

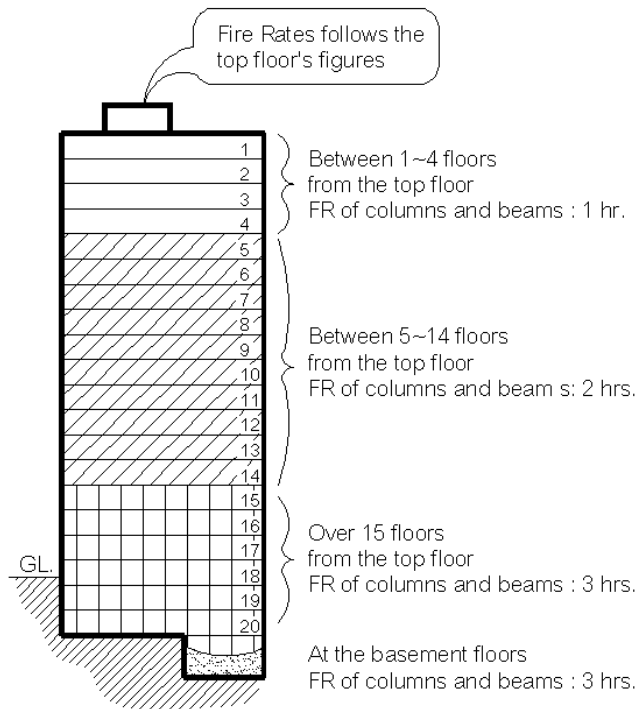
6 PREVENTION OF BUILDING COLLAPSE

Outbreak	Initial Fire	Fire Spread	Evacuation	Fire Fighting	Collapse	Exposure Fire	6.1.1
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Principle of Fire Resistant Construction

The fire resistant construction aims to prevent the destruction of a building by fire. The principal structure of a building must have sufficient fire-resistance rating to prevent any deformation, destruction and collapse. The principal structure includes columns, beams, slabs, and walls that bear the structural load of a building.

Fire-resistance Rating in Japan



Higher fire-resistance rating is necessary for the lower part of a high-rise building.

element	floor	Fire-resistant Rating of a Floor from The top floor (hrs)		
		1 ~ 4	5 ~ 14	over 15
Column and Beam		1	2	3
Slab		1	2	3
Structural wall	Inner	1	2	2
	Exterior	1	2	2
Roof		0.5		
Staircase		0.5		

FR. : Fire-resistant Rate

Fire-resistance rating for complex buildings are determined as follows:

- Fire-resistance rating for complex buildings should be the highest fire-resistance rating of ones for building uses.
- In case, where a complex building is completely separated by fire wall which is made with fire-resistance materials continuously from the bottom to the top of building, separated parts are considered as individual buildings. Therefore, fire-resistance rating is determined as the one for each separated part.

Evaluation of fire-resistance is specified in ISO834 'Fire-resistance Tests - Elements of Building Construction' as shown below.

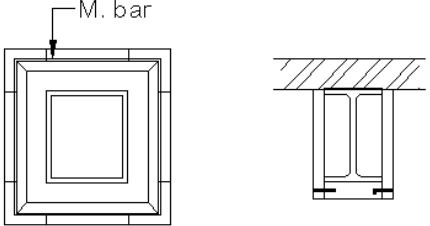
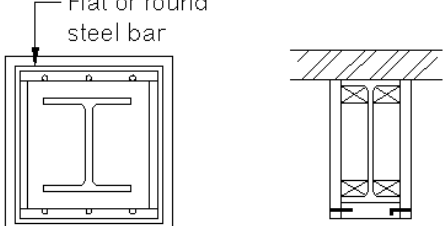
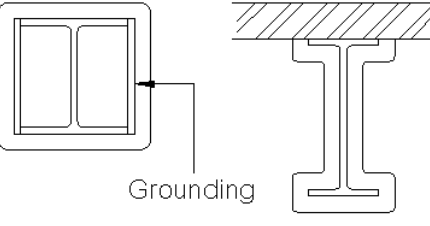
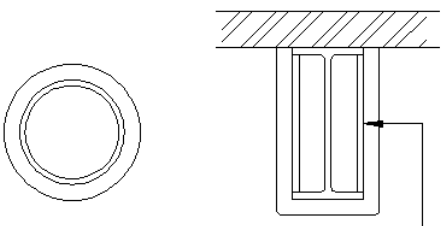
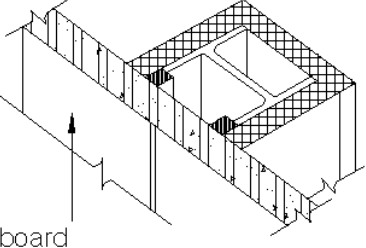
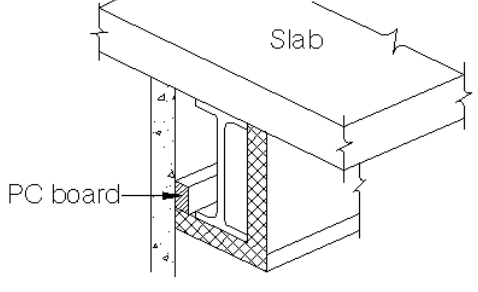
- Specimen: At least 3m x3m for Walls, 4m x 3m for Floors/Roofs, 3m height for Columns, and 4m height for Beams
- Heat temperature: $T-T_0=345\log_{10}(8t+1)$ (whereby, T: temperature at current time, To: temperature before heating, t: time of heating)
- Heated side: All sides for columns and one side for walls
- Loading factor: Allowable design load
- Evaluation criteria:
 - i) Structural stability: National fire code is permitted.
 - ii) Flame resistance: No ignition of cotton pad at unheated side, and no flame breaks out to the unheated side for 10 seconds.
 - iii) Heat resistance: Temperature of unheated side should be less than 140+initial temperature for average, 180 +initial temperature for highest and 220.

Essentials by Fire Resistant Steel Structure

Technical requirements for fireproofing of the steel structure are;

- Low heat conductivity and large heat capacity,
- Small thermal expansion and shrinking at high temperature,
- No cracks and exfoliation from structure
- Good adhesion to the steel,

Example Dimension of Fire Resistant Covering Method

		Examples	
Prefabrication Method	Ready Fomed Board Merit : Easy quality control	 <p>Square column</p>	 <p>H-shaped column H-shaped beam</p>
	PC Board Merit : Smooth finishing		
Cast in site	Spraying type Merit : Low cost	 <p>Grounding</p>	 <p>Grounding</p>
	Plastering type Merit : Fit to complicated form		
Compound method	Compound type Merit : Reduce a dangerous work	 <p>PC board (Exterior wall)</p>	 <p>Slab PC board</p>
	Membrane type		

Outbreak	Initial Fire	Fire Spread	Evacuation	Fire Fighting	Collapse	Exposure Fire	6.2.2
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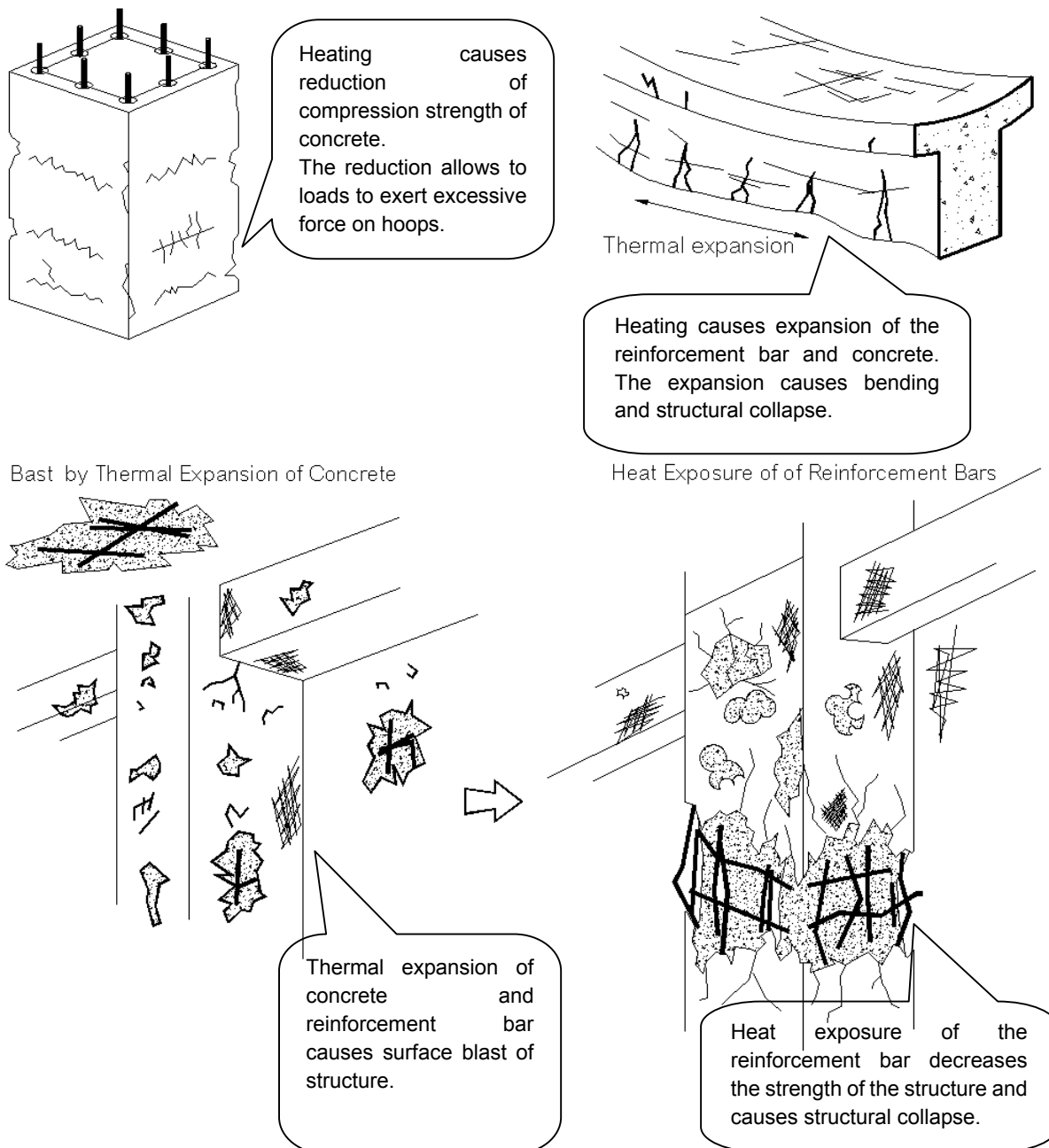
Essentials by Fire Resistant Reinforced Concrete Structure

