

Large cinema safe evacuation simulation analysis and research

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Abstract

With the rapid development of social economy and the improvement of people's living standard, the demands for cultural entertainment activities become more and more strong. In recent years, the construction of the cinema shows a tendency of rapid development. The cinema than in the past, appears the characteristics of the luxury decoration, the large scale and the structure complexity, in the event of fire, the consequences is more serious. It is of great importance to protect a large number of viewer's personal safety for this study on safety evacuation problem of large cinema. Using the Zhongying International Cinema (Beijing) as the research object, this paper summarizes its main site fire-fighting design strategy. On the basis of the investigation and analysis of personnel density and properties, the evacuation simulation software STEPS was used to study the evacuation time needed for a variety of scenarios. This paper analyzes the spread of fire smoke on all kinds of fire scenario and determines the corresponding permission evacuation time by FDS software simulation, thus the reliability of the safe evacuation of the construction is evaluated. The related suggestions and measures for safety that are given according to the result, provide reference to improve the fire safety level.

Keywords

Cinema, Safety evacuation, The spread of smoke, Software simulation.

1. Introduction

This article selects a typical large cinema—the Zhongying international cinema (Beijing) as an example, simulates and analyzes personnel safety evacuation based on field measurement and investigation statistics, and puts forward the corresponding security strategies, the main research contents include:

- (1) Discuss the numerical simulation methods of the existing main safe evacuation and fire smoke, and choose the numerical simulation software that is suitable for this paper.
- (2) Analyze the fire safety strategies of the Zhongying international cinema (Beijing) according to its architectural feature, research the scene-settings of the fire size, smoke spread and personnel evacuation combined with the existing research results, and establish basal fire scenario that is suitable for safety evacuation simulation and analysis of this paper.
- (3) Analyze personnel safe evacuation time in various circumstances using STEP software, and permission evacuation time using the FDS software. Obtain the reliability of the construction safety evacuation by comparing, and put forward the related suggestions and measures on this basis.

2. The fire scenario Settings of large cinema safe evacuation simulation and analysis

2.1 Basic informations of the research object

The Zhongying international cinema(Beijing)located in Beijing XXXX mansion's 5th floor and 6th floor, is class A oversize cinema, it contains 16 cinema halls (5th floor has 9, 6th floor has 7), with a total area of 14206 m², can accommodate about 3186 people at most.

5th Floor: the main entrance is located in the middle of movie theatre area west side, is connected to the commercial part, 5th floor sets 1st to 9th cinema hall, 1st, 2nd, 3rd, 9h hall entrance is towards the main entrance hall, 4th, 5th, 6th, 7th hall is the VIP hall, it has special entry, area and the corresponding service facilities,8th hall sets the films release venue double as the VIP lounge at the west site, the east and the west sides of the entire movie theatre area respectively sets an exit passageway, connects cinema hall exports and stair evacuation exits.

5th Floor Sandwich: 5th floor sandwich is the screening corridor and accessory occupancy for 1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 9th hall, it sets up two stairs to connecte with 6th floor, screening corridor is equipped with several projector equipments, staff toilets and service rooms.

6th Floor:6th floor has 10th, 11th, 12th, 13th, 14th, 15th and 16th cinema hall, from 5th floor cinema main entrance by escalator can reach here directly, this floor's hall layout is similar to 5th floor, besides cinema halls, it also has some auxiliary space and traffic space.8th hall's inlet and outlet are located at 6th floor.

6th Floor Sandwich: 6th floor sandwich is the screening corridor and accessory occupancy for 8th, 10th, 11th, 12th, 13th, 14th, 15th and 16th hall, it sets up three evacuation stairs to 6th floor.

The whole movie theater is divided into four fire compartments, the first fire compartment covers an area of 2865 m², the second fire compartment covers an area of 3540 m², the third fire compartment covers an area of 3791 m², the fourth fire compartment covers an area of 2975 m².Every cinema hall is a "closed tank", its outer wall refractory limit is 2 hours, the refractory limit of fire compartment partition wall is three hours, the whole movie theater and other parts are for different fire partitions[1].

