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Ventilation effectiveness of different diffusors with partitions

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Manuscript: **"Ventilation effectiveness of different diffusers with partitions"**

SUMMARY

Full scale tests in simulation chambers are performed in order to determine what the best comfort conditions and air exchange rates are for two occupied zones in a future building. The fresh air exchange rates are determined through the SF6 tracer gas decay method. The comfort measurements are determined through different parameters such the air performance diffusion index, air velocity and predicted percentage of dissatisfaction. Different arrangements of supply air and conditions are tested: types of diffusers, locations of diffusers and air returns, types of supply unit., heights and elevations of partitions, air pressures in the returns, outside window conditions and so on. The results show the significiant influence of some parameters on comfort and air exchange conditions and offer the designer the optimal choice of a combination of arrangements for the two occupied zones.

INTRODUCTION

The purpose of this research project is to find out the ventilation effectiveness of two office ventilation systems. The owner of a future office building would like to design the real amount of fresh air delivered to the occupied spaces under different conditions and arrangements. The results will help him to select the ventilation systems under the optimal conditions of comfort and the best fresh air exchange rates. Full scale tests are not popular in North America but are often desirable (1) for this purpose.

TEST SET-UP

Ventilation effectiveness is defined by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) as "the proportion of fresh air actually delivered to the occupied spaces". In order to calculate the ventilation effectiveness, we have used the SF6 tracer gas decay method . The future office building has two different ventilation systems: one system for the peripheral zone and another for the central zone. To simulate the actual conditions in these two zones, we have built two mock-up.chambers. In the first chamber for simulating the central zone with partitioned offices, a constant air volume unit with diffusers and returns on the ceiling was used. Two types of diffusers were tested: the square conic diffuser and the light troffer diffuser. The office partitions were of two different heights (48 inches and 62 inches) and can be raised above the floor by 3, 6, 9 and 12 inches. In the second chamber for simulating the peripheral zone with closed offices, an induction unit was installed. The diffuser was installed on the ceiling and on the floor, and so was the return . The glass window was submitted to simulated outside temperatures of -30, +10 and +30 degrees Celcius. Parallel to the ventilation effectiveness tests, we have also conducted other comfort measurements such as the Air Performance Diffusion Index (APDI), the air velocity, the predicted percentage of dissatisfaction and the predicted mean vote (PPD vs PMV).

MEASUREMENT SET-UP

Measurements were carried out witn the decay method using the SF6 as a tracer gas A homogeneous starting concentration was achieved by using mixing fans during tracer gas injection and for half an hour after injection. The equation for the decay is :

$$Ln\ (C/Co) = -\ (I).t$$

where:
Co = starting concentration
C = concentration of tracer gas at time t
I = fresh air exchange rate per hour
t = time length

RESULTS IN CHAMBER FOR SIMULATING CENTRAL ZONE

Table 1 summarizes the results of fresh air exchange rates with different arrangements of partitions and types of diffusers (the complete tests also showed the variations of pressures in the returns and other particular conditions)

Table 1: Fresh air exchange rates of the central zone simulation chamber (in Air change per hour)

Height of partition (inches)	Elevation of partition (inches)	Diffuser Square conic (ACH)	Diffuser Light troffer (ACH)
62	3	**1,7**	**1,6**
62	6	**0,8**	**2,4**
62	9	**2,3**	**1,8**
62	12	**1,4**	**1,3**
48	9	**1,5**	
48	3		**1,3**

Table 2 shows an example of air velocity results with the same arrangements as table 1:

Table 2: Air velocity of the central zone simulation chamber

Percentage of measuring points in the chamber within different velocity ranges

Height of partition (inches)	Elevation of partition (inches)	Diffuser Square conic			Diffuser Light troffer		
		0-0,15 (m/s)	0,15-0,25 (m/s)	0,25-> (m/s)	0-0,15 (m/s)	0,15-0,25 (m/s)	0,25-> (m/s)
62	3	**75**	**25**	**0**	**83**	**17**	**0**
62	6	**79**	**21**	**0**	**75**	**21**	**4**
62	9	**83**	**17**	**0**	**92**	**4**	**4**
62	12	**79**	**21**	**0**	**58**	**42**	**0**
48	9	**71**	**25**	**4**			
48	3				**79**	**17**	**4**

