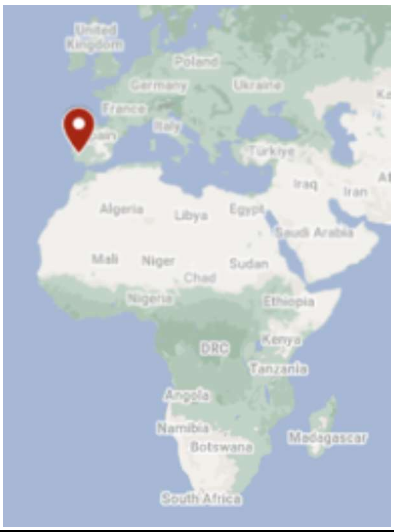
CASE STUDY 2-02: RUINHA HOUSE | PORTUGAL

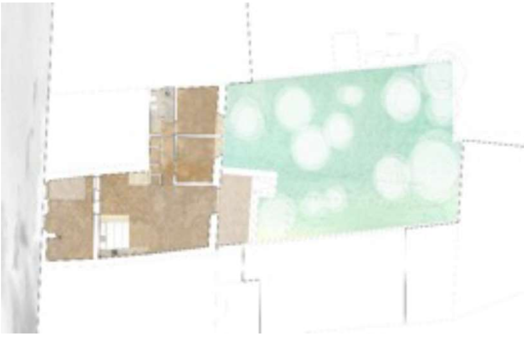


GEOGRAPHICAL AND CLIMATE INFORMATION	
Location	Ruinha nº34, Montemor-o-Novo, Portugal
Latitude; Longitude	38.64812,-8.21353
Climate zone (Köppen–Geiger classification)	Cwa: Warm temperate climate with dry winter and hot summer
BUILDING INFORMATION	
Building Type	Residential
Project Type	Extension and Refurbishment
Completion Date	2021
Number of buildings	1
Number of storeys	1 with mezzanine
Total Floor Area (m²)	156.5
Net Floor Area (m²)	126.2
Thermally conditioned space area (m²)	90 (heated space)
Spaces with Natural Ventilation (with or without Ceiling Fans) Only (m²)	90
Total cost (€)	120 000
Cost /m² (€/m²)	800
Performance Standards or Certification	None
Awards	None
STAKEHOLDERS	
Building Owner/ Representative	Tânia Teixeira + André Pereira/ 938137907
Architect / Designer	Tânia Teixeira/ CRU atelier, 938137907
Construction manager	Tânia Teixeira/ CRU atelier, 938137907
Structural Engineer, Civil Engineer	Domingos Dias Pereira/ Edilestreito, 914992550
Energy Consultant and Electrical Engineer	André Pereira, 914318313

ABC21 is funded by the EU's H2020 programme

PROJECT DESCRIPTION

Ruinha House Project is a self-built refurbishment located in Montemor-o- Novo city centre. Rammed earth walls with around 200 years meets contemporary ones. The same material, earth, separated by two centuries of history. The house with around 100 m2 is located in a very old and narrow street, Ruinha. Ruinha means literally small street. It is one of the oldest streets of the outer city wall. In a street characterized by ground floor houses with big chimneys that are so characteristic of Alentejo, the facade is kept with its prominent chimney. Responding to this paradigm, an entrance patio was predicted to function as a buffer zone articulating exterior and interior, public and private zones. The rusted metal doors and window allow light and wind to cross. The patio catches the south light and brings it in all day long, in a house that is oriented east-west. The Alentejo Blue colour chosen for the south facing patio wall refreshes the light that enters the house. It mixes also with the blue sky. In the patio there is a outdoor kitchen and storage space. The patio leads to the main room. It is the social area of the house, with a large open kitchen and the living room with a fire place in its core. In the future there will be a mezzanine that will host the library and office, that will be kept open to the living room. From the 4 high windows on the top, we can see the Castle. These high windows help cross ventilate the room and release the hot air. The house is turned into the back garden that faces East where there is more privacy and nature can enter through the large windows framed by the new rammed earth walls. The elements connect with nature, earth and wood. A small corridor illuminated by a translucent glaze connects the social area to the small bedrooms. The bedroom windows are at the high of the garden floor, where a typical "namoradeira", a bench, is created. The toilet is a monolith of tadelakt, from walls to the floor. The light enters above the shower in a zenithal light and through an indirect zenithal light above the sink. The texture and colour of the lime plaster give a dynamic to the walls.



