PASSIVE COOLING IN BUILDINGS

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LAYOUT OF THE RESEARCH PAPER

- Introduction
- System Description
- Experimental Set-Up
- Measurement Procedure
- Observations and Calculations:
  - a) Measured data
  - b) Heating and cooling capacity of the system
  - c) Heating and cooling potential of the system
  - d) Velocity Profile factor
- Results and Discussions
- Conclusions

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- **What are Earth Energy Systems?**

Earth energy systems use temperatures found in the earth or groundwater to heat or cool air and water for buildings.

INTRODUCTION

- The hourly temperature fluctuations (periodicity 24hours) of the earth surface die down within 15-20 cm from the earth surface as hourly thermal wave travels downward.

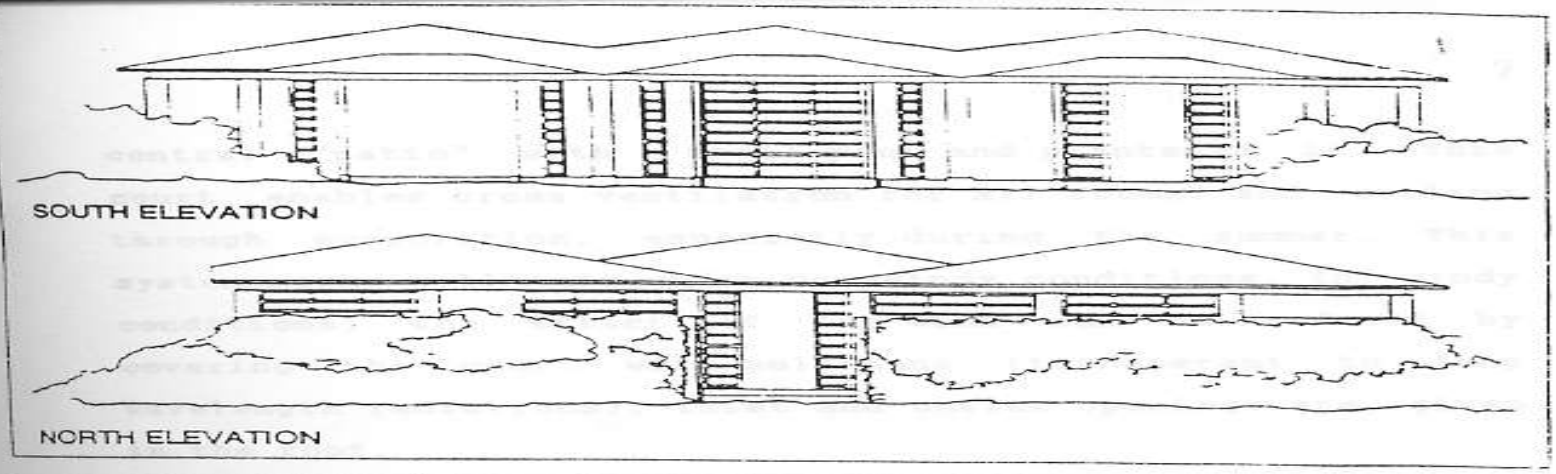
- Hence at a depth of about 4-5m, earth provides a very stable thermal environment in that region.

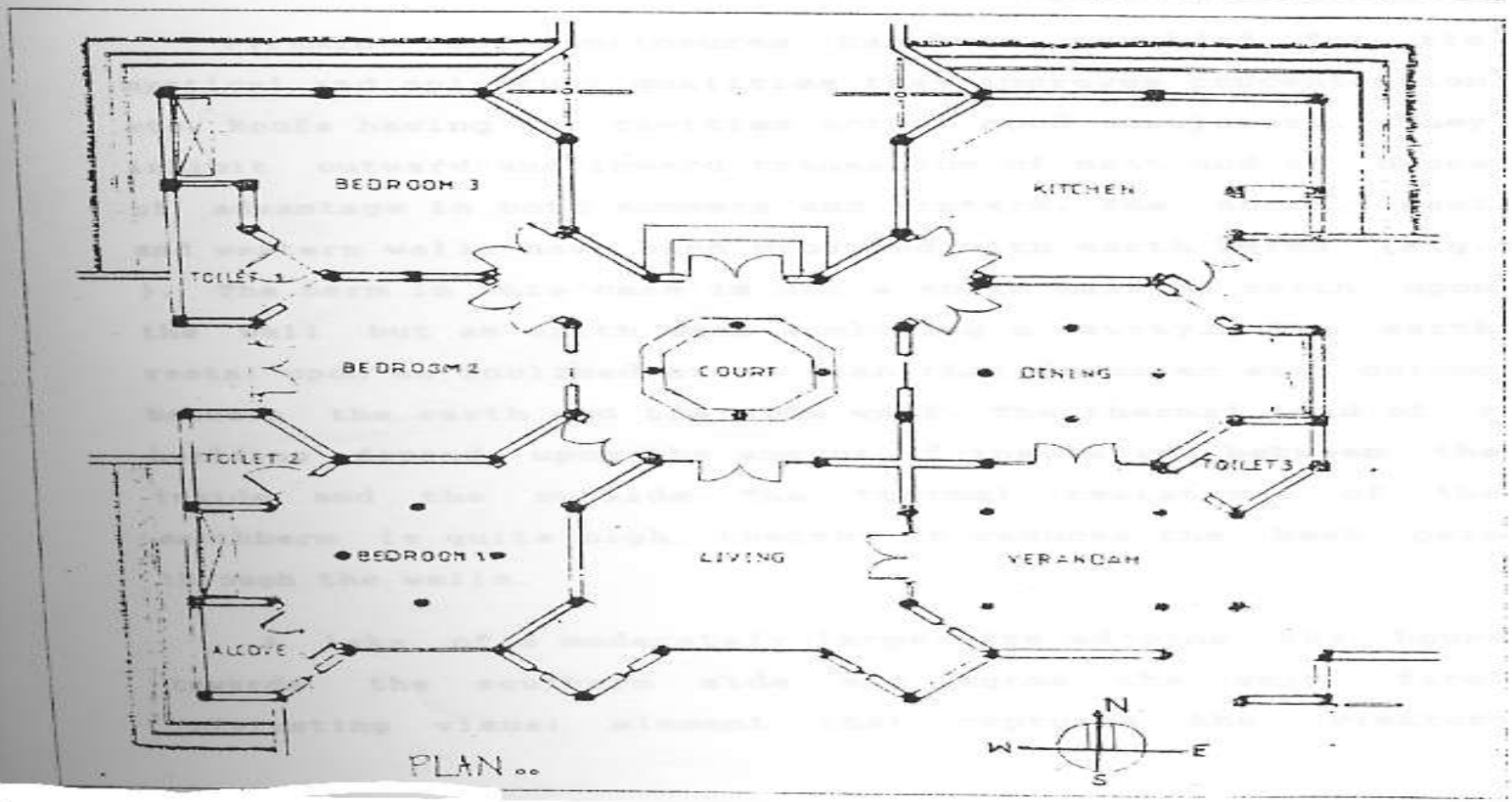
- The system consists of two main rectangular tunnels (0.8m x 0.6m) of length 67.5m buried at a depth of 4m .The two tunnels at the two ends are joined together into one tunnel of 0.8mx0.6m sizes.

