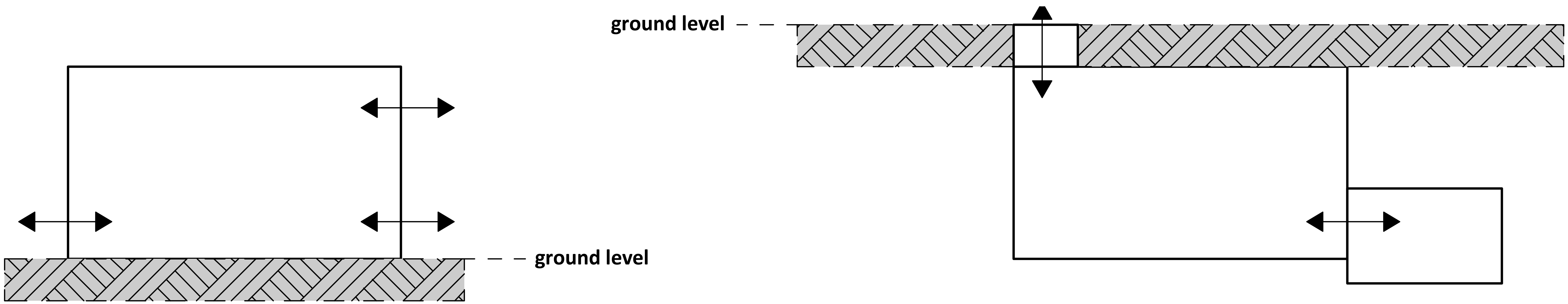


Figure 8. *Schematic translation made by author of information from Centrum Ondergronds Bouwen (Centrum Ondergronds Bouwen, COB, 2002, p. 17-31) (2026)*

3.2.4. Blast-wave resistance

Cao et al. (2021) discusses possible solutions for a blast-wave, namely a ''rapid assembling anti-blast wall'' (p. 1). These are filled with either stone or sand and soil.
Two examples that are discussed in Cao et al. (2021) can be seen in Figure 9. The results can be seen in Figure 10. Both the walls remained in the same position as before the conduction of the test and no ammunition debris has gone through the walls. However, the walls are damaged as can be seen in Figure 10 (Cao et al., 2021).

Mourão et al. (2022) states that experiments with building blast-resistance timber structures have often been conducted individually as research into blast-resistant timber structures, because the existing design regulations are underdeveloped.

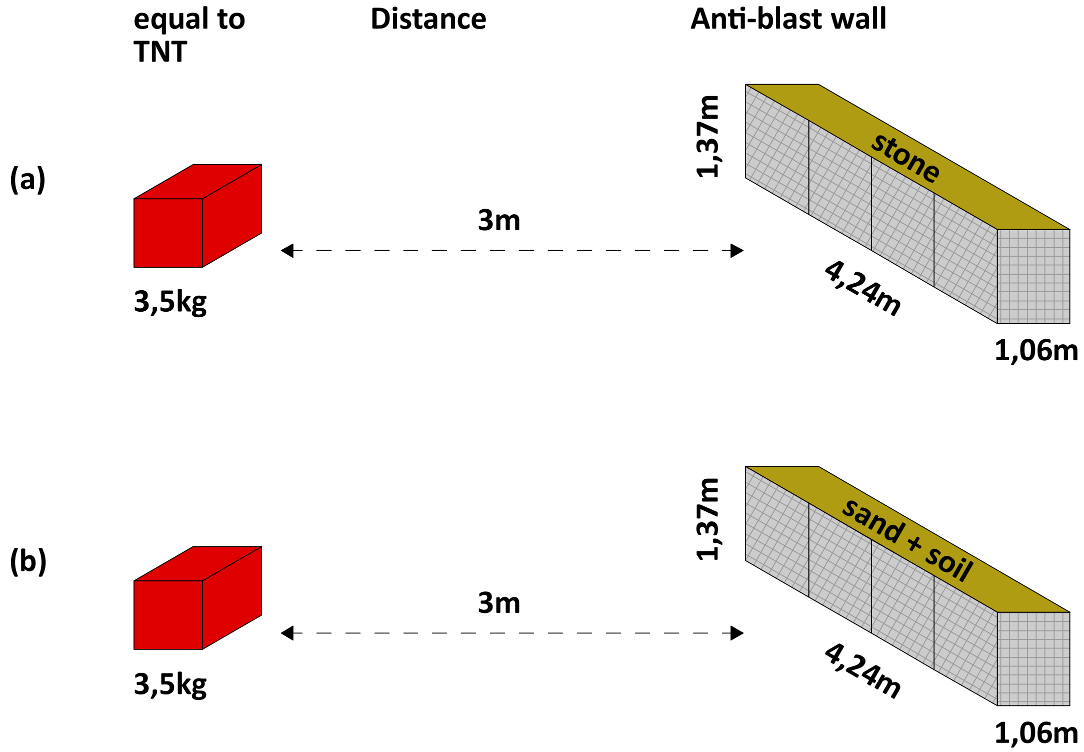


Figure 9. *Schematic translation made by author of information from Cao et al. (2021) (2026)*

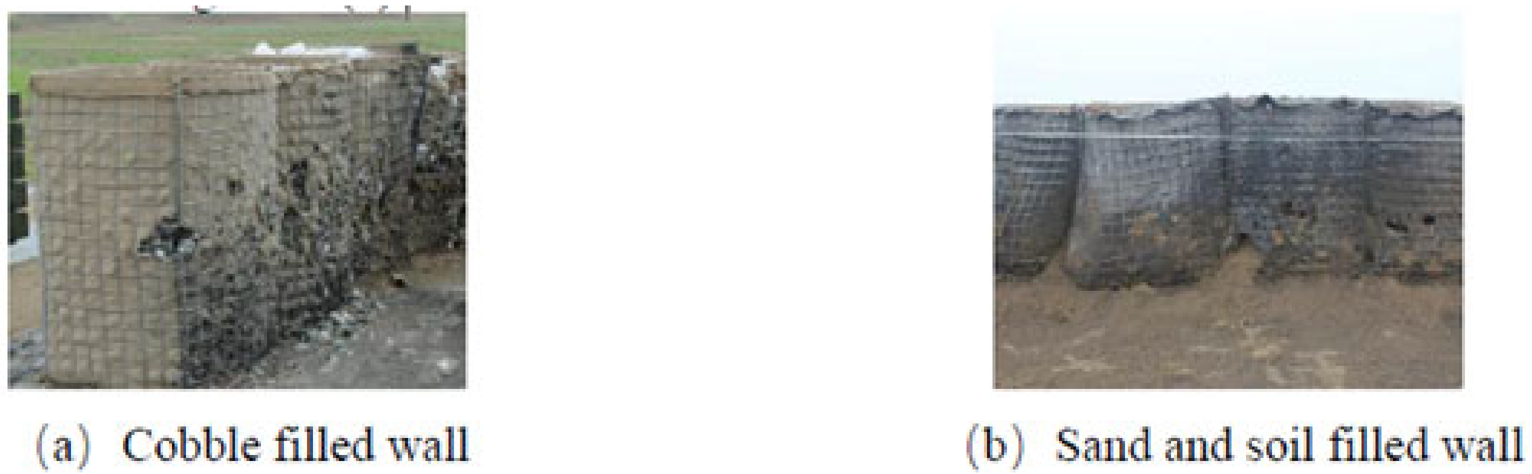


Figure 10.Figure 10. Stationary explosion experiment. From *IOP Conf. Series: Earth and Environmental Science, 638*, 1-6. doi:10.1088/1755-1315/638/1/012121, by Cao, H., Zhang, Z., Chen, P., Cao, L., Chen, & Chen, Z. (2021). IOP Publishing Ltd, licensed under CC A 3.0. Purpose-Led Publishing.

3.2.5. Building Configurations - Compact and Dispersed

Lostumbo et al. (p. xxiv-271) states that a large centralized base (Figure 11-a) can have the disadvantage that attacking such a base can be profitable for the attacker. However, an advantage of such a self-defending base can be that the defenses can be located close together.

With a distributed base (Figure 11-b), there is a greater chance of preserving important elements, as the attacker must decide exactly where to target the weapons. The attacker may decide to select specific targets or to attack all parts with less force. In this case, there is a chance that attacks will be less profitable.

(a) Centralized plan **(b) Distributed plan**

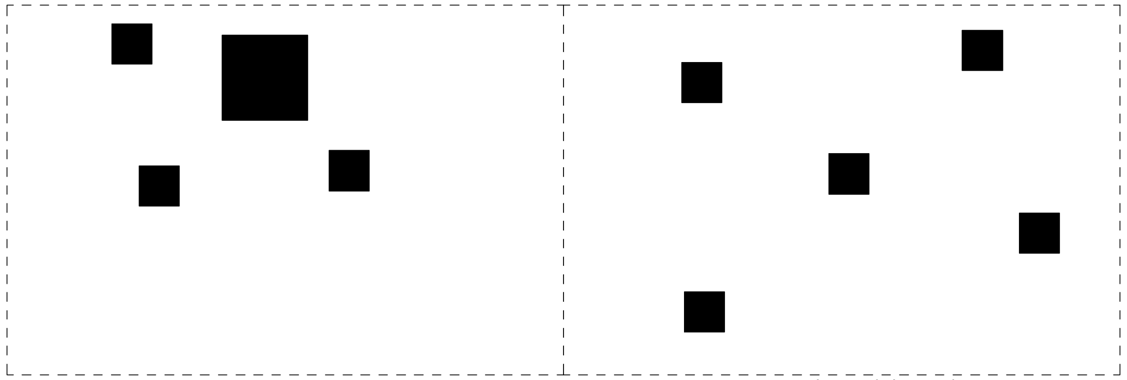


Figure 11. *Schematic impression made by author based on Lostumbo et al. (2013) (2026)*

Case-study:
A Maunsell army fort (Figure 12) consists of seven towers with each three floors, and they used to be connected by an elevated steel walkway above sea-level. Because of this connection, the design formed one whole, but with distributed towers, with different functions. Each tower could function on its own (Mallory & Ottar, 1973, p. 144-148).

Figure 12. Redsandsforts. From *"Wikimedia Commons, "* by Russs, 2011 (https://commons.wikimedia.org/w/index.php?curid=16180197). Licensed under CC BY-SA 3.0.

4. Part 3 - Results

Based on the research, design-experiments have been done during the design phase. From there, the final design has been created.

4.1. Research and Design Explorations

In this chapter, the subquestions form the structure of the exploration.

Subquestion 1: Which bunker design elements contribute to resilience?

The initial idea was to design large, single-story rectangular buildings with wide spans. The supporting structure would consist of concrete, with an inner layer of sand and timber to prevent concrete debris from immediately falling on occupants in the event of an impact. Buildings that were (partially) above ground also featured this protective timber-and-sand layer on the roof and façade, which could move via rails. (Figure 13).

Ultimately, the author concluded that such large buildings were impractical in the context of defensive resilience, as they required very large spans. Through experimentation, the author found that smaller buildings were more effective. This led to the development of the concrete arch concept, which could move via water - a system less vulnerable than rails. The permanent concrete structure could therefore remain in place and protect itself against surprise attacks through its own arch structure. Openings would be integrated into the ground (Figure 14).

It became clear that an arch design must be relatively high compared to a rectangular structure to use space efficiently. This led to the idea of anchoring the main protective elements—the concrete arch and the sand layer above it—into the ground, while turning the permanent building into a movable building, as the hangar itself provides protection. The rectangular form was therefore retained only for the movable building, creating usable space above it while keeping the hangar height unchanged. Since research shows that sand can absorb explosive impact, the arch structure is covered with a sand layer. To keep the movable building light enough to float with relatively little water, the structure was changed from concrete to a timber framework (HSB) (Figure 15).

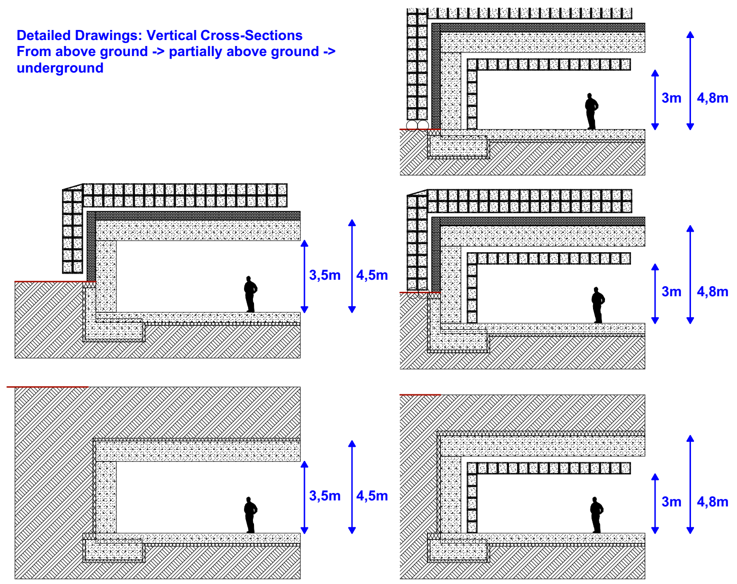


Figure 13. *Sketches – made by author (2026)*

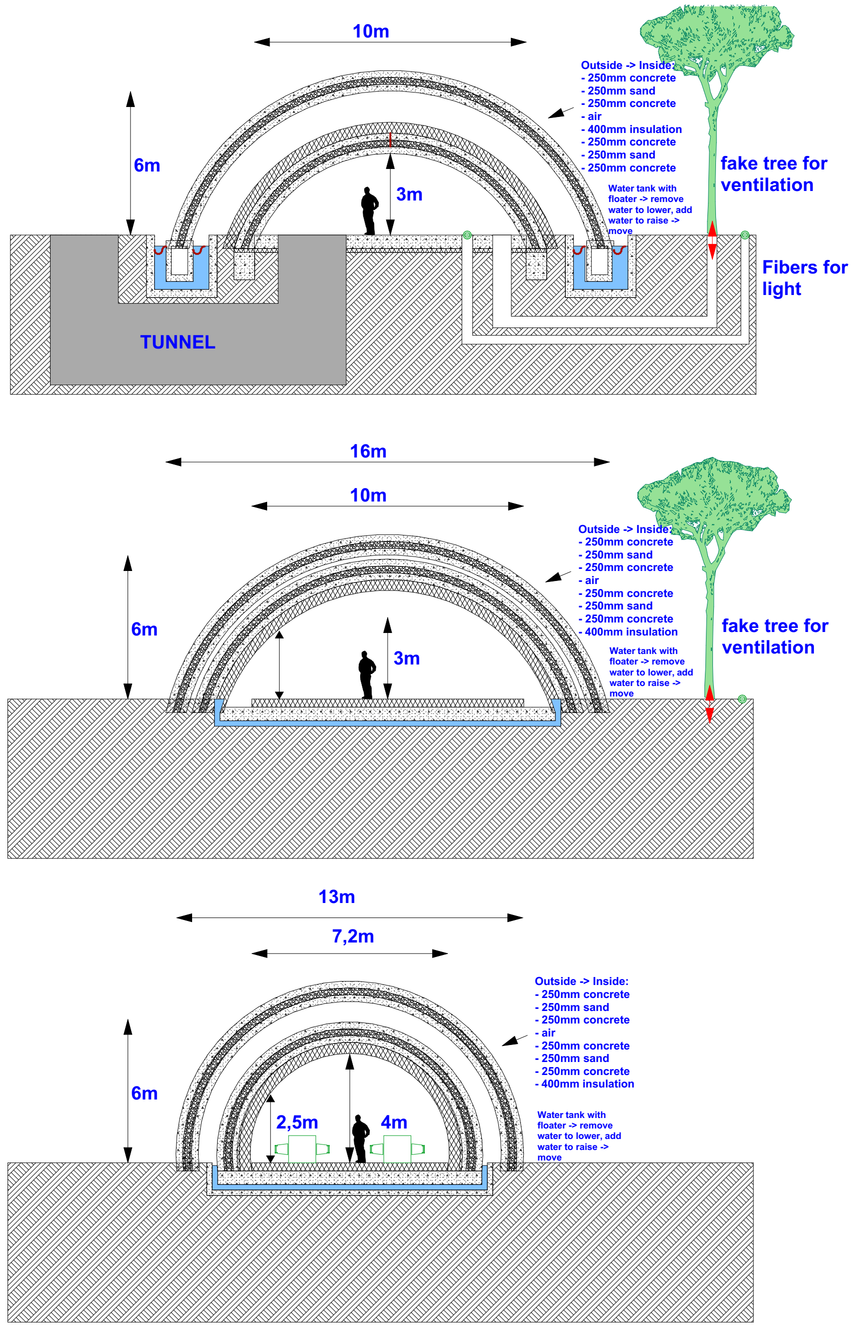


Figure 14. *Floating hangar – made by author (2026)*

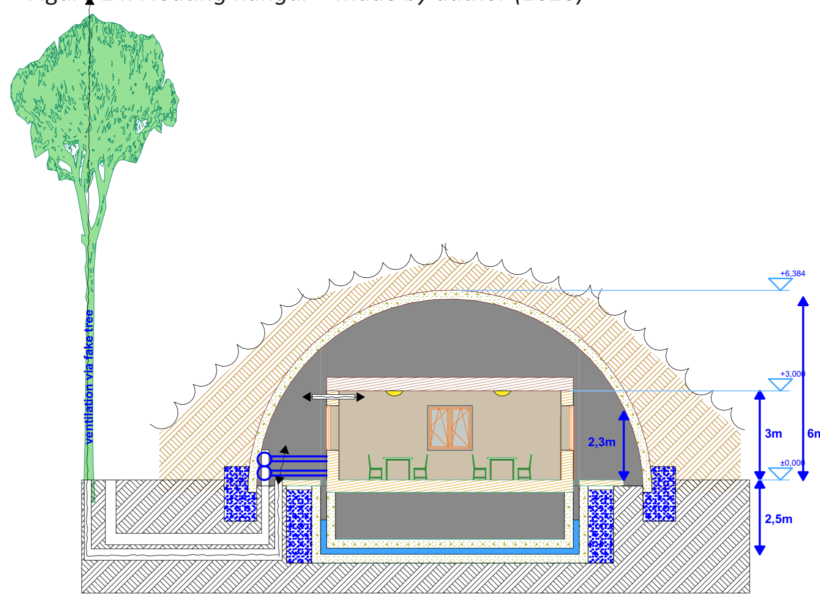


Figure 15. *Concept of cafetaria – made by author (2026)*

Subquestion 2: How does the spatial configuration of earth and building influence safety, environmental comfort, and user perception?

