CHAPTER 7

CASE STUDIES

Contents:

This chapter presents examples of buildings incorporating various aspects of energy conscious design. They demonstrate the successful use of passive solar architecture, sustainable materials, conservation of resources, and integration of renewable energy technologies. The examples are chosen from different climatic zones so as to present a wide variety of techniques.

7.1 INSPECTOR GENERAL OF POLICE (IGP) COMPLEX, GULBARGA [1]

Location : Gulbarga, Karnataka
Climate : Hot and dry

Brief description of the building:

This building is a ground and two-storeyed structure designed by Kembhavi Architecture Foundation to house the offices of the Inspector General of Police, Gulbarga. The building is constructed using innovative materials. For example, the external walls are composite walls (i.e. granite blocks on the outer side and rat-trap bond brick walls on the inner side) and the roof is made of filler slab. The U-values of the walls and roof are 1.53 W/m^2-K and 2.15 W/m^2-K respectively. The building is roughly rectangular with the longer axis along the north-south direction. Most windows face east or west. A layout plan of the building is given in Fig. 7.1. As the building is located in a hot and dry climate, evaporative cooling has been used for providing comfort. Most of the offices are cooled by passive downdraft evaporative cooling (PDEC) tower system. Figure 7.2 shows a photograph of the building as well as a sketch section of a typical PDEC tower to explain its principle.

Energy conscious features:

- Passive downdraft evaporative cooling (PDEC) towers for providing comfort
- Tinted glasses to reduce glare
- Alternative building materials such as composite walls to reduce heat gain and filler slabs to reduce the quantity of concrete in the structure
- A central atrium to enhance cross ventilation and provide daylighting
- Solar PV lighting and pumps, rainfall harvesting and water conservation facilities incorporated

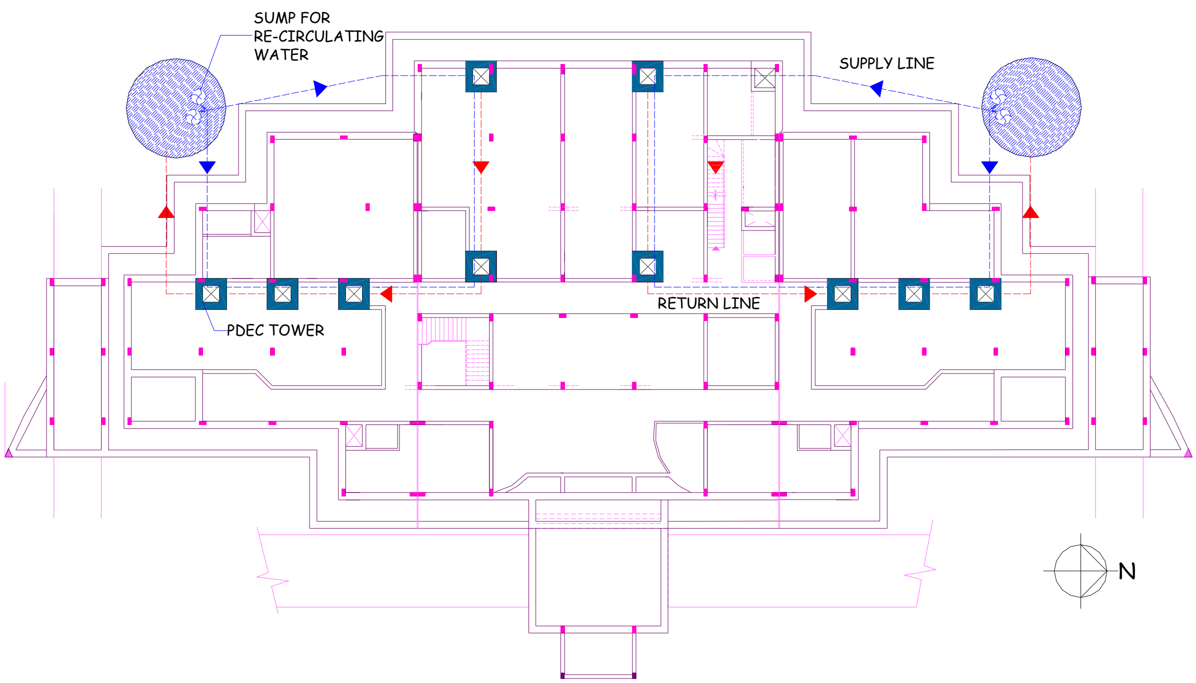


Fig. 7.1 Layout plan of I.G.P. Complex, Gulbarga

Performance of the PDEC system:

The building is in the final stage of construction. The PDEC system's design is based on the "shower tower" (discussed in Chapter 3) concept developed by Givoni [2]. Preliminary measurements taken in May and September, 2005 showed that the temperature of the air exiting from the tower is lower by about 10°C and 4°C respectively, compared to that of ambient air. Figure 7.3 presents the hourly values of the temperature of air exiting from the tower on a typical day in September. The corresponding measured values of ambient temperature are also plotted for comparison. Additionally, the figure shows the theoretically calculated values based on Givoni's model of the shower tower. It is seen that the measurements agree reasonably well with the predictions. Figure 7.4 shows the estimated performance of a tower in various months during daytime. It presents the results of exit temperature of air leaving the tower and the corresponding ambient dry bulb temperature. It is seen from the figure that the performance of the cooling tower is quite satisfactory in the summer months. The drop in temperature is about 12 - 13 °C in March, April and May. Considering that the PDEC system is used in these months, the predictions of the energy savings of the building per annum, as compared to an air-conditioned building maintained at 27.5 °C, are as follows:

