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Sustainable Design Strategy for Single-Family Housing in Bosnia and Hercegovina

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ABSTRACT

According to environmental statistics, the construction industry is one of the biggest pollutants of the environment. Given the current climate crisis and the rise of global warming, it is of essence that each country adjusts its construction norms in order to address this concern. In fact, many of the EU and North American countries have already introduced strict legislation and have developed different methods of sustainable design strategies in order to minimize their environmental impact. However, most Western Balkan countries are still behind in this regard. For this reason, this paper will focus on the improvement of building practices in the construction of single-family houses in Bosnia and Herzegovina (BH) based on the existing EU practices. The paper examines three predominant climatic zones present in BH and offers improvement strategies based on each of the climatic specificities. The goal of the paper is to create a guideline for creating more sustainable single-family architecture in BH which will decrease the construction pollution in the country but also provide energy savings for the end users in the long run. It is the hope that further down the line, these strategies will also be applied to other building typologies.

***Keywords**: Sustainable design, single-family home, passive design, energy efficient, sustainable construction, environment.*

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CHAPTER ONE

INTRODUCTION

Global climate crisis has become a real threat in the last century, and unfortunately the construction industry plays a major role in furthering the pollution. Many of the EU and North American countries have already identified this issue and have developed different strategies to introduce a more sustainable way of building. However, some of the underdeveloped countries, such as Bosnia and Herzegovina, still lag behind. This paper focuses on single-family housing as a prime case study since it is the most malleable typology to change due to its scale and ownership. It will explore how sustainable standards developed in the EU countries for passive design could be applied in the building of single-family homes in Bosnia and Herzegovina and thus avoiding much of the energy wastage not only during construing but also during the building's lifespan as well.

Furthermore, the paper will outline the basic design principles of passive design and its implementation in the three different climatic zones: Continental, Alpine and Mediterranean climate zones which are present in BH. It will be based upon the Western European case studies where sustainable design principles are already greatly developed and implemented.

Following the European case studies, the paper will then examine three houses from Bosnia and Herzegovina for each of the above-mentioned climatic zones. The goal is to identify the discrepancies in BH design and construction methods and to create an improvement strategy based on the already existing European case studies.

Sustainability in Architectural Design and Passive Design

Sustainability is quite a broad term and could be applied to many different fields. In terms of architecture, it is often associated with designing for a comfortable quality of life while keeping in mind the environment and its resources. It is also about creating a link between financial development, environmental quality, social equality, more precisely, sustainability is a strategy for the survival of nature and its resources (Jong-Jin, 1998). In terms of sustainable architecture, there are many design strategies which are implemented in various parts of the world under different names such as:

- Energy Efficient Building Design
- Low Energy Building Design
- Zero Energy Building Design
- Solar Design
- Green Design
- Passive Design

The most basic design principle and thus the one that is the most easily implemented is passive design. Passive design takes advantage of the climate to maintain a comfortable temperature range in the home. It reduces or eliminates the need for adding too much heating or cooling (sometimes none), which accounts for about 40% (or much more in some climates) of energy use in the average home. Although many cultures have built passively throughout history it was in the 1980's that it became patented as a design strategy.

In the 1970s, the Department of Energy (DOE) and the government of Canada were the first to pioneer passive building concepts. Building on that study and those values, the German Passivhaus Institute (PHI) developed a quantifiable success norm in the late 1980s that continues to operate well in Central European and similar climate zones.

Design principles for Passive Design

Passive Design is based on a set of design principles that ultimately helps achieve a high level of energy efficiency that meets the established standards. Based on the climatic zones and conditions in the field, it is necessary to harmonize everything according to the principles of passive construction such as:

- Orientation on the site to maximize natural sunlight and wind.
- Continuously insulate the house without heat bridges (to avoid heat loss especially at the corners and openings).
- Insulation must hermetically seal the house so that warm air does not come out, also cold does not enter the house.
- Installation of windows of high-quality performance according to climatic conditions is necessary (again to prevent heat escape)
- Use an air recuperator to balance the air in the house, so that moisture does not occur
- Using a method of minimum space conditioning. (Hoyle, 2011)

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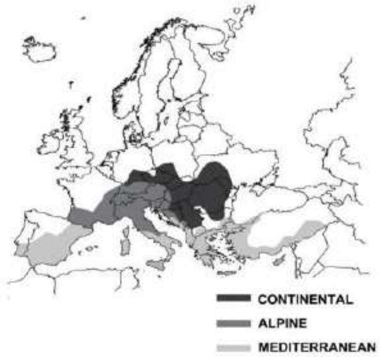
CHAPTER TWO
METHODOLOGY

As stated earlier, the passive house analysis will be conducted in the EU countries with the same climatic conditions which are present in BH (Continental, Alpine, and the Mediterranean). For each climate condition, four houses will be analyzed in accordance to the Passive House criteria.

(Figure 1) Graphic representation of all countries in Europe that have the same or similar climate



as BiH

Europe - climate conditions

(Figure 2) climate conditions of BIH (Branislav Cvjetković, 2019)

"Climatic map of B&H. (Source: hydrometeorological Institute of the Federation of Bosnia and Herzegovina)"

These criteria are:

- Orientation - by analyzing the orientation of a house, the study will investigate whether the building is properly oriented to benefit from its natural disposition in terms of solar energy and airflow.
- Topography- by analyzing the topography, the study aims to determine how topography has been taken into account in the design process in order to maximize its insulation.
- Glazing- the study will examine the percentage of glazed surfaces on each facade.
- Roof type- this will determine R-values (insuation) of the walls
- Shading system- shading system block access of heat gain from the sun exposure
- Cross section (wall, slab and roof)- this will determine R-values (insulation) of the walls

Window type (glass type)-preferably triple glazed and argon filled (again to prevent heat escape).

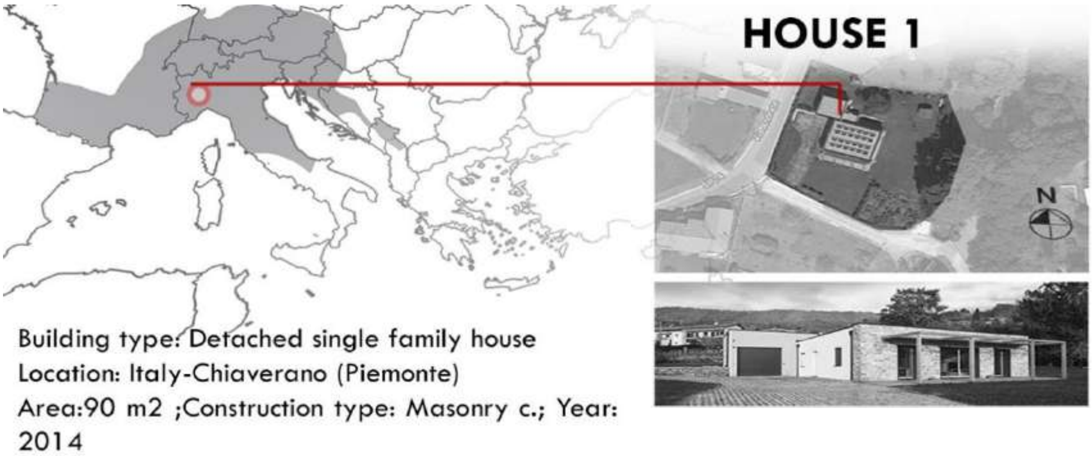


Figure 3. location and picture of house

1. ORIENTATION

The orientation of the house is positioned so that the surface of the walls is directly facing the sides of the world **(Figure 3).**

By analyzing the orientation of house 1, this study concludes that it is properly oriented and thus benefits from nature such as solar energy and airflow.

The organization of the rooms in the house is graphically shown (**Figure 3.1**) and shows where the entrance, private space and public space in the house are located.

The private space includes bedrooms, pantries, dressing rooms and garage and orientation with openings faces east and west, while the public space, which includes the living room and dining room, is oriented south.

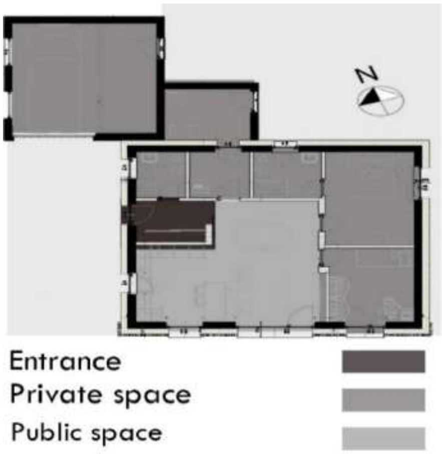


Figure 3.1 Floor plan of house

2. TOPOGRAPHY

The house is made in a mountainous area where the alpine climate is represented. An overview of the wider picture of the site (**Figure 3.2**) shows that there is a huge fall in the terrain, north of the mountain and south of the slope. The place and the smaller circle on which the house is located are quite flat.

ne part of the house on the north side is totaled in the ground about 1.5 m deep (**Figure 3.3**) and it is part of the private space of the house, which is not a disadvantage of this house but it is advantageous because in some way it is protected from strong winds from the north side.

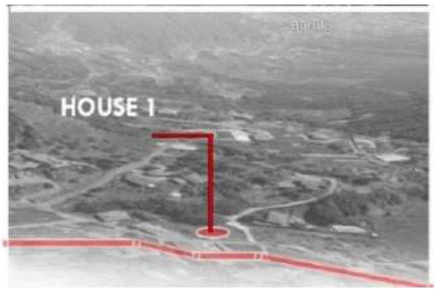


Figure 3.2 Graphical presentation of topography and position of the house 1 on the site

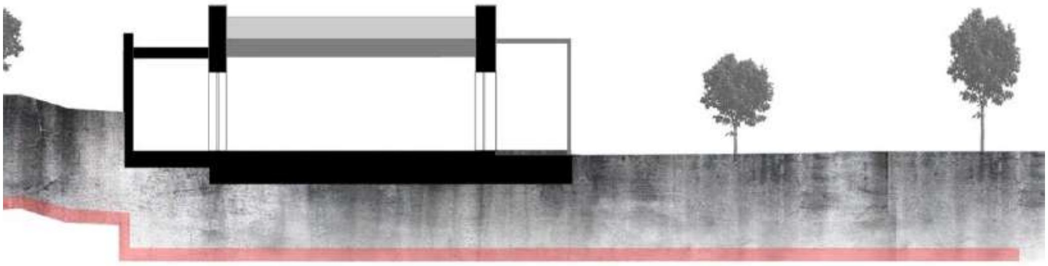


Figure 3.3 Graphical presentation of cross section through the house and the site where the house is located

3. GLAZING

With this analysis, we calculate the surface area of the openings on the facade. By separating each facade, we separately obtained the total area of the openings, and the final result of the total area of the openings will be expressed in percentages.

The purpose of this analysis is to show the percentage of openings in the facades and what key roles are in the home in relation to the alpine climate represented in this area.
As shown (**Figures 3.4**) in the north facade is 2% in the south 25% which is a huge difference while in the east 7% and in the west 11% which is very approximate.

The northern façade has the lowest percentage of openings since the lowest percentage of solar energy is used and the other key thing is that strong winds **(Figure 3.5**) come from the north, which in this case would be difficult to control if the facility had a larger percentage of openings on the north side.

The south side has 25% openings, which is a drastic difference from the north. The fact is that the house uses a huge amount of solar energy to illuminate the rooms, in this case, the public space of the house (**Figure 3.1**) where the living room and dining room are located and that it uses the sun's heat to heat these rooms, which are the largest in the house.

As for the winds on the south side **(Figure 3.5)**, they are much milder than the north winds and can be more easily controlled.

The east and west sides are almost identical with respect to the south and north sides, and private rooms such as bedrooms and pantries are positioned there **(Figure 3.1)** and on these sides, a smaller amount of solar energy is required and winds are weaker on those sides than on the south and north so that the percentage of openings is moderate and in line with the position of the house and the organization of the rooms in it.

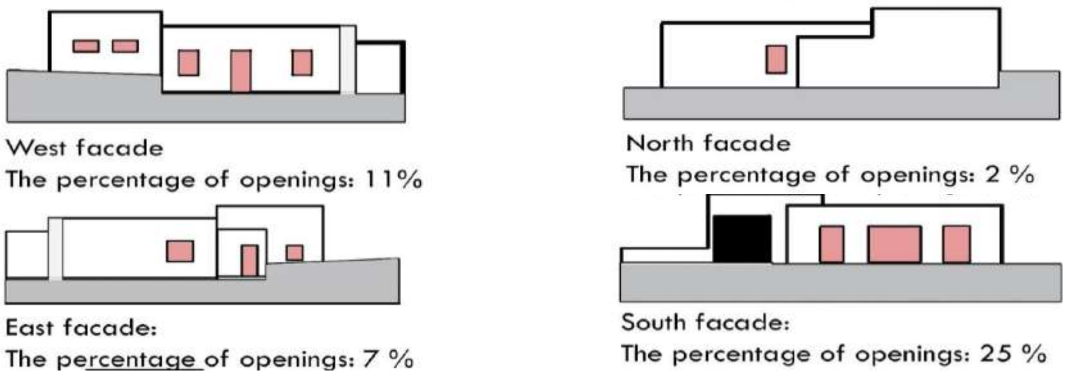


Figure 3.4 Percentage of the openings on facade

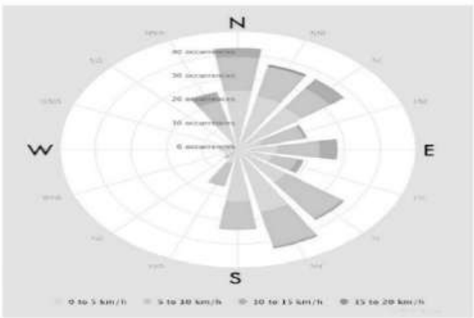


Figure 3.5 Wind rose for Chiaverano

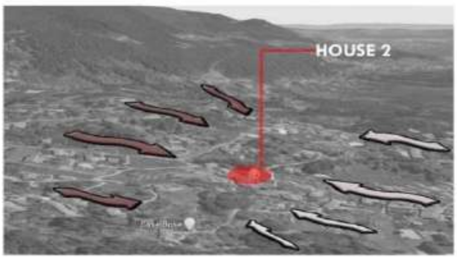


Figure 3.6 The movement of the winds

4.ROOF TYPE

One of the key things about passive homes is the type of roof and how that roof is made.
With each passive house certificate as with this HOUSE 1 the type of roof, as well as the roof structure, is made to contribute in some way to the passive house. In the case of HOUSE 1, a flat roof was made
(Figure 3.7) with a slight fall and multi-layered insulations of a cubic thickness of about 90 cm, which indicates the architect was careful because it is an alpine climate where winters can be

strong and long.
It is rare for homes in mountainous areas to have flat roofs, but in this case, the architect intentionally designed a flat roof to use a flat roof surface.
Above the entrance, public, and part of the private spaces, a flat roof was used to install 5.5 kWp. Photovoltaic solar panels **(Figure 3.8)**. These panels are huge benefits for the house to reduce energy consumption, because of this house in such a location that it needs more space heating than houses located in places where it is continental or Mediterranean climate zone.
Installation of photovoltaic solar panels the production of renewable energy is 61 kWh / (m2a) based on a projected surface what is a great result for these conditions.

Figure 3.7 Cross-sectional view of a flat roof

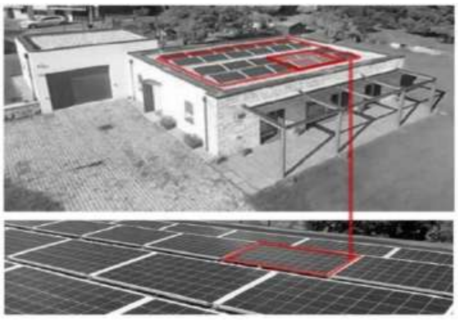


Figure 3.8 Solar panels installed on the roof

5.SHADING SYSTEM

Cross-section of a shading system
(Figure 3.9) shows the type of shading system, which is positioned only on the south side due to the summer weather for easier control of the required sun rays and the second key thing is there is a public space where the users spent a lot of time.
The construction of this shading system is constructed of wood **(Figure 3.10)** and has the option of opening and closing the roof structure on the shading system as needed because the sun's rays are not at the same angle during summer and winter **(Figure 3.11)**

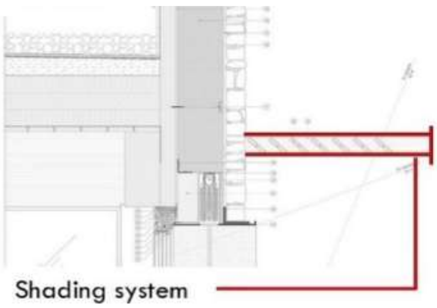


Figure 3.9 Shading system view through cross section

Figure 3.10 Shading system and wooden construction

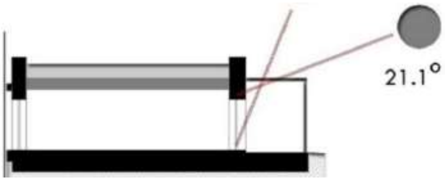
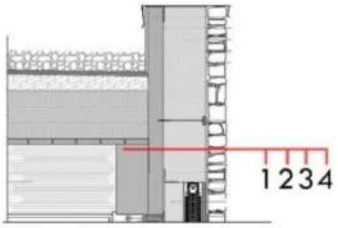


Figure 3.11 Graphical representation of the influences of the sun's rays

6.WALL, SLAB AND ROOF CROSS SECTIONS
With these detailed sections, this study represents the type of construction and all layers of insulation used on house HOUSE 1.
The analysis of details will be a contribution to the construction strategy for BiH. A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator.
The value of Airtightness is also important in passive houses and refers to the speed of air leakage through a building the value of it is usually 50 Pascals.

Exterior wall (Figure 3.12)
1. Interior plaster,2. Ytong Sismic Bricks
3. Exterior Thermal Insulation EPS Panel ,4. Finishing System,
U-value =0.1 W/(m2K)
Basement floor (Figure 3.13)
1. Floor slab Ceramic Tiles, 2. Concrete floor slab for underfloor heating, 3. EPS Panel for underfloor heating, 4. Lightweight Screed, 5. Thermal Insulation XPS Panel, 6. Concrete Slab
U-value = 0.11 W/(m2K)



Roof (Figure 3.14)

1. Gravel,2. PVC waterproof membrane,3. Lightweight screed, 4. Thermal Insulation EPS Panel
5. Wooden Plank, 6.
U-value = 0.1 W/(m2K) Air tightness n50 = 0.52/h

Figure 3.12 Wall section

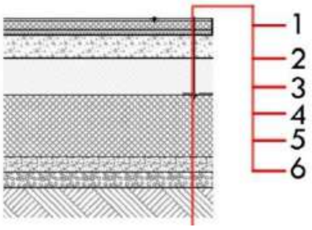


Figure 3.13 Section of the slab

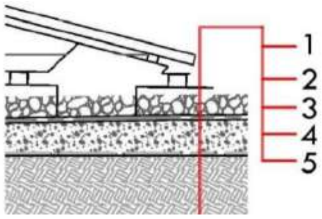


Figure 3.14 Section of the roof

7.WINDOW TYPE

Passive houses attach great importance to the type of insulation and also the key to the insulation of the house is the type of windows that in this case is certified by the Institute of a passive house.

HOUSE 1 features Wood windows with polyurethane inserts [0,024 W / (mK)], with aluminum drips developed by Marles company d.o.o. (MEGA PASIV-P). An important detail in this type of window is glass. Triple glazing with low emissivity glass with high insulation is installed on the windows of this house
(Figure 3.15).

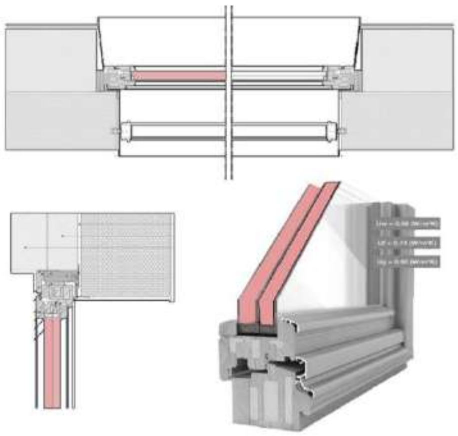


Figure 3.15 Section and picture of the window set

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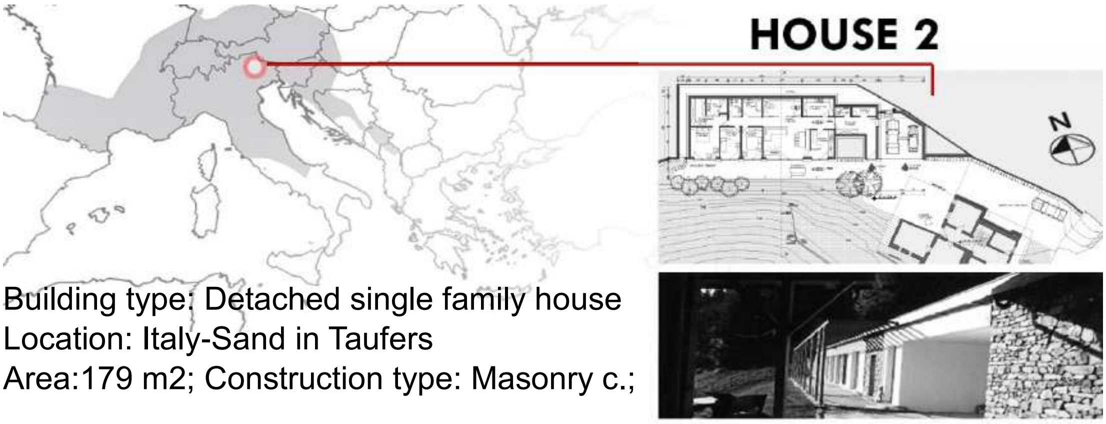

Building type: Detached single family house
Location: Italy-Sand in Taufers
Area:179 m2; Construction type: Masonry c.;

Year: 2008

Figure 4 location and picture of house

1. ORIENTATION

the situation is very specific in the case of the house and can be said to be oriented northeast.
The specificity of this house is that only one side of the house has openings and is oriented to the northeast, while the other three wall surfaces are buried in the ground. **(Figure 4)**
The living room, kitchen, and bedrooms are all organized to the northeast because there is natural light, while all service rooms, bathrooms, pantries, etc. are in the southern part where the house is underground and there is no natural light. **(Figure 4.1)**

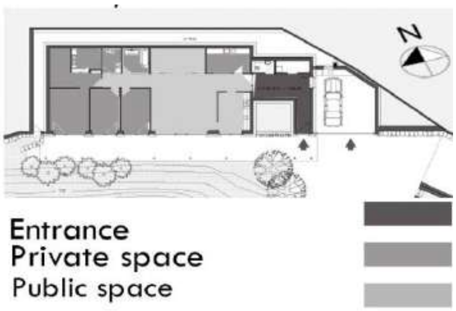

Figure 4.1 Floor plan of house

2. TOPOGRAPHY

The house is made in a mountainous area where the alpine climate is represented. An overview of the wider picture of the site **(Figure 4.2).** It can be seen that the huge drop of the terrain from south to north, (**Figure 4.2**) therefore the position of the object towards the terrain can be seen **(Figure 4.3)** the southern, part western, and eastern sides are underground.
For the most part, the roof surface is covered with earth in a different thickness as can be seen in the cross-section **(Figure 4.3)**

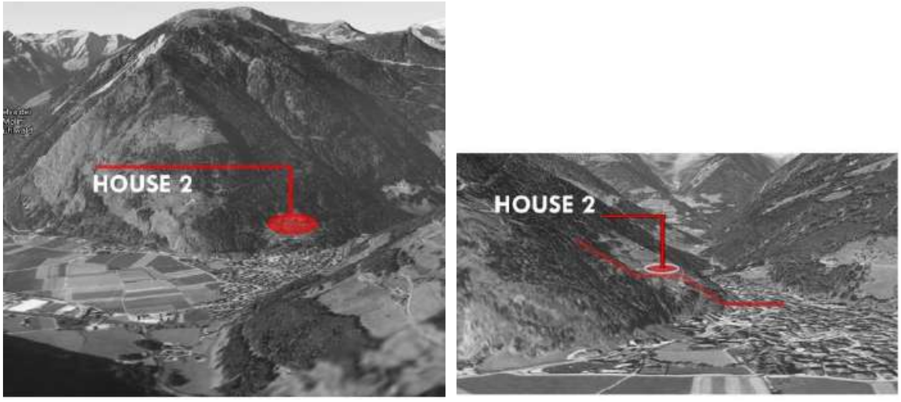

Figure 4.2 Graphical presentation of topography and position of the house on the site

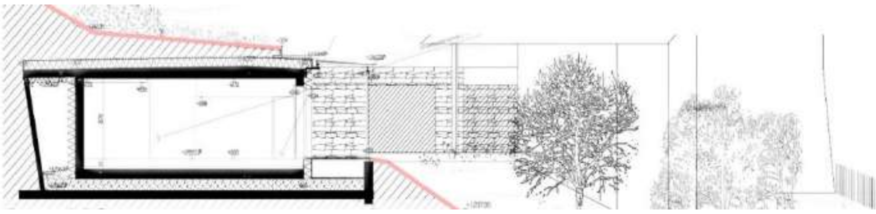

Figure 4.3 Graphical presentation of cross section through the house and the site where the house is located

3. GLAZING

By analysis and calculation of house 2, as already mentioned, the openings are located only on the northeast side, while the rest is in the ground. The number of openings on the north-east side is estimated at 34.7%, **(Figure 4.4)** which is quite large and represents a huge challenge to protect the building from cold winters, given the alpine climate. Another very important factor is the flow of strong winds from the north-east side **(Figure 4.5)**, which additionally bears the costs of high-ranking openings (windows and doors with multi-layer insulation).

