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An experimental study of summer performance of a recirculation type underground airpipe air conditioning system

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Abstract

The thermal performance of the underground airpipe air conditioning system constructed at the Non-Conventional Energy Research Institute, Ghosi has been studied. The heat exchanger is used in recirculation mode to aircondition eight rooms in a guest house at the Institute. The temperature and relative humidity of a conditioned and non-conditioned room are measured every two hours. The cooling potential of the system is estimated. It is observed that reasonably good thermal comfort conditions can be created in the building with such a system. The *COP* of the installed system is found to be 3.35. © 1998 Elsevier Science Ltd. All rights reserved.

Keywords: Underground airpipe air conditioning; Earth-coupled heat exchanger tubes; Below grade blower chamber; Below grade inspection chamber; Cooling potential; *COP*

1. Introduction

The comfort of the human body primarily depends on three factors: temperature, relative humidity and air motion, temperature being the single most important factor. People feel comfortable when the temperature is between 22 and 27°C. After the temperature, relative humidity is the next important factor affecting human comfort, since it affects the amount of heat a body can dissipate through evaporation. People feel comfortable when relative humidity is within the range of 40–60%. Air motion also plays an important role in human comfort. It removes the warm, moist air that builds up around the body and replaces it with fresh air. Therefore, air motion improves heat rejection by both convection and evaporation. Air motion should be strong enough to remove the heat and moisture from the vicinity of the body, but gentle enough to be unnoticed. According to literature, comfortable air speed is observed to be 15 m/min.

The temperature in the ground at a depth of about 4–5 m in tropical regions is generally in the human comfort range (27–29°C). For a large thermal mass of earth, provides a very stable thermal environment, even if a large amount of heat is dumped or withdrawn from these depths. The stable and comfortable environment of the ground at these depths can be used to create thermal comfort conditions in living spaces by directly or indirectly coupling the ground at these depths to the building. In indirect coupling, air passing through the airpipes buried in the ground is conditioned and circulated through the living spaces. Air passing through the airpipes can be drawn either from ambient (single pass system) or from the conditioned space itself (recirculation system).

In the present paper, the experimental results obtained from a recirculation type underground airpipe air-conditioning system situated at the Non-Conventional Energy Research Institute, Ghosi, are reported. The layout of the earth airpipe system, and the portions of the building air-conditioned by the system, are indicated in Figs 1, 2 and 3 for evaluation of its thermal performance during the summer season. The parameters measured during this study include temperature, relative humidity and air velocity. The system was monitored continuously day and night for 31 days during the month of May 1997. The measured results are presented in the form of graphs and tables.

2. Description of the system

The earth airpipe airconditioning system under evaluation is used in the Solar Passive Guest House, which is a double storey building having two guest suites, two deluxe suites, two reception lounges, a dining hall and

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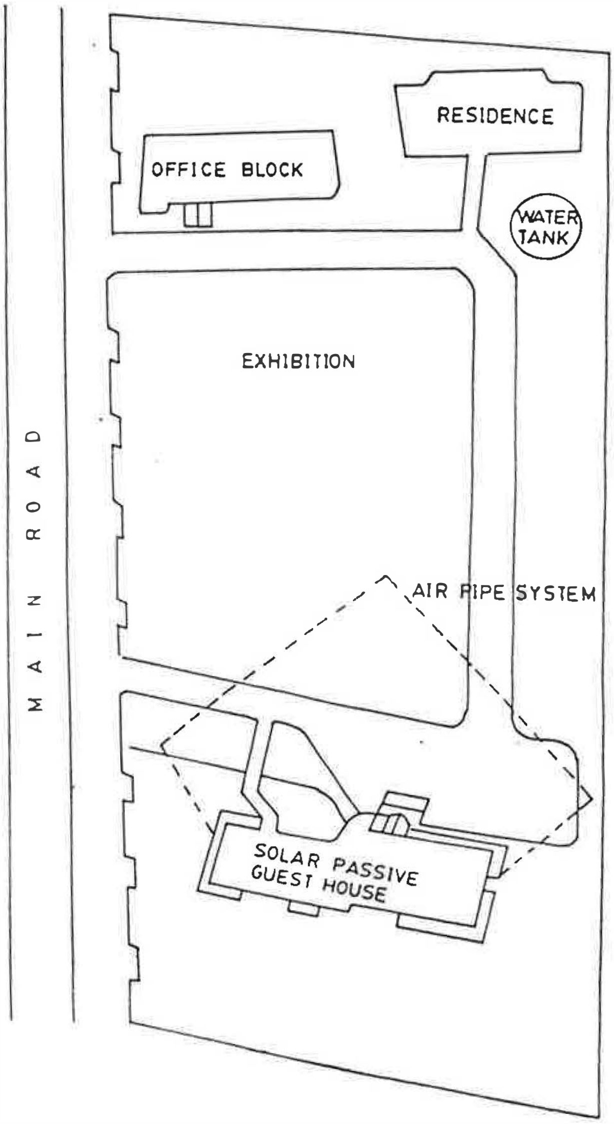

Fig. 1. Layout of the earth airpipe system.

a solar power plant battery room. The airpipe system comprises a below-grade blower chamber, a below-grade inspection chamber, two heat exchanger tubes on the suction side of the blower and two heat exchanger tubes on the delivery side of the blower. The concrete heat exchanger (length 85 m, diameter 0.5 m) are buried parallel to each other at spacing of 1 m and at a depth of 2.5 m. The delivery side heat exchanger tubes start from the below-grade blower chamber, pass through the below-grade inspection chamber and run under the main building. The suction side heat exchanger tubes start from the building, run under it and finally are connected to the below-grade blower chamber. For circulation of conditioned air through the rooms, each heat exchanger tube is connected to four delivery ducts (on delivery sides) and four suction ducts (on suction side) of 23 cm diameter each.