8th cinema hall sets 4 evacuation exits, the rest of the cinema halls set two evacuation exits.5th floor plan establishes 10 evacuation stairs, total evacuation width of 20.50 meters, of which 2 special emergency stairs are to the cinema, evacuation width of 4.100 meters, the number of 5th floor that should be evacuated to 1411 people, can satisfy the evacuation demands of 100 people/m;6th floor plan establishes 9 evacuation stairs, total evacuation width of 18.45 meters, of which 2 special emergency stairs are to the cinema, the number of 6th floor that should be evacuated to 1797 people, can satisfy the evacuation demands of 100 people/m[1,2,3].The area and containable population of each cinema hall are shown in table 2-1[1].

Table 2-1 The area and containable population of each cinema hall

	Area(m ²)	Audience number(people)
Cinema hall 1	310	240
Cinema hall 2	319	247
Cinema hall 3	320	249
Cinema hall 4	140	29
Cinema hall 5	152	29
Cinema hall 6	156	33
Cinema hall 7	154	33
Cinema hall 8	876	570
Cinema hall 9	377	309

Cinema hall 10	320	234
Cinema hall 11	158	98
Cinema hall 12	231	165
Cinema hall 13	319	254
Cinema hall 14	288	180
Cinema hall 15	377	309
Cinema hall 16	319	207

2.2 Fire scenario settings summary

Based on the above analysis, set up the following fire scenarios in view of the personnel safety evacuation and smoke control system design and so on various aspects , see table 2-2.

Table 2-2 Fire scenario summary

Fire scenario	Fire source location	Fire scale(KW)	Closed export	Purpose
0	—	—	—	Comparison and analysis
1	Cinema hall 2	2.4	A Cinema hall export	Assess the Smoke control system effectiveness personnel safety evacuation of medium-scale auditorium
2	Cinema hall 4	3.0	A Cinema hall export	<ul style="list-style-type: none"> Assess the Smoke control system effectiveness personnel safety evacuation of small-scale VIP auditorium
3	Cinema hall 8	8.0	A Cinema hall export(Floor 6)	Assess the Smoke control system effectiveness personnel safety evacuation of large-scale auditorium
4	Cinema hall 13	2.4	A Cinema hall export	Assess the Smoke control system effectiveness personnel safety evacuation of medium-scale auditorium
5	Cinema hall 16	2.4	A Cinema hall export	Assess the Smoke control system effectiveness personnel safety evacuation of medium-scale auditorium
6	The VIP lounge	3.0	A group(2) of scissors stairs(Floor 6)	Assess the Smoke control system effectiveness personnel safety evacuation of passage

3. Numerical simulation analysis of large cinema safe evacuation process

3.1 The analysis of the personnel safety evacuation time

Evacuation start time

(1) The cinema hall

Directly discovered fire, value $t_d = 1.0 \text{min}$.

value personnel evacuation delay time $t_{pre} = 1 \text{min}$.

This project personnel are in the waking state, evacuation knowledge and guiding system are complete, value response time $t_{res}=1min$, then the evacuation start time is $t_{start}=t_d + t_{pre}=1.0+1.0=2.0min$.

(2)The hallway, lounge, passageway and whole floor

Building sets perfect fire detection alarm, and fire detection time is short, value $t_d =1.0min$.

Value alarm time $t_a=0.5min$.

Value personnel evacuation delay time $t_{pre}=3.0min$.

This project personnel are in the waking state, not familiar with the evacuation facilities, value recognition time $t_{rec}=2min$.

This project personnel are in the waking state, evacuation knowledge and guiding system are complete, value response time $t_{res}=1min$, then the evacuation start time is $t_{start}=t_d + t_a + t_{pre}=1.0+0.5+3.0=4.5min$.

(3)The whole building

Building sets perfect fire detection alarm, and fire detection time is short, value $t_d=1.0min$

Value alarm time $t_a=0.5min$.

Value personnel evacuation delay time $t_{pre}=5.0min$.

This project personnel are in the waking state, not familiar with the evacuation facilities, value recognition time $t_{rec}=2min$.

This project personnel are in the waking state, evacuation knowledge and guiding system are complete, value response time $t_{res}=3.0min$, then the evacuation start time is $t_{start}=t_d + t_a + t_{pre}=1.0+0.5+5.0=6.5min$.

Table 3-1 The personnel response time all-purpose buildings and alarm system[4]

Buildings' applications and characteristics	response time/min		
	Alarm system type		
	W1	W2	W3
Office buildings, commercial or industrial buildings, schools(Residents are in the waking state, and they are familiar with the buildings, the alarm system and evacuation measures .)	<1	3	>4
Shops, exhibition halls, museums, leisure centers, etc(Residents are in the waking state, but they aren't familiar with the buildings, the alarm system and evacuation measures .)	<2	3	>6
Note: W1 is live broadcasting, from closed-circuit television system control room;W2 is recorded voice broadcast system in advance;W3 is the alarm system like alarm bell,alarm whistle or other similar alarm devices.			