Table 3 shows results of measurements of the Air Performance Diffusion Index (APDI) for the same arrangements :

Table 3: Air Performance Diffusion Index (APDI) in %

Height of partition (inches)	Elevation of partition (inches)	Diffuser Square conic (%)	Diffuser Light troffer (%)
62	3	**95,8**	**94,8**
62	6	**97,9**	**95,8**
62	9	**97,9**	**97,9**
62	12	**97,9**	**93,7**
48	9	**97,9**	
48	3		**95,8**

RESULTS IN CHAMBER FOR SIMULATING PERIPHERAL ZONE

Table 4 summarizes the results of fresh air exchange rates with different locations of diffusers and returns (the complete tests also showed the variations of pressures in the returns and other particular conditions)

Table 4: Fresh air exchange rates in the chamber in Air Change per Hour (ACH)

Location of diffuser	Location of return	Temperature of glass window	ACH
ceiling	floor	-25 deg.C	**2,0**
ceiling	floor	+10 deg.C	**1,5**
ceiling	floor	+30 deg.C	**1,5**
ceiling	ceiling	-25 deg.C	**1,4**
ceiling	ceiling	+30 deg.C	**1,5**
floor	ceiling	-25 deg.C	**2,0**
floor	ceiling	+30 deg.C	**2,0**

Table 5 summarizes the results of the Air Performance Diffusion Index:

Table 5: Air Performance Diffusion Index in (%)

Location of diffuser	Location of return	Temperature of glass window	APDI (%)
ceiling	floor	-25 deg.C	**83**
ceiling	floor	+10 deg.C	**89**
ceiling	floor	+30 deg.C	**100**
ceiling	ceiling	-25 deg.C	**86**
ceiling	ceiling	+30 deg.C	**89**

Figure 1 : PLAN VIEW OF THE SIMULATION CHAMBER (with partitions) FOR THE CENTRAL ZONE

SUPPLY DIFFUSER

AIR RETURN

POINTS OF MEASUREMENTS (APDI, AIR EXCHANGE, AIR VELOCITY,...)

