PALANGA GOAT SHELTER

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1. ABSTRACT

Palanga Art and Architecture Farm (PAAF) is located in the northeastern part of Turkey and the Goat Shelter is part of the sprawling property of the farm. It has been designed in line with goat physiology, geographical features, local climate and seismic demands of the land. The project entails a structure with high earthquake resistance designed by using two semi-circular rammed-earth walls of different diameters on a deep stone foundation. Project design was initiated with approaches such as seeking sustainable solutions, adapting to current conditions, using natural materials and traditional stone-earth-timber craftsmanship as a construction technique, communicating with the craftsmen in the region and producing collective knowledge, coordinating with academic parties, putting materials to the test and questioning technical decisions. An age-old technique called khorasan was recreated and used to build the foundation and the surrounding walls. The structure is a successful experimental example of zero-impact construction. It has the feature of completely dissolving back into nature without leaving any trace or impact.

Keywords: *palanga, local, traditional methods, goat, shelter, rammed-earth, wooden structure*

2. INTRODUCTION

Palanga Art and Architecture Farm (PAAF) is located in the northeastern part of Turkey and falls approximately 1200 kilometers to the east of Istanbul. The PAAF project is first of its kind in Turkey. PAAF'S motto is *"from agriculture to culture"*. The owner of PAAF is Kutluğ Ataman, who is a Turkish filmmaker and contemporary artist. He lives in Istanbul, Erzincan and London. The Palanga of Mehmet Ali Bey, where he started his experimentation, is nearly two hundredth of its original sprawling size, now down to only 100 hectares. The land was administered by his family since 1473. Since then, wars, revolutions, earthquakes, massacres and economic downfall reduced the land to its current size. He acquired palanga in 2014 with the aim of turning it into a hideaway for himself and his friends. Later on, Ataman decided to run it as a profit-making holistic ranch that would create employment for the locals.

The word "Palanga" means small fort in the Turkish language. In time, the word came to indicate a large semi-communal ranch, where working families were employed by the local bey responsible for their economic and social needs including, but not limited to, the administration of justice, healthcare and, to a lesser degree, education. The families were entitled to half of a Palanga's generated income. During the Republican Era, this system was abolished, but entire areas of land continued to be referred to as palangas.

The farm contains several projects such as KA House, House of Chicken, Goat Shelter, Semi Open Cattle Barn etc. **(Figure 1)** When the main building received critical acclaim,

as well as two international design prizes, Kutluğ Ataman mustered the courage to turn Palanga into an architectural collection documenting contemporary Turkish architecture. As a result, he decided to knock down the workers' buildings in subsequent years and commission established and young architects to rebuild them. Once the house project designed in collaboration with Erginoğlu & Çalışlar Architects was completed and he began living on the farm, he came to notice the need for a number of different structures in varying sizes. **[1]**

Erginoğlu & Çalışlar Architects is an Istanbul based, independent firm of architects founded in 1993 by Hasan Çalışlar and Kerem Erginoğlu. The firm specialises in urban planning, architecture, and interior design projects together with providing assistance for planning applications. In addition to architecture and design services, the partners also give lectures and organize architectural workshops in universities across Turkey.

In due time, Erginoğlu & Çalışlar Architects put together a selection of young, promising and up-and-coming architects capable of undertaking such a project and Kutluğ Ataman and his team evaluated them together. The curator, Hasan Çalışlar, also suggested inviting several renowned Turkish architects to the project to motivate their young colleagues. This proved highly effective, giving PAAF the opportunity to observe how different generations of architects treated the subject with their respective experiences on the same terrain.

Figure 1. Aerial view of PAAF, *PAAF 2021*

2.1 Purpose

When looking at reference projects for rammed-earth construction technique, which have survived to the present day, it is understood that it is a technique that can easily adapt to changing conditions. The aim of this project is to analyze the basic principles of the rammed-earth construction technique, which stands out as an alternative to existing construction techniques, with drawings containing simple experimental setups and to examine the interaction of the technique with other disciplines. In this project experience is

shared on how a masonry building with a wooden roof structure was built in Erzincan climate and geological conditions. The priority principle of this constructionis avoiding the usage of concrete, cement and chemical additives.

2.2. Scope

Palanga Goat Shelter started as an architectural project to take place in PAAF. The project has been shaped by research conducted before and after construction, additionally was presented at national and international conferences and platforms.**[2]**, **[3]** In 2020, it was awarded in the project category of the national architecture awards.**[4]** The construction process, which started at the end of 2019, was completed at the end of the summer of 2021 after the pandemic.