The technical requirements for the fire resistant reinforced concrete structure are;

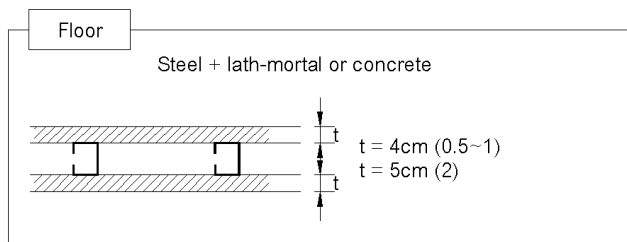
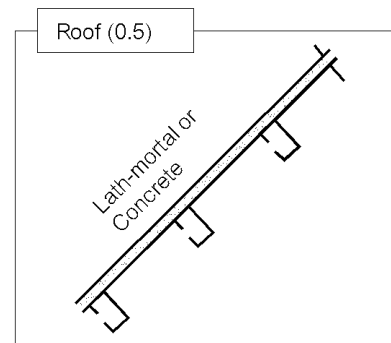
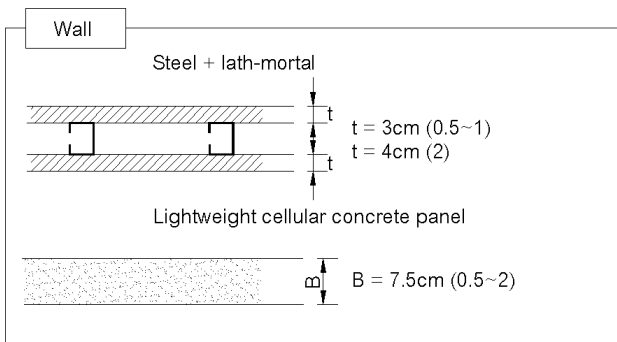
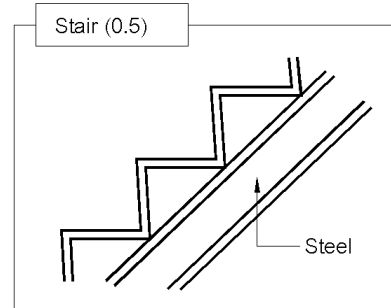
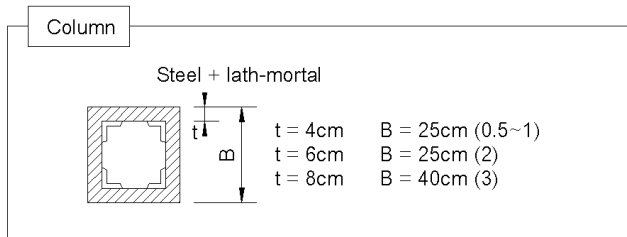
- To prevent collapse of column and beam,
- To prevent surface blast of the main structure due to thermal expansion of iron bars and concrete.

The column and beam resists different structural forces. The column resists compression, while the beam resists bending forces. When the temperature of concrete reaches 500 degrees, its strength decreases to two thirds of the original strength. The concrete, further heated to 800 degrees or more, does not have any strength to prevent collapse.

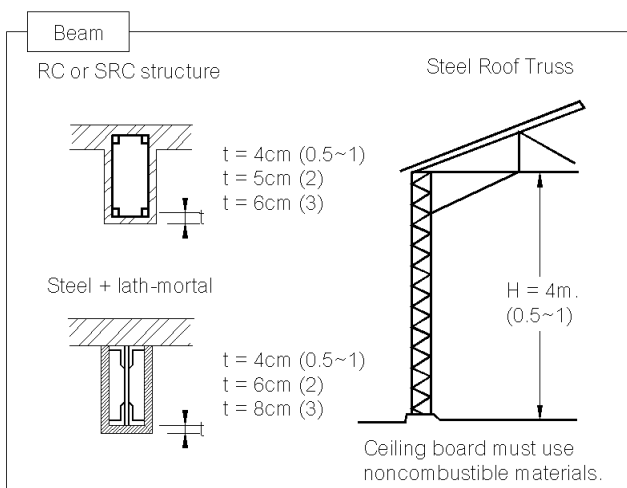
Sequence of Collapse of Reinforced Concrete Structure



Samples of Fire Resistant Steel Structure in Japan

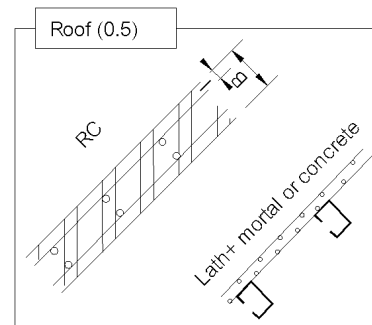
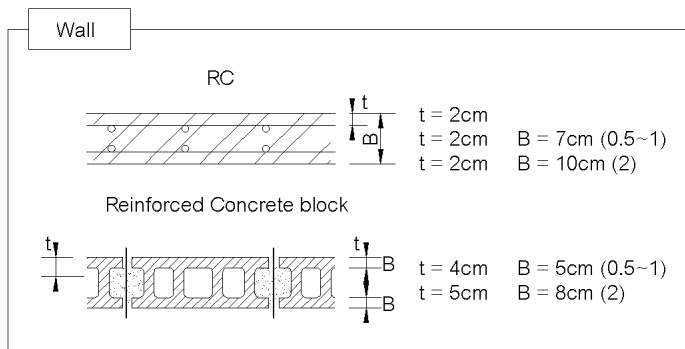
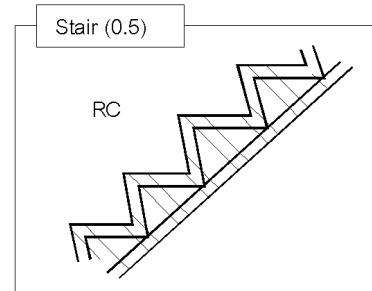
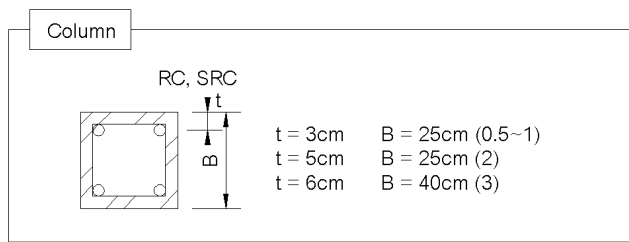


Note: Figures in parenthesis show fire-resistance rating (hr)

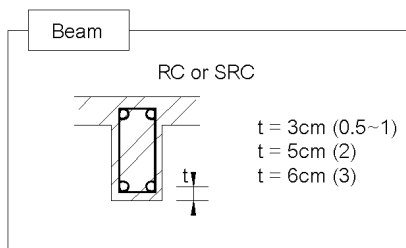
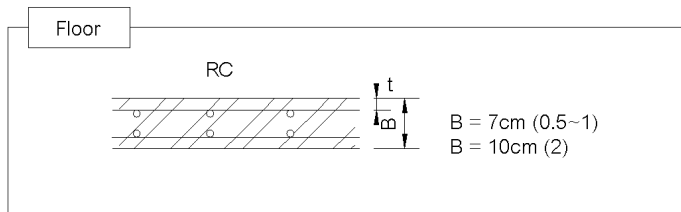


Outbreak	Initial Fire	Fire Spread	Evacuation	Fire Fighting	Collapse	Exposure Fire	6.3.2
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Samples of Fire Resistant Reinforced Concrete Structure in Japan



Note : Figures in parenthesis show fire-resistance rating (hr)



The Study on Development of a Building Safety System Focusing on Fire Prevention in the Kingdom of Thailand
Final Report - Volume III - Technical Manual for Planning of Fire Prevention System

	Outbreak	Initial Fire	Fire Spread	Evacuation	Fire Fighting	Collapse	Exposure Fire
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7 PREVENTION OF EXPOSURE FIRE

Outbreak	Initial Fire	Fire Spread	Evacuation	Fire Fighting	Collapse	Exposure Fire	7.1.1
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Principle of Prevention against Exposure Fire

