

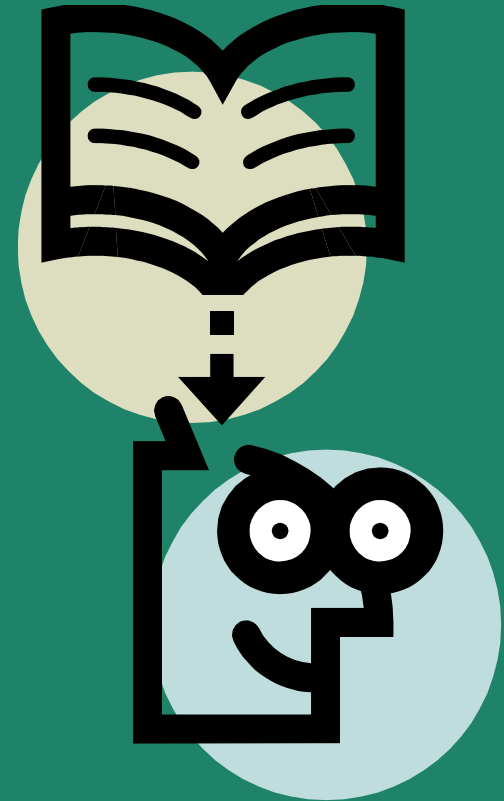
# Passive Downdraught Evaporative Cool Towers

Dr A B Datye

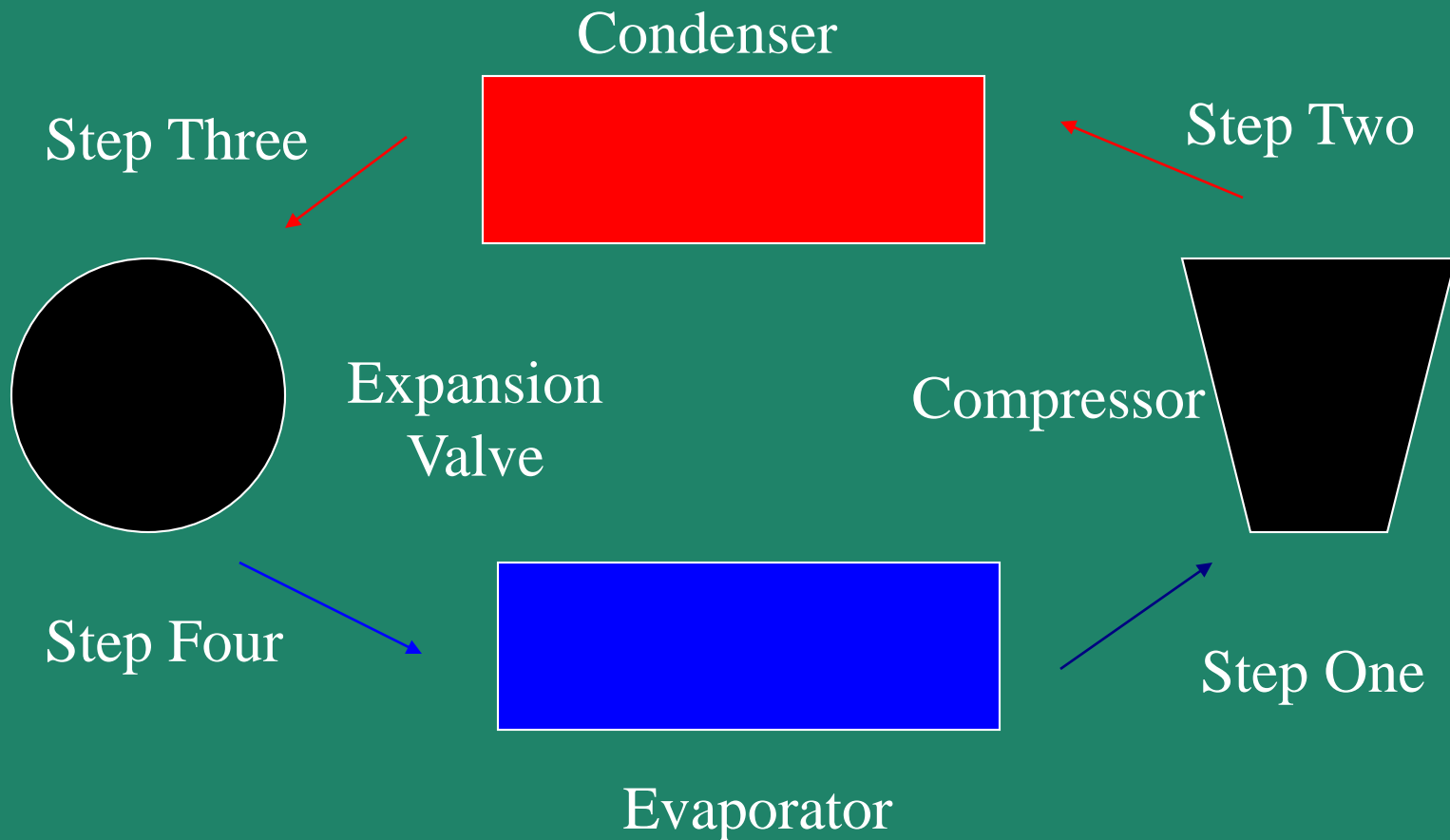
Shivaji University Kolhapur

# Definitions

- Air Conditioning: process of treating air to control simultaneously its temperature, humidity, cleanliness, and distribution to meet the requirements of the conditioned space



# Refrigeration Cycle Simplified



# Cooling Towers

- More expensive-more efficient
- Dependent on relative humidity & barometric pressure
- Air blows through stream of water causing some to evaporate
- Water flows through thick sheet of mesh plastic
- Air blown through plastic at right angles to water flow
- Water cooled by evaporation
- Water constantly added to compensate for evaporation



# Introduction

- ⌘ **PSA** : an ancient concept
- ⌘ **Modern science has provided quantitative support**
- ⌘ **Large potential for energy conservation**
- ⌘ **Can lead to a thermally comfortable indoor environment**

