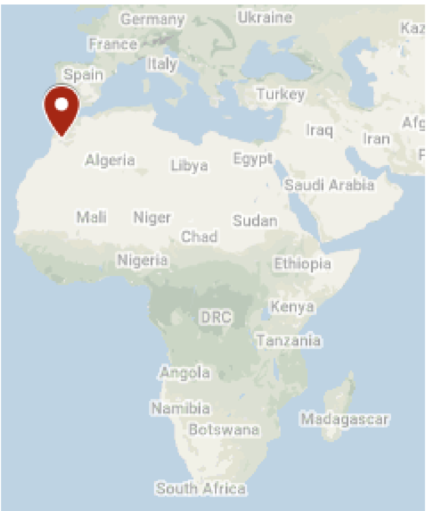
CASE STUDY 09: VILLAS DES CHERCHEURS | MOROCCO



GEOGRAPHICAL AND CLIMATE INFORMATION	
Location	Ben Guerir, Morocco
Latitude; Longitude	32.214157096376795, -7.935813503615992
Climate zone (Köppen–Geiger classification)	BSh: Hot semi-arid steppe
BUILDING INFORMATION	
Building Type	Residential, Villas
Project Type	New construction
Completion Date	2016
Number of buildings	100 villas
Number of storeys	2 (Villa Zitoune)
Total Floor Area (m^2)	330 (Villa Zitoune)
Net Floor Area (m^2)	184 (Villa Zitoune)
Thermally conditioned space area (m^2)	184 (Villa Zitoune)
Spaces with Natural Ventilation (with or without Ceiling Fans) Only (m^2)	184 (Villa Zitoune)
Total cost (€)	2 307 162 (24 000 000 MAD)
Cost /m^2 (€/m^2)	125 (~1 304 MAD)
Performance Standards or Certification	None
Awards	COP 22 label
STAKEHOLDERS [1]	
Building Owner/ Representative	OCP
Architect / Designer	Elie Mouyal
Construction manager	CAP INGENIERIE
Environmental consultancy	JESA
Structural Engineer, Civil Engineer	CAP INGENIERIE

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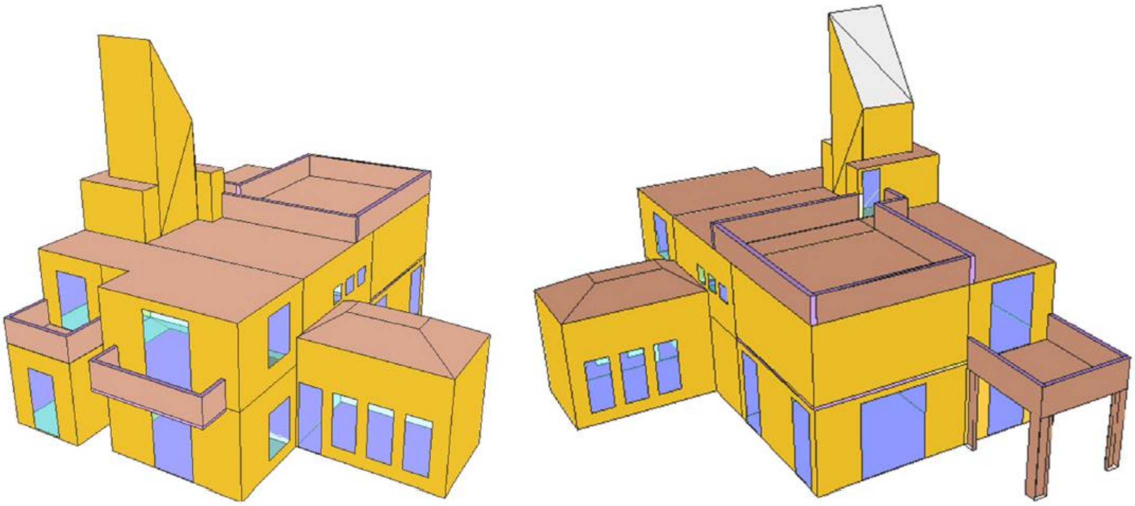
Product Manufacturer	-
Certification company	-
Others	-

