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SOME FIREPROOF PROBLEMS OF HIGH-RISE BUILDING

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ABSTRACT

In the light of engineering practice of overthrow some views and propose are given in this paper for Chinese Code of fireproof in system design of air conditioning and ventilating.

As there are many of high-rise building and ultra-high-rise building existing, it is now the time to consider the significance of fireproofs problems. Now the Chinese national standard GB50045-95 "Code for fire protection design of tall buildings"(CFTB) have been obliged executed. Because the CFTB is a programmatic document, it could not make detail regulations for every condition in practical project. This paper tries to propose some references for the designer to deal with some of the fireproof problems.

1. CONTROL OF PRESSURE SYSTEM FOR ANTI-SMOKE STAIRCASE AND SHARED FRONT-ROOM IN HIGH-RISE BUILDING

According to the CFTB 6.1.13: "The public buildings, which height is over 100 m, should arrange refuge layers." So it is necessary to set up one or several refuge layers in high-rise buildings, especially ultra-high-rise buildings. The distance between two refuge layers should be less than 15 layers. The CFTB request that anti-smoke staircase must be divided in refuge layer. Here the staircase, which belong to one core, have been divided into several stages at Fig. 1. When there is fire, all the pressure air-supply system will be run for safety. But this will add the load of the fireproof power supply or the capacity of the diesel-generators, and increase the original investment. The author think to divide the pressure system in accordance with the refuge layers and to correctly control the running and stopping of the pressure blower is an effective method to solve the above mentioned problem. In Fig. 1, there are two refuge layers in the high-rise building. When there is fire in different areas, under the control mode of Table 1, people could be safety evacuated.

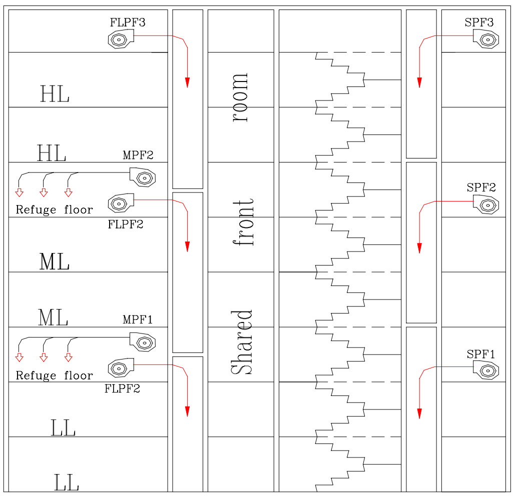

Fig. 1

Table 1: The control modulate of pressure increasing fan

Fire area	SPF1	SPF2	SPF3	FLF1	FLF2	FLF3	MPF1	MPF2
LL	•	×	×	•	×	×	•	×
ML	×	•	×	×	•	×	•	•
HL	×	×	•	×	×	•	×	•

• : ON × : OFF

SPF1 to 3: pressure blower for anti-smoke staircase
FLF1 to 3: pressure blower for shared front room
MPF1 to 2: pressure blower for refuge layer

In the same way, the pressure blower in shared front room (for staircase and elevator) should also be controlled individually. The run mode could be seen in Table 1. But the shared front room in a refuge layer belonged to two divisions, and should be pay more attention. It is requested to divide the pressure air well into two parts in order to adapt to this characteristic. Suppose the fire limit in one division, the fireproof power load of pressure air supply must be the maximum of the 3 run mode listed in Table 1.

$$P_f = \max\left\{\begin{matrix}(P_{SPF1} + P_{FLF1} + P_{MPF1})or \\ (P_{SPF2} + P_{FLF2} + P_{MPF1} + P_{MPF3})or \\ (P_{SPF3} + P_{FLF3} + P_{MPF2})\end{matrix}\right\}$$

Because of the setting up of refuge layer, the staircase in one core becomes individual staircase. So it is reasonable to divide pressure system by using the refuge layer as the boundary. In the CFTB, the table form supplied pressure air volumes are based on the fire existing in one layer. Based on this opinion, as the distance between two refuge layers is 15 layers, when the door size of staircase, shared front room is identical, the pressure blower in the refuge layer could belong to the neighbouring two divisions. These neighbouring two division could share the pressure blower, when there is an electric control damper at the pressure air duct leading to these two divisions. It is showed in Fig. 2. Using this method, the building volume and original investment could be saved.

