CASE STUDY 2-12: CHILDREN'S SURGICAL HOSPITAL | UGANDA

GEOGRAPHICAL AND CLIMATE INFORMATION	
Location	Plot 120-122 Bishop Dunstan Nsumbuga Road, Entebbe, Uganda
Latitude; Longitude	0.08378874306047031, 32.45785942464613
Climate zone (Köppen–Geiger classification)	Af: Equatorial rainforest
BUILDING INFORMATION	
Building Type	Health Facility | Hospital
Project Type	New construction
Completion Date	2020
Number of buildings	1
Number of storeys	2
Total Floor Area (m²)	**Unknown**
Net Floor Area (m²)	9 700
Thermally conditioned space area (m²)	9 700
Spaces with Natural Ventilation (with or without Ceiling Fans) Only (m²)	**0**
Total cost	22 715 036 € (construction and equipment)
Cost /m² (€/m²)	**2 341.8**
Performance Standards or Certification	None
Awards	None
STAKEHOLDERS	
Building Owner/ Representative	EMERGENCY
Architect / Designer	Renzo Piano Building Workshop & Studio Tam Associati
Design team	▪ RPBW - G.Grandi (partner in charge), P.Carrera, A.Peschiera, D.Piano, Z.Sawaya and D. Ardant; F.Cappellini, I.Corsaro, D.Lange, F.Terranova (models) ▪ TAMassociati -R.Pantaleo, M.Lepore, S.Sfriso, V.Milan, L.Candelpergher, M.Gerardi

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	▪ EMERGENCY Field Operations Department, Building Division - Roberto Crestan, Carlo Maisano
Mechanical, Electrical and Plumbing (MEP) engineering	Prisma Engineering
Structural Engineer, Civil Engineer	Milan Ingegneria
Landscape design	Studio Giorgetta - Franco and Simona Giorgetta
Fire Consultants	GAE Engineering, J&A Consultants

PROJECT DESCRIPTION [1][2]

Figure 155 : Floor plan of the building © RPBW architects

The Children’s Surgical Hospital is a project of medical, health, economic and environmental sustainability.
The challenge was to combine excellent paediatric surgery and excellent architecture, creating a “healing architecture”. This concept is based on the fact that: “Beauty is not just an aesthetic choice; it is part of treatment” [3]. One of the guiding principles of the project was the idea of a hospital that was not just functional and efficient from a medical point of view, but also ‘beautiful’. Every detail of the hospital was built with children in mind. The walls are covered in pictures, colour is everywhere and the garden offers a place to play. This modern building is also firmly linked to tradition, using the rammed earth technique. The same architectural principles used for traditional houses was implemented but in an innovative way.

Figure 2: Section of the building. © RPBW architects

SITE INTEGRATION

Figure 156 : Aerial view of the building in its surrounding environment. (Source: Google Map)

The Children’s Surgical Hospital is located in Entebbe, Uganda, close to the Victoria Lake and to an urbanised area. The Children’s Surgical Centre sits on the banks of Lake Victoria. It is a very green spot, almost 4000 feet (1,150 m) above sea level, chosen for its clean air and beautiful surroundings. “The building follows the curves that slope down to the lake. By following the course of the land, the hospital walls and the boundaries of its outdoor pathways will form terraces on which the hospital itself will stand, in a spatial continuum between interior and exterior, above and below. The stacked walls will break the distinction between the various zones, creating a unity between the lake, the park and the internal hospital environment” [1][2].