- At one end the tunnel is connected to a 3 hp blower. At the other end the tunnel is divided into four channels (0.25mx0.25m each), three of which are further divided into two with the help of PVC pipes of dia 25cm.

- The seven pvc pipes open up into different rooms of a main house which is under construction at the farm house of Wazirpur.

- So it is observed that this natural air-conditioning system is not success for heating purpose and now needs for further research works for making it most effective and successful.





PLAN OF NATURAL AIR-BUILDING

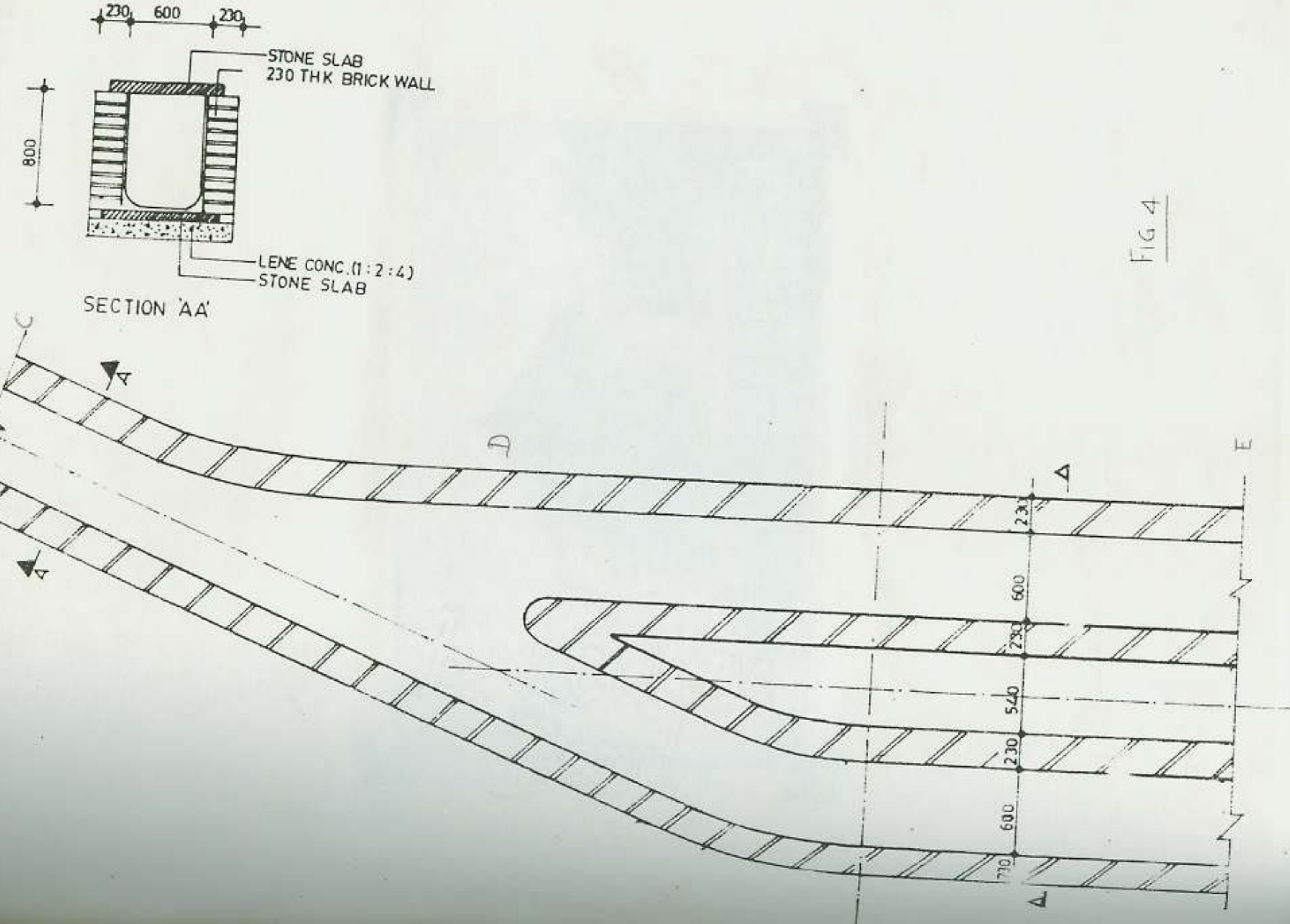

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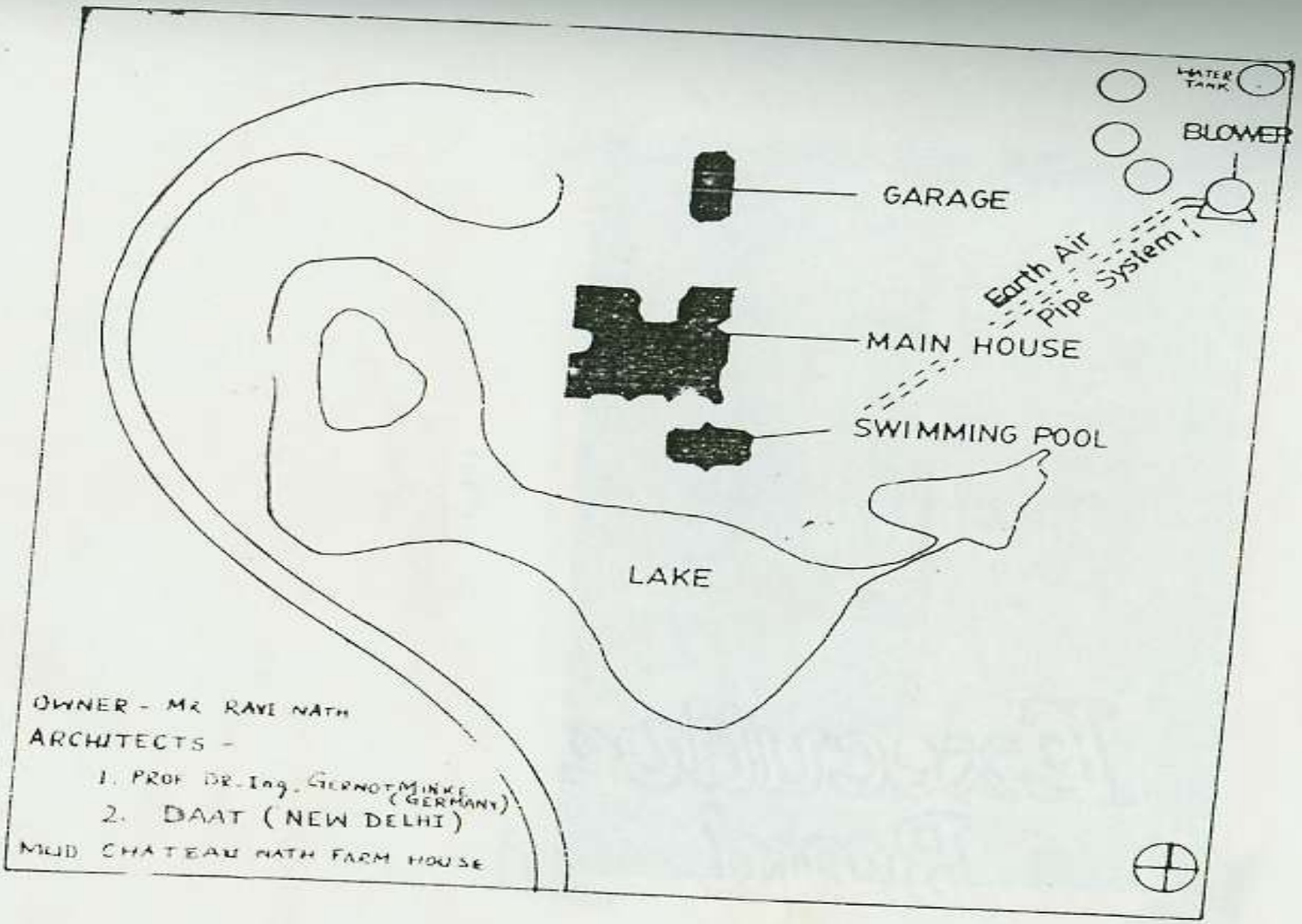
FIG 4



SCALE 1:375

FIGURE - 1 GULMOHAR FARM HOUSE, WAZIRPUR (HARYANA)

PLATE-3

PLATE-4

EXPERIMENTAL SET-UP

- Measurements were taken for the air temperatures at the centre of seven outlets of the air pipes, ambient air (at a point under the water tank) and air of the hut in which blower is installed.

- The temperatures were measured using mercury or alcohol thermometers fixed at each location.