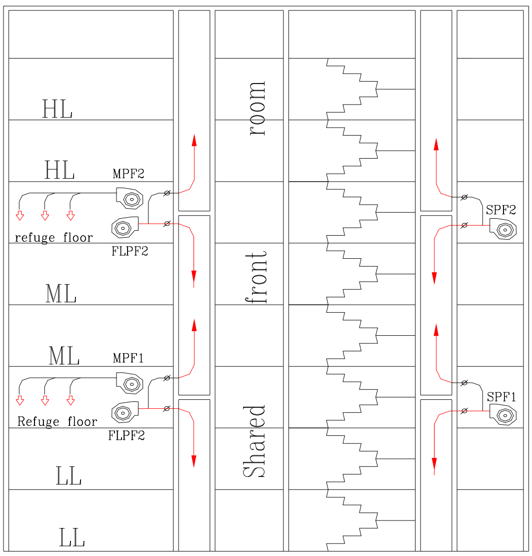

Fig. 2

2. SMOKE EXHAUSTING PROBLEM IN TALL AND LARGE SPACE BUILDING

In order to display a architectural style or to satisfy a functional request, the space in surrounding part of the high-rise building or in one or several stories of the main building is very large, for example, the shopping center in the building. The CFTB 8.2.24 regulate: "When the area of openable external windows is larger than the 2 percent area of the room, natural smoke exhausting method could be adopted. The author think it is not a perfect method to decide the smoke exhausting way only by the openable external windows area. The CFTB point out that the longest distance could be across by a common person in heavy smoke, with head low and nose hold, is 20-30 meter."

In Fig. 3, the distance between the shadow area to the external windows is over 30 meter, so the smoke exhausting method should be the hybrid of natural and mechanical smoke exhausting method. If partial natural smoke exhausting is practical, it is necessary to carefully divide the anti-smoke division. When natural smoke exhausting could not satisfied, mechanical smoke exhausting system should be set up. In the situation of Fig. 3, in order to save investment and be convenient to duct arrangement, mechanical smoke exhausting volume should be based on the area of shadow, while the natural smoke exhausting should be used in the other part of area. The openable external windows area only need to be larger than 2 percent of the area of individual anti-smoke division, when the whole area have been divided to several anti-smoke division. The distance between one point in the anti-smoke division to the openable external window should still be considered.

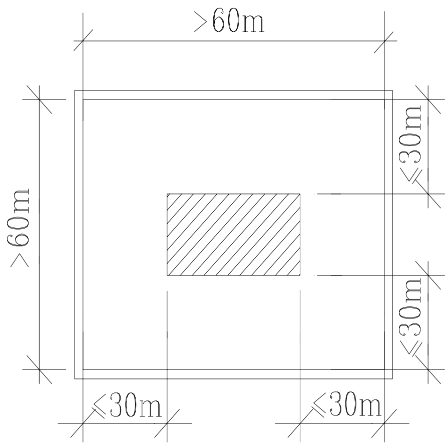

Fig. 3

3. CONTROL OF SMOKE-EXHAUSTING SYSTEM WHICH IS ACROSS SEVERAL FIREPROOF DIVISIONS

The CFTB 8.4.6 pointed out: “the mechanical smoke exhausting system in corridor should be vertically set up.” The vertical set up of corridor smoke exhausting system is a common used form in building fireproof design. The fireproof divisions are linked by the vertical smoke exhausting duct, which joint to the smoke exhausting entrance in different layers. So each branch of smoke exhausting duct must have close installation at 280°C. In building fireproof design, there are three choices: 1. set up smoke exhausting louver for fireproof, 2. set up common smoke exhausting entrance and fireproof damper, 3. set up common outlet and smoke exhausting & fireprotect damper.