According to table 3-1, in the system of W1, W2, W3, the personnel identify time of W1 system is the shortest. Because this project personnel is more, so for this project W1 system, setting the fire emergency broadcasting, shall induce for evacuees during fire, avoid trouble analysis, realize the orderly evacuation.

Evacuation action time

Set scenario E0 as normal situation evacuation, scenario E1 as a situation that cinema hall 2 is on fire and a security exit of it is blocked, scenario E2 as a situation that cinema hall 4 is on fire and a security exit of it is blocked, scenario E3 as a situation that cinema hall 8 is on fire and a security exit of it is blocked, scenario E4 as a situation that cinema hall 13 is on fire and a security exit of it is blocked, scenario E5 as a situation that cinema hall 16 is on fire and a security exit of it is blocked, and scenario E6 as a situation

that hall and passageway are on fire as well as a group of scissors stairs are blocked on the 6th floor. By the simulation calculation STEPS, it is concluded that the evacuation action time of different parts in the cinema as table 3-2 , table 3-3:

Table 3-2 Scenario E0 floor evacuation action time

Floor	Action time $t_{act}(s)$
6th floor sandwich	23
6th floor	225
5th floor sandwich	29
5th floor	273
4th floor	181
3th floor	245
2th floor	247
The whole floor	592

Table 3-3 Scenario E0-E6 floor evacuation action time statistics

Area number	Scenario E0 action time $t_{act}(S)$	Scenario E1 action time $t_{act}(S)$	Scenario E2 action time $t_{act}(S)$	Scenario E3 action time $t_{act}(S)$	Scenario E4 action time $t_{act}(S)$	Scenario E5 action time $t_{act}(S)$	Scenario E6 action time $t_{act}(S)$
Cinema hall 1	68	70	66	64	64	66	67
Cinema hall 2	68	117	66	66	66	68	71
Cinema hall 3	67	70	66	67	66	68	67
Cinema hall 4	25	22	22	24	21	24	22
Cinema hall 5	11	14	15	16	12	15	14
Cinema hall 6	30	26	23	36	25	24	23
Cinema hall 7	22	17	20	16	23	15	18
Cinema hall 8 (The 5th floor)	94	107	100	136	99	103	93
Cinema hall 8 (The 6th floor)	79	78	77	101	78	76	76
Cinema hall 9	75	75	74	75	77	76	75
Cinema hall 10	77	92	86	89	87	79	81
Cinema hall 11	71	99	82	80	86	93	129
Cinema hall 12	48	47	47	46	48	47	50
Cinema hall 13	122	105	117	113	219	106	70
Cinema hall 14	108	108	92	109	102	103	133
Cinema hall 15	80	76	76	77	77	79	75
Cinema hall 16	77	79	84	101	79	130	204
Anteroom and passages(5th	273	263	261	287	238	250	199

floor)							
Anteroom and passages(6th floor)	225	223	223	230	288	233	291
4_1	181	155	160	192	184	152	166
4_2	68	72	70	70	67	69	70
3_1	245	244	232	240	222	231	223
3_2	101	110	102	98	103	107	101
2_1	247	254	241	251	249	246	250
2_2	143	137	286	137	139	139	138
The fire room		117	22	136	219	130	291

The calculation results shows that:

(1)Scenario E0

The export utilization rates of the 5th floor cinema hall 4~6 are not very balanced, but these halls have fewer viewers, no congestion occurs, and the evacuation time is shorter, so the disequilibrium of the export using impact on the evacuation time is not big, can accept the evacuation design. The other exports of 5th floor are used a more balanced.

Calculation results show that the export utilization rates of the 6th floor cinema hall 11,13,14 and 16 are unbalanced, it is because the layout of cinema hall exports is unreasonable. The cinema hall has two exports, one is located in the entryway's entrance, the other one is located on the side wall near the export of entryway. Personnel arrive near the entryway, will give priority to evacuate to the export of entry side wall. In order to avoid this situation, the export of cinema hall side wall should not be installed on entryway, and distance to entryway points should be greater than 5 m.