2.3. Method

Palanga Goat Shelter project started with the design of Erginoğlu & Çalışlar Architects. Later advanced by receiving multi-disciplinary consultancy such as; vernacular architecture, archaeological restoration, civil engineering, agriculture and art. Progress has been made by conducting material tests in university laboratories. During the entire construction period in Erzincan flow of information continued between the consultants, PAAF and Erginoğlu&Çalışlar Architects. All these recorded data have been archived. This study was prepared by compiling in a certain cause and effect relationship.

3. PALANGA GOAT SHELTER

Palanga Goat Shelter **(Figure 2)** designed within the framework of the requirements in PAAF and Erzincan; goat physiology, geographic attributes, local climate and seismicity. In a region where there is a shared earthquake memory based on the second strongest earthquake recorded in 1939 in Turkey. For this reason, it is of great importance that the structure to be proposed here is highly resistant to earthquakes.

The architectural design phase has been advanced by taking all the geographical features of the land into account. The prevailing wind direction, the snow load on the roof, etc. Another aim of the project is to minimize the carbon footprint by producing the goat shelter using completely local materials and local labor. In addition, local materials and construction technique do not contain any chemical additives. Attention has been paid to ensure that the materials to be used are durable and maintenance-free. Another important point is to choose the kind of materials that the goats cannot eat.

Figure 2. Aerial view of Palanga Goat Shelter during construciton, *PAAF 2021*

The earth material near PAAF was tested for earthquake resistance before the construction. According to laboratory test results, the type with the highest strength was obtained. In order to obtain the required strength without using concrete, cement-free hydraulic lime is used as a binder in the stone foundation. After laying the foundations, in order to slow down and control the strong winds coming from the northwest, the construction process continued by creating a wind barrier with pile of earth that rose and damped in a curvilinear direction around the shelter walls. (**Figure 3**)

The purlins and rafters of the roof that will cover the shelter are made of poplar wood. The coating is made of twigs, jute and covering materials and is detailed with a high degree of inclination against snow load. It is planned to make a non-hydraulic natural mortar using archaeological restoration techniques on the roof surface. Thus, a durable roof that will need less maintenance and high impermeability will be created. Floor purlins are placed instead of reinforced concrete beams where the purlins sit on curved earth walls. (**Figure 4**)