The air delivery ducts enter all the conditioned room at a height of 2.2 m from the floor. In a similar manner suction ducts are connected to the rooms at the same height of 2.2 m. The openings of the delivery and suction ducts into the room are covered with metal wire mesh, to prevent the entry of insects and foreign matter.

The below-grade inspection chamber (constructed in between the below-grade blower chamber and the guest house) is used for periodic maintenance and to pump out any water leaked into the heat exchanger tubes from the ground. The below-grade blower chamber (constructed underground) has two blowers, which suck the air from the rooms and force it into delivery ducts via the heat exchanger tubes. The blowers are belt driven by 3 HP electric motors. An airtight tarpaulin cloth is used to connect the heat exchanger tubes to the blowers.

3. Working principle

During the operation, the blower sucks air from the rooms and circulates it through the earth-coupled heat exchanger tubes. In summer, warm air from the rooms gives up its heat to the heat exchanger tubes by convection which is then dissipated to the earth by conduction. The cool air from the system is supplied to the living space through the delivery ducts. In winter, the cold air from the rooms is heated in the earth-coupled heat exchanger tubes and the supplied back to the area that needs heating. Thus building space is cooled during the summer and heated during the winter by utilizing the stable underground environment, with the help of the earth airpipe system.

4. Measurements

For comparison, measurements were taken in an air conditioned room (dining hall) and non-conditioned room (kitchen). The temperature and relative humidity were measured at five different locations with the help of a digital thermo-hydrometer, Therm 2227-2, at regular intervals of 2 hours. Five points were selected for temperature and humidity measurements to include ambient (under shade), opening of the delivery, and suction ducts of dining hall, centre of the dining hall and centre of the kitchen. For determining the velocity profile of the air at the delivery and suction ducts, air velocity was measured across the openings at nine different points using an anemometer. (Four points in central horizontal line, four points in central vertical line and one in the centre of the opening.) The average value of air flow velocity was found to be 6.3 m/s. The temperature and relative humidity measurements were taken for the entire month of May, the hottest month of the year at Ghosi.

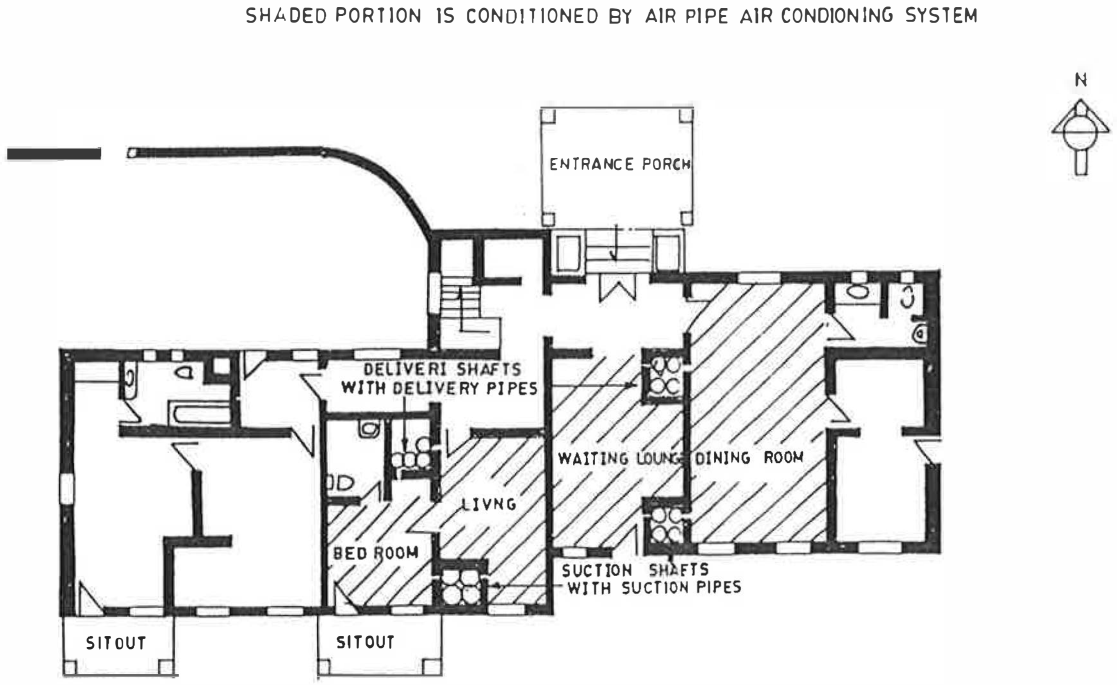

Fig. 2. Portions of the building airconditioned by the system on the ground floor.