The second fire partition-2 located in the middle of 8th floor, hinders the personnel evacuation of cinema hall 11 and 12, and blocks the personnel flow freely of the third fire partition both east and west sides. Should adjust the position of the fire partitions to reserve a personnel evacuation passageway for cinema hall 11 and 12, and allow the personnel flow freely of the third fire partition both east and west sides.

In addition, the calculation results show a phenomenon: several cinema halls' exports are located in choke points to the evacuation stairs, due to the passageways jam, the cinema hall staff can't evacuate to the hallway at a short time.

(2)Scenario E1

After closing an exit of cinema hall 2, the evacuation time of it is significantly increased by 72.06%, but the evacuation times of the whole floor and building are no significant growth.

(3)Scenario E2

After closing an exit of cinema hall 4, the evacuation times of cinema hall 4, the whole floor and building are all no significant growth. This is due to fewer evacuation crowd and lower congestion degree, close a export had no obvious effect on the evacuation time.

(4)Scenario E3

After closing an exit of cinema hall 8, the evacuation time of it is significantly increased by 44.68%, but the evacuation times of the whole floor and building are no significant growth.

(5)Scenario E4

After closing an exit of cinema hall 13(6th floor), the evacuation time of it is significantly increased by 79.51%, the evacuation time of 6th floor is significantly increased by 28%, the evacuation time of 5th floor is significantly decreased by 12.82%, the evacuation time of the whole building is slightly increased, and the evacuation times of other floors are no significant growth. After closing an exit of cinema hall

13,the only exit of it faces congestion situation, personnel is difficult to flow smoothly, and causes a substantial increase of the evacuation time.

(6)Scenario E5

After closing an exit of cinema hall 16,the evacuation time of it is significantly increased by 68.83%,but the evacuation times of the whole floor and building are no significant growth.

(7)Scenario E6

After closing, the evacuation time of it is significantly increased by 68.83%,but the evacuation times of the whole floor and building are no significant growth.

After closing a group of evacuation stairs (two) in 6th floor northeast corner and the passageway in front of them, the evacuation time of the passageway(6th floor) is significantly increased by 29.33%,but the evacuation time of the passageway(5th floor) is decreased by 27.11%;in addition, the evacuation times of 3rd floor,4th floor and the whole building are slightly shorter.

The evacuation time of 6th floor increasing is because of a decline in evacuation stair; And the evacuation times of 3rd floor,4th floor and 5th floor increasing are because the 6th floor staff cannot use two stairs of the northeast corner, thus it make other floors have more people.

3.1.3 Evacuation time
Considering the uncertain factors in the process of actual evacuation may extend the actual evacuation time, so the safety factors are introduced. For general constructions, safety factors are of 1.2 to 1.5;for complex constructions, safety factors are of 2.0.In this project, when calculating the fire rooms, passageways, and floors evacuation time,adopted safety coefficient is 1.5,while computing the whole building evacuation time, adopted safety coefficient is 2.0.The resulting RSET see table 3-4.

Table 3-4 Evacuation time REST

	Scenario order	E0	E1	E2	E3	E4	E5	E6
	Floor	—	5th Floor	5th Floor	5th Floor、6th Floor	6th Floor	6th Floor	5th Floor、6th Floor
	Fire location	—	Cinema hall 2	Cinema hall 4	Cinema hall 8	Cinema hall 13	Cinema hall 16	Anteroom and passages
Fire room	Evacuation start time(s)		120	120	120	120	120	270
	Evacuation start time(s)		117	22	136	219	130	291
	Safety factor		1.5	1.5	1.5	1.5	1.5	1.5
	RSET(s)		296	153	324	449	315	707
	RSET(min)		4.93	2.55	5.40	7.48	5.25	11.78
The whole floor	Evacuation start time(s)		270	270	270	270	270	270
	Evacuation start time(s)		263	261	287	288	233	291
	Safety factor		1.5	1.5	1.5	1.5	1.5	1.5
	RSET(s)		665	662	701	702	620	707
	RSET(min)		11.08	11.03	11.68	11.70	10.33	11.78
The Whole	Evacuation start time(s)	390	390	390	390	390	390	390
	Evacuation start time(s)	592	578	592	600	614	587	569

building	Safety factor	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	RSET(s)	1574	1564	1574	1590	1618	1564	1528
	RSET(min)	26.23	26.07	26.23	26.50	26.97	26.07	25.47

3.2 Analysis of the spread of fire smoke

The project is the cinema, a total of two floors, mainly including the cinema hall, the hall, the lounge, the passageway, and other function areas, different areas adopt corresponding strategies at the time of smoke control system design[5-9].