CLIMATE ANALYSIS

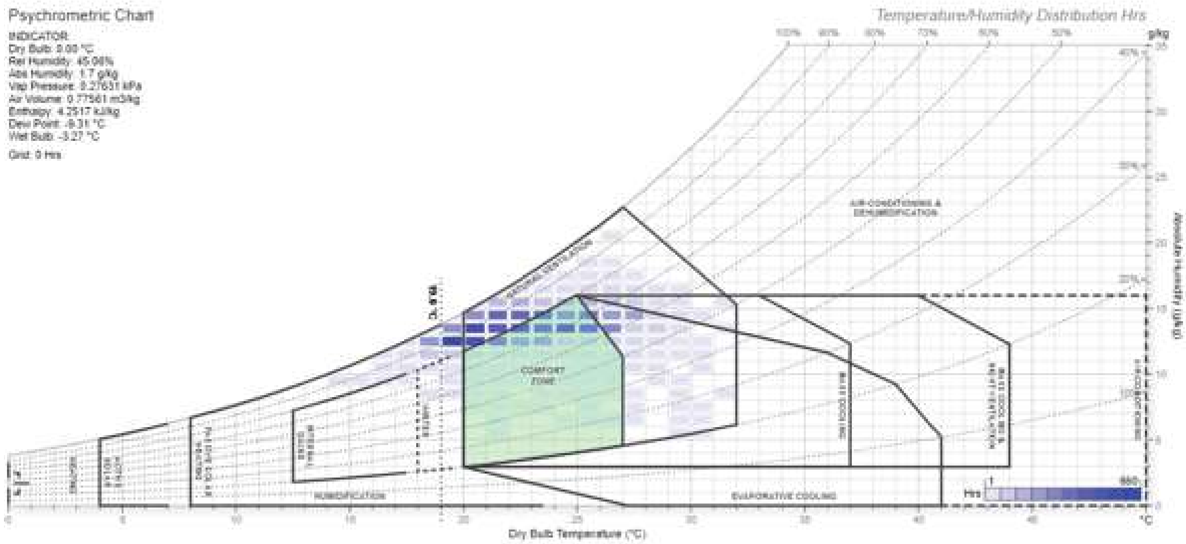


Figure 157: Givoni Bioclimatic chart for the climate of Entebbe, Uganda using Andrew Marsh online tool [2]. Climate data are extracted from the database of the climate.onebuilding.org website.

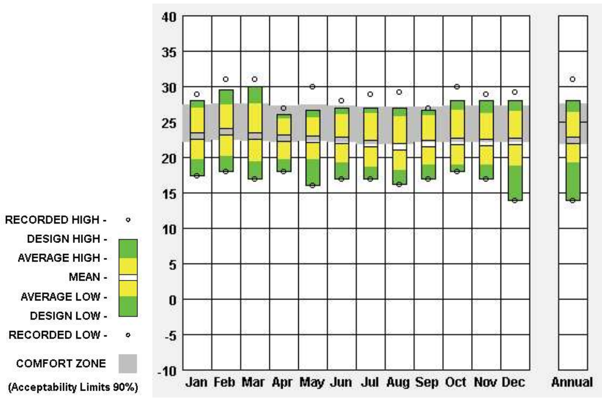


Figure 158: Temperature range by month for Entebbe, Uganda (Source: Climate consultant – Adaptative Comfort model).

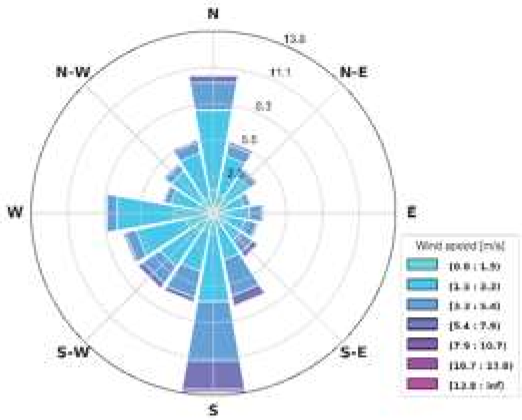


Figure 159: Wind rose for Entebbe, Uganda (Beaufort wind scale).

Global horizontal radiation (Avg daily total) Min (month) / Max (month)	Min: **4 999** Wh/m² (May) Max: **6 249** Wh/m² (March) Mean: **5 662,7** Wh/m²
Annual Degree-Days for weather classification according to ASHRAE Standard 169-2020	HDD 18°C: **2** CDD 10°C: **4 545**
Annual Degree-Days for the Adaptive Comfort Base Temperature according to the ASHRAE 55-2017	HDD: **196** CDD: **3**
Annual Degree-Days for a static comfort temperature approach	HDD 18.6ºC: **9** CDD 26º: **40**

KEY BIOCLIMATIC DESIGN PRINCIPLES	
Passive cooling strategy	The rammed earth has a high level of thermal inertia, which makes it easy to control the temperature in the building and stop heat entering and cold escaping.
Passive heating strategy	High thermal mass of the load-bearing walls made of raw earth.
Solar protection	The roof canopy structure, “floating” above the building, will provide shade for the building and all the uncovered walkways.
Building orientation	The main façades of the two wings of the building are oriented North-East and South-West.
Insulation	The massive walls made of raw earth contribute significantly to cooling down the interior spaces.
Vegetation	Gardens are an essential feature of EMERGENCY’s hospitals all over the world, and not just because they are natural air conditioners, but they are the basis of so-called ‘healing architecture’. The heart of the Children’s Surgical Centre is its garden which is full of plants grown during construction, using the technique of air pruning. The plants are grown above ground, in huge pots made of wire frames and jute. Over two years the plants have doubled in size, thanks in part to the favourable climate. A garden with 350 trees offers a place to play and to recover to children.
Natural daylighting	Large windows fill the rooms with natural light.
Use of local and embedded materials	The excavated land has been used to build the load-bearing walls with the rammed earth technique. The same architectural principles used for traditional houses were used in an innovative way.
Water saving and flood management	A gutter runs from the roof of the facility, collecting rainwater, filtering it and reusing it to water plants and clean outdoor areas, so as not to waste the water that comes from the mains.
Waste management	**Unknown**
Others features	-