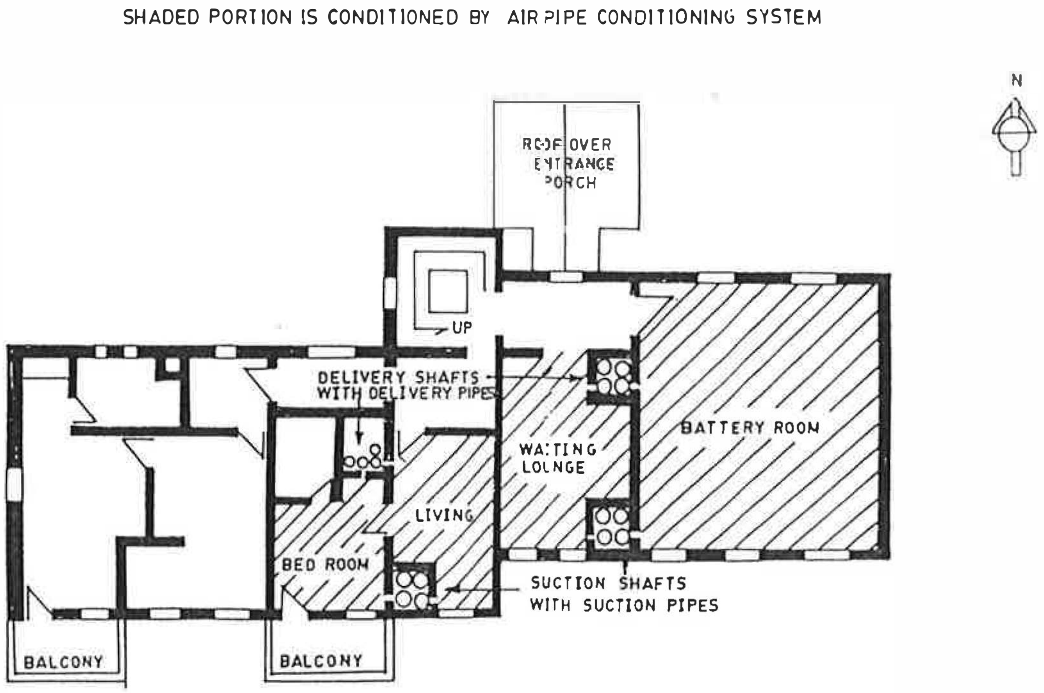

Fig. 3. Portions of the building airconditioned by the system on the first floor.

5. Results and discussion

The maximum, minimum and average values of the recorded temperature and relative humidity for five locations on each day are given in Tables 1 and 2, respectively. Temperature and relative humidity readings measured at five locations on three typical days of month (17, 18 and 19 May 1997) are plotted in Figs 4 and 5. From these figures and tables, it is observed that during the summer period, the ambient temperature varied between

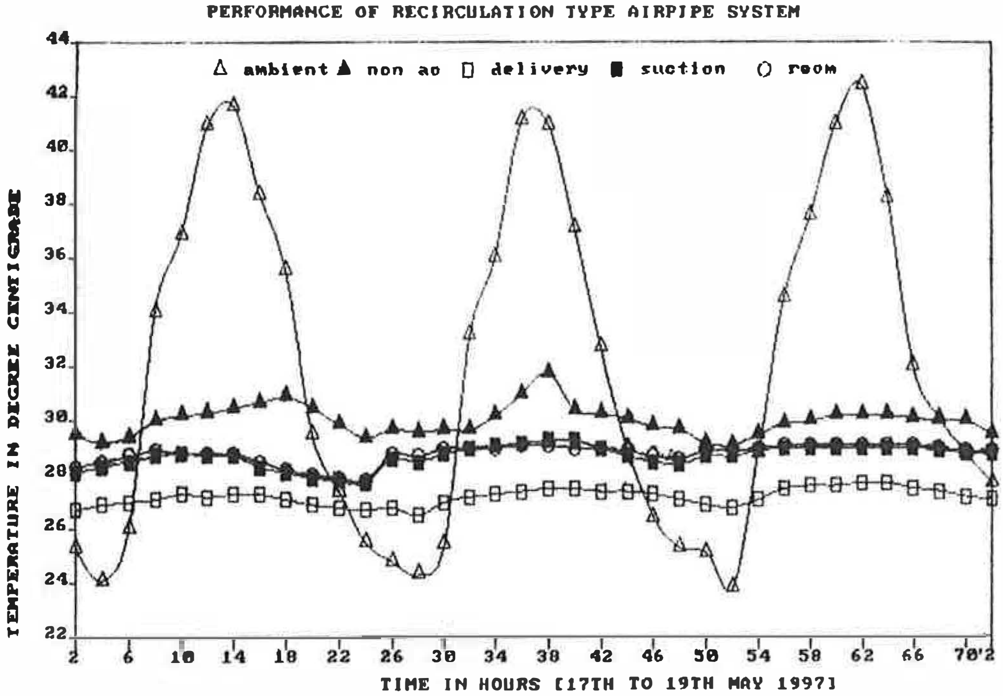

Fig. 4. Performance of recirculation type airpipe system. Variation of temperature with time.