Date	t_i	T_i (°C)	RH_i (%)	HR_i (Kg/Kg)	t_o	T_0 (°C)	RH_o (%)	HR_o (Kg/Kg)	V (Volts)	I (Amp)
June, 94	5.06 a.m.	29	33	0.0086	5.37 a.m.	27	47	0.0104	310	5.5
	8.37 a.m.	36	33	0.0134	9.09 a.m.	31	38	0.0110	310	5.5
	11.41 a.m.	40	15	0.0074	12.12 p.m	29	28	0.0072	300	5.5
	2.44 p.m.	40	16	0.0075	3.15 p.m.	30	24	0.0066	310	5.5
	6.21 p.m.	41	14	0.0070	6.52 p.m	29	25	0.0067	310	5.5
	9.24 p.m.	38	21	0.0094	9.54 p.m	28	43	0.0104	320	5.5
June, 94	3.06 a.m.	34	46	0.0168	3.36 a.m.	27	68	0.0154	310	5.5
	6.36 a.m.	33	29	0.0090	7.04 a.m.	26	34	0.0076	320	5.5
	11.26 p.m.	39	23	0.0100	11.56 a.m.	29	27	0.0070	330	5:5
	2.51 p.m.	42	15	0.0076	3.19 p.m.	29	23	0.0058	300	5.5
	6.01 p.m.	43	22	0.0118	6.29 p.m.	27	31	0.0072	350	5.5
	9.05 p.m.	38	20	0.0093	9.34 p.m.	28	42	0.0100	390	5.5
June, 94	12.16 a.m.	35	25	0.0090	12.45 a.m.	26	36	0.0078	330	5.5
	4.27 a.m.	30	35	0.0096	4.59 a.m.	28	48	0.0107	320	5.5
	7.35 a.m.	33	34	0.0108	8.05 a.m.	28	40	0.0096	310	5.5

TABLE 1.2

COMPARISON OF INLET AND OUTLET CONDITIONS (AT OUTLET NO. 7)

Date	t_i	T_i (°C)	RH_i (%)	HR_i (kg/kg)	t_o	T_0 (°C)	RH_o (%)	HR_o (kg/kg)	V (Volts)	I (Amp)	WHr
22nd August, 94	4.51 p.m.	31	69	0.0193	5.22 p.m.	28	74	0.0177	310	5.5	260.0
	7.05 p.m.	31	68	0.0193	7.34 p.m.	27	75	0.0167	320	5.5	261.0
	8.50 p.m.	31	68	0.0193	9.20 p.m.	29	76	0.0193	340	5.5	261.8
	11.04 p.m.	30	68	0.0183	11.37 p.m.	28	75	0.0177	330	5.5	262.1
23rd August, 94	1.34 a.m.	30	70	0.0187	2.07 a.m.	27	76	0.0170	360	5.5	263.0
	6.40 a.m.	29	69	0.0173	7.10 a.m.	29	74	0.0187	330	5.5	263.2
	7.46 a.m.	28	70	0.0166	10.14 a.m.	28	72	0.0167	320	5.5	263.2
	12.05 p.m.	28	62	0.0147	12.37 p.m.	30	72	0.0190	340	5.5	263.2
	3.06 p.m.	29	64	0.0160	3.36 p.m.	29	74	0.0187	310	5.5	264.8
	6.13 p.m.	30	69	0.0183	6.41 p.m.	30	75	0.0197	350	5.5	265.2
	9.05 p.m.	29	69	0.0170	9.37 p.m.	30	73	0.0193	350	5.5	265.6
24th August, 94	12.04 a.m.	27	70	0.0163	12.25						

5.2 HEATING AND COOLING CAPACITY OF THE SYSTEM

For measuring the heating/cooling capacity ($m_{Cp}\triangle T$) of the air-pipe system, the average value of the temperature and the velocity of the air of the seven outlets was calculated and is presented in Tables 2.1 - 2.5. These results are also presented in figures 8.1 - 8.5.

The average cooling capacity (when air is cooled as it passes through the air-pipe system) and heating capacity (when air is heated as it passes through the air-pipe system) shown by +ve and -ve sign respectively. It is seen in the months of May - June, we have cooling only and the average cooling capacity capacity in these months is given in Ton Refrigeration. In the months of August, October, November and December, both cooling and heating capacity are given in kilowatts.