## ⌘ DEFINITION

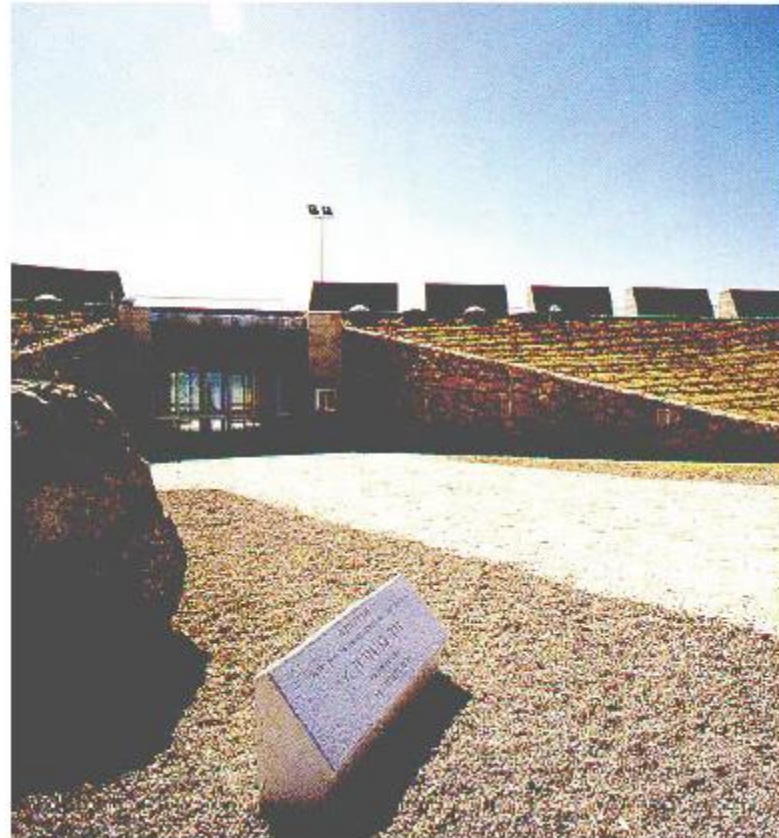
☒ **Collection, storage, distribution and control of energy flow by natural processes of heat and mass transfer**

## ● WORKING DEFINITION

- **Use natural energy (sun, wind, etc.) to conserve conventional energy for achieving thermal comfort**
- **Thermal comfort refers to comfortable indoor conditions (temperature, humidity, air movement)**

# Examples: NEGEV

- ⌘ **ARID CLIMATE**
- ⌘ **PARTIAL SUNK**
- ⌘ **EARTH-BERMING**  
**( $U=0.19 \text{ W/m}^2\text{-K}$ )**
- ⌘ **ROOF INSULATION**  
**( $U=0.28 \text{ W/m}^2\text{-K}$ )**
- ⌘ **SHADING**
- ⌘ **CROSS-VENTILATION**