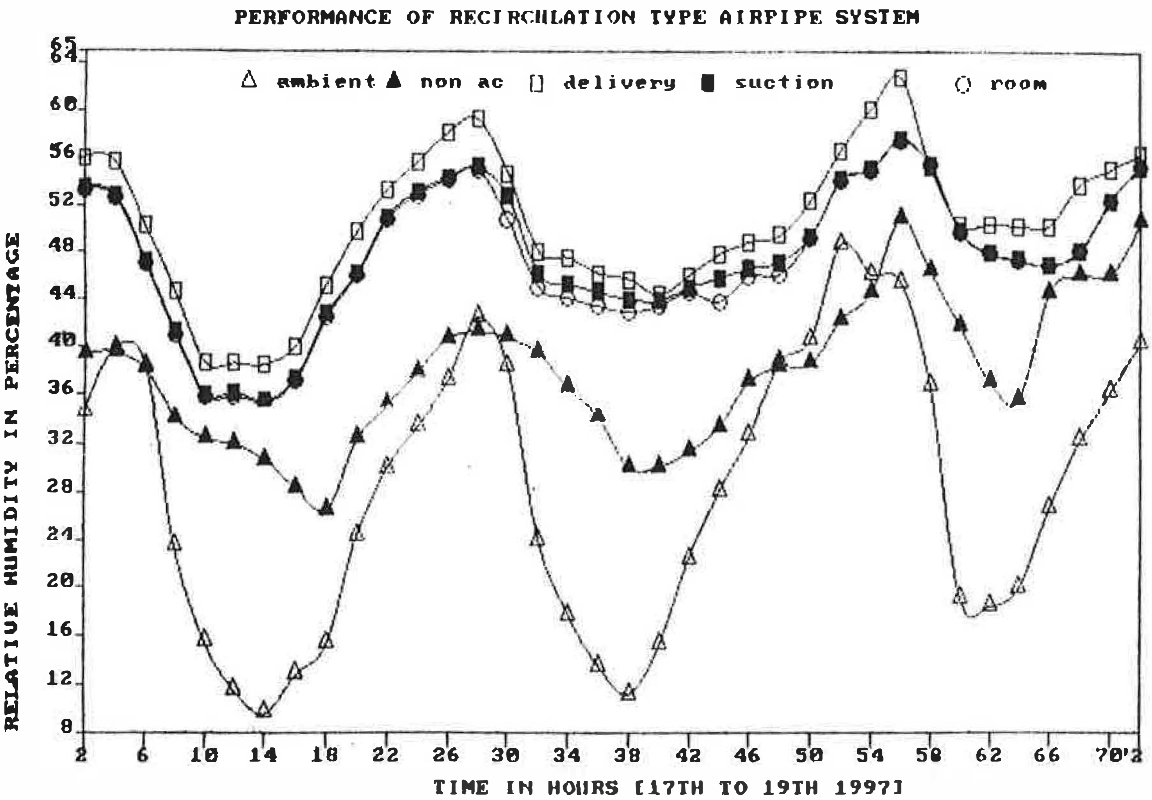

Fig. 5. Performance of recirculation type airpipe system. Variation of relative humidity with time.

22.5 and 44.2°C, whereas relative humidity varied between 9.4 and 75.8%. The conditioned air from the system, at the delivery opening in the room, showed variations in the dry bulb temperature between 25.3 and 28.4°C, and relative humidity variation between 40.8 and 70.3%. At the centre of the air conditioned room the temperature varied between 27.6 and 29.7°C, while relative humidity varied between 38.9 and 65.7%. The temperature and relative humidity of the kitchen (non-conditioned room) during the same period ranged between 26.4 and 32.8°C and 25.8 and 65.4% respectively. The monthly average value of daily minimum, daily maximum and daily average values of the temperature and relative humidity for 31 days at the five locations are given in Tables 1 and 2. The monthly average value of the daily minimum temperature (a) for the ambient, (b) for the non-conditioned room and (c) for the conditioned room were recorded as 23.9, 28.2 and 28.2°C respectively, while the monthly average value of the daily maximum temperature recorded is 40.7, 30.7 and 29°C. The recorded monthly average value of the daily minimum and daily maximum relative humidity is 70.7, 40.7 and 48% and 55.8, 54.3 and 57.4% respectively. It is seen from Fig. 4 and Table 1 that during summer, air from the room is cooled by about 1.5°C as it passes through the earth-coupled heat exchanger tubes, and the temperature of the non-conditioned room is about 1.5°C higher than that of the conditioned room. Effectively this means that air from the non-conditioned room is cooled by about 30°C as it passes through the earth coupled heat exchanger tubes.

