

Air Conditioning Simulation

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the air environment in the building in which people

1. Introduction

In Japan in recent years, utilization of VAV air conditioners is increasing for accomplishment of an air conditioning project owing to their simplicity in structure, low cost, availability for energy conservation, etc. On the other hand, the number of buildings designed to have atrium is also in a trend of increase. However almost none of VAV devices for air conditioning in office in individual buildings are available with the ventilation pipes except with the discharging pipes. “The air conditioning system accordance with the variable air volume method” allows not only the air volume in each room to be changed but also the pressure to be concurrently altered. Despite the above, no consideration is made in performing the pressure control individual office. In almost all of the business buildings in Japan, much importance is hardly attached to the said pressure problems. However it seems likely that the pressure problems are considered with respect to the Century Tower Building designed by Foster Associates at the time of its design. We, the authors of this paper, constructed a computation model based on a variety of information concerning the building, and attempted to make calculation taking up a building having a large-scale atrium as an example with the use of “Heat and Air Environment calculation program” developed by us. With the room pressure problem during the time when the VAV air conditioning attempt is in progress and the problematic points of the air current directed toward the atrium, a method to solve such problems and deal with such problematic points was examined.

2. Outline of the calculation program

In constructing buildings in recent years, research for performance of the buildings is made in advance of starting the construction. Meanwhile even just for the purpose of the preparatory research, simulation technology is exhibiting rapid progress. In case of executing construction design, surrounding air current situation is often available in light environment, or with large-size buildings. However simulation is seldom made with the air environment or air currents in buildings in advance of the setup, notwithstanding that

reside is a matter of importance. On the other hand, realization of good air environment exercises much influence also on the heat environment. The heat environment simulation programs in recent years include in themselves problem of air currents. However heat computation is regarded as a pivotal point of the problems, and almost all of the projects are quite simple ones with which none of air volume calculation, crack air volume computation, and heat balance calculation, and fans, filters, cooling coils, etc. as air conditioner elements can be installed. Thus calculation of the heat/air environment of the system can be made in accordance with a calculation formula almost the same as the one utilized at the time of designing air conditioners. The said program makes it possible to do simulation ranging from small-scale buildings to large-scale construction.

3. Outline of the computation formula

The program in question can arbitrarily make plans for ducts, cracks, FANs, and cooling coils, and makes it possible to control and calculate the temperature, humidity, pressure, CO₂ gas concentration in an arbitrary room. Removal heat quantity calculation of the air handling unit (hereafter abbreviated as AHU) is made in connection with sensible heat and latent heat based on convection current heat conduction computation.

The volume of air flowing through the ducts, cracks, and open mouth is calculated in accordance with Darcy-Wysbach’s formula. In other words, the said calculation is made by the local pressure loss and friction loss. Crack air volume calculation is made by parallel plate approximation of laminar airflows, and Colebrook’s calculation formula is used for friction resistance in the duct air volume computation. Change of the turbulent flow friction coefficient caused by the change of Reynolds number (hereafter abbreviated as *Re* number) is hyperbola-approximated, and the duct inside roughness and the friction coefficient by the *Re* number are calculated by applying them to Darcy-Wysbach’s formula. For that purpose, the friction coefficient in the duct air volume calculation is divided into 6 types of the *Re* number regions including laminar flow (Table 1). Meanwhile with the static

pressure air volume curve of the FAN which is hyperbola-approximated in consideration of the static pressure and air volume, a curve to allow the axis of the hyperbola whose axis comes to the minus side of the air volume to correspond to minus values of the static air volume one by one is selected.

3.1 Approximated ducts

In this paper, a duct which branches and blows out into the same room was approximated by a single turbulent flow duct. First all, approximation was made on the assumption that the temperature is 20.0 °C. After the duct was constructed, re-calculation made with the coefficient dependent on the temperature in the program corresponding to the change of the temperature and humidity together with change of the air volume. The air volume change by the Re number change according to the temperature change in connection with the duct constructed at this stage to be approximated is the same as that of the original turbulent flow duct. This is due to the fact the turbulent flow friction coefficient λ is based equation shown below.

$$\lambda = r_0 + (r_1/Re) + (r_2/Re^2) \quad (1)$$

This is furthermore due to the fact that the approximated duct has a term r_0 equivalent to the local pressure loss except r_1 , and has a term of r_2 equivalent to a term which is to be a unit of the pressure in the formula of the pressure loss. In addition to the above, the coefficients of r_0 , r_1 , and r_2 make calculation of the data of the 6 groups (Table 1) corresponding to the Re number with respect to the individual ducts at the time of reading the duct data as described before and is in possession of the said data.