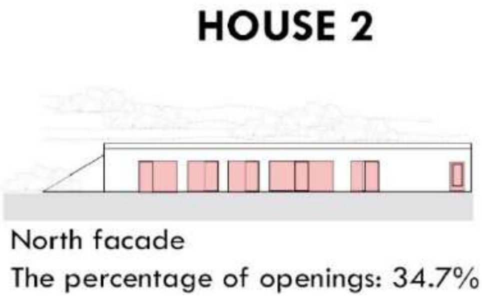

Figure 4.4 Percentage of the openings on facades

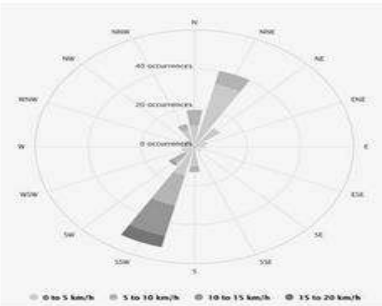

Figure 4.5 Wind rose for Sand in Taufers

4.ROOF TYPE

As it has already been stated that a higher percentage of the house is underground, so the roof structure is covered with the earthen surface at different levels. The southern part of the roof structure is covered with an earthen surface over 2 m, after which the level descends to the north side to **0 (Figure 4.6)** under a certain slope so that no rainwater is retained on the roof of the house. Due to the amount of earth on the roof, the structural concrete system is reinforced and protected by insulation because it is located underground.
All the water that passes over the roof structure is conducted under the fall into the gutters after which it goes into all the wastewater.

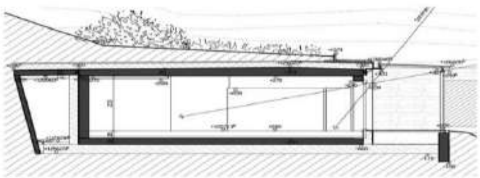

Figure 4.6 Cross section through the house

5.SHADING SYSTEM

Cross-section of the shading system
(Figure 4.6) shows the type of system session that is positioned on the northeast side due to summertime for easier control of the required sun rays.
The construction of this shading system is made of metal structures that are fixed.

Covering the roof structures with canvas on the system shaded as needed because the sun's rays are not at the same angle (yellow line 1&2) in summer and winter **(Figure 4.7)**

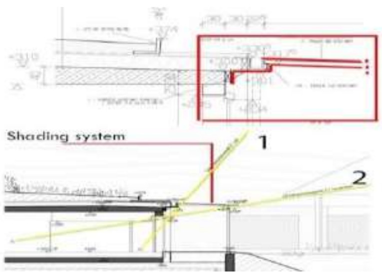

Figure 4.7 Shading system view through cross section

6.WALL, SLAB AND ROOF CROSS SECTIONS

Detailed technical section **(Figure 4.8)**
all layers of protection, structural elements, selection of materials, insulation, and method of

building a house 2 are shown were through the cross-section we can see the construction strategy that has met all the conditions of a passive house.
(A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator. The value of Airtightness is also important in passive houses and refers to the speed of air leakage through a building the value of it is usually 50 Pascals)

Exterior wall: Plaster, 30 cm brick, 30 cm insulation ETICS (031), Plaster
U-value = 0.1 W/(m2K)
Basement floor / floor slab: Parquet, 4 cm insulation board (Screed), 10 cm insulation EPS, 10 cm bulk (Base plate),50 cm insulation
U-value = 0.1 W/(m2K)
Roof: Abdichtung ins. ,30 cm XPS insulation, Vapor barrier, 30 cm reinforced concrete ceiling
U-value = 0.12 W/(m2K)
Air tightness: n50 = 0.47

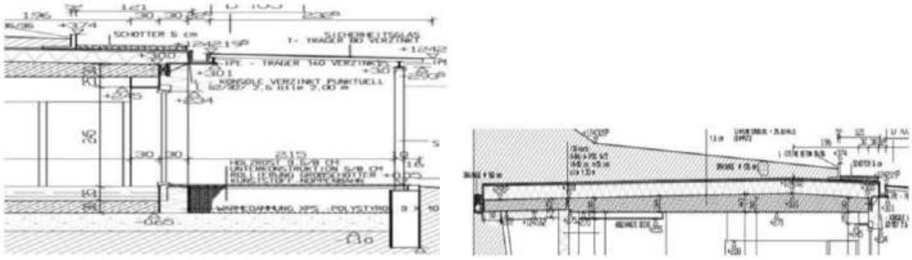

Figure 4.8 Cross section -slab, wall and roof

7. WINDOW TYPE
This house has windows of the company OPTIWIN, **(Figure 4.9)** which has a certificate of passive design that their products meet the criteria of a passive house.
Window specifications:
Wood types: Fir, spruce, larch, oak. Special wood types such as walnut are available for interior use.Interior view: Wood with individualized colour arrangements: Natural oils, thin or thick glazes
Exterior view:
Wood with individualized colour arrangements: Natural oils, thin or thick glazes
Special functions: Sound, sun, and break-in protection
Glazing
3-way insulating glass
U g-value = 0.6 W / (m2K)
Energy efficiency: Window system certified by the Passive House Institute PHI Darmstadt: A-component

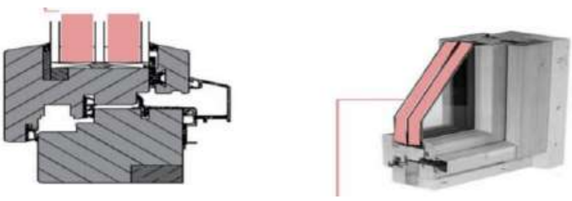

Figure 4.9 Section and picture of the window set

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Building type: Detached single family house Location: France-Onnion (Rhône-Alpes) Area:135 m2 ;
Construction type: mixed construction.; Year: 2016
Figure 5 location and picture of house

1. ORIENTATION
As mentioned, the orientation of the house plays a key role as well as the position of passive houses.
The position of the house is purposefully resolved according to the orientation to the sides of the world and harmonized according to the terrain (**Figure 5**).
Accordingly, the analysis of house 3 concluded that:
The house is properly oriented and that benefits from nature such as solar energy and airflow.
The organization is solved so that all public spaces (living room and dining room are positioned on the south-east side where the highest concentration of sunlight. While private and service space is positioned on the north-west side which can be concluded that the correct way of organizing space according to the system of passive houses.
(Figure 5.1)

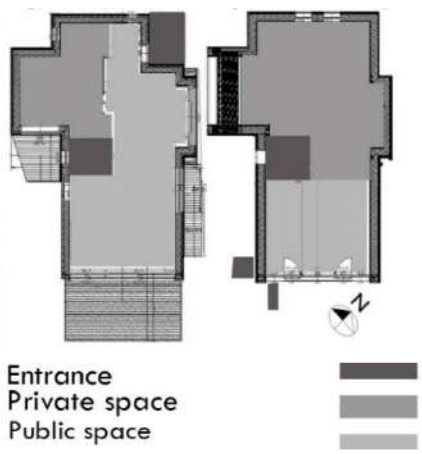

Figure 5.1 Floor plan of house

2. TOPOGRAPHY

The alpine climate is present in the area where house 3 was built.
The terrain is sloping from the highest point in the northwest to the southeast where the lowest point of the terrain is (**Figure 5.2**). Space on which the house 3 positioned had to be excavated, taking into account the percentage of the slope of the terrain.
About 50% of the facility is underground under a slope where the highest ground level is more than 2 m where it descends to the zero points as can be seen in the technical cross-section through the terrain and the house. (**Figure 5.3)**

Figure 5.2 Graphical presentation of topography and position of the house on the site"

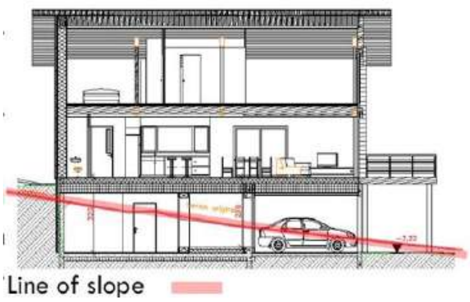

Figure 5.3 Graphical presentation of cross section through the house and the site where the house is located"

3. GLAZING

By a detailed analysis of house 3, we concluded several key segments as well as differences concerning houses 1 and 2.
Open are positioned on all 4 sides of the building. The largest percentage of openings is on the southeast side, about 38%, of course with the intention of the designer to use as much sun energy and natural light on that side, as already mentioned on that side are positioned public spaces (living room dining room).
On the east-north side, the total area of the opening is 18.1%, which is quite enough for optimal natural lighting where part of the kitchen and bedrooms are positioned. northwest side 3.82% which is the lowest percentage of wind and there are positioned bathrooms. the south-south side is 6.4% and the bedrooms are positioned (**Figure 5.4**). The wind circulation is strongest on the east side and the west side (**Figure 5.5**) we can conclude that according to the total area of the opening on these sides it is properly distributed with minimal risk of air leakage.

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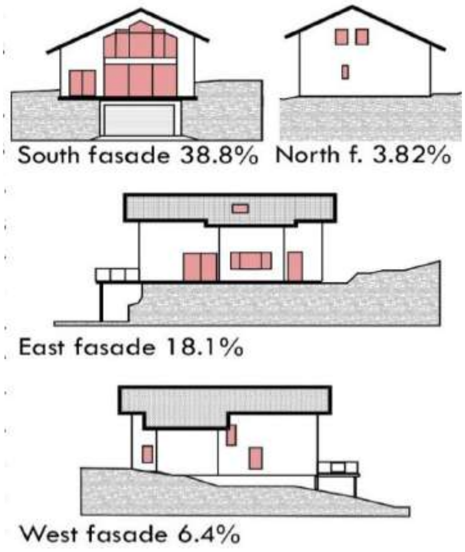

Figure 5.4 Percentage of the openings on facades

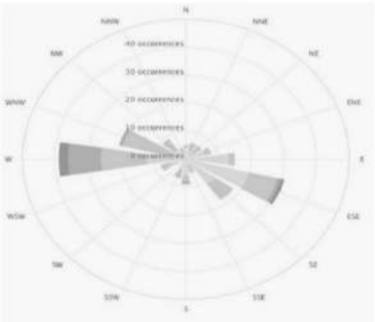

Figure 5.5 Wind rose for France -Onnion

4.ROOF TYPE

House 3 has a gabled roof (**Figure 5.6**) built of wooden construction (**Figure 5.7**). The roof is falling by 26%, which is better compared to the previous two houses where the roofs are flat, because when it comes to the alpine climate, a huge amount of snow falls annually, which often stays on the roofs and it requires strengthening structures, as well as additional insulation which is not an economic plus, and is needed for many years to be cost effective.

Figure 5.7 Roof-Method of construction

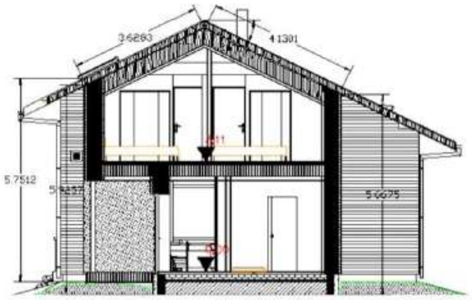

Figure 5.6 Roof cross section through the house

5.SHADING SYSTEM

As already mentioned, the roof of house 3 is gabled, with it being let over the walls of the house 50-60 cm **(Figure 5.8)**. Such a system has been common in construction for a long time. The reason for leaving 50 60cm is exactly how much it takes to cover the sidewalk around the whole house so that the users can take shelter during the rain. As a sun protection system in the case of house 3 there is no significant effect.

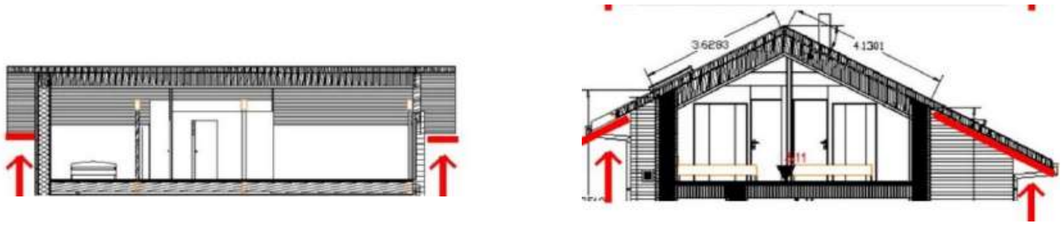

Figure 5.8 Shading system view through cross section

6.WALL, SLAB AND ROOF CROSS SECTIONS

Through a detailed section, **(Figure 5.9**) we ex-tracted all types of layers from the roof, walls, and floor and their value, presented in U-value, which is according to the regulations of passive houses. (It refers to the permeability of warm air and the lower the U-value the material is the better insula-tor).

(The value of Airtightness is also important in passive houses and refers to the speed of air leak-age through a building the value of it is usually 50 Pascals).

Exterior wall: Gypsum board, Air layer, OSB, Cellulose wool, Wood structure, Wood fibres U-value = 0.1 W/(m2K)
Basement floor / floor slab: Carrelage, Screed, Screed insulation, Concrete slab, Polystyrene U-value = 0.124 W/(m2K)

Roof: Gypsum board, Air layer, OSB, Cellulose wool, Wood structure, Wood fibres U-value = 0.105 W/(m2K) Air tightness: n50 = 0.61/h

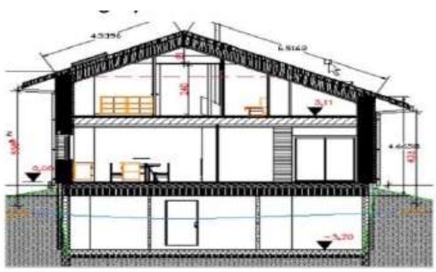

Figure 5.9 Cross section -slab, wall and roof

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7.WINDOW TYPE

This house has windows of the company INTER-NORM. The window is made of a combination of wood and aluminum and thermal insulation foam in between, which is far high quality and corresponds to the system of passive houses. It is very resistant to all weather conditions; a very important detail is that it is a three-layer glass **(Figure 5.10)**

Figure 5.10 Section and picture of the window set

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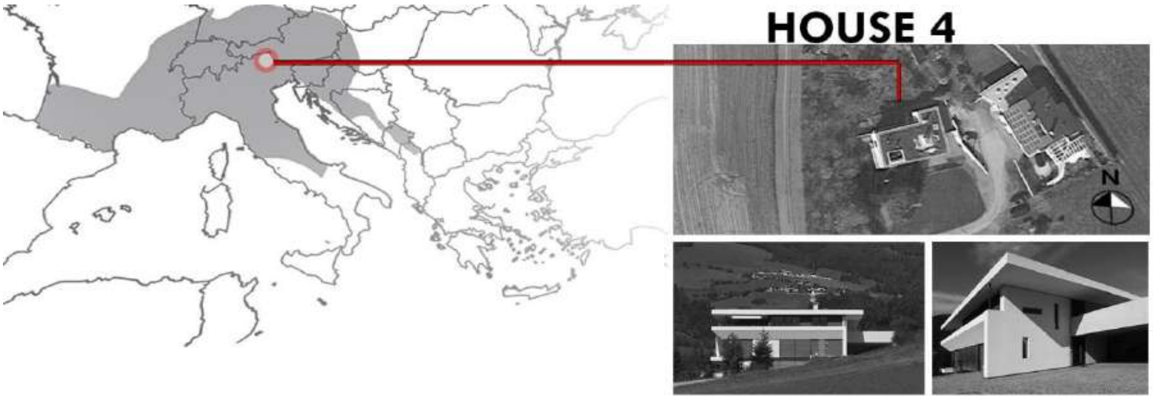

Building type: Detached two family house
Location: Italy-Pfitsch (Südtirol - Alto Adige)
Area: 261 m2; Construction type:Timber construction
Year: 2009

Figure 6 location and picture of house

1. ORIENTATION

According to the terrain and area where house 4 is **(Figure 6)**, it can be said that the orientation of the house and as a room organization is almost perfect to what is required by the institute for passive houses.
A more detailed analysis of the organization of space in the house shows that the greatest importance was given to the public space (living room and dining room). The position of the public space is south and west so that it uses the most solar energy and natural light, after which the north side and part of the east were used for private and service rooms **(Figure 6.1)**.

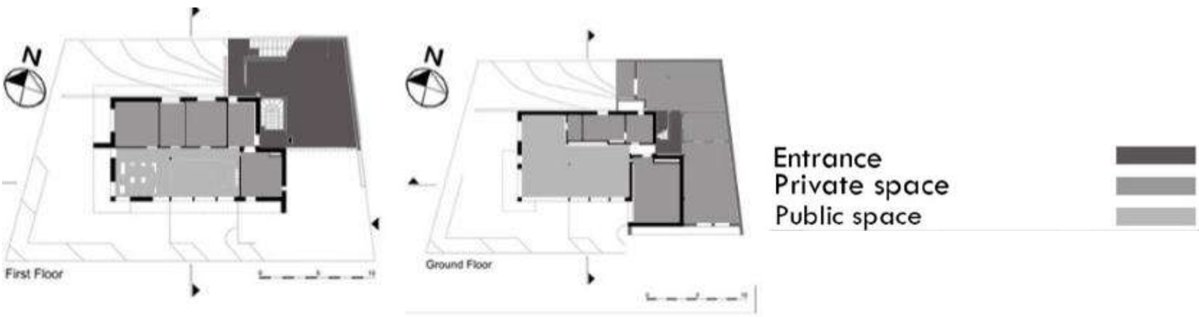

Figure 6.1 Floor plan of house

2.TOGRAPHY

The terrain on which house 4 is positioned is under a slight slope **(Figure 6.2)**.
In relation to the position of the house, the slope of the terrain (highest point) is from east to west (the lowest point of the terrain), where it was necessary to bury two floors of the house on the east side. Cross-section through the terrain and the house **(Figure 6.3)** presented clearly that more than 50% of the house is underground, which is not economically profitable at the very beginning of construction, but in a slightly longer time benefit is that House is protected from strong alpine winds.

Figure 6.2 Graphical presentation of topography and position of the house 4 on the site.

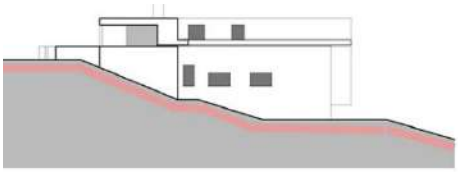

Figure 6.3 Graphical presentation of cross section through the house and the site where the house is located.

3. GLAZING

Detailed technical drawings of the façade of house 4 presented all the surfaces of the openings. According to detailed drawings **(Figures 6.4)**, it can be clearly seen that on the south side of the building, the highest percentage of openings is 41.95%, which is the highest percentage of all 4 houses in the Alpine climate so far. After which the second largest percentage of openings is borne by the west side 26.32%.

By analyzing the organization of space in house 4, it can be clearly concluded that on the south and west side there are public spaces such as living room dining room, and resting room, which is the reason why architects have increased the number of openings on that side, to use natural light and used as much heat energy as possible from the sun.

One of the disadvantages is the wind flow (**Figure 6.5**) from the south side and since the alps are the climate, the architects had to carefully choose quality windows and doors to avoid air leaks in the house.

On the north side, it is 5.75% because according to the graphical representation of the wind flow is (**Figure 6.5**) intense and quite strong. and on that side are located service rooms and part of the private ones.

The west side carries 5.45% and, on that side, also positioned communications and private and service rooms, which is also good if we compare with other houses that are passive.

Figure 6.4 Percentage of the openings on facades

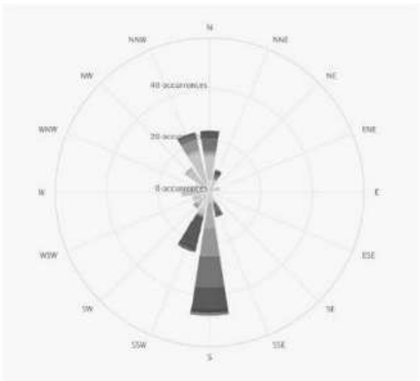

Figure 6.5 Wind rose for Pfitsch

4.ROOF TYPE

The roof of house 4 is flat with multi-layer insulation, and the last layer is the soil on which the grass is sown (**Figure 6.6**).

Strengthening the wooden structure was necessary in order to accept all the load of the last layer (earth), as well as the load that will cause snow during the winter, with an emphasis on the alpine climate in which the winter is long with a lot of precipitation.