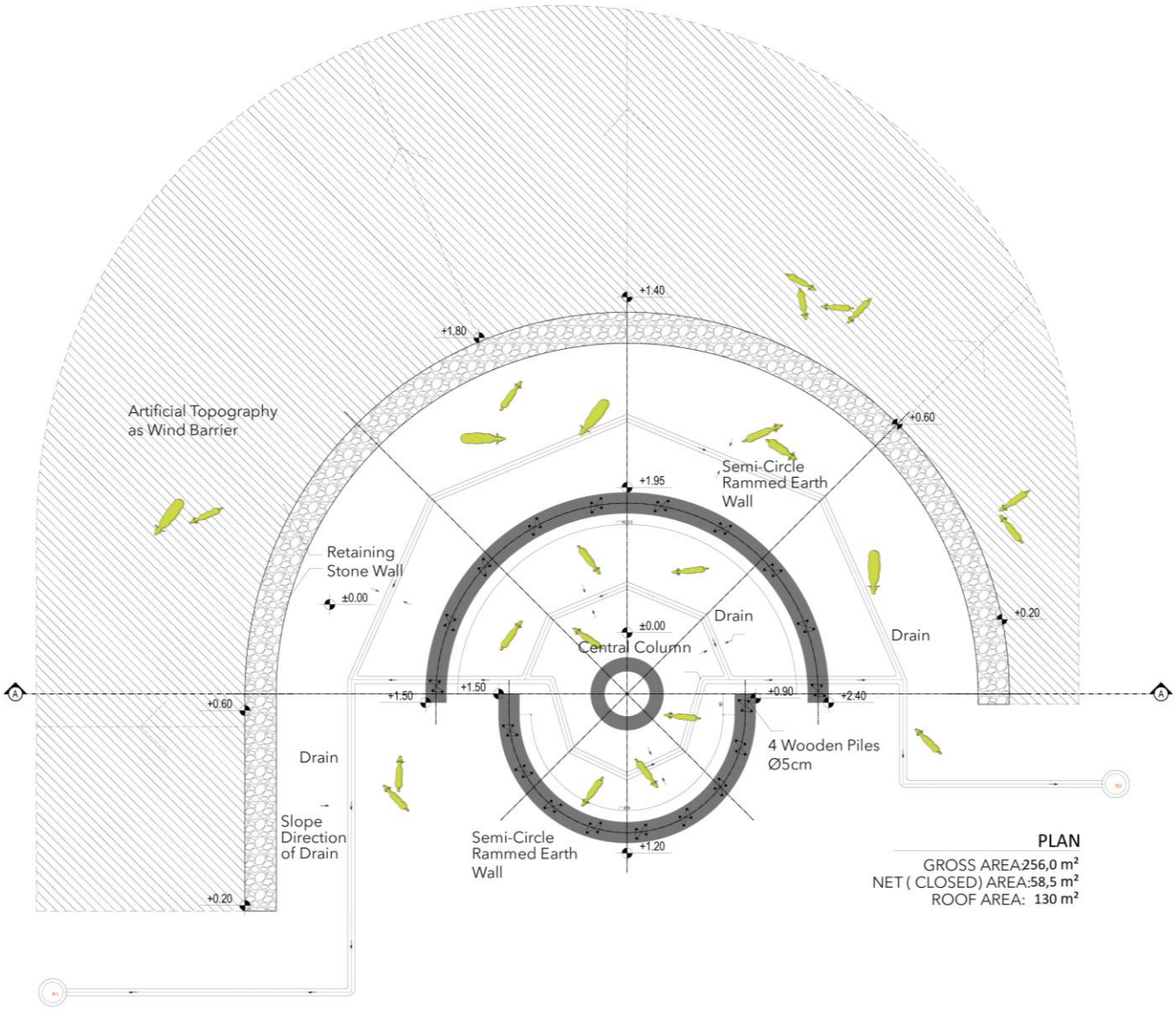

Figure 3. Floor Plan, *Dilara Demiralp, 2019*

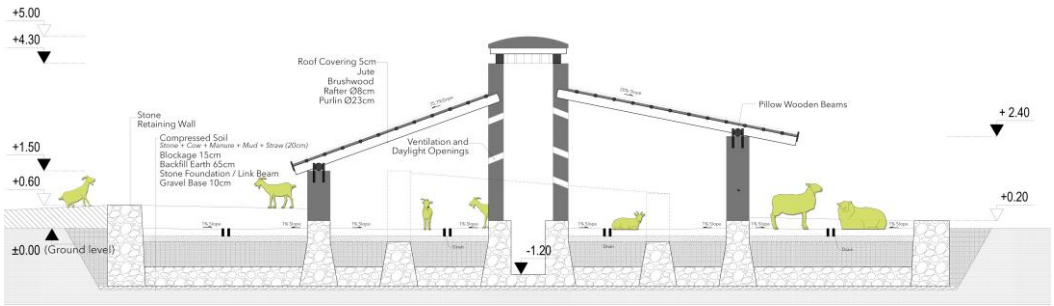

Figure 4. Section, *Dilara Demiralp, 2019*

3.1. Pre-Construction Material Analysis

3.1.1. Laboratory experiments

In Palanga, Prof. Bilge Işık has determined the suitable points for earth alternatives. The soils extracted from the selected points were tested in ITU and Erzincan Binali Yıldırım University. The contents of the samples, consisting of gravel and sand, were determined by "sieve analysis". **(Table 1)** and **(Table 2)** Consistency limits have been determined for universal nomenclature of samples with the combined soil class system.

Excavated soil from the construction of the PAAF cattle facility, the E1 sample, performed best in these "sieve analysis" and "compressive strength" tests. **(Figure 5)** The soil to be chosen as a source must be devoid of organic components, rich in minerals. In addition, damage to agricultural lands must be avoided during the process. At this point, the first thing to do is to strip the first layer of soil rich in organic components and devoid of minerals to be used for agriculture. Layer underneath is needed.**[5]**