3.2 Calculation formula of the room pressure and room temperature

Calculation of the room pressure P_i [pa] in the room i in question is made as shown below from its pressure difference ΔP_{ij} on the assumption that the pressure in the room j where open mouths, cracks ducts, etc. are connected is known.

$$P_i = \frac{\sum_{j=1}^n ((\Delta P_{ij} + P_i) s_j / (b_{ij} + \sqrt{b_{ij}^2 + 4a_{ij}|\Delta P_{ij}|}))}{\sum_{j=1}^n (s_j / (b_{ij} + \sqrt{b_{ij}^2 + 4a_{ij}|\Delta P_{ij}|}))} \quad (4)$$

$$\Delta P_{ij} = (P_j - \rho_i g h_j) - (P_i - \rho_i g h_i) + \delta P_h - \delta P = a_{ij} v^2 + b_{ij} v$$

$$\delta P_h = \rho_i g (h_j^* - h_i^*)$$

δP : Term concerning r_2 in Eq. (1)

ρ_i : Density of air passing through the open mouths, cracks, ducts, etc. [kg/m³]

s_j : Representative area the open mouths, cracks and ducts

v : Passing air average speed of the open mouths, cracks, ducts, etc. [m/s]

ρ_d : Duct passing air density [kg/m³]

h_k : Height from the floor to the pivotal point of a duct open mouth [m]

h_k^* : Absolute height [m]

k : Express i or j . Volumetric flow ranging from j to i is plus.

The calculation formula of the room temperature was obtained from the stationary heat balance equation. This is a heat equilibrium formula of the heat balance of the sensible heat and latent heat of the room inflow/outflow air and the heat balance on the wall surface together with in-room generated heat quantity and in-room generated vapor quantity. On the other hand, the vapor are given by the in-room generated heat quantity on the simulation contains the sensible heat and latent heat together with the heat generation from the equipment and apparatus and solar-radiated inflow heat quantity. The calculation formula of the room temperature t is as shown below.

$$t = \frac{[(\sum h P_{in,j} q_{in,j} - G \cdot w \cdot R_w) + h_q + \sum \alpha_k A_k t_{s,k}]}{[G \{c_p(t) + w \cdot c_v(t)\} + \sum \alpha_k A_k]} \quad (6)$$

Where G is given as shown below.

$$G = \sum q_{in,j} \quad (6)$$

$q_{in,j}$: Volume of air flowing from the j chamber to the chamber in question [kg/s]

α_k : Convection heat conductivity in the inside of the chamber on the k -th wall in the chamber in question [kW/(m²K)]

A_k : Area of the k -th wall in the chamber in question [m²]

$t_{s,k}$: Surface temperature in the inside of the k -th chamber of the chamber in question [°C]

$h P_{in,j}$: Enthalpy heat quantity [kJ/kg] of air flowing into the chamber through the ducts/cracks

h_q : In-room generated heat quantity [kW]

$c_p(t)$: Isopiestic specific heat [kJ/(kgK)] to be changed according to temperature, approximately 1.01kJ/(kgK)

$c_v(t)$: Vapor specific heat [kJ/(kgK)] to be changed according to temperature, approximately 1.8282 kJ / (kgK)

R_w : Vapor latent heat quantity [kJ/kg], 2500.132 kJ/kg

w : Absolute humidity [kg/kg]

4. Calculation model

The data of the Century Tower were available for the calculation model of this time, and were constructed based on the obtained information (Figs. 1 and 2). The information is for construction of the 5th and 6th floors of the building. The structure of the building, which is fundamentally the same as that of the Tower except the 1st and 2nd floors, was designed with respect to the 3rd floor through the 10th floor in accordance with the said information. On the other hand, the offices are placed symmetrically with the atrium as their boundary point. The ducts, which are constructed based on the

information, are used by approximating them as described before. FAN data is constructed based on the information by being hyperbola-approximated as referred to before (fig. 3). No design of the elevator halls was formed.

4.1 Performance of the AHU for simulation

The AHU is constructed by a combination of an air cooling coil and an FAN. Coil specification are read by the data. It is possible to incorporate plural AHUs whose specification are different from each other into a single type of simulation. Calculation results allow the individual data of the AHU to be outputted. Performance of the cooling coil of the AHU is shown in Fig. 4.