Through the design process, the author realized how vulnerable a (partially) above-ground rectangular building is in terms of defensive resilience. Its advantage, however, is the direct connection to the outside world. The author therefore explored alternative configurations. In addition, experiments were conducted with both a basin and a canal as water systems for the movable building (Figure 16).

However, freezing conditions would make it difficult to keep the canal operational and prevent the water from freezing for building movement. Therefore, the design process continued with the basin concept.

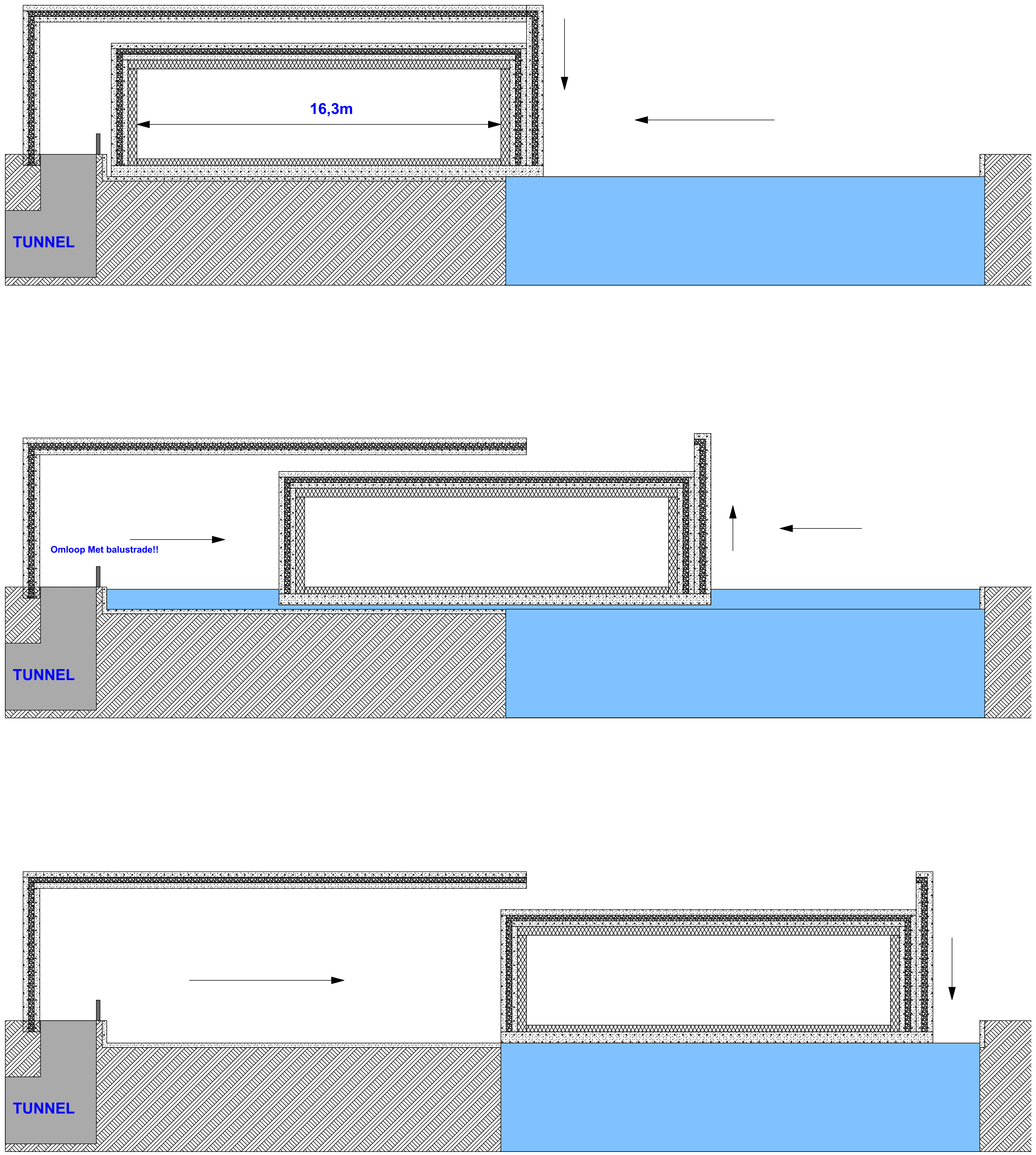


Figure 16. *Building in canal – made by author (2026)*

Subquestion 3: How can soil and timber contribute to a blast resistance base?

Research has shown that sand can absorb explosive impact, so a layer of sand has been placed on the arch structure. Underground depots were also explored, allowing the sand to naturally enhance building safety (Figures 17 and 18). Besides, since trees also provide mass, they contribute to blast resistance. As a result, the hangar is located within the woods, while the "see" function is placed in the more open parts of the site.

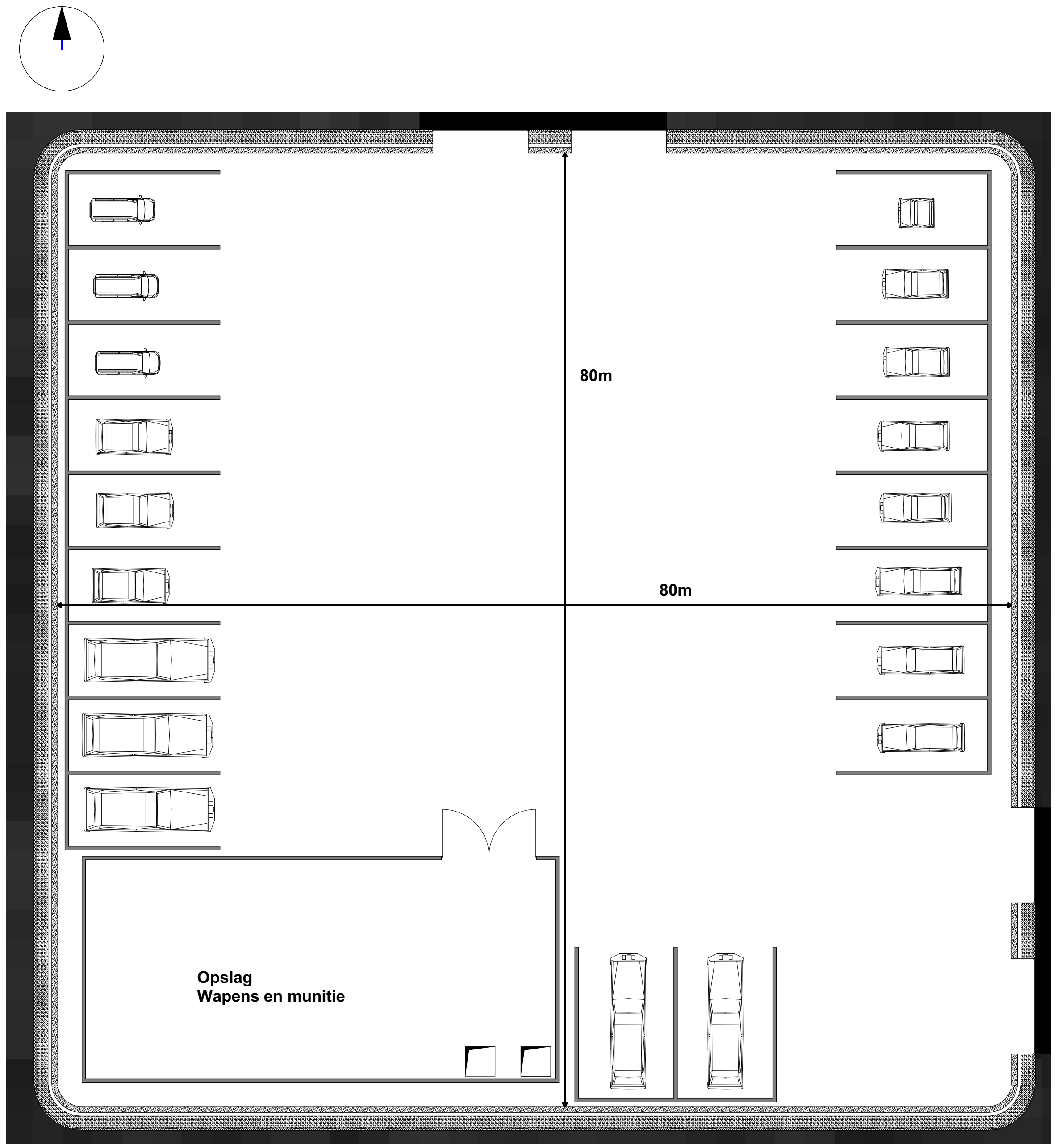


Figure 17. *Vehicle building underground version 1 – made by author (2026)*

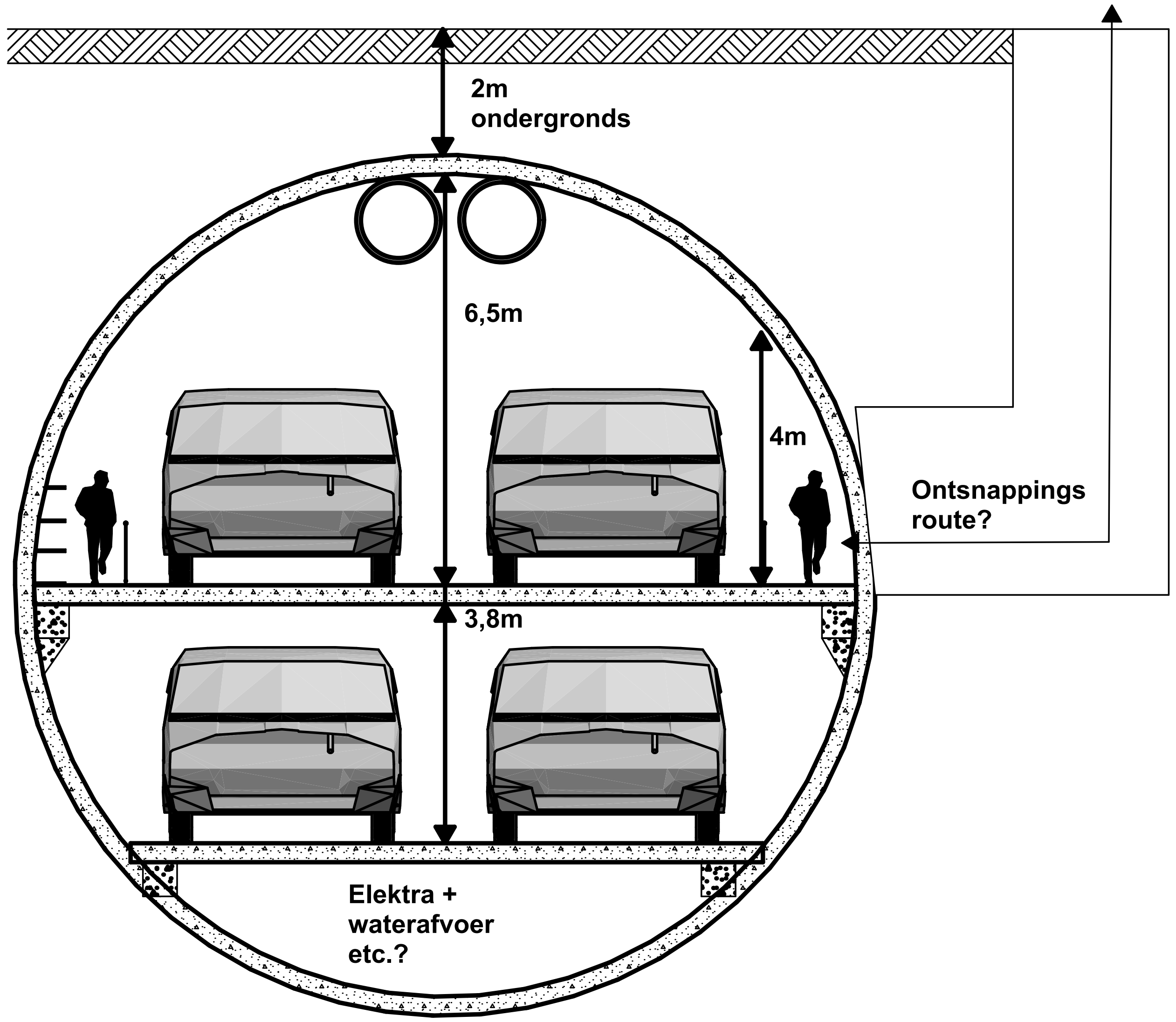


Figure 18. *Vehicle building underground version 2 – made by author (2026)*

Subquestion 4: How do compact and dispersed spatial configurations contribute to resilience?

A dispersed spatial configuration remained consistent throughout the design process (Figure 19). The author decided to fragment the floorplans to further distribute the design more. (Figure 20). This led the author to further design and fragment the sleep building, which led to a design that is easier to place systematically, just like the first fragmentation of the cafeteria and kitchen (Figure 21). Due to the fragmentation of the building plans, each building accommodates fewer people, which limits damage in the event of an attack and forces an attacker to choose between more targets. This can significantly reduce the attacker's potential impact.