Numune Adı =	E1	E2	K1
Numunenin Çakıl İçeriği (%) =	2,4	10,8	14,8
Numunenin Kum İçeriği (%) =	88,0	23,6	33,7
Numunenin Silt İçeriği (%) =	8,9	62,8	48,3
Numunenin Kil İçeriği (%) =	0,7	2,8	3,2
Numunenin Silt + Kil İçeriği (%) =	9,6	65,7	51,5
D10 =	0,090	0,009	0,007
D30 =	0,600	0,045	0,025
D60 =	1,800	1,800	0,400
Üniformluk Katsayısı, Cu =	20,0	*	*
Derecelenme Katsayısı, Cc =	2,2	*	*
Likit Limit Değeri, LL =	17	37	34
Plastik Limit Değeri, PL =	*	23	21
Plastisite İndeksi, PI =	*	14	13
Zemin Sınıfı =	SW-SM	ML	ML
SW-SM =	İyi derecelenmiş siltli kum		
ML =	Düşük plastisiteli silt		

Table 1. Sieve analysis results of E1, E2, and K1 Samples, *Istanbul Technical University, 11 September 2020*

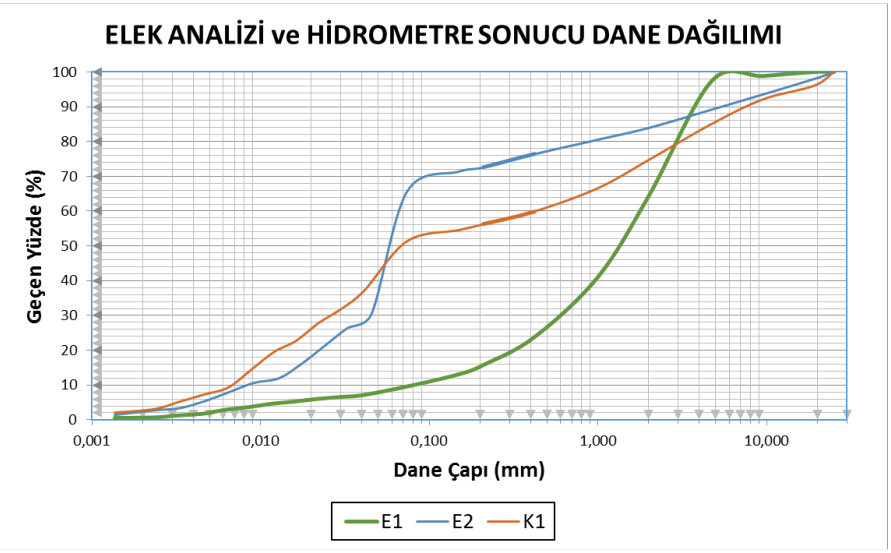

Table 2. Grain distribution as a result of Sieve Analysis and Hydrometer Measurements of E1, E2 and K1 Samples, *Istanbul Technical University, 11 September 2020*

Figure 5. E1 soil sample (in the middle) was tested for compressive strength and passed, *Erzincan Binali Yıldırım University, 22 October 2020*

3.1.2. Rammed-earth workshop

As of May 2021, construction process has began with a workshop held in Istanbul with the consultants. **(Figure 10)** The soil mixture was prepared according to the following formula:
10% Gypsum + 5% Lime + Earth from Erzincan

Figure 6. Rammed-Earth Workshop with the sample soils from Erzincan, *26 May 2021, Participants: Prof. Dr. Bilge Işık, Suat Işık, Suat Güvenç, Dilara Demiralp*

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4.1. Stone Foundation and Retaining Wall

The construction of the project started with the construction of stone foundation and retaining wall in the winter season of 2019. Due to the fact that Erzincan is an earthquake zone, the depth of the foundation reached 150 cm. **(Figure 7)**