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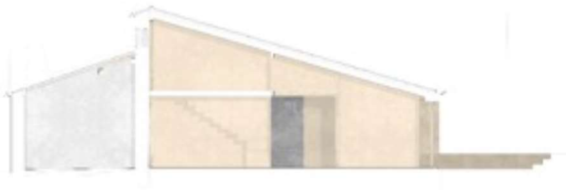

.(b)

(c)

(d)

Figure 14 : (a) Ground floor plan, (b) section (c) East facade and (d) West façade of the Ruinha House

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SITE INTEGRATION

Figure 15 : (a) Aerial view of the project in its surrounding environment (Source: Google Map)

Ruinha 34 House is located in the historical center of Montemor-o-Novo small town, located in the rural area of Alentejo, southern Portugal. The house with around 100 m^2 is located in a very old and narrow street, Ruinha. Ruinha means literally small street. It is one of the oldest streets of the outer city wall. The plots of this town area are characterised by small one floor houses with big chimneys that are so characteristic of Alentejo and with a vegetable garden on the back. The houses are made a mix of traditional rammed earth and stone/brick masonry.

CLIMATE ANALYSIS

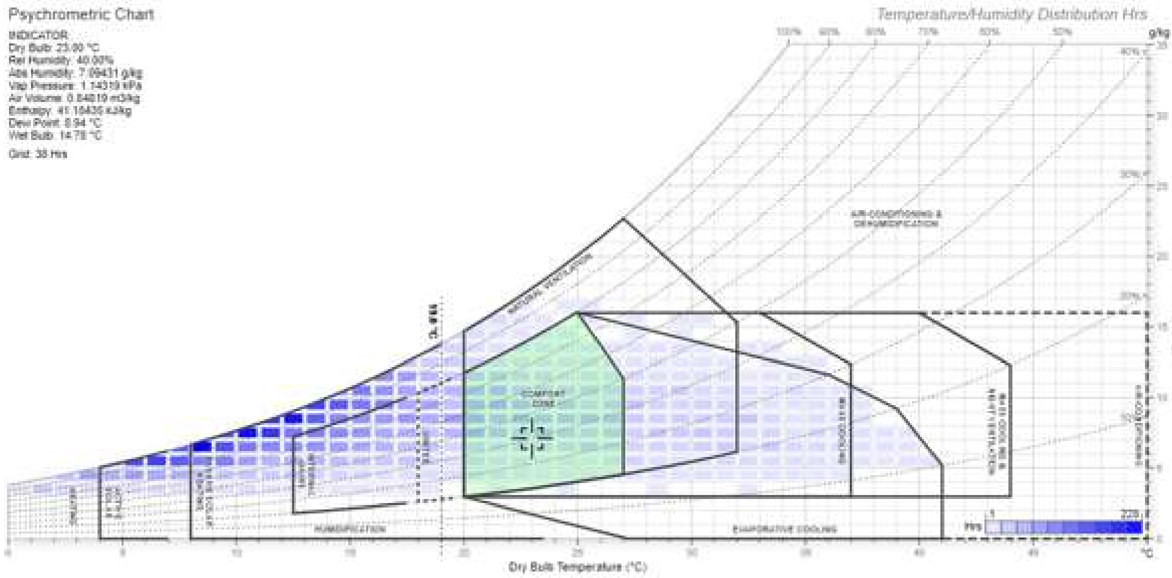


Figure 16: Givoni Bioclimatic chart for the climate of Monter-o-Novo, in Portugal using Andrew Marsh online tool [2]. Weather data are extracted from the PVGIS tool of the jrc for the 2005 – 2020 period.