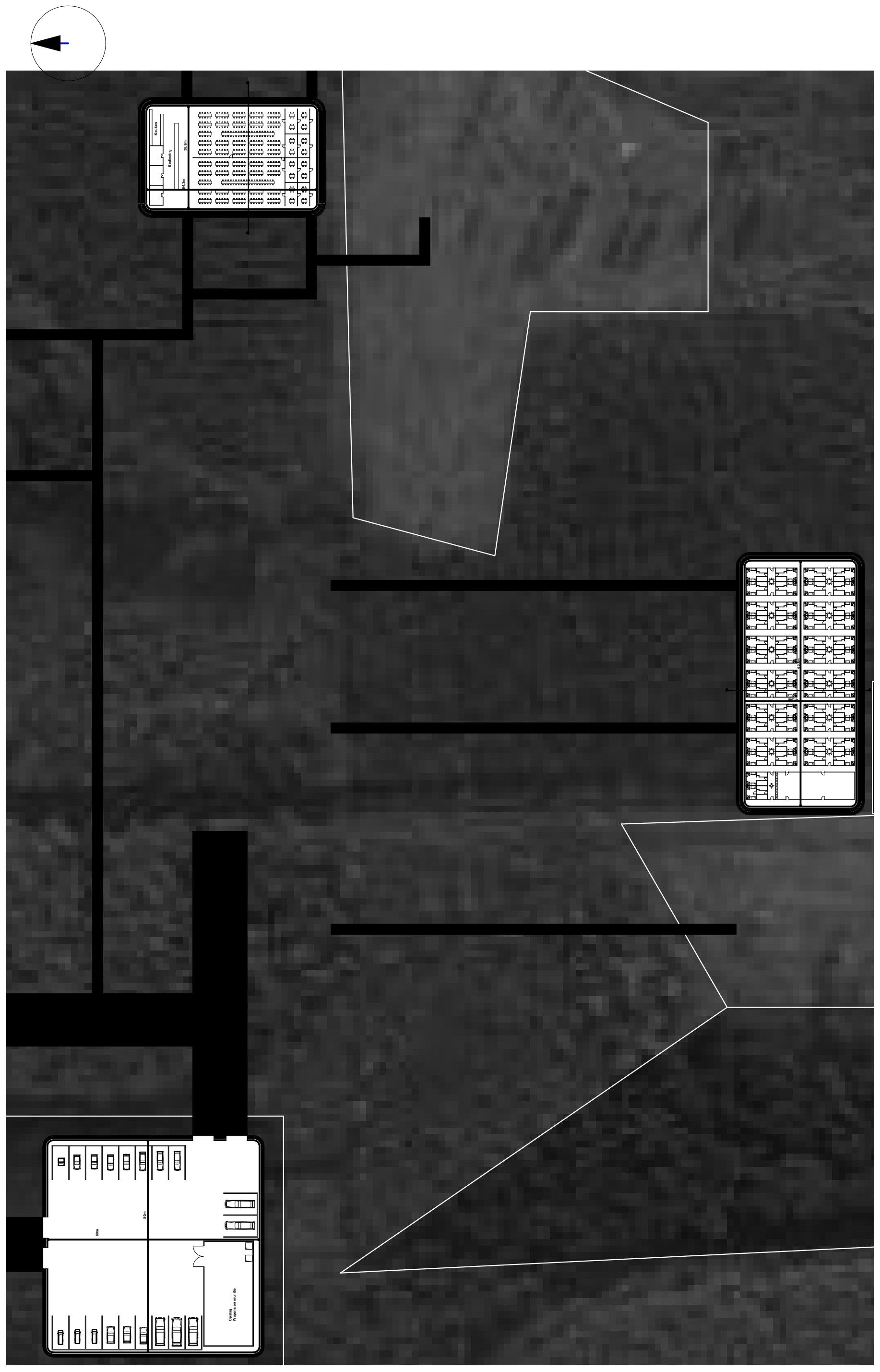


Figure 19. *Distributed plan – made by author (2026)*

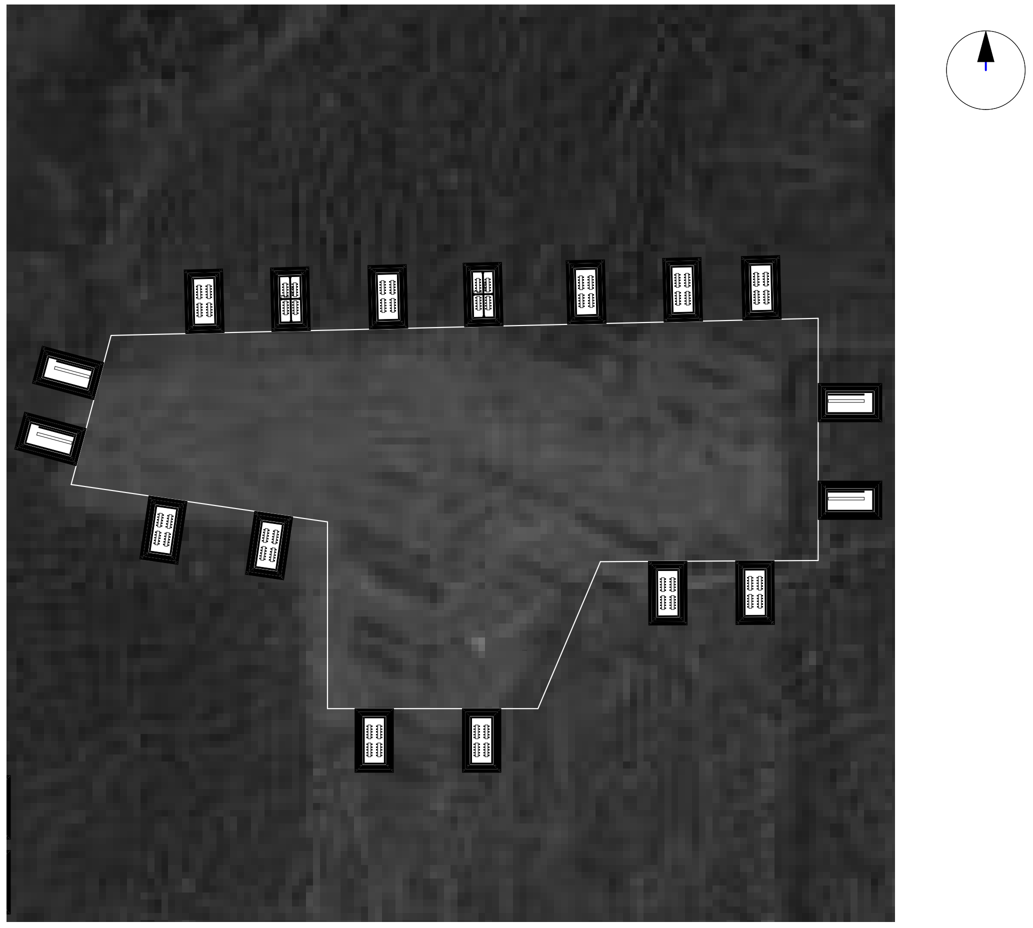


Figure 20. *Fragmented floorplans – made by author (2026)*

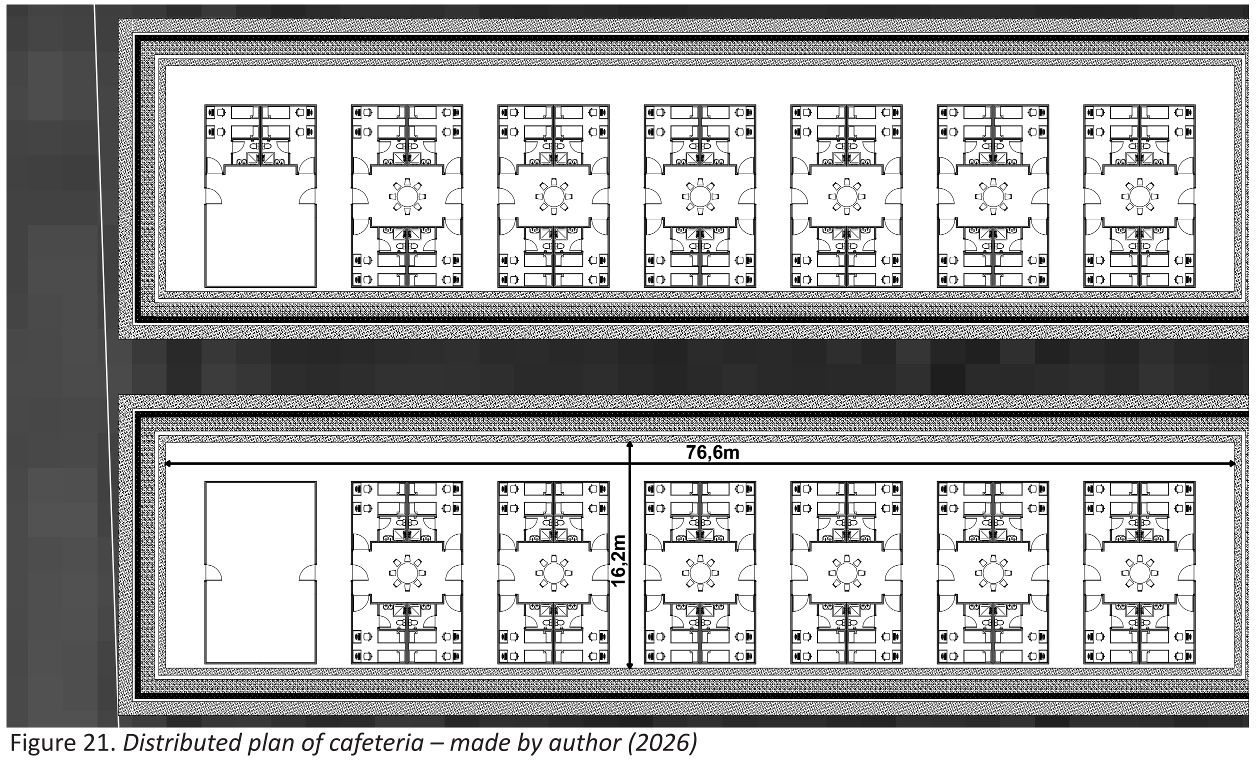


Figure 21. *Distributed plan of cafeteria – made by author (2026)*

4.2. Final Design

In the final design, the hangar has been created, which provides a safe space for the movable building. Figure 22 shows the different scenarios. The Masterplan is created on the pointed out location within the Rūdninkai Training Area. The open spots at this location form the basis of the masterplan. See Figure 23. The underground functions are constructed using a tunnel boring machine. The main design focus is within the red block, with Figure 24 highlighting specific locations. The top right segment—the sleeping quarters—is the primary focus of this Masterplan. In addition, placing the two above-ground buildings (sleeping quarters building and cafeteria) next to open areas allows trees to be replanted there, creating space in the forest and further hide and protecting the building.

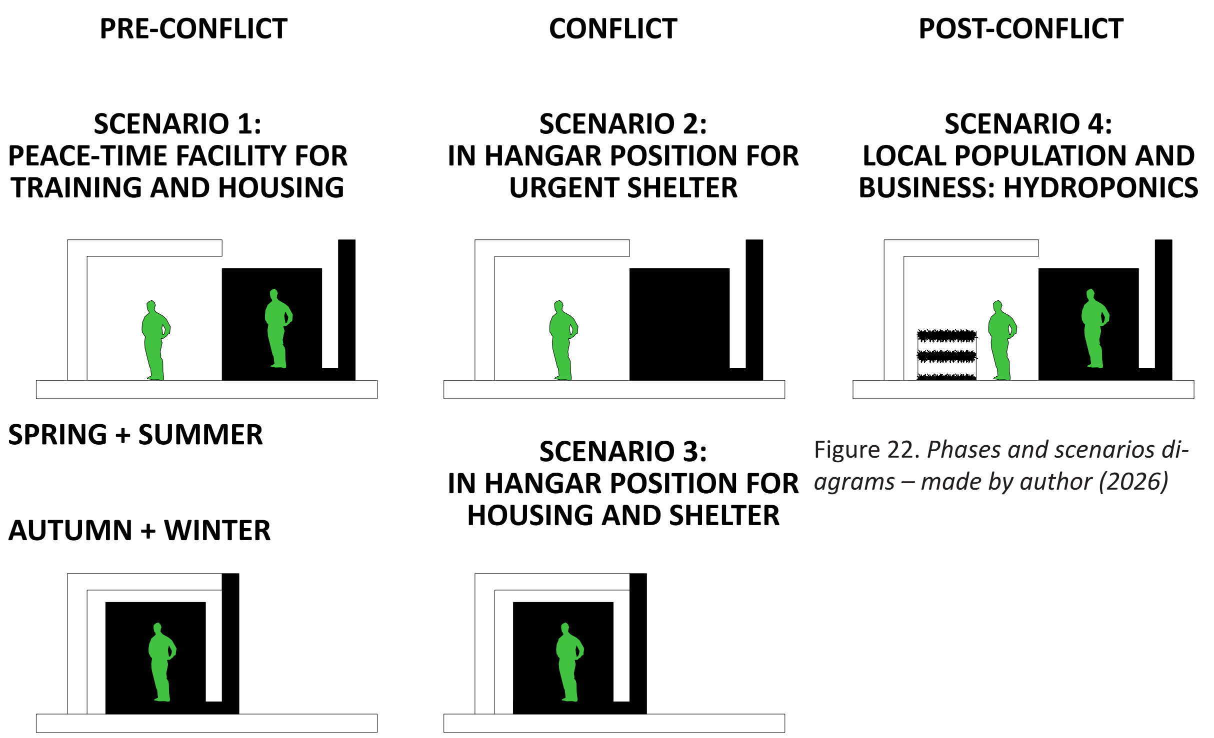


Figure 22. *Phases and scenarios diagrams – made by author (2026)*

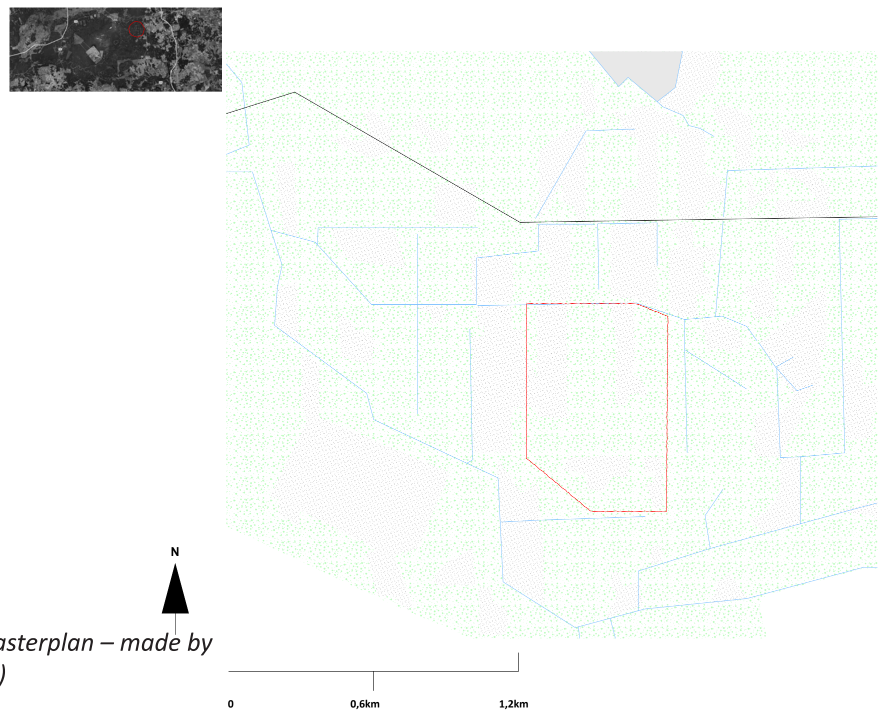


Figure 23. *Masterplan – made by author (2026)*

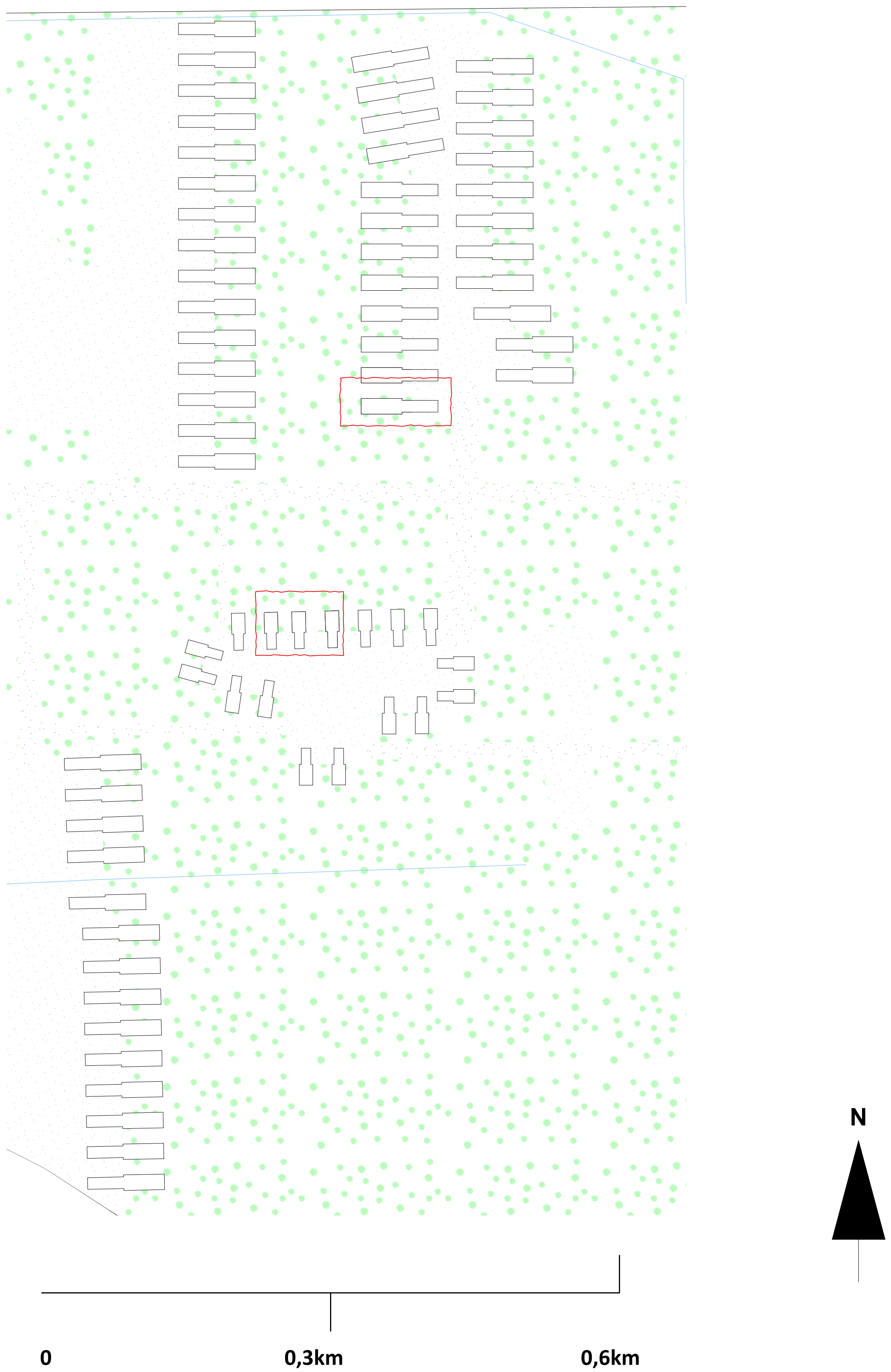


Figure 24. *Masterplan focus – made by author (2026)*

The movable building is located in a basin that can be filled with water to enable movement. The water is stored in hydrobags, bags filled with water, which are filled and drained via a piping system connected to a centrifugal pump. When water needs to be controlled, a fire hose is attached to the pump and the internal piping system. Heating in the concrete float structure is only required to prevent the water inside the boat from freezing. To secure the movable building in place, the basin is drained. Figure 25 and Figure 26 show the water system and its operation.