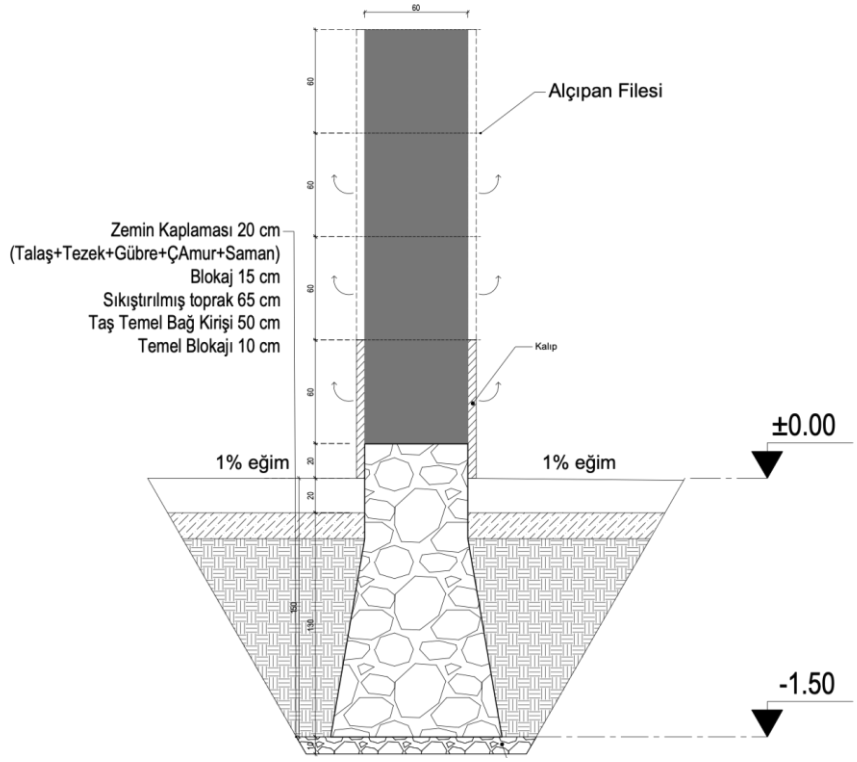

Figure 7. Principle section for rammed-earth wall and stone foundation, *Dilara Demiralp, 2019*

An age-old technique called khorasan was recreated and used to build the foundation and the surrounding walls. In order to obtain the required strength without using concrete, a mortar of hydraulic lime and Khorasan mortar, which does not contain cement, was used as a binder on the foundation. The foundation level was left 15 cm above the 0.00 level and the wall level was kept above to prevent water intake **(Figure 8)**.

After the foundations were laid, a wind barrier was created around the shelter walls with an earth filling that rises and dampens in a curvilinear direction in order to slow down and control the strong wind coming from the northwest **(Figure 9)**. Soil was piled up behind the stone masonry retaining wall and the pile was expected to settle and turn green for 1 year.

Figure 8. Stone foundation upper level is 20 cm above ground, *Novemvber 2019*

Figure 9. Retaining wall as a wind barrier with horizontal wooden beam inside, *December 2019*

4.2. Earth Wall

Erzincan has a continental climate with cold, snowy winters and hot, dry summers. Spring is the wettest season whilst summer is the driest. The lowest temperature recorded was −32.5 °C (−26.5 °F) in January 1950. The highest temperature recorded was 40.6 °C (105.1 °F) in July 2000. The highest snow thickness recorded was 74 cm (29.1 inches) in February 1950. Use of adobe is common in such climates. In order to ensure Erzican is an earthquake zone, structure with high resistance was constructed by using two semi-circular planned rammed-earth walls with different diameters on a deep stone foundation.

After the foundation construction, the wall construction couldn't be possible to start immediately. Due to COVID-19 pandemic construction has stopped for a year. In order to ensure Erzican is an earthquake zone, structure with high resistance was constructed by using two semi-circular planned rammed-earth walls with different diameters on a deep stone foundation.

According to the mixing ratios of the sample made in the workshop in Istanbul, a sample was made in Erzincan according to the following formula, **10% Gypsum + 5% Lime + Earth from Erzincan**, then the first 60 cm of the two main walls were built.

Figure 10. The first 60 cm of the two main earth walls were built., *10 June 2021*

Expected results could not be obtained. Problems were detected in the bonding of the mortar due to ruptures and rapid drying on the wall surface.

Figure 11. Soil mixture samples at different ratios were prepared and poured into the mold, *20 June 2021*

Unlike the mixture in the workshop in Istanbul, a new formula was tried by considering the hot weather conditions and soil type in Erzurum. Since gypsum is a material that absorbs water, it was removed from the mortar. There are breaks and cracks in the surface.