From Fig. 5 and Table 2, it may be seen that relative

Table 1
Daily minimum, average and maximum temperature in five selected points

	Air temperature (°C)														
	Ambient			Centre of kitchen (non ac)			Delivery opening			Suction opening			Centre of dining hall		
Date	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
1	23.0	30.5	39.1	30.0	30.7	31.2	25.3	25.3	25.4	28.2	28.3	28.4	28.1	28.2	28.5
2	24.4	31.3	38.0	30.0	30.9	31.4	25.3	25.4	25.4	28.2	28.3	28.4	28.1	28.2	28.5
3	23.6	31.6	40.7	29.2	29.5	30.0	25.3	25.3	25.4	28.2	28.3	28.4	28.1	28.3	28.5
4	23.3	31.6	39.8	29.2	29.4	29.7	25.3	25.4	25.5	28.2	28.3	28.4	28.1	28.3	28.5
5	23.1	32.0	39.9	29.3	29.7	31.2	25.4	25.5	25.6	28.2	28.4	28.8	28.2	28.4	28.7
6	24.8	30.9	38.3	28.8	29.6	30.1	25.5	25.6	25.7	28.0	28.5	28.7	28.0	28.5	29.1
7	24.0	31.7	40.0	28.6	29.7	30.5	25.5	25.6	25.7	28.3	28.6	28.9	28.1	28.4	28.9
8	22.6	25.8	34.3	28.2	28.7	29.8	25.6	25.8	26.0	28.1	28.4	28.7	28.1	28.4	28.6
9	22.5	30.8	39.3	28.0	28.8	29.8	25.5	25.7	25.8	27.6	27.8	28.0	27.1	27.7	28.0
10	24.2	30.8	40.8	27.0	28.8	30.2	25.5	25.7	25.9	27.4	27.6	27.8	27.4	27.8	28.1
11	22.8	31.4	41.0	28.3	28.9	29.2	25.5	25.5	25.6	27.4	27.6	27.7	27.6	27.9	28.3
12	22.5	32.0	41.5	28.1	29.3	30.2	25.5	25.7	25.9	27.5	27.7	28.3	27.8	28.1	28.5
13	23.0	32.1	41.8	28.4	30.0	32.4	25.6	26.3	27.0	28.1	28.4	28.6	28.2	28.4	28.6
14	24.7	32.7	42.8	28.0	30.3	32.8	25.6	26.2	27.0	28.3	28.4	28.7	27.6	28.3	28.7
15	25.2	32.4	41.7	29.1	30.0	31.1	25.3	26.7	27.1	28.2	28.5	28.9	28.3	28.6	28.9
16	24.9	32.5	40.6	29.1	30.0	31.4	26.4	26.8	27.2	28.2	28.6	28.7	28.2	28.6	28.8
17	24.1	32.1	41.6	29.2	30.0	30.9	26.7	27.0	27.3	27.7	28.3	28.8	27.8	28.4	28.9
18	24.3	31.3	41.1	29.6	30.2	31.8	26.5	27.2	27.5	28.4	28.9	29.3	28.6	28.9	29.1
19	23.8	32.5	42.4	29.1	29.8	30.2	26.8	27.3	27.7	28.7	28.9	29.0	28.9	29.0	29.1
20	24.6	33.2	42.7	29.1	30.0	30.4	26.9	27.3	27.6	28.7	28.9	29.2	28.8	29.0	29.2
21	22.5	33.9	44.2	26.4	29.2	30.2	27.1	27.3	27.5	28.5	28.8	29.3	28.6	28.9	29.4
22	24.1	33.8	43.9	26.9	29.7	31.1	26.9	27.5	27.8	28.6	29.0	29.4	28.7	29.1	29.5
23	24.4	34.2	42.6	26.8	29.2	31.1	26.8	27.5	28.0	28.4	29.2	29.7	28.5	29.3	29.7
24	24.6	32.9	40.2	26.7	29.7	31.3	26.9	27.7	28.3	28.0	29.0	29.5	28.0	29.1	29.5
25	24.6	31.2	38.5	27.0	29.8	31.0	27.6	27.8	28.1	28.4	28.9	29.3	28.4	28.9	29.4
26	24.9	31.6	40.9	27.5	29.4	30.5	27.7	28.0	28.3	28.4	29.0	29.6	28.4	29.0	29.7
27	24.1	31.4	39.5	27.5	29.4	30.2	27.6	28.0	28.3	28.6	28.9	29.3	28.6	29.0	29.4
28	24.6	32.7	42.8	27.6	29.4	30.4	27.6	28.0	28.4	28.4	29.0	29.4	28.5	29.1	29.5
29	25.4	31.8	41.2	27.5	29.3	30.4	27.6	28.1	28.4	28.6	29.0	29.3	28.5	29.0	29.5
30	23.1	29.0	37.6	26.9	28.8	30.0	27.6	28.0	28.3	28.6	29.0	29.3	28.7	29.1	29.4
31	24.0	32.5	42.5	27.8	29.2	30.4	27.6	28.1	28.3	28.6	29.1	29.3	28.6	29.1	29.3
May	23.9	31.7	40.7	28.2	29.6	30.7	26.3	26.7	27.0	28.2	28.6	28.9	28.2	28.6	29.0

Table 2
Daily minimum, average and maximum relative humidity in five selected points

