A PASSIVE SOLAR ENERGY BUILDING FOR ECOLOGICAL RESEARCH IN ARGENTINA

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ABSTRACT An energy efficient building was designed and built, featuring energy conservation, passive solar heating and natural cooling strategies. Located in the semiarid region of central Argentina, the resulting compact design houses 350 m2 of usefull floor area, with main spaces facing north and service spaces facing south. Solar upper windows provided for all main spaces, contribute to add solar gain to the south side space. Summer cooling strategies include passive induction of exterior air into de building (daytime) and cross ventilation (nighttime). Simulation analyses were performed along the design stage to assess performance. Results obtained so far anticipate encouraging possibilities.

1. INTRODUCTION

The territory of the province of La Pampa can be divided into two regions namely East and West, according to a simplified macro-environmental classification that takes into account geomorphological, altimetric, pluviometric and phytogeographic data. The East appears as the region presenting the greatest development and major productive and economic potentialities. It belongs to the semiarid region of Argentina with an annual rainfall of 650 mm. It is in this area that the city of Santa Rosa, La Pampa is situated. North of the city outside the urban area we find the College of Agronomical Engineering of the National University of La Pampa, which concentrates in its campus a series of isolated buildings for teaching and research purposes.

Table 1: Geographical coordinates and climatic data of location: Santa Rosa, La Pampa, Argentina

Geographical coordinates Latitude:-36.57° Longitude:64.45 Altitude: 180 m.a.s.l					
Climatic data	*Annual Records*			*July*	*December*
Dry bulb	Mean	Absol.max	Absol.min	Mean min.	Mean max.
Temperature (°C)	15.5	42	-12	1.4	31.9
Annual Heating DD (base 16°C):1136 Annual Cooling DD (base 23°C): 128					
Horizontal global radiation: 16MJ/m2d					

The passive solar building designed and constructed in the campus is used to carry out teaching and research activities in the field of Ecology and Physiology. Table 1 shows the geographical localization of the city of Santa Rosa and the climatic data which characterize the area [1].

2. DESIGN AND TECHNOLOGY

The design of the building was subject to a major concern: the fixed budget the University had alloted for the construction of a conventional building. The architectural project provided an answer to the needs submitted by the Ecology and Physiology staff. Design guidelines were: the building's bioclimatic conditioning and energy use optimization. Following design guidelines, the strategies implemented included the concepts of passive heating, ventilation and cooling, thermal inertia and energy conservation.

The building's compact design houses six office rooms facing north, with the laboratories and service areas facing south. It also includes a sun-space as an area of thermal compensation and physical and visual extension. Table 2 shows the constructive technology used and the thermal resistance of the building's envelope components.

Table 2:Constructive technoloqy and thermal resistance of building's envelope components.

Envelope Components	Technology Description and thickness in meters Inner layer	Intemed layer	Outerlayer2	Ourterlayer	Total Thermal resistance (°Cm2/W)
Levelled Roofs	Composite Reinf. Slab(.12)	Rigid insulat(.07)	Lightweight infil (.05 to.07)	Water proof alum coat.mem(-)	2.35
Tilted Roofs	Composite Reinf. Slab(.12)	Rigid Insulation (.07)	Air space non-air tight (.05)	Corrugated met. sheet(-)	2.58
Exterior walls	Solid Brick (.18)	Rigid Insulat.(.05)		Face brick (06)	1.66
Exterior foundation (to.6m deep)	Solid brick (.27)	Rigid insulation (.05)		Face brick (.06)	1.66
Solar openings	Metal frame double glazed(.05)		Air space non-air tight	PVC rolling shutter(.02)	0.33

Table 3: Energy values of the building for a heating season

Volumetric loss coefficient(W/°Cm3)	1.09	Load-collector Ratio(W/°CM)	9.5
Net loss coefficient	503	Solar savings Fraction (%)	70
Collecting Area (m2)	53	Annual auxiliary heat (Kwh)	4114

3. PASSIVE SOLAR HEATING SYSTEMS.

During the winter the building's thermal conditioning would be solved by means of passive solar systems. The building is characterized by direct solar gain combined with storage mass in floors and walls, the system being the result of a serious study of all conservation aspects. The direct gain area is characterized by placing all office, upper windows facing north and high transparent areas in the laboratories facing south. A sun-space included in the central part of the building completes the 53 m2 collecting area, figure that corresponds to 17% of the building's useful area.