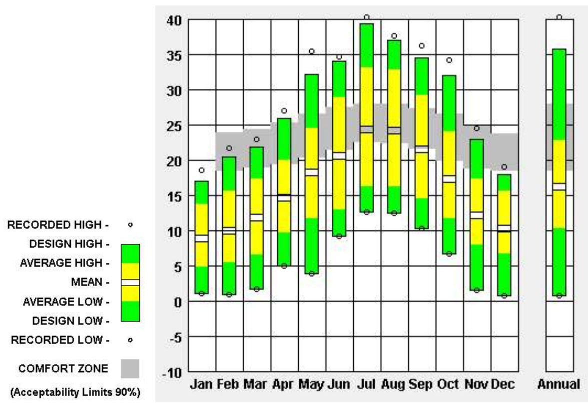


Figure 17: Temperature range by month for Monter-o-Novo, Portugal (Source: Climate consultant – Adaptative Comfort model).

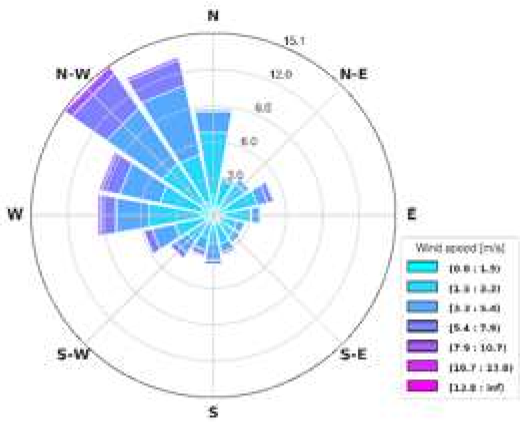


Figure 18: Wind rose for Monter-o-Novo, Portugal

Global horizontal radiation (Avg daily total) Min (month) / Max (month)	Min: **2 226** Wh/m² (Dec.) Max: **7 824** Wh/m² (Jul.) Mean:**4 899** Wh/m²
Annual Degree-Days for weather classification according to ASHRAE Standard 169-2020	HDD 18°C: **1492** CDD 10°C: **2493**
Annual Degree-Days for the Adaptive Comfort Base Temperature according to the ASHRAE 55-2017	HDD: **1694** CDD: **117**
Annual Degree-Days for a static comfort temperature approach	HDD 18.6ºC: **1638** CDD 26º: **208**

Figure 19 : General view of the East facade with the garden

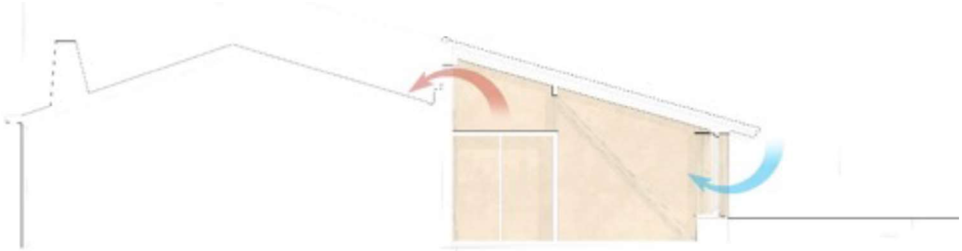
Figure 20 : Detailed view of outside window shadow

KEY BIOCLIMATIC DESIGN PRINCIPLES	
Passive cooling strategy	**Comfort ventilation (**cross natural ventilation) **Nocturnal convective cooling** **Thermal inertia** of the rammed earth walls Natural cross ventilation in each room. Night ventilation combined with thermal inertia due to colder nights (normally 15º-20ºC less than the day temperature). Exposed rammed earth walls and clay and lime plasters to allow indirect evaporative cooling. In extreme hot days (above 38°C), water is sprayed in the rammed earth walls and earth lime plasters to help swamp cool the building. During the day shadings outside the windows are placed, especially on the eastern façade which has the biggest windows turned to the garden. Both the garden and the entrance patio contribute to refresh the air.
Passive heating strategy	**Passive solar heating** **Thermal inertia** of the rammed earth walls
Solar protection	Outside shadings
Building orientation	The exposed façades of the building are East-West oriented.
Insulation	Only the roof is unsulated with 16cm of recycled cotton wool
Vegetation	Front patio towards West with a small pot garden, East vegetable garden with fruit trees mainly deciduous, All the rooms have also air purifying plants.