TABLE 2.1

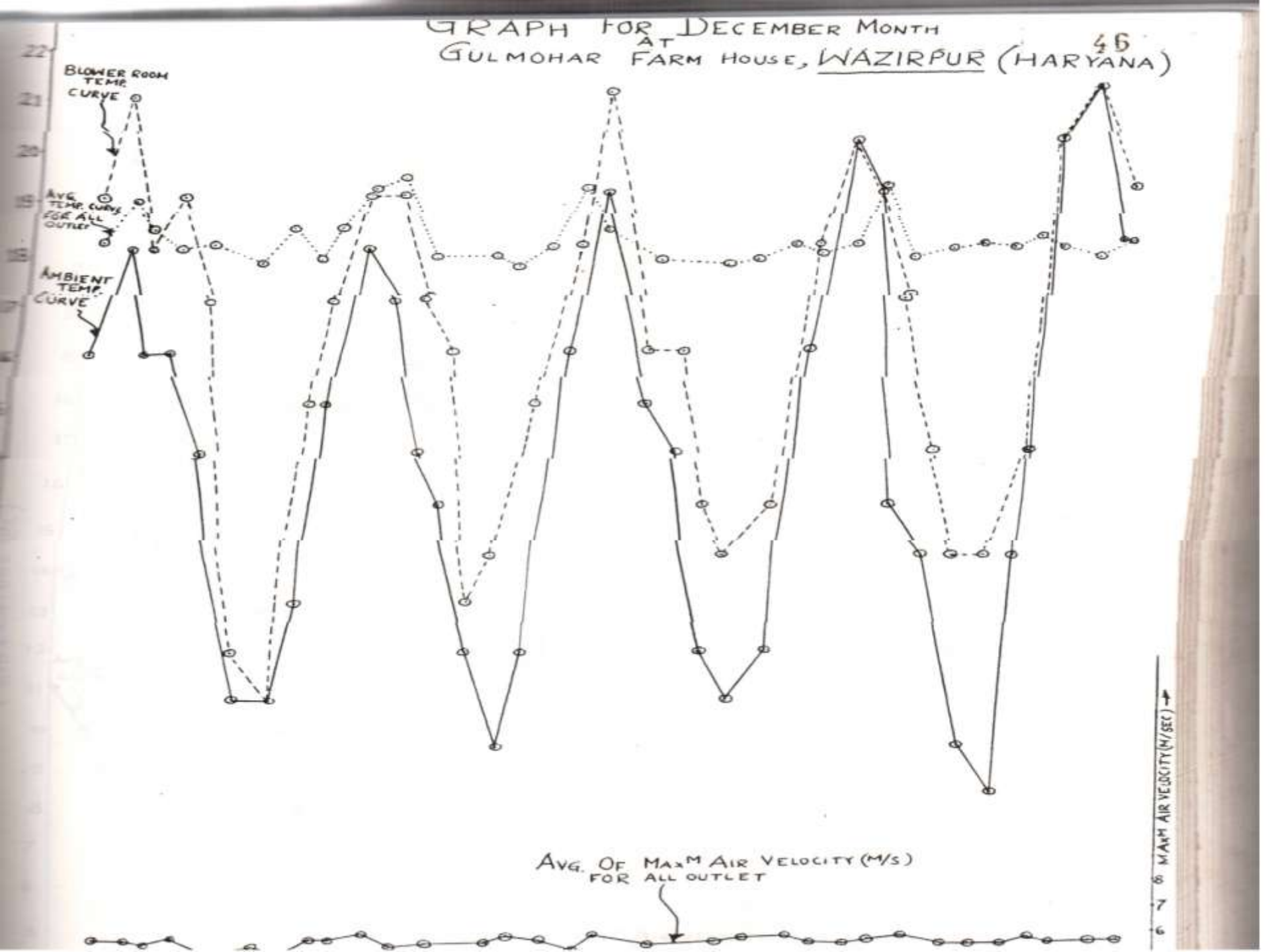
AVERAGE TEMPERATURE AND AVERAGE VELOCITY OF THE AIR FROM THE SEVEN OUTLETS OF THE AIR-PIPE SYSTEM.

Date	Observation Time	Mean Time	$\bar{T}$ (°C)	$\bar{u}$ (m/s)	ρ (Kg/m^3)	C_p (KJ/KgK)	ΔT (°C)	$\dot{m}C_p\Delta T$ (TR)	$\rho x\dot{m}C_p\Delta T$ (TR)
27 May 94	10.05 p.m. - 10.38 p.m.	10.22 p.m.	26	5.30	1.181	1.005	15	1.317	1.069
28 May 94	2.50 a.m. - 3.18 a.m.	3.04 a.m.	25	5.60	1.185	1.005	5	0.465	0.378
	7.10 a.m. - 7.40 a.m.	7.25 a.m.	31	5.60	1.161	1.005	1	0.091	0.074
	9.12 a.m. - 9.55 a.m.	9.34 a.m.	27	5.30	1.177	1.005	8	0.700	0.568
	12.40 p.m. - 1.35 p.m.	1.08 p.m.	28	5.50	1.173	1.005	13	1.176	0.955
	4.22 p.m. - 5.13 p.m.	4.48 p.m.	29	5.60	1.169	1.005	14	1.286	1.044
	10.46 p.m. - 11.21 p.m.	11.04 p.m.	27	5.60	1.177	1.005	7	0.647	0.525
29 May 94	2.38 a.m. - 3.22 a.m.	3.00 a.m.	25	5.30	1.185	1.005	4	0.352	0.286
	5.18 a.m. - 5.55 a.m.	5.37 a.m.	26	5.70	1.181	1.005	4	0.378	0.307
	8.22 a.m. - 9.02 a.m.	8.42 a.m.	29	5.90	1.169	1.005	5	0.484	0.393
	12.36 p.m. - 1.28 p.m.	1.02 p.m.	28	6.00	1.173	1.005	14	1.382	1.122
	4.38 p.m. - 5.17 p.m.	4.58 p.m.	29	5.60	1.169	1.005	14	1.286	1.044
	11.14 p.m. - 11.51 p.m	11.32 p.m.							

Contd...