Estimated Cost of PDEC system	= Rs. 17,50,000
Estimated savings per annum	= Rs. 3,52,000
Simple payback period	= 5 years (approximately)

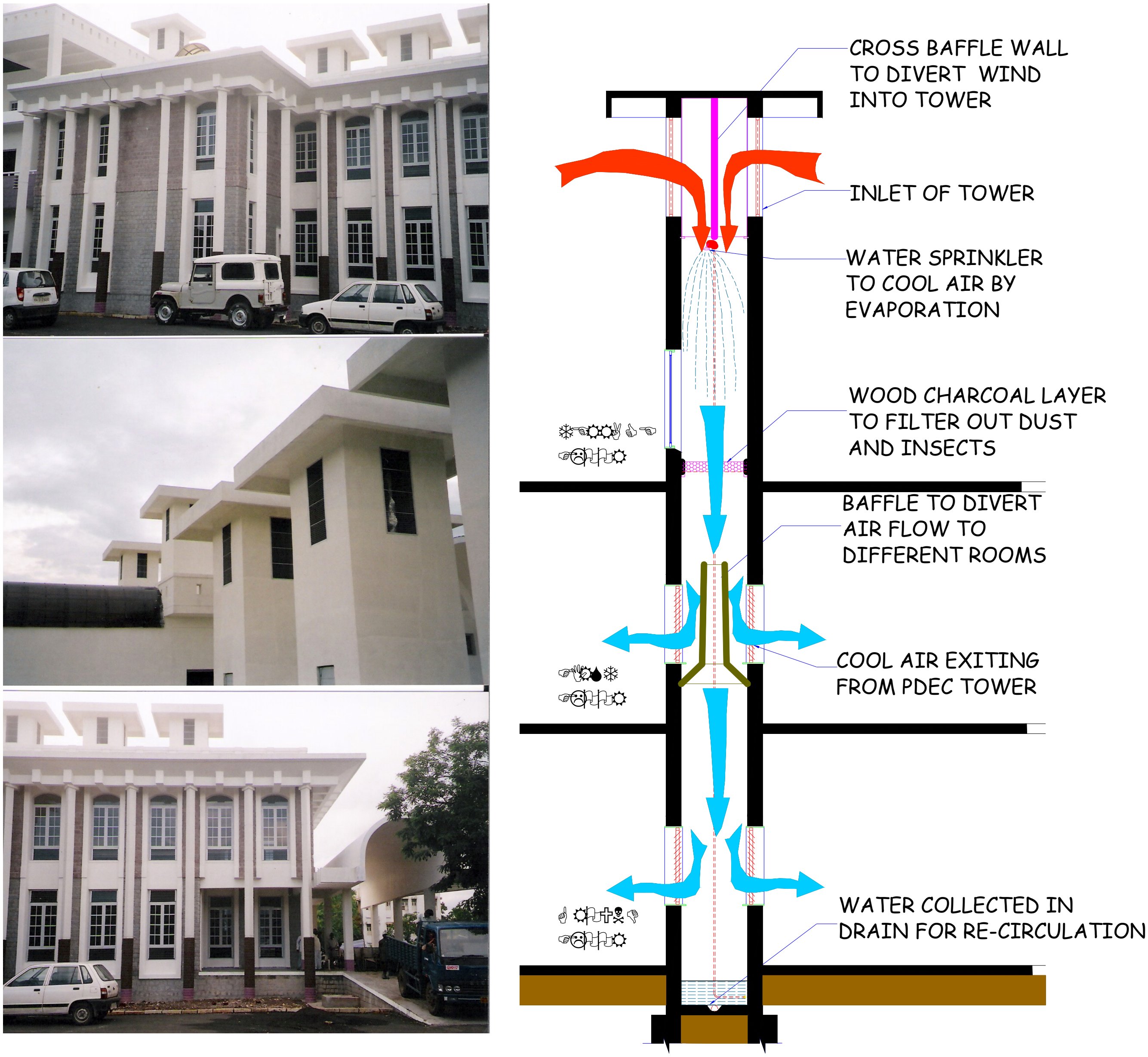


Fig. 7.2 Photgraphs of IGP Complex, Gulbarga and sketch showing the principle of a PDEC tower