4. BUILDING'S THERMAL PERFORMANCE AND WINTER PERFORMANCE PREDICTION.

The Volumetric Loss Coefficient, according to the building's construction characteristics is 1.09 W/°Cm3 and according to the designed collecting area it results in a solar saving fraction of 70%, being the auxiliary heat 4114 Kwh for degree-days over a 24 hour heating period. (Table 3). The building's thermal performance was simulated from August 1st through standard computer models (SIMEDIF), calculating temperature evolution in rooms and walls by means of a scheme in finite differences[2]. Meteorological data considered were: 9,6 MJ global radiation over a horizontal area , 16,5 8,4 and 1,7° C as maximun, mean and minimun temperatures respectively. Considering an increase of 3°C in the indoor temperatures as a result of internal energy contribution, indoor mean temperatures in the offices and laboratories would reach 18.5°C to 20°C and 17.8°C to 18.7°C at 10 a.m. and 2 p.m. respectively. The thermal performance would show an important stability during the simulated stage in which the indoor thermal amplitude would not exceed 6°C whereas outdoors it would reach 19°C.

5. PASSIVE COOLING A

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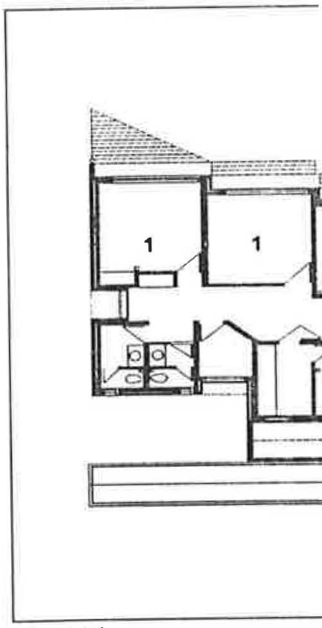
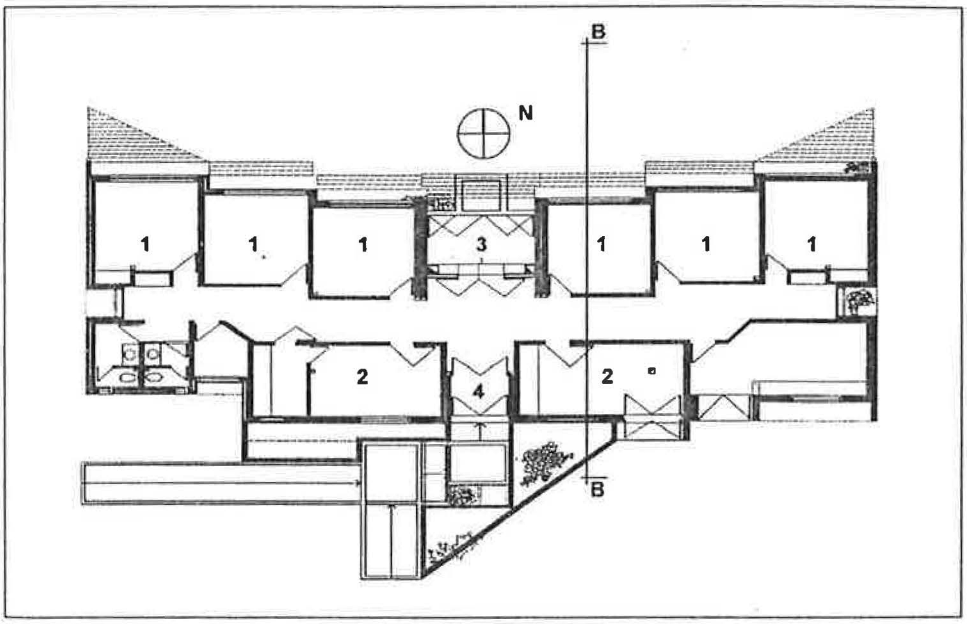