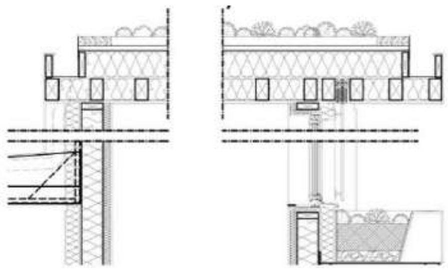

Figure 6.6 Cross-section of the roof

5.SHADING SYSTEM

Detailed cross-section through the house with the presentation of the sun's rays

(**Figure 6.7**) as they affect the building during the summer is a clear indicator of what kind of shading system it is. The shading system was done on the top floor by letting the roof over the walls while on the floor below it was made at an angle prefabricated from a wooden structure over which the facade was done. As a whole, it aesthetically met the needs, however, and the efficiency is quite good, and it is useful only during the summer at the highest temperatures when the sun is in angle over 60% relative to the ground.

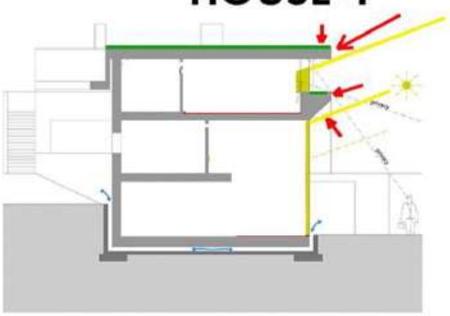

Figure 6.7 Shading system view through cross section

6.WALL, SLAB AND ROOF CROSS SECTIONS

With a technical cross-section

(**Figure 6.8**) through all floors and analysis of the structure, we get the strategy followed by the architect's how did this project to make this house pass all the criteria of a passive house.

(A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator. The value of Airtightness is also important in passive houses and refers to the speed of air leakage through a building the value of it is usually 50 Pascals)

Exterior wall: gypsum fiberboard,Thermohanf ,Lattung, OSB board, Thermohanf,Holzsteher, OSB board,Thermohanf **(040) U-value = 0.122 W / (m2K)**

Basement floor / floor slab: wooden floor, screedheat transfer XPS, marble plate, steel concrete **U-value = 0.074 W / (m2K)**

Roof: gypsum fiberboard, Thermohanf, Lattung ,OSB board, Thermohanf / Sparren

U-value = 0.12 W/(m2K)

Air tightness n50 = 0.59/h

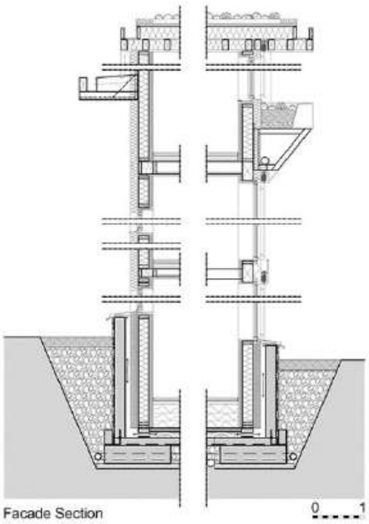

Figure 6.8 Cross section -slab, wall and roof

7.WINDOW TYPE

This house has windows of the company SMARTWIN, which has a certificate of passive design.

Glazing

Triple thermal insulation glazing
U g-value = 0.56 W / (m2K)
It was done with combinations of tested
materials such as in the category's timber, timber-alu, alu and vinyl

Wood-aluminum window (Triple glazing with lowemissivity glass)

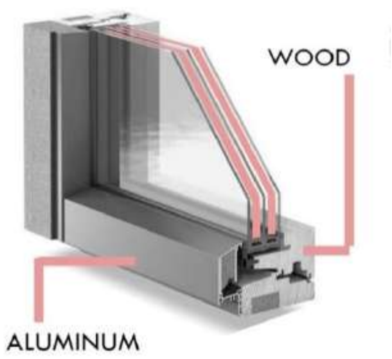

Figure 6.9 Section and picture of the window set

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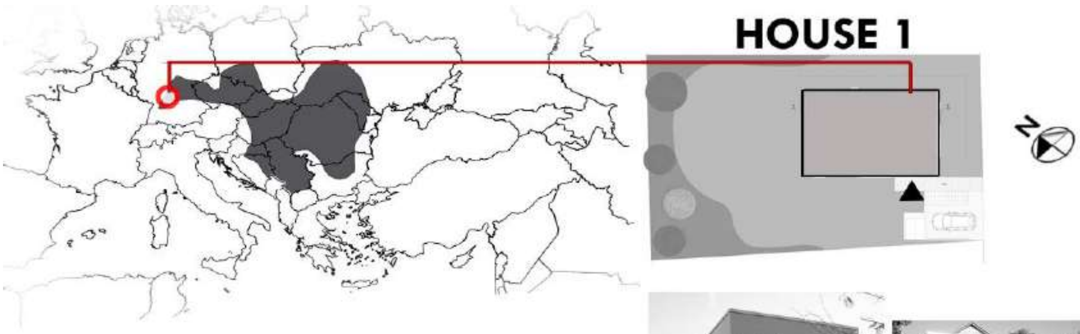
HOUSE MADE IN THE CONTINENTAL CLIMATE



Building type: Detached single family house
Location: Germany-Eberbach
Area:78 m2;
Construction type: Timber c.; Year: 2015

Figure 7 location and picture of house

1. ORIENTATION

The orientation of HOUSE 1 is not parallel to the sides of the world, because it was done according to the requirements of the urban project, but that does not have a bad impact on the HOUSE 1.

The graphic display **(Figure 7.1)** shows the organization of space in the house towards the sides of the world, so it is evident that public areas are oriented to the southeast, which is too much in passive houses to use solar heat and daylight. With relatively small openings, the bedrooms as a private space, positioned to the northwest, which is a very common occurrence in passive houses.

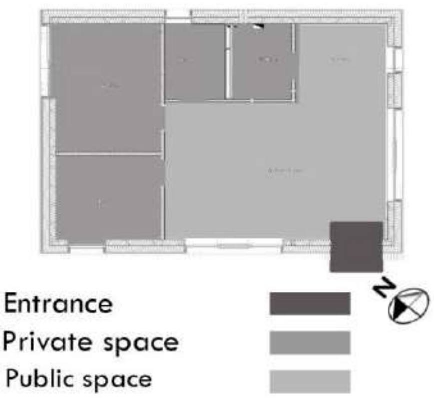
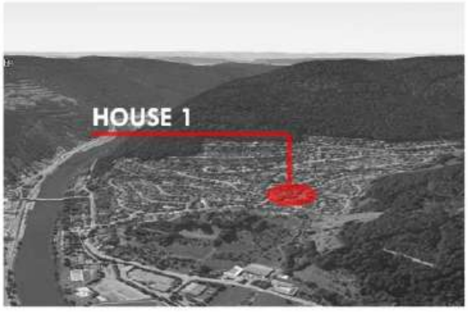


Figure 7.1 Floor plan of house

2. TOPOGRAPHY

The position of the house is in a relatively hilly part of town where the continental climate is represented **(Figure 7.2 & 7.3)**

In this case, the building is not buried in the ground as in previous cases, but is raised by one floor on poles, which saves on digging and also on additional insulation needed when the building is in the ground.



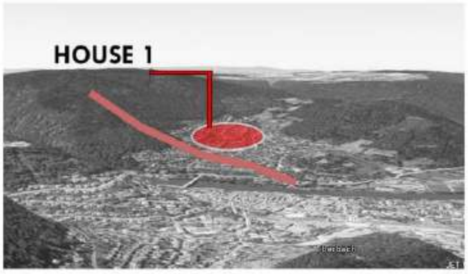


Figure 7.2 Graphical presentation of topography and position of the house 3 on the site

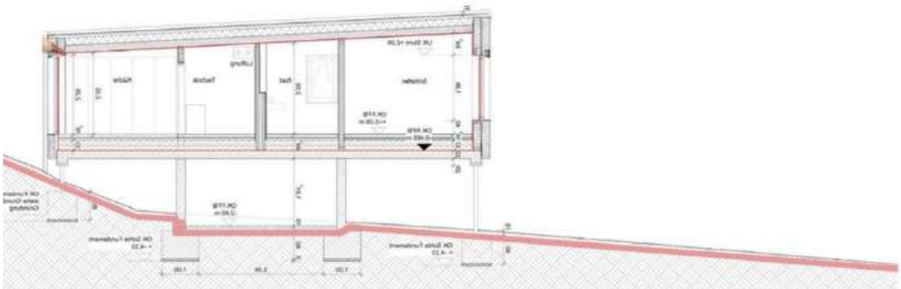


Figure 7.3 Graphical presentation of cross section through the house and the site where the house is located

3. GLAZING

With this analysis of the dismantling of the facade into parts and the calculation of the openings on each part, we show on which side is the largest percentage of openings and what is the reason for that.

Therefore, as shown (**Figure 7.4**), the Southwest side has the highest percentage of openings 26.03% and as we have already pointed out in the description of the orientation, there are positioned public areas such as the living room and dining room where most natural light is needed because users are usually most, they spend time there.
Southeast 24.12% where part of the public areas is positioned so that the percentage of openings is increased so that the house receives as much natural light as possible.

Northwest 12.88% is the part to which they were opened used for private rooms such as bedrooms and study rooms, while on Northeast there is a bathroom and there is an opening of 2.16% according to the minimum need of that space.

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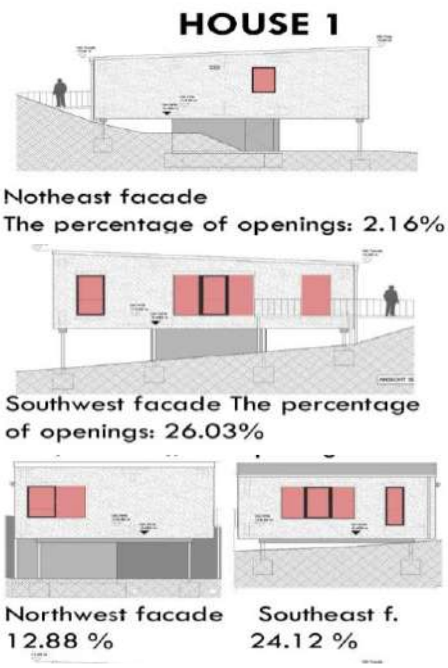

Figure 7.4 Percentage of the openings on facades

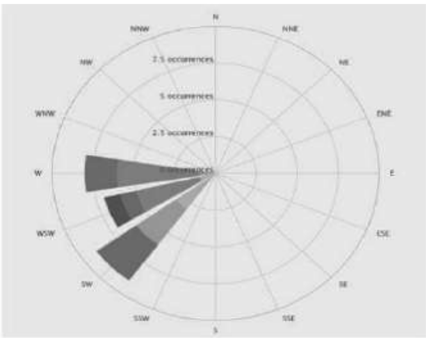

Figure 7.5 Wind rose for Germany-Eberbach

4.ROOF TYPE

The type of roof is flat with a slope of 3%, the slope starts from the northwest side to the southeast side as can be seen in the cross-section (**Figure 7.7)**

The architect predicted that the entire roof surface would be covered with sheet metal, to avoid additional insulation when the House has a This move saves a lot of money and the roof has been done adequately green surface or stone.

Figure 7.6 Pictorial representation of the roof surface finish

Figure 7.7 Cross-section through the house

5.SHADING SYSTEM

The shading system on this house is done in the form of blinds, which are hidden in the facade and the descent down covers the glass surface of the opening according to the needs of the user. **(Figure 7.8)**

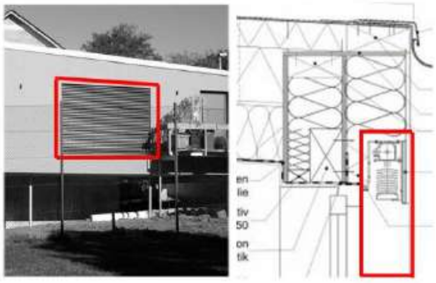

Figure 7.8 Section cross wall and shading system

6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical sections **(Figure 7.9)** of all layers of protection, structural elements, selection of materials, insulation, and method of building a house 1 is shown. Through the cross-section, we can see the construction strategy that has met all the conditions of a passive house. (A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator. The value of Airtightness is also important in passive houses and refers to the speed of air leakage through a building the value of it is usually 50 Pascals).

Exterior wall: Gk 12.5mm, OSB 15 mm,
insulation/post 200mm, OSB 18mm Insulation WLG 032 220mm, plaster 15 mm
U-value = 0.087 W/(m2K)

Basement floor / floor slab: Screed 65mm, system plate 85mm, thermal insulation WLG 032 300 mm, reinforced concrete 2200 mm

U-value = 0.082 W/(m2K)
Roof: Roof membrane 2 mm, insulation WLG 027 100 mm, insulation WLG 035 200 mm OSB 25 mm, insulation / rafters (80/200) 200 mm, per clima intello Plus12.5 mm

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U-value = 0.076 W/(m2K)
Air tightness: n50 = 0.4/h

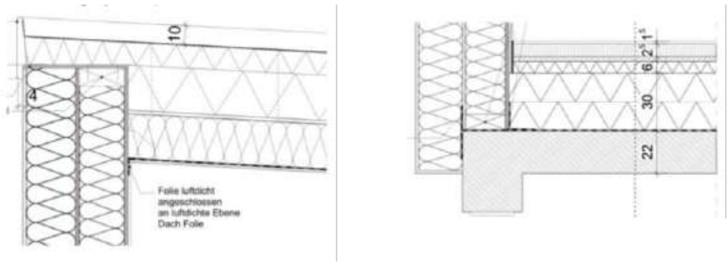


Figure 7.9 Cross section -slab, wall and roof

7.WINDOW TYPE

This house has windows of the company ALUPLAST GmbH, which has a certificate of passive design that their products meet the criteria of a passive house.

PVC, energeto® 8000 85 mm construction depth. **(Figure 7.10)**

This type of window that this company has made meets all the needs of passive houses and especially HOUSE 1 on which this study performs the analysis. With its appearance and straight lines, this window is in line with the design of this house.

Glazing

U g-value = 0.5 W/(m2K)

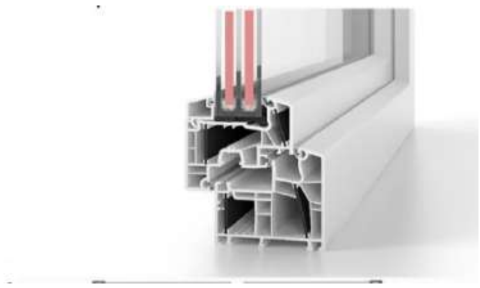
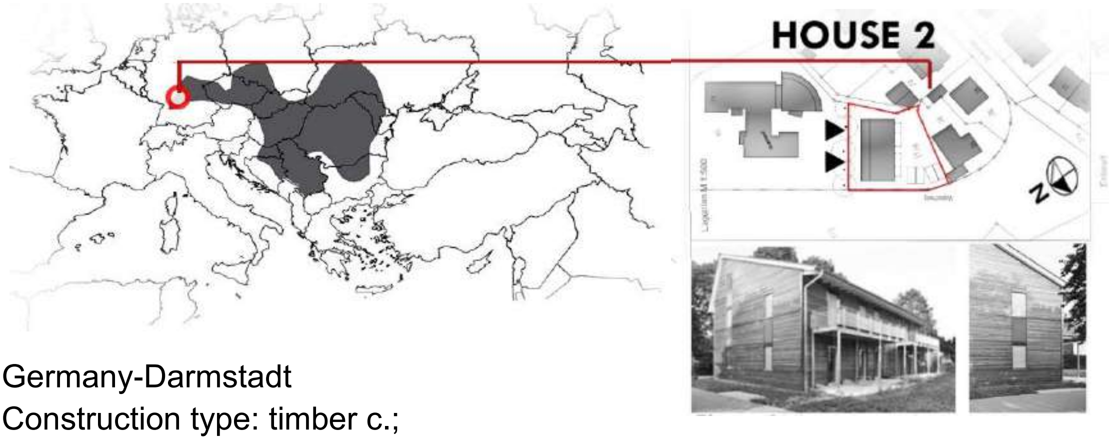


Figure 7.10 Section and picture of the window set



Building type: Semi detached family house
Location: Germany-Darmstadt
Area: 403 m2;
Construction type: timber c.;
Year: 2014

Figure 8 location and picture of house

1. ORIENTATION

The Orientation house is positioned towards the urban plan **(Figure 8)** and as a result, the facade surfaces are not parallel to the sides of the world and it is at a slight angle so that it does not adversely affect the proper orientation of this house. The organization of the ground floor is that all public areas are oriented south and a small part to the west, while all private areas in the north are a large part east and in one part and west, the entrance is positioned in the north. On the second floor, as shown (**Figure 8.1**), the central part is the communication, while the other is all private space (bedrooms).

Figure 8.1 Floor plans of house

2. TOPOGRAPHY

The terrain on which the house is located is relatively flat in a circle of about 5 to 10 km after which the terrain is hilly. The house is on a flat surface so no additional digging was required. The only excavation was for the base concrete slab.

The place where the house is located is very populated and the continental climate is present in this area. **(Figure 8.2)**

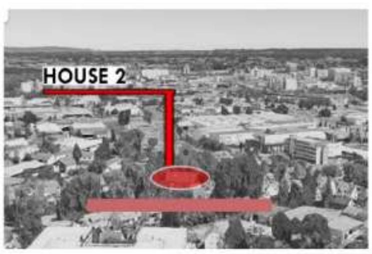


Figure 8.2 Graphical presentation of topography and position of the house 3 on the site

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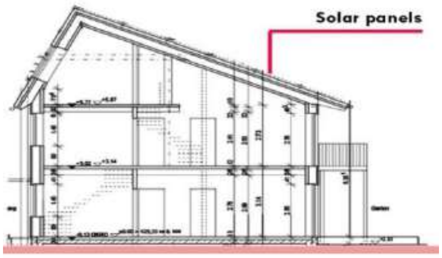


Figure 8.3 Graphical presentation of cross section through the house and the site where the house is located.

3. GLAZING

Given that it is a two-family house, it can be concluded through analysis that the house looks like a whole according to the layout of openings such as a single-family house. 80% of the openings are the same size but the number of openings varies.

The highest percentage is on the Southside of 14.11% and as we could see in the analysis (orientation) that on the south side is positioned public spaces such as living room open kitchen and dining room.

North 7.78%, West 7.53%, and East 7.53% show that there is private and communication space on these sides and that the area of the opening is approximately the same for all three sides **(Figure 8.4)** Wind flow is not as strong as can be seen in the analysis of wind flow **(Figure 8.5)**

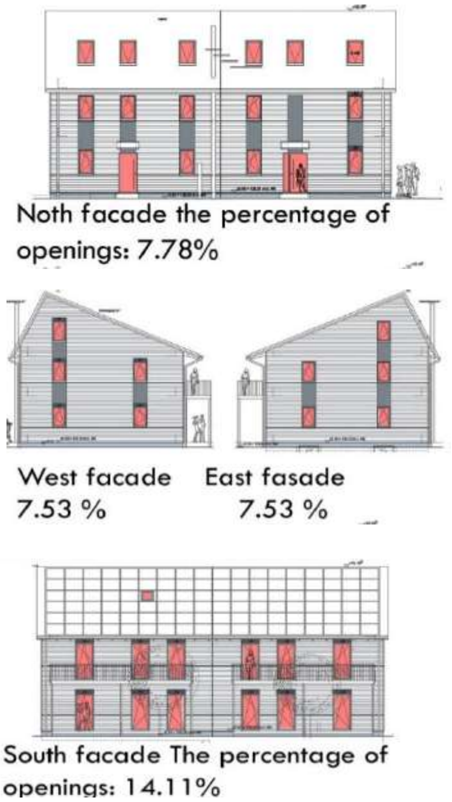


Figure 8.4 Percentage of the openings on facades

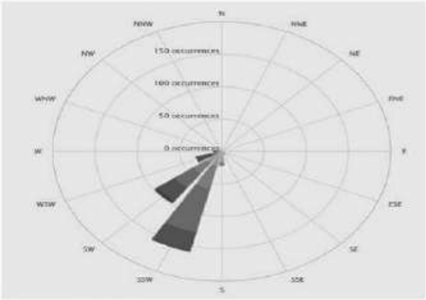


Figure 8.5 Wind rose for Germany-Darmstadt

4.ROOF TYPE

On house 2, which is in the area of continental climate, the architects predicted a gabled roof. he orientation of the roof surface is south-north. The arms of the roof are not at the same angle (**Figure 8.7),** the side facing south is purposely at a slight slope as while the north side is at a sharp angle, to get a larger roof area on the south side. The main reason for this move is to place solar panels **(Figure 8.6)** on a larger area (south), which is a huge contribution to this project, without the roof structure being expensive in practice.