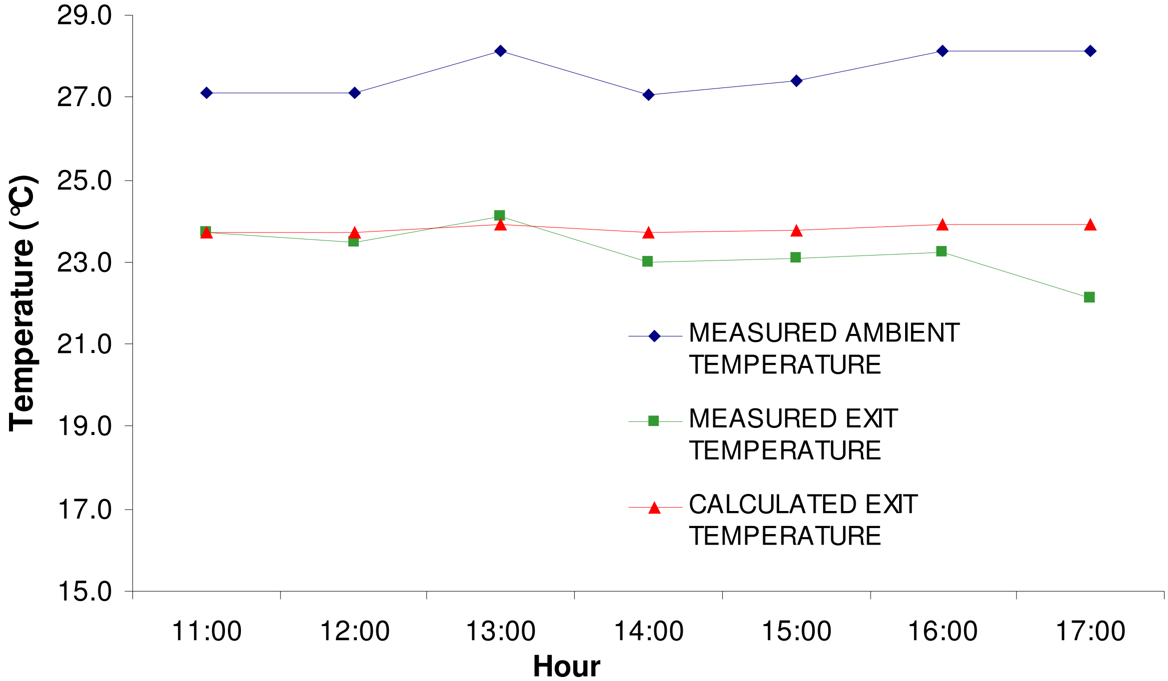


Fig. 7.3 Comparison of measured and predicted temperature of air exiting PDEC tower

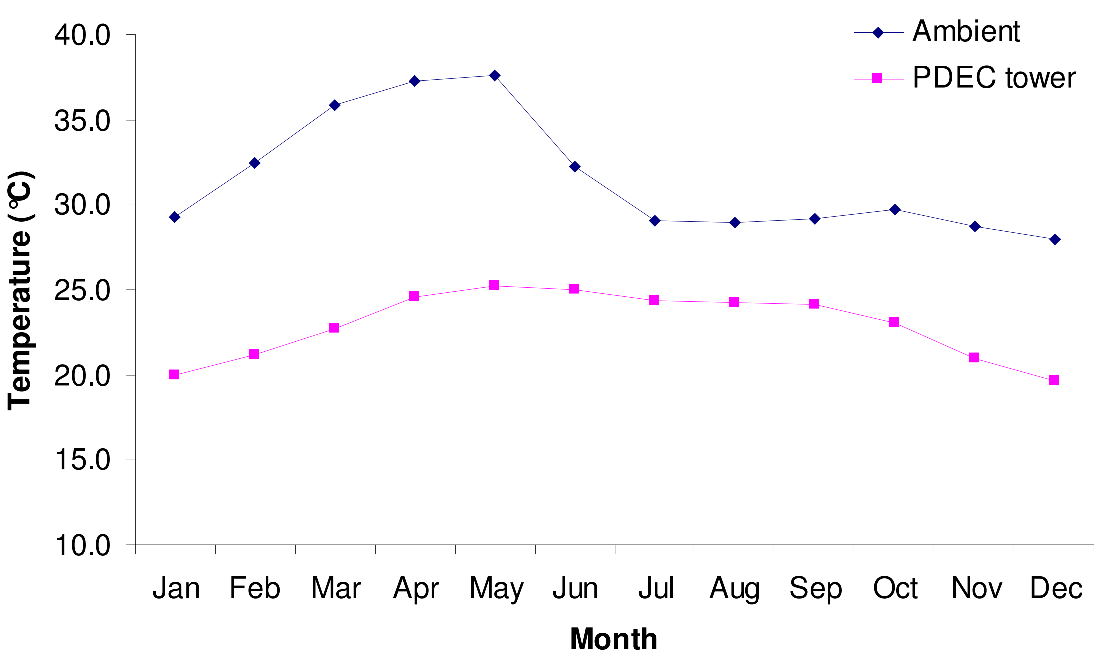


Fig. 7.4 Monthly prediction of the temperature of air exiting the PDEC tower

7.2 AUROVILLE ECOHOUSE, AUROVILLE [3]

Location : Auroville, Pondicherry
Climate : Warm and humid

Brief description of the building:

The Ecohouse was built in 1976 by a team co-ordinated by Dr. C. L. Gupta at Auroville. This house can be considered as one of the first prototypes of an ecologically sustainable building to be constructed in India in modern times. It is a two storeyed structure with longer axis along the east-west direction, designed for catching wind. A courtyard is provided in the building which is cooled by Venturi effect. The overhangs above the windows and doors are designed for optimal shading from the sun. A sketch plan and section of the Ecohouse are given in Fig. 7.5.

Energy conscious features:

- Optimum orientation of built form for cooling by ventilation
- Shading of windows to reduce heat gain
- Alternative building materials such as (i) structurally insulated roof units (size 1.0m X 0.5m), developed by Central Building Research Institute, Roorkee, (ii) jack arches of hollow ceramic Gunna tiles
- A courtyard to enhance cross ventilation and provide daylighting
- Other features such as solar cooker integrated in south facing kitchen, rainfall harvesting system, biogas plant for waste management and production of methane gas for cooking, an aero- generator for domestic electric load and a thermosyphon solar water heater are also incorporated into the building design

Performance of the house:

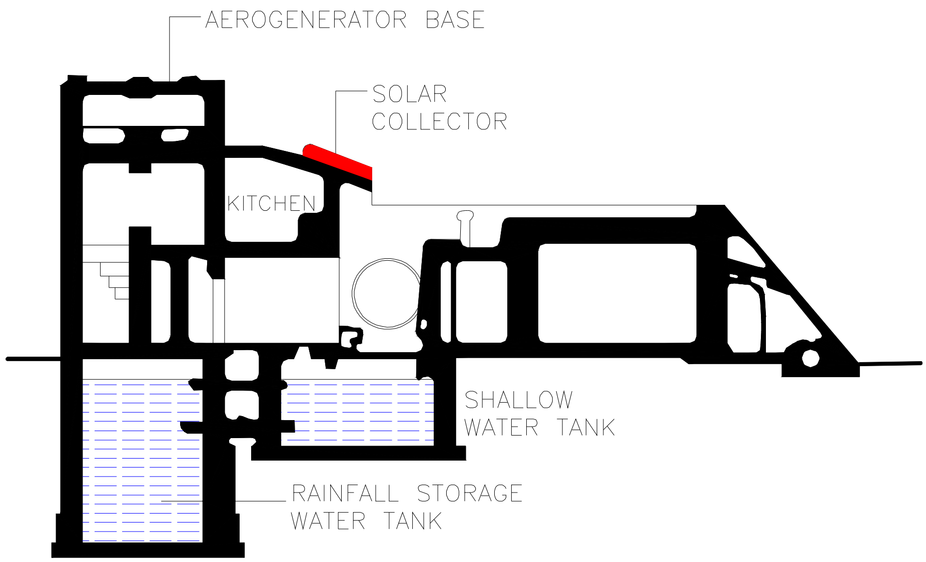
The house has no fans and is reported to be one of the coolest houses in Auroville as observed by the occupants.

7.3 CENTRE FOR APPLICATION OF SCIENCE AND TECHNOLOGY FOR RURAL AREAS (ASTRA), BANGALORE [4]

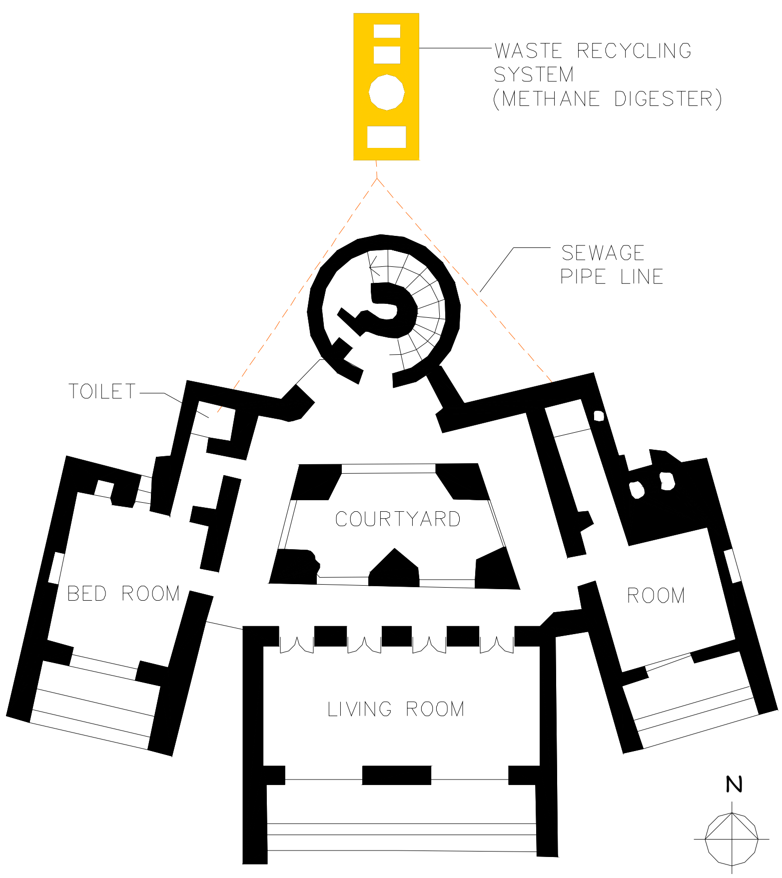
Location : Bangalore, Karnataka
Climate : Moderate

Brief description of the building:

The building is a ground and one-storeyed structure and is used as an office building. The salient feature of the building is the use of various alternative building



(a) Section of Ecohouse



(b) Sketch plan of Ecohouse

Fig. 7.5 Section and sketch plan of Ecohouse, Auroville

materials that are affordable, environment friendly and energy efficient. It was built in 1999 in the campus of the Indian Institute of Science, Bangalore. Figure 7.6 shows the typical floor plan of the building. A photograph of the building is given in Fig. 7.7.

Energy conscious features:

- Sized stone masonry with composite mortars in foundations, steam-cured stabilized blocks for ground floor load-bearing walls, and soil-cement blocks for the first floor walls. The external exposed walls are coated with transparent silicone paint for protection from erosion
- Precast chajjas and brackets are made of ferrocement
- Reinforced blockwork lintels are used above openings such as doors and windows
- Soil-cement block filler slabs are used for floors and roof. An additional weatherproof course using tiles is provided on the roof

Performance of the building:

The cost of construction of this building was Rs. 4247 per square metre of plinth area in 1999. The component-wise cost of the building and the corresponding percentage of total cost are presented in Table 7.1.

7.4 SOLAR ENERGY CENTRE, GURGAON [5,6]

Location : Gurgaon, Haryana.
Climate : Composite (predominantly hot)

Brief description of building :

It is a single storeyed research centre. The buildings include a guest house, a workshop, offices and laboratories. Being situated on a large open plot of land, the buildings are spread out and possess courtyards around which the various activities are clustered. A plan and section of the administrative block of the same is given in Fig. 7.8.