# Earth Berming





# PASSIVE DOWNDRAFT EVAPORATIVE COOLING SYSTEM

A system of inlet and outlet shafts

Locations, sizes and heights :  
generate required air movement

A fine spray of water cools the air at entry

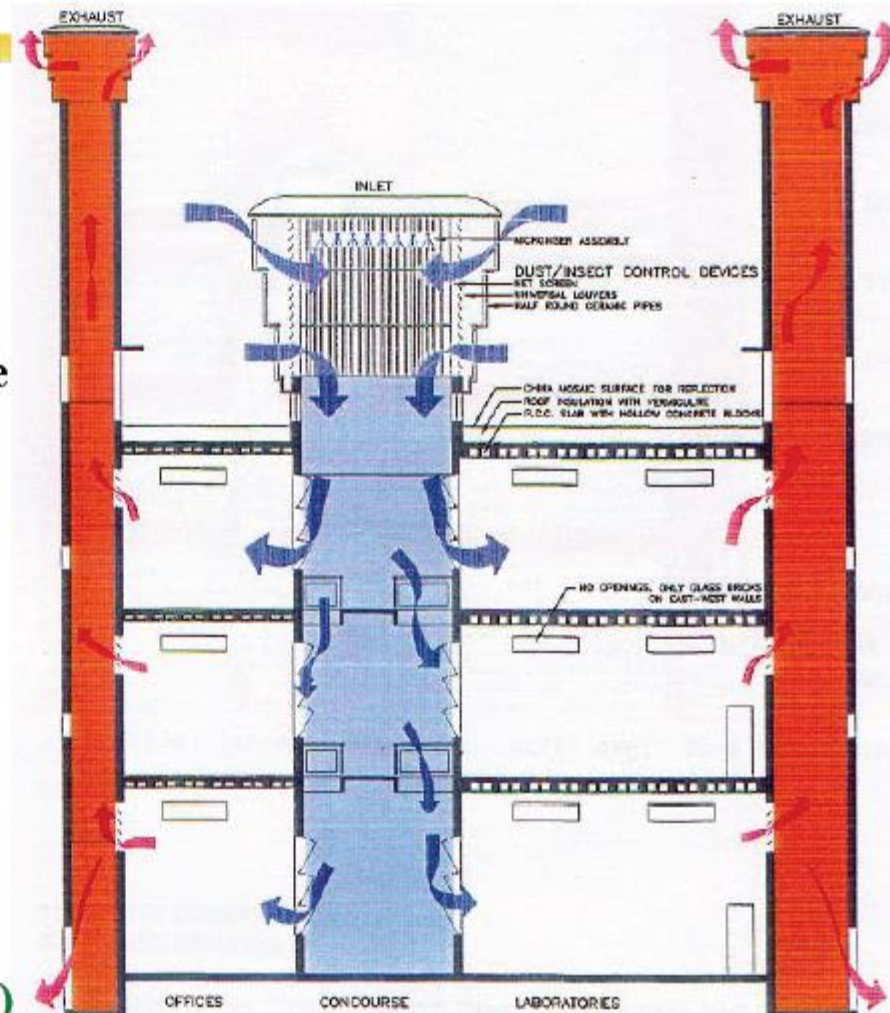
6-9 air change rates per hour observed

**Strategy:**

**Hot season:** evaporative cooling

**Monsoon:** cooling off, induce ventilation by fans

**Winter:** ventilation minimised  
(inlets closed by shutters)





# **TORRENT RESEARCH CENTRE, AHMEDABAD**

**HOT & DRY CLIMATE**

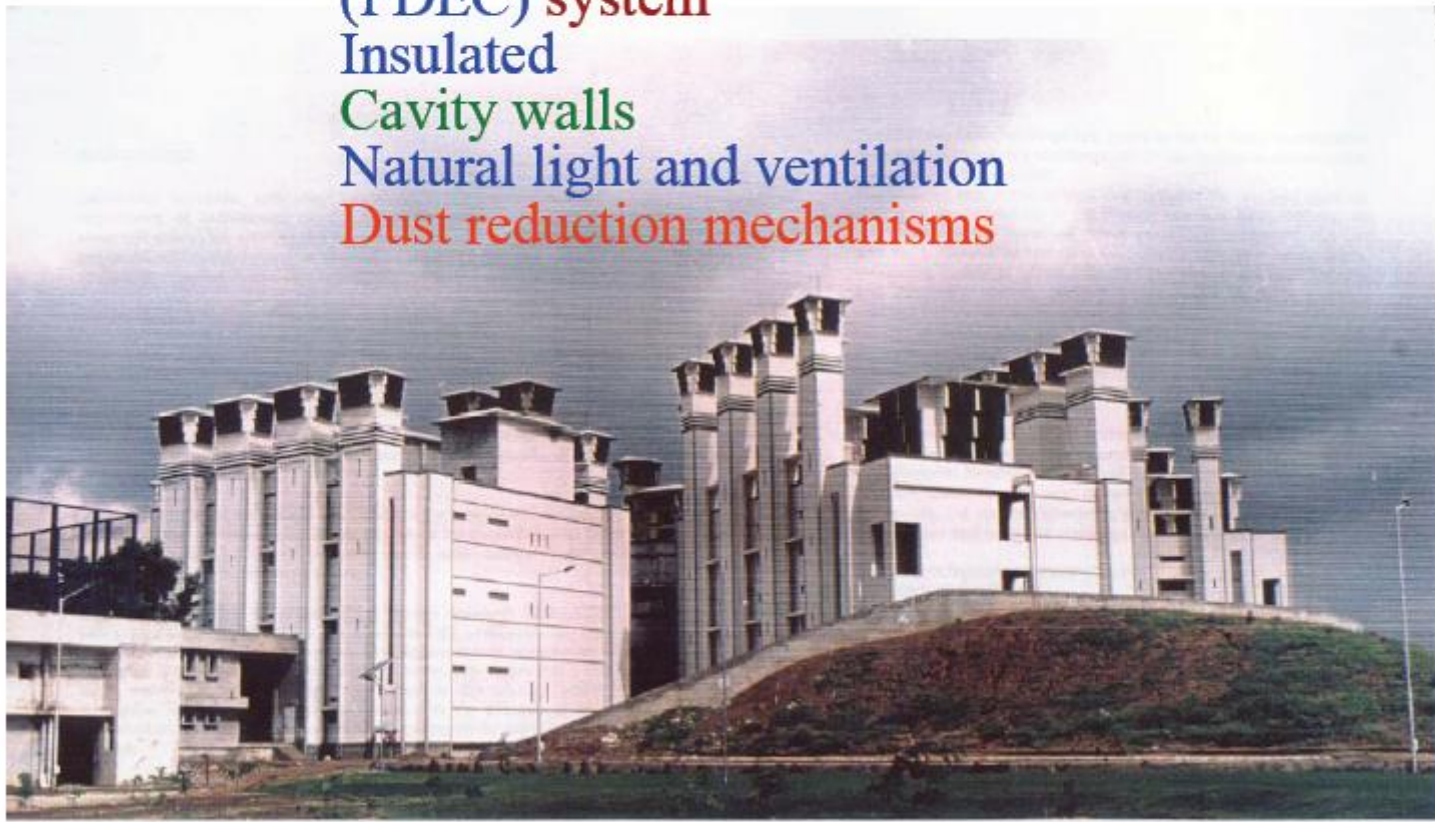
**BUILDING: Passive down-draft evaporative cooling (PDEC) system**

**Insulated**

**Cavity walls**

**Natural light and ventilation**

**Dust reduction mechanisms**



# Implications of PDEC system

## ADVANTAGES

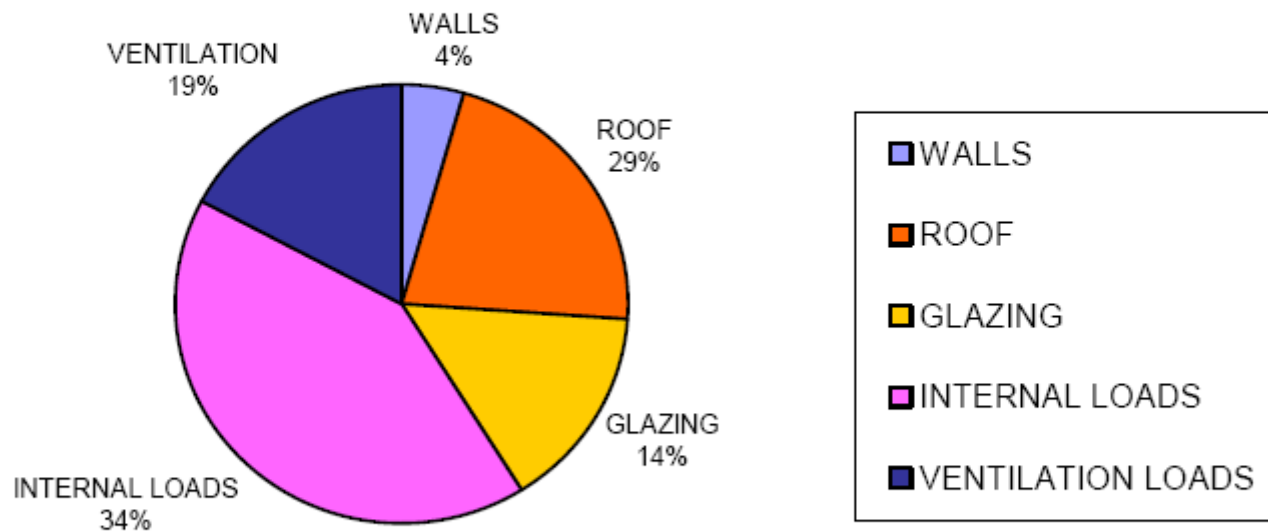
- Low cost single pass system
- Easy to maintain
- Entry of birds and pests prevented
- Charcoal tray to filter out dust
- Sophisticated water treatment is not required
- Single tower serving multiple floors
- Can be used for pre-cooling the building at night