Fig .1 Plant

REFERENCES
1. Office
2. Laboratory
3. Sunspace
4. Hall

5. PASSIVE COOLING AND VENTILATION SYSTEMS.

Advantages in ventilation, cooling and air speed increase are added to the architectural design of the building. The non residential building had to be aired and cooled during the summer avoiding voluntary opening of windows at night for safety reasons and for the risk of incidental storms common to the season. A passive cooling system was chosen characterized by earth coupled masonry ducts allowing natural ventilation through suction cowls placed on the roof. This technique uses the earth as a heat sink for the air that circulates to the building driven by pressure differences between air input areas surrounding the building and air output areas consisting in static suction ducts placed on roofs. A small wooden window indicates the existence of a duct in each office. The area was calculated taking into account the required ventilation for offices and medium smokers (35 m3/hour/person) and the average wind's mean speed in the severest month [3].In order to check the effects of the principal cause of overheating, the facade's transparent areas were protected by an eave designed to that purpose. A metal structure for caducous plants and spray sprinklers would create a microclimate in the surroundings, favouring evaporative cooling. To diminish reflectivity on the exterior surfaces, paved areas were replaced by earth slopes up to the building's perimetral wall (Fig. 1, 2y 3).



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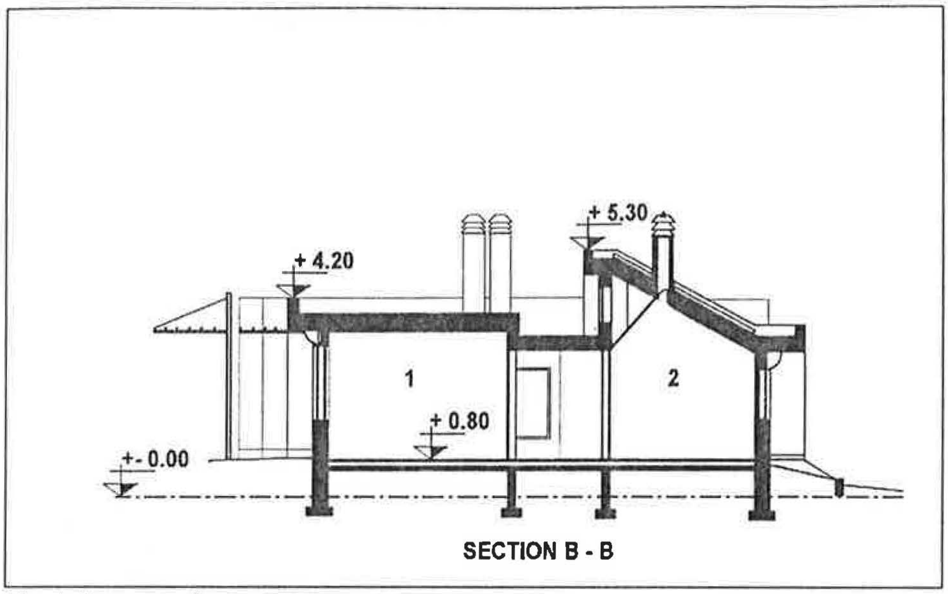