Tile powder (or crushed ceramic) as an aggregate can be found in mortars associated to water-bearing structures from the early Hellenistic to the early Byzantine periods. Tile powder can also be found in mortars that aren't immediately related to water-bearing structures, such as those used to keep the inside of a wall dry. **[7]**

The aggregate used is volcanic material, which was added to mortars by both Greeks and Romans to improve their quality since it increased the hardness of the combination and generated mortars that hardened even underwater (Vitruvius, De architectura II, 4–5, VII, 4 and VIII, 6 and 14). Mortars including volcanic stones were utilized in construction projects requiring higher compressive strength, such as the masonry of the Roman Baths. **[7]**
Considering these studies **[7]** shared by Mustafa Çakalgöz; During the casting process, hydraulic lime, cream lime and tile powder were added to prolong the drying time and increase water resistance. The mortar was prepared according to the following formula:

16 kg Hydraulic lime + 14 kg cream lime + 150 dm3 Earth + 12 kg tile powder
1- Mix tile dust and soil (45 shovels) for 5-10 minutes
2- Add hydraulic lime and mix for another 10 minutes
3- Add cream lime
4- Add water until you get the consistency of mud

Figure 12. The earth wall mortar was prepared and applied gypsum additive, *30 June 2021*

4.3. Central Rammed-Earth Column

Essence of the historical design with the opening on the top is that the building functions like an atrium, and the opening modifies the indoor climate passively. It gives the user orientation in the space and focuses to bring them together. Also, it creates the smoke escape of the fire place in the center. **[6]** The rammed-earth column in the center where the purlins are set is also designed to function as a chimney that facilitates the discharge of the methane and gas accumulated in the space, openings on the surface large enough to not reduce the static strength of the overall structure **(Figure 13)**.

Figure 13. The rammed-earth central column with the openings on the surface, *31 August 2021*

4.4. Wooden Constructed Roof

The purlins and rafters of the roof that will cover the shelter were obtained from the poplar trees in the region. Purlins with an average diameter of 23 cm were covered with rafters with a diameter of 8 cm. Poplars were dried for a long time (19 months) with the timber drying technique, as the construction was suspended during the pandemic. It has been cleared of its bark by the timber drying method without being subjected to chemical treatment and made ready to turn into purlins that would form the structure (**Figure 13).** After the wall construction was completed, the roof purlins began to be placed on the wall **(Figure 14)**. The piles, which were burned with a blowtorch, were left in the drying wall and pillow wooden beams were used to connect the purlins with the wall and were connected to each other with nailed wires **(Figure 15)**. The form of the roof, which will cover the semi-circular walls of which slopes change, also consists of variable slopes. Curvilinear artificial topography is made behind the shelter to protect goats, roof and walls from being exposed to the wind.

Figure 13. Timber drying technique, *October 2019*

Figure 14. All poplar purlins were carried by the central earth column and attached to certain points on the semi-circle earth walls, *27June 2021*

Figure 15. Poplar purlins and pillow wooden beams joint detail, *27 June 2021*

4.5. The Roof Covering

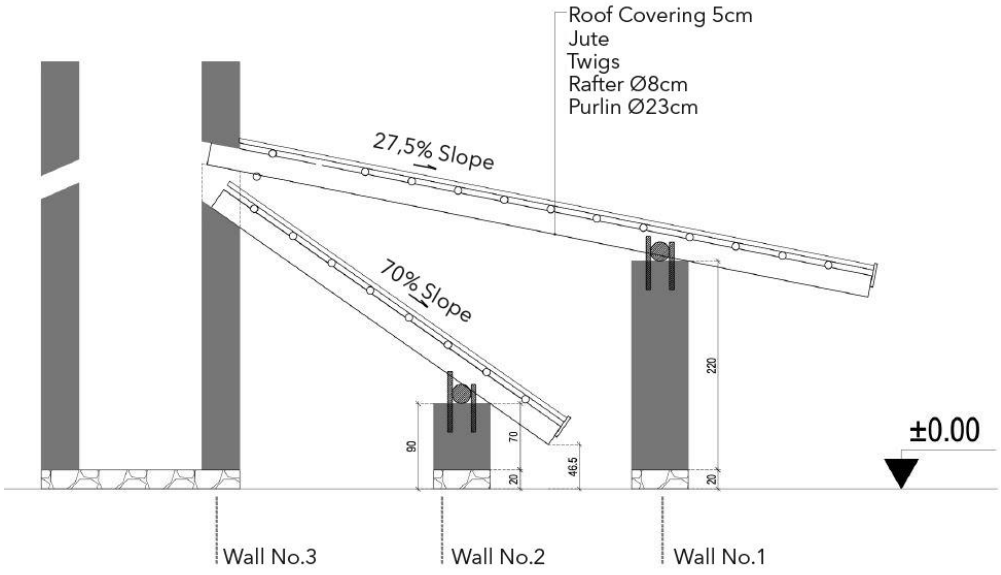

Figure 16. Variable slopes of roof, *Dilara Demiralp, 2019*

The form of the roof, which will cover the semi-circular walls of which slopes change, also consists of variable slopes **(Figure 20)**. A maintenance-free roof finish material was needed to find that could work in harmony with these slope grades, was resistant to climatic conditions and the movement of goats on it. The coating is made of twigs, jute and covering materials.