A profile of smoke control system design

(1)The cinema halls

This project two floors total 16 cinema halls, among them cinema hall 1, 2, 3, 4, 5, 6 and 7 are located in the 5th floor, cinema hall 10, 11, 12, 13, 14, 15 and 16 are located in the 6th floor, the cinema hall 8 runs through the 5th and 6th floors.

Cinema halls are set to "closed tank", with mechanical smoke exhaust system. According to the cinema halls' different conditions of area, clear height, storage smoke height, clear height, set different amount of smoke, smoke exhaust port area.

Cinema hall 8's mechanical smoke exhaust quantities are big, so should set mechanical wind supplement in the low post and air supplement volumes should be 50% of the smoke. In addition to the cinema hall 8, other cinema halls should be natural wind supplement.

(2)Passageways, halls and lounges should adopt transparent hung ceilings

In order to make the flue gas can smoothly rise to smoke storage tank, the passageways, hallways, lounges in this project if need set hung ceilings, should adopt transparent hung ceilings. The British CIBSE Guide E pointed out: "The aperture ratio of transparent hung ceiling should be greater than 25%." Beijing local standards Code for design, construction and acceptance of natural smoke exhaust system article 2.1.7 provision points out that: "The required height of hang wall (vertical blind) should be respectively determined aiming at whether there is a ceiling and ceiling way in area.", see figure3-1[10].

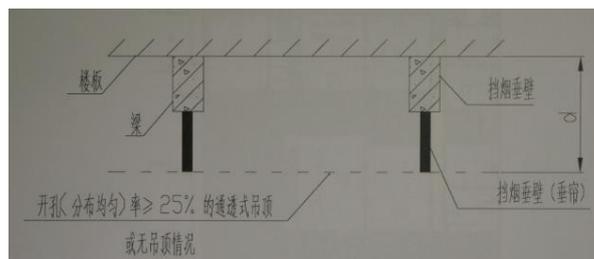


Figure3-1(a) No hung ceilings or set transparent hung ceilings (even-distributed aperture ratio $\geq 25\%$).

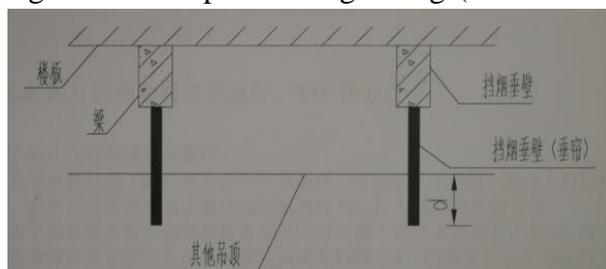


Figure3-1(b) Transparent hung ceilings (aperture ratio $< 25\%$ or not uniform open holes) and general hung ceilings.

Reference to the above specification requirements, opening holes of transparent hung ceilings should be evenly distributed, and aperture ratio should be greater than 25%.

(3)The audience entrance hallway

The cinema 5th floor sets the audience entrance hallway with larger area, combined with the tunnel and passageway, a total area of about 3302 m².The audience entrance hall and the tunnel as a smoke partition, sets the mechanical smoke exhaust, and the films release VIP lounge is as an independent smoke partition.

(4)The films release VIP lounge and VIP lounge

①The films release VIP lounge

Sets films release VIP lounge on 5th floor south side, connecting with 5th floor tunnel and the audience entrancer hallway. In the films release VIP lounge sets mechanical smoke extraction,as an independent smoke partition.

In order to avoid the films release VIP lounge on fire impacting on the entire floor evacuation, should set hang wall between the films release VIP lounge and 5th floor tunnel, the height of hang wall is 20% of the VIP lounge.

②The VIP lounge

On the east side of 5th floor besides passageway sets the VIP lounge. Attached directly to the passageway, area of the VIP lounge is bout 76 m²,it may put fuel load large furniture such as sofa, so set up the mechanical smoke extraction, as an independent smoke partition. Passageway clear height is of 3.8 m, VIP lounge clear height is of 7.2 m, higher than that of passageway, so at the top of the VIP lounge form the smoke storage tank naturally, do not need to set hang wall.