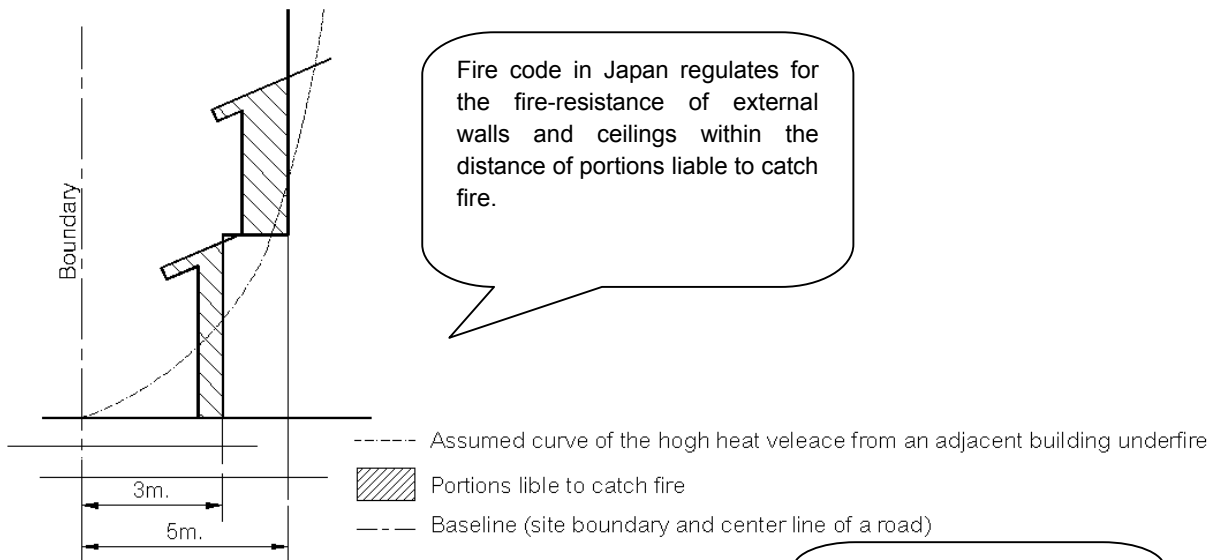
The prevention of exposure fire aims to;

- Prevent fire from spreading to an adjacent building,
- Prevent a building from catching fire from an adjacent building

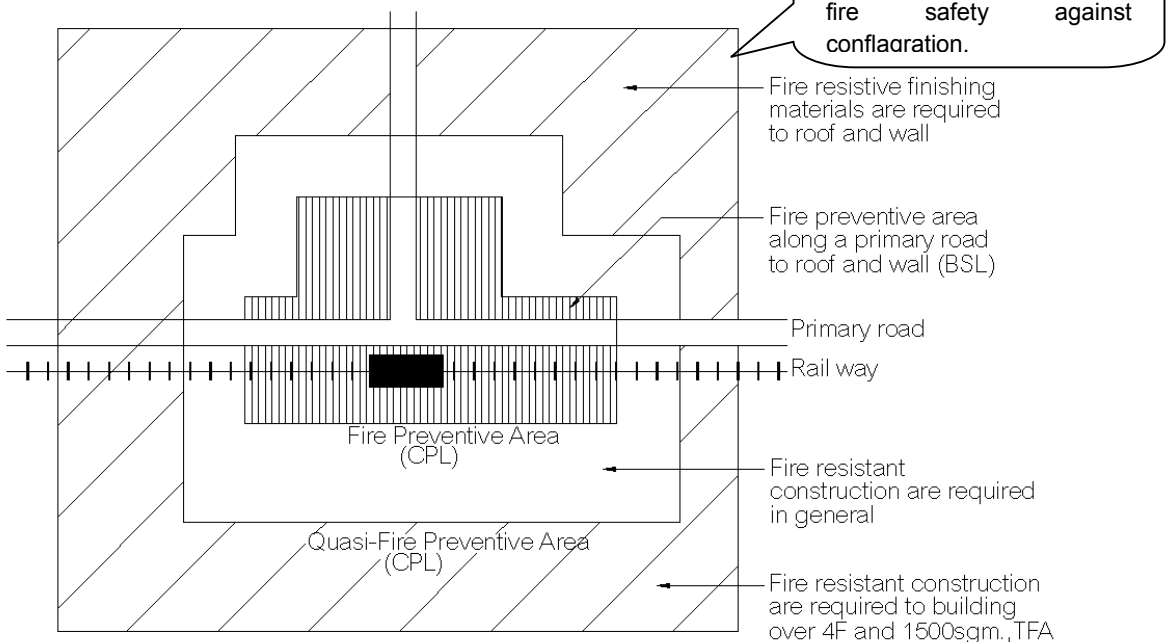
Typical methods of fire protection against fire exposure are to;

- Keep adequate distance between buildings,
- Secure fire-resistance of external walls, ceilings, and openings thereof, if the separation distance is not adequate.

Portions liable to catch fire in Japan



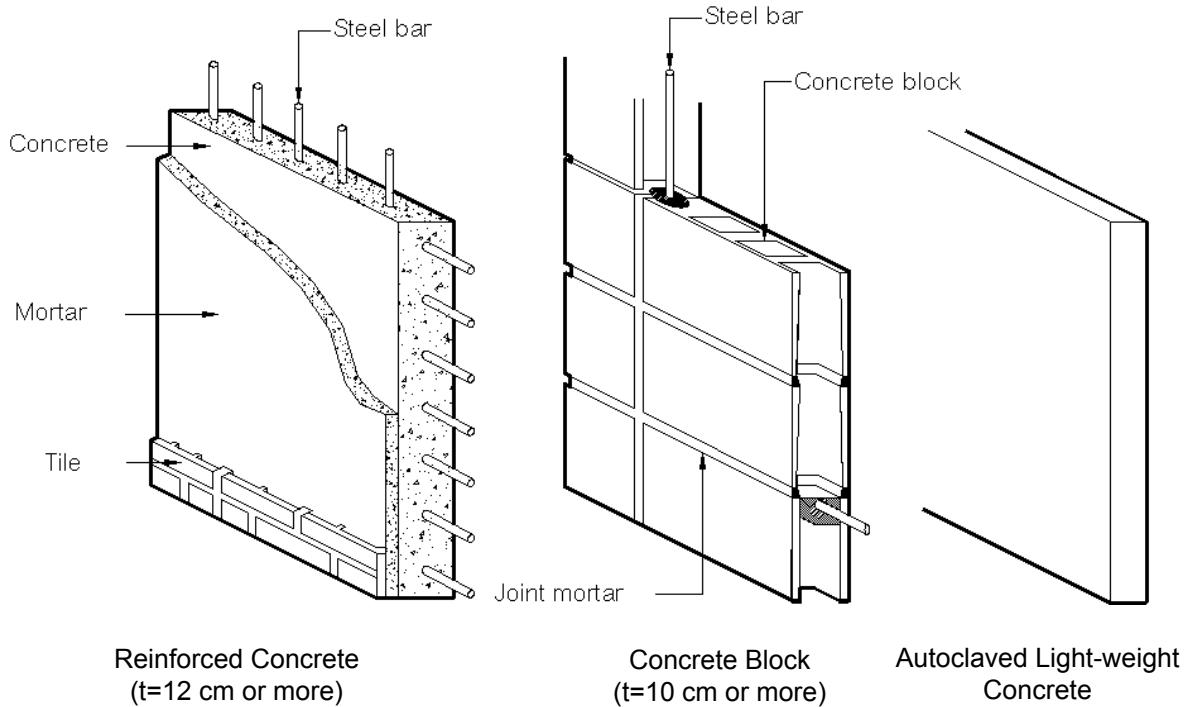
Designation of Fire Zone in Japan



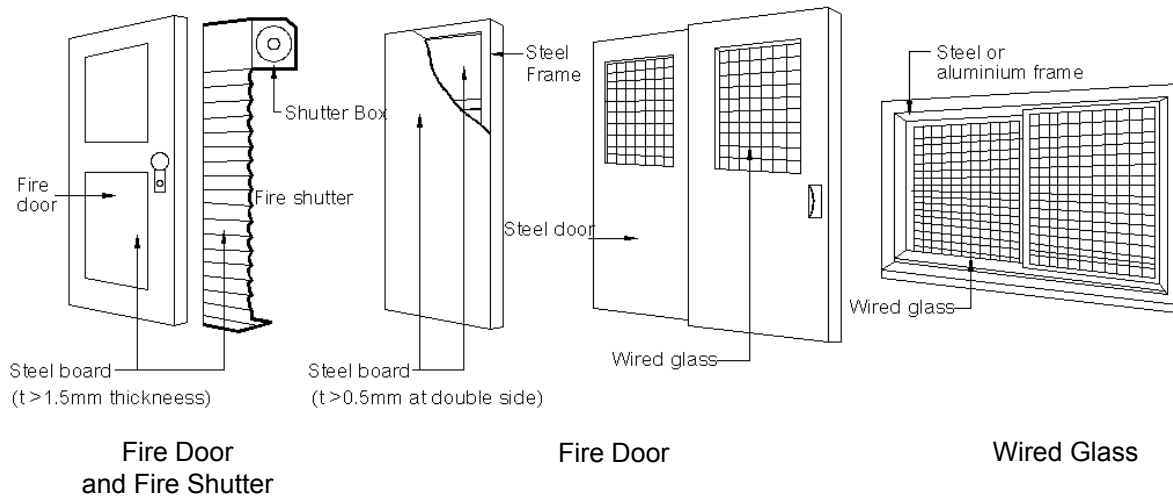
7.1.2	Outbreak	Initial Fire	Fire Spread	Evacuation	Fire Fighting	Collapse	Exposure Fire
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Fire Resistant Construction of External Wall and Opening (1/2)

1) Fire Resistance Construction of External Wall in Japan



2) Fire Protection at Opening of External Wall in Japan



Outbreak	Initial Fire	Fire Spread	Evacuation	Fire Fighting	Collapse	Exposure Fire	7.1.2
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Fire Resistant Construction of External Wall and Opening (2/2)

3) Fire-resistance Rating of External Wall in United States

Distance between Buildings (m)	Group-1	Group-2
	Fire-resistant Rating (Hour)	
1.5	1	2
1.5	1	2
3.0	1	1
3.0	1	1
9.0	1	1
9.0	0	0

Fire code in the US specifies the fire-resistance rating of external walls. The fire-resistance rating is decided by the distance between buildings.