PROJECT DESCRIPTION

Figure 132: Exterior view of the "Villas des Chercheurs"

The project is a collective residential zone for scientific researchers of the Mohammed VI Polytechnic University. There exist 4 kinds of villas depending on their architectures and areas: Villas Zitoune, Villas Limoune, Villas Roumane and Villas Kermous. The buildings walls are constructed with solid stone locally extracted, which is considered to be an eco-friendly building material. External walls and roof are insulated with hempcrete panels. Other bioclimatic concepts are applied. This report takes Villa Zitoune as case study for next descriptions. The 1st floor consists of one bedroom, two halls, a lobby and a kitchen; while the 2nd floor has two bedrooms.



(a) (b)

Figure 133: 3D architectural sketches of the studied house: (a) North-East sight, (b) South-East sight [2]

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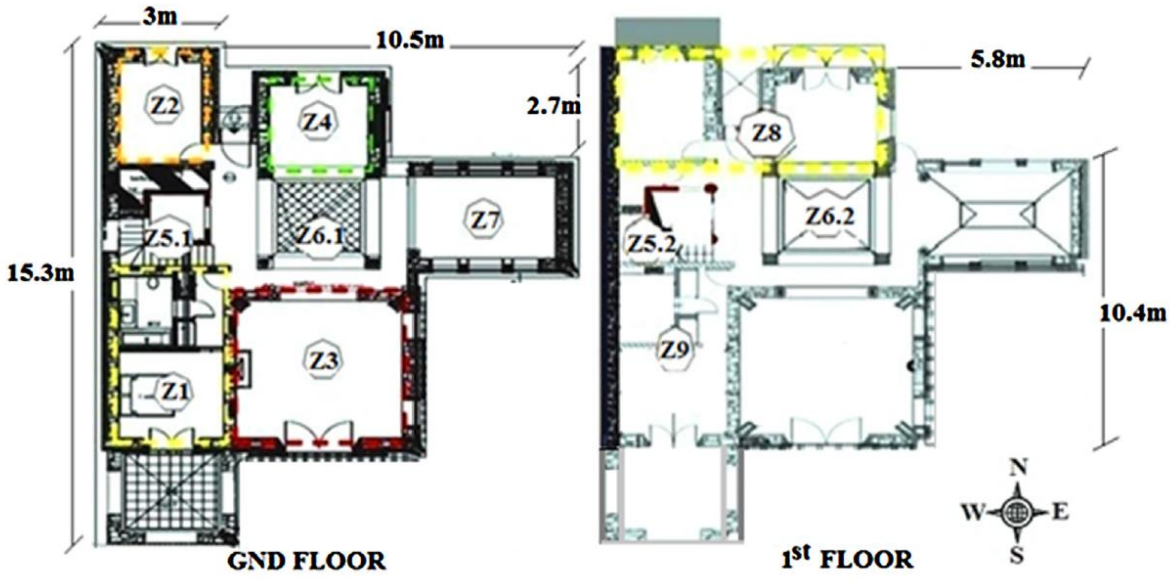

Figure 134 : Architectural plans of the studied house. The thermal zones as defined in TRNSYS are indicated [2].

SITE INTEGRATION

Figure 135 : Aerial view of the "Villas des Chercheurs" and its' surrounding

Located in a hot semi-arid steppe region, the project includes necessary facilities for living (school, market, club…). The construction of the 100 Villas is inspired from the architecture of traditional Moroccan Medina constructed. Each villa has its own green space dedicated to urban agriculture activity.