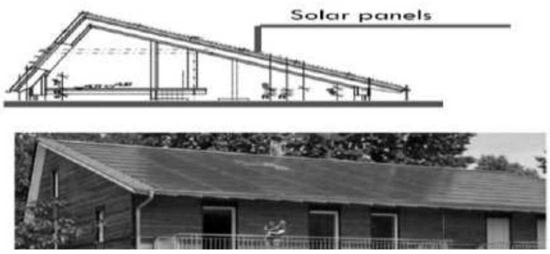


Figure 8.7 Section and picture of the roof

Figure 8.6 Solar panels over the roof tiles

5.SHADING SYSTEM

The shading system is of the classic type, the first floor is protected by the roof overhang, while the ground floor protects the balcony on the south side, where the public areas are located. **(Figure 8.8)**

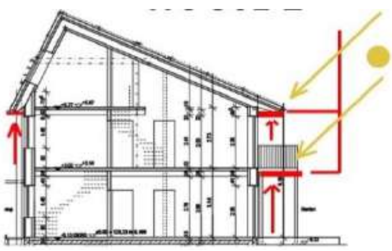


Figure 8.8 Section cross of the house and shading system

6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical sections **(Figure 8.9**) of all layers presents the quality of the construction.
Exterior wall: Plasterboard, OSB panel, 2.0 cm horizontal formwork larch wood, 4.0 cm battens, 6.0 cm soft wood fiber board HFD 050
24/6 cm KVH with full cellulose insulation 040
1.5 cm OSB N + F, 8/4 cm KVH with full insulation MW 035 (Inst. Level),1.2 cm OSB N + F
1.25 cm plasterboard planking

U-value = 0.102 W / (m2K)

Basement floor / floor slab: 1.5 cm top covering, 4.5 cm cement screed, 2.0 cm impact sound insulation, 4.0 cm insulation (line level), 25 cm reinforced concrete floor slab
20 cm thermal insulation XPS,
U-value = 0.137 W / (m2K)

Roof: 7.0 cm solar module / concrete roof tile cover, 3.0 cm battens
4.0 cm counter battens, 8.0 cm soft wood fiber board HFD 045, 30/6 cm KVH with full cellulose insulation 040, 1.5 cm OSB N + F
8/4 cm KVH with full insulation MW 035 (inst. Level), 1.25 cm plasterboard cladding
U-value = 0.093 W / (m2K)
Air tightness n50 = 0.4/h

Figure 8.9 Cross section -slab, wall and roof

7.WINDOW TYPE

This house has windows of the company VEKA. **(Figure 8.10)** VEKA ALPHALINE 90 MD WINDOWS-Alphaline is one of the better offers that the company Veka has produced for houses that are energy-efficient, which in most cases has shown very good results, such as on this house.
U g-value = 0.54 W/(m2K)

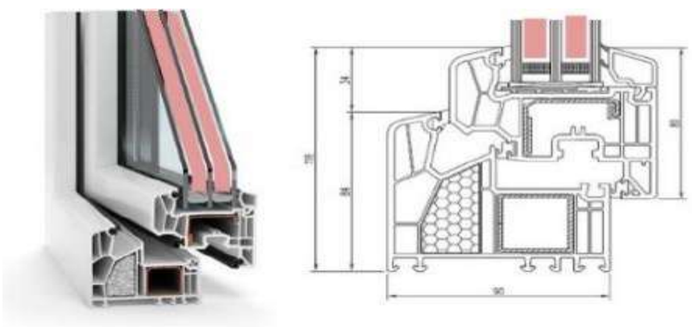
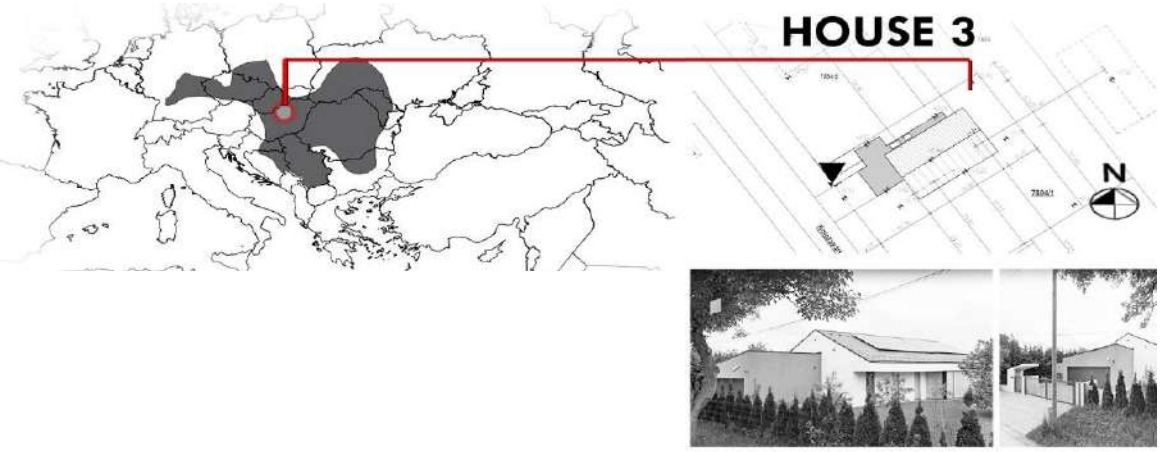


Figure 8.10 Section and picture of the window set



Building type: Detached single family house
Location: Hungary-Biatorbágy
Area:127 m2;
Construction type: Masonry c.;
Year: 2016

Figure 9 location and picture of house

1. ORIENTATION

The orientation of house 3, which is located in a moderately populated place where the continental climate is present, is determined according to the urban plan, but the position of the rooms in it are very well used. As can be seen **(Figure 9.1)**

on the southeast side where the highest concentration of the sun is positioned public areas while in the southwest are positioned private spaces such as bedrooms, even part of the bedrooms are located on the northwest where the entrance and horizontal communication. From this, it can be concluded that the position, orientation, and organization are according to what passive houses possess.

Figure 9.1 Floor plan of house

2. TOPOGRAPHY

The area where house 3 is located is flat even in a district of a few tens of kilometers **(Figure 9.2).** The area is heavily populated and urbanized. The advantage is that the base is extremely flat and there was no need to bury the house, except for the excavation provided for the concrete foundations, which support the entire house. In such terrains, a problem in the wind flow can often occur, where the mountainous winds descend towards the flat part uncontrolled from all sides.

Figure 9.2 Graphical presentation of topography and position of the house 3 on the site

ISSN No:-2456-2165

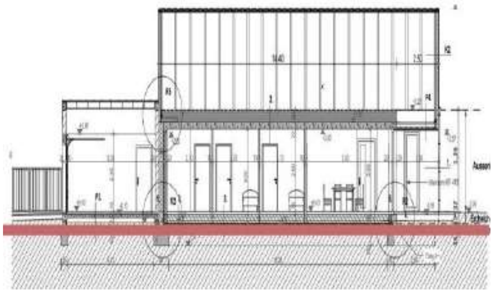


Figure 9.3 Graphical presentation of cross section through the house and the site where the house is located

3. GLAZING

According to the given analysis (**Figure 9.4**), it is clear that the southeast side has drastically the highest percentage of openings 37.25% because as we have already analyzed on that side are located public spaces such as the living room and a large part of the bedrooms. While Northeast 12.29% and Northwest 13.8% are pretty much up to the standard of the area of openings that these rooms need. on the southwest, there is an entrance and it is 5.87% of the total area of the facade. Another thing is very important to mention that the analysis of wind **(Figure 9.5)** currents showed that the strongest wind flow comes from the Northwest, however, even if there is a budget of 13.8% openings along the dimensions are small. According to the project, two toilets and storage were positioned in the northwest, which required that the size of the opening be smaller and thus reduce the risk of air leakage.

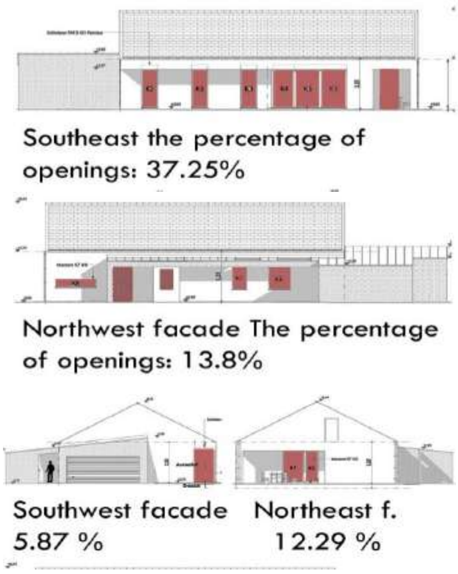


Figure 9.4 Percentage of the openings on facades

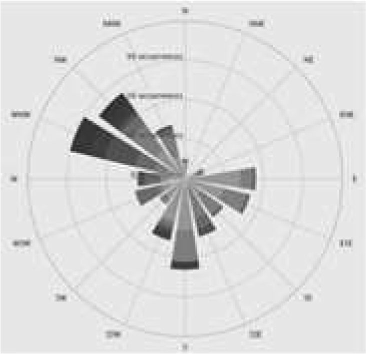


Figure 9.5 Wind rose for Hungary-Biatorbagy

4.ROOF TYPE

On house 3, which is located in the area of continental climate, the architects envisioned a gabled roof. The orientation of the roof surface is northwest-southeast. The arms of the roof structure are made symmetrically at the same angle. An interesting detail that can be seen in the cross-section **(Figure 9.6)** is that the architects did not plan to let the roof over the walls and make a shading system but did it in another way. Solar panels

(Figure 9.7) are placed on the surface of the roof structure facing south-east.

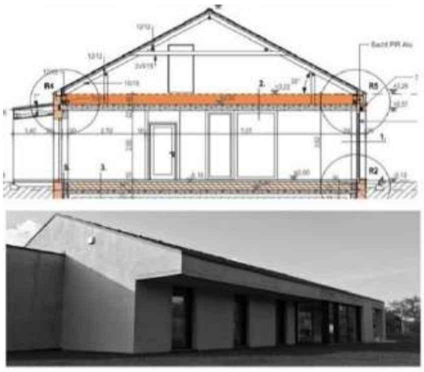


Figure 9.6 Section and picture of the roof

Figure 9.7 Solar panels over the roof tiles

5. SHADING SYSTEM

As already mentioned, the highest concentration of sun and solar heat is reflected on the southeast facade, especially during the summer. The architects have indented one part on the south-east side so that the roof slab and roof are over that space if we look through the cross-section **(Figures 9.8)** and with this step protection is gotten for the public space in the house from strong sunlight and heat.

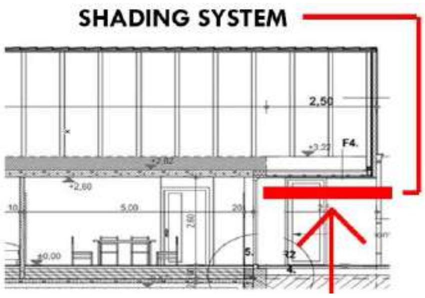


Figure 9.8 Section cross of the house and shading system

6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical sections (**Figure 9.9)** of all layers presents the quality of the construction.
(A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator. The value of Airtightness is also important in passive houses and refers to the speed of air leakage through a building the value of it is usually 50 Pascals)

Exterior wall

Interior plaster, Silka 20, Austrotherm Grafit Reflex, External plaster
U-value = 0.098 W / (m2K)

Basement floor / floor slab: Ceramic, Baumit screed, Impact sound insulation, Austrotherm, Reinforced concrete,
U-value = 0.117 W / (m2K)
Roof: Interior plaster, Reinforced concrete,
Cellulose,
U-value = 0.095 W / (m2K)
Air tightness: n50 = 0.26/h

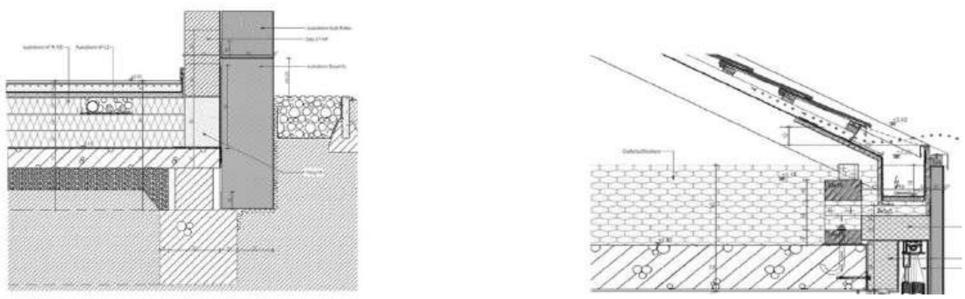


Figure 9.9 Cross section -slab, wall and roof

7.WINDOW TYPE (glass type)

This house has windows of the company Internorm, KF 410 **(Figure 9.10).** Plastic-aluminum windows,

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Whether in classic white plastic or with a weatherproof aluminum shell - with KF 410 right decision. The angular design of the frame and sash is coordinated with the construction of the home pure design style. Thanks to the new I-tec Insulation technology, the frame is completely insulated and the thermal insulation is significantly improved. If required, the I-tec ventilation can be integrated into this window. This innovative ventilation system ensures sufficient fresh air and a perfect indoor climate for 24 hours.

Glazing U g-value = 0.57 W/(m2K)

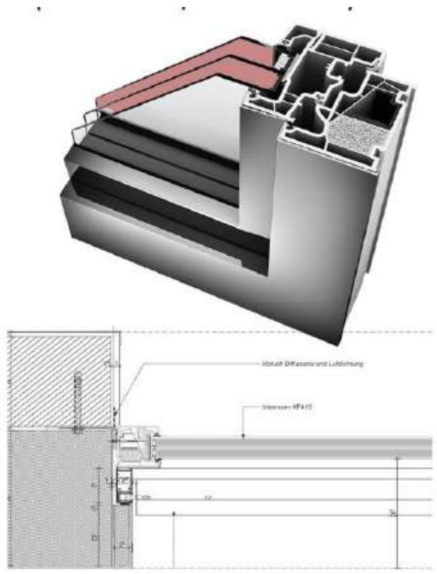

Figure 9.10 Section and picture of the window set

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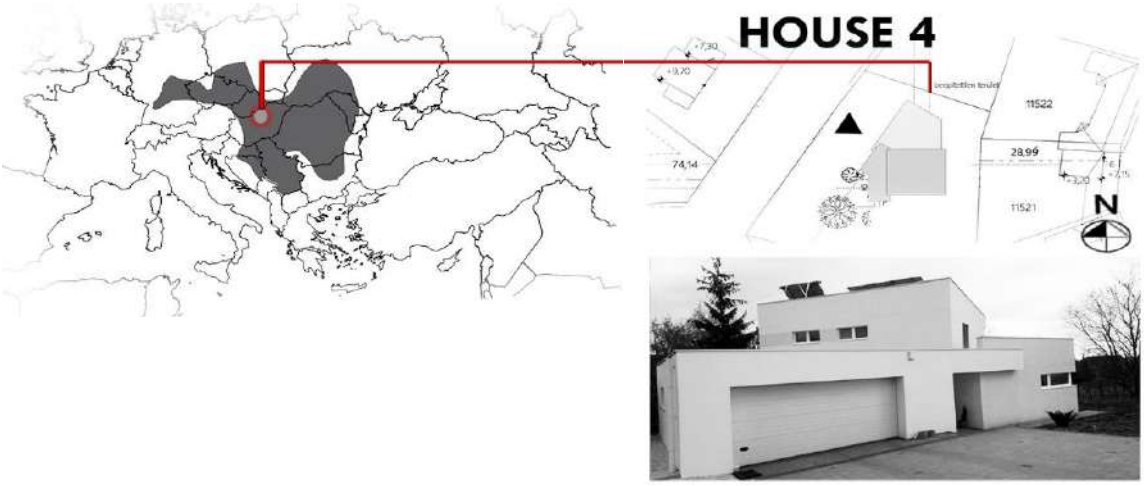

Building type: Detached single family house
Location: Hungary-Eger
Area:187 m2;
Construction type: Masonry c.;
Year: 2012

Figure 10 location and picture of house

1. ORIENTATION

House 4 is made in an area where the continental climate is represented. The shape of the house as can be seen in the picture **(Figure 10)** is very specific and useful. One part of the house follows the line of the road to follow the urban plan, while one part is oriented so that the walls are parallel to the sides of the world, which is an ideal solution when it comes to passive houses. As with the others passive house, house 4 is planed: the public space (living room and dining room)are positioned to the south, while the private spaces as bedrooms face north and east on the ground floor, and on the first floor there is one bedroom or study on each side, with different number and size of the openings. Communication (entrance) is central and north which is ideal for these conditions.

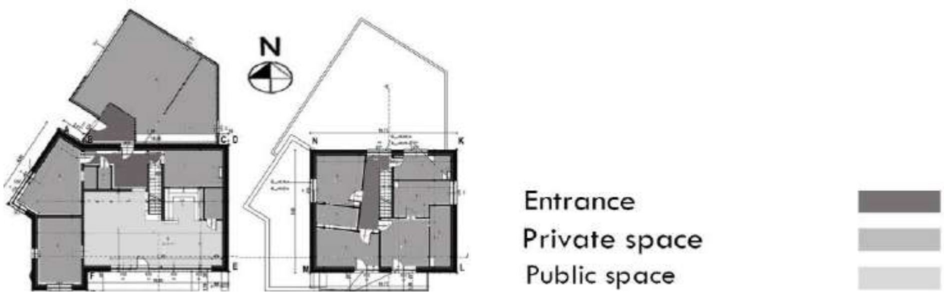

Figure 10.1 Floor plan of house

2. TOPOGRAPHY

The location where house 4 is located is slightly hilly,
(Figure 10.2) the position where the house is located is slightly sloping, so it was necessary to bathe and level the part where the house is positioned. No part of the house is total in the ground except the concrete structural ground floor slab that accepts the load of the whole building.

(Figure 10.3)

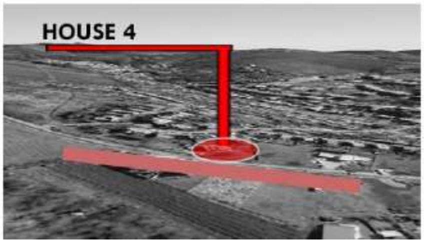

Figure 10.2 Graphical presentation of topography and position of the house 3 on the site

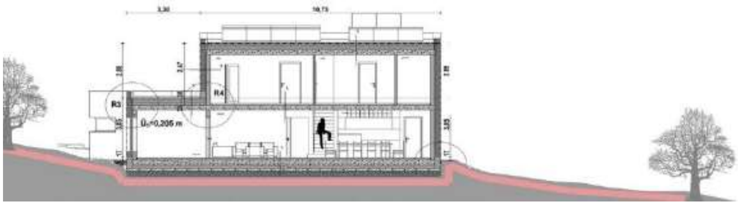

Figure 10.3 Graphical presentation of cross section through the house and the site where the house is located.

3. GLAZING

By calculating the area of facades **(Figure 10.4)**, we obtained that the highest percentage of openings on the South Facade is 32.6%, which we saw in the orientation analysis that the position of public spaces is in the south so that the area of openings is properly distributed and the area of openings is ideal. Westside 8.3% the second largest area of the opening, according to analysis number 1, the orientation there are positioned private space (bedrooms, pantry, as well as garage space). Northside 5.33% are positioned entrances and horizontal communication between the spaces. Eastside 2.98% also have private rooms such as bedrooms, and study rooms which is not the practice to have the lowest percentage of openings on that side, however, House 4 is still with quality and the way it is made passive.

Through the analysis of wind rose **(Figure 10.5)**, we can see that the strongest winds flow from the east and west, which is not common as in other houses, and thus we can conclude that the main reason why architects reduced the area of openings on the east side to avoid air leaks through windows.

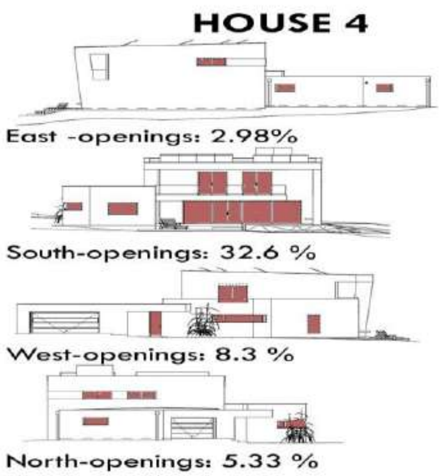

Figure 10.4 Percentage of the openings on facades

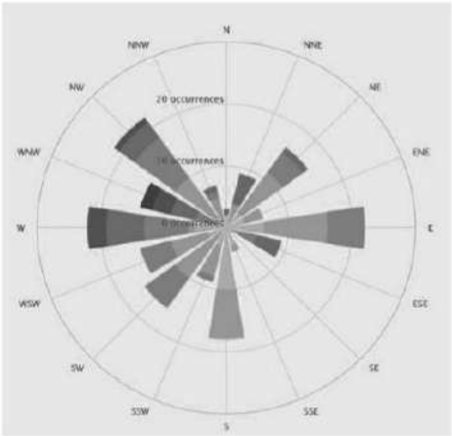

Figure 10.5 Wind rose for Hungary-Eger

4.ROOF TYPE
According to the area where house 4 is, it is positioned as we have already stated the continental climate. The sun's heat reaches about 300 degrees, which the architects used for energy purposes. The roof is flat with multi-layer insulation and solar panels are positioned on the roof surface **(Figure 10.7),** which is of great benefit if take into account the summer temperature we have stated.

Figure 10.7 Solar panels over the roof tiles

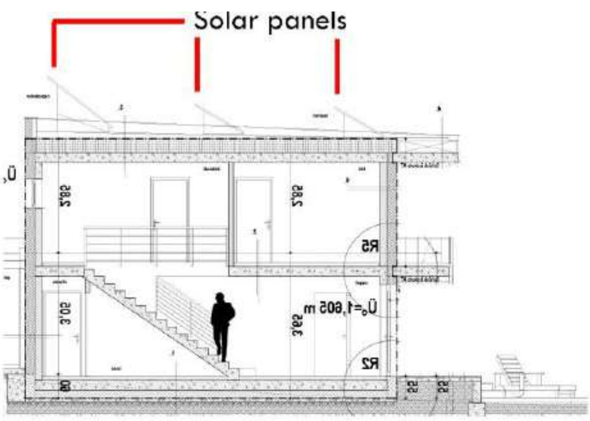

Figure 10.6 Picture of the roof

ISSN No:-2456-2165

5.SHADING SYSTEM

The biggest influence of the sun is on the south side. An architect on that side let the roof over the wall and protect the private rooms upstairs, also on the ground floor protection is the terrace from the first floor and all this is a shading system that is effective during summer heat and strong sunlight. However, in winter this shading system does not affect (**Figure 10.8)**

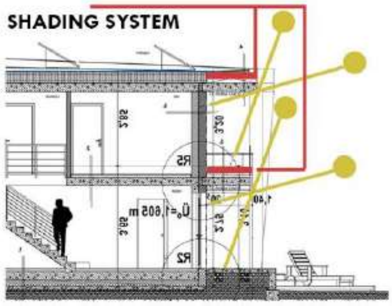

Figure 10.8 Section cross of the house and shading system

6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical section (**Figure 10.9)** of all layers presents the quality of the construction.
(A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator. The value of Airtightness is also important in passive houses and refers to the speed of air leakage through a building the value of it is usually 50 Pascals)

Exterior wall: Lime-gypsum plaster, sand-lime brick masonry, Bachl, mineral external plaster
U-value = 0.097 W / (m2K)

Basement floor / floor slab: Ceramic, screed, footfall sound insulation, reinforced concrete floor slab, insulation
U-value = 0.159 W / (m2K)

Roof: Thermal insulation, reinforced concrete ceiling
U-value = 0.097 W / (m2K) Air tightness: n50 = 0.22/h

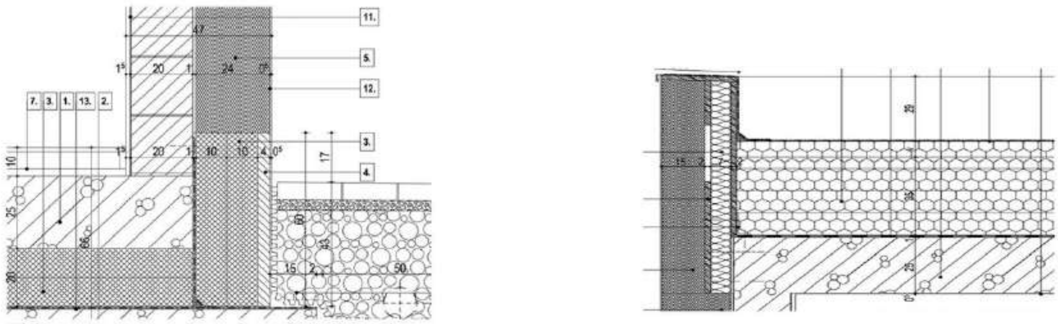

Figure 10.9 Cross section -slab, wall and roof

7.WINDOW TYPE

his house has windows of the company
Internorm, Thermo-Passiv (KF400) **(Figure 10.10).**
The KF400 Thermo Passiv window is a combination of minimalist design and very high technical parameters, confirmed by a certificate of the Passive House Institute in Darmstadt.

The KF400 window from Internorm is characterized by: a multi-chamber system with an additional heat-insulating foam with high thermal insulation, deep glazing, profile thickness equal to 90 mm and the Fix-O-Round technique of direct gluing of the glass, consisting in gluing the glass to the window frame around the entire perimeter.