Note:

Group-1 : Hotel, Office, Theater, Hospital, School, Factory, Multi-story Housing

Group-2 : Department Store

The Study on Development of a Building Safety System Focusing on Fire Prevention in the Kingdom of Thailand
Final Report - Volume III - Technical Manual for Planning of Fire Prevention System

	Outbreak	Initial Fire	Fire Spread	Evacuation	Fire Fighting	Collapse	Exposure Fire
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PART III FIRE PROTECTION SYSTEM BY CLASSIFICATION OF BUILDING

General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	1
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General Understanding of Characteristics by Classification of Building (1/3)

1) Office

Typical points for the fire protection system of offices, especially for high-rise buildings, are to:

- Select the appropriate core type which relates to the location of escape stairs, pipe shafts, elevator shafts, and other service facilities,
- Keep the proper distance between escape stairways to secure smooth evacuation,
- Prevent smoke spread into the escape staircases, elevator shafts and other vertical shafts,
- Have the base of fire fighting for the building higher than the ladder truck.

2) Hotel

Typical points for hotels are to:

- Strengthen the detection and reporting system by installation of detectors and public address system,
- Ensure two or more clear evacuation routes by locating the escape stairways at both ends of corridors.

In hotels, occupants are often sleeping and start evacuation after late awareness of fire. They are also not familiar with the evacuation route of the hotel.

3) Multi-story Housing

Typical points for multi-story housings are to:

- Strengthen the detection and reporting system by installation of detectors and public address system,
- Strengthen the redundancy of evacuation routes by setting up balcony linking as an alternative evacuation route,
- Strengthen the prevention of fire spread by building up fire resistant partition wall between housing units,

In multi-story housing, sleeping occupants often start evacuation late after the outbreak of fire. They also include the weak against fire, such as the aged, infants, and handicapped who are unable to self-evacuate.

1	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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General Understanding of Characteristics by Classification of Building (2/3)

4) Hospital

Hospitals have the disadvantage of a large number of occupants who have difficulties to self-evacuate due to physical and mental impediment.

Typical points for hospitals are to:

- Ensure easy evacuation routes by the horizontal exits without any travel in a vertical direction,
- Strengthen safety for occupants in operation rooms, intensive care units, and artificial dialysis room by confined horizontal exits.

The horizontal exit is to subdivide a floor into blocks which are formed by fire resistant structures. The occupants horizontally evacuate to the safe area. The confined horizontal exit resists fire and smoke until suppression of the fire. It provides safety for occupants who are unable to move at all.

5) Department Store

Typical points for department stores are to:

- Have smooth evacuation routes by setting up a well-balanced layout and sufficient storing space and well-coordinated guiding by staff,
- Prevent fire spread by subdividing the selling area into blocks by fire shutters,
- Prevent smoke spread by enclosing escalators and other vertical openings by fire and smoke resistant shutters.

The points above are necessary because department stores have the disadvantages of:

- Large amount of combustible goods in the selling area,
- Various types and large numbers of occupants who are unfamiliar with the building and can easily fall into panic.

General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	1
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General Understanding of Characteristics by Classification of Building (3/3)

6) Theater

Typical points for theaters are to:

- Secure smooth evacuation by setting up well-balanced and sufficient evacuation routes and well-coordinated guiding by staff,
- Secure fire safety of stages by installing sprinklers and smoke exhaust system above the stage,

Doorways of the evacuation routes should open in the same direction as the evacuation direction. The fire safety of the stage can be further strengthened by fire separation between the stage and seating area. Theaters have disadvantages of:

- People can easily panic due to the large number and various types of occupants at high density and who are unfamiliar with the building,
- High hazards to break out fire at the stage.

7) School

Typical points for schools are to;

- Secure smooth evacuation by having multiple evacuation routes similar to the path of daily use,
- Take high precaution for students of lower grades by well-coordinated guiding by staff.

Schools have the disadvantage of a large number of occupants which include lower grade students who do not well-understand about fire.

8) Complex Building

Typical points for complex buildings are to simplify the fire protection system by subdividing the building into blocks separated by:

- Physical structure, service facilities, and spatial layouts,
- Functional operation and management system.

The fire protection system is set up in each block with self-reliance because complex buildings have the disadvantages of:

- Complicated operation and management system, due to different building owners, operators, and classification of building,
- Continuous operating time which allow occupants to use the building all day, due to different operating times,
- Large numbers and various types of occupants.

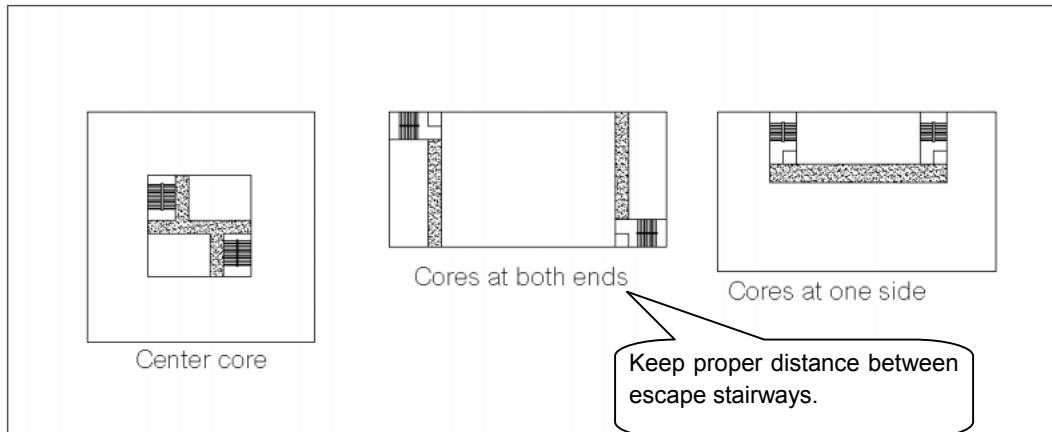
General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.1
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Office (1/5)

1) Core Type and Evacuation Planning

Principle: Any point of a building must have two or more evacuation routes to escape stairways.

Type of Core Space



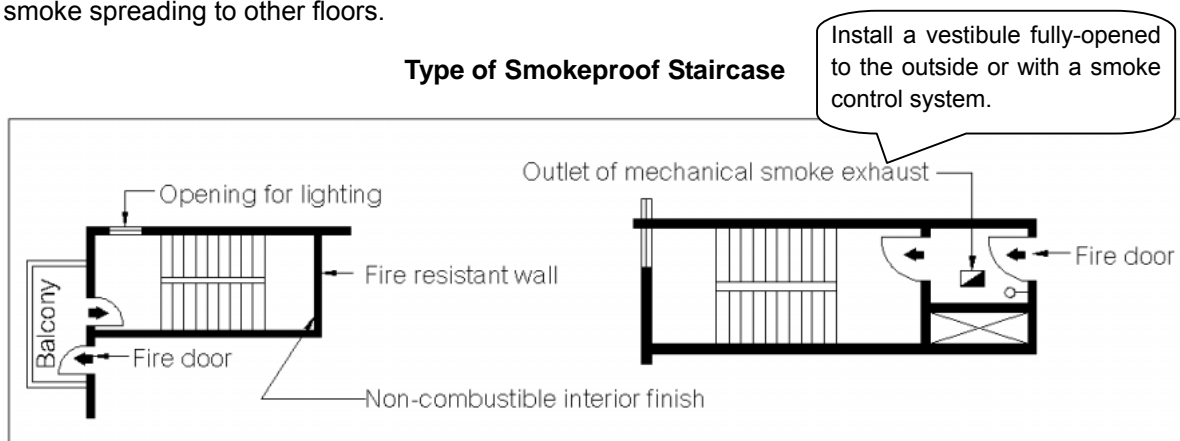
It is fundamental to have the multiple evacuation routes that is located away from each other as far as possible. On the other hand, the layout of core space, consisting of elevator shafts, staircases, toilets, and service facilities, is strongly related to the layout of the evacuation routes. The core type should be selected suitable to the floor area and form of the building;

- One side core type is useful for small-scaled buildings, while it has difficulty to secure multiple evacuation routes,
- Linear core and both ends core types are useful for medium-scaled building. Those types easily provide the multiple evacuation routes,
- Center core type is useful for large-scaled building. The escape stairs are at the center of a floor.

2) Prevention of Smoke Spread through Staircases and Elevator Shafts

Principle: Staircases and elevator shafts must be tightly enclosed by fire resistant structures to prevent smoke spreading to other floors.