## DISADVANTAGES

- High humidity
- Noise due to spraying of water

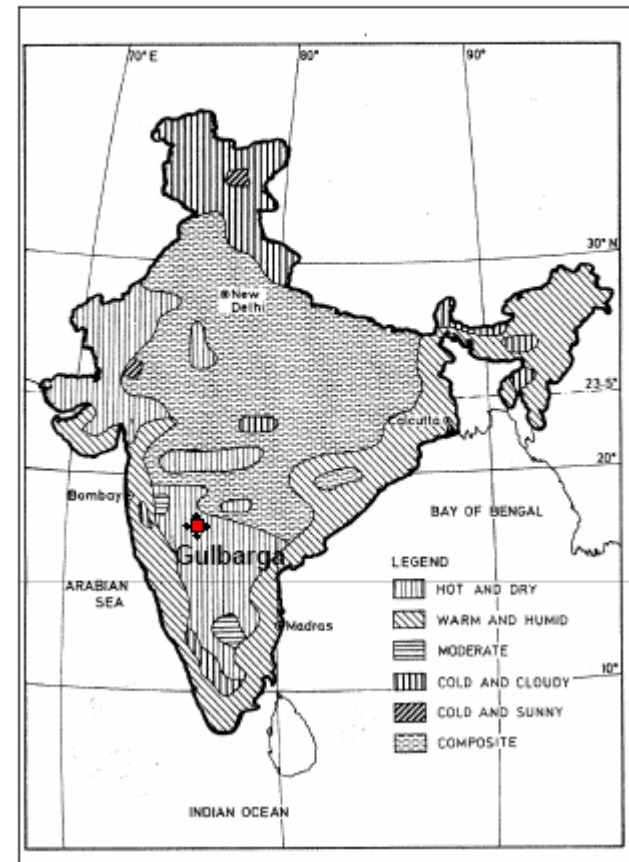


# Cooling Loads - Typical Room



# Climatic Zones of India

- **HOT & DRY**
- **WARM & HUMID**
- **MODERATE**
- **COMPOSITE**
- **COLD & SUNNY**
- **COLD & CLOUDY**



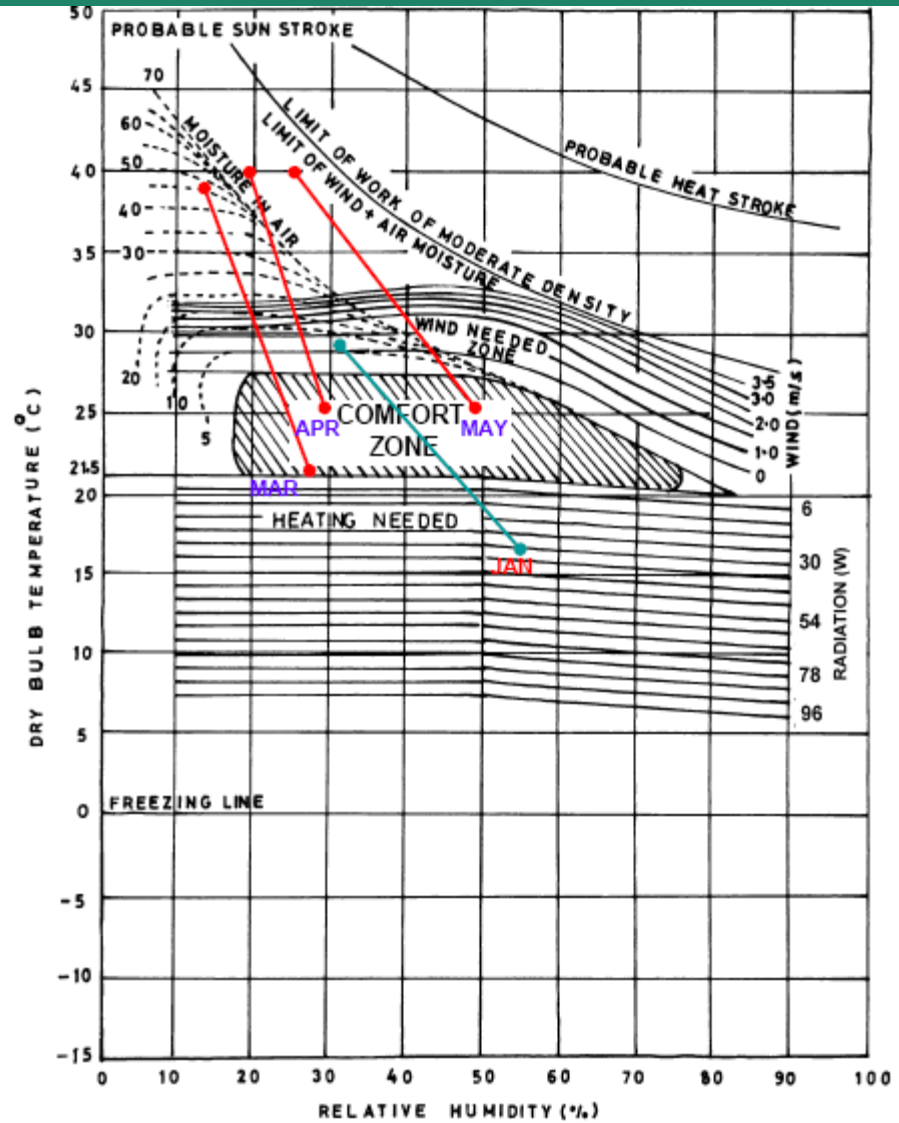