The roof covering is made of brushwood, jute and earthen materials and is detailed with a high degree of slope against snow load. A water-proof and maintenance-free layer was created with the archaeological restoration technique. The mortar includes hydraulic lime, cream lime, perlite sand, gypsum and tile dust.

On the basis of archeological restoration technique research; the strength of the mortar can be improved by adding limes to the mix. The grain size distribution of this aggregate, on the other hand, is a critical aspect in this process. The mortars with tile powder (or crushed ceramic) are suited for situations where frost resistance is not a concern but waterproofing is. **[7]**

The mortar which was prepared based on archeological restoration technique, has created a waterproof, maintenance-free, long-lasting roof layer. There is no soil in the mortar. The roof covering mortar was prepared according to the following formula:

5 units of Hydraulic Lime
2.5 units of Cream Lime
1.5 units of Perlite Sand
2.5 units of Tile Powder

Figure 17. Samples prepared for roofing mix, *16 July 2021*

The reed grass was laid on the rafters. A plaster net placed over the reed grass. Then, the mortar for the roof poured on top of them. Perlite was sprinkled on the top surface to make it hardened (**Figure 18)**

Figure 18. Layers visible during roofing, *31 August 2021*

The current situation of the shelter and the roof covering is under control by PAAF. Necessary repairs will be applied after the control to be made in summer 2022 regarding how the building and especially roof covering is affected by the winter and spring climate.

5. CONCLUSION

PAAF is a privileged, multi-disciplinary and experimental attempt taking place in Turkey. Palanga Goat Shelter is also an experimental project created by an architectural team (Erginoğlu&Çalışlar Architects) with the guidance of consultants from different disciplines. Competent people from academia, art and architecture came together and created a contemporary collective knowledge. The foundations of this knowledge are based on experience, vernacular architecture, culture, animal physiology, geographical features and local climate.

Palanga Goat Shelter project has principles related to using local and natural materials and reducing carbon footprint. These principles have been tested with issues such as climatic conditions, pandemic restrictions, budget and material supply in the Erzincan region. Air temperatures of up to 40 degrees, low humidity accelerated the drying time, causing direct damage to the wall. Breaks and cracks were observed on the wall surface. Therefore, the gypsum-containing formula, which gave good results in sample testing in Istanbul, was reviewed. Instead of gypsum, cream lime and hydraulic lime were added. The consultants came up with this idea and they suggested this change in accordance with the ancient-age archaeological restoration technique. Water was added until the powder mixture became yoghurt-like. Since the water absorbency performance of gypsum causes fast drying, hydraulic and creamer lime with high water resistance prolonged this drying time.

This intervention, which was made with a multi-disciplinary decision, yielded good results. This also shows that rammed-earth construction technique can adapt to different geographies and with different mineral additives. People who have been informed about the rammed-earth construction technique can build without the need for large machinery and technologies by using natural and easy-to-procure materials. This shows the sustainability of the rammed-earth construction and the project. As a technique with high adaptability and sustainability, the rammed-earth construction method can be used much more widely and effectively.

The earth structure, which is natural and lives in interaction with nature, is real and in this aspect, it is like any living thing on earth. Prolonging the life of an old-age knowledge with trial-error and spreading this collective knowledge is an important contribution to both humanity and the world.

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Client: Kutluğ Ataman
Consultants:
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Istanbul Aydin University · Department of Architecture
Mustafa Çakalgöz (Archaeologist):
Ege University, Bergama Vocational Training School / Head of Department 2019-
Suat Güvenç (Civil Engineer)
Construction Date: October 2019 - September 2021
(construction was suspended during the pandemic)
Location: Erzincan / Turkey
Land Area: 8000 m²
Constructed Area: 256 m²
Construction Type: Masonry Wall (rammed-earth technique) – Wooden Structured Roof
Funciton: Goat Shelter
Supplier: Palanga Art and Architecture Farm (PAAF)

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