4.2 Pressure control in a room

Settlement of the pressure control was made with respect to the individual systems having respectively an air conditioner. Which this simulation for example, the damper after the ventilating flows were combined was designed to be regulated for the 3rd and 4th floors. In addition, when no heat was generated and no inflow of the outer air was seen, pressure control was made by means of the return VAV of the individual rooms with respect to the individual rooms.

4.3 Pressure settlement method to obstruct the atrium flow in case that the atrium is devoid of heat load

In case that the temperature and humidity in a room are controlled and the atrium is devoid of the heat load from the glass and wall of the atrium, the atrium flow can be obstructed by designation the pressure settlement values of the individual floors as the values in accordance with the calculation formula shown below. When indoor and outdoor temperature difference is brought about in the inside and outside of the room. However when the outer atmosphere on the earth is taken up as a criterion, the pressure difference $\delta P'_h$ is given as shown below.

$$\delta P'_h = gh/v(t_i, w_i) - gh/v(t_o, w_o) \quad (7)$$

$$v(t, w) = 287.055 \cdot (273.15 + t) \cdot (0.9995 + 1.60777 \cdot w) / 101325.0 \quad (8)$$

$g = 9.80665 \text{ m/s}^2$, h : Height [m],

$v(t, w)$: Specific volume assessed from dry-bulb temperature and absolute temperature [m^3/kg]

t : Dry-bulb temperature

w : Absolute humidity i : inside o : outside

By taking up a value of a height in accordance with the calculation formula shown above as a criterion, a control target value is determined. Utilization of the said value for the pressure control in the individual rooms makes it possible to liberate the flow from being

directed from the individual floors to the atrium. However in case that difference is noted with the air density of the individual floors, the density difference and the open mouth position are related with each other. From this reason, it is necessary to make calculation with respect to the individual cases.

4.4 Calculation result

The individual Case patterns are listed in Tables 2. No difference is noticed with the north and south buildings for Case 1 though 5, and a symmetrical result is obtained. Therefore the result is described exclusively with the north building. In this connection, the result of the AHU and inputted heat quantity is tabulated exclusively with the 3rd and 4th floors owing to the restriction of the pages in this paper. On the other hand, the values of the atrium ventilation, stairs ventilation, and open mouth inflow quantity are given as the sum of the inflow and outflow owing to the restriction of the page in this paper. Therefore even in case that the numerical values are low, exchange air quantity is sometimes abundant.

4.4.1 Operation with the unrectified air conditioning design data

Although no operation of the air conditioning design is made as a system because the design is made with respect to the individual elements, investigation can be made to check to see if the performance strictly in accordance with the settled design is obtained by the operation by means of simulation. First of all, operation is made as Case 1 by being devoid of entire heat generation quantity. The outer atmosphere temperature at that time is 20°C, whereas the outer atmosphere relative humidity is 50%. As a result of the calculation, the volumetric flow from the FAN is obtained as design prediction values. None of natural ventilation is caused because no heat is generated, and no flow is produced on the upper and lower floors.

4.4.2 Heat input operation (room pressure control)

Case 2 reveals that control is made with the area of the glass window facing the outer atmosphere 92.642m², room temperature as 26°C, relative humidity as 50% and CO₂ gas concentration as 999ppm under the condition that the heat quantity applied to the individual offices is 24.5kW in Case 1. The crack of the sash was determined to be 22.5m long with the stability floor, whereas the 2 horizontal cracks with a length of 22.5m and 16 vertical cracks with a length of 2.96m were determined. Meanwhile with the mezzanine floor, 3 horizontal cracks with a length of

22.5m and 16 vertical cracks with a length of 2.97m were determined. For the room pressure settlement value in Eq. (7) is used so that the flow on the upper and lower floors will be reduced.

4.4.3 Applied heat quality reduction (room pressure control available and room pressure control unavailable)

Case 3 reveals that the applied heat quantity to be given to the individual offices was determined to be 17.15kW as 30% reduction in Case 2. Also for the pressure settlement in Case 3, the pressure settlement value in Eq. (7) is used likewise in Case 2. Even under the condition that the applied quantity is reduced 30%, the state of equilibrium in the room can be maintained by performing room pressure control.