	Relative humidity (%)														
	Ambient			Centre of kitchen (non ac)			Delivery opening			Suction opening			Centre of dining hall		
Date	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
1	23.5	39.6	56.0	51.0	55.0	58.1	61.0	63.3	65.4	55.4	58.3	60.4	56.5	59.3	61.5
2	24.6	37.7	55.3	45.2	52.3	57.3	63.5	64.4	65.3	58.2	59.2	60.3	59.2	60.2	61.3
3	21.0	39.4	62.5	49.9	53.9	57.5	62.3	64.6	66.6	57.3	59.6	61.6	58.4	60.6	62.6
4	19.6	35.3	53.2	44.8	50.7	57.1	58.0	62.0	66.1	50.3	55.5	61.1	51.2	56.8	62.2
5	16.8	32.6	55.7	42.2	47.2	52.6	56.1	59.4	63.0	48.5	51.4	54.2	47.7	51.4	54.1
6	20.8	39.9	65.0	45.5	49.5	56.6	59.4	63.3	69.2	51.3	54.0	59.0	52.0	54.6	58.1
7	21.0	38.0	52.9	40.3	46.0	51.4	59.6	63.1	67.0	52.2	54.5	56.9	53.7	55.0	56.7
8	40.0	64.3	75.8	47.1	57.0	63.5	64.8	70.5	74.4	56.6	61.0	64.4	56.5	61.6	65.7
9	21.2	43.2	76.5	48.0	54.8	63.9	60.0	67.6	74.6	54.0	59.8	64.5	55.8	60.5	65.1
10	9.4	24.5	48.1	25.8	36.6	49.7	46.6	53.7	64.7	41.6	48.5	55.9	41.3	47.7	55.9
11	9.8	22.7	36.2	26.9	35.7	41.4	46.4	50.8	55.0	42.0	46.8	50.1	40.9	45.1	48.6
12	12.0	26.8	43.0	27.6	36.6	42.6	49.5	54.2	60.6	45.1	48.9	53.1	44.4	47.8	52.2
13	14.5	30.9	46.5	34.8	42.5	54.0	51.9	56.7	61.8	51.3	52.8	55.3	51.6	52.4	55.0
14	14.2	32.5	48.7	35.1	45.7	52.8	50.2	55.7	62.8	46.1	51.3	56.9	45.9	51.5	56.8
15	14.8	31.6	48.0	33.4	42.8	50.1	53.4	55.3	60.8	47.5	51.5	60.1	47.2	51.0	60.2
16	14.3	27.1	48.6	34.5	40.0	46.1	42.0	48.6	54.8	39.1	44.9	52.2	38.8	44.6	51.8
17	9.6	24.1	39.9	26.5	33.9	39.5	38.5	47.2	56.0	35.5	44.4	53.4	35.3	44.2	53.2
18	11.2	26.8	42.5	30.1	36.2	41.3	44.5	49.7	59.3	44.0	47.6	55.2	43.0	46.7	55.0
19	18.5	34.3	48.8	35.6	43.8	50.9	50.3	54.5	62.8	47.0	51.7	57.6	47.0	51.6	57.5
20	10.3	33.1	55.6	36.2	45.7	56.8	40.8	53.6	66.9	39.0	49.5	62.0	39.0	49.5	61.8
21	13.8	25.6	42.0	34.2	39.0	44.4	43.2	46.2	54.2	39.1	42.2	45.8	38.9	42.1	45.7
22	16.1	29.1	43.7	29.1	41.1	49.1	45.2	48.0	52.4	44.0	45.5	47.9	44.0	45.3	47.7
23	15.3	29.9	44.2	31.8	42.1	50.1	42.2	47.3	54.5	39.0	44.0	49.4	39.0	43.9	49.8
24	30.1	43.0	56.1	41.8	48.9	58.1	55.3	60.3	66.1	48.7	54.8	61.3	49.8	55.7	61.5
25	27.1	45.0	61.8	40.7	47.2	61.8	52.5	56.8	62.8	47.8	51.9	57.2	47.7	51.8	57.2
26	32.0	51.7	66.1	51.8	55.7	59.1	60.7	62.4	63.4	54.0	56.8	58.5	53.1	55.9	57.8
27	34.4	48.8	68.1	54.5	57.1	59.2	57.5	61.2	62.9	52.3	55.5	57.1	52.2	55.0	56.9
28	28.9	48.7	70.2	55.8	59.7	65.3	61.6	65.2	70.3	53.8	56.2	58.1	56.1	60.2	65.0
29	31.3	49.0	69.1	51.9	56.8	63.2	59.1	61.7	63.6	55.2	58.4	62.8	53.7	56.3	58.3
30	37.0	56.8	74.4	56.0	59.8	63.2	60.6	63.5	68.7	55.2	58.4	62.8	55.2	58.1	62.7
31	28.2	48.6	74.2	54.4	59.4	65.4	57.2	62.5	67.3	52.1	57.3	62.5	52.0	57.4	62.4
May	20.7	37.4	55.8	40.7	47.5	54.3	53.4	57.8	63.3	48.5	52.7	57.3	48.6	52.7	57.4

Table 3
Daily minimum, average and maximum humidity ratio in five selected points