Date	Observation Time	Mean Time	$\bar{T}$ (°C)	ρ (Kg/m^3)	$\bar{u}$ (m/s)	C_p (KJ/KgK)	ΔT (°C)	$\rho x \dot{m} C_p \Delta T$ (KW)
17th December,94	12.39 a.m. - 1.06 a.m.	12.53 a.m.	17.86	1.214	6.14	1.005	-4.86	-1.427
	4.18 a.m. - 4.46 a.m.	4.32 a.m.	17.57	1.215	5.71	1.005	-5.57	-1.526
	6.17 a.m. - 6.47 a.m.	6.32 a.m.	17.86	1.214	5.43	1.005	-6.86	-1.783
	9.18 p.m. - 9.45 p.m.	9.32 p.m.	18.14	1.213	5.57	1.005	-5.14	-1.368
	1.22 p.m. - 1.51 p.m.	1.37 p.m.	18.86	1.209	6.00	1.005	-0.14	-0.039
	3.30 p.m. - 3.56 p.m.	3.43 p.m.	18.14	1.213	5.86	1.005	+0.86	+0.243
	5.26 p.m. - 5.52 p.m.	5.39 p.m.	18.00	1.213	5.29	1.005	-2.00	-0.506
	9.31 p.m. - 9.59 p.m.	9.45 p.m.	17.43	1.216	5.86	1.005	-2.43	-0.682
18th December,94	12.28 a.m. - 12.58 a.m.	12.43 a.m.	17.00	1.218	6.00	1.005	-4.00	-1.154
	5.43 a.m. - 6.07 a.m.	5.55 a.m.	17.57	1.215	5.86	1.005	-4.57	-1.284
	8.50 a.m. - 9.17 a.m.	9.04 a.m.	18.14	1.213	5.71	1.005	-6.14	-1.681
	11.25 a.m. - 11.56 a.m.	11.41 a.m.	18.57	1.211	5.71	1.005	-1.57	-0.429
	1.35 p.m. - 2.01 p.m.	1.48 p.m.	17.57	1.215	6.00	1.005	+1.43	+0.411
19th December,94	1.39 a.m. - 2.08 a.m.	2.54 a.m.	17.57	1.215	6.00	1.005	-4.57	-1.315
	3.59 a.m. - 4.28 a.m.	4.14 a.m.	17.71	1.215	5.57	1.005	-4.71	-1.259

GRAPH FOR DECEMBER MONTH AT GULMOHAR FARM HOUSE, WAZIRPUR (HARYANA)



5.3 HEATING AND COOLING POTENTIAL OF THE SYSTEM

The average value of heating potential and cooling potential of the pipes ($m C_p \triangle T$. $\triangle t$, where $\triangle t$ is time interval between two readings) is given in Tables 3.1 - 3.5.

The seasonal performance of the earth air - pipe system is depicted in Table 4.

Table 3.1

Heating and Cooling Potential of the System for the month of May-June'94.

Mean Time (hours.minutes)	Time Interval $\triangle T$ (hours.minutes)	Heating/Cooling Capacity of the All Seven Pipes ($7 \times m_{Cp/\triangle T}$) (RW)	Heating/Cooling Potential for All Seven Pipes ($7 \times m_{Cp/\triangle T} \times \triangle t$) (RWh)
27th May'94			
10.22 p.m.	4.42	26.32	123.69
28th May'94			
3.04 a.m.	4.21	9.31	40.48
7.25 a.m.	2.09	1.82	3.92
9.34 a.m.	3.34	13.98	49.87
1.08 p.m.	3.40	23.51	86.21
4.48 p.m.	6.16	25.70	161.06
11.04 p.m.	3.56	12.93	50.84
29th May'94			
3.00 a.m.	2.37	7.04	18.42
5.37 a.m.	3.05	7.56	23.30
8.42 a.m.	4.20	9.68	41.93
1.02 p.m.	3.56	27.62	108.65
4.58 p.m.	6.35	25.70	169.21
11.33 p.m.	7.31	9.23	69.39
30th May'94			

Mean Time (hours.minutes)	Time Interval ΔT (hours.minutes)	Heating/Cooling Capacity of the All Seven Pipes ($7 \times m_{Cp/\Delta T}$) (KW)	Heating/Cooling Potential for All Seven Pipes ($7 \times m_{Cp/\Delta T} \times \Delta t$) (KWh)
2nd June'94			
3.26 a.m.	3.30	16.15	56.53
6.56 a.m.	4.52	14.85	72.25
11.48 a.m.	3.23	23.76	80.38
3.11 p.m.	3.10	28.09	88.95
6.21 p.m.	3.05	30.11	30.11
9.26 p.m.	3.10	21.05	66.66
3rd June'94			
12.36 a.m.	4.12	14.77	62.04
4.48 a.m.	3.08	7.56	23.68
7.56 a.m.	4.17	11.67	49.98
12.13 p.m.	5.14	21.22	111.06
5.27 p.m.	4.55	28.44	139.81
10.22 p.m.	4.13	8.03	33.84
4th June'94			

Table 5

Variation of Velocity Profile Factor as Measured on Different Days for all the Seven Outlets

te	P1	P2	P3	P4	P5	P6	P7	$\bar{P}$	$\bar{P}$ (used)
May 94	0.810	0.774	0.850	0.830	0.780	0.880	0.650	0.796	
June 94	0.854	0.860	0.900	0.780	0.810	0.800	0.760	0.823	0.812
Aug 94	0.816	0.800	0.850	0.788	0.790	0.840	0.790	0.811	
Aug 94	0.803	0.790	0.830	0.809	0.788	0.801	0.809	0.804	0.825
Aug 94	0.836	0.894	0.920	0.857	0.898	0.807	0.811	0.860	
Oct 94	0.850	0.744	0.922	0.804	0.824	0.770	0.810	0.820	
Oct 94	0.785	0.744	0.860	0.850	0.764	0.713	0.824	0.791	
Oct 94	0.800	0.764	0.840	0.840	0.710	0.710	0.744	0.773	0.796
Oct 94	0.880	0.770	0.770	0.800	0.820	0.790	0.774	0.801	