Fig .2 Cross section

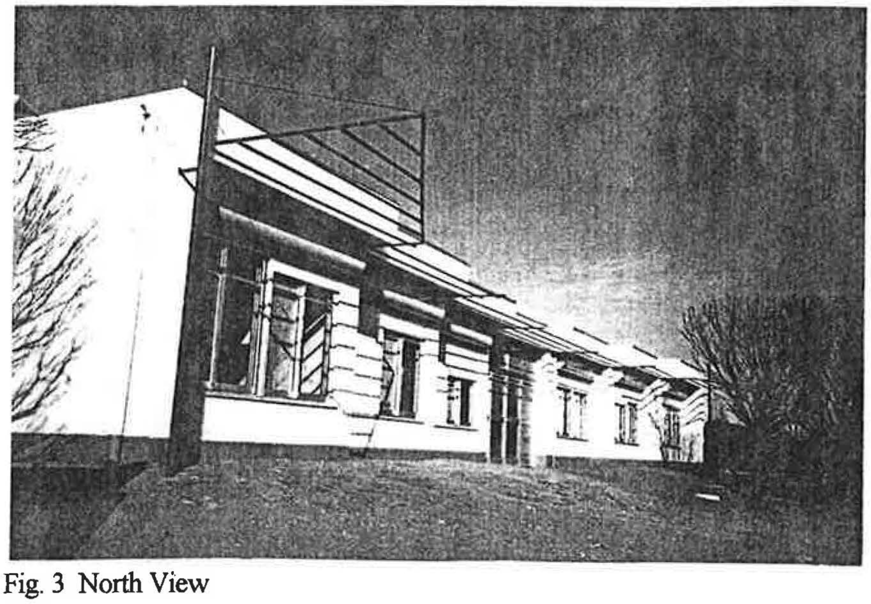

Fig. 3 North View

6. BUILDING EXPERIMENTATION AND VALIDATION.

Winter Performance: The building was ready for use in July, 1995. A monitoring plan was immediately implemented, within real in-use conditions, in order to quantify thermal performance. To assess the exterior ambient temperature, data are collected from a meteorological station placed at a distance of 100 m. from the building, with the aid of a Data Aquisition System (METOS 93) and with the aid of temperature and humidity sensors, the first hourly measurements were taken over a long time span in one of the

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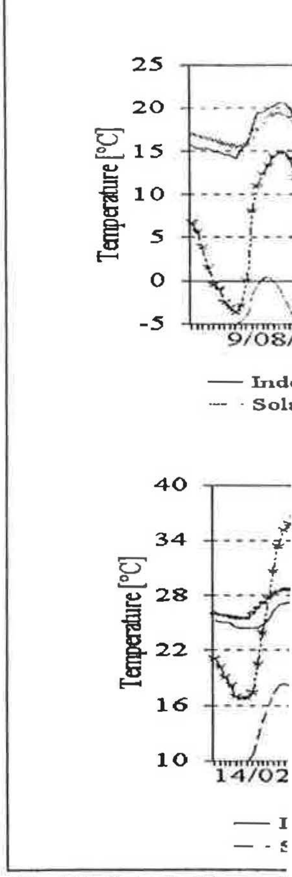

Fig.4.Builging's Thermal

Summer Performance :
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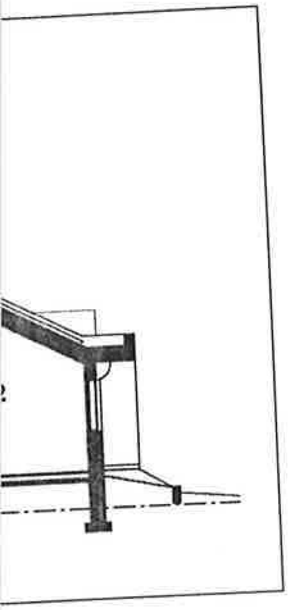

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offices. While assessing the sector's performance within in-use conditions it is important to know how energy control mechanisms were operated by users. According to a report submitted by users, there was no need of auxiliary heat, with shutters rolled up at 8 a.m. and down at 6 p.m., time span which had been used to simulate thermal performance during the design stage. Fig. 4 shows the indoor thermal performance for the first days of August. It can be observed an important correlation between values obtained through thermal simulation and those recorded via the Data Aquisition System. Thermal amplitude values obtained during the period were: 6ºC (indoors) and 19ºC (outdoors). According to Givoni's Bioclimatic Diagram, the relative temperature and humidity in the assessed office would be included within winter's comfort area.