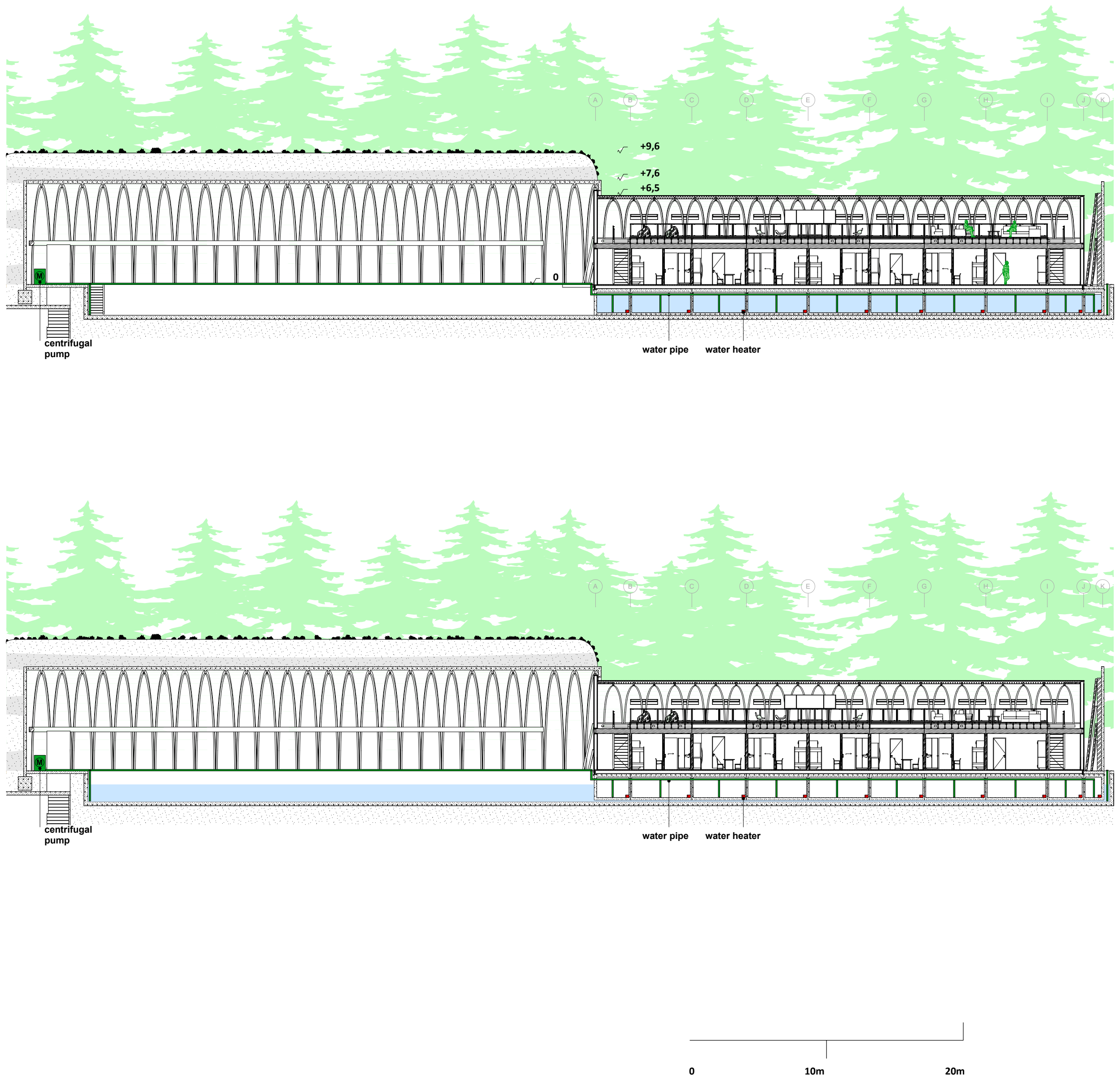


Figure 25. *Water manipulation floating system – made by author (2026)*

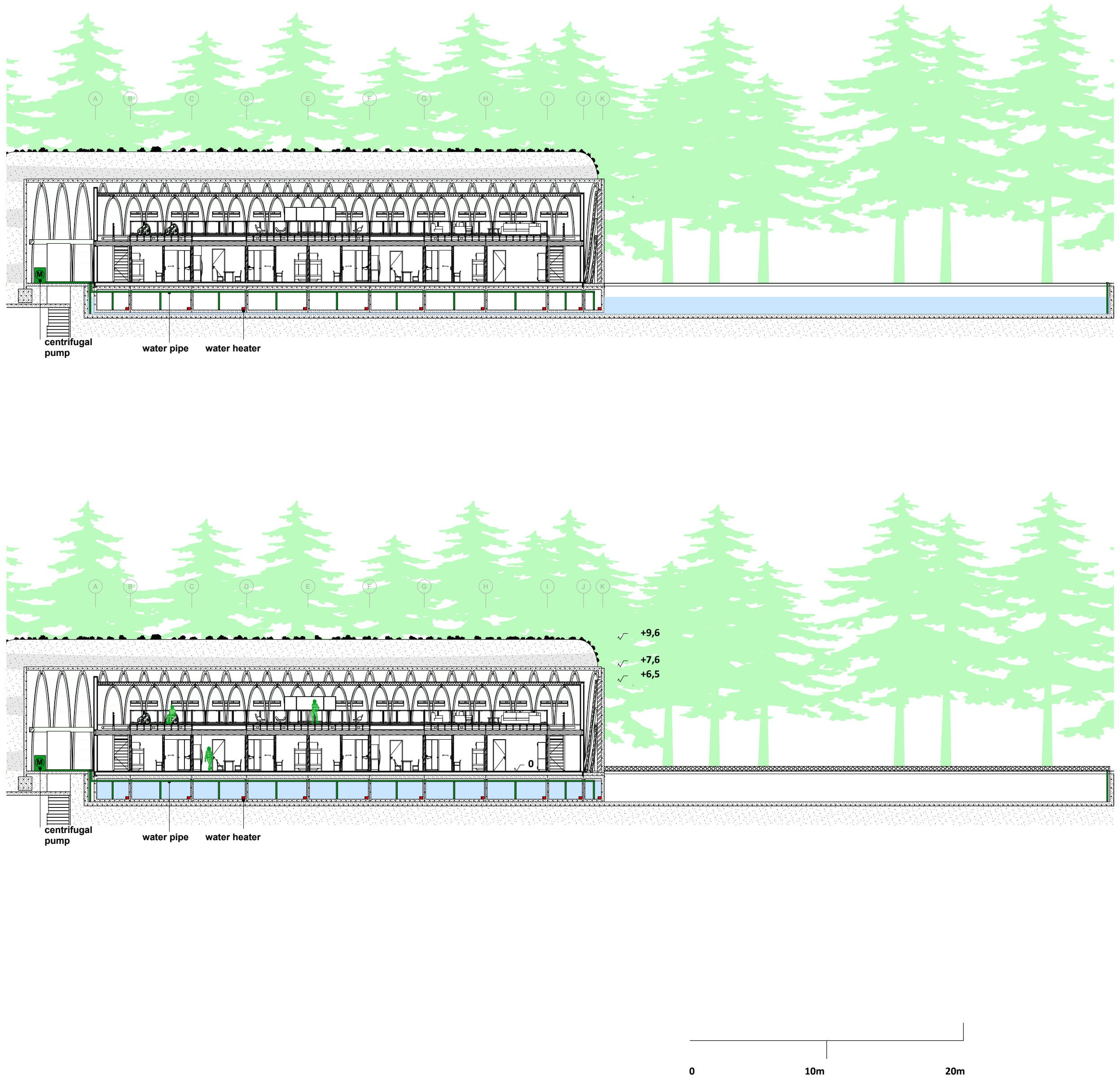


Figure 26. *Water manipulation floating system – made by author (2026)*

Furthermore, the design of the sleeping quarters exists of a ground floor and a first floor. The ground floor contains the sleeping quarters clusters. These consists of bedrooms, and a communal space including the pantry. Next to the clusters is the open hallway placed. Meanwhile, the open space within the hangar provides training space for the soldiers. In the event of a surprise attack, soldiers can take shelter in the sand-protected hangar and escape via the tunnel (Figure 27).

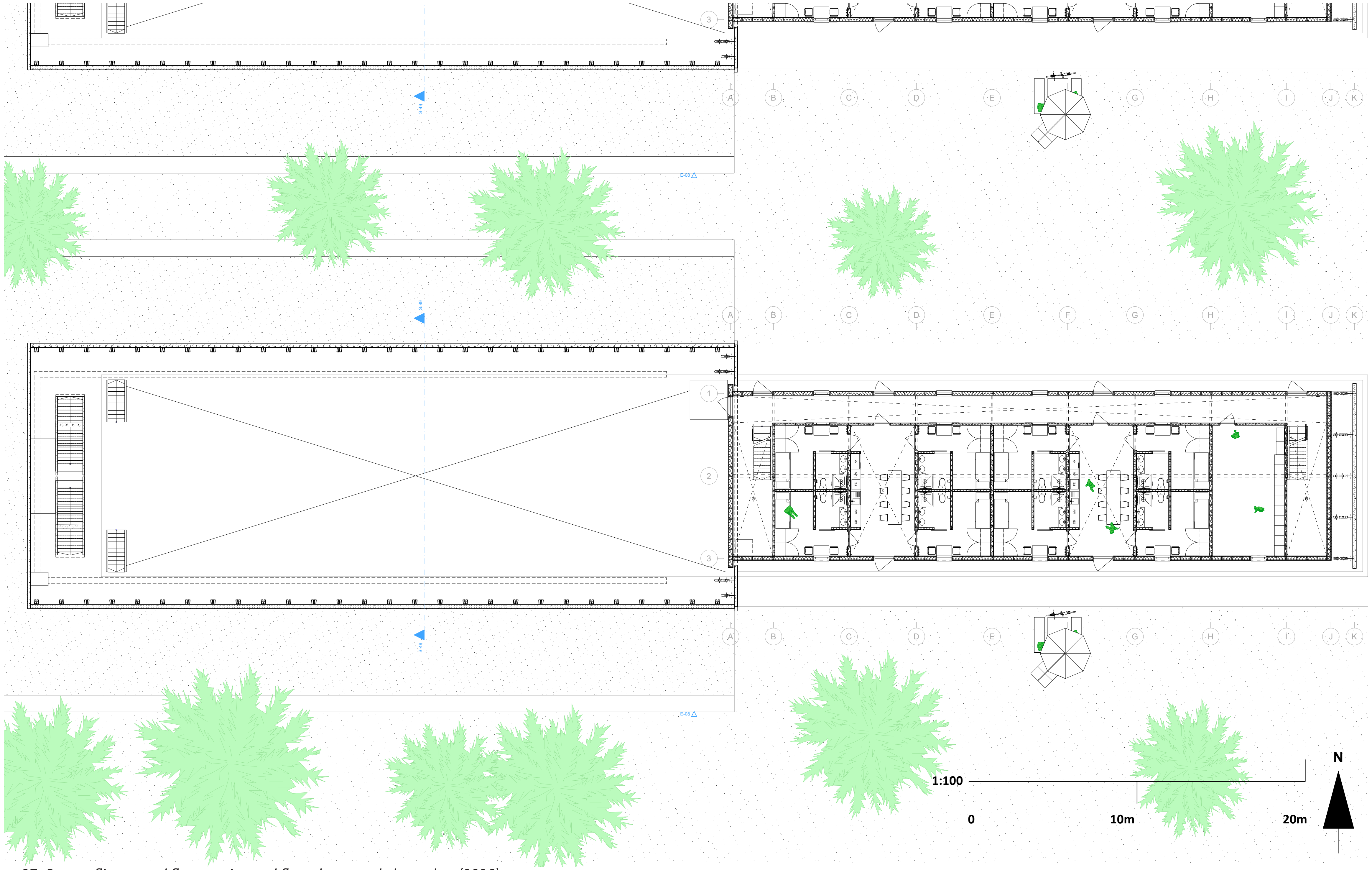


Figure 27. *Pre-conflict ground floor section and floorplan – made by author (2026)*

Figure 28 shows the first floor. The soldiers have been given a seating space they can arrange as they see fit. In the middle is space to discuss final thoughts together.

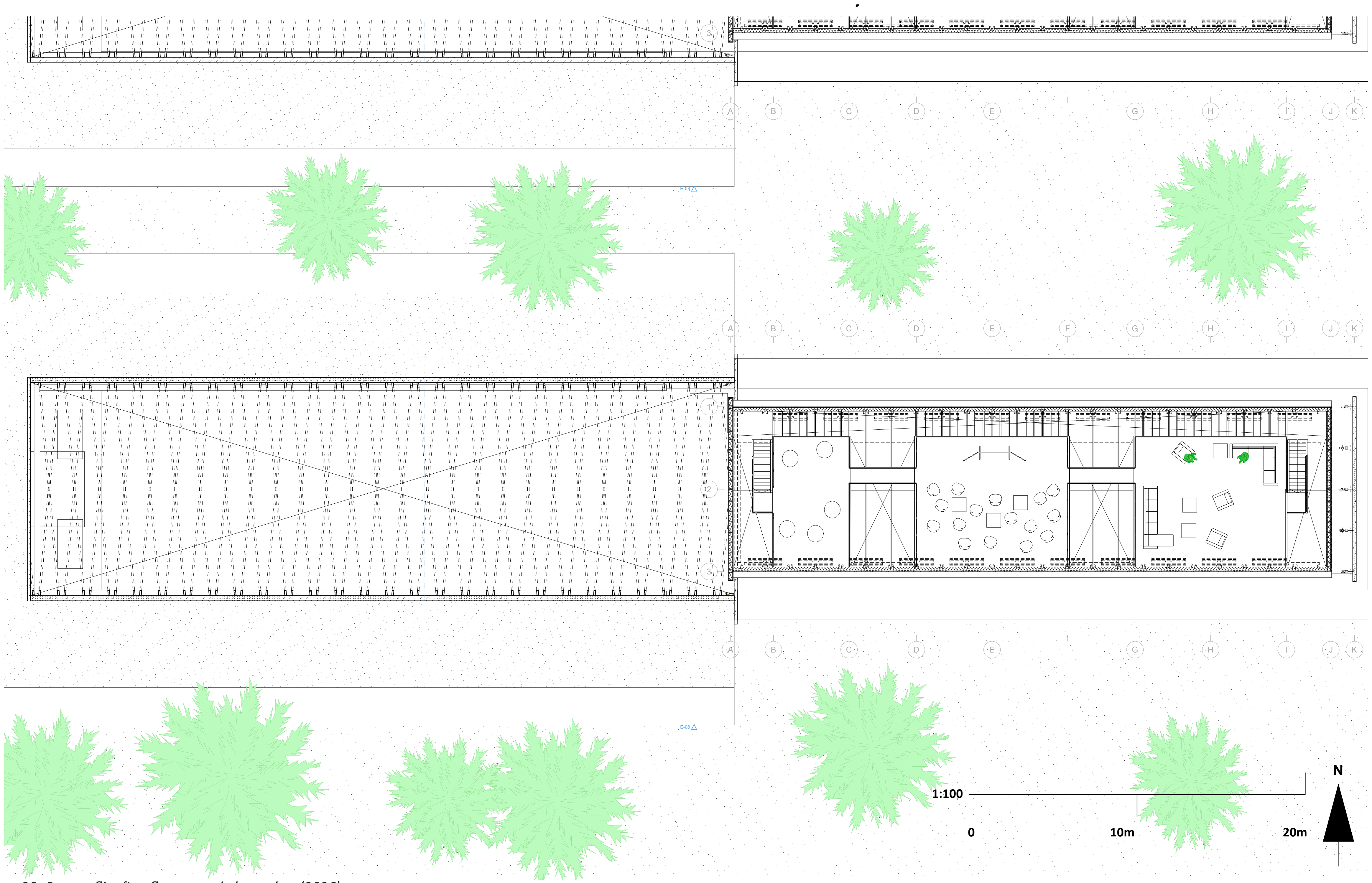


Figure 28. *Pre-conflict first floor – made by author (2026)*

Figure 29 shows the next scenario, namely hiding the building inside the hangar for either as protection against the cold in Autumn and Winter, or for attacks. Inside the hangar, there is a walkway around the movable building, providing access to the movable building and underground tunnels.