Energy conscious features:

- Roof surface evaporative cooling system
- Appropriate planning in which laboratories requiring air conditioning are put together in a well-insulated building
- Hollow concrete block walls to resist heat gain by conduction
- Reflective finish on roof surface
- Windows designed for cross ventilation and daylighting. The east and west-facing windows incorporate openable louvered shutters

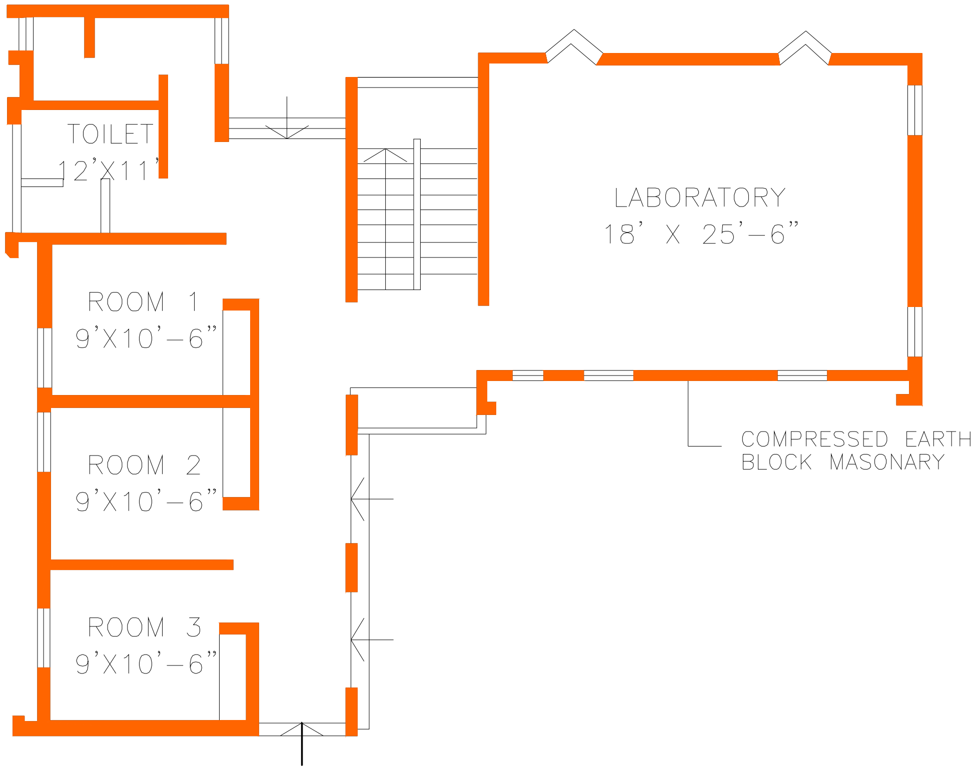


Fig. 7.6 Ground floor plan of ASTRA building, Bangalore

Fig. 7.7 Photograph of ASTRA building, Bangalore

Table 7.1 Component-wise distribution of costs of ASTRA building at I.I.Sc., Bangalore

Effective plinth area = 280m^2, Carpet area = 223.64m^2
Cost of construction per m^2 of plinth area = Rs.4247/m^2 (Rs.395/ft^2)

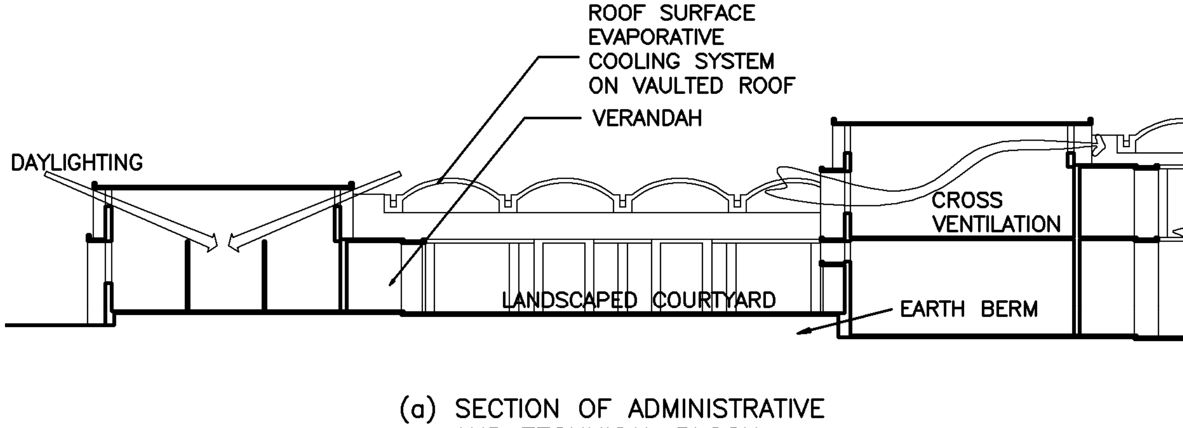
Component	Cost (Rs.)	% of total cost
Structure		
• Foundation	1,01,799.00	8.8
• Plinth	6,797.00	0.6
• Walls/beams	3,28,022.00	28.2
• Roof & Floor slabs	1,88,811.00	16.3
• Staircase	10,828.00	0.93
Sub-total	6,36,257.00	54.8
Openings		
• Doors & Windows	1,08,720.00	9.4
• Lintel & Chajjas	16,039.00	1.4
Sub-total	1,24,759.00	10.8
Finishes		
• Flooring	38,233.00	3.3
• Painting	32,377.00	2.8
Sub-total	70,610.00	6.1
Services		
• Plumbing & Sanitary	1,40,861.00	12.1
• Electrical	1,58,829.00	13.7
Sub-total	2,99,690.00	25.8
Architect fee	30,000.00	2.5
Miscellaneous	27,942.00	
Total cost	11,89,258.00	