Case 4 reveals that the applied heat quantity given to the individual offices is determined to be 17.15kW as 30% reduction, but this is the case that no pressure control is performed and affairs are physically the same as the duct state in Case 2. Under the condition that the applied heat quantity is reduced 30% and the affairs are the same in Case 2, the room pressure becomes too low.

4.4.4 Inputting the heat and window cracks to the atrium

To the prevision Case, the atrium unit was devoid of heat load and was placed in a closed state. In Case 5, the heat load brought about by solar radiation and window crack (air-tight sash) data are inputted into the atrium. The atrium has heat load. Therefore when the temperature is higher than in the lower part, it is necessary for the upper room pressure settlement value to be reduced by the amount of the temperature elevation corresponding to the pressure reduction quantity.

4.4.5 In case that the heat quantity is increased exclusively with the 3rd floor of the north building

Case 6 reveals that increased heat quantity more than in other room was supplied exclusively to the 3rd floor of the north building. The generated heat quantity in the room is 24.5kW with the 3rd floor of the north building, whereas the quantity is 17.15kW with the other floors. Difference is noted with the heat generation quantity, and difference is likewise noted with the volume of air to be supplied to the room for the purpose of the temperature control of the 3rd and 4th floors of the north building. However since room pressure is controlled, the factors including the flow to the atrium are kept low

enough without being different from the state in Case 5.

5. Conclusions

- (1) It is possible, it is said, for the VAV unit to correspond to the change, provided that the variation in the heat quantity is as small as 30%. However it is necessary for the variation of the room pressure to be checked. When no correspondence to the room pressure control is made, dangerous pressure lowering liable to allow the room pressure to be lowered to the extent of the outer barometric pressure more than 200Pa is seen.
- (2) Also in case that cracks, e.g. windows are in existence, no mitigation of the room pressure lowering can be reached with the air-tight windows in this simulation. As long as the said result is taken into account, a considerable amount of the cracks to mitigate the room pressure lowering becomes necessary.
- (3) When the atrium where space is connected with the offices is devoid of heat load, it is possible for the flow directed toward the atrium to be reduced as seen in Case 2.
- (4) When the atrium where space is connected with the offices is in possession of heat load and no control is made with the atrium room temperature at the same office room temperature, a flow is produced in the atrium. In Case 5, production of ascending air current together with elevation of the temperature in the upper part was seen. When vigilant to the atrium temperature, room pressure control on the individual floors is possible. Despite the above, temperature difference is noted with the offices and the atrium. Thus exchange of air is brought about as seen in Case 5.
- (5) When increase of heat land is seen exclusively with the south office on 3rd floor, pressure balance compels a large amount of air to be directed toward the atrium exclusively with return damper. In that, occasion, control of the individual floors makes it possible to reduce the flow. Meanwhile from the Comparative results in Case 5 and 6, it is explained that the outcomes with which almost none of difference is noted were obtained with the floors except the floors providing the heat land with change. From this reason, it is imagined that just a small amount of influence in to be exercised on the other floors provided that room pressure control is continuously performed.

Reference

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2. Ian Ranbot and Colin Davis, "Century Tower" , Water Mark publications(UK), September, 1992, Japanese Edition
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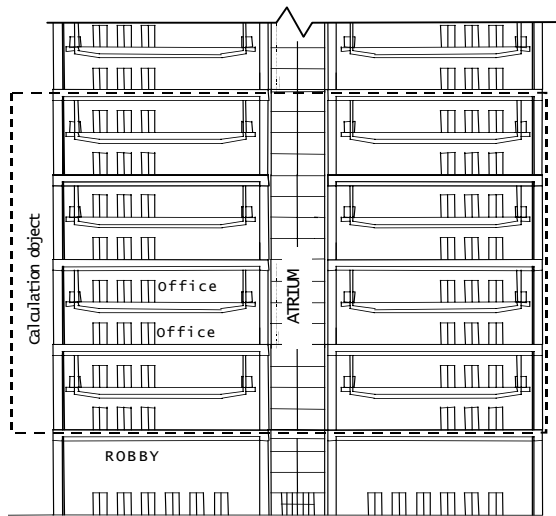