Glazing U g-value = 0.5 W/(m2K)

Figure 10.10 Section and picture of the window set

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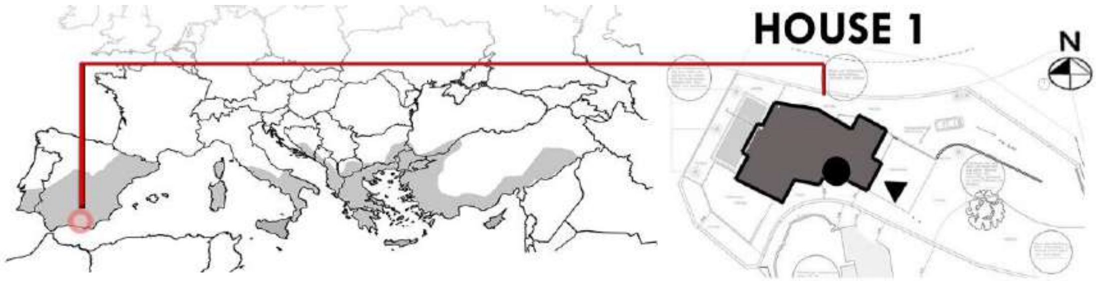

Building type: Detached single family house Location: Spain-Mijas molag Construction type: Masonry c.; Year: 2014 Area:403 m2;

Figure 11 location and picture of house

1.ORIENTATION Since House 1 is located in a very hilly place, the plot has affected the position of the house in relation to the terrain **(Figure 11).** The place is moderately populated, but the landscape is highly mountainous and if the Mediterranean climate is present. Regardless of the circumstances in which the house is located, the architect has organized the space so that the organization is adequate to what the passive system of the house requires. According to the analysis **(Figure 11.1**) on the ground floor on the south and west side is positioned public space as is usual with passive houses to use natural light and sunlight, on the first floor in the same position are private rooms, such as the master bedroom. As for the private rooms (bed-rooms and study rooms), in addition to the south and west sides, they are located in the north of the house. The entrance and communications are positioned to the east because on that side there is a road that leads to the house.

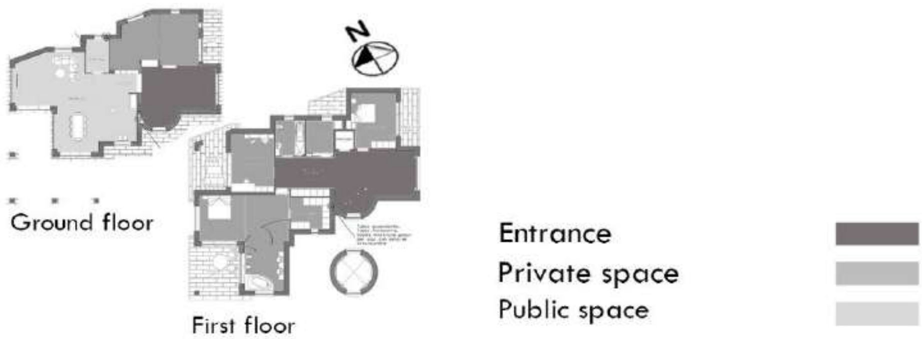

Figure 11.1 Floor plan of house

2.TOPOGRAPHY

Regardless of the Mediterranean climate, the position of the house is at a very hilly terrain. Near the house, there is a sea where the altitude is zero, but the position of the house is away from the sea and at the top of the mountain area. According to the analysis of the technical cross-section through the terrain and the house **(Figures 11.3),** it can be seen that one floor is completely underground while the others are on the surface. This venture was inevitable given the situation of the terrain and the area in which the house is located.

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Figure 11.2 Graphical presentation of topography and position of the house 3 on the site.

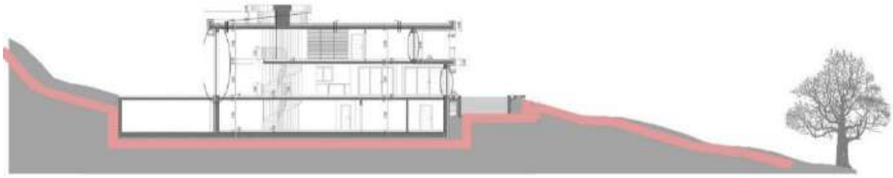

Figure 11.3 Graphical presentation of cross section through the house and the site where the house is located.

3. GLAZING

As already mentioned in the analysis 1 orientation, the public space (living room and dining room) is located to the south and west, and therefore we see that on that side is the largest percentage of openings so that in house 1 can access as much sunlight, that is, natural light as well as heat from the sun. South facade 30.2% and West facade 26.5%. While in the North it is 8.85% where the bedrooms are positioned. East facade 24.73% purpose of this amount of openings is that on that side is also part of the bedrooms as well as all horizontal and vertical communication.
Based on the analysis of winds **(Figure 11.5)** for the areas where house 1 is located, we can conclude that winds are present from all sides. The strongest wind currents come from the north. Depending on the climate zone, the winds will not adversely affect the house 1

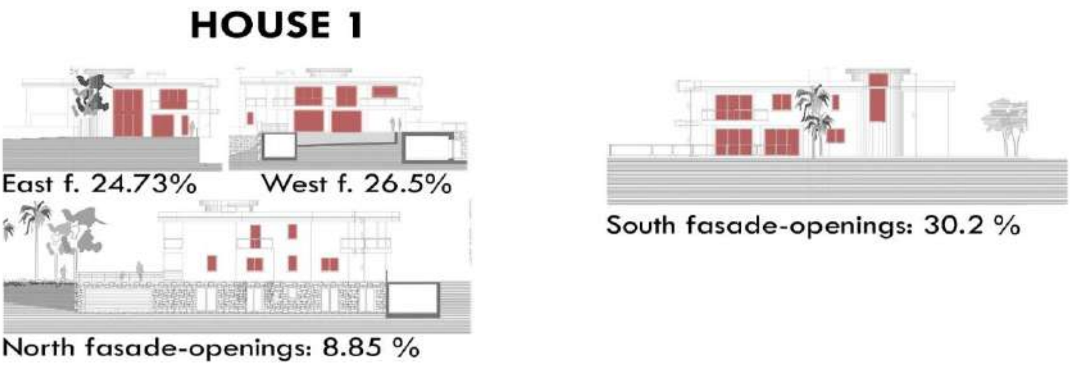

Figure 11.4 Percentage of the openings on facades

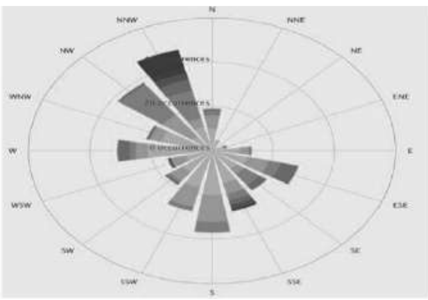

Figure 11.5 Wind rose for Spain-Mijas

4.ROOF TYPE

As already mentioned, that the house is located in a hilly area but with a Mediterranean climate, the architect predicted a flat roof, which is recommended for this area. What should be emphasized is that the roof area is about 140 square meters, which is quite large, and with vertical communication, it is always possible to access the roof. An architect decided on an energy-efficient step. As can be seen in the picture **(Figure 11.6)** on the roof surface are positioned solar panels, which make a huge contribution to energy savings, especially when it comes to the Mediterranean climate where there are many sunny days during the year.

Figure 11.6 Solar panels over the roof tiles.

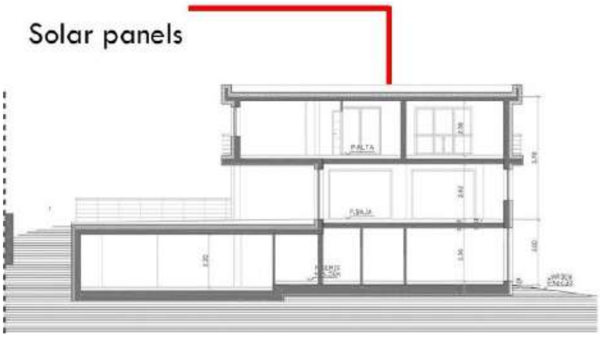

Figure 11.7 The position of the Solar panels on top of the roof surface

5.SHADING SYSTEM

The strongest impact of the sun is on the south side. The architect on that side lets the roof slab over the wall to cover the bedrooms upstairs, the terrace from the first floor also covers the ground floor, and all this is a shading device that is efficient during summer heat and strong sunlight. However, this shading system does not impact in winter **(Figure 11.8)**

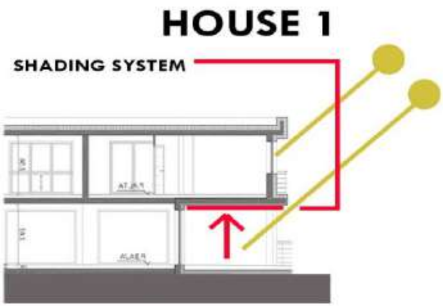

Figure 11.8 Section cross of the house and shading system

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6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical section (**Figure 11.9)** of all layers presents the quality of the construction. (A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator. The value of Airtightness is also important in passive houses and refers to the speed of air leakage through a building the value of it is usually 50 Pascals)
Exterior wall: Inner path, Porenbetonstein Ytong, SATE Steinwolle-dam Isover, Outer path
U-value = 0.22 W / (m2K)

Basement floor / floor slab: Marble, cement screed, impact sound insulation, Styrodur insulation, reinforced concrete ceiling, blinding layer lightweight concrete, Styrodur insulation,
U-value = 0.235 W / (m2K)
Roof: Tiles on a mortar bed, Cement screed,
EPDM, polymer bitumen sheeting, Cortipan cork insulation, Cement screed, Reinforced concrete ceiling, Interior plaster,
U-value = 0.23 W / (m2K)
Air tightness: n50 = 0.469/h

Figure 11.9 Cross section -slab, wall and roof

7.WINDOW TYPE

This house has windows of the company
GUTMANN MIRA **(Figure 11.10)**
With a broad range of profiles, the GUTMANN MIRA wood-aluminum package provides tailored solutions for every requirement, from residential to commercial buildings. Classic offset architecture covers solid technology with outstanding characteristic values. All regular window constructions, opening forms, and window shapes, including slanted windows, semi-circular, segmented, or lancet arches, can be executed in a variety of profile designs.
Glazing
U g-value = 1 W/(m2K)

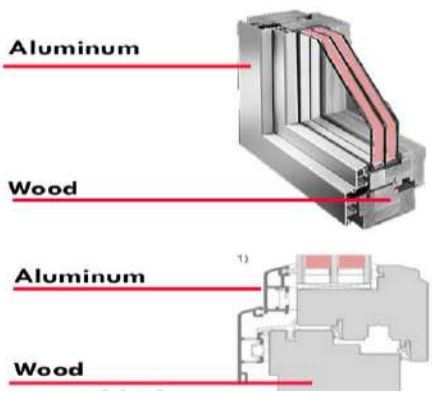

Figure 11.10 Section and picture of the window set

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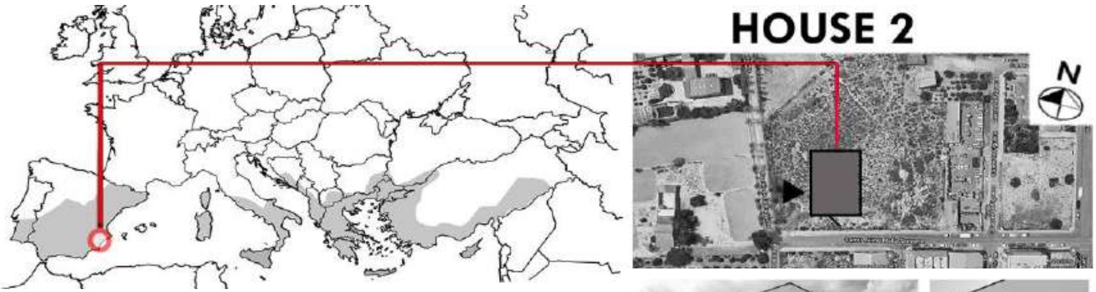

Detached single family house
Torrellano
Construction type: Timber c.;

Building type:
Location: Spain-
Area:102m2;
Year: 2019

Figure 12 location and picture of house

1. ORIENTATION

The orientation of house 2, which is situated in a moderately populated area where the Mediterranean climate is present, is oriented according to the urban plan (**Figure 12),** but the organization of space is rationally used. As you can see

(Figure 12.1)

The entire space on the west and half of the building on the south is designed to be a public area (living room, dining room). The other half of the southern part of the house is designed for private space, ie the master bedroom. The northern part of the house was used for service rooms (bathrooms and kitchen)

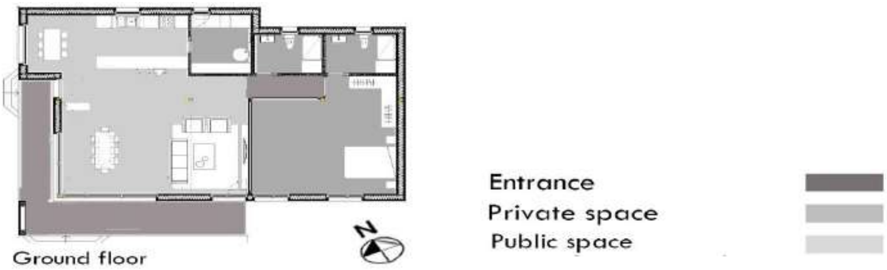

Figure 12.1 Floor plan of house

2. TOPOGRAPHY

The terrain on which the house is positioned is completely flat and at zero altitudes.
The climate in this area is Mediterranean and the distance between the plot on which the house is positioned and the sea is about 6km.
As already mentioned, the terrain is absolutely flat, which is analyzed by the technical cross-section through the terrain and through the house **(Figure12.3),** the financial advantage is that it is not necessary to bury the part of the house, as is the case with houses on hilly terrain.

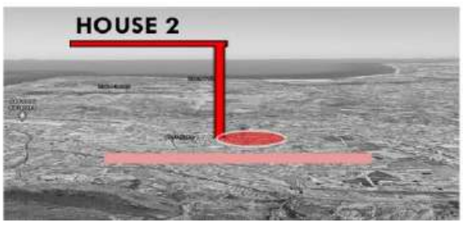

Figure 12.2 Graphical presentation of topography and position of the house 3 on the site.

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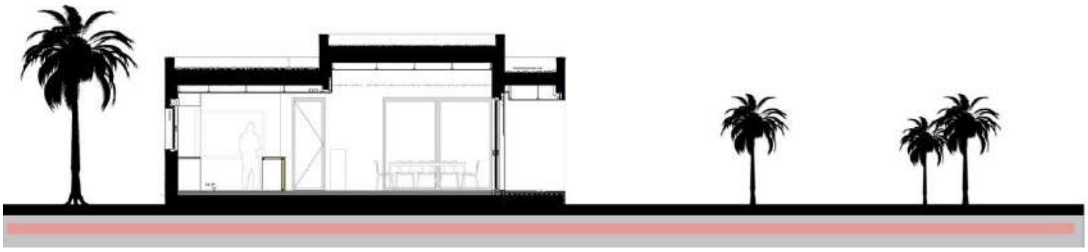


Figure 12.3 Graphical presentation of cross section through the house and the site where the house is located.

3. GLAZING

This analysis of the studies shows the percentage of the opening to the entire surface of the facade, and what is the purpose of that.

The calculation shows that the highest percentage on the west facade is 32.46%, while on the south facade 31.81% is a huge opening capacity. From the first analysis (Orientation), it was concluded that there is a public space on that side, where there is a need for great natural light and solar heat.

On the south side, there is also a master bedroom so a certain percentage of the openings on the south side is divided into public and private space. As we have already mentioned, there are service rooms on the north side and on that side, the percentage is 4.9%, which is in line with the needs of that area. However, it is important to mention that we do not have openings on the east side, so the percentage is 0% (**Figure 12.4**) Analysis of the winds (**Figure 12.5)** showed that the strongest current comes from the east, and the premise of this study is that the architects did not design openings on that side, to avoid air leakage through the openings due to strong winds.

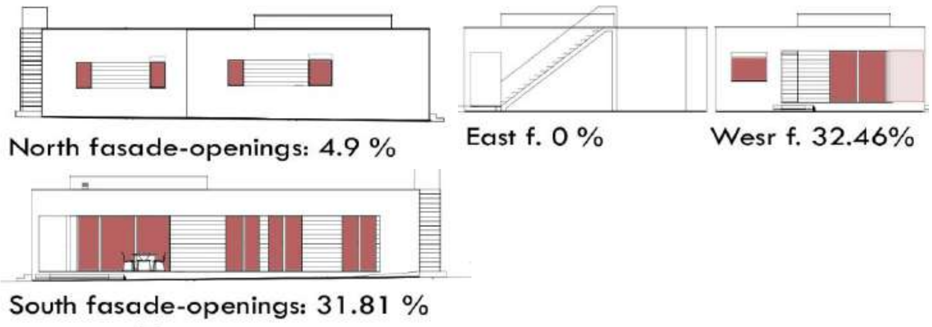


Figure 12.4 Percentage of the openings on facades

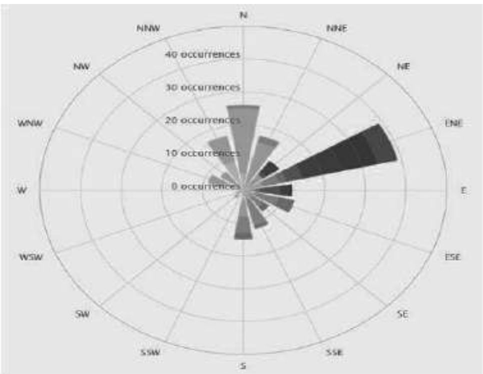


Figure 12.5 Wind rose for Spain-Torrellano

4.ROOF TYPE

Since the house is located in an area where the Mediterranean climate is presented, the architects designed a flat roof, which is common for such an area. **(Figure 12.6 & 12.7)**

Along the east side on which we have mentioned that there is no opening, stairs have been built leading to the roof. All things considered, the only drawback is that no solar panels are installed on the roof surface, as we have found that access to the roof is possible and that the area is ideal for solar panels.

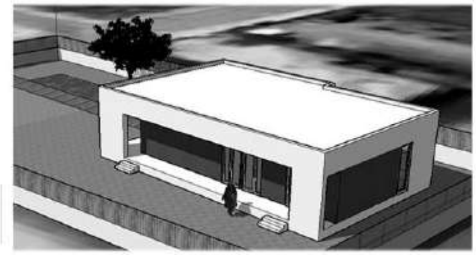


Figure 12.6 Picture of the roof

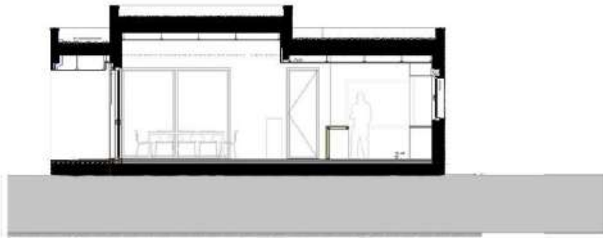


Figure 12.7 Section of the roof structure

5.SHADING SYSTEM

As has already been stated, the highest concentration of sun and solar heat is reflected on the south-eastern facade, particularly during the summer. Architects have indented one portion of house on the south and east side so that the roofing slab and roof are over that space if we look through the cross-section (**Figures 12.8**) and with this step security the public space in the house is shielded from strong sunlight and heat.

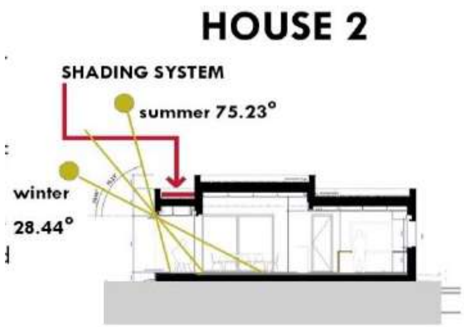


Figure 12.8 Method of the shading system

6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical section **(Figure 12.9**) of all layers presents the quality of the construction.