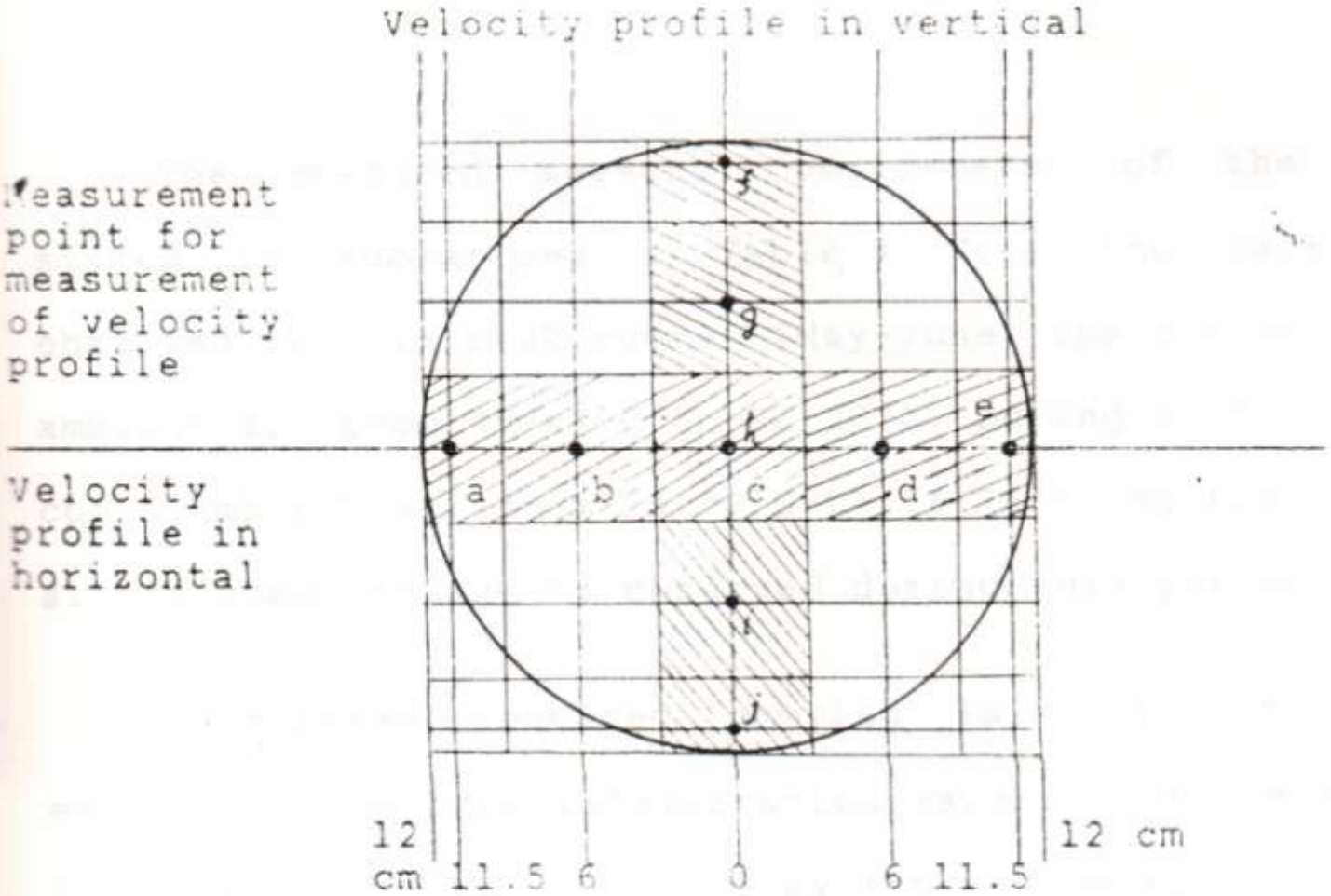

Velocity profile in vertical
Measurement point for measurement of velocity profile
Velocity profile in horizontal
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Fig-8

Hence, the total required pumping power is given by :

$$= \triangle P_{AB} \times Q_{AB} + \triangle P_{BC}\, Q_{BC} + \triangle P_{CD}\, Q_{CD} + \triangle P_{DE}\, Q_{DE}$$

$$= 548.41 \text{ watt}$$

Considering blower efficiency and motor efficiency in calculation :

Taking blower efficiency = 30%

and motor efficiency = 85%

combined efficiency = 0.255,

Hence, required pumping power for blower

$$= \frac{\text{Air power}}{0.30 \times 0.85} = \frac{548.41}{0.30 \times 0.85} = 2150 \text{ watt} = 2.88 \text{ HP}$$

where installed blower capacity is 3 hp.