## Passive Downdraft Evaporative Cooling (PDEC) System



**Inspector General of Police  
(I.G.P.) Complex, Gulbarga**

# Bio-climatic Chart

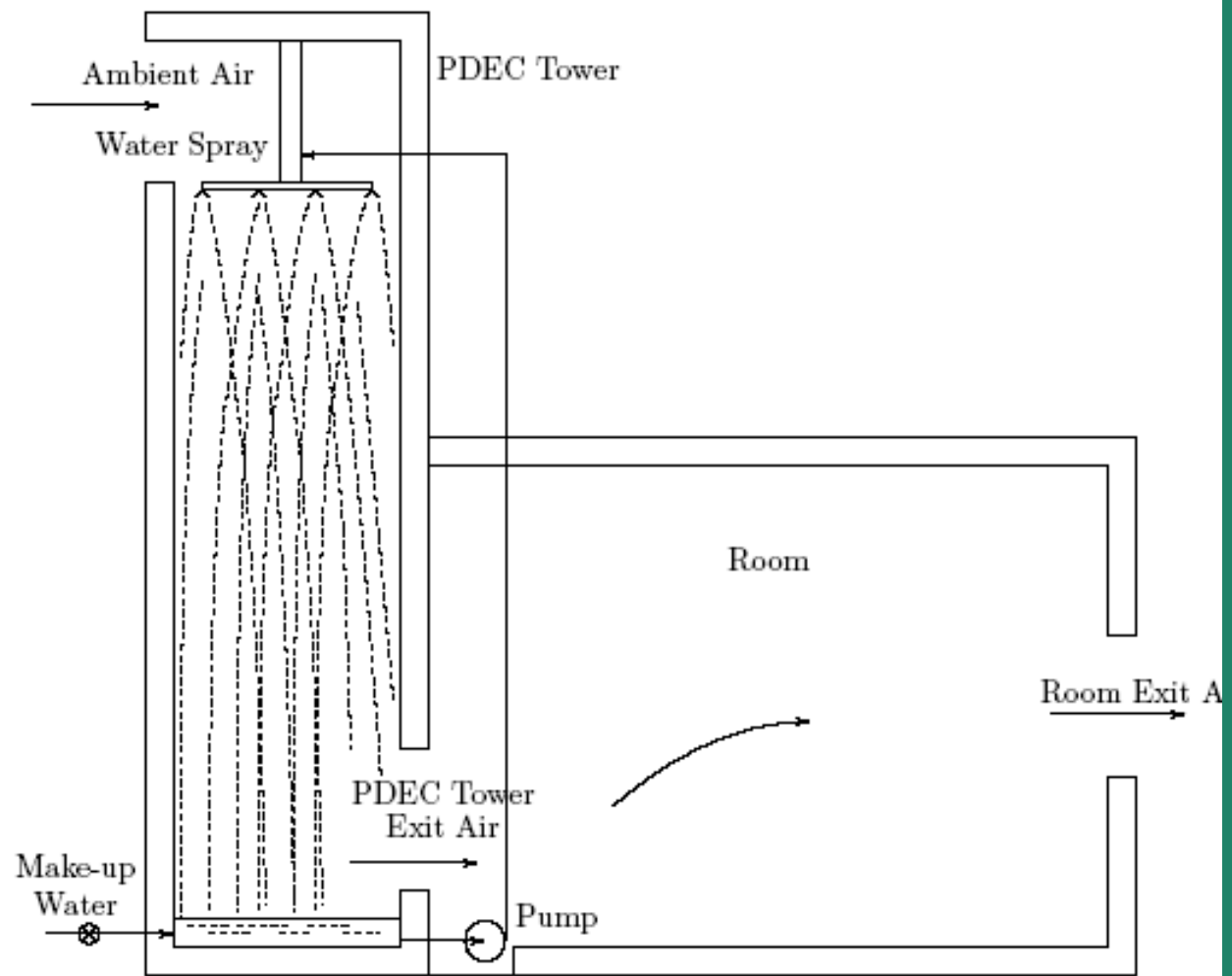


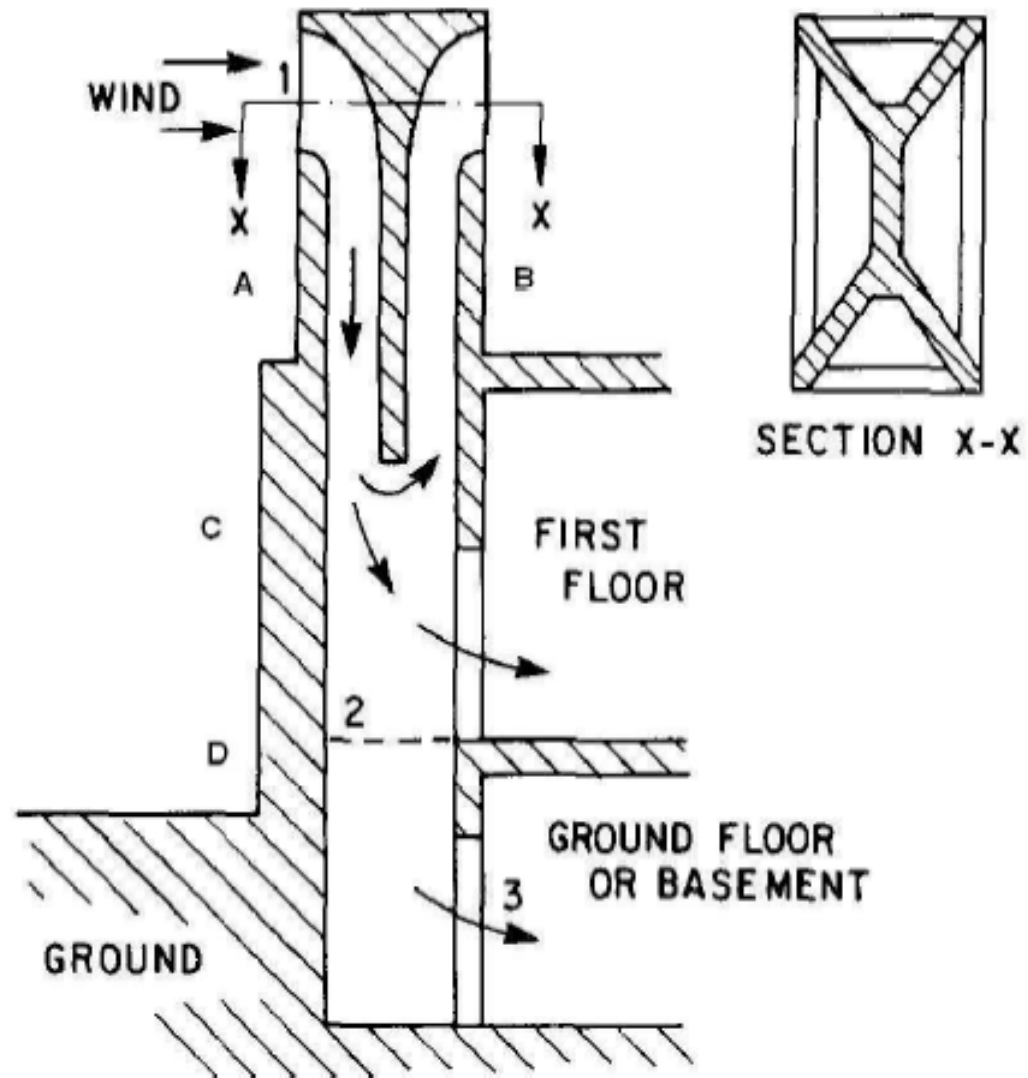


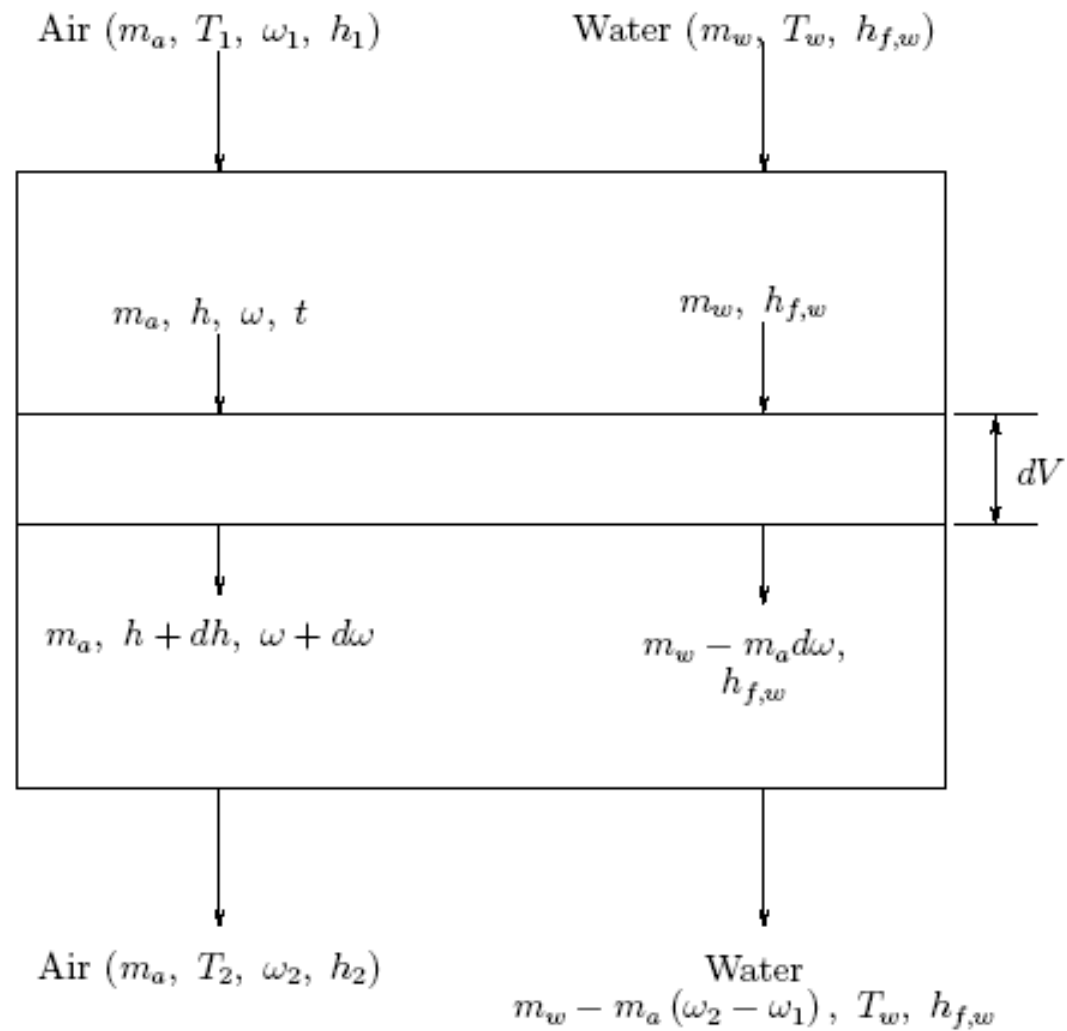
# Hot and Dry Zone

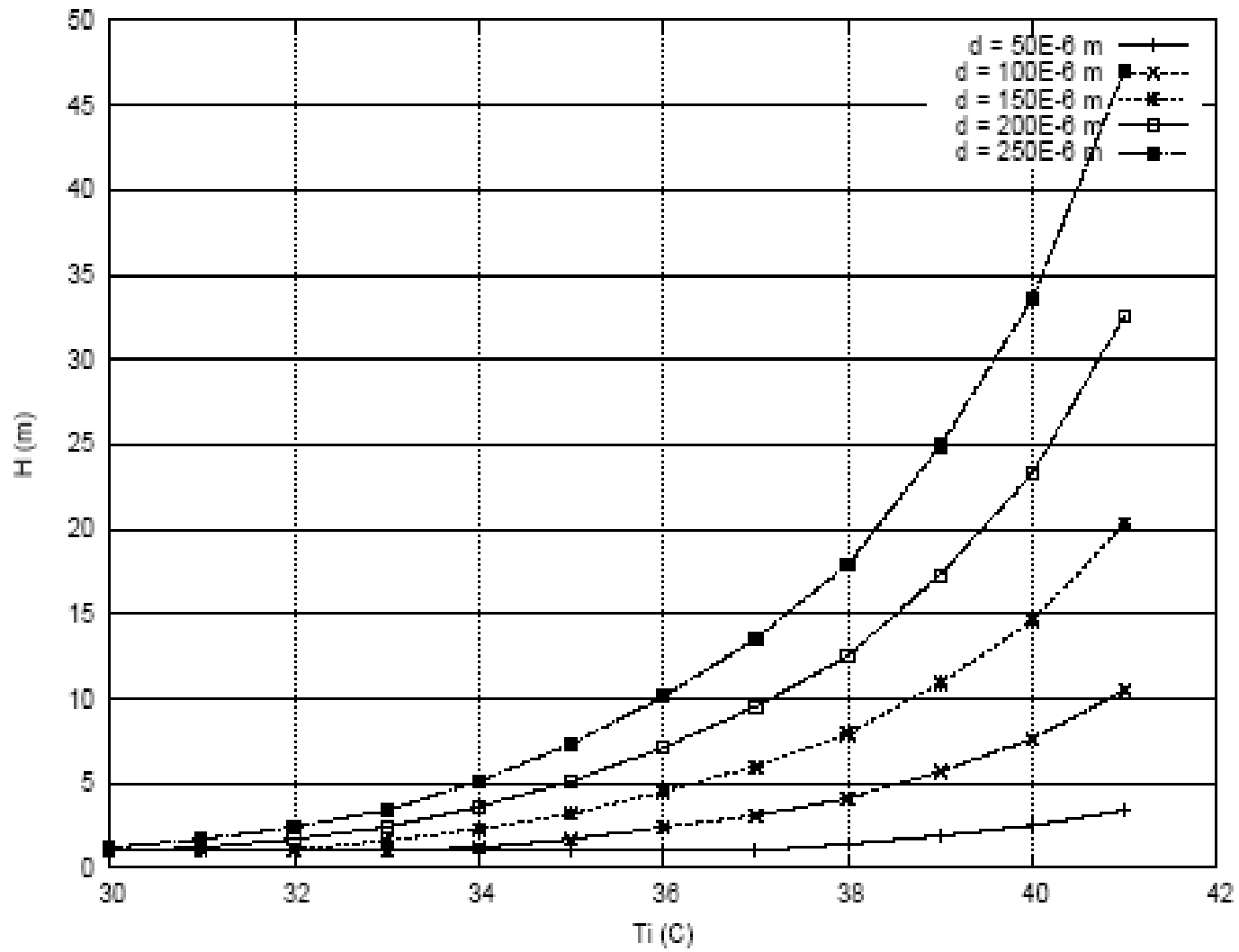