Figure 1 Sectional view

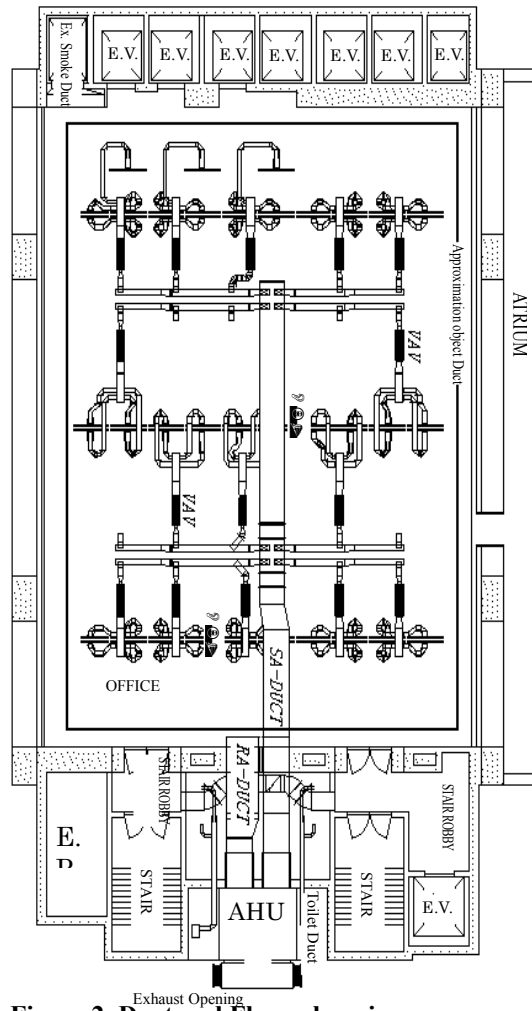


Figure 2 Duct and floor plan view

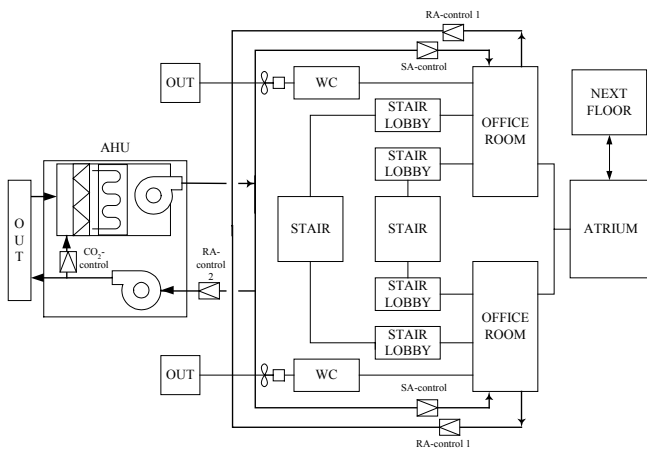


Figure 3 System

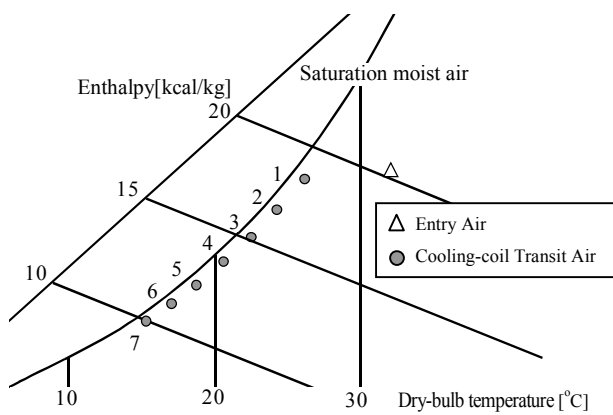


Figure 4 Cooling-coil transit air condition

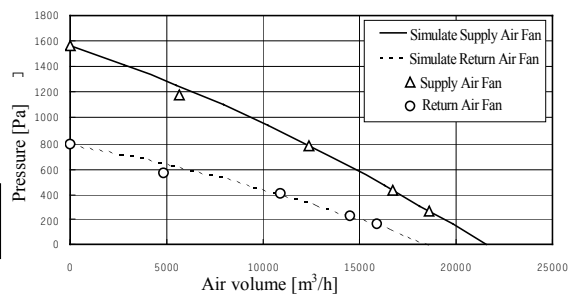


Figure 5 The air volume of Fan

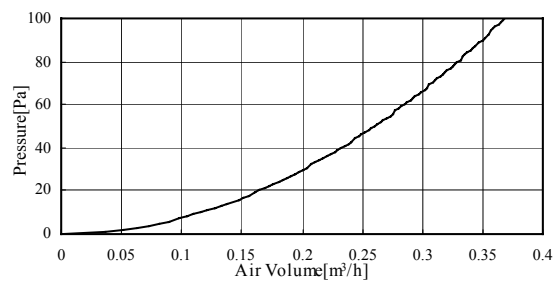


Figure 6 The air volume of Fix sash

	1	2	3
1	Laminar flow.		
2	1000	4000	8000
3	8000	16000	40000
4	40000	80000	200000
5	200000	400000	1000000
6	1000000	2500000	7500000