CLIMATE ANALYSIS

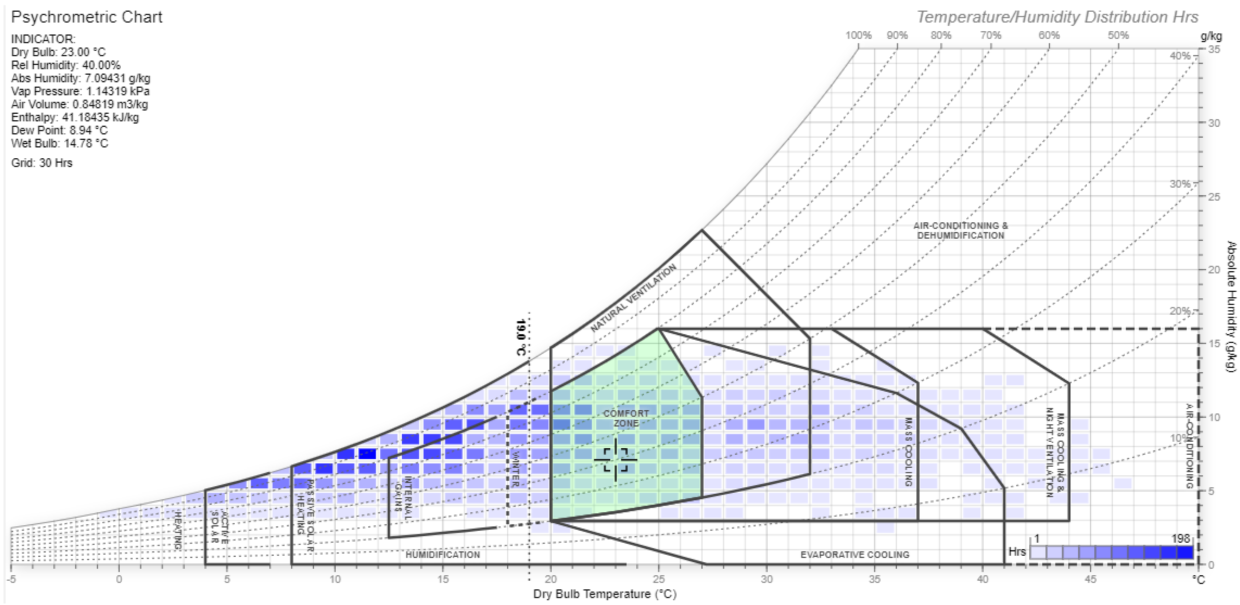

Figure 136: Givoni Bioclimatic Chart for the climate of Ben Guerir using Andrew Marsh online tool [3]. Climate data are extracted from https://climate.onebuilding.org/WMO_Region_1_Africa/MAR_Morocco/MS_Marrakech-Safi/MAR_MS_Ben.Guerir.AB.602051_TMYx.zip.

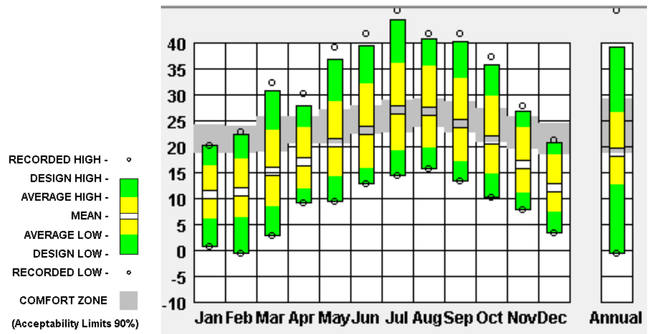

Figure 137: Temperature range by month for the city of Ben Guerir. Source: Climate consultant – Adaptative Comfort model [4]

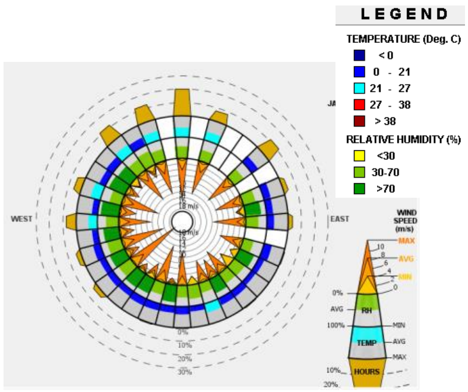

Figure 138: Annual Wind rose for Ben Guerir. Source: Climate consultant 6.0 [4]