Low-rise passive cooled  
office building

- **Identification of Climatic Zone**
  - **Analysis of Climate**
- **Analysis of Building Design**
  - **Indoor Temperature**
  - **Cooling Loads**
- **Passive Technique**
  - **Passive Downdraft Evaporative Cooling Tower**
- **Implications of Design**

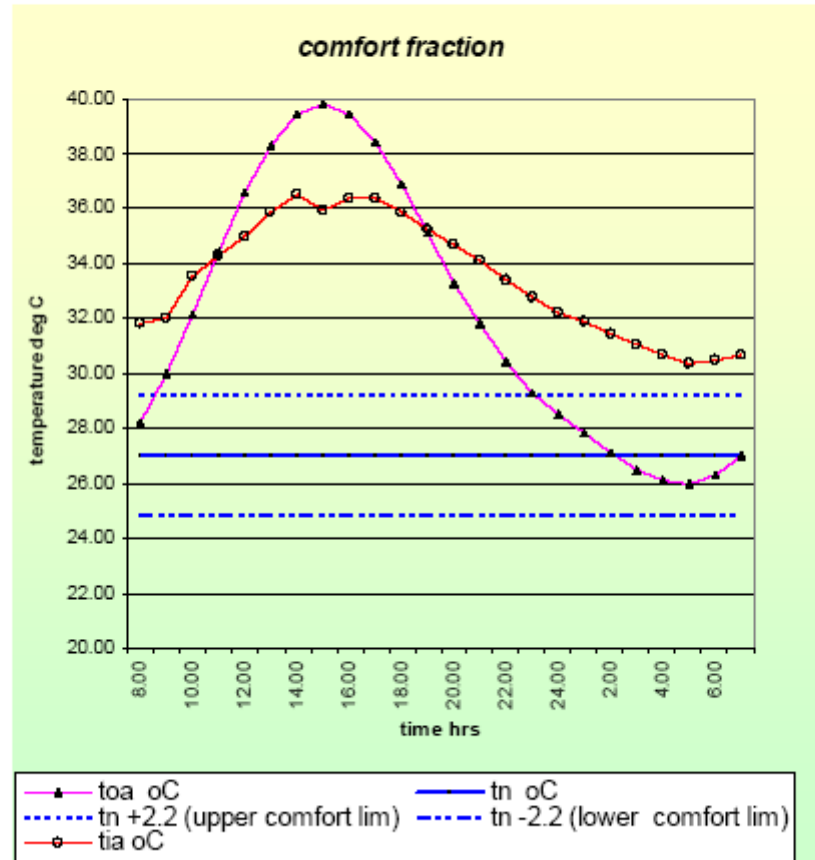








# Inside Temperature of a Typical Room



# Performance of PDEC at Gulaberga

Location	Dry-bulb Temperature, °C			Relative Humidity, %		
	Lowest	Average	Highest	Lowest	Average	Highest
Ambient	32.8	38.25	41.7	14	24.4	43
First Floor	29.5	30.36	32.6	34	51.8	64
Ground Floor	27.9	28.77	30.9	42	63.47	77