Graph For August Month (Rainy Season) At Gulmohar Farm House, Wazirpur (Haryana)

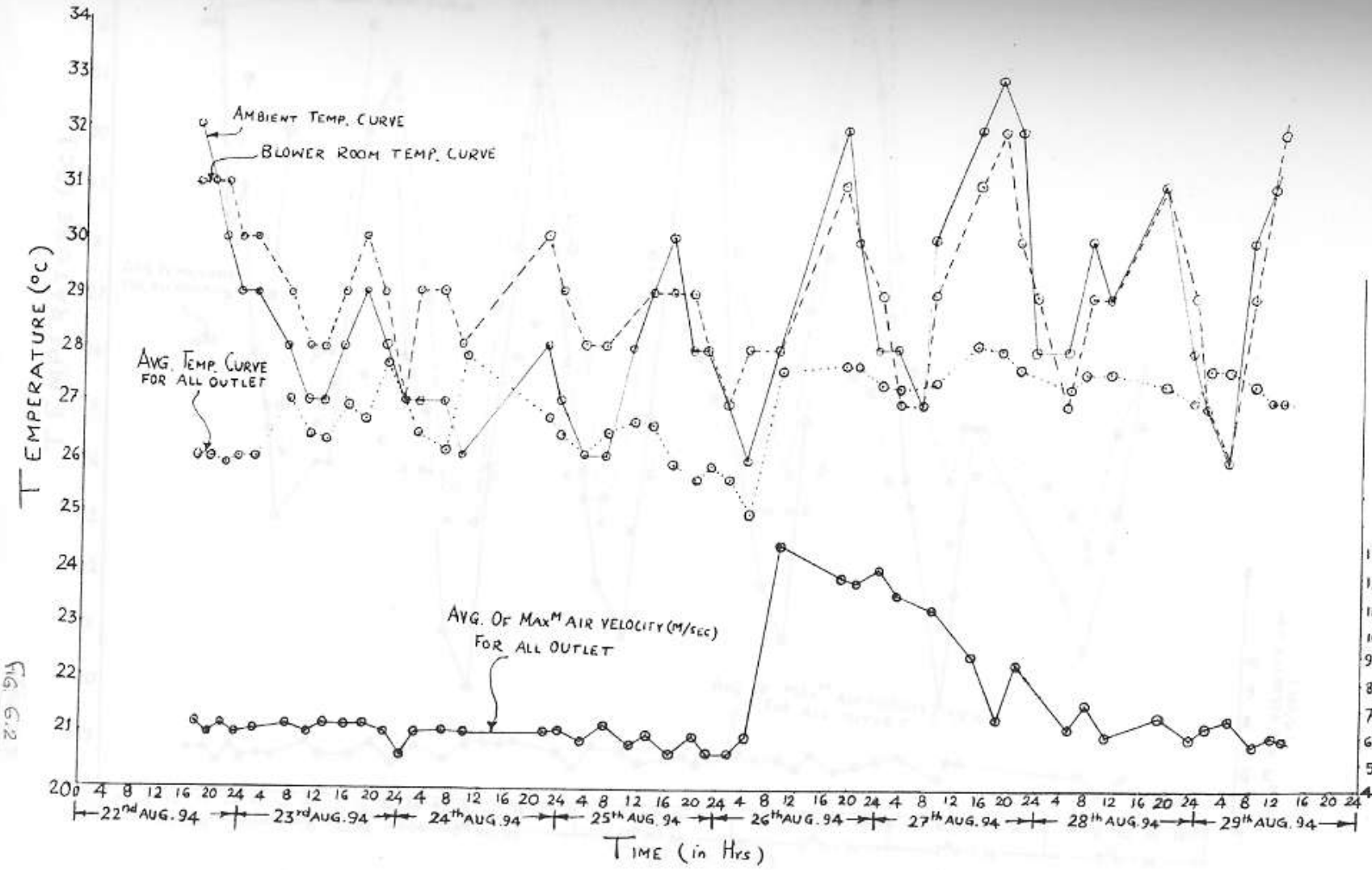

Fig 6.2

Table :

Seasonal Performance of the earth Ait-Pipe System

Season	Month	Inlet Temp (^{0}c)	Inlet HR (Kg / Kg)	Outlet Temp (^{0}c)	Outlet HR (Kg / Kg)	Max^m Heating Capacity (KW)	Max^m Cooling Capacity (KW)	Daily Potential Heating (KWH)	Daily Potential Cooling ((KWH)
Summer	May-June'2003	28-44	0,0065-0.0250	26-30	0.0042-0.0154	-	32.94	-	400.39
Monsoon	August'03	27-32	0.0140-0.0197	27-30	0.0150-0.0217	6.475	12.92	5.35	100.05
-	October'03	26-34	0.009-0.016	25-28	0.012-0.016	1.057	14.38	0.72	114.11
Mild-Winter	November'03	17-29	0.0086-0.0138	21-24	0.0086-0.0128	7.238	11.55	6.38	98.99
Winter	December '03	10-21	0.0038-0.0090	18-20	0.0057-0.0094	16.730	6.33	115.83	12.27

CONCLUSIONS

- There is hardly any change in the humidity ratio of the air in summers and winters
- In summer is estimated to be 32.94 kw and heating capacity during winter is 16.73 kw. In monsoon the humidity ratio decreases or increases.
- Value of average daily cooling potential in summer is recorded to be 400 kwh and avg. daily heating potential in winter is recorded 116 kwh.
- Natural air-conditioning system is not success for heating purpose

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Thank You