<u>Materials used:</u>

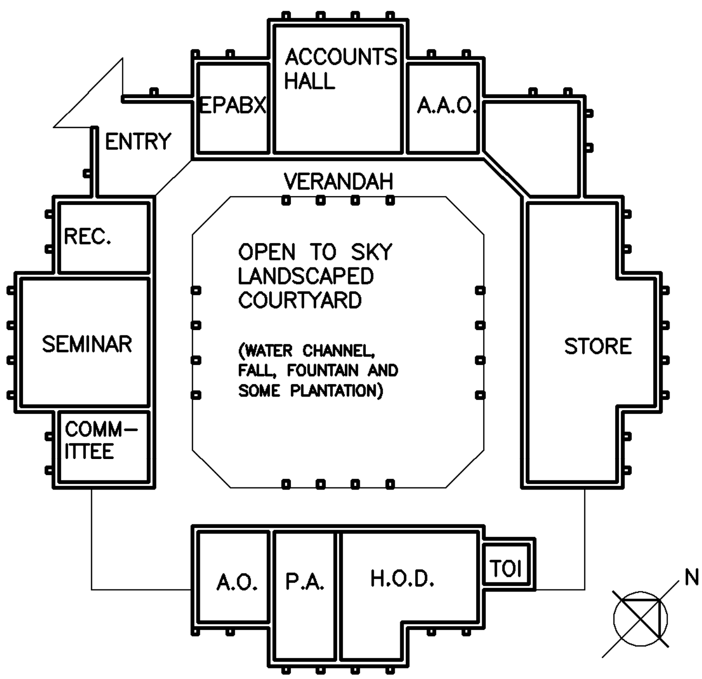
(A) Cement: 842 bags (B) Lime: 5.5 tonnes (C) Steel: 2.66 1MT

1) Volume of bed concrete (1:4:8) : 9.86 m^3
2) Size tone masonry in foundation : 71.68m^3
3) Plinth beam: a) Concrete : 1.497m^3, b) steel : 420 kgs (Reinforced masonry)
4) Volume of masonry walls (load bearing) : 101.33 m^3
5) a) Roof area : 271.56m^2 a) Concrete: 34.03m^3, b) Steel: 2.241MT
   b) Floor area : 223.64 m^2
6) Area: a) Doors: 24.80 m^2, b) Windows : 24.08 m^2

<u>Miscellaneous items:</u>
Jali works, Parapet



(a) SECTION OF ADMINISTRATIVE
AND TECHNICAL BLOCK



(b) PLAN OF
ADMINISTRATIVE BLOCK

Fig. 7.8 Administration block of Solar Energy Centre, Gurgaon

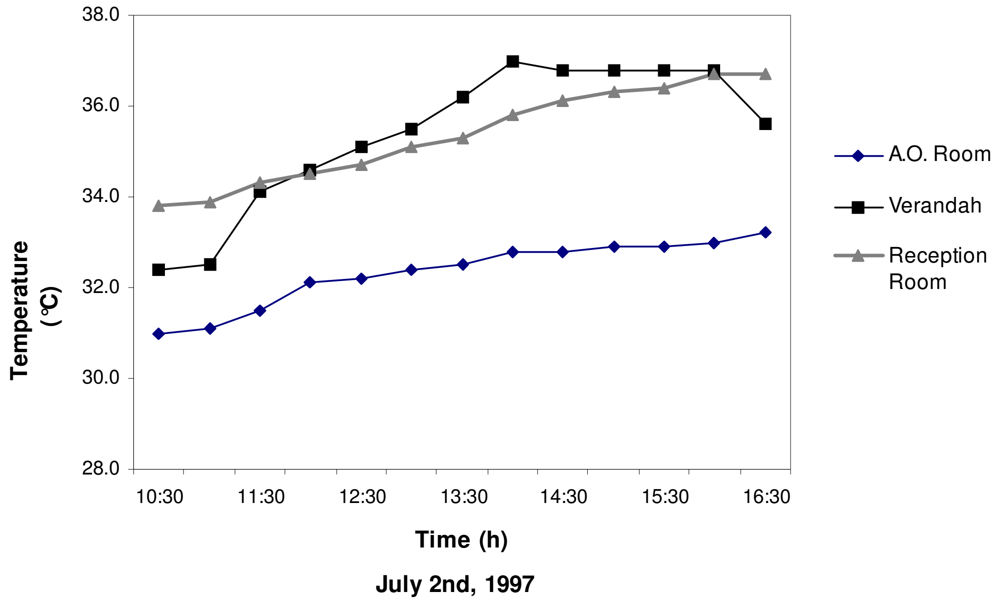


Fig. 7.9 Comparison of indoor temperatures – Solar Energy Centre, Gurgaon

Performance of the building:

The Solar Energy Centre conducted a post-occupancy evaluation of this building [5]. It was observed that the roof surface evaporative cooling (RSEC) system caused a lowering of temperature by 2-3ºC in comparison with rooms without RSEC system. Figure 7.9 shows the comparison of measured temperatures of the reception room (with RSEC system) with those of A.O. room and verandah, both being without RSEC system. One advantage of the RSEC system is that it cools in a healthy manner as it does not humidify the ambient air of the room. On the other hand if a desert cooler were to be used, it would pump moist air inside the room and increase the humidity, which would cause discomfort and affect the health of occupants.

7.5 H.P. STATE CO-OPERATIVE BANK BUILDING, SHIMLA [6,7]

Location : Shimla, Himachal Pradesh
Climate : Cold and Cloudy

Brief description of building :

This building is a ground and three-storeyed structure with its longer axis facing the east-west direction. The smaller northern wall faces the prevailing winter winds from the north-eastern direction. The building shares a common east wall with an adjoining structure. Its west façade overlooks a small street from which the building draws its main requirements of ventilation and daylighting. A plan and section of the building showing the various passive techniques incorporated is given in Fig. 7.10.