Table 1 Reynolds areas

Table2 Simulation Calculation result

	Case1	Case2	Case3	Case4	Case5	Case6_N	Case6_S	5th-6th Floor	Case1	Case2	Case3	Case4	Case5	Case6_N	Case6_S
Supply-air VAV	Condition	-	ON*1	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
Return-air VAV	Condition	-	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
RA-SA VAV	Condition	-	ON	ON	-	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
ATRUM T class	Condition	-	-	-	-	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
Temperature	°C	20	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6
Relative humidity	%	50	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4
CO ₂ concentration	ppm	350	350	350	350	350	350	350	350	350	350	350	350	350	350
5th-4th AHU															
The amount of cooling-coil cold water	l/min	-	250	250	250	250	250	250	250	250	250	250	250	250	250
The number of cooling-coil trains	line	-	8	8	8	8	8	8	8	8	8	8	8	8	8
Cold-water inlet-port temperature	°C	-	8.481	9.396	9.166	9.395	8.954	9.393	9.393	9.393	9.393	9.393	9.393	9.393	9.393
Cold-water outlet temperature	°C	-	14.059	14.118	13.879	14.118	14.106	14.120	14.120	14.120	14.120	14.120	14.120	14.120	14.120
Cooling-coil load	kW	-	97.291	82.365	82.208	82.349	89.872	82.453	82.453	82.453	82.453	82.453	82.453	82.453	82.453
The amount of latent heat	kW	-	25.985	25.985	25.985	25.985	25.985	25.985	25.985	25.985	25.985	25.985	25.985	25.985	25.985
Amount condensation of water	kg	-	36.830	36.830	36.238	36.843	36.805	36.840	36.840	36.840	36.840	36.840	36.840	36.840	36.840
Input data															
Stability The amount of heating	kW	-	24.5	17.15	17.15	17.15	24.5	17.15	17.15	17.15	17.15	17.15	17.15	17.15	17.15
Stability Outer wall sensible-heat acquisition	kW	-	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314
Stability Staying-in-the-room number	person	-	50	50	50	50	50	50	50	50	50	50	50	50	50
Stability Human body occurrence heat quantity	kW	-	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83
Stability Human body occurrence steam quantity	kg/h	-	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358
Stability CO ₂ occurrence quantity	m ³ /h	-	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Mezzanine The amount of heating	kW	-	24.5	17.15	17.15	17.15	17.15	17.15	17.15	17.15	17.15	17.15	17.15	17.15	17.15
Mezzanine Outer wall sensible-heat acquisition	kW	-	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314
Mezzanine story Staying-in-the-room number	person	-	50	50	50	50	50	50	50	50	50	50	50	50	50
Mezzanine Human body occurrence heat quantity	kW	-	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83
Mezzanine Human body occurrence steam quantity	kg/h	-	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358	5.358
Mezzanine CO ₂ occurrence quantity	m ³ /h	-	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Mezzanine supply air FAN occurrence heating value	kW	-	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Mezzanine return air FAN occurrence heating value	kW	-	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
5th-4th Floor															
Stability Temperature	°C	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Stability Relative humidity	%	50.0	50.0	49.6	50.0	50.0	49.6	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Stability CO ₂ concentration	ppm	350	999	976	999	999	979	999	999	999	999	999	999	999	999
Mezzanine Temperature	°C	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Mezzanine Relative humidity	%	50.0	50.0	50.5	50.0	50.0	50.5	50.0	50.0	50.0	50.0	49.4	50.0	50.1	50.1
Mezzanine CO ₂ concentration	ppm	350	999	1022	999	999	1026	999	999	999	999	999	999	999	999