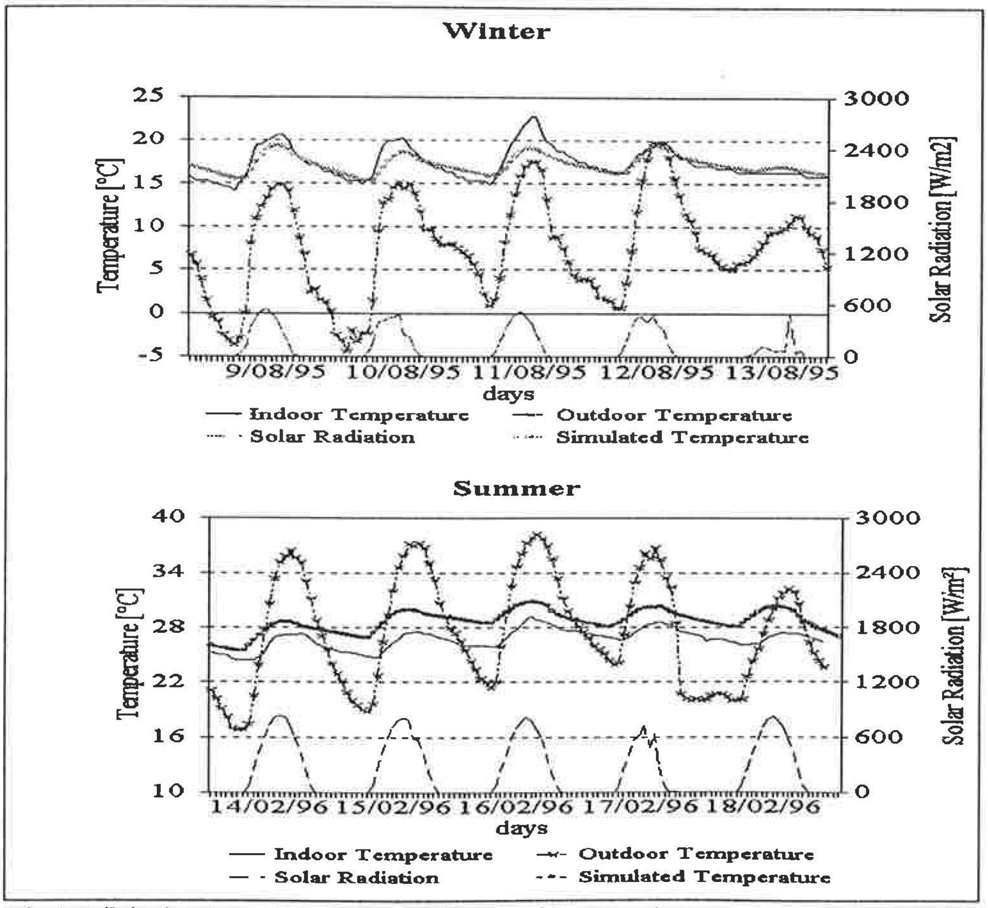

Fig.4.Builging's Thermal Perfomance: Winter and Summer Assessment

Summer Performance : During the summer the assessment sector was extended to the building's east area. With a Data Aquisition System (BAPT) monitoring within in-use conditions was started in February for a period of 15 days. Indoor temperatures recorded, without artificial conditioning were 27,4ºC (maximum) and 26,6ºC (minimum). Figure 4 shows the average of results obtained for the office sector in the period 2/14/96 to 2/18/96. Ventilation, apart from renewing polluted air and increasing the indoor air speed, also helps to cool buildings during the summer nights. For 1,2 met metabolic activity, an increase of 0,2m/sec. in air speed means a decrease of the recorded temperature of 1ºC[4].

The interaction of natural ventilation and cooling systems was one of the aims of the project and it was via earth coupled ducts that it was tried and tested. According to Givoni's bioclimatic diagram the values reached for the indoor ambient temperature are right in the comfort area's boundary, without any artificial conditioning. Including ventilation as part of the cooling system favours comfort. Taking into account the effective temperature diagram and average comfort in summer, for an average indoor ambient temperature of 27ºC (monitoring period) and a relative humidity of 50%, corresponds an effective temperature of 22ºC and 90% of users are in comfort in summer[4].

7. FINANCIAL ASSESSMENT.

Bioclimatic construction results 9,5% more expensive than traditional construction without central heating; but if central heating is added, the difference decreases to 5,3% and if central cooling systems are added, bioclimatic construction results only 1% more expensive than traditional ones. As regards total prices, carpentry and glass have a bearing of 60% on the whole, corresponding the other 40% to thermal insulation.

8. CONCLUSIONS

The Passive Solar Building constructed for the College of Agronomical Engineering, is the first non residential, state funded building for research purposes of its kind. Under these circumstances, having a limited budget, a twelve-month construction stage, following strict bioclimatic design guidelines and taking into account the risks that all public works presuppose, the results of the first measurements, as well as users'opinions were highly satisfactory. Users and maintenance personnel's good disposition to analyse and apply the advice presented in the User's Manual, favoured the thermal performance of the building. Passive solar heating does not appear as critical, existing the possibility to transfer the technology used without major problems. The selected carpentry seems to be satisfactory. For the concluded period (August-June), the actual solar saving fraction would be higher than the estimated one: 2.5 gas bottles used as compared to the 5.5 estimated for the period, support the system's performance. From the financial point of view the passive cooling system adopted has proved to be the appropriate one, enabling the building to cool naturally. Reassessing weak and strong points will be a future challenge.

Acknowledgements

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ABSTRACT
In order to popularize the p
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houses with similar plans
discussed, focusing on the
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through glazing is important.

1. INTRODUCTION

With respect to indoor climat
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