Natural daylighting	All the rooms take benefit from natural lighting thanks to the large windows and the patio.
Use of local and embedded materials	Rammed earth (new and old) on outer walls, wattle-and-daub/light earth partition walls, lime plasters, stone from demolition of the old wall, handmade terracota tiles.
Water saving and flood management	▪ Water saving taps, ▪ A future rain water deposit for garden watering will be implemented, ▪ No heat recovery on hot water drain.
Waste management	▪ Reuse of the demolition materials like stones and tiles, ▪ Recycling station on the kitchen, ▪ Double compost pile in the garden.
Others features	Semi-open entrance patio for general storage, bike and surfboard storage, laundry drying space

Figure 21 : Interior view of the kitchen

Figure 22 : Interior view of the living room.



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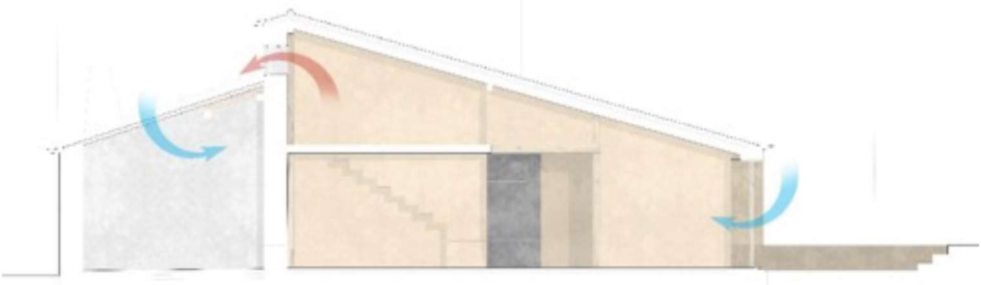

(b)

Figure 23 : Schemes of the cross-ventilation principle: (a)in the bedroom and (b) in the entrance patio on the left and in the living room from the garden on the right.

INFRASTRUCTURES and REGULATIONS to enable SUFFICIENCY ACTION	
Dressing code	Informal dressing, adapted to the season, is welcome and promoted (e.g. short trousers and short leaves in hot periods): **Yes**
Protected bike parking and showers	**Yes** Ratio with number of users: **-**
Ceiling fans	In every room, even those conditioned: **No** *Pre-installed in the living room*
Lighting system fractioned to allow using light only in zones occupied and where daylighting insufficient	In every room, even those conditioned: **Yes**
Space and facilities for line drying clothes (especially important in residences, hotels, sport facilities…)	In every room, even those conditioned: **Yes** *(in the entrance patio)*
Book of instruction for correct use of the passive features (windows, solar protections, water savings) and active (lighting…) in order to promote sufficiency and efficiency actions	Available through leaflets and posters at relevant places, online, etc.: **No** *It is not necessary since the building is a private house and the users are aware how to use the building correctly.*