Figure 161 : View of the shaded exterior walkways

Figure 160: The suspended canopy structure provides shade to the building and the walkways. © Emmanuel Museruka – Malaika Media

© Emmanuel Museruka – Malaika Media

Figure 162: View of the load-bearing walls made of raw earth. © Emmanuel Museruka – Malaika Media

Figure 163: View of the inner courtyard © Emmanuel Museruka – Malaika Media

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): **No for the staff**
Protected bike parking and showers	**Unknown** If yes, Ratio with number of users: **Unknown**
Ceiling fans	In every room, even those conditioned: **No** No ceiling fans, air is supplied and extracted by Ahus through ducts; exceptions are some small extractions fans from toiles not reachable by main ducting and in technical rooms in plant area.
Lighting system fractioned to allow using light only in zones occupied and where daylighting insufficient	In every room, even those conditioned: **Yes** Lighting system is fractioned by areas (supply by means of lv electrical boards) and by service (normal and emergency lighting system).
Space and facilities for line drying clothes (especially important in residences, hotels, sport facilities…)	In every room, even those conditioned: **Unknown**
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.: **Unknown**

BUILDING FABRIC AND MATERIALS	
Roof	Suspended canopy structure in galvanised steel. The solar energy system is linked to one of the hospital's most distinctive features: its pair of roofs. The higher of the two, used for cover, is made of corrugated sheet metal and supports the 2,500 panels, which have

	the twofold function of capturing energy and providing shade, thereby helping control the temperature in the building. The lower roof is made of Zintek, an alloy of zinc, titanium and copper. There is a space between the two varying from seven to 20 feet (two to seven metres), which is used for maintenance.
Windows	Clear glass
Walls	Load-bearing walls made of raw earth. The walls are approximately two feet (60 cm) wide and have a volume of 62,285 cubic feet (1,763.7 m3).

Figure 164: View of the canopy structure.
© Emmanuel Museruka – Malaika Media

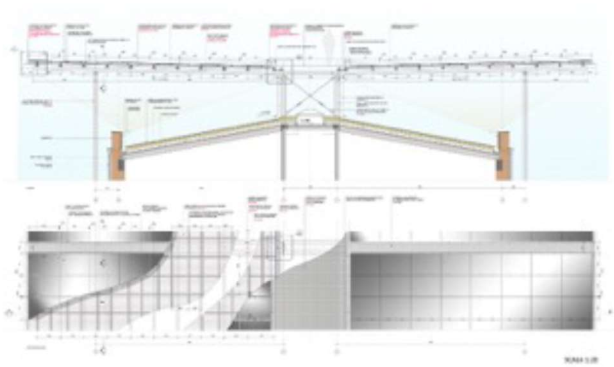


Figure 165: Details of the suspended canopy structure.
© RPBW architects

ENERGY EFFICIENT BUILDING SYSTEMS

Low-energy cooling systems Mechanical ventilation / air renewal	HVAC systems In order to protect patients, staff and visitors from germs, the hospital is served with a pass-through system without recovering and retreating the air (which could give an energy saving): air is filtered, thermal treated, used by relevant areas and then disposed to the outside, without reusing it. Air Handling Units (AHU) have been used to take air from outside then filtering the air thanks to various types of filters (depending upon the function of the area standards and finally, thermally treat the air by using Cool or Hot water produced by chiller (cold) or multipurpose machine (cold and hot) and boiler (hot). Cold water to 7/12°C is produced to lower air temperature, use economizers on AHUs to raise a bit the temperature of the air in order to dehumidify it, and give the desired temperature before releasing it in ambient by means of postheating batteries; in specific cases cold water was used to fan coils and VRF (pharmacy and kitchen stores, electrical rooms, corridors or areas exposed to direct sunlight) to mitigate the irradiation and convection effects during the exposure to the sun or emitted by the devices and boards). All the AHU are equipped with a water recovery system with a dedicated circulation pump that performs a free pre-cooling of the external air, through a battery system: the first one removes heat from the incoming air; the second transfers it to the cooled air by carrying out a first free post-heating. The system starts when the outside temperature is favourable. In