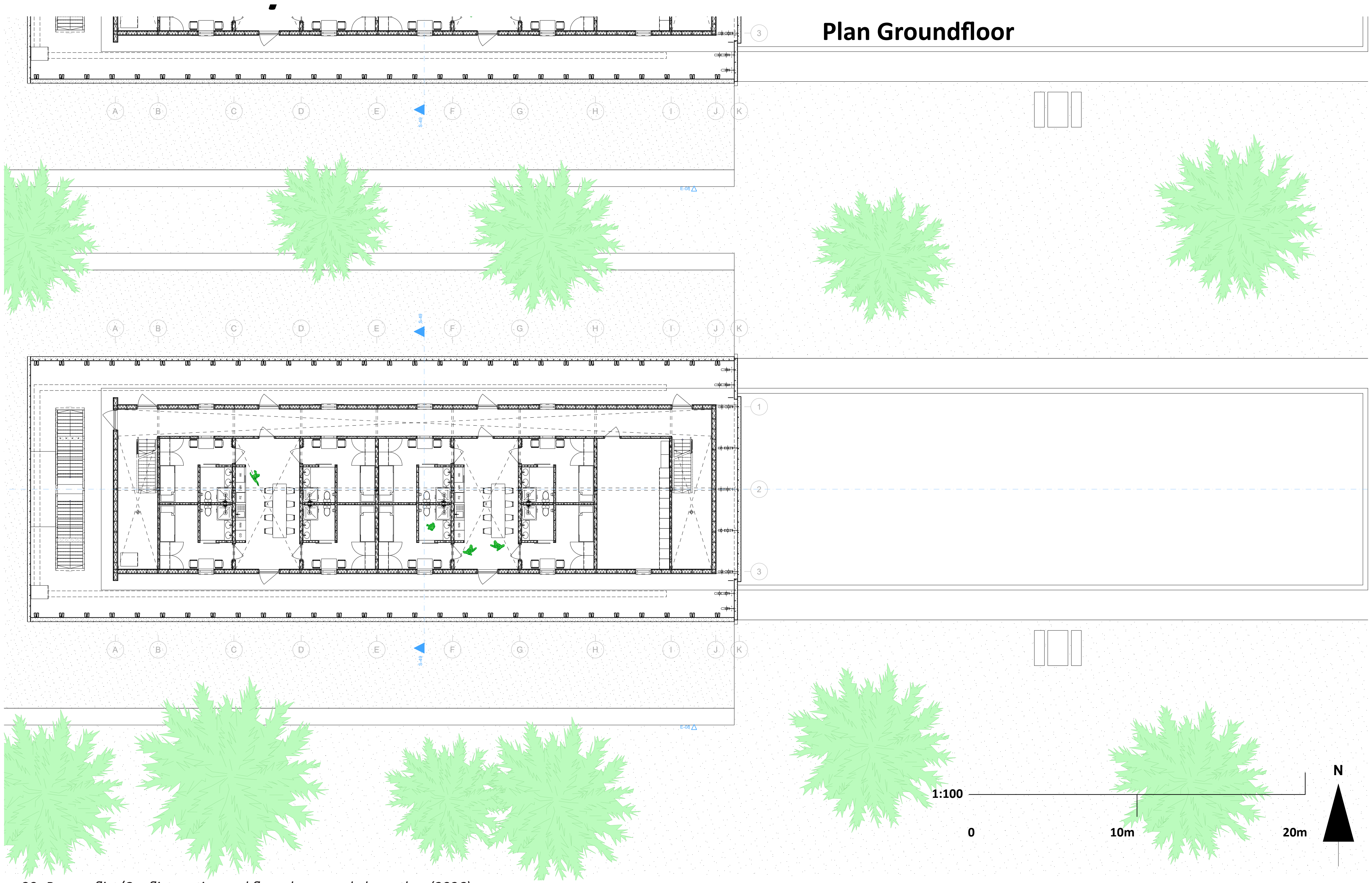


Figure 29. *Pre-conflict/Conflict section and floorplan – made by author (2026)*

After the conflict phase, the design transitions to providing space for hydroponics. Inside the hangar, racks are installed for farming. In the movable building, the ground floor retains its load-bearing structure while the layout is adapted. In this phase, the movable building serves as a production space after farming, while the first floor continues to provide the same relaxation space on the first floor as for the soldiers (Figure 30).

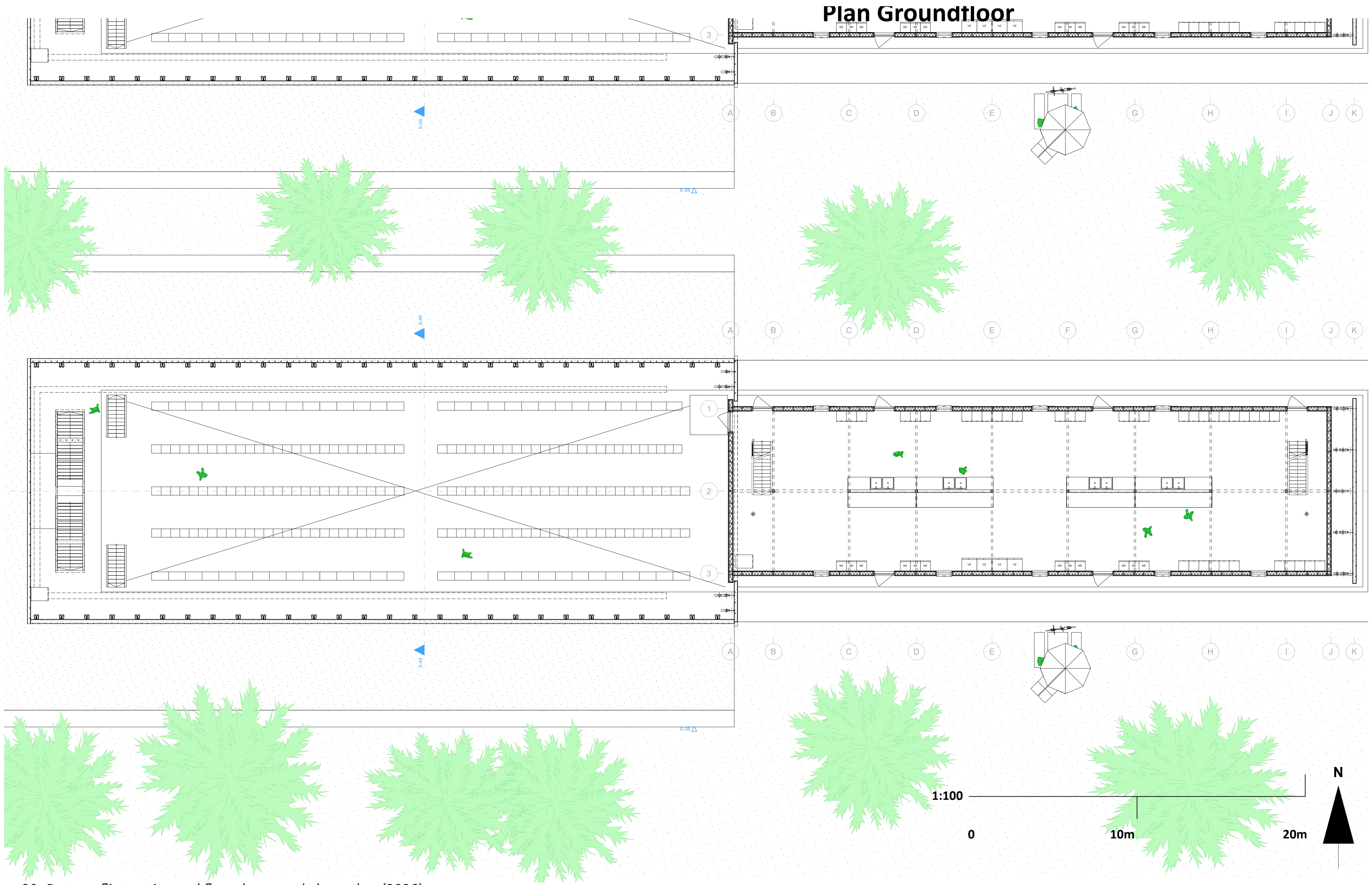


Figure 30. *Post-conflict section and floorplan – made by author (2026)*

The side-focus of the Masterplan is the design of the cafeteria. This is done, to show two different suggestions for movable building design - two different sizes. The dining space and kitchen are separated from each other, to provide enough space for both functions. Figure 31 shows the post-conflict phase. During this phase, the cafeteria remains intact in order to provide the farmers and others a place to retreat. The hydroponics racks are placed inside the hangar (Figure 31).

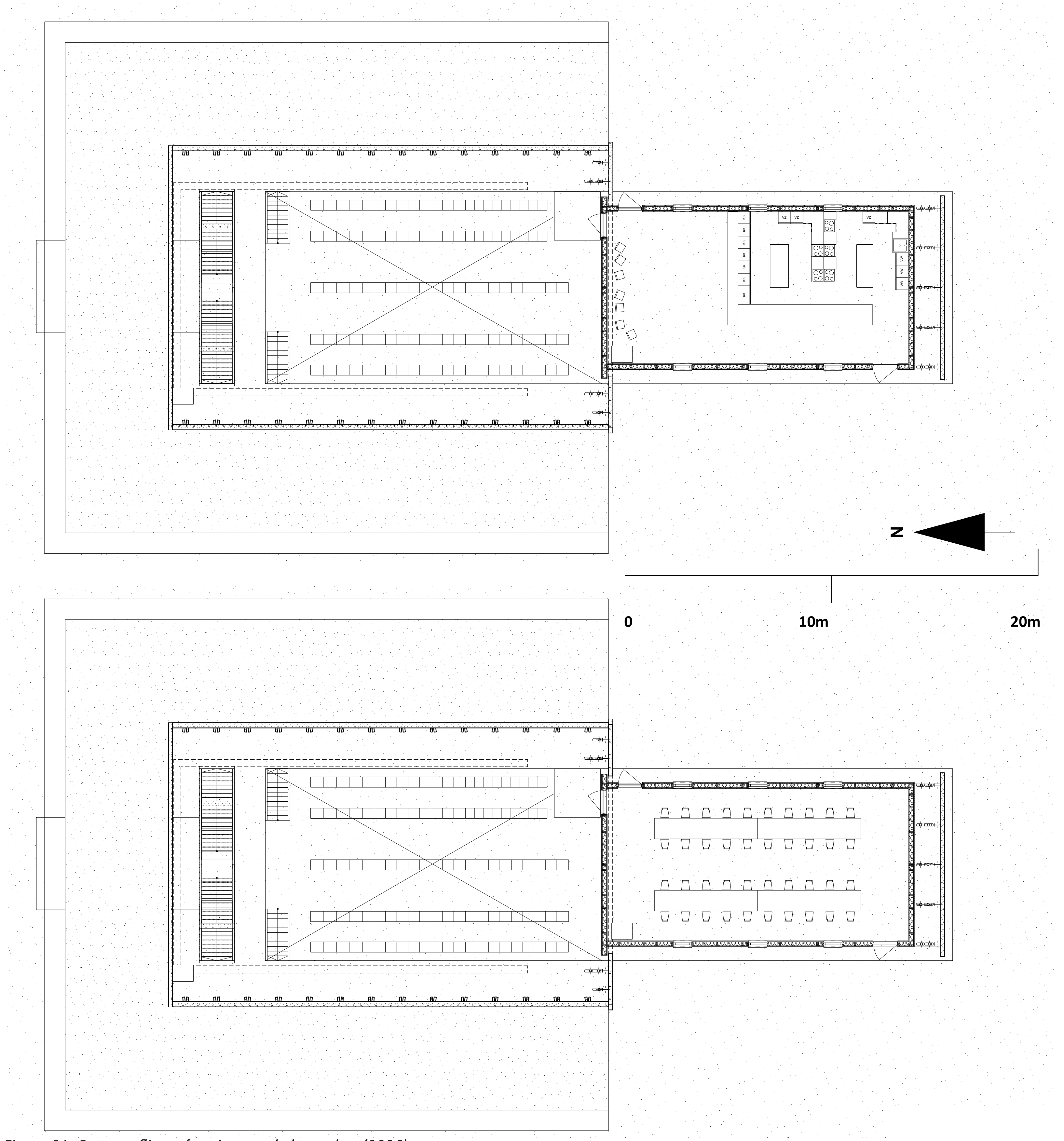


Figure 31. *Post-conflict cafeteria – made by author (2026)*

Figure 32 shows the load-bearing structure axonometry of the sleeping quarters. The roof-structure exists of crossed Glulam beams, connected by tie-rods and steel structure.

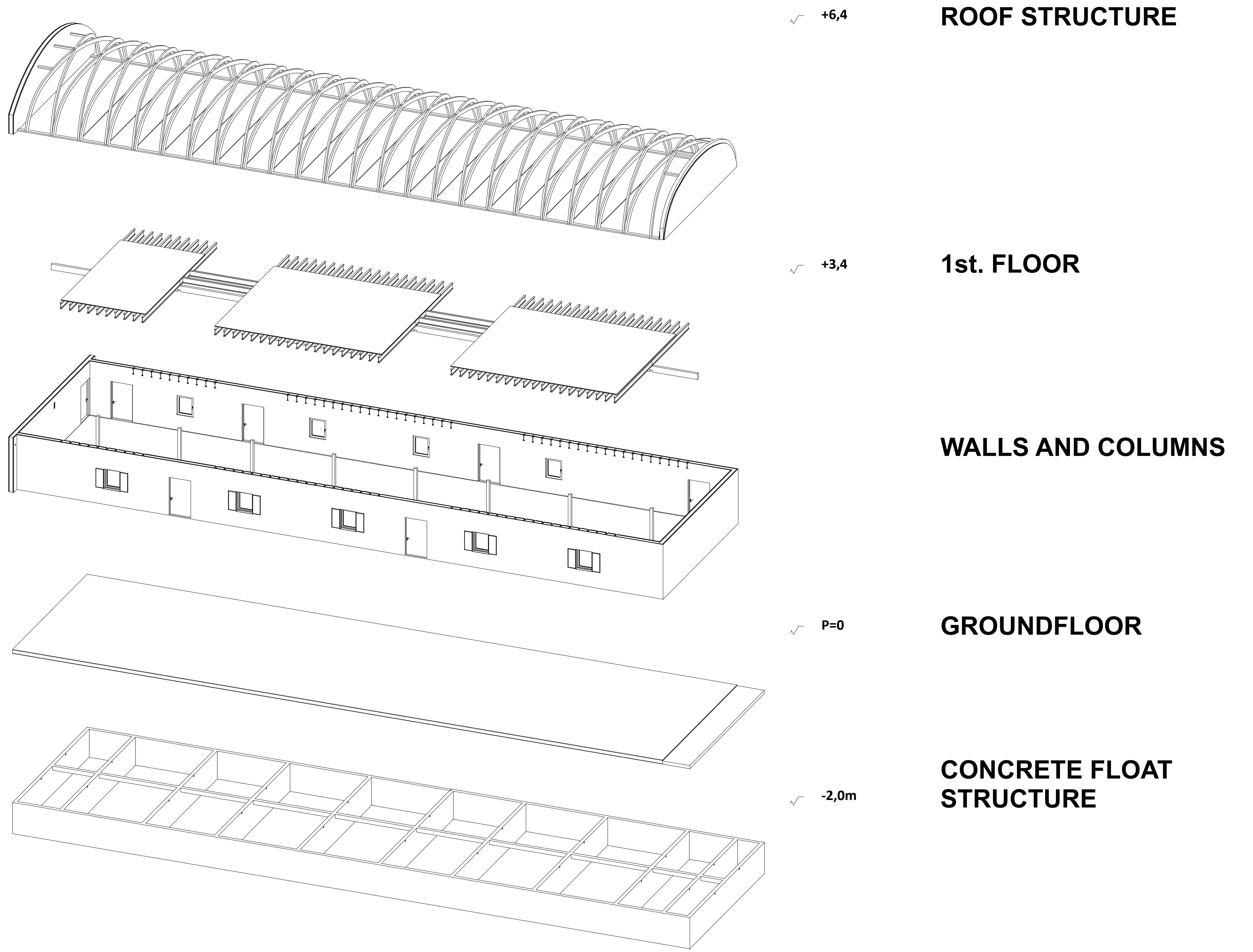


Figure 32. *Axonometry of load-bearing structure – made by author (2026)*

As can be seen in Figure 33 of the sleeping quarters building, the roof-finish exists of corrugated sheets. These sheets are bendable to the radius of the roof. Skylights are placed in the roof, to provide additional daylight and to enhance connection to the outside world. The load-bearing structure consists of wooden framework with PIR insulation. PIR insulation is chosen, since this requires minimal space while providing good insulation values. Window shutters are placed outside to keep the sun's heat outside the building on the clusters' level.

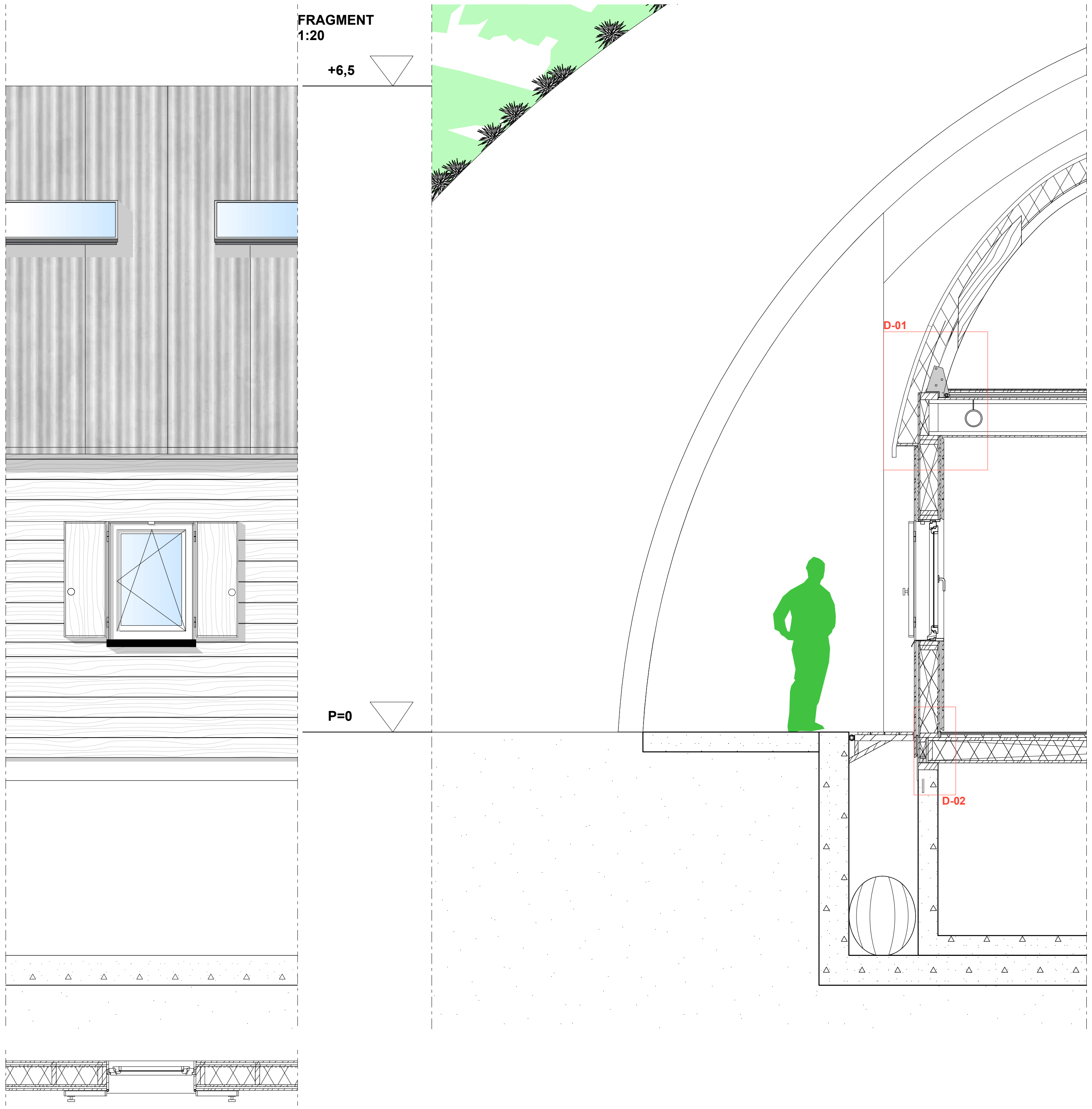


Figure 33. *Fragment see of sleeping quarters building – made by author (2026)*

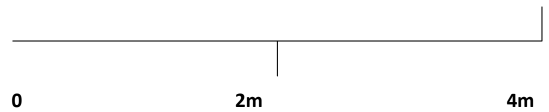


Figure 34 shows the cross-section of the sleeping quarter building in the 'See' phase. When the building needs to move, the floating ball fenders prevent the building to move sideways.