(A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator. The value of Airtightness is also important in passive houses and refers to the speed of air leakage through a building the value of it is usually 50 Pascals)

ISSN No:-2456-2165

Exterior wall: Industrialized timber frame panel with cellulose insulation.
Internal service cavity
ETICS Neopor external render
U-value = 0.126 W/(m2K)

Basement floor / floor slab: Concrete slab
XPS 036 insulation
U-value = 0.163 W/(m2K)
Roof: Flat roof, Glulam timber with mineral insulation in between the rafters.
U-value = 0.122 W/(m2K)
Air tightness: n50 = 0.5/h

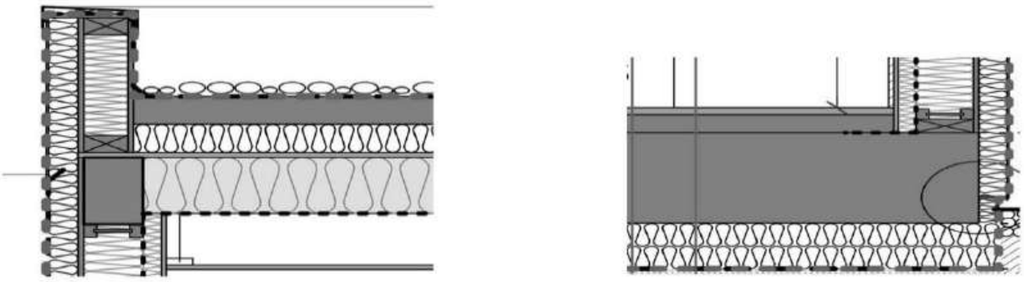


Figure 12.9 Cross section -slab, wall and roof

7.WINDOW TYPE
This house has windows of the company
Hoco **(Figure 12.10)**

Frame
HX95, 1.10
HOCO HX95 window frame
U w-value = 1.1 W/(m2K)
Glazing
Triple glazing
Swisspacer ultimate spacer
U g-value = 0.78 W/(m2K)
g -value = 32 %
Entrance door
HOCO H671 PVC entrance door

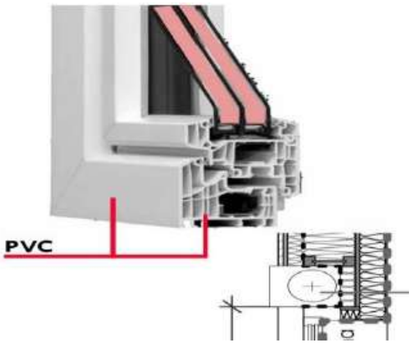
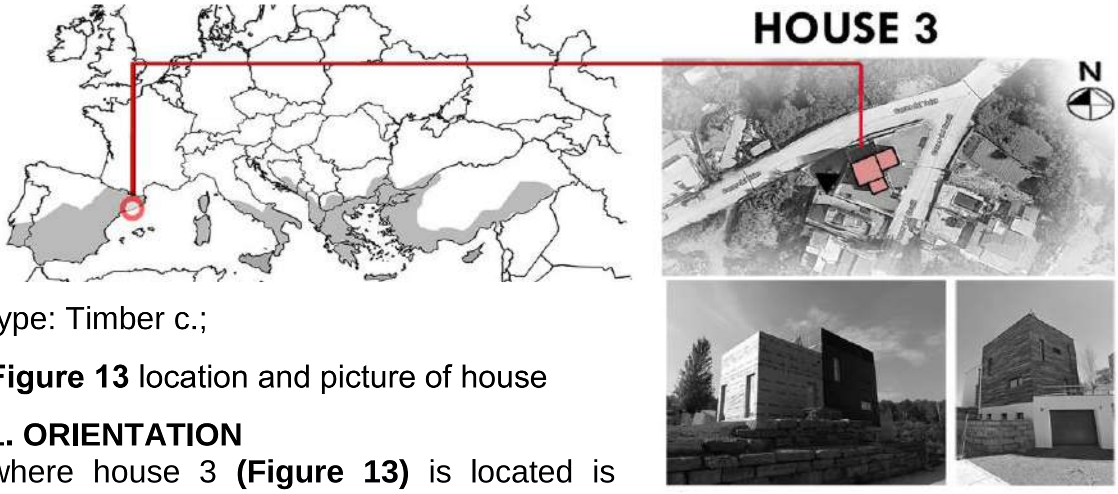


Figure 12.10 Section and picture of the window set

ISSN No:-2456-2165



Building type: Detached single family house
Location: Spain-Sant Quirze del Valles
Area:122 m2; Construction type: Timber c.;
Year: 2018

Figure 13 location and picture of house

1. ORIENTATION

The place where house 3 **(Figure 13)** is located is relatively populated, and it can also be said that the terrain is slightly hilly. In this area where the house is positioned, the Mediterranean climate is represented. How the house is oriented and the positions of the rooms have not been a practice in previous analyzes of passive houses. The architects placed the public areas (living room, kitchen and dining room) on the north side and the private rooms on the south. However, a more detailed analysis of the terrain and topography **(Figure 13.2)** concludes that the architects opted for the north side because of the view of the city, because it is a public space (living room, kitchen and dining room) where users spend most time in the house. Upstairs, the organization is such that all private rooms, service and communication, are positioned. **(Figure 13.1)**

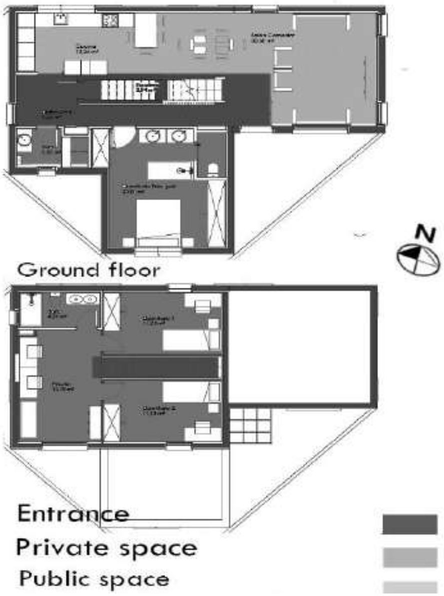


Figure 13.1 Floor plans of house

2. TOPOGRAPHY

As we have already mentioned the house is positioned on slightly hilly terrain. as shown in the detailed technical section **(Figure 13.3)** one part of the ground floor had to be underground, due to a slight drop in terrain. The fall of the terrain starts from the south side as the highest altitude and descends towards the northern part, and that is how we stated the reason why the architects did not turn the public spaces towards the south.

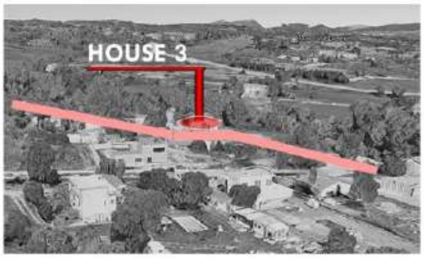


Figure 13.2 Graphical presentation of topography and position of the house 3 on the site

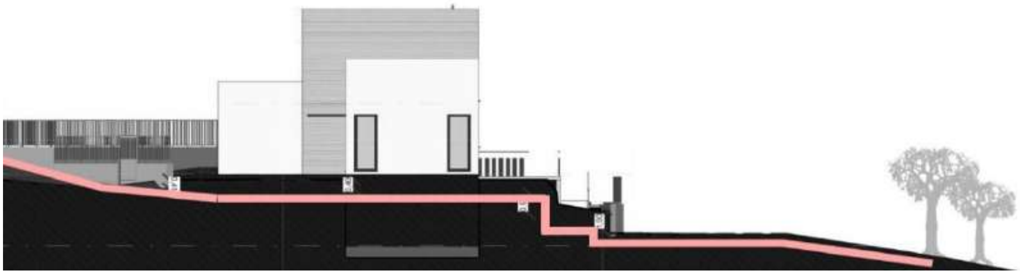


Figure 13.3 Graphical presentation of cross section through the house and the site where the house is located.

3. GLAZING

Through the analysis of the surfaces of the facades from house 3, the percentage of openings will be separated and analyzed. According to the surface calculation, the South Facade has the highest percentage of openings to the façade surface, 18.46%. According to the analysis (orientation), it was concluded that all private rooms, such as study and bedrooms, are located in this position, and the reason given is that due to the hilly part of the plot on the south side. After the south, the eastern façade has the highest percentage of 7.10% and then the northern 6.85% where it is emphasized that there are public rooms (living room, bedroom, and kitchen), however, given that these are public areas where the greatest amount of natural light is needed, the architects did not take a risk but design with a minimal percentage. The western facade of 6.59% has the smallest area of the opening and according to the first analysis (orientation), we see that the communication and service rooms are positioned. As for wind analysis (**Figure 13.5**), wind currents come from three sides, north, south, and east with the strongest intensity from the east, and this is one of the reasons why the architects.

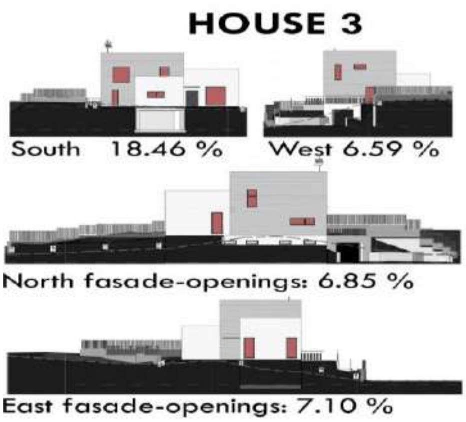


Figure 13.4 Percentage of the openings on facades

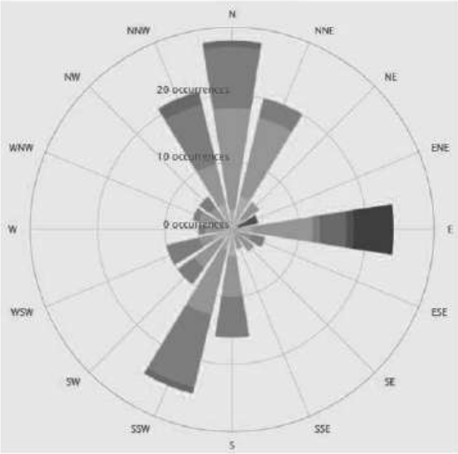


Figure 13.5 Wind rose for Spain-Sant Quirze

4.ROOF TYPE

At house 3 the case is identified as at house 2. Both locations have a Mediterranean climate and a flat roof, which is as we mentioned in this study that is a practice in the Mediterranean climate, but house 3 has an even larger roof area, and as in house 2 is not used for energy-efficient step (installation of solar panels) which is a very large contribution to the facility given that it is located in such an area.

Figure 13.6 Picture of the roof

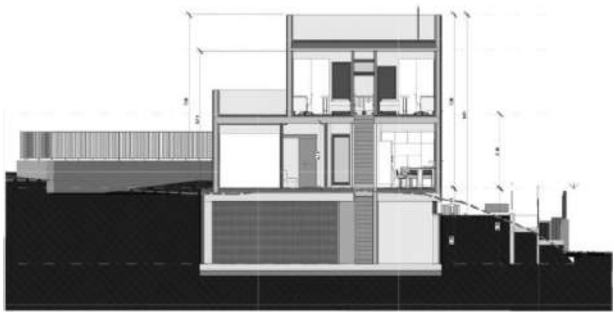


Figure 13.7 Section of the roof structure

5.SHADING SYSTEM

A more detailed analysis concluded that house 3 does not any shading system. The assumption of this study is that in the case of house 3 where the public areas are on the north side and the area of the openings is reduced, there is not much need for a special shading system.

6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical section **(Figure 13.9)** of all layers presents the quality of the construction. (A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator. The value of Airtightness is also important in passive houses and refers to the speed of air leakage through a building the value of it is usually 50 Pascals)
Exterior wall: Insulated service cavity
VCL membrane, closed timber frame panel.

Neopor ETICS, Mortar / timber cladding
U-value = 0.146 W/(m2K)

Basement floor / floor slab: Polish concrete finishing, RC slab, XPS 300, Gravel
U-value = 0.435 W/(m2K)
Roof: Bitumen membrane, EPS Neopor, VCL membrane, GLT ceiling
U-value = 0.221 W/(m2K)
Air tightness: n50 = 0.22/h

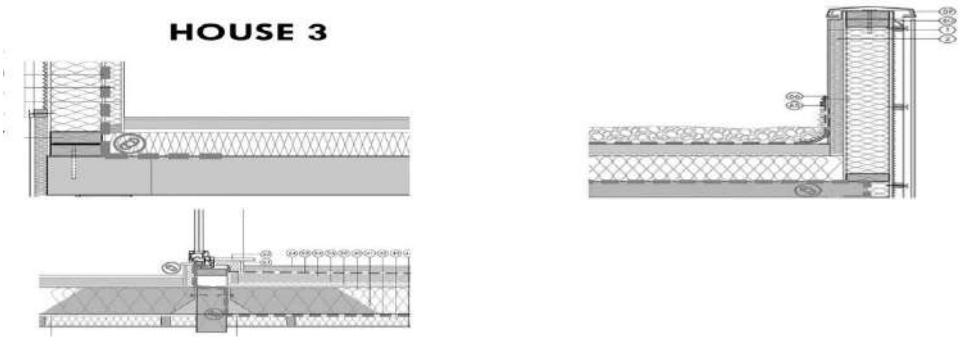


Figure 13.8 Cross section -slab, wall and roof

7.WINDOW TYPE

This house has windows of the company
Cortizo PVC
(Figure 13.19) A 84 Passivhaus HI is a product of this factory which is intended for cold and temperate climate zone, however, the results showed that it is an ideal type of window for passive houses, with a special tape with which the glass is attached acts as one high-quality structural element.
By installing this type of window, one huge problem of air leakage into the interior of the house has been solved.
Glazing
Triple glazing
U g-value = 0.53 W/(m2K)

Figure 13.9 Section and picture of the window set

Detached single family house
Madrid
Construction type: Timber c.;

Building type:
Location: Spain-
Area:103 m2;
Year: 2014

Figure 14 location and picture of house

1. ORIENTATION

The location of house 4 is moderately populated, so to speak, in the development of population settlement. **(Figure 14)** The area is slightly hilly, and the Mediterranean climate is represented. By analyzing the orientation and organization of the space, it can be said that the architects, as is usual with passive houses, positioned the public space to the south and the part of the east where the highest concentration of the sun is. Private rooms (bedrooms and study rooms) are positioned to the west and a lesser extent to the north, Horizontal communication is central and north. From this analysis it can be concluded that the position, orientation and organization of space in house 4 was done correctly and following the requirements of passive houses **(Figure 14.1)**

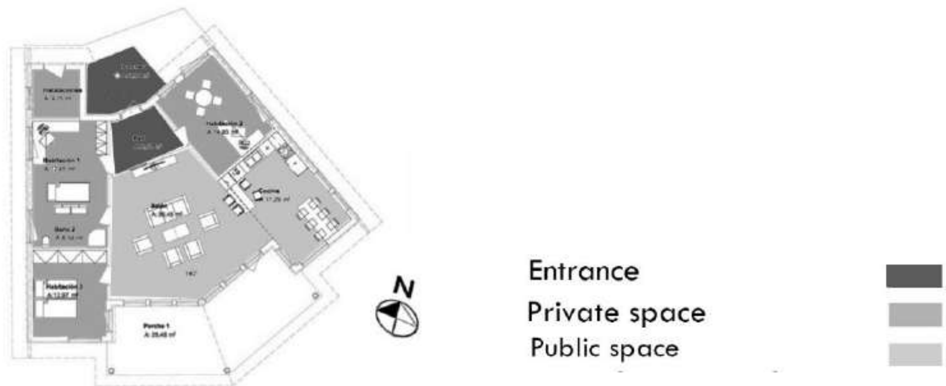


Figure 14.1 Floor plan of house

2. TOPOGRAPHY

The house is situated on mildly hilly terrain, as we have already described. As the comprehensive technical section shows **(Figure 14.3)**

The terrain on which the house is built was in a very small slope so excavation was needed only for the foundation.

The fall of the terrain begins on the west side and descends at a slight angle to the east side.

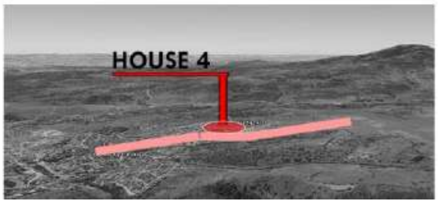


Figure 14.2 Graphical presentation of topography and position of the house 3 on the site

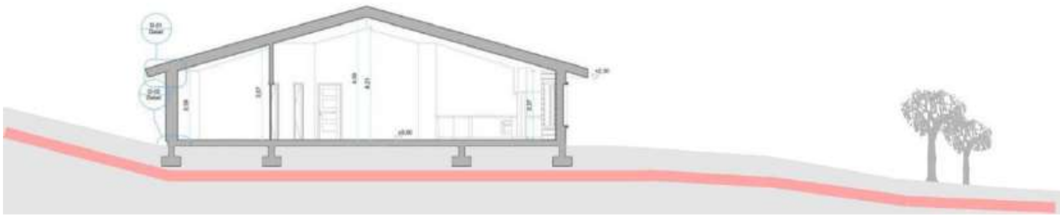


Figure 14.3 Graphical presentation of cross section through the house and the site where the house is located

3. GLAZING

The percentage of the opening to the entire surface of the facade is seen in this study of the experiments, and what the intention is **(Figure 14.4)**.The estimate reveals that 43.03 % is the highest percentage on the south facade.
On the south side, as we have already mentioned, there is an organized public space where users spend most of their time, and on that side is the highest concentration of sun, which is why it has the highest percentage of openings.

After the southern highest percentage of openings, it has the northern side of 21.22%, on which the central entrances and the horizontal communication between the spaces are positioned. East side 18.69%, on that side there are bedrooms and working rooms (private space). With the lowest percentage of openings, the east side is 12.09%, and the kitchen and dining room are positioned on that side, which can be concluded that it is in line with the needs of the positioned space.
Analysis of winds **(Figure 14.5)** shows that the strongest current comes from the eastern side, which is an assumption that on that side is the smallest percentage of openings.

Figure 14.4 Percentage of the openings on facades

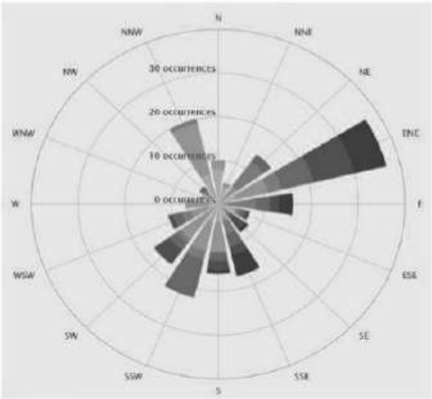


Figure 14.5 Wind rose for Spain-Madrid

4.ROOF TYPE

On the house 4 type of roof is gabled, with a slope of 15.70 % **(Figure 14.6 & 14.7),** the assumption is that the classic roof structure, which is one of the cheapest types of roofs. It should be emphasized that a drop of 15.70% is not common, in places where there are heavy rainfall and snow, but it is a Mediterranean climate so it is not problematic. It is also important to emphasize that in the western part of the roof are installed several solar panels, which is not a huge contribution, but it is useful for smaller needs of the house.

Figure 14.6 Picture of the roof

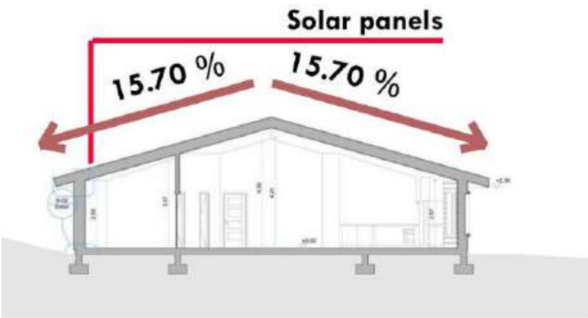


Figure 14.7 Solar panels over the roof tiles

5.SHADING SYSTEM

By overhanging the roof structure over the walls on the south side where, as we analyzed, the highest percentage of openings and where the highest concentration of the sun is, was obtained a shading system which is effective during the summer period (**Figure 14.8**).

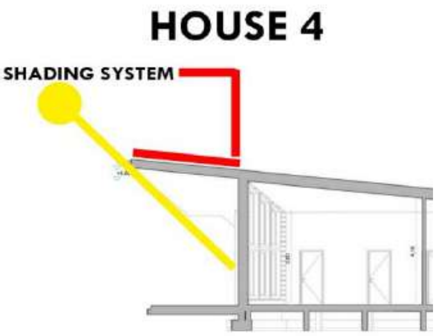


Figure 14.8 Shading system

6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical section (**Figure 14.9)** of all layers presents the quality of the construction.
(A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator. The value of Airtightness is also important in passive houses and refers to the speed of air leakage through a building the value of it is usually 50 Pascals)
Exterior wall: OSB board, Fiberwood - timber frame, OSB board, Fiberwood,
Gypsum plasterboard
U-value = 0.135 W/(m2K)

Basement floor / floor slab: Floor surface, Anti-impact layer, Gypsum plasterboard, OSB board, Fiberwood isonat plus,
Fiberwood sylvactis HD
U-value = 0.164 W/(m2K)
Roof: OSB board, Fiberwood Isonat plus,
OSB board, Wall cavity, Fiberwood isonat plus
Wood shuttering,
U-value = 0.138 W/(m2K)
Air tightness: n50 = 0.6/h

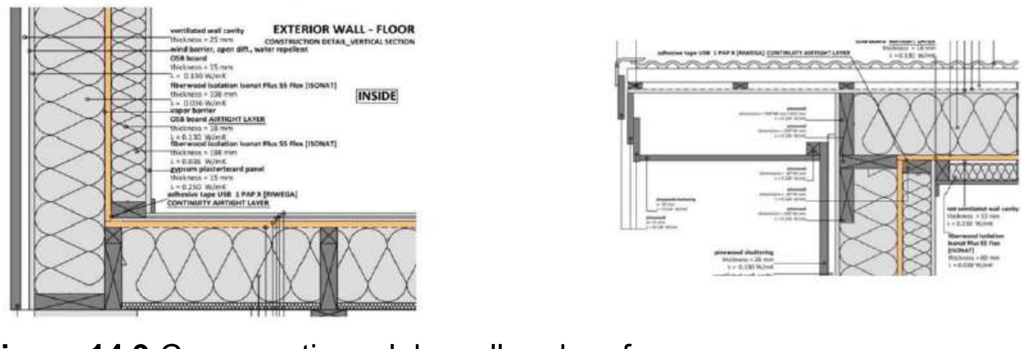


Figure 14.9 Cross section -slab, wall and roof

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7.WINDOW TYPE

This house has windows of the company
Carinbisa V92 **(Figure 14.10)**

Passivhaus element certification for Carinbisa V92 mixed timber and aluminum window frames. Thermal transmission estimation of the frame, Uf, in compliance with EN-ISO 10077 1: 2010 and EN-ISO 10077 2: 2012. Calculated from the Dartwin Frame Simulator Pro software kit of finite elements. wDocumentation and management with the Passivhaus Institut, Darmstadt, Germany, of the qualification process.

Glazing

U g-value = 0.55 W/(m2K)

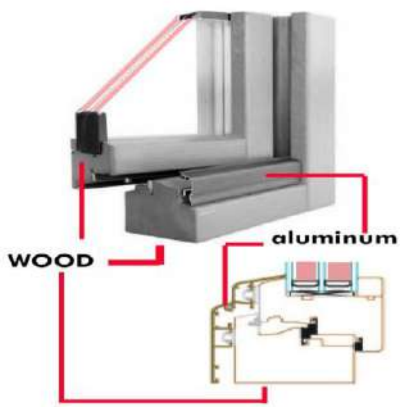

Figure 14.10 Section and picture of the window set

Houses in Bosnia and Herzegovina

The map of Bosnia and Herzegovina shows the location of the three houses in the three different climatic zones continental, alpine and Mediterranean. In the following section, we will identify the shortcomings of these house, and suggest improvements in accordance to passive design strategies would change render these houses sustainable.

(Figure 15) The map of Bosnia and Herzegovina with the three case studies

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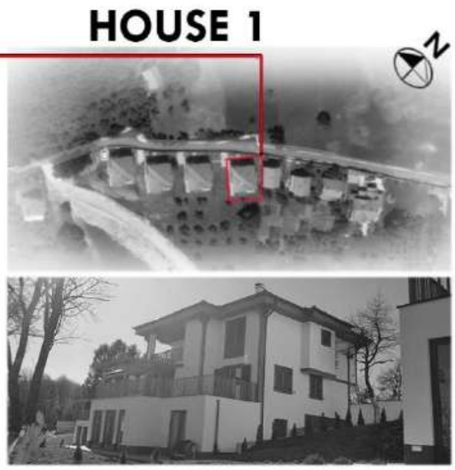

Building type:
family house
BIH/Sarajevo/Ilidža Area:127 m2
type: Masonry c.; Year: 2016

Detached single
Location:
; Construction

Figure 16 location and picture of house

1. ORIENTATION

The orientation of house 1, which is located in a moderately populated place **(Figure 16)** where the continental climate is present, is determined according to the urban plan, but the position of the rooms in it is very well used. As can be seen **(Figures 16.1)** On the entire Southside as well as half of the east and west on the floor -1 and ground floor is located a public space such as a living room dining room, with huge balconies for outdoor seating. On the ground floor on the east side of the house is the kitchen and pantry. In the west, there is one bedroom with a bathroom, while in the north there is a central entrance and communication. Upstairs are the layout of 4 bedrooms, each of which shares openings on two sides - one-bedroom divides with south and east another with south and west third with north and east fourth with north and west in the central part there are communications and, on the west, and east there are toilets.

The study determines that the orientation is correct according to the requirements of passive houses.

Figure 16.1 Floor plan of house

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2. TOPOGRAPHY

The area where house 1 is located is slightly hilly, which is shown by the analysis of the technical cross-section **(Figure 16.3)** through the house and the terrain. Considering the terrain, one part of the house is in the earth (north side of -1floor), in this case, the public area on the -1st floor faces south, and the ground floor is zero with the access road to the house on the north side.