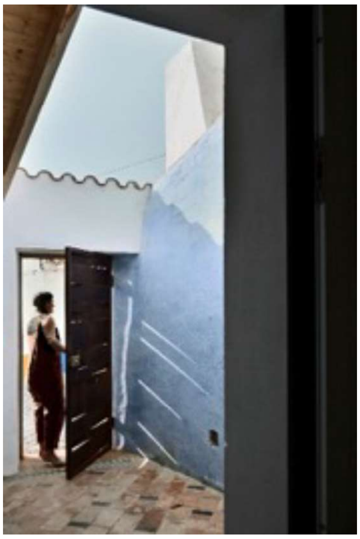

Figure 24: Interior view of the entrance

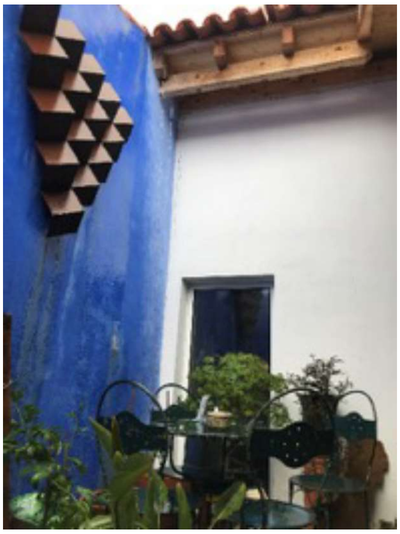

Figure 25 : View of the interior patio

Figure 26 : View of the central fireplace

BUILDING FABRIC AND MATERIALS	
Roof	Wood boards, smart vapour barrier (Intello Proclima), 16 cm of recycled cotton wool between structural wood beams, OSB board, breathable waterproof membrane, traditional ceramic tile roof with clamps to improve breathing.
	Overall R-value: 4,366 [m^2K/W]
Walls	Exterior walls in rammed earth with around 55cm thickness. Interior walls in wattle-and-daub/light earth with earth lime plaster and clay paint with 14cm.
	Overall R-value 0,761 [m^2K/W]

Windows	Wood frame with 80 mm thickness double glazed on east façade and aluminium with thermal cut double glazed with 70 mm thickness	
	Window-to-wall ratio (WWR): EAST Facade 7.5m²/30m²=0.25; SOUTH Facade: 0; WEST Facade: 6.1m²/38.4m²=0.16	
	U-value | Wood windows specification (λ = 0,14 W/(m.°C) = 2,42 [W/(m².°C)] | Aluminium windows specification Uw=1,8	
	Visual transmittance= 89%	
Basement floor	No Basement floor but an aerated floor base with a box of gravel of 30cm	

Figure 27: View of the rammed earth wall from the interior.

Figure 28:. View of the exposed rammed earth wall from the exterior.

Figure 29 : Exterior view of the main façade in rammed earth and the hanging roof protection made of traditional ceramic tiles.

ENERGY EFFICIENT BUILDING SYSTEMS	
Low-energy cooling systems	**None**
Low-energy heating systems	Wood burner to heat water with 80% energy efficiency, that heats up anticorrosion liquid to an insulated 800L inertia deposit with a C efficiency rate. This deposit feeds the heated pavement and the hot water domestic grid. The heating system is intelligent and controlled in every room with a "nest" thermostat, allowing different temperatures per space, and an interactive use with adaptive learning (the thermostats learns your life patterns and gets information from weather predictions to be more and more efficient).
Ceiling fans	Ceiling fan pre installed in the living room.

Mechanical ventilation / air renewal	Only in the toilets
Domestic Hot Water	Wood burner and inertia deposit in winter time. Electrical resistance fed by photovoltaic panels in mid season and summer.
Artificial lighting	All rooms have natural light. All artificial light in LED. Living room: 0,5W/m^2 Toilet: 2,8W/m^2 Bedrooms: 0,7 W/m^2
Control and energy management	Off-grid house with photovoltaic production energy production controlled by an application. All the big appliances are programmed to work at the solar peak manually or thanks to the application. Kitchen stove work with Propane bottled gas (1 bottle of 12kg every 2-3 months)

Figure 30 : View of the wood burner.

Figure 31 : View of the "Nest" thermostat

Figure 32 : View of the pipes and system that feeds the heated pavement and the hot water domestic grid.

RENEWABLE ENERGY	
PV	9 mono crystalline panels on the eastern roof of 255W. Total Peak Power=2295W with accumulation of 2 lithium batteries; 17 kWp/m^2; 9 m^2 surface of PV Architectural integration: aligned with the eastern roof towards the garden, not visible from the street. Azimuth= 17º (degrees from south tilt angle)
Solar thermal	None
Wind	None
Geothermal	None
Biomass	Biomass wood stove with 80% efficiency for central heating and domestic water heating

Figure 33: 9m² of mono crystalline panels are installed on the eastern roof.