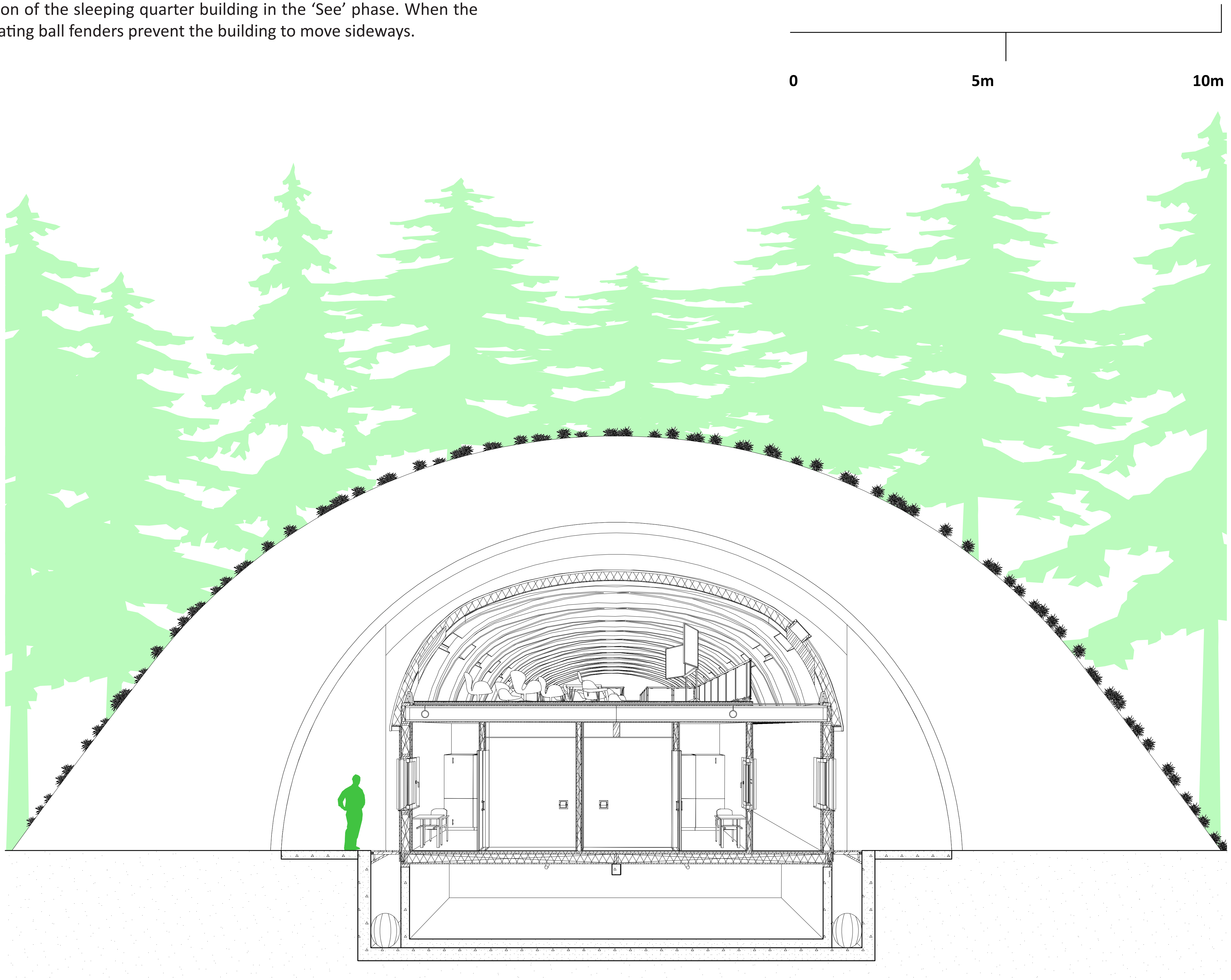
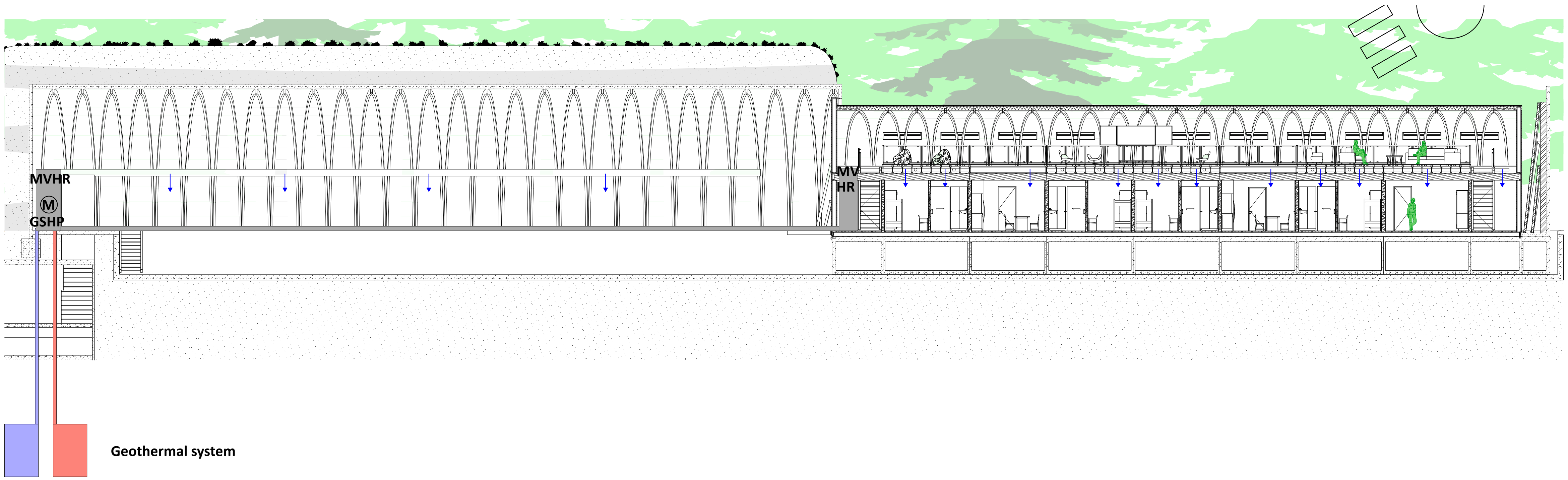


Figure 34. *Cross-section see – made by author (2026)*

Figure 35 shows the climate scheme of de ‘see’ phase. The climate-systems are routed through the ground in the hangar and connected to the movable building. The unit can be heated using geothermal energy. The hangar is covered by sand and surrounded by trees, which form extra protection against explosion/blast waves/bomb impact. Ventilation occurs through direct outside air, together with mechanical ventilation in order to either cool or heat the building.



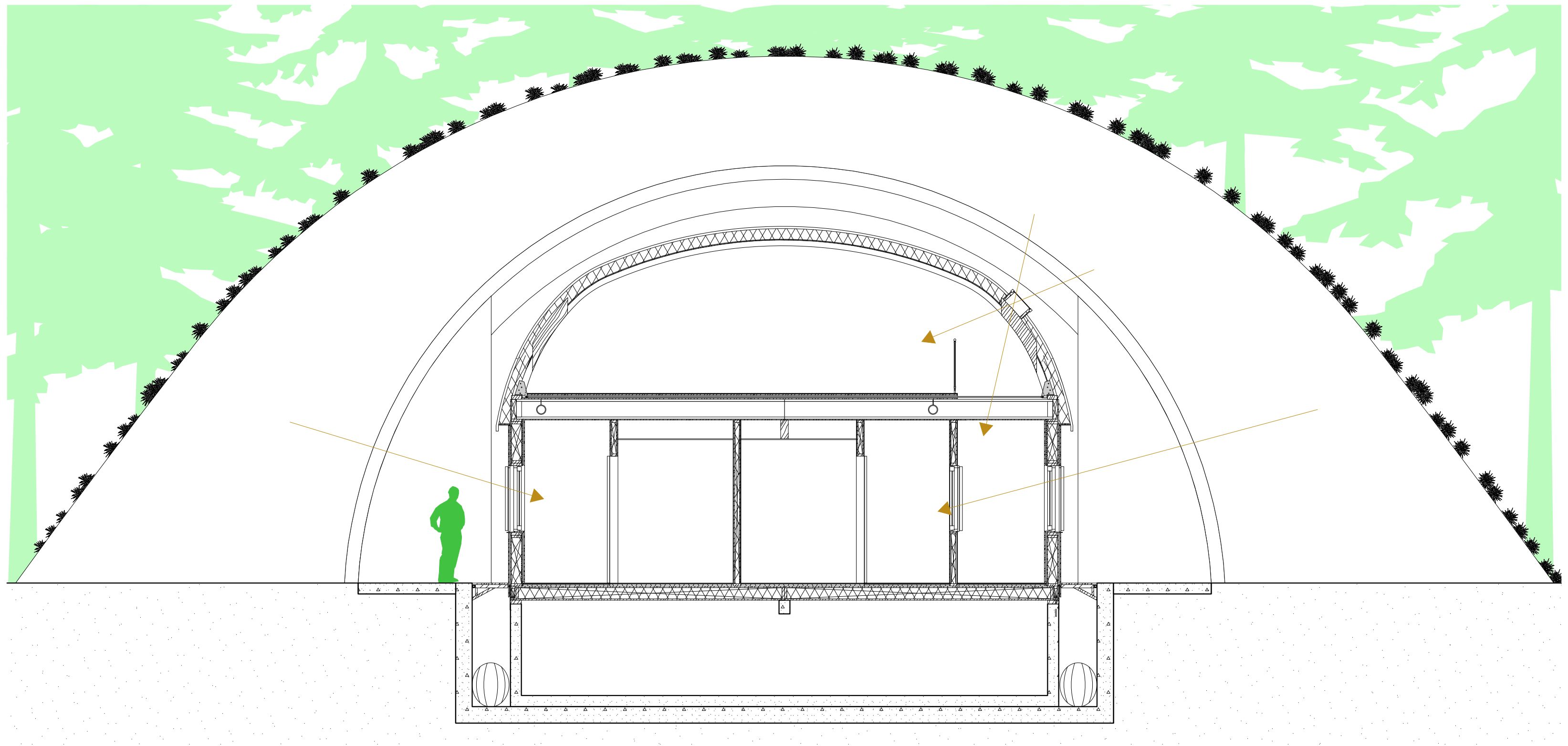


Figure 35. *Climate see – made by author (2026)*

Once the building is inside, the fragments look like as is shown in Figure 36.

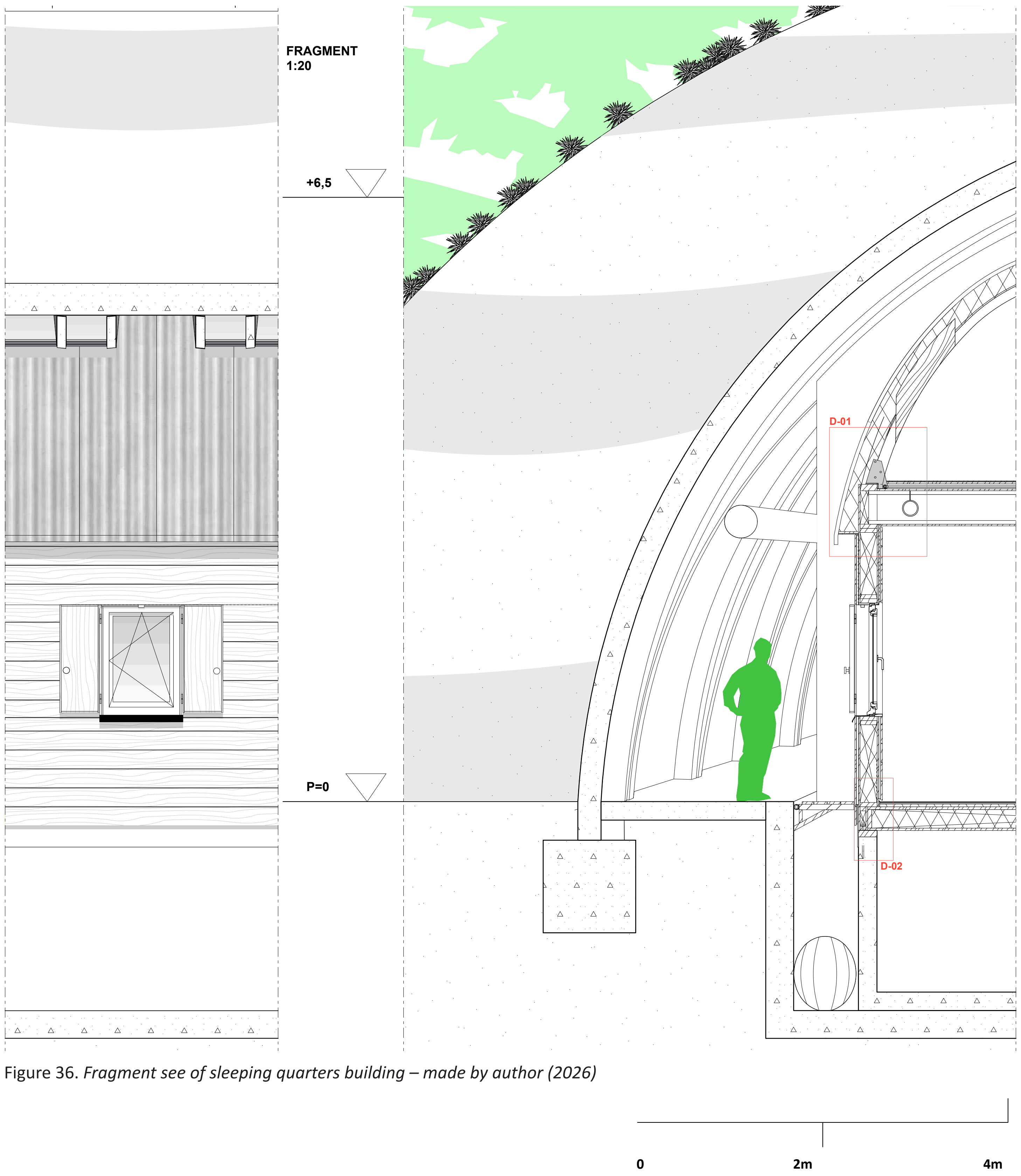


Figure 36. *Fragment see of sleeping quarters building – made by author (2026)*

Figure 37 shows the cross-section of the sleeping quarters building in the 'Hide' phase.