Global horizontal radiation (Avg daily total) Min (month) / Max (month)	Min: **2530** Wh/m² (Dec) Max: **7573** Wh/m² (Jul) Mean: **4867,25** Wh/m²
Annual Degree-Days for weather classification according to ASHRAE Standard 169-2020	HDD 18°C: **987** CDD 10°C: **3382**
Annual Degree-Days for the Adaptive Comfort Base Temperature according to the ASHRAE 55-2017 for 80% of acceptability	HDD: **1263** CDD: **198**
Annual Degree-Days for a static comfort temperature approach	HDD 18.6ºC: **1100** CDD 26º: **380**

KEY BIOCLIMATIC DESIGN PRINCIPLES [1]	
Passive cooling strategy	▪ **Comfort ventilation:** Natural ventilation strategy is achieved through openings. ▪ **Nocturnal convective cooling:** Wind-tower coupled with a pebble foundation that serves as bioclimatic thermal mass for cooling. ▪ **Indirect evaporative cooling:** Overhangs and shadowing. ▪ **Radiant cooling:** Insulated roofs, massive stone walls with high thermal resistance. ▪ **The soil as a cooling source:** Using ground thermal inertia.
Passive heating strategy	Use of wind-tower coupled with a pebble foundation that serves as bioclimatic thermal mass for heating.
Solar protection	Following the standards to have the shadowed portion of the glazed area should be as large as possible in summer and as low as possible in winter.
Building orientation	_
Insulation	Hempcrete
Vegetation	Each house owns a green space dedicated to urban agriculture activity.
Natural daylighting	Trough glazed surfaces.
Use of local and embedded materials	Stone extracted from local quarries.
Water saving and heat recovery on hot water drain	Water collection from rain.
Waste management	Wastewater treatment.
Others features	_

Figure 139: Key bioclimatic design principles of the « Villas des chercheurs »

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Figure 140 : Digital model of the « Villa des chercheurs ».

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**
Ceiling fans	In every room, even those conditioned: **Unknown**
Lighting system fractioned to allow using light only in zones occupied and where daylighting insufficient	In every room, even those conditioned: **No**
Space and facilities for line drying clothes (especially important in residences, hotels, sport facilities…)	In every room, even those conditioned: **Yes**
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**

BUILDING FABRIC AND MATERIALS [2]	
Roof	Double slab of hempcrete (12 cm each)
	Overall R-value: **4.329** m².K/W
Windows	Double glazing: 6 mm thickness and 8 mm spacing filled with air
	Window-to-wall ratio (WWR): **21%**
	U-value: -
	Visual transmittance: -
Walls	Double wall with natural stone shaped on site (40 cm) Hempcrete insulation between the walls (10 cm) Porphyry rock hobs (10 cm)
	External walls: Overall R-value: **2.994** m².K/W Internal walls: Overall R-value: **2.267** m²K/W

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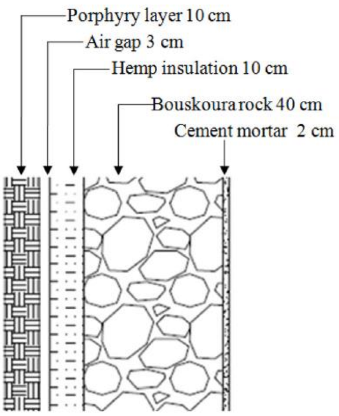

Figure 141 : External walls composition [2].