	Humidity ratio														
	Ambient			Centre of kitchen (non ac)			Delivery opening			Suction opening			Centre of dining hall		
Date	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
1	9.3	10.3	12.4	14.4	15.1	15.8	12.4	12.8	13.2	13.3	14.0	14.5	13.7	14.1	14.6
2	9.3	10.3	11.2	12.8	14.4	15.3	12.8	13.0	13.2	13.9	14.2	14.5	14.1	14.4	14.6
3	9.0	10.7	13.1	12.8	13.9	15.1	12.6	13.1	13.4	13.8	14.3	14.8	14.2	14.5	15.0
4	8.4	9.5	10.3	11.4	12.9	14.5	11.7	12.6	13.3	12.1	13.3	14.6	12.4	13.6	14.8
5	7.5	8.8	10.1	11.0	12.2	13.5	11.4	12.1	12.8	11.7	12.4	13.0	11.7	12.4	12.9
6	8.6	10.3	12.8	12.0	12.7	14.0	12.2	13.0	14.1	12.1	13.1	14.3	12.3	13.2	14.3
7	9.4	10.4	12.0	10.8	11.9	13.0	12.3	13.0	13.8	12.6	13.2	14.0	12.7	13.3	13.7
8	11.0	13.2	14.6	11.7	14.0	15.3	13.4	14.6	15.5	13.7	14.7	15.4	13.7	14.8	15.8
9	8.0	11.2	14.1	11.5	13.5	15.4	12.4	13.9	15.3	12.7	13.9	15.2	12.6	14.0	15.4
10	4.2	5.9	9.1	6.5	8.9	11.7	9.7	11.0	13.3	9.6	11.1	12.9	9.6	11.0	12.7
11	4.5	5.8	7.1	6.6	8.8	9.9	9.4	10.3	11.2	9.6	10.7	11.5	9.4	10.5	11.6
12	5.8	7.0	8.9	7.3	9.2	11.3	10.2	11.1	12.6	10.4	11.3	12.7	10.5	11.3	12.6

Table 3
Continued

	Humidity ratio														
	Ambient			Centre of kitchen (non ac)			Delivery opening			Suction opening			Centre of dining hall		
Date	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
13	7.1	8.4	9.3	9.6	11.1	13.0	11.5	12.1	12.9	12.3	12.7	13.1	12.4	12.6	13.2
14	7.2	9.2	12.9	9.9	12.2	14.7	11.0	11.8	13.4	11.1	12.4	13.7	11.1	12.3	13.6
15	6.9	8.8	10.8	9.1	11.3	13.1	11.9	12.1	12.4	11.7	12.5	14.4	11.6	12.4	14.4
16	6.4	7.5	9.5	9.3	10.5	11.8	9.3	10.6	11.9	9.5	10.9	12.4	9.4	10.8	12.3
17	4.7	6.4	8.0	7.3	8.8	10.0	8.6	10.4	12.3	8.6	10.6	12.6	8.6	10.6	12.7
18	5.3	6.9	8.0	8.1	9.5	10.6	10.1	11.1	12.8	11.1	11.7	13.4	10.7	11.5	13.5
19	7.8	10.0	15.5	9.4	11.4	13.3	11.5	12.3	14.4	11.7	12.8	14.4	11.7	12.9	14.4
20	4.7	9.7	14.4	9.5	12.0	14.5	9.1	12.1	14.8	9.6	12.3	15.2	9.7	12.3	15.3
21	6.9	7.7	8.8	8.3	9.8	11.5	9.7	10.4	12.1	9.6	10.4	11.4	9.6	10.4	11.4
22	6.7	8.9	10.5	7.9	10.5	12.4	10.3	10.9	11.6	11.1	11.3	11.6	11.0	11.3	11.7
23	7.3	9.3	11.6	8.8	10.5	11.3	9.8	10.8	12.2	10.1	11.0	12.1	10.1	11.1	12.1
24	10.8	13.1	15.5	11.1	12.6	14.1	12.6	14.0	15.4	12.5	13.7	14.6	12.7	14.0	15.1
25	10.2	12.2	14.6	11.2	12.2	13.7	12.3	13.2	14.6	12.1	12.8	13.8	12.1	12.8	13.8
26	12.8	14.4	16.3	13.5	14.2	15.3	14.6	14.7	14.9	13.8	14.2	14.7	13.4	14.0	14.5
27	11.5	13.5	15.8	13.5	14.6	15.3	13.8	14.4	14.8	13.2	13.8	14.1	13.2	13.7	14.1
28	11.7	14.4	17.8	13.7	15.3	16.9	14.6	15.5	16.8	13.2	14.0	14.3	14.1	15.1	16.5
29	11.7	13.8	15.4	13.7	14.4	15.3	13.8	14.6	15.0	13.6	14.6	15.5	13.2	14.1	14.4
30	11.1	13.7	15.4	13.4	14.8	16.1	14.0	15.0	16.1	13.6	14.6	15.5	13.6	14.5	15.4
31	12.1	13.9	15.7	14.2	15.0	15.8	13.6	14.8	15.7	13.2	14.3	15.3	13.2	14.4	15.3
May	8.3	10.2	12.3	10.7	12.2	13.7	11.7	12.6	13.7	11.8	12.8	13.9	11.9	12.8	13.9