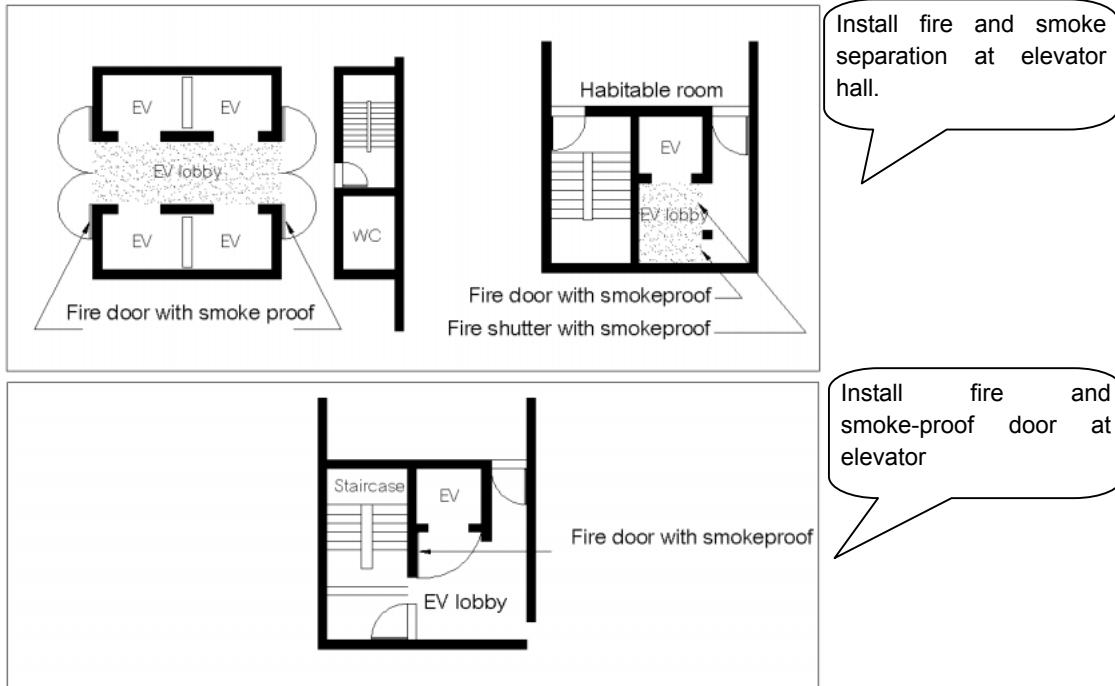
Type of Smokeproof Staircase



2.1	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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Office (2/5)

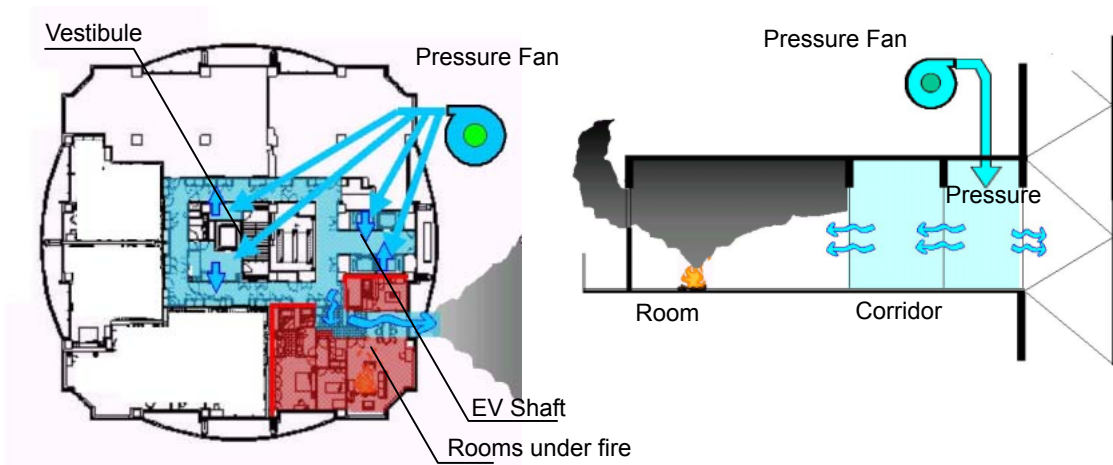
Smokeproof Staircase at Elevator Hall



Smoke rapidly goes up through vertical openings of escape staircases and elevator shafts of the core space. However it is impossible to eliminate the gap at elevator door, due to its opening and closing function. Typical fire protection of elevators and elevator halls is to;

- Install smokeproof doors on elevators activated by smoke detectors, or
- Separate elevator halls by fire and smoke resistant structures,
- Install pressurized smoke control system at the elevator shaft and vestibule of smokeproof staircase.

Pressurized Smoke Control System



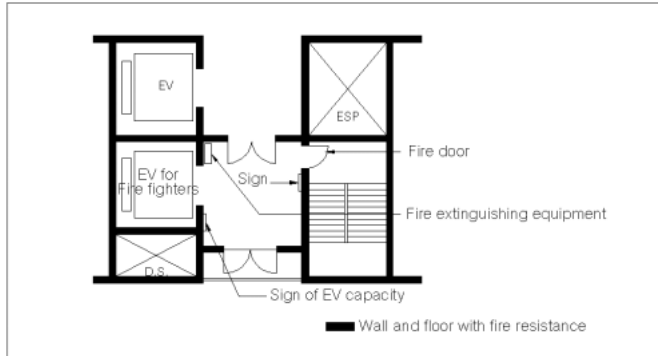
General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.1
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Office (3/5)

3)Base of Fire Fighting and Rescue for High-rise Building

Principle: High-rise buildings should have an access and base for fire fighting.

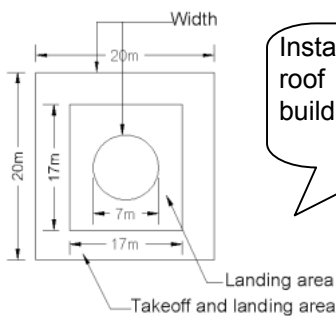
Layout of Escape Staircase and Elevator for Firefighters



Set up the base at the life lobby for firefighters.

Set up a buffer zone for refuge area and base of fire fighting at intermediate floors

Dimension of Heliport for Emergency

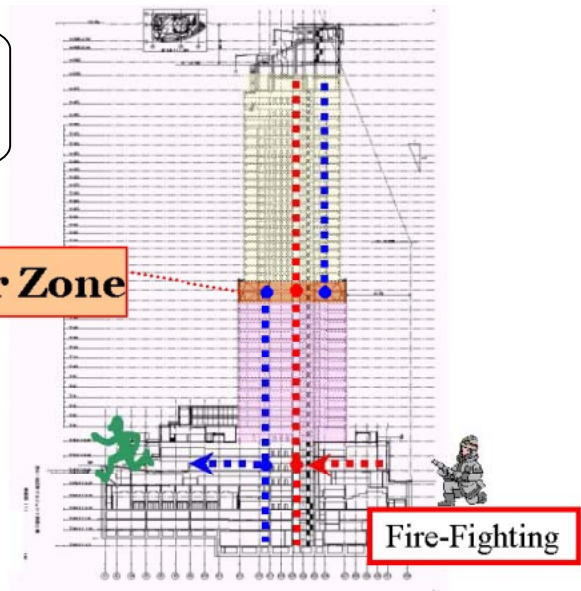


Install heliports on the roof of high-rise buildings.



Layout of Buffer Zone with Fire Fighting

Buffer Zone



It is difficult to conduct fire fighting for high-rise buildings higher than the reach of ladder trucks. It is recommended to:

- Install the firefighter's life lobby with the sufficient floor area and the emergency communication system connected to the fire fighting control room,
- Set up heliports on the roof for landing firefighters,
- Set up buffer zones on an intermediate floor as a refugee area and base for fire fighting.

2.1	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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Office (4/5)

4) Flexibility to Changes of Floor Layout

Principle: Office buildings, especially buildings for rent, often change their floor layout. Fire protection systems have to remain effective after modification of the floor layout.

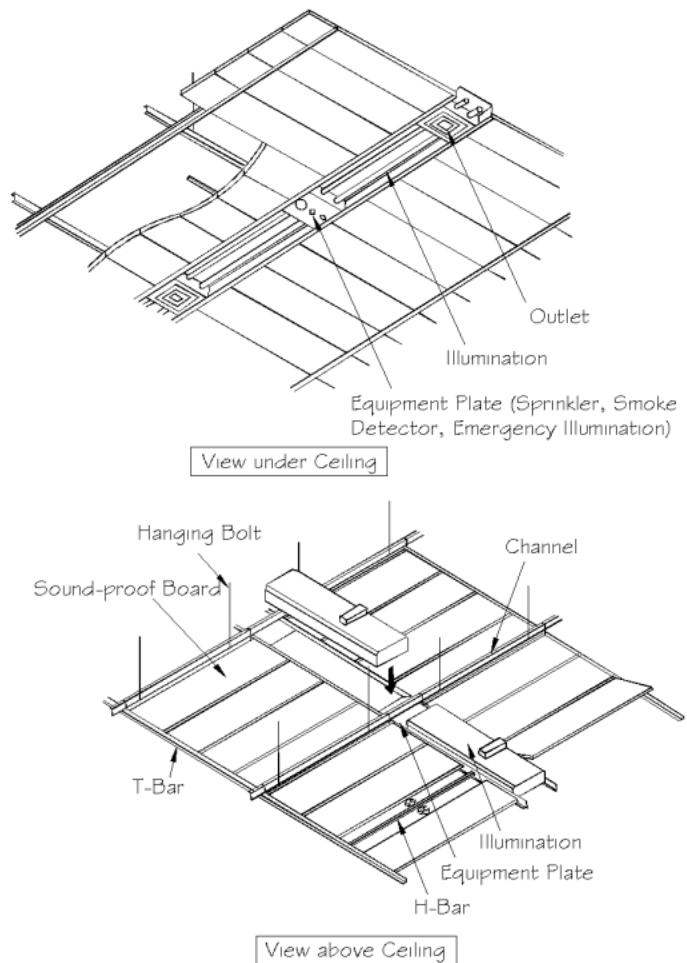
Perspective View of Integrated Ceiling System



The integrated ceiling system has the advantage of easily following the changes of floor layout by:

- Integration of air conditioning, lighting, and fire protection equipment, including sprinklers, emergency lighting, and fire detectors, in a unique module,

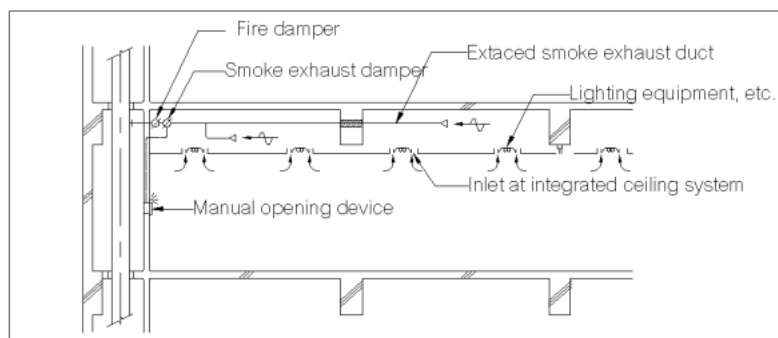
Layout of Integrated Ceiling System



General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.1
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Office (5/5)

Section of Integrated Ceiling System and Chamber Smoke Exhaust System



The chamber type of smoke control system is to convey smoke through a chamber behind the ceiling to an outlet. The inlet to the chamber is installed in the ceiling in accordance with the module of the integrated ceiling system.