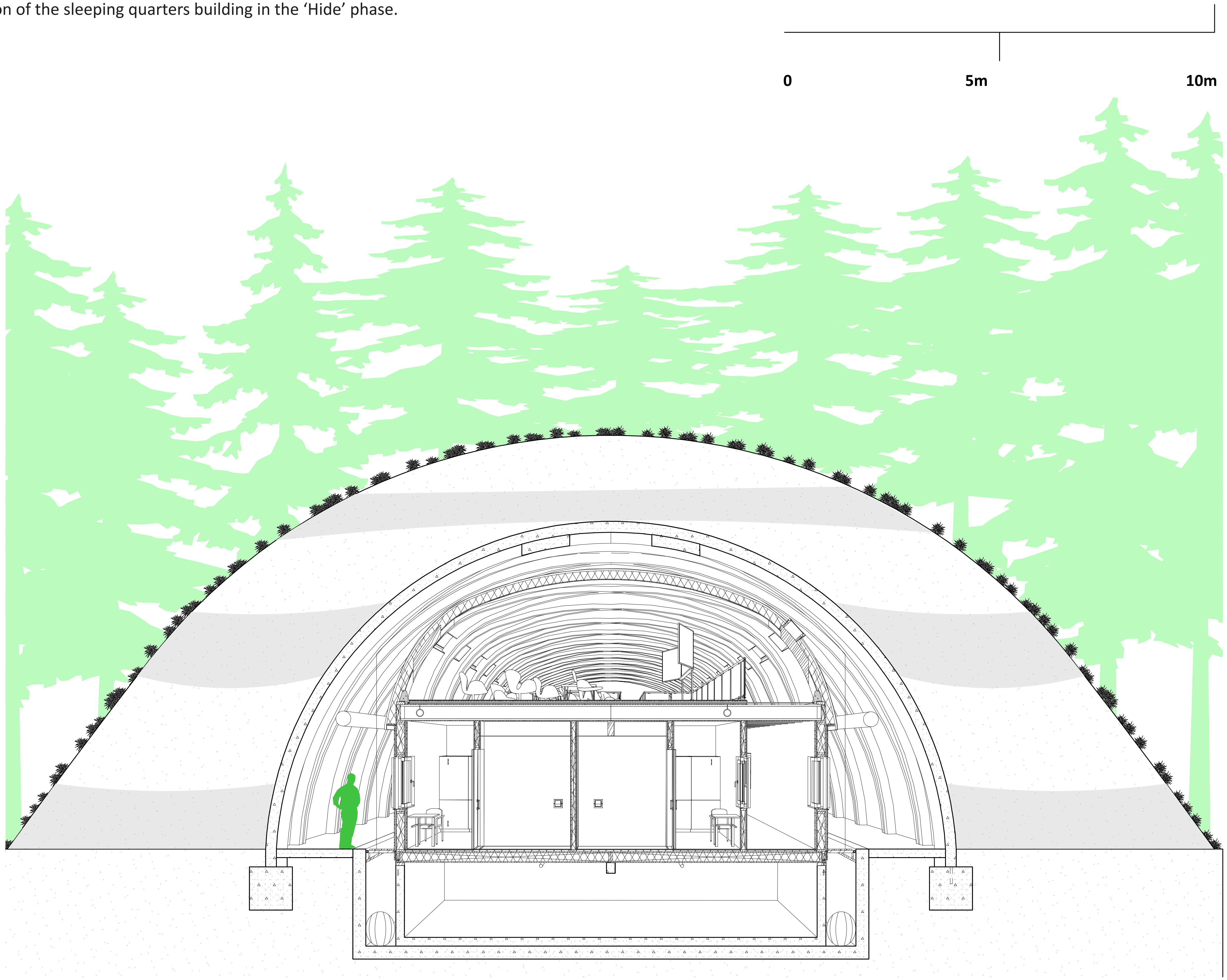


Figure 37. *Fragment see of sleeping quarters building – made by author (2026)*

Figure 38 shows the climate scheme of de 'hide' phase. The climate-systems are routed through the ground. The unit can be heated using geothermal energy and connected to the movable building. The hangar is covered by sand and surrounded by trees, which form extra protection against explosion/blast waves/bomb impact. Mechanical ventilation occurs through air circulation via the ground within the hangar.

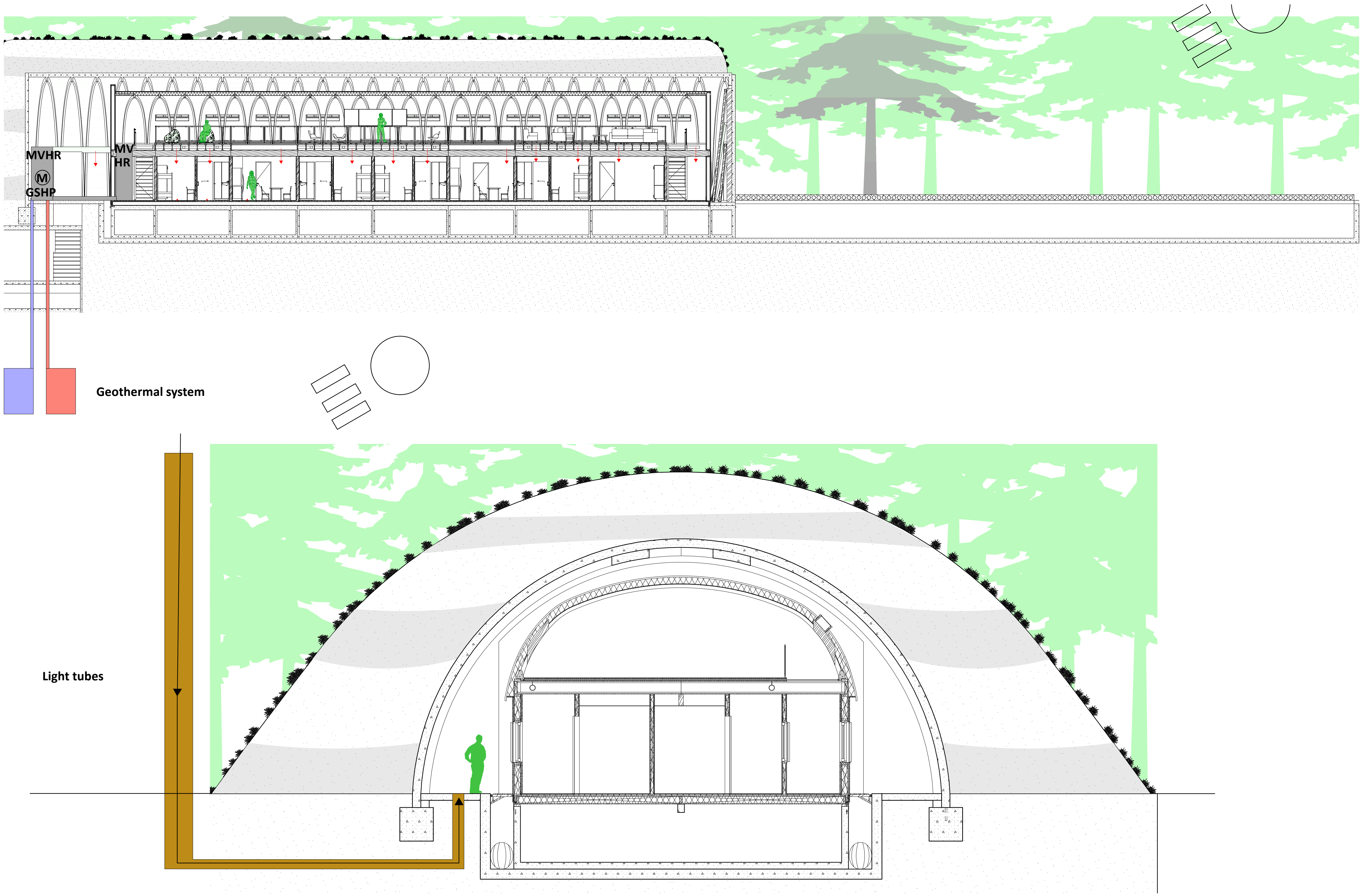
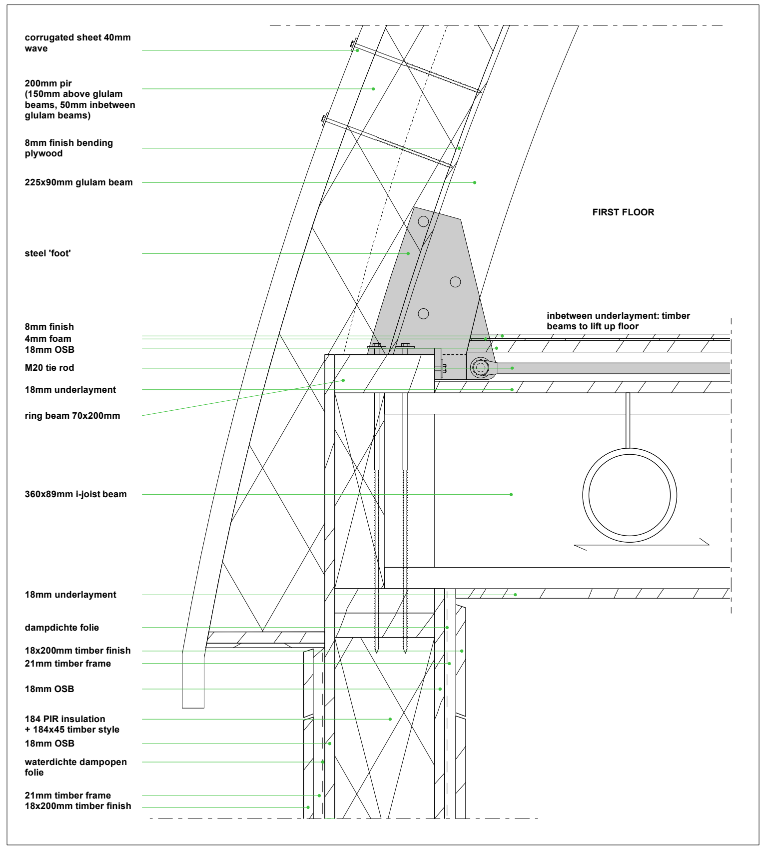
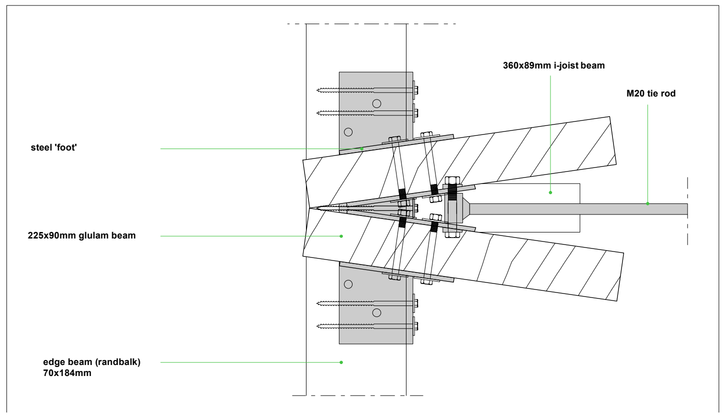


Figure 38. *Climate hide – made by author (2026)*

The details are shown in Figure 39. The timber structure of the building, including the tie-rods, metal frame, and the concrete float-structure form the building.

D-01 1:5 **Rd = 9**

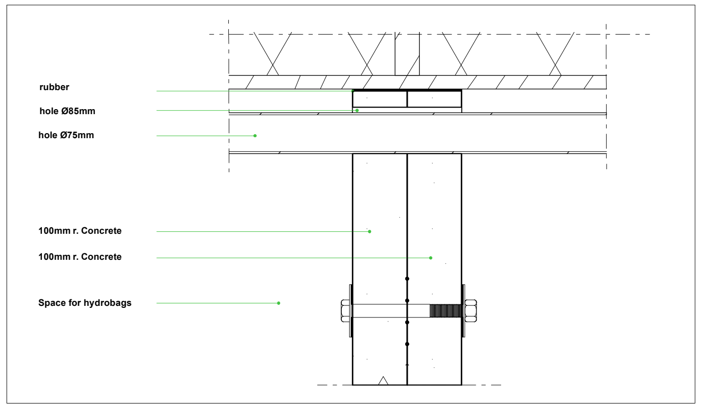


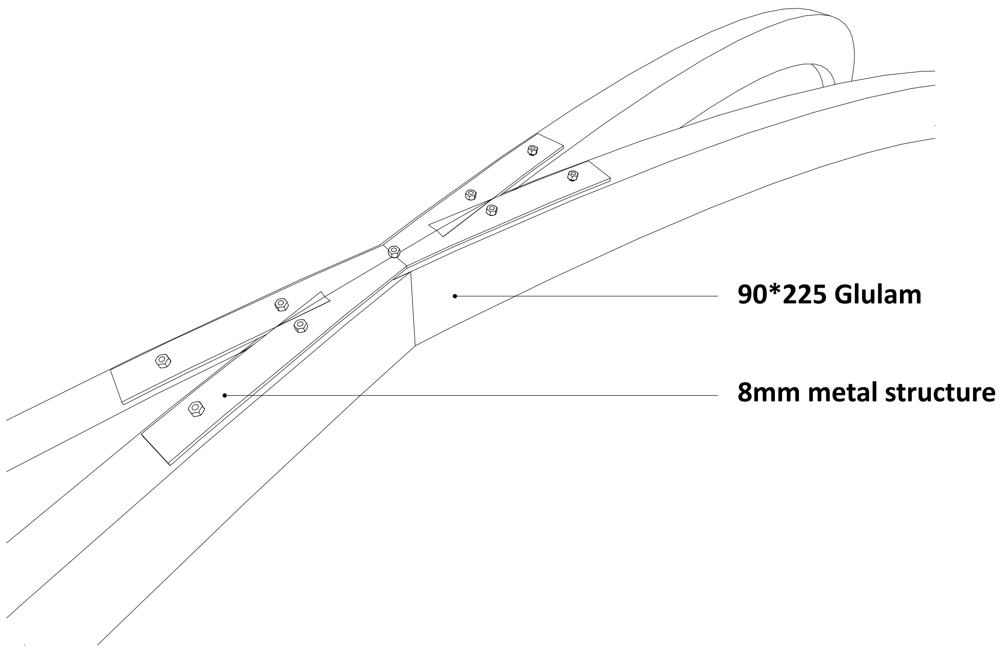


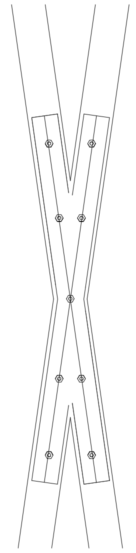
D-03
1:5
horizontal principle detail

Rd = 9

D-04
1:5
vertical longitudinal detail of floating structure







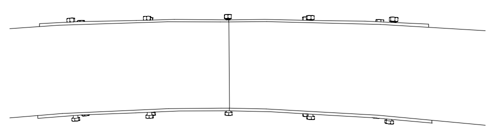


Figure 39. *Detailing – made by author (2026)*

Two impressions are shown in Figure 40 and Figure 41.

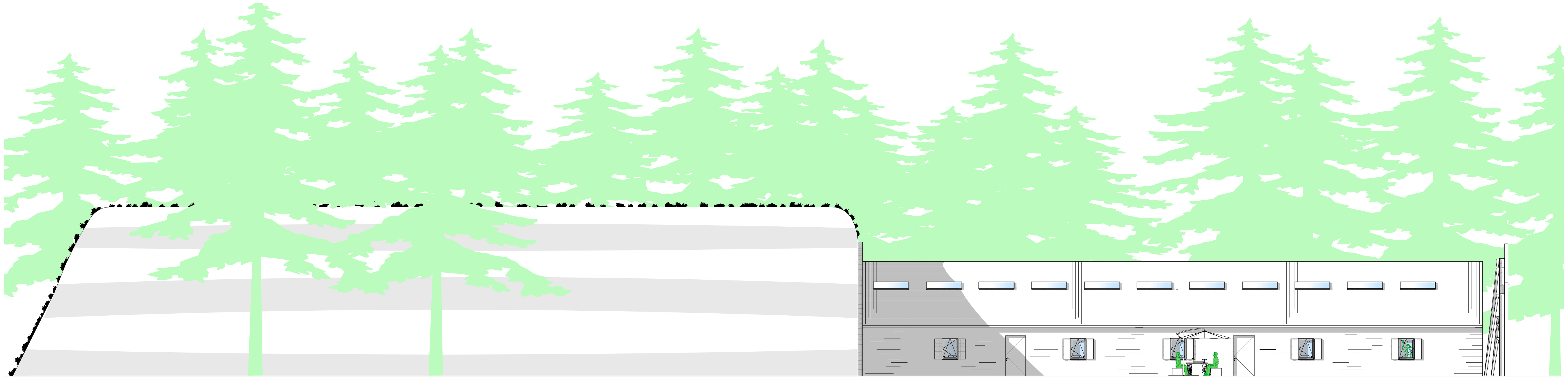
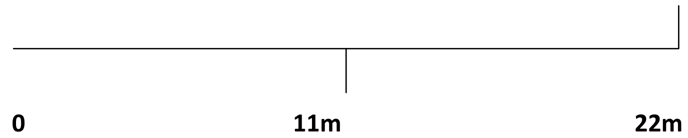


Figure 40. *Façade sleeping quarters see – made by author (2026)*



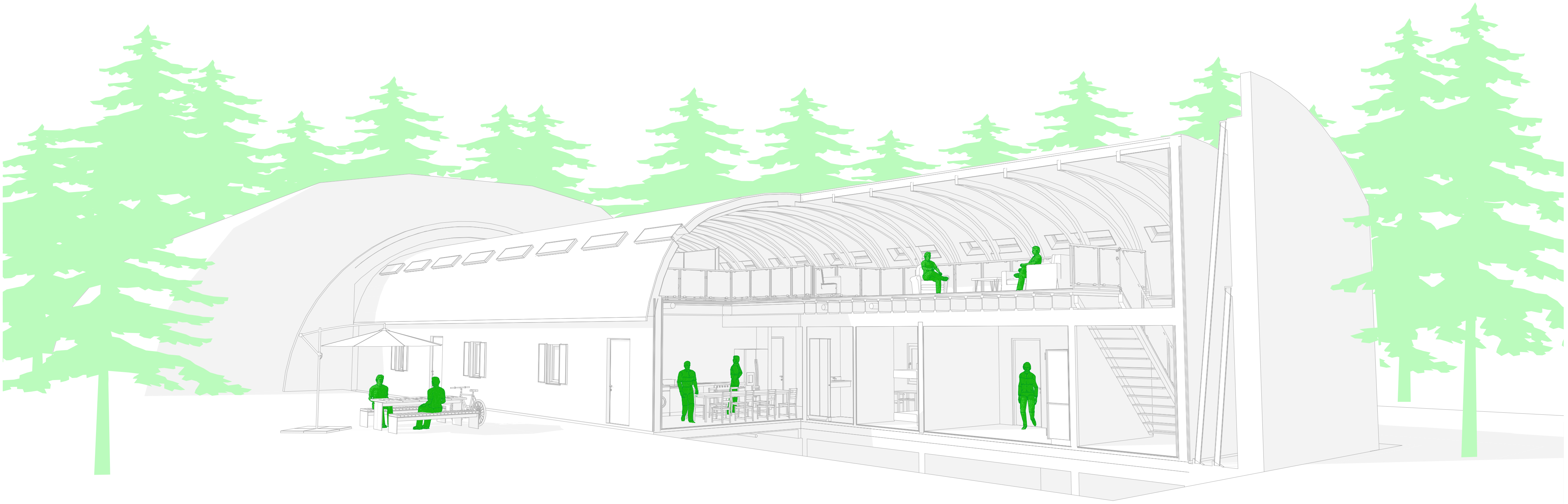


Figure 41. *Façade sleeping quarters see – made by author (2026)*

5. Part 4 - Conclusion and Discussion

5.1. Conclusion

This design explored how spatial strategies can contribute to defensive resilience in military base design for its soldiers, using natural materials where feasible. The final design shows that defensive resilience and architectural quality can work together through spatial organization, material use, and adaptability.