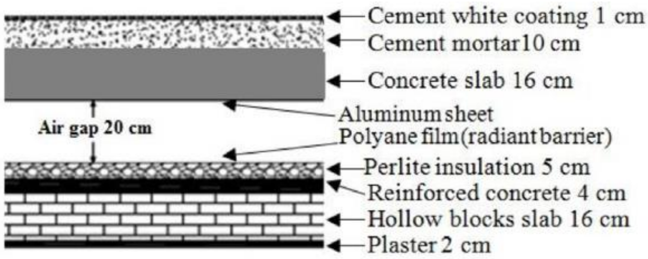

Figure 142 : Roof slab composition [2]

ENERGY EFFICIENT BUILDING SYSTEMS [1]	
Low-energy cooling systems	Two cooling systems are the most interesting ones: First: A Wind-tower that receives and blows air into a pebble-based foundation which serves as thermal masse. The pebble-based foundation is cooled using fresh air at night. Then, the air flow cooled is blowed using a network of ducts into the building rooms. Second: Small openings on the upper part overhanging the roof are designed, allowing the hot upward flow to escape. This creates an air movement that will cool the room.
Low-energy heating systems	The Wind-tower coupled with the pebble-based foundation serves for heating. The pebble-based foundation is heated using solar air collectors. Then, the air flow heated is blowed using a network of ducts into the building rooms.
Ceiling fans	Unknown
Mechanical ventilation / air renewal	Wind-tower
Domestic Hot Water	A solar air collector heats water ensuring the supply in bathrooms and from the kitchen.
Artificial lighting	High-efficiency LED lighting (3 W/m^2)
Control and energy management	None

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Figure 143 : Wind Tower of the "Villa des chercheurs".

RENEWABLE ENERGY	
PV	None
Solar thermal	A solar air collector for water heating.
Wind	None
Geothermal	None
Biomass	None

BUILDING ANALYSIS AND KEY PERFORMANCE INDICATORS	
Thermal comfort indicators	1. Percentage of time outside an operative temperature range (Adaptive): **Number of discomfort hours: 1578 hours**
	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
	6. Percentage of time inside the Givoni comfort zone of 0m/s
	7. Number of hours within a certain temperature range
Energy performance indicators	1. Energy needs for heating (kWh/y/m2): **9.4**
	2. Energy needs for cooling (kWh/y/m2): **23.2**
	3. Energy use for lighting (kWh/y/m2)
	4. Energy needs for Sanitary Hot water (kWh/y/m2)
	5. Total Primary energy use (kWh/y/m2)
	6. Renewable Primary energy generated on-site (kWh/y/m2)
	7. Renewable Primary energy generated on-site and self-consumed (kWh/y/m2)
	8. Renewable Primary energy exported to the grid (kWh/y/m2)
	9. Ratio of renewable primary energy over the total primary energy use (with and without compensation) (%)
	10. Delivered energy (kWh/y/m2) (from electricity bills)
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

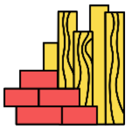
Indoor Air Quality indicators	1. Organic compound
	2. VOCs
	3. Inorganic gases
	4. Particulates (filtration)
	5. Minimum outdoor air provision
	6. Moisture (humidity, leaks)
	7. Hazard material
Users' feedback	-

LESSONS LEARNED AND RECOMMENDATIONS

Lessons learned	-
Recommendations	-

BUILDING STRENGTHS AND WEAKNESSES

Strengths

		
Passive Design	**Energy Efficiency**	**Local Materials**

Weaknesses

-

REFERENCES

[1] « Dix cas de bonnes pratiques au Maroc ». Available at: http://www.archi.ac.ma/images/publications/Catalogue%20web.pdf

[2] H. Mastouri, B. Benhamou, H. Hamdi, et E. Mouyal, « Thermal performance assessment of passive techniques integrated into a residential building in semi-arid climate », Energy Build., vol. 143, p. 1-16, mai 2017, doi: 10.1016/j.enbuild.2017.03.022.

[3] Andrew Marsh Psychrometric Chart. Available at: https://drajmarsh.bitbucket.io/psychro-chart2d.html.

[4] Climate Consultant tool. Available at: https://climate-consultant.informer.com/6.0/

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