Figure 34 : View of the Growatt Hybrid inverter to PV systems, specially designed for storing current in batteries.

BUILDING ANALYSIS AND KEY PERFORMANCE INDICATORS

Thermal comfort indicators

1. Percentage of time outside an operative temperature range (Adaptive)
2. Percentage of time outside an operative temperature range (Fanger)
3. Degree-hours (Adaptive)
4. Degree-hours (Fanger)
5. Percentage of time inside the Givoni comfort zone of 1m/s: **99.7%**
6. Percentage of time inside the Givoni comfort zone of 0m/s: **76%**
7. Number of hours within a certain temperature range:

Hot period (28th Jun.to 30th Sep. 2022) Occupation time: 6:00 pm to 8:00am	Living room		Bedroom	
Range	Nb of Hours	Frequency	Nb of Hours	Frequency
Ta<22°C	**87**	**5.3%**	**51**	**3.1%**
22°C≤Ta<24°C	**392**	**24,1%**	**262**	**16.1%**
24°C≤Ta<26°C	**587**	**36%**	**687**	**42.1%**
26°C≤Ta<28°C	**292**	**17.9%**	**415**	**25.5%**
28°C≤Ta<30°C	**186**	**11.4%**	**179**	**11%**
30°C≤Ta<32°C	**78**	**4.8%**	**35**	**2.1%**
32°C≤Ta<34°C	**7**	**0.4%**	**1**	**0%**
34°C≤Ta<36°C	**0**	0%	0	0%
Ta≥36°C	**0**	0%	0	0%

Energy performance indicators

1. Energy needs for heating: [kWh/m²/year]
2. Energy needs for cooling: [kWh/m²/year]
3. Energy use for lighting: - [kWh/m²/year]
4. Energy needs for Sanitary Hot water: [kWh/m²/year]
5. Total Primary energy use: [kWh/m²/year]
6. Renewable Primary energy generated on-site: - [kWh/m²/year]
7. Renewable Primary energy generated on-site and self-consumed: - [kWh/m²/year]

	8. Renewable Primary energy exported to the grid: - [kWh/m^2/year]
	9. Ratio of renewable primary energy over the total primary energy use (with and without compensation): - %
	10. Delivered energy (from electricity bills) : - [kWh/m^2/year]
Acoustic comfort indicators	1. Airborne sound insulation
	2. Equivalent continuous sound Level
	3. HVAC noise level
	4. Reverberation time
	5. Masking/barriers
Visual comfort indicators	1. Light level (illuminance)
	2. Useful Daylight Illuminance (UDI)
	3. Glare control
	4. Quality view
	5. Zoning control
Indoor Air Quality indicators	1. Organic compound
	2. VOCs
	3. Inorganic gases
	4. Particulates (filtration)
	5. Minimum outdoor air provision
	6. Moisture (humidity, leaks)
	7. Hazard material
Users' feedback	Owners are very satisfied by the comfort conditions either in summer or in winter
	LESSONS LEARNED AND RECOMMENDATIONS
Lessons learned	The results obtained from this monitoring campaign have highlighted the importance of the study, following the appropriate materials, of the exterior walls, which, thanks to their excellent thermal inertia values, become essential to ensure good results in terms of maintaining indoor temperature to achieve comfort. Working on the envelope can bring benefits and achieve concrete results, verifiable in this case especially in the summer context and even more so in a continental climate like this one. In the winter period, on the other hand, by turning on the heating system, consisting of a photovoltaic-powered heat pump and a high-performance wood-burning stove, an good level of comfort can be maintained by keeping the stove on even once a week.
Recommendations	The main recommendations are to understand how critical it is to work with the appropriate materials and optimal knowledge of their performance

BUILDING STRENGTHS AND WEAKNESSES		
	Strengths	
		
Passive Design	**Energy Efficiency**	**Renewable Energy**
	Weaknesses	

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REFERENCES
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