The design is based on the idea that a military base functions both as a static defensive object, and as a system that responds to different scenarios over time. The final design is about how spatial organization, landscape integration, and adaptability can contribute to both safety and usability. The combination of the above-ground structure, a flexible spatial system and tunneling-options, makes it possible for the base to function in both conflict and non-conflict situations. This creates a design that is not fixed in one condition, but can shift between different scenarios. The movable building moves from one fixed position to another fixed position by using water and buoyancy for smooth transition from outside to inside. When there is no water in the system, the movable building has a solid position in the basin. The relation between building and landscape is therefore both visual, functional and protective. Trees, sand, and terrain are treated as active parts of the defensive system.

The main research question focused on how spatial strategies can contribute to defensive resilience in military base design for its soldiers, while using natural materials where feasible. The final design answers this through the combination of sand-covered structures, an adaptable spatial system, tunneling-option, timber structure and protection by trees. The design shows that resilience is not only created through the reinforced concrete hangar, but also through flexibility and the dispersed spatial configuration of the masterplan.

The first sub-question explored which bunker design elements contribute to resilience. The design shows that resilience is created through the reinforced concrete hangar, the underground escape route, the use of sand as shielding material and its own climate system per hangar and building. The sleeping quarters are positioned inside the hangar covered with sand. This limits visual detection. In addition, the underground tunnel system allows safe movement during attacks and provides escape possibilities when necessary. The hangar functions as a protective shell around the movable building design.

The second sub-question focused on how the spatial configuration of earth and building influences safety, environmental comfort, and user perception. The design shows that sand contributes both technically and architecturally. Technically, the sand improves blast resistance, thermal stability, and camouflage. Architecturally, the integration into the landscape reduces the closed character often associated with bunker typologies. Through skylights, open circulation spaces, and the movable building, soldiers maintain visual contact with the outside world during peaceful periods in spring and summer. This improves environmental comfort while having the option for protection.

The third sub-question investigated how soil and timber can contribute to a blast-resistant base. The design shows that both materials contribute to resilience while also improving architectural quality. Together with the surrounding trees, the sand surrounding the hangar structure absorbs blast forces, and therefore provides protection. Besides, the sand provides camouflage within the forest.

The fourth sub-question explored how compact and dispersed spatial configurations contribute to resilience. The dispersed spatial configuration is implemented in the final design. The functions within the masterplan are dispersed across the site to reduce vulnerability during attacks. Via underground infrastructure, another building can be reached. This combination increases both safety and resilience.

The final design strongly relates to the technical and architectural ambitions formulated in the introduction. Technically, the final design creates defensive resilience by sand-covered hangars, positioning within the forest, and adaptable scenarios for war and peace. Architecturally, the final design improves the living environment for soldiers by avoiding a fully closed bunker typology. Through the use of timber, daylight, skylights, and visual connections to the surrounding landscape, the design creates moments of openness during peaceful periods in Spring and Summer. During these periods, the movable building can move outside the hangar to allow direct contact with nature. During conflict situations or colder seasons in the pre-conflict phase, it can move back into the protective hangar. In the post-conflict phase, the final design provides hydroponics to further serve the community.

The combination of sand, timber, the movable system and forest integration ensures that the building can respond to different levels of threat while still maintaining architectural quality. The final result shows that military infrastructure can be more than purely defensive, and can also support comfort, orientation and connection to the environment, depending on the scenario. This balance between openness and protection forms *FLOAT hide and see*.

5.2. Implications and/or Recommendations

As described in Chapter 1, war destroys many lives. However, war keeps happening. Therefore, the brave soldiers need to be protected while maintaining visual contact with the outer world based on the mentioned scenarios. The final design explored how spatial strategies can contribute to defensive resilience in military base design for its soldiers, using natural materials where feasible.

The final design responds to this through the combination of sand-covered structures, an adaptable spatial system, timber elements, and an adaptable spatial system that can shift between different scenarios, and the suggestion for underground infrastructure,. In terms of transferability, the design principles are not limited to Lithuania. The combination of layered protection, dispersed masterplanning and the use of natural materials can also be applied in other similar contexts. This makes the approach flexible. While the location for *FLOAT hide and see* is in Lithuania, the protective and architectural elements of the final design can be implemented where timber, water and reinforced concrete are available. This availability is important, as using local materials results in lower CO2 emissions than if materials have to be imported. This directly links back to the relevance from the introduction, where building locally is an important aspect.

The use of sand as a protective layer and the trees surrounding the buildings shows that natural materials can be part of a defensive system. Trees have not been cut down, but replanted. This is especially relevant because timber in shock-wave environments is still underresearched, which makes this type of design relevant for further exploration. In this way, the project also contributes to architectural knowledge about how natural materials can perform in defensive and high-risk conditions.

An important implication of *FLOAT hide and see* for the architectural profession is that military architecture does not have to be purely temporary or only focused on defence. Instead, it can be seen as a more flexible system that changes over time and remains useful in different scenarios.

The project is also relevant in terms of repurposing and sustainability. Instead of creating a building that is only useful during conflict, the design continues to function in the post-conflict phase - *FLOAT hide and see* will not be abandoned, but repurposed once the threat of war has passed. Therefore, the final design continues to serve the community in the post-conflict phase. This makes the final design more circular and more efficient in the long term, which is important in military infrastructure that often remains after conflicts have ended. In this way, the final design contributes to a more sustainable approach within the built environment, where buildings are designed for multiple life cycles instead of single use. With this knowledge, the Dutch Military of Defense is invited to take inspiration from *FLOAT hide and see*, especially in exploring how layered protection, adaptability and local material use can be further developed in future military base design.

5.3. Reflection

The literature research informed the design, which means the research was valuable for the design process. During the design process, drawings and sketch model were created. Those led to the insight to create a movable design.

The author kept in mind the various possibilities, including permanent structures, underground facilities, form and functionality, floorplans and movement, that were considered. After weighing these options, a bunker still emerges as a viable option for protection against attacks. This led to the design of a reinforced structure; however, spending time there during peacetime is less desirable, as people want to maintain contact with the outside world. The cold seasons, particularly winter, pose a threat to livability, which is why, through the choice of a flexible structure that combines protection with openness, it must be possible to move a building into and out of a bunker. There are various options for this, such as rails and water. Given the availability of water and the vulnerability of rails, it has been determined that water and buoyancy offer an effective means of moving an object.
Fixed –> float –> move –> defloat –> fixed is the consequence of this design approach. See Figure 42 for the different scenarios.

The assignment of creating a military base was very different from what the author created before, and important in today's society. Furthermore, no moral or ethical issues or dilemmas arised. Therefore, the motivation was high to create a valuable design. The studio focusses on designing in Extreme environments, and *FLOAT hide and see* forms an Extreme solution to an Extreme environment.

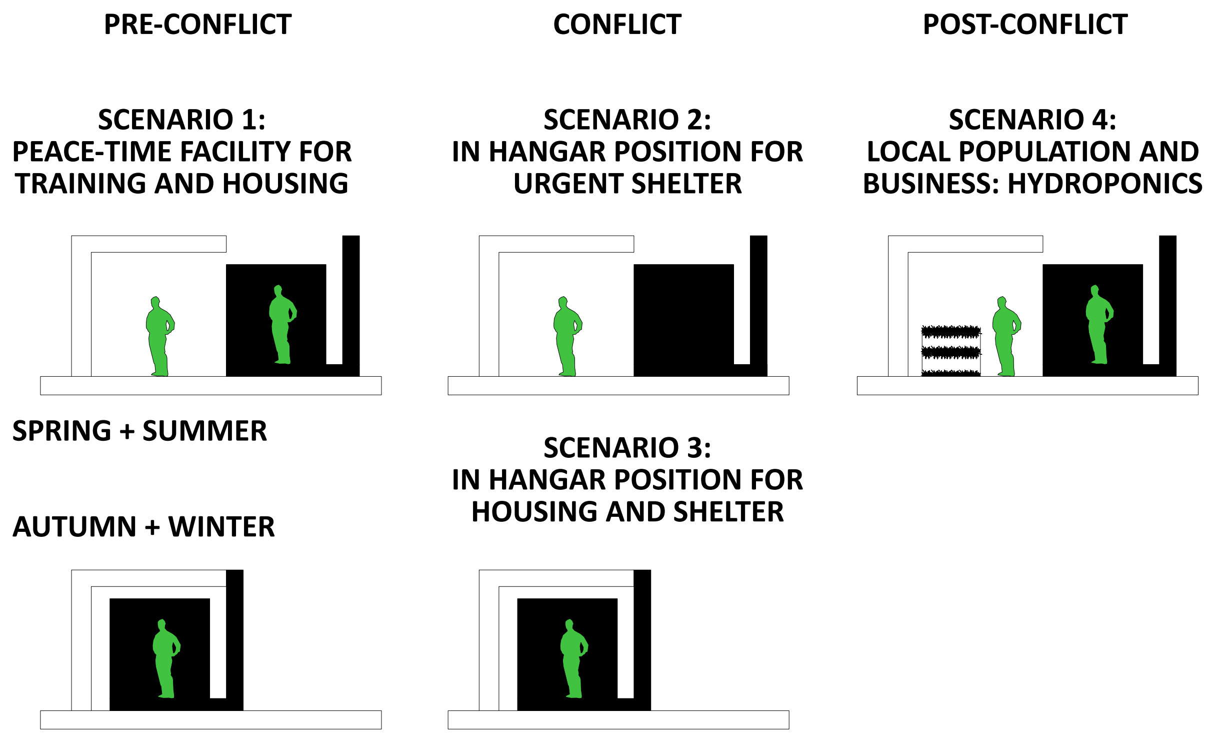


Figure 42. *Phases and scenarios diagrams - made by author (2026)*

Appendice - Data Management Checklist

Section A. General considerations	yes	no
1. Is the graduation project conducted as part of an internship (at a company), or as part of a research project at TU Delft? If a student's graduation project is conducted at a company or as part of a research project at the university, questions of data ownership and intellectual property rights need to be addressed in a written graduation or internship agreement before the project begins. Student and supervisor should consult the Intellectual Property Rights of Students webpage. Additional information can also be found in the Extended Personal Research Data Workflow. If applicable, complete the Confidentiality Agreement.		✓
2. Does the project involve conducting (part of) the research outside the Netherlands? Students who intend to travel abroad (even to other EU countries) for study, exchange, research, internship, or graduation project purposes need to follow the Travel Safety Protocol. This includes attending a mandatory Travel Safety Training Session: see the Disclaimer.		✓
3. Will the research involve processing data from humans, such as running a survey, conducting interviews or workshops, collecting data through social media or internet forums, or re-using existing datasets about humans provided by a third party? (If 'yes', see follow-up questions 4 to 13 in Checklist B.) Students who work with data from human participants must complete the next section and apply for and receive ethical approval from the Human Research Ethics Committee (HREC) before conducting the research.		✓

References

Literature

Cao, H., Zhang, Z., Chen, P., Cao, L., Chen, & Chen, Z. (2021). Performance and Application of Rapid Assembling Anti-blast Wall. IOP Conf. Series: Earth and Environmental Science, 638, 1-6. doi:10.1088/1755-1315/638/1/012121

Centrum Ondergronds Bouwen. (2002). Inleiding Ondergronds Bouwen (n.e.).

Federal Research Division of the Library of Congress. (1995). Estionia, Latvia, and Lithuania country studies (1st ed.).

Gillett, P. N. (1943). The Design of Bomb Shelters [Master's Thesis, Graduate School of Michigan]. https://d.lib.msu.edu/etd/9892?__goaway_challenge=header-refresh&__goaway_id=986abc653175fdbaa651ee9075373da4&__goaway_referer=https%3A%2F%2Fd.lib.msu.edu%2F

Kirby, P. (2025). Fears of Russian aggression in Lithuania: 'The threat is real. We know this from our history'. Voxeurop. https://voxeurop.eu/en/russia-attack-lithuania-evacuation-war/

Lostumbo, M. J., McNerney, M. J., Peltz, E., Eaton, D., Frelinger, D. R., Greenfield, V. A., Halliday, J., Mills, P., Nardulli, B. R., Pettyjohn, S. L., Sollinger, J. M., & Worman, S. M. (2013). Overseas Basing of U.S. Military Forces. (Document Number RR-201-OSD). RAND Corporation. https://www.rand.org/pubs/research_reports/RR201.html

Mallory, K., & Ottar, A. (1973). Architecture of Aggression. Architectural Press Ltd.

Monumentenzorg Den Haag. (1997). Van Ouwenlaan 11. Retrieved January 5, from https://monumentenzorgdenhaag.nl/monumenten/van-ouwenlaan-11

Mourão, R., Caçoilo, A., Teixeira-Dias, F., Montalva, A., Stone, H., & Jacques, E. (2022). Blast resistance of timber structural elements: A state-of-the-art review. International Journal of Protective Structures, 14(2), 263-295. DOI: 10.1177/20414196221092466

National Renewable Energy Laboratory & Information Services Program. (1997). Earth- Sheltered Houses (FS 120). DOE Office of Energy Efficiency and Renewable Energy Clearinghouse. DOE/GO-10097-373

Perperi, A., Perperi, A., Surianinova, D., & Otrosh, V. (2023). The Bunker - Like a Structure for Storing the Life of the Civilian Population in Conditions of Danger. Construction Technologies and Architecture, 9, 69-76. DOI: 10.4028/p-TnRF2z

Rijksoverheid. (n.d.). Klimaatverandering en gevolgen. Retrieved January 6, 2026, from https://www.rijksoverheid.nl/onderwerpen/klimaatverandering/gevolgen-klimaatverandering

Slepentiene, A., Amaleviciute-Volunge, K., Slepetys, J.m Liaudanskiene, I., & Volungevicius, J. (2018). The Status of Pachiterric Histosol Properties as Influenced by Different Land Use. IntechOpen, n.v.n., 49-74. http://dx.doi.org/10.5772/intechopen.74151

Voorden, van der, M. (1999). Bouwfysische Knelpunten bij de realisatie van Ondergrondse Ruimten (n. e.). COB.

Images and Tables

Image front page: made by author (2026)

Figure 1. Planning made from A1 onwards – made by author (2026)

Figure 2. Location – made by author (2026)

Table 1. Planning made from A2 Try-out onwards – made by author (2026)

Figure 3. Forest Coverage and climate information – made by author (2026):

Official Statistics Portal. (2025). Forest Coverage. [Data set]. https://osp.stat.gov.lt/statistiniu-rodikliu-analize?indicator=S9R041#/

(Estimated Height Location) Geoportal. (n.d.). Map. [Data set].
https://www.geoportal.lt/map/

Official Statistics Portal. (2023). Annual precipitation. [Data set].
https://osp.stat.gov.lt/statistiniu-rodikliu-analize?indicator=S2R002#/

Official Statistics Portal. (2023). Average snow depth. [Data set].
https://osp.stat.gov.lt/statistiniu-rodikliu-analize?indicator=S2R004#/

Official Statistics Portal. (2023). Frost line. [Data set].
https://osp.stat.gov.lt/statistiniu-rodikliu-analize?indicator=S2R001#/

Official Statistics Portal. (2023). Average temperature. [Data set].
https://osp.stat.gov.lt/en/statistiniu-rodikliu-analize?hash=f2ee6809-6d05-450f-9a07-6154b95903c2#/

Figure 4. Schematic translation made by author of information from Perperi et al. (2023, p. 71-72) (2026)

Figure 5. Schematic translation made by author of information from Gillett (1943, p. 3-24) (2026)

Figure 6. Schematic translation made by author of information of shelters that are entirely or partially built above ground from Gillett (1943, p. 3-24) (2026)

Figure 7. Schematic translation made by author of information from Monumentenzorg Den Haag (1997) (2026)

Figure 8. Schematic translation made by author of information from Centrum Ondergronds Bouwen (Centrum Ondergronds Bouwen, COB, 2002, p. 17-31) (2026)

Figure 9. Schematic translation made by author of information from Cao et al. (2021) (2026)

Figure 10. Cao, H., Zhang, Z., Chen, P., Cao, L., Chen, & Chen, Z. (2021). Performance and Application of Rapid Assembling Anti-blast Wall (638). Purpose-Led Publishing.

Figure 11. Schematic impression made by author based on Lostumbo et al. (2013) (2026)

Figure 12. Russs. (2011). Redsandsforts [Photograph]. https://commons.wikimedia.org/w/index.php?curid=16180197

Figure 13. Sketches – made by author (2026)

Figure 14. Floating hangar – made by author (2026)

Figure 15. Concept of cafetaria – made by author (2026)

Images and Tables

Images and Tables

Acknowledgements

Thank you to everyone involved!