(5)The passageway and small lounge

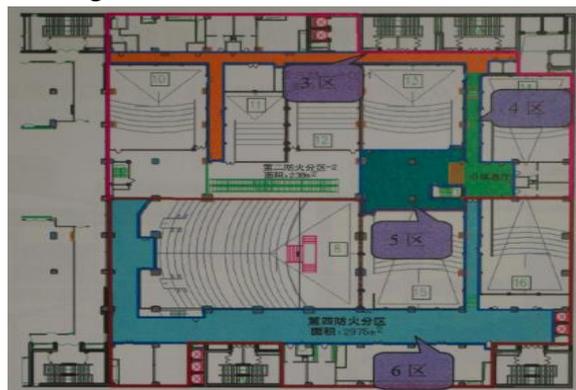


Figure3-2 The 5th floor passageway location plan



Figure3-3 The 6th floor passageway and small lounge location plan

Passageway is the main channel of away from the cinema hall during personnel evacuation. From figure 3-2 and 3-3,you can see that passageeway and hallway form a evacuation route of three horizontals and two verticals, personnel have more than one directions of evacuation, and evacuation routes are more clear. Passageways set mechanical smoke exhaust, and according to the specific location and trend of passageways, set a number of smoke partitions(The positions as shown in figure 3-2,figure 3-3).

On the 6th floor east side sets a small lounge, area of about 46 m², and don't set separately the smoke partition, so control the fuel load in order to reduce the fire risk, putting sofa and other combustible loads are prohibited.

Safety decision

According to the specific circumstances of this project, have chosen six typical fire scenarios to conduct CFD calculation and analysis at the same time of smoke control design, fire scenario and calculating list see table 3-5.

Table 3-5 Fire scenario security judgment list

Fire scenario	Fire location	Fire scale (MW)	Fire type	RSET(s)	ASET(s)	Security judgment	conclusion
1	Cinema hall 2	2.4	FAST t ₂	296	≥1200	ASET>RSET	Security
2	Cinema hall 4	3.0	FAST t ₂	153	≥1200	ASET>RSET	Security
3	Cinema hall 8	8.0	FAST t ₂	324	≥1200	ASET>RSET	Security
4	Cinema hall 13	2.4	FAST t ₂	449	≥1200	ASET>RSET	Security
5	Cinema hall 16	2.4	FAST t ₂	315	≥1200	ASET>RSET	Security
6	Films release VIP lounge	3.0	FAST t ₂	707	≥1200	ASET>RSET	Security

3.2.3 Smoke control scheme design proposal

Simulate the process on the development of fire by CFD software to adjust smoke control system of the preliminary design and wind supplement system parameters, to verify its effect, ultimately determine the design parameters of smoke control system are as follows:

(1) The cinema halls

① Cinema halls are set to "closed tank", they set up the mechanical smoke exhaust system, according to different conditions of cinema halls' area, clear height, smoke storage height and clear height, set different amounts of smoke exhaust and the number of smoke exhaust ports. Note that smoke exhaust quantities listed on this form are effective exhaust quantities, the actual set of effective smoke exhaust quantities and the number of smoke exhaust ports should not be less than the values listed in table 3-6. Exhaust ports should be uniform layout.

② The cinema hall 8 sets up mechanical wind supplement system. Wind supplement port is set in the low order of the hall side wall, wind supplement volume is of 120000 m³/h, wind supplement speed should be less than 5 m/s. In addition to the cinema hall 8, other cinema halls adopt the natural wind supplement.

③ The smoke exhaust system and wind supplement system of each halls link with automatic fire alarm system, linkage to start the mechanical smoke exhaust in fire.

Table 3-6 The cinema hall smoke control system setup parameters summary

Cinema number	Amount of smoke(m ³ /h)	Exhaust port number
1	68873	4
2	68873	8
3	68873	4
4	54915	2
5	54915	2
6	54915	2
7	54915	2
8	240000	8
9	68873	4
10	68873	4
11	60064	2
12	68873	6
13	68873	4
14	57696	6
15	72889	4
16	57696	6

(2) Entrance hallways of 5th floor cinema halls

① Entrance hallways of 5th floor cinema halls as a separate smoke partition, set up the mechanical smoke exhaust system, its effective exhaust quantities are not less than 43860 m³/h, mechanical smoke exhaust ports are not less than two, exhaust ports should be uniform layout.

② Natural wind supplement.