Figure 16.2 Graphical presentation of topography and position of the house 3 on the site.

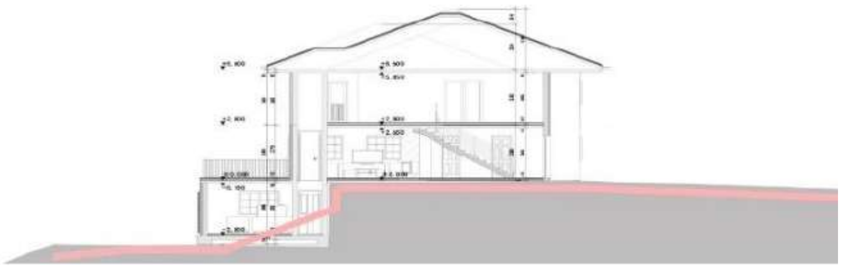

Figure 16.3 Graphical presentation of cross section through the house and the site where the house is located.

3. GLAZING

According to the analysis **(Figure 16.4),** it is clear that the south side has drastically the highest percentage of openings 37.52% because as already analyzed on that side are located public spaces such as the living room and a large part of the bedrooms at the first floor. After the south, the north side has the highest percentage of 16.14%, which is not the practice when it comes to passive houses. Communications and the entrance to the house are positioned on the north side, and bedrooms are positioned on the first floor, and consequently, there is more than enough area of the openings, which is not an advantage, but a disadvantage. The western part of the façade has 12.98% of the area of the opening and the western part has a part of public and sleeping spaces, which is in line with the needs of these rooms.

The eastern part of the façade has 5.88% of the area of the opening, in these parts the kitchen and bedrooms are positioned, and consequently, it isn't enough for this type of spaces. Analysis of winds for this area (**Figure 16.5**) shows that the strongest winds come from the southeast, and thus indicate another shortcoming in the surface of the openings, that on these sides there is a huge percentage which increases the risk of air leakage through the openings
Conclusion-The organization of the opening as well as the surface is not adequate and following the requirements of passive houses. Proposal-Change the position and area of the openings per the needs of the spaces.

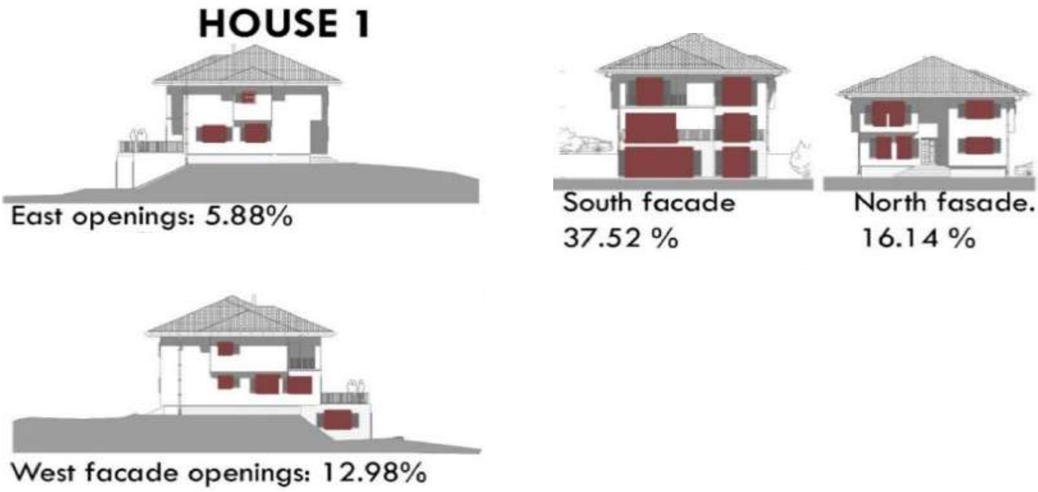

Figure 16.4 Percentage of the openings on facades

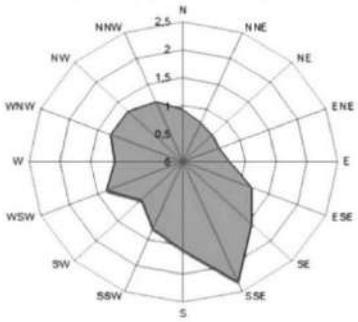

Figure 16.5 Wind rose for BIH-Sarajevo /Ilidza

4.ROOF TYPE

On house 1, which is located in the area of continental climate, the architects envisioned a hip & valley roof. The slope of all roof surfaces is 25 ^{0}. (**Figure 16.6**) The roof surfaces are not used for solar panels and if the roof position is ideal for that.

Impression The roof surfaces are broken into several parts, which is an additional cost for the construction of the roof structure.

Figure 16.6 Cross section of the roof and picture of the roof

5.SHADING SYSTEM

As already mentioned, the highest concentration of sun and solar heat is reflected on the southeast facade, especially during the summer. As seen in the technical cross-sectional analysis **(Figure 16.7)** The roof surface crossed the walls, but not so much as to shield the openings

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(windows) from the strong sun rays. The windows have wooden blinds, which move by hand and are more decorative than having the function of shading system

Proposal

Let the roof surface over the walls, so much that it can cover the openings (windows) during the summer heat, and a larger overhang of the terraces in the south would protect the public space on the floors -1floor and ground floor.

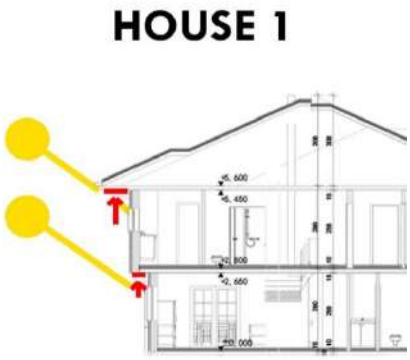

Figure 16.7 The influence of the sun rays on the house

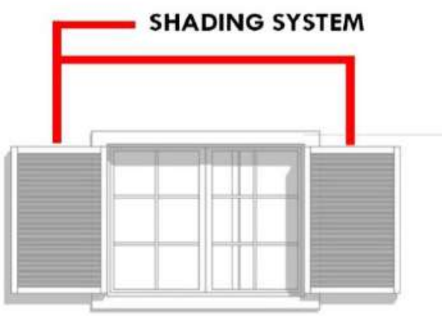

Figure 16.8 Method of the shading system

6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical section (**Figure 16.9)** of all layers presents the quality of the construction. (A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator.

Exterior wall 1. facade glue + paint 1 cm 2. thermal insulation 10 cm 3. brick block (wall) 20 cm, 4. paint + mortar 1 cm

Conclusion

The structural material of house 1 in the territory of BIH is concrete and blocks (GITER BLOCK). The company that manufactures the blocks obtained the results of the analysis, and the thermal conductivity of this type of block is U-value = 0.88 W / (m2K), which is much higher than the requirements of passive houses where the thermal conductivity coefficient does not exceed the value of U-value = 0.15 W / (m2K).

The thermal insulation material is styrofoam.

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Styrofoam or expanded polystyrene is the most popular external insulation material, and insulation 10 cm thick of such material has a thermal transmittance coefficient of 0.385 W / m2K.

Proposal
Comparison of passive houses 1 and houses 1 in BiH with the area where the continental climate is represented has identified that a mistake is being made at the very beginning. Constructive walls are made of energy-inefficient materials.
Changing the material at the beginning of construction is a key solution.

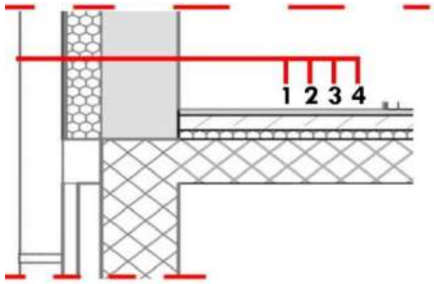


Figure 16.9 Cross section through the wall

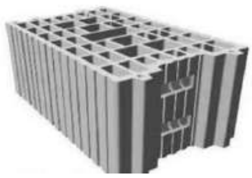


Figure 16.10 Giter block EKOTERM

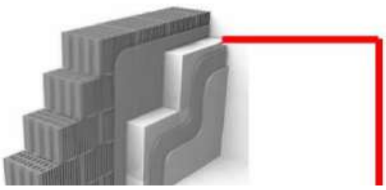


Figure 16.11 The thermal insulation material ESP

Basement floor / floor slab: 1. Parquet/ Laminate 2,0 CM 2. screed cement 4,0 cm 3.PVC foilc4.EPS 4,0 cmc 5. reinforced concrete slab 15 cm 6. Mortat 2cm

Conclusion
Through the detailed cross-section of the floor of house 1 in BIH, it is noticeable that the structural slab is reinforced concrete 15 cm thick, screed cement 4 cm, and ESP 4 cm. Comparing house 1 in BiH with house 1, which is passive, will resulting that the floor system is similar, with a huge difference in the thickness of the material.
In passive house 1**(Figure 16.13),** the thickness of the slab is 20 cm, while screed cement is 6.5 cm and ESP is 20 cm, which is an indicator that in the passive house the thickness of insulation materials is far thicker than house 1 in BIH.

Proposal

What is crucial regarding the lack of floors is the small number of layers of insulation materials. Needs to be an increased number of layers of insulation materials that are energy-efficient, as well as their thickness.

Roof: 1. roof tiles 2. lath 3. lath 4. protective
foil 5. roof sheating 6. rafters 7. thermal insulation layers (wool) 8. aluminum holders
9. gypsum plasterboard

Conclusion

By analyzing through the technical cross-section of the roof structure of house 1 and comparing the roof structure of passive house 1, the study concluded a huge difference in the method of constructing and the type of the roof layers. House 1 in BiH has a traditional roof structure that together with all layers of thermal conductivity U-value of approximately 2.5 W / m2k, which is a huge loss of thermal energy compared to passive house 1 where U-value = 0.076 W / (m2K) far better result.

Proposal

As we have already mentioned for floors, the situation is similar to the roof. A small number of layers of insulating materials. It is necessary to increase the number of layers of insulation materials that are energy-efficient, their thickness, and set according to the regulations of passive houses.

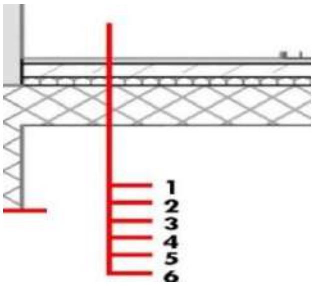


Figure 16.12 Cross section through the slab

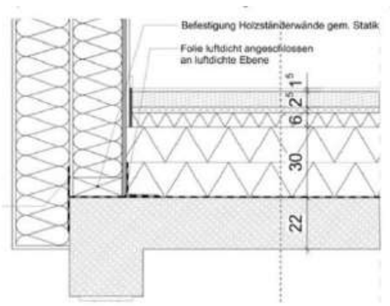


Figure 16.13 Cross section through the slab of the passive house 1 where is Continental climate zone

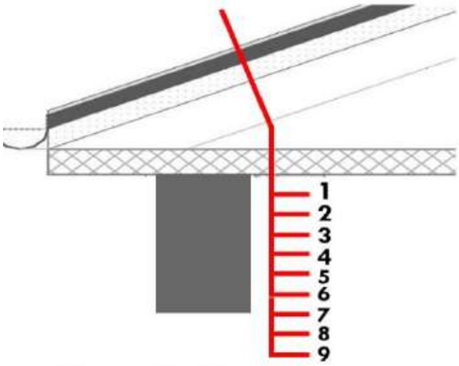


Figure 16.14 Cross section through the roof

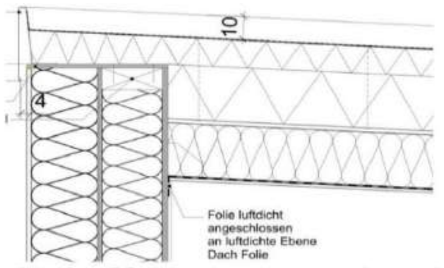


Figure 16.15 Cross section through the roof of the passive house 1 where is Continental climate zone.

7.WINDOW TYPE

This house has windows of the company
Salamander
The Brügmann AD 73mm system window will meet your needs for a sophisticated window with an attractive and solid design. High-density surfaces enable very much maintenance, but also extremely long service life. The design and layout of the cells are designed in a way that significantly reduces household costs. Intelligent profile construction with large steel inserts ensures excellent stability and reliable safety of the plastic window.
Technical data: Number of chambers 5 Thermal insulation

Ug = 1.0 W / m2K (glass)

Conclusion
According to the requirements of passive houses, the window coefficient must not exceed U Value ≤ 0.8 W / m2K, however, the window model installed in house 1 on the territory of BiH **(Figure 16.16)** exceeded the allowed coefficient, and therefore it can be concluded that the windows are not adequate.

Proposal
By analyzing the detailed cross-section **(Figure 16.17)** of the window that was installed in the passive house, the study concludes that it has triple glazing and that the coefficient Ug meets the

needs of passive houses. By replacing the windows on the house with 3 windows that have a better coefficient Ug and triple glazing, it would significantly increase energy efficiency.

Figure 16.16 Section and picture of the window set

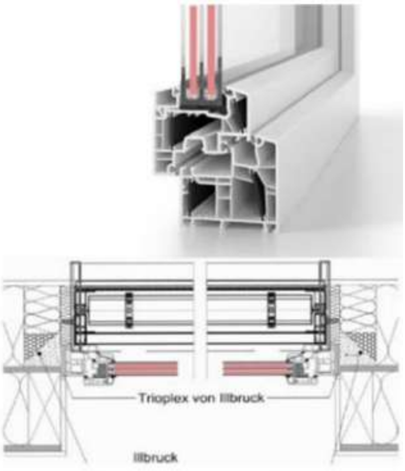
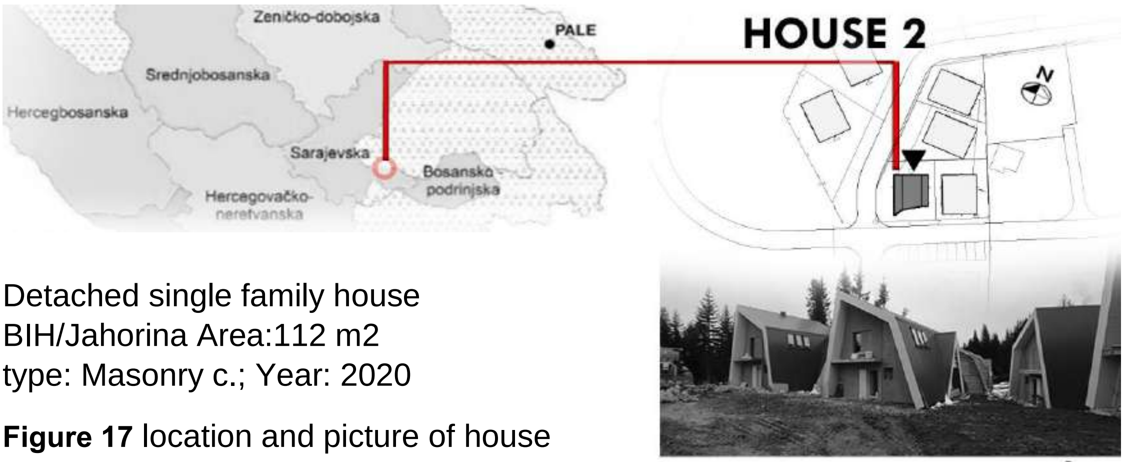


Figure 16.17 Section and picture of windows installed on a passive house

ISSN No:-2456-2165



Building type:
Location:
Construction

Detached single family house
BIH/Jahorina Area:112 m2
type: Masonry c.; Year: 2020

Figure 17 location and picture of house

1. ORIENTATION

The area where house 2 in Bosnia and Herzegovina is located in mountainous where the alpine climate zone is represented **(Figure 17)**. A more detailed analysis of the orientation and organization of space **(Figure 17.1)** by the analysis study concluded: On the ground floor, the entire south side is used for public space (kitchen, dining room, and living room), which is a great advantage, on the north is a bathroom and entrance to the house. On the first floor of the house, there are bedrooms with orientation north, west, and south, while on the east side there are communications and service rooms.

Conclusion

According to this analysis, it can be concluded that house 2 is oriented and the rooms are organized as is the case with passive houses. It must be emphasized that house 2 is not designed to be passive.

Figure 17.1 Floor plan of house

2. TOPOGRAPHY

As already mentioned in the analysis, the area is mountainous and according to the topographic analysis **(Figure 17.2)**, it is evident that the terrain is hilly and uneven. A more detailed analysis of the technical cross-section of house 2 **(Figure 17.3)** concluded that it was necessary to dig deeper foundations and perform a cascade method of foundation construction. The study concludes that this method was used due to the larger unevenness and slope of the terrain starting from the east with the highest peak and altitude of about 1900 m to the west where the slope descends to about 1200 m above sea level.

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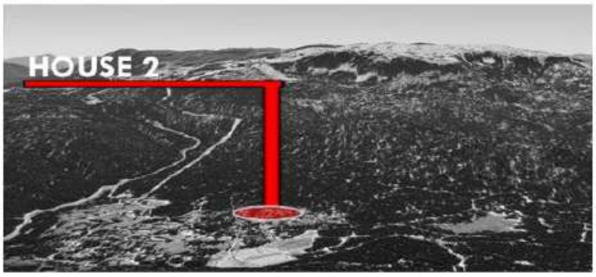

Figure 17.2 Graphical presentation of topography and position of the house 3 on the site.

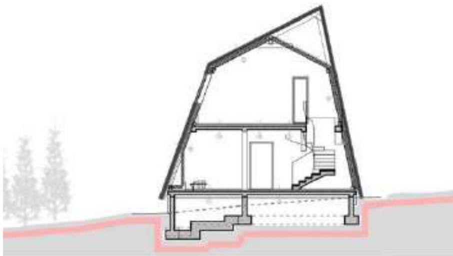

Figure 17.3 "Graphical presentation of cross section through the house and the site where the house is located"

3. GLAZING

According to the analysis **(Figure 17.4),** it is clear that the south side has drastically the highest percentage of openings 28.91% because as already analyzed on that side are located public spaces such as the living room and part of the bedrooms on the first floor. After the south side is followed by the west side of 6.49% and on that side on the ground floor the openings are used for living room, while on the first floor there are bedrooms, and according to the mountain climate situation, the surface of the openings on that side is adequate.

North side 4.73%, the position of communication for house 2, and on the first floor there is one bedroom with an opening on that side. According to the strength of the winds from the north which can be seen in the picture **(Figure 17.5)**, it's concluded that it is

an ideal area of openings. The eastern side has no openings, since the analysis of the topography of the study shows that the highest slope and the highest altitude is on the eastern side, it can therefore be concluded that the architects did not make openings on the eastern side.

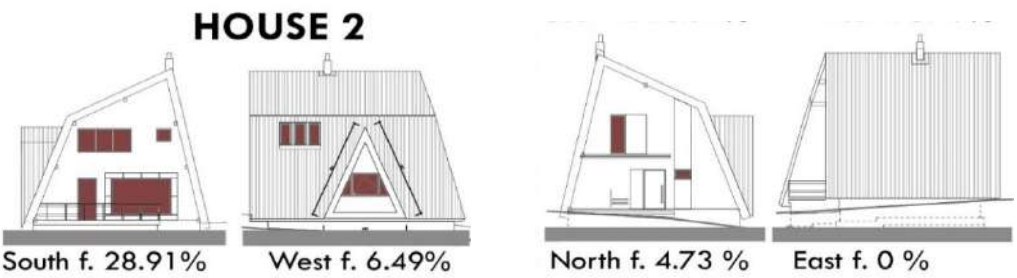

Figure 17.4 Percentage of the openings on facades

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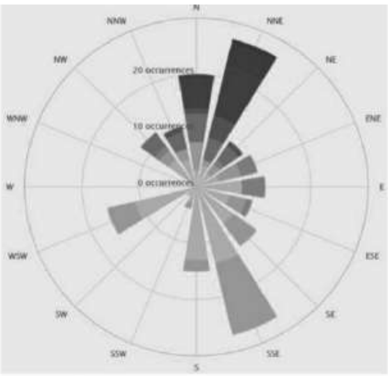


Figure 17.5 Wind rose for BIH-Jahorina

4.ROOF TYPE

By analyzing the roofs from the case study from the areas of Europe where the alpine climate, the study concluded that there are no rules, that there is a possibility of a flat roof or other types of roofs. In BiH, this is not the case, most roofs are made with a sharp angle, in order to reduce additional insulation and avoid the retention of snow on the roof surface. In house 2, the A-Frame roof has been done, and the roof structure is lowered to the floor **(Figure1 7.6)**. The east and west sides of the roof surface are the walls of the house 2.

Conclusion

there are no rules when it comes to the type of roof, but as far as the layers of insulation are concerned, this is a second case analysis.

Figure 17.6 Cross section of the roof and picture of the roof

5.SHADING SYSTEM

By analyzing the technical cross-section through the house as well as the plan of the roof structure **(Figure 17.7),** the study concludes that letting the roof structure over the walls in the analysis so far is an indicator that one of the most cheap and effective method. In the case of house 2 on the south side, the roof is unevenly overhanging and the overhang increases from the eastern part of the roof to the western.

Conclusion

Consistent with all analyzes, study introduced that this method is adequate sun protection during the summer period, and protects public spaces on the south side, which are most used by users.

ISSN No:-2456-2165

Figure 17.7 Method of the shading system

6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical section of all layers presents the quality of the construction.

(A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator.

Exterior wall 1. mortar 1.5 cm .2wall (concrete, brick) 20.0 cm 3. thermal insulation (rock wool) 15.0 cm 4. reinforcing mesh in reinforcement adhesive 5. smoothing glue

6.finishing decorative plaster on substrates

Conclusion

The structural material of house 2 in BIH is concrete and blocks **(Figure 17.10).** The thermal conductivity of this type of block is U-value = 0.88 W / (m2K), which is much higher than the requirements of passive houses where the thermal conductivity coefficient does not exceed the value of

U-value = 0.15 W / (m2K).

Rock wool has far less resistance to water vapor diffusion than Styrofoam, but is also more favorable in case of fire (preserves properties up to a temperature of 900 ° C and prevents the spread of fire, although Styrofoam is a highly flammable material). Thermal insulation for this thickness is

U-value = 0.17 W / m2K.

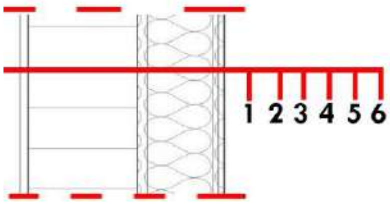


Figure 17.8 Cross section through the wall

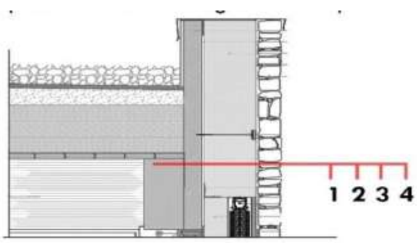


Figure 17.9 Cross section through the wall of passive house

ISSN No:-2456-2165

Proposal

Comparison walls of passive houses 1and houses 2 in BiH with the area where the alpine climate is represented has identified that a mistake is being made at the very beginning. Constructive walls are made of energy-inefficient materials.