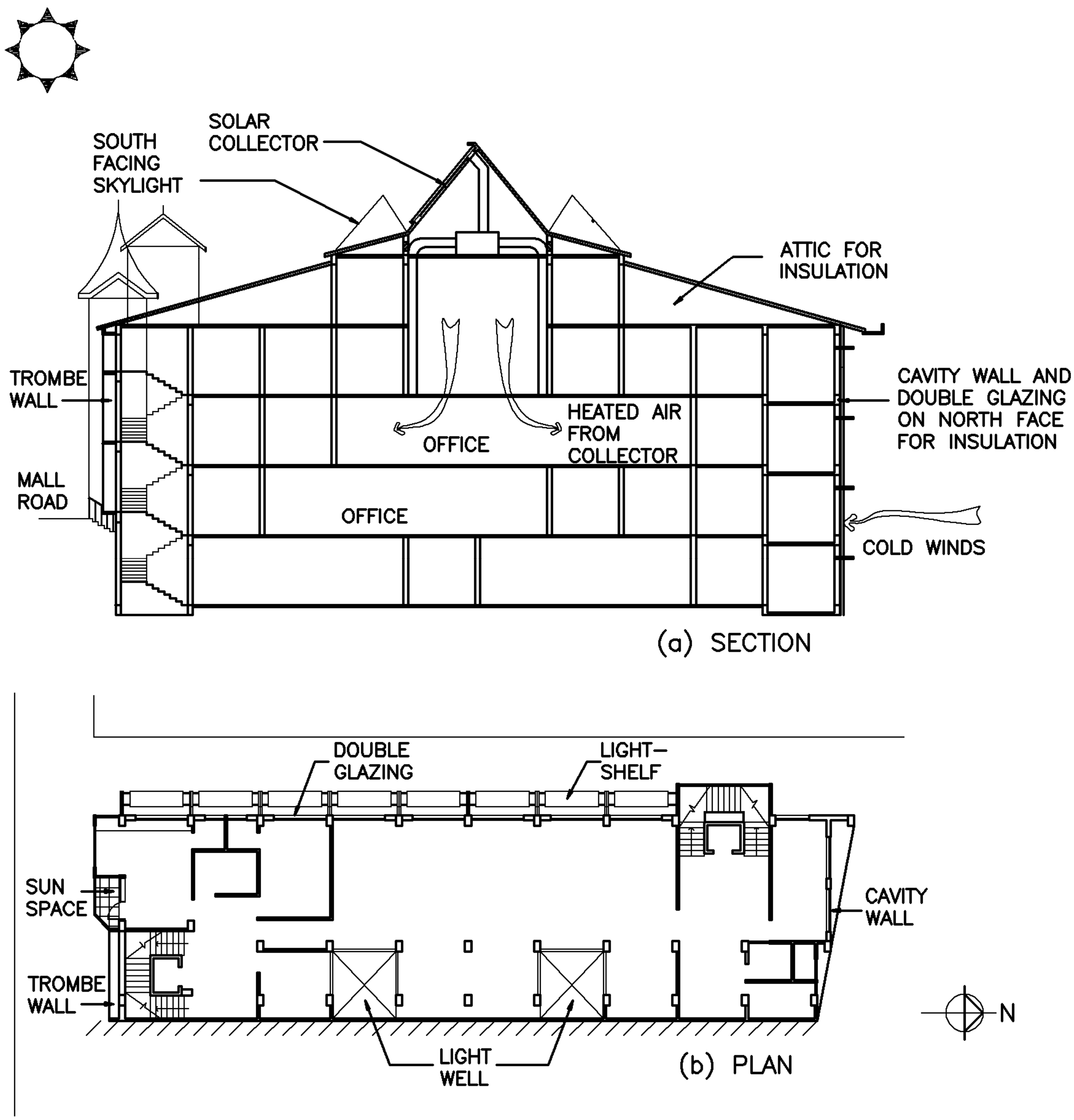


Fig. 7.10 Section and plan of H. P. state co-operative bank, Shimla

Energy conscious features:

- South-facing Trombe wall and sunspace heats up the interior
- South-facing solar collectors on the roof provide warm air, which is circulated by means of ducts

- North face is protected by a cavity wall that insulates the building from prevailing winter winds
- Western wall is provided with insulation as well as double glazing
- Daylighting is enhanced by providing light shelves. Skylight on the terrace also provides daylighting
- Air lock lobbies are provided to reduce air exchange

Performance of the building:

The predictions of the energy savings of the building (component-wise) per annum, as compared to a conventional building are as follows:

West wall (double glazing and insulation)	= 43248 kWh
Roof insulation	= 23796 kWh
Roof top solar collector	= 10278 kWh
Trombe wall	= 7398 kWh
Total	= 84720 kWh