Stability	Pa	53.259	9.09	9.09	-202.97	7.20	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30
WC (Stability)	Pa	51.786	7.85	7.85	-203.00	5.97	6.07	6.07	6.07	6.07	6.07	6.07	6.07	6.07	6.07
Mezzanine story	Pa	53.259	7.95	7.95	-204.09	6.14	6.20	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
WC (Mezzanine)	Pa	51.786	6.72	6.72	-204.12	4.92	4.98	4.99	4.99	4.99	4.99	4.99	4.99	4.99	4.99
Supply air (Stability)	kg/h	9.652	9.456	7.069	6.994	7.061	9.519	7.070	7.070	7.070	7.070	7.070	7.070	7.070	7.070
Return air (Stability)	kg/h	9.189	9.049	6.663	7.166	6.559	8.876	6.450	6.450	6.450	6.450	6.450	6.450	6.450	6.450
Toilet exhaust (Stability)	kg/h	460	409	409	-143	407	407	407	407	407	407	407	407	407	407
Atrium discharge *2	kg/h	-0.8	1.4	3.6	-35.3	-405.23	-511.22	-486.98	-486.98	-486.98	-486.98	-486.98	-486.98	-486.98	-486.98
Aperture inflow (Stability)	kg/h	0.0	0.2	0.2	20.8	154	136.83	136.76	136.76	136.76	136.76	136.76	136.76	136.76	136.76
Stairway discharge *2	kg/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aperture inflow (Mezzanine)	kg/h	9.650	9.456	7.069	6.994	7.059	6.201	7.090	7.090	7.090	7.090	7.090	7.090	7.090	7.090
Return air (Mezzanine)	kg/h	9.186	9.047	6.658	7.167	6.564	7.099	6.454	6.454	6.454	6.454	6.454	6.454	6.454	6.454
Toilet exhaust (Mezzanine)	kg/h	460	408	408	-143	406	406	406	406	406	406	406	406	406	406
Atrium discharge *2	kg/h	-0.5	-1.0	-2.2	-25.1	-360.3	-403.4	-460.76	-460.76	-460.76	-460.76	-460.76	-460.76	-460.76	-460.76
Aperture inflow (Mezzanine)	kg/h	3.1	-0.9	-0.9	6.5	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72
Stairway discharge *2	kg/h	0.0	0.1	0.1	24.1	136.65	127.22	126.25	126.25	126.25	126.25	126.25	126.25	126.25	126.25
Supply-air temperature	°C	20	15.64	15.79	15.58	15.78	15.71	15.79	15.79	15.79	15.79	15.79	15.79	15.79	15.79
Supply-air humidity	%	50	89.59	87.04	86.91	87.02	88.49	87.04	87.04	87.04	87.04	87.04	87.04	87.04	87.04
5th-6th Floor															
Stability Temperature	°C	20.0	26.0	26.0	26.0	26.0	25.98	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Stability Relative humidity	%	50.0	50.0	50.0	50.0	50.0	49.92	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Stability CO ₂ concentration	ppm	350.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
Mezzanine Temperature	°C	20.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Mezzanine Relative humidity	%	50.0	50.0	50.0	50.0	50.0	50.0	50.0	49.94	50.0	50.0	50.0	50.0	50.0	50.0
Mezzanine CO ₂ concentration	ppm	350.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
Stability	Pa	53.259	2.27	2.27	-209.55	2.003	2.003	2.003	2.003	2.003	2.003	2.003	2.003	2.003	2.003
WC (Stability)	Pa	51.786	1.07	1.07	-209.58	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mezzanine story	Pa	53.259	1.14	1.14	-210.64	1.25	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
WC (Mezzanine)	Pa	51.786	-0.06	-0.05	-210.66	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Supply air (Stability)	kg/h	9.652	9.456	7.069	6.982	7.253	7.265	7.265	7.265	7.265	7.265	7.265	7.265	7.265	7.265
Return air (Stability)	kg/h	9.189	9.054	6.682	7.115	6.780	6.872	6.872	6.872	6.872	6.872	6.872	6.872	6.872	6.872
Toilet exhaust (Stability)	kg/h	460	401	401	-145	401	401	401	401	401	401	401	401	401	401
Atrium discharge *2	kg/h	-0.8	0.4	14.1	29.2	232.74	292.66	287.36	287.36	287.36	287.36	287.36	287.36	287.36	287.36
Aperture inflow (Stability)	kg/h	2.5	-0.2	-0.2	5.3	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22
Stairway discharge *2	kg/h	0.0	-0.1	0.3	-14.3	-156.72	-147.09	-147.01	-147.01	-147.01	-147.01	-147.01	-147.01	-147.01	-147.01
Aperture inflow (Mezzanine)	kg/h	9.650	9.456	7.069	6.983	7.184	7.195	7.							