The chamber smoke exhaust system has the advantages of:

- Easily following changes to the floor layout,
- Increasing the smoke storing volume by the dimension of the chamber,
- Increasing the efficiency of smoke exhaust by the pressure difference of thick smoke layer.

2.2	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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Hotel (1/2)

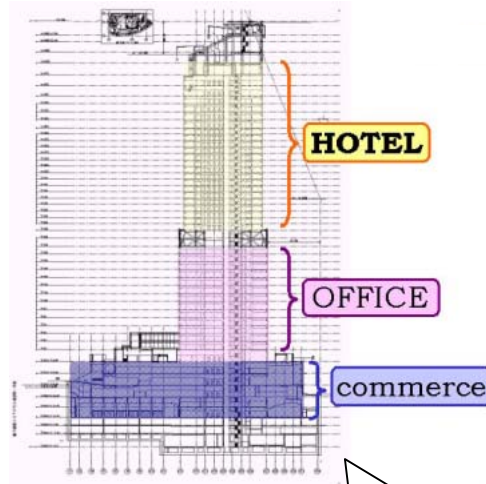
1) Zoning by Classification of Building

Principle: Large-scale hotels often contain different classifications of building. Self-reliant blocks are necessary to subdivide a building into blocks of uniform classification.

Large-scale hotels usually contain two or more kinds of classifications of building. Guests mainly use and stay in the guestrooms section, while visitors use the public section that includes meeting halls, shops, restaurants, and parking. Those sections are often divided by offices on intermediate floors.

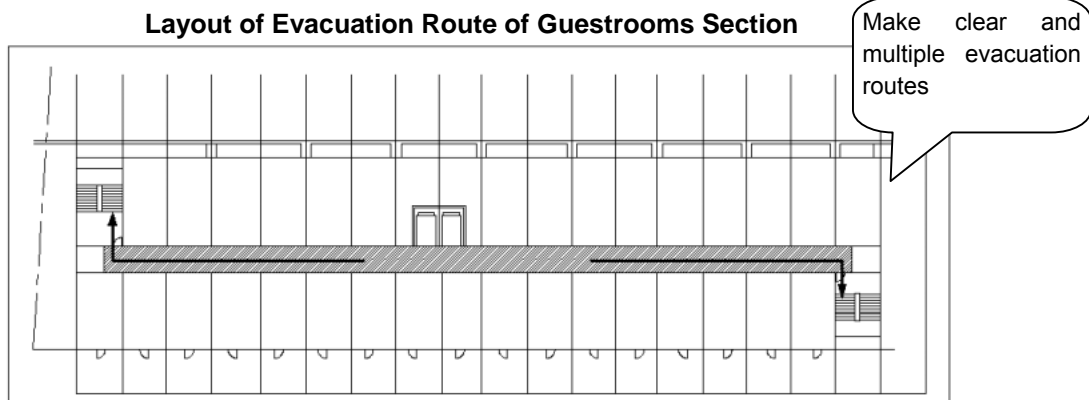
It is recommended to subdivide a building into self-reliant blocks of uniform classification by fire separation and smoke enclosure. Each block has self-reliance with respect to service facilities and the administration system. Staircases and elevator shafts will, however, penetrate through different classifications. Those parts should have vestibules and fire separation to prevent smoke spread.

Zoning by Occupancy



2) Layout of Guestrooms and Evacuation Routes

Principle: Evacuation routes should be clear and multiple from guestrooms to escape stairways.



Occupants do not know the evacuation route of the building because the path of daily use is strongly influenced by the location of elevators, which is not the same as the evacuation route. Occupants variously include ill-informed, aged, disabled, and drunk guests. Evacuation routes should be:

- Clear, unobstructed and short in dead-end routes,
- Connected to escape stairways and balconies at both ends of corridor.

General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.2
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Hotel (2/2)

3)Early Awareness of Fire to Guests and Reliability of Evacuation Guides

Occupants have disadvantages in early awareness of fire, due to:

- Being isolated in sound-proof guestrooms,
- Sleeping.

Typical requirements of the fire protection system are to:

- Install public address system in every guestroom,
- Install sub-receiving panel and public address system at the front and offices for reliable evacuation guide.

4)Prevention of Fire and Smoke Spread between Guestrooms

Typical requirement is to:

- Separate guestrooms by fire resistant structures,
- Separate corridor and guestrooms by fire resistant structures.

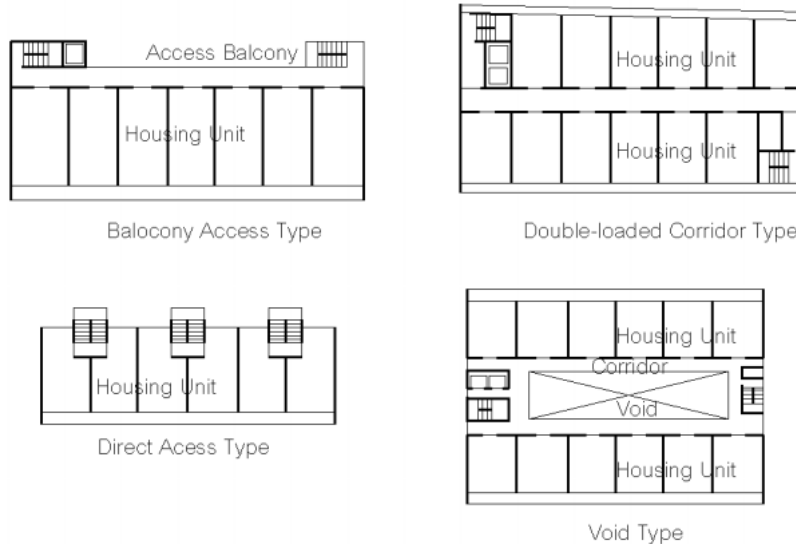
2.3	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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Multi-story Housing (1/3)

1) Selection of Appropriate Corridor Type

Principle: Any point of a building must have two or more evacuation routes.

Type of Corridor



Selection of core type relates to the layout of evacuation routes. The corridor type generally has four different types:

- Balcony access type,
- Double-loaded corridor type,
- Direct access type,
- Void type.

Typical requirements for the double-loaded corridor type and direct access type is to install smoke exhaust system in the corridor operated by remote control from a fire fighting control room or escape staircase.

2) Multiple Evacuation Routes from any Housing Units (especially bedrooms) to Escape Stairs

Multi-story housing has the disadvantages of:

- Occupants of the aged, infants, disabled and patient,
- Late awareness of fire, due to sleeping occupants.

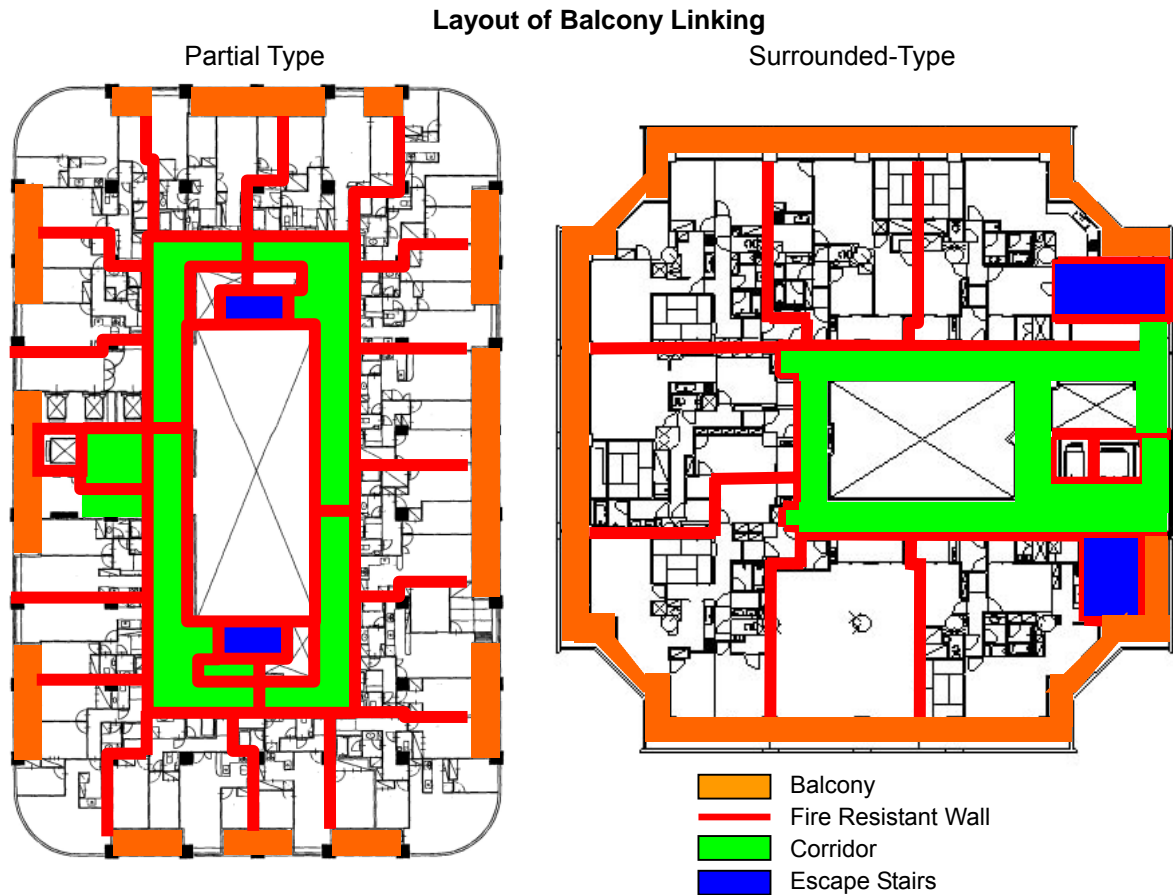
Typical requirement is to:

- Install balcony and corridor from housing units to set up multiple evacuation routes to escape stairs.