Changing the material at the beginning of construction is a key solution.

Basement floor / floor slab: 1.parquet 1.5 cm
2. cement screed 4.5 cm 3.pvc foil 4. (XPS) 6.0 cm 5. waterproofing in three layers 1.0 cm 6. floor concrete slab 10.0 cm

Conclusion

Through the detailed cross-section of the floor of house 2 in BIH **(Figure 17.11)**, it is noticeable that the structural slab is reinforced concrete 10 cm thick, screed cement 4.5 cm, and XPS 6 cm. Comparing house 2 in BiH with a passive house, will resulting that the floor system is similar, with a huge difference in the thickness of the material.

In passive house **(Figure 17.12),** the thickness of the slab is 40 cm, while screed cement is 15 cm and ESP is 24 cm, which is an indicator that in the passive house the thickness of insulation materials is far thicker than house 2 in BIH.

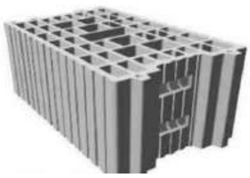


Figure 17.10 Giter block EKOTERM

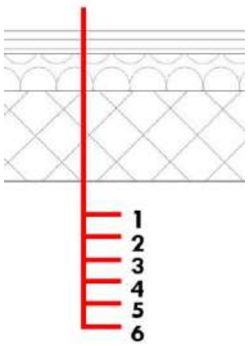


Figure 17.11 Cross section through the slab

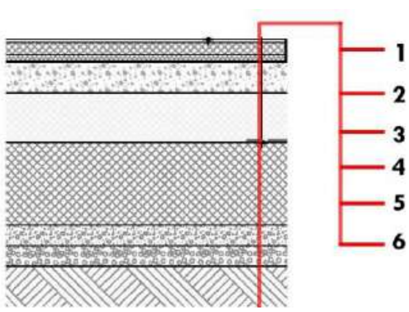


Figure 17.12 Cross section through the slab of the passive house from area where is alpine climate zone

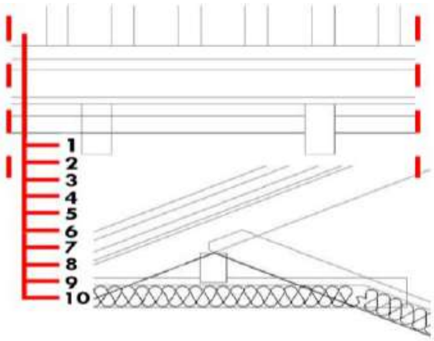


Figure 17.13 Cross section through the roof

Proposal
What is crucial regarding the lack of floors is the small number of layers of insulation materials. Needs to be an increased number of layers of insulation materials that are energy-efficient, as well as their thickness.

Roof: 1. trapezoidal sheet metal 2. slat 5x3 cm 3.0 cm 3. counter bar 5x5 cm 5.0 cm
4.anti-condensation foil "Tajvek"
5.board cover 2.4 cm 6. refters 20.0 cm
7.tervol 12.0 cm 8. hard tervol 3.0 cm
9.PVC foil 10. gypsum ceiling "Knauf" board thickness 12.5 mm

Conclusion
By analyzing through the technical cross-section of the roof structure of house 2 (**Figure 17.13**) and comparing the roof structure of passive house (**Figure 17.14**), the study concluded a huge difference in the method of constructing and the type of the roof layers. House 2 in BiH has a traditional roof structure that together with all layers of thermal conductivity U-value of approximately from 1.5 to 2.5 W / m2k, which is a huge loss of thermal energy compared to passive house where U-value = 0.1 W/(m2K) far better result.

Proposal
As we have already mentioned for floors, the situation is similar to the roof. A small number of layers of insulating materials. It is necessary to increase the number of layers of insulation materials that are energy-efficient, their thickness, and set according to the regulations of passive houses

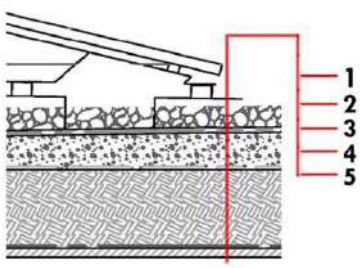


Figure 17.14 Cross section through the roof of the passive house from area where is alpine climate zone.

7.WINDOW TYPE

This house has windows of the company
Alumil SMARTIA S67 PHOS
Multi-leaf portal made of aluminum profiles type Alumil SMARTIA S67 PHOS (**Figure 17.15**) with fixed parts. Glazing with triple glazing and aluminum spacer 4 LOWs + 14 argon + 4 + 14 argon + 4 LOWs. Ug = 1.0 W / m2K
Made of Alumil SMARTIA S67 PHOS type aluminum profiles, with three levels of seals with EPDM rubber.
The final treatment of the profile is electrostatic plastic coating in RAL 7016 color

Conclusion

According to the requirements of passive houses, the window coefficient must not exceed U Value ≤ 0.8 W / m2K, however, the window model installed in house 2 on the territory of BiH exceeded the allowed coefficient, and therefore it can be concluded that the windows are not adequate.

Proposal

As you can see **(Figure 17.16)** the windows installed on the passive house are triple glass and their coefficient met the needs of the passive houses. Consequently, the study concludes that by replacing windows with passively certified windows, energy efficiency results would be far better

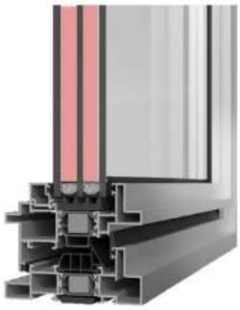


Figure 17.15 Section and picture of the window set

Figure 17.16 Section and picture of windows installed on a passive house

ISSN No:-2456-2165

Building type: Detached single family house
BIH/Čapljina Area: 81,6 m2
type: Masonry c.; Year: 2020

Location:
; Construction

Figure 18 location and picture of house

1. ORIENTATION

The location of house 3 is moderately populated **(Figure 18).** In this area, there is a Mediterranean climate, and the place is about 30 km away from the sea.

By analyzing the orientation of the house **(Figure 18.1)** as well as the organization of the rooms in it, the study found the following:

On the ground floor, more than half of the house on the south side is a public space (living room, kitchen, and dining room) as well as part of the communication space. In the north, there are private rooms (bathroom and one-bedroom). On the first floor of house 3 are all private rooms facing north, west, and south while on the east side is Horizontal and vertical communication through the house.

Conclusion

According to the analysis, the conclusion is that house 3 has a fairly good orientation and organization of spaces if compare with passive houses.

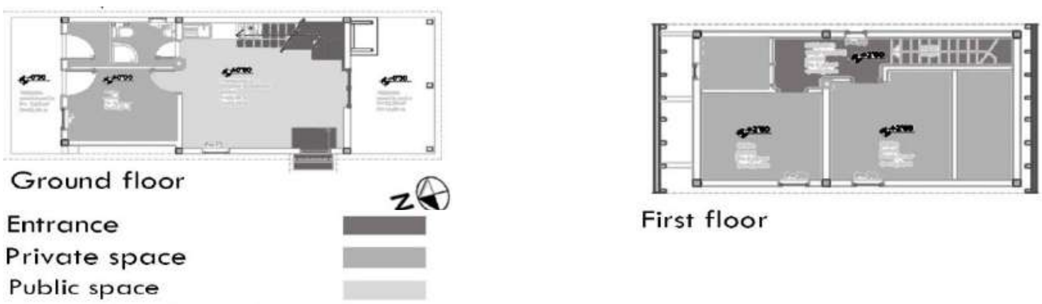


Figure 18.1 Floor plan of house

2. TOPOGRAPHY

The terrain where house 3 is is very specific which is concluded by a bird's eye view and a technical cross-section (**Figures 18.2 and 18.3).** The terrain looks like one huge canal leading from Mostar through the place where house 3 is to the sea. The height difference between the canal and the area above the canal is higher than 150 m.

The river Neretva runs through this canal and as we have already mentioned, there are small villages and settlements along the entire canal. However, there are also inhabited places on the surface above the canal, ie on the edge of the riverbed.

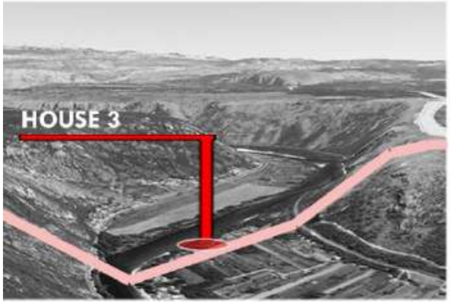


Figure 18.2 Graphical presentation of topography and position of the house 3 on the site.

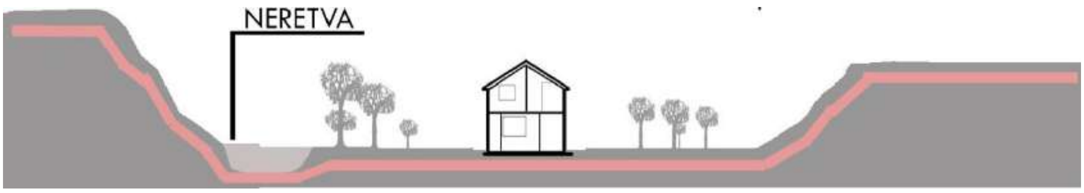


Figure 18.3 Graphical presentation of cross section through the house and the site where the house is located.

3. GLAZING

With the technical analysis of the facade **(Figure 18.4),** the study concludes the surface of the openings as well as their position concerning the space used. The northern façade has the highest percentage of openings, 19.88%, as already mentioned, there are private rooms on that side. The south façade has 11.72%, and on that side, there is public space on the ground floor while there are private rooms on the first floor. East side 0.82% and there is a service room (bathroom). On the west side, we have no openings.

Figure 18.4 Percentage of the openings on facades

ISSN No:-2456-2165

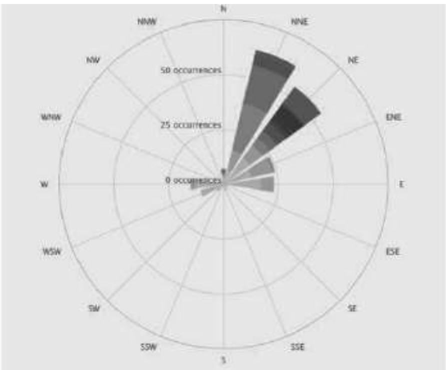
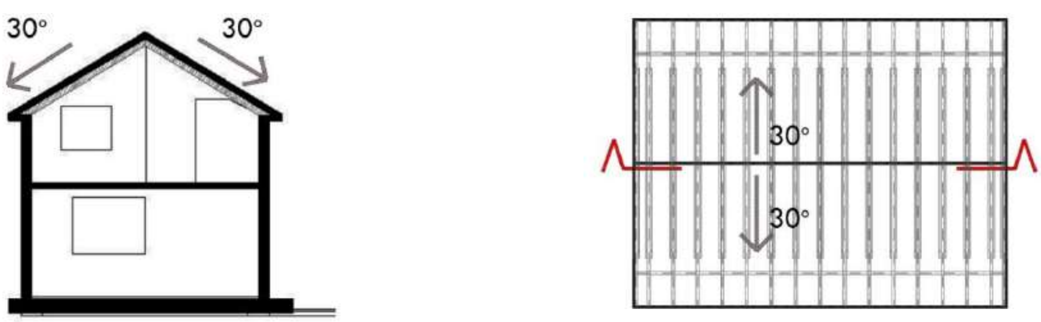


Figure 18.5 Wind rose for BIH-Čapljina

Conclusion.
By comparing previous passive houses, as well as typical houses, usually, it is not a practice for the north side to have the highest percentage of openings. The factor that has a bad impact on the house is the wind, according to the analysis of winds (**Figure 18.5**) and the area of the openings on the north side, the study concludes that this is a disadvantage of house 3. Surfaces on the east and west sides are not used useful, also it is a disadvantage. According to a more detailed analysis, the south side does not have a sufficient surface area for a sufficient amount of natural light to enter the public space.

Proposal
Change the position and area of the openings per the needs of the spaces

4.ROOF TYPE
As already mentioned, that the house is located in the Mediterranean climate, accordingly, the architects envisioned a gabled roof.
The angle of the roof surfaces is 30°



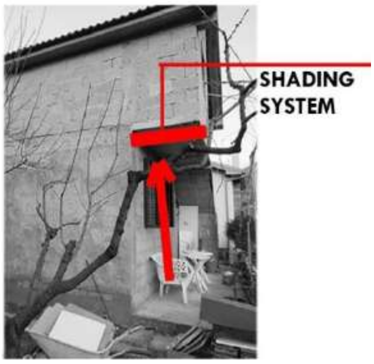
(Figure 18.6)

Figure 18.6 Cross section of the roof and roof plan

Conclusion and proposal
Due to the Mediterranean climate and the fact that there are many sunny days a year, the roof type could be flat, and the roof surface could be used for solar panels, which is not necessary, but it would provide greater energy efficiency.

5.SHADING SYSTEM

By a more detailed analysis through the technical cross-section **(Figure 18.7)** and the current state of house 3, the study shows the ways in which the house is protected from the sun's rays.



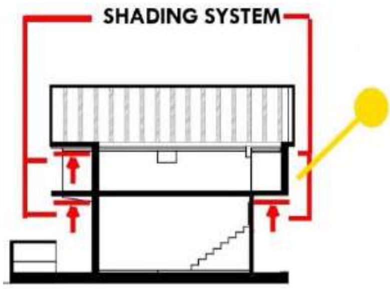


Figure 18.7 Method of the shading system

6.WALL, SLAB AND ROOF CROSS SECTIONS

The detailed technical wall section **(Figure 18.8)** of all layers presents the quality of the construction.
(A very important value for this research is U-value it is the process of measuring how effective a material is as an insulator. It refers to the permeability of warm air and the lower the U-value the material is the better insulator.
Exterior wall 1. Mortar 2. Concrete block 20 cm 3.EPS Styrofoam facade system 8cm

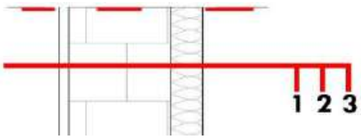


Figure 18.8 Cross section through the wall

Conclusion

The structural material of house 2 in the territory of BIH is concrete blocks **(Figure 18.9).** The company that manufactures the blocks obtained the results of the analysis, and the thermal conductivity of this type of block is U-value = 0.35 W / (m2K), which is much higher than the requirements of passive houses where the thermal conductivity coefficient does not exceed the value of U-value = 0.15 W / (m2K).
The thermal insulation material is Styrofoam.
Styrofoam or expanded polystyrene is the most popular external insulation material, and insulation 10 cm thick of such material has a thermal transmittance coefficient of 0.385 W / m2K.

Figure 18.9 Concrete Block

Proposal

Comparison walls of passive house **(Figure 18.10)** and houses 3 in BiH with the area where the Mediterranean climate is represented has identified that a mistake is being made at the very beginning. Constructive walls are made of energy-inefficient materials.
Changing the material at the beginning of construction is a key solution.

Basement floor / floor slab:

1. Floor panels 2cm 2. cement screed 4cm 3. PVC foil 4. EPS acoustics 3 cm 5. concrete slab 12 cm 6. Lime mortar 2 cm

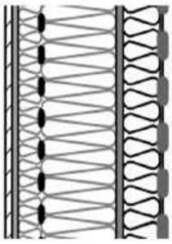


Figure 18.10 Cross section through the wall of passive house

Conclusion

Through the detailed cross-section of the floor of house 3 in BIH, it is noticeable that the structural slab is reinforced concrete 12 cm thick, screed cement 4 cm, and ESP 3 cm. Comparing house 1 in BiH with passive house, will resulting that the floor system is similar, with a huge difference in the thickness of the material.

In passive house (**Figure 18.12**), the thickness of the slab is 40 cm, while screed cement is 8 cm and XPS is 10 cm, which is an indicator that in the passive house the thickness of insulation materials is far thicker than house 3 in BIH.

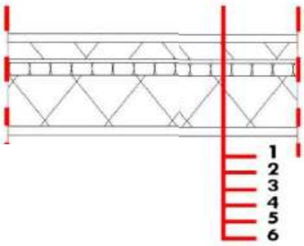


Figure 18.11 Cross section through the slab

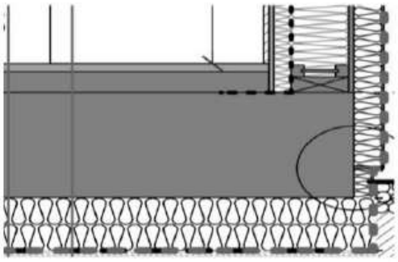


Figure 18.12 Cross section through the slab of the passive house from area where is alpine climate zone

Proposal

What is crucial regarding the lack of floors is the small number of layers of insulation materials. Needs to be an increased number of layers of insulation materials that are energy-efficient, as well as their thickness.

Roof: 1. roof tiles 2. lath 3. lath 4. protective foil 5. roof sheating 6. rafters 7. thermal insulation layers (wool) 8. aluminum holders 9. gypsum plasterboard.

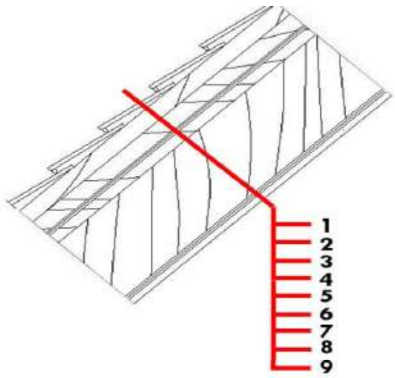


Figure 18.13 Cross section through the roof

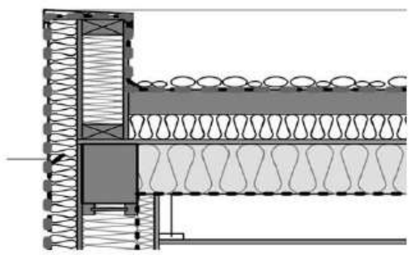


Figure 18.14 Cross section through the roof of the passive house from area where is alpine climate zone

Conclusion

By analyzing through the technical cross-section of the roof structure of house 3 (**Figure 18.13**) and comparing the roof structure of passive house (**Figure 18.14**), the study concluded a huge difference in the method of constructing and the type of the roof layers. House 3 in BiH has a traditional roof structure that together with all layers of thermal conductivity U-value of approximately 2.5 W / m2k, which is a huge loss of thermal energy compared to passive house where U-value = 0.122 W/(m2K) far better result.

Proposal

As we have already mentioned for floors, the situation is similar to the roof. A small number of layers of insulating materials. It is necessary to increase the number of layers of insulation materials that are energy-efficient, their thickness, and set according to the regulations of passive houses.

7.WINDOW TYPE

This house has windows of the company

aluplast IDEAL 5000®
with a thermal insulation value

Ug = 1.1 W/m²K

(steel reinforcement with thermal break)
-double design variety in the sash
-design glazing bead for the inside
-concealed drainage is possible
-embedded hardware channel for the highest level

of burglary protection
-5-chamber profile
center gasket system available in countless decor finishes
Excellent insulation values ensure first-class living comfort with IDEAL 5000®. Top-quality profile systems made by aluplast promise burglary protection at the highest level and provide comforting security

Conclusion

According to the requirements of passive houses, the window coefficient must not exceed U Value ≤ 0.8 W / m2K, however, the window model installed in house 3 on the territory of BiH **(Figure 18.15)** exceeded the allowed coefficient, and therefore it can be concluded that the windows are not adequate.

Proposal

By analyzing the detailed cross-section **(Figure 18.16)** of the window that was installed in the passive house, the study concludes that it has triple glazing and that the coefficient Ug meets the needs of passive houses. By replacing the windows on the house with 3 windows that have a better coefficient Ug and triple glazing, it would significantly increase energy efficiency.

Figure 18.15 Section and picture of the window set

Figure 18.16 Section and picture of windows installed on a passive house

IMPROVEMENT STRATEGY FOR BH CONTEXT

By comparing standardized passive houses in the EU with the houses in BiH within the same three climate zones, the study has been able to identify the major building and material usage flaws in the BiH context. Following the comparison, the study has offered possible changes to the BH scenario in order to make it more energy efficient.

According to the obtained results, it has become clear that the houses in the territory of BiH, have a fairly good position, orientation, as well as the organization of the premises to the sides of the world.

Topographically, their positions are on terrains with different altitudes according to the climate zone, and where they often inhabited houses.

The area of openings on houses is not as ideal, their position in relation to the sides of the world, also not satisfied requirements of passive houses. Roof constructions are at a certain angle, and flat roofs are often avoided, and one of the disadvantages is that they are not used enough for the shading system, as is the case with passive houses.

Detailed technical cross-sections through the slab, wall and roof, study concluded that the difference compared to passive houses is that the thickness of the material is much greater in passive houses, the way the layers are arranged, and the materials from which the skeletal system is made. One of the major shortcomings that this study concluded was the installed windows.

Comparison of windows that are passively certified and windows that are installed on houses from the areas of Bosnia and Herzegovina shows a drastic difference in the coefficient of thermal conductivity, the number of chambers, and the choice of glass. Consistent with all the results, the study concludes that some of the houses, initially choosing materials and methods of construction, have lost the value of energy efficiency as well as the ability to become passive.

CONCLUSION

Given the current environmental crisis and the role of construction in its perpetuation, it is of extreme importance that the design strategy and construction industry adapt in order to reduce its impact. This research focuses on the design and construction strategies of a single house as the simplest topology in which changes are perhaps the most easily implemented. In the EU and North America there are a number of methods of certification and evaluation of sustainability within the construction, but the passive system is the most dominant and economical. By analyzing three climatic zones within the EU, which are also found in BH, the study analyzes passive design strategies in each zone and compares it to the practices in BH.

The study concludes that the construction industry in BiH is not operating through an environmentally conscious manner yet alone within the passive house system. However, with improvement of insulation strategies, better choice of windows installation, an adequate training of constitution methods as well as an introduction of a certification system within the legislative frame, there would be a real possibility to implement the passive strategy in BH. For example, within the examples form the EU countries, the study shows that a large percentage of houses are built on the basis of prefabricated or mixed construction systems. Thus, professional training in the manufacturing and implementation of this system is required in BH, primarily for architects but also for construction firms. The building method can adapt in compliance with the knowledge of these two groups.

Another example is within the choice of materials in BH. Building materials with very poor thermal conductivity, such as GITER BLOCK, are often used, the climate zone is not taken into account, so the thickness of the insulation is incorrectly processed without adequate calculation and thermal brigining. The structural roof system and the insulation system are often repeated regardless of the climate zone, and a lot of heat is lost through the roof structure because it is not done properly. The selection of carpentry (windows and doors) is another essential point, where in most houses in BiH they are of low quality and thus a lot of heat is lost or, conversely, a large amount of heat produces moisture in houses.

Although the upfront costs of these changes might be higher during the construction process, the savings in energy usage would offset the difference and, in the end, the environmental impact would also be greatly minimized. Once these changes are implemented in the single-family housing, the framework could also be used to develop a sustainable strategy for larger typologies in BH.

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