③ Smoke control system is link with automatic fire alarm system, linkage to start the mechanical smoke exhaust in fire.

④ Should adopt transparent hang ceilings, trepannings of transparent hang ceilings should be evenly distributed, and aperture ratio should be greater than 25%.

(3) The films release VIP lounge

① The films release VIP lounges set up the mechanical smoke exhaust system, as a separate smoke partition, its effective exhaust quantities are not less than 60000 m³/h, mechanical smoke exhaust ports are not less than two, exhaust ports should be uniform layout.

② Should set hall walls between films release VIP lounges and entrance hallways of 5th floor cinema halls, and the sag height of hall wall is not less than 1.8m.

③ Natural wind supplement.

④ Smoke control system is link with automatic fire alarm system, linkage to start the mechanical smoke exhaust in fire.

⑤ Should adopt transparent hang ceilings, trepannings of transparent hang ceilings should be evenly distributed, and aperture ratio should be greater than 25%.

(4) The 5th floor VIP lounge

①The 5th floor VIP lounges set up the mechanical smoke exhaust system,as a separate smoke partition,,its effective exhaust quantities are not less than 30000 m3/h, mechanical smoke exhaust ports are not less than two,exhaust ports should be uniform layout.

②Natural wind supplement.

③Smoke control system is link with automatic fire alarm system, linkage to start the mechanical smoke exhaust in fire.

④Should adopt transparent hang ceilings,trepannings of transparent hang ceilings should be evenly distributed, and aperture ratio should be greater than 25%.

(5)The passageway

①Each passageways set mechanical smoke exhaust systems, divided into different smoke partitions.The divisions of passageway smoke partitions see figure 3-2, figure 3-3,the effective smoke exhaust quantities and moke exhaust ports number passageway smoke partitions should not be less than the values listedlisted in table 3-7.Exhaust ports should be uniform layout.

②Natural wind supplement.

③Smoke control system is link with automatic fire alarm system, linkage to start the mechanical smoke exhaust in fire.

④Should adopt transparent hang ceilings, trepannings of transparent hang ceilings should be evenly distributed, and aperture ratio should be greater than 25%.

⑤The small lounge on the east side of 6th floor, delimits passageway smoke partition 4.

Table 3-7 The cinema passage numerical list of smoke control system

Passage location		Amount of smoke(m3/h)	Condole top form	Exhaust port number
5th Floor	1,See figure 3-2	30000	Transparent form	2
	2,See figure 3-2	30000	Transparent form	2
6th Floor	3,See figure 3-3	30000	Transparent form	2
	4,See figure 3-3	30000	Transparent form	2
	5,See figure 3-3	30000	Transparent form	2
	6,See figure 3-3	45000	Transparent form	3

6)samdwich screening passageway

Setting mechanical exhaust system should in accordance with Code for fire protection design of tall buildings.

4. Conclusions and recommendations

4.1 Conclusions

After smoke flow analysis and personnel evacuation analysis of this project the cinema typical fire scenario, under the precondition of the above calculation, can get the following conclusions:

Set the cinema audience halls to "closed tank" (set up automatic sprinkler system, improve the mechanical smoke exhaust system requirements).Improve the fire safety level conditions of hallway, lounge and passageway (limit combustible load capacity, set up automatic sprinkler system, improve the mechanical smoke exhaust system requirements),use the adjusted smoke control system design and evacuation design, make the current building plane design can meet the requirements of the safety evacuation.

4.2 Adjustment and recommendations

The original architectural design does the following adjustments:

The flank wall of cinema hall should not be installed in the entryway, and the distance to entry passageway should be greater than 5 m.

The second fire zone-2 boundary should move southward to reserve an evacuation path for 11th and 12th cinema hall, and allow the personnel to flow freely of the third fire zone east and west on both sides. Mezzanine screening corridor evacuation ladders should be enclosed staircase.

Set ceiling screen that sags height to the roof not less than 1.8 m between New film release VIP lounge and passageway. And Suggestions:

- a. 《Code for fire protection design of tall buildings》 require the ground minimum intensity of illumination of emergency lighting for evacuation should not be below 0.5lx. This project is a crowded place, suggest appropriately raise the ground minimum intensity of illumination of emergency lighting for evacuation on the basis of national standards to make it not less than 1.0lx, and should maintain it a good uniformity.
- b. Advice set the video monitoring system and broadcasting system at the same time then, then the staff of central control room can induce the personnel evacuation in real time.

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