General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.3
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Multi-story Housing (2/3)

3) Balcony Linking



Sleeping occupants are often late to become aware of the outbreak of fire. Balcony linking aims to strengthen evacuation routes for occupants who start evacuation late after the corridor and aisle of a floor are closed by fire and smoke.

Balcony linking consists of two types:

- Surrounded-type: having an access directly to an escape stairway without passing through other housing units,
- Partial-type: having access to an escape stairway via neighboring housing units.

It should be noted that the balcony linking is an additional route to the regular routes required in the fire codes. Balcony linking does not replace corridors and aisles as regular evacuation routes. The fire code in Japan requires a width of 600 mm or more for balcony linking.

2.3	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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Multi-story Housing (3/3)

4)Early Awareness of Fire to Occupants

Typical requirements are to:

- Install a fire detector in every housing unit,
- Install a public address system with speaker in common space and every housing unit.

The public address system takes the role of reporting the conditions of fire and guiding the occupants. It should also be put to daily use for information distribution through the housing information panel to secure reliability of the system.

5)Prevention of Fire and Smoke Spread between Housing Units

Typical requirement is to:

- Install fire resistant walls between housing units, corridor, and other parts,
- Install fire doors with automatic closing system at the doorway to the evacuation route.
Door-stoppers at the doorway should be removed by proper maintenance.

General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.4
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Hospital (1/3)

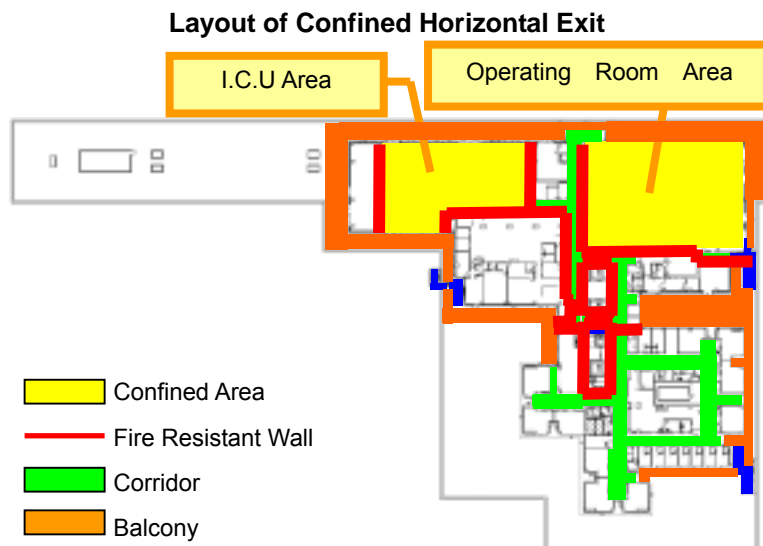
1) Spatial Diversities

Hospitals have spaces for inpatients, outpatients, operating, material and management. Those spaces have disadvantages of:

- Inpatients unable to self-evacuate,
- Outpatients of the aged, infant, and disabled,
- Sleeping patients who are left in sick rooms with sometime insufficient observation,
- Combustible goods and fuels such as bedding, medicines, and gases,
- Use of fire in kitchens.

2) Evacuation via Horizontal Exit, Confined Method

Principle: The confined method of horizontal exit aims to secure safety for patients in operating rooms, intensive care unit (ICU), and artificial dialysis rooms who are unable to move.



The confined horizontal exit is to secure the safety of occupants without any evacuation by:

- Isolating a room or compartment from fire and smoke by fire separation until suppression of the fire,
- Forming two sets of fire separation,
- Locating far from hazardous spaces, such as kitchens, on same and adjacent floors,
- Installing smoke exhaust system and air ducts exclusive for the confined area,
- Securing access for rescue by firemen.
- Installing life-support system,
- Prohibiting use of fire in the confined area.

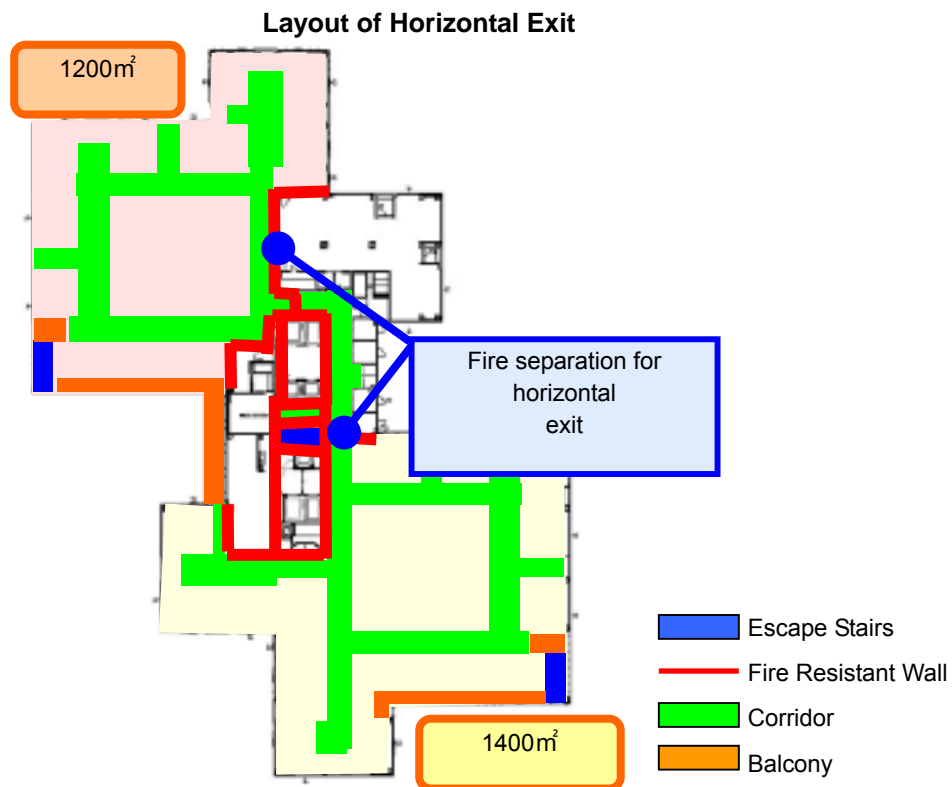
2.4	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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Hospital (2/3)

3)Horizontal Exit

Principle: Hospitals have a large number of occupants disable to self-evacuate. The horizontal exit aims to:

- Secure temporary refuge area with fire and smoke resistant structures from where occupants can evacuate without any vertical travel,
- Allow the occupants to evacuate in the vertical direction with sufficient time.



The horizontal exit is required to:

- Be accessible from any part of a floor through the evacuation route with smoke control system,
- Be located in the same position on every floor,
- Have no penetrated parts by smoke control system, air conditioning system, or other service facilities,
- Have openings to evacuation direction,
- Have sufficient width for wheelchairs stretchers to smoothly pass through.

General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.4
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Hospital (3/3)

4) Balcony Linking for Occupants left in a Building

Principal: Occupants are often left in a room or floor on fire due to late awareness of the fire and their disability to evacuate. The balcony linking aims to:

- Form an alternative evacuation route to an elevator for firefighters and escape stairway, and other horizontal exits without any travel through rooms that are on fire.

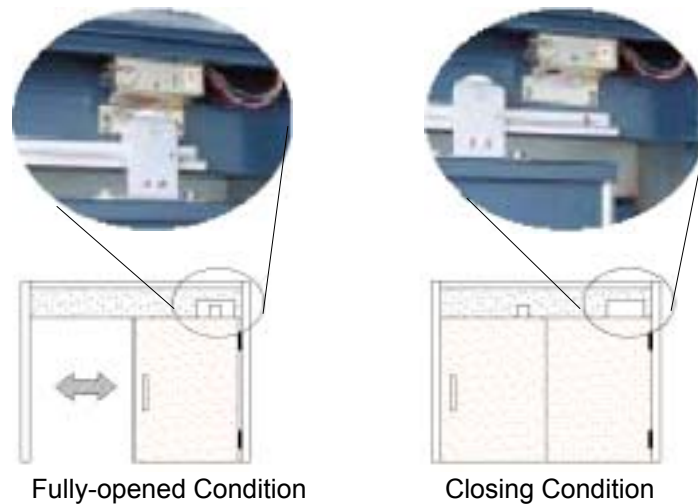
The balcony linking requires to:

- Minimize gaps between the balcony and inside building for smooth traveling,
- Have sufficient width for wheelchairs and stretchers to pass through,
- Have storing space to temporarily wait for rescue from outside.