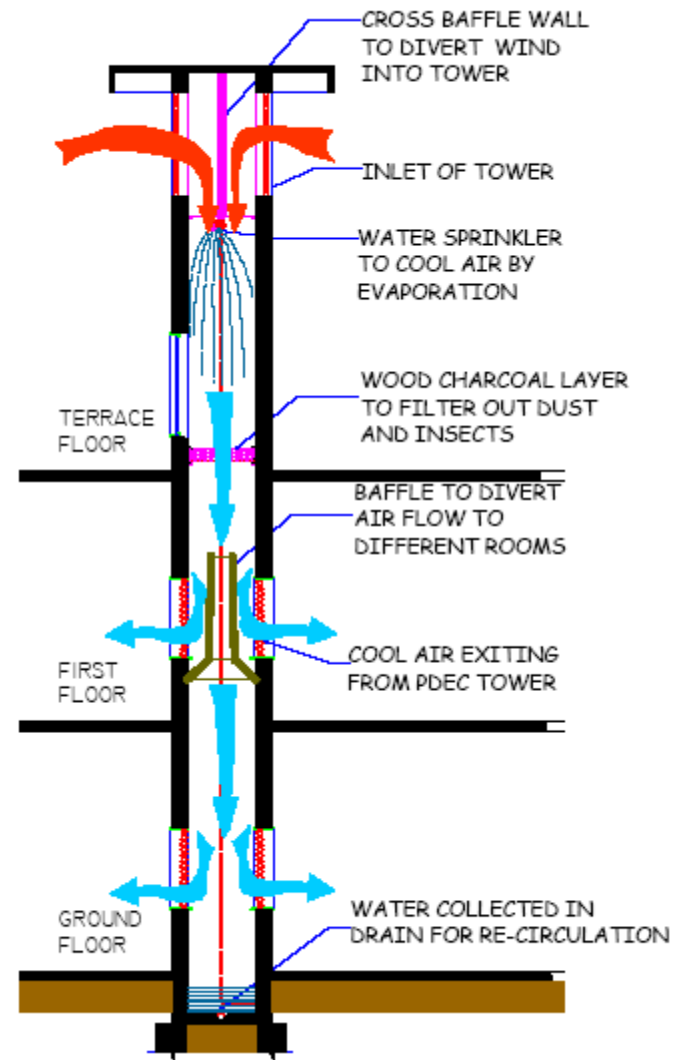


# Design of PDEC System

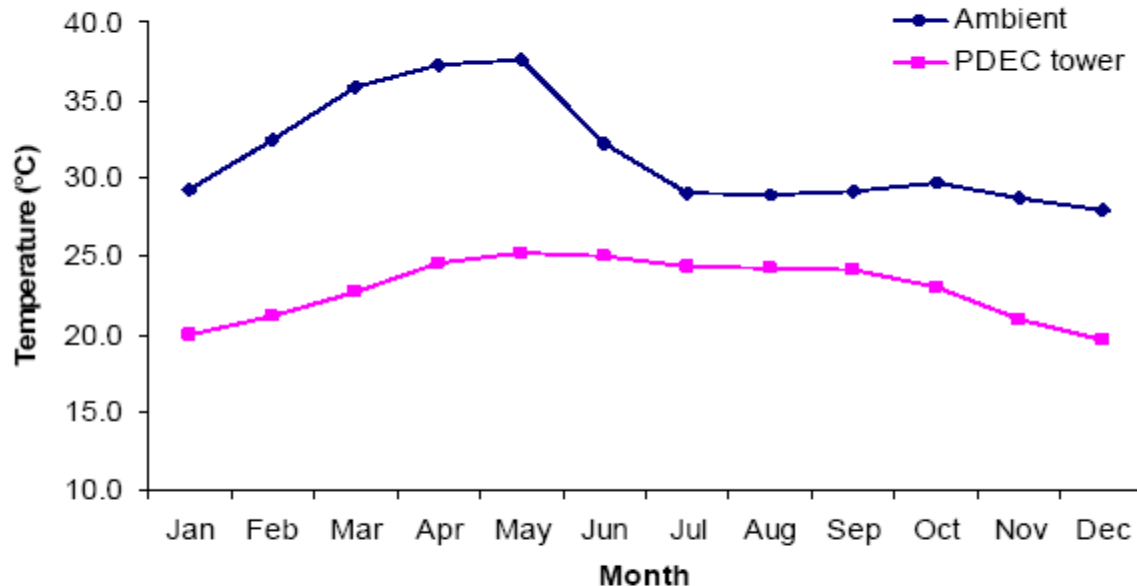
- Ambient hot-dry air is trapped, cooled by evaporation of water and then introduced in the building.
- Simple system based on shower spray system developed by B. Givoni
- Cost = 17.5 lakhs
- Area cooled = 1100sqm.
- Estimated Performance in May :
  - Outside air temperature = 38 °C
  - Temperature of air = 25 °C (at exit of tower)
- About 4 - 10 air changes per hour

Note:

Approximate cost and area



## Estimated performance of PDEC tower in various months



- **PDEC system works very well in the summer months**

For example, in May, the temperature of cooled air leaving the tower is about 25°C while the corresponding ambient temperature is about 38 °C. Thus, the drop in day-time temperature is significantly high in May, i.e. about 13 °C.

# Energy Savings

## Estimated Savings

- **Approx. Rs. 3.5 lakhs/ annum**

## Simple Payback Period

- **5 years**

# Conclusion

Shower type PDEC towers are part of the design of the IGP Complex at Gulbarga. To validate our model, experimental data was collected from one of these shower type PDEC towers. The predictions made by our model and the measurements were compared and were found to be in very good agreement. It is concluded that:

1. The experimental data collected at IGP Complex, Gulbarga proved that shower type PDEC tower is an effective and efficient passive cooling system which can be used in hot and arid region.
2. The measurements show that comfort condition was maintained inside the building.
3. From the validation of the model, it is concluded that the proposed model can predict the performance of shower type PDEC tower with sufficient accuracy.

Monthly saving of Rs 50,000 can be saved per tower by using this technique.

Thank you