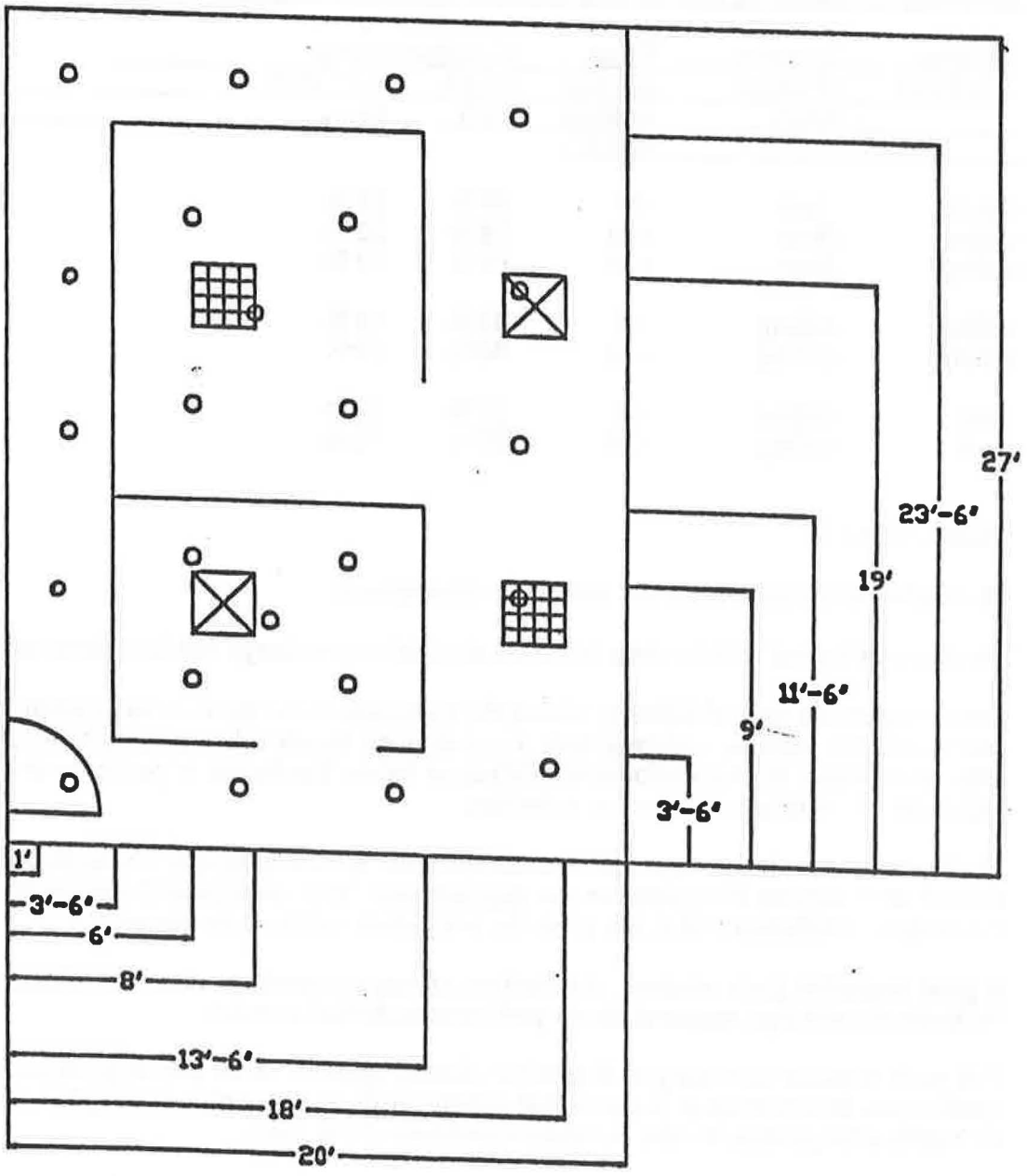

Table 5: Air Performance Diffusion Index in (%) (suite)

Location of diffuser	Location of return	Temperature of glass window	APDI (%)
floor	ceiling	-25 deg.C	**100**
floor	ceiling	+30 deg.C	**100**

Table 6 shows the results of air velocity in the chamber

Table 6: Air velocity of the peripheral zone simulation chamber

Percentage of measuring points in the chamber within different velocity ranges

Location of diffuser	Location of return (m/s)	Temp. of glass window (deg.C)	Air velocity range 0-0,15 (m/s)	0,15-0,25 (m/s)
ceiling	floor	-25	**89%**	**11%**
ceiling	floor	+10	**78%**	**22%**
ceiling	floor	+30	**89%**	**11%**
ceiling	ceiling	-25	**89%**	**11%**
ceiling	ceiling	+30	**90%**	**10%**
floor	ceiling	-25	**33%**	**67%**
floor	ceiling	+30	**67%**	**33%**

CONCLUSIONS

The results permit us to make the following observations:

The shape or type of diffuser does influence the fresh air exchange rate in a chamber

Depending on the type of diffuser, raising the partitions above the floor at a certain elevation does provide a better fresh air exchange rate. It also changes the air velocity significantly, but it does not seem to influence the Air Performance Diffusion Index. The height of partitions does also have an impact on air exchange rates and air velocities.

The highest air exchange rates are reached when the induction supply unit is situated on the floor and the air return on the ceiling on the opposite side. This arrangement also permits the best Air Performance Diffusion Index, but gives the worst draft problems in winter.

A good insulation glass window submitted to extreme temperatures does not influence significantly the fresh air exchange rates and the air performance diffusion index.

Full scale tests are necessary to determine whether good fresh air exchange rates and good room comfort can be achieved at the designed supply air flows and temperatures, the selected different air supply arrangement and the particular conditions of the room.

REFERENCE

(1) Larkfeldt, B.. Full-scale tests for determining air movements and temperature distributions. Papers, Roomvent-87, Stockholm, Sweden, 1987

(2) Majanen,A., Helenius,T., Seppanen,o., Roos,R..Air exchange efficiency in residential and office buildings. Papers, Roomvent-87, Stockholm, Sweden, 1987

Figure 2. Cross Section of Test Facility