7.6 S.O.S. TIBETAN CHILDREN'S VILLAGE, CHOGLAMSAR [8]

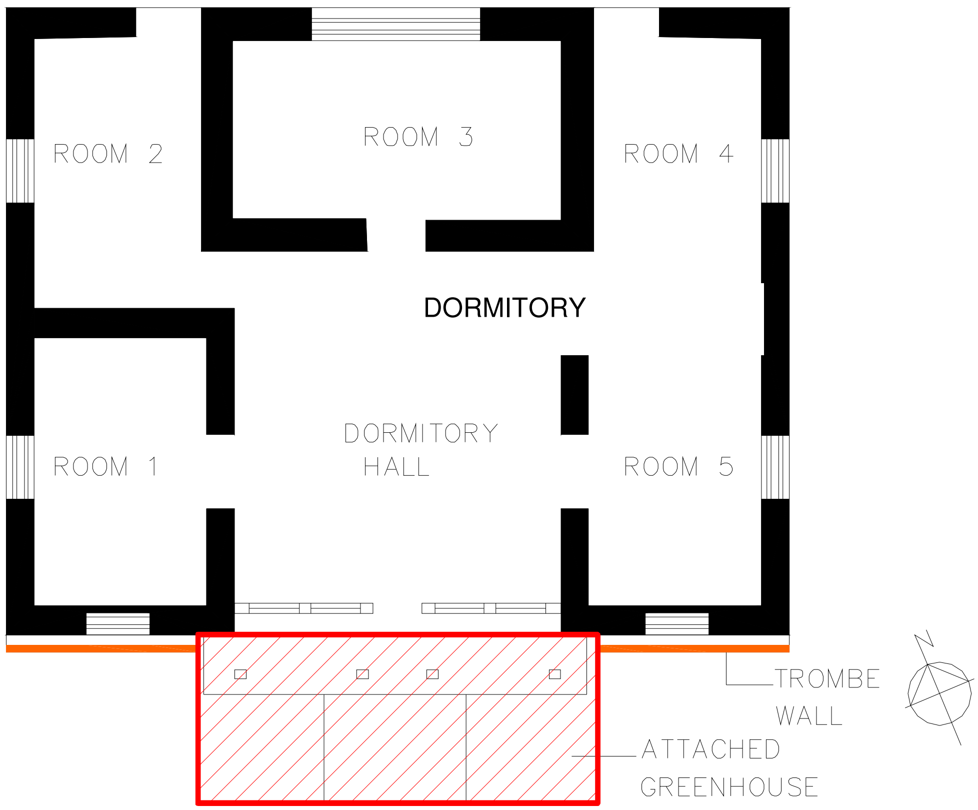
Location : Choglamsar, Leh
Climate : Cold and dry

Brief description of the building:

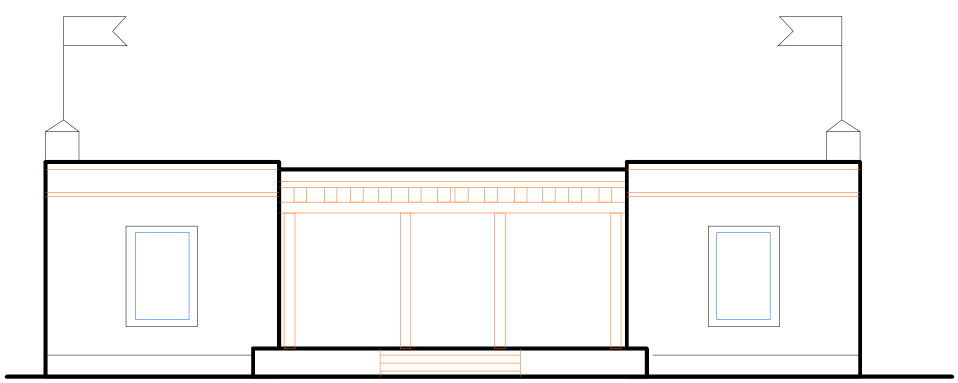
Twenty existing ground storey structures acting as dormitories have been retrofitted with an attached green house and vented Trombe walls, in the extremely cold region of Leh. The original construction consists of solid adobe for walls (U-value 1.64 W/m^2-K) and wooden roof with mud topping (U-value 2.44 W/m^2-K). The floor is of wooden deck over a crawl space. A sketch plan and section of a typical building are given in Fig. 7.11.

Techniques:

- The common room in the centre is provided with an attached green house facing south for trapping heat. The extended floor of the green house consists of solid masonry to provide good thermal storage mass of 1.44 MJ/m^2-K. The green house is fitted with a movable internal shade for the ceiling. The common room receives heated air by opening the vents of the adjacent glass wall of the green house.
- Two end rooms on the south side are provided with double glazed, vented Trombe walls for heating.



(a) Sketch plan



(b) Elevation

Fig. 7.11 Sketch plan and elevation of S.O.S building, Choglamsar

Performance of the building:

Table 7.2 gives the measured temperature data, namely, the maxima and minima for the Trombe wall room, green house, a room without solar heating (control room) and ambient temperature. It is seen that in winter months, the maximum and minimum temperature can be appreciably higher than both the ambient temperature as well as the room without solar heating (control room).

Table 7.2 Monthly mean measured temperature – (S.O.S. Tibetan children's village)

Year	Month	Maximum Temperature (^{O}C)					Minimum Temperature (^{O}C)				
		Trombe		Greenhouse		Ambient	Trombe		Greenhouse		Ambient
		Solar	Control	Solar	Control		Solar	Control	Solar	Control	
1980	September	32.2	27.0	29.6	26.2	17.4	20.0	16.6	17.6	14.5	6.3
	October	29.4	20.7	25.6	-	11.6	16.2	11.4	13.4	-	1.2
	November	21.8	13.7	20.5	-	7.1	11.6	5.9	5.8	-	-5.6
	December	21.6	10.2	17.0	-	2.8	6.8	2.4	4.6	-	-9.4
1981	April	24.0	19.0	24.8	-	11.6	17.0	14.0	15.0	-	-1.6
	May	25.8	23.6	25.2	22.2	16.6	21.0	19.0	19.0	17.0	3.2
	June	27.8	26.8	29.4	25.0	19.6	21.0	20.4	21.0	20.0	7.0
	July	31.1	29.2	31.8	28.6	25.0	25.4	23.6	24.0	23.0	12.8

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