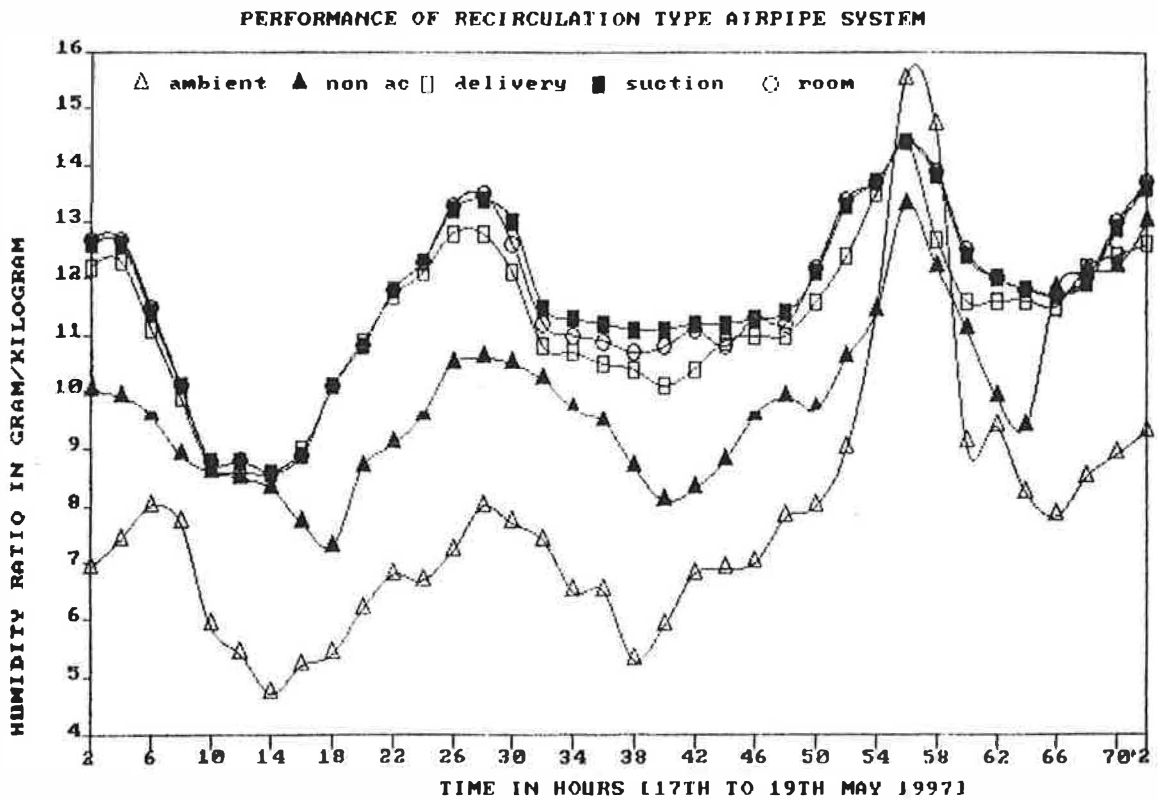

Fig. 6. Performance of recirculation type airpipe system. Variation of humidity ratio with time.

Table 4
Daily cooling potential of the system in summer 1997

Period	Daily cooling potential (KWh)
1/5/1997	335.4
2/5/1997	341.2
3/5/1997	260.5
4/5/1997	249.4
5/5/1997	265.2
6/5/1997	246.7
7/5/1997	250.7
8/5/1997	182.8
9/5/1997	195.1
10/5/1997	189.6
11/5/1997	205.9
12/5/1997	223.0
13/5/1997	228.9
14/5/1997	255.2
15/5/1997	205.5
16/5/1997	196.4
17/5/1997	185.9
18/5/1997	182.8
19/5/1997	153.2
20/5/1997	166.0
21/5/1997	118.5
22/5/1997	135.9
23/5/1997	107.6
24/5/1997	123.8
25/5/1997	118.1
26/5/1997	84.3
27/5/1997	86.3
28/5/1997	85.9
29/5/1997	79.6
30/5/1997	49.4
31/5/1997	71.4
Total	5580.6

humidity inside the non-conditioned room for most of the day (except one or two hours during the night) remains higher than the ambient (on average about 10%). The relative humidity of the conditioned space is found to be always higher (about 5% on average) than that observed in the non-conditioned room. While relative humidity of the air measured at the outlet of the delivery duct was found to be higher than the conditioned room (about 5% on average).

To investigate the addition of any moisture in the heat exchanger tubes, the humidity ratio at five locations was also calculated and is plotted in Fig. 6. The corresponding daily maximum, daily minimum and daily average values for all 31 days are also given in Table 3. It may be observed from Fig. 6 and Table 3 that moisture is added to the air as it is circulated through the earth-coupled heat exchanger tubes. It may also be seen that to the water vapour of 10.2 g/kg in the ambient, 2 g/kg is added in the non-conditioned room and 0.4 g/kg is added in the earth-coupled heat exchanger tubes.

The cooling potential ($\dot{Q}$) of the earth coupled heat exchanger tubes can be estimated from the relation:

$$\dot{Q} = 8\int \dot{m}\cdot C_p\cdot(T_{nac} - T_{delivery})\cdot dt$$

where $\dot{m}$ = mass flow rate of air in each of the eight delivery pipes, C_p = Specific heat of air; T_{nac} = non air conditioned room temperature, $T_{delivery}$ = temperature of conditioned delivery air, dt = time interval.

The calculated value of $\dot{Q}$ for each day of the month is given in Table 4. It may be observed from the Table that during the month of May, the maximum cooling potential of the system is 341 KWh (thermal) and its monthly average value is about 180 KWh (thermal). As the air was forced through the system by the 3 HP blower the Cooling Potential (COP) of the system will come out at about 3.35 only.

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