	this regard, a special thermostat is installed on the external air channel. A thermostat on the air delivery stops recovery if the air temperature is higher than the need for air conditioning. The air exhaust from Toilets is made by AHU (because there is no air recirculation and all the air collected is pulled outside) or by means of local exhaust fans.
Low-energy heating systems	None
Ceiling fans	None
Domestic Hot Water	The production of hot domestic water is made by solar panels combined with a diesel boiler. Basically, both boiler and solar panels are heat exchangers: one exchanges the heat produced by burning oil through the fumes to a primary water circuit (the boiler primary water circuit) the other the heat produced by the sun to the solar panels fluid circuit. These circuits go to the tanks in Water treatment plant and exchange heat with the sanitary water going to the hospital (tanks are water to water heat exchangers); these tanks are filled by cold domestic water, with a dedicated line that starts from the stainless-steel manifold; hot domestic water circuit is built mainly by multilayer pipes (the underground portion is made by pre-insulated pipes)
Artificial lighting	All the lighting of the hospital was realized using LED lamps (to reduce power consumption). In the offices and all the spaces, where computers are often used, the lighting devices are UGR<19 in accordance to UNI EN 12464-1. Depending upon the installation location, different lighting commands (switches, buttons, presence sensors, etc.) have been installed. Total power for internal lighting= 32 kW Total power for external lighting= 5 kW
Control and energy management	The temperature control is made by zones. The system has post-heating coils. Each post-heating coil is for a zone made by more rooms. For each zone there is a panel RLU220, with a temperature sensor installed on the exhaust duct. The universal controllers RLU220 controls the temperature of the zone in relation to the temperature set point required. The post-heating coil circuit will be better described in next paragraphs. For each operating room, there are two set point adjusters: one is used to modify the temperature set-point on RLU220 adding or reducing the temperature up to a maximum 3 °C; the other one for the regulation of the VAV installed on the supply and exhaust ducts in order to modify the air change – 20 volumes per h during the operation, less (5 volumes /h) during the stand-by of the room.

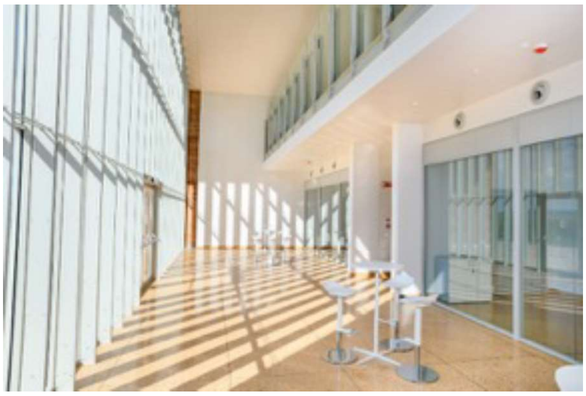


Figure 166: Large windows provide natural light inside the building. © Emmanuel Museruka – Malaika Media

Figure 167 : Interior view of the building. © Emmanuel Museruka – Malaika Media .

RENEWABLE ENERGY	
PV	The hospital is equipped with 3600 m2 of photovoltaic panels. This system will provide a portion of the electricity needed by the building, in order to reduce energy usage. The hospital's maximum demand is 750 kW, a third of which is provided by the panels in the daytime, enough to provide the necessary air conditioning. **Type:** Building integrated PV over-roof **Technology:** thin film **Number of panels:** 2352 **Surface covered:** 3600 m2 **Power at peak as per data sheets: 276,3 kWp** Average monthly downtime of national power from Feb. to May 2022: 62 hours/month
Solar thermal	Thermal solar system made by 28 panels on the roof of the Plant Area with horizontal installation with an angle of 15°, ideal inclination in relation to the latitude of the place, connected with a closed circuit made by copper pipes to the heat exchangers tanks.
Wind	None
Geothermal	None
Biomass	None

Figure 168: 3 600 m^2 of photovoltaic panels are installed on the rooftop of the building. © Emmanuel Museruka – Malaika Media

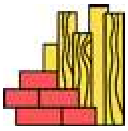
BUILDING ANALYSIS AND KEY PERFORMANCE INDICATORS	
Thermal comfort indicators	1. Percentage of time outside an operative temperature range (Adaptive)
	2. Percentage of time outside an operative temperature range (Fanger)
	3. Degree-hours (Adaptive)
	4. Degree-hours (Fanger)
	5. Percentage of time inside the Givoni comfort zone of 1m/s
	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)
	2. Energy needs for cooling (kWh/y/m2)
	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



Local Materials

Renewable Energy

Weaknesses

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2. Children's Surgical Hospital / Renzo Piano Building Workshop + Studio TAMassociati " 27 Jul 2021. ArchDaily. Accessed 12 May 2022. https://www.archdaily.com/965709/childrens-surgical-hospital-renzo-piano-building-workshop-plus-studio-tamassociati . ISSN 0719-8884
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