On the control of smoke exhausting, whenever one smoke exhausting entrance is open, smoke exhausting blower should run. Only if each smoke exhausting entrance is closed, smoke exhausting blower could stop running. This function could be realized by the joint of smoke exhausting damper and the smoke exhausting blower or the control of fireproof control room. The CFTB 8.4.7 regulate: There must be a auto-close fireproof equipment at 280 °C on inlet of smoke exhausting blower”. This regulation is set to prevent the fire from spreading to the room of smoke exhausting blower. As we know, the spreading of fire is rapidly. The fire spreading speed in vertical direction is about 3-4 m/s. If the smoke exhausting blower is set up at the top story, the fire could quickly extend to the intake of smoke exhausting blower, when the fire appear at the second top story. As the fireproof fuse time hardly be controlled within ms class, the fuse of smoke exhausting blower intake and the 280 °C the fuse of the branch smoke exhausting duct may be fused at the same time. While the fuse of smoke exhausting damper is fused, it could only run again when the fuse box being changed or artificially reopen it. In the above situation, smoke exhausting could not be done when there is fire on the top story. In the author’s opinion, the fireproof smoke exhausting damper at the intake of smoke exhausting blower should not be set up.

4. FIREPROOF OF THE AIR INTAKE OF DIESEL-GENERATOR ROOM

As the diesel generator system only used in accident, the fireproof of it must be pay more attention. The diesel generator of high-rise building usually be arranged in underground mechanical room or ground mechanical layer. While running, much air is needed for cooling. According to reference 1, the engine of the generator need 5 m^3/hr of air per one horsepower. For water cooled generator, the ventilation air volume is 50 m^3/hr/hp, while for air cooled generator, the ventilation air is over twice of time than the water cooled generator. In some project, the designer only considered the exhausting air and smoke of the engine, the air supply were ignored. It is unsafe to draw air from the local layer directly. While the fire happen in the layer where the generator placed, the air intake will be closed. Without the cooling air supply, the generator will stop running. So we should regulate that the cooling air must be draw from outside directly. The local air supply must be forbidden.

5. IMPROVEMENT OF THE UNSTABILITY OF FIREPROOF ELEVATOR AND FIREPROOF MEASUREMENT

The CFTB 6.3.37 regulate: The speed of the fireproof elevator should satisfied the equipment that the time must be less than 60s when the elevator run from the bottom to the top of the building. So the speed of fireproof elevator must be faster than the common guest elevator. In accordance with the CFTB regulation, the well of fireproof elevator must isolate to the other well.

$$V_2 = \frac{V_0 S}{S_2} \tag{1}$$

Fig. 4 showed an elevator which is running up at speed V_0. In the light of relativity of movement, we could consider that the air at section 1-1 moves to the elevator at speed V_0 too. Supposed that the air is hardly to be compressed, the air speed at section 2-2 could be expressed.

According to the fluid energy function, when the potential energy of air being neglected, we get:

$$P_1 + r\frac{V_0^2}{2g} = P_2 + r\frac{V_2^2}{2g} \tag{2}$$

$$P_2 = P_1 + \frac{rV_0^2}{2g}\left[1 - \left(\frac{s}{s_2}\right)^2\right] \tag{3}$$

The static pressure on 2-2 level is find the solution from formula (1) and (2).

Various sections of the well are different. That lead to the various of P_2. When the elevator run at high speed, people in it fell shake.

$$\because \frac{s}{s_2}\rangle 1 \qquad \therefore P_1 \rangle P_2$$

By formula (1) and (2):

$$P_2 = P_1 - \frac{rV_2^2}{2g}\left[1-\left(\frac{s_2}{s}\right)^2\right] \tag{4}$$

When V_2 lowed down, the variation of P_2 become small. When digging two holes at either the top or the bottom of the well wall, because of the air flow from the well to outside, V_2 could be lowed down effectively. That makes P_2 more stable. It requires to set up 70°C closed fireproof damper in hole place. But the fireproof damper could not affect the running of the elevator. When designing the size of the well, we should consider the position of the fireproof valve.

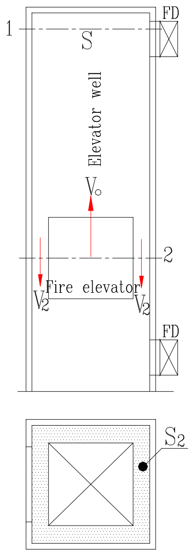

Fig. 4

6. VENTILATION AND SMOKE EXHAUSTING OF UNDERGROUND GARAGE

The main compound of the exhausting gas in the garage is CO (Carbon Monoxide). Chinese Standard <<Industrial Hygiene Designing Standards>> (TJ36-79) regulate : Exposure time less than 10 to 20 minute, the maximum tolerate CO concentration is 200 mg/m^3. That means it is necessary to use mechanical ventilating system in the underground garage. Fig. 5 showed a garage with mechanical ventilating system. In accordance with the mass balance equation, we could get:

$$GC_0 = GC_i + Q$$
$$G = Q \big/ (C_0 - C_i) \tag{5}$$

Where G = ventilating flow rate
C = concentration of CO mg/m^3
Q = total generation of CO mg/m^3

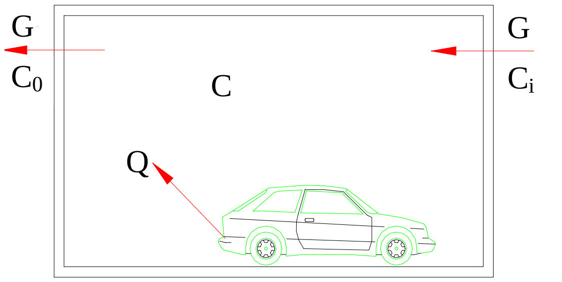

Fig. 5

As Q is a statistical value, it is not easy to be decided during the designing stage. The value of Q is based on the number of vehicles that is running in the garage during a period of time. The Chinese Guide "HVAC design technology of public building" regulates when there is no calculation information, the ventilation flow rate could be determined in the light of air exchange rate. Usually the air exhausting rate is over 6 hr^{-1}, and the air supply rate is over 5 hr^{-1}. The air exhausting of the underground garage is divided into two parts. The lower part exhaust 2/3 of air, while upper part exhaust 1/3 of air. Now the vehicles in North China often use antifreeze in the water tank. But the "Code for fire protection design of garage, motor repair shop and parking area"(GB50067-97 7-2-1) regulate: The garage, which has over 10 parking positions, should set up Spring fireproof system. So the temperature in the garage should keep over 0° centigrade. Using radiator could not keep well distribute temperature. The best way is adding a heating coil in the air supply duct. When using organized natural ventilation, heating air curtain should be set up at the air intake.

When fire appearing in underground garage, it will give out much smoke and gas. The smoke and gas is poisonous. The garage 8.2.1 regulate: The underground garage, which area is over 2000 m^2, should have mechanical ventilation system. When a smoke exhausting division is less than 2000 m^2, the capacity of smoke exhausting blower is in light of the air exchange rate. Hear the air exchange rate should over 6 per hour. So the air flow rate of the smoke exhausting blower volume is accordance with the common ventilating flow rate. In a smoke exhausting division in the underground garage, they could share the duct system. Considering the noise and fireproof factors, they could also use one blower. When the duct system is shared by the smoke exhausting and common ventilating system, a closed fireproof damper at 70 should be set up at the lower part of exhausting duct. These valve should be electronic control, automatic or artificial control. When fire happen, the valve should be closed immediately.

Although the CFTB has been published for three years, there are still some problems need further development.

REFERENCES

1. Code for fire protection design of tall buildings, GB50045-95 (1995).
2. Code for fire protection design of garage motor-repair-shop and parking area, GB50067-97 (1997).

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