5) Fire and Smoke Resistant Structures for Patients Rooms' Floor

Principal: The fire and smoke resistant structures between the patients rooms and corridor are necessary on floors having patients rooms to secure the safety of patients who often take time to evacuate and are unable to evacuate by themselves.

Fire and Smoke-proof Doors interlocked with Smoke Detector



Typical points for the patients room and incidental facilities are to:

- Install fire and smoke proof doors with automatic-closing system, because those are usually opened for nursing care except night time,
- Install wire-glazed glass surrounding the nurse office, if any,
- Install smoke curtain to delay smoke spread.

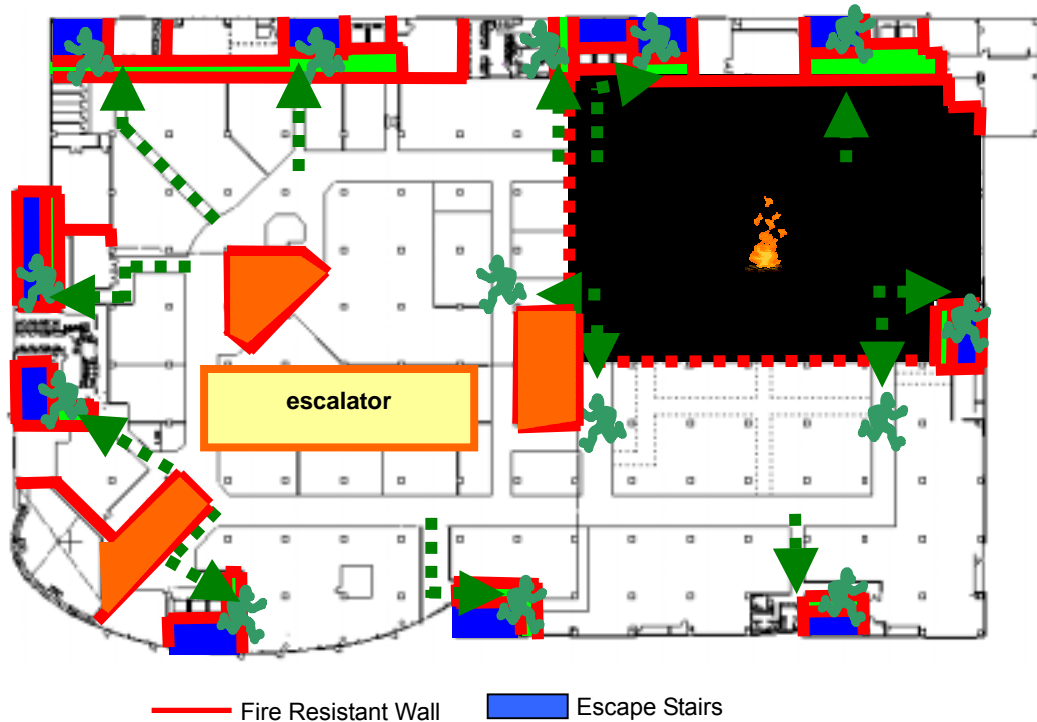
2.5	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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Department Store (1/3)

1) Multiple and Well-balanced Evacuation Routes

Principle: Department stores have a large number of occupants consisting of the aged, infants and disabled. Those characteristics of the occupants have the disadvantage of easily falling into panic. Department stores should enable smooth evacuation for the occupants without any obstruction.

Well-balanced Evacuation Routes



Typical points of the evacuation planning are to:

- Have many escape stairways with well-balanced location and sufficient capacity to evacuate without any stagnation,
- Plan for well-coordinated guiding by staff and exit guide illumination.
- Form the layout of the evacuation route so that it can be easily identified and understood by customers,
- Have no rooms and compartments on the evacuation routes.

General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.5
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Department Store (2/3)

2) Fire Shutters for Large Floor Area and Flexible Floor Layout

Principle: Department stores usually have to provide large selling areas, which have heavy fire load which increases the hazard level of the building. The fire protection system should be designed to meet the needs of selling areas with proper fire safety level and flexibility of the floor layout



The fire shutters offer the advantages of:

- Ability to prevent fire spread from the large amount of combustible goods in the selling areas,
- Flexibility of the floor layout.

The selling area sometimes requires a room for convenient display without any openings. The enclosed room accelerates the generation of smoke which obviously obstructs evacuation and fire fighting. The fire shutter is useful to prevent smoke and fire spread from the display rooms.

Due to the opening and closing functions, requirements of the fire shutter are:

- Well-maintained with no obstacles, such as exhibition cases, under the shutter,
- Well-coordinated with the exhibition layout.

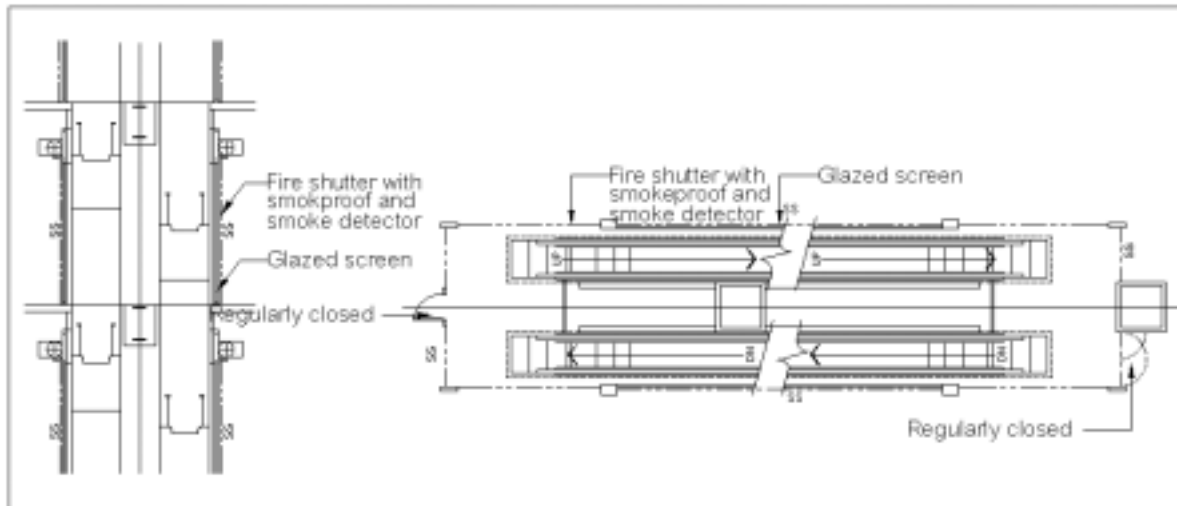
2.5	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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Department Store (3/3)

3) Fire Shutter and Glass Screen of Escalators

Principle: The vertical openings of escalators are a significant cause of smoke spread in fires. The fire protection system should include provisions at escalators to prevent smoke spread.

Fire Shutters and Glazed Screen around Escalators



The fire shutter is useful to form fire separation and smoke enclosure at the escalator opening. The fire shutter is able to provide spatial continuity of floors and occupants' traffic around the escalator in the daily use. It is requires to have:

- Glazed screen to secure reliability when fire separation is not complete, due to damage or delay of closing down the fire shutter,
- Handrails between the shutter and glazed screen when large gaps remain between them.

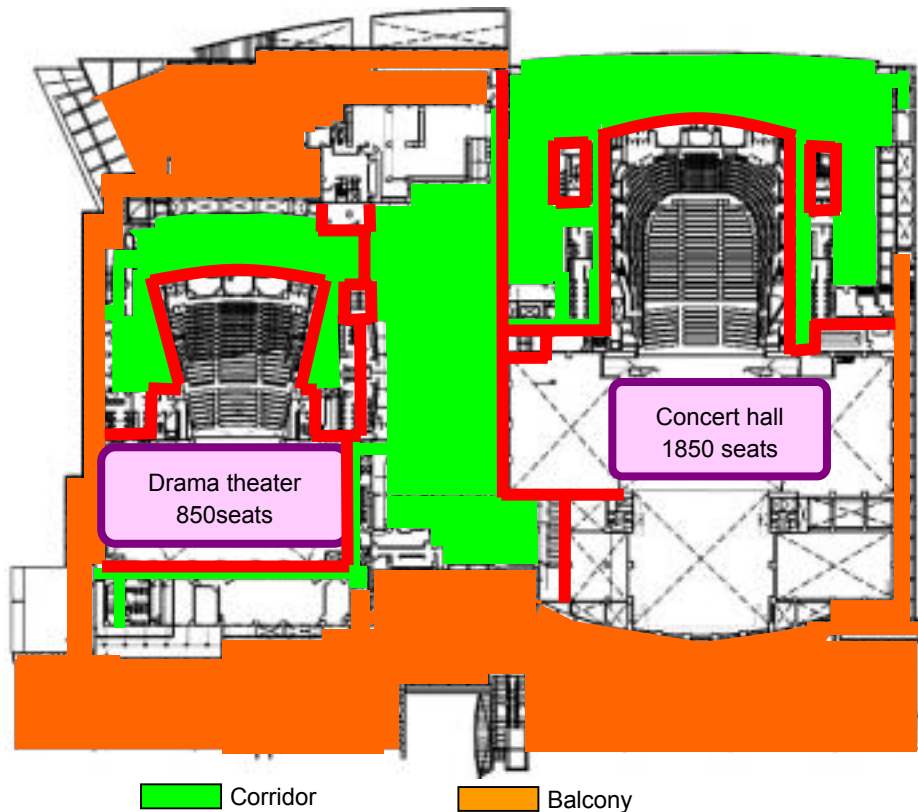
General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.6
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Theater (1/2)

1) Smooth Evacuation for Various and a Large Number of Occupants

Principle: Theaters have the disadvantage of various and a large number of occupants in the seating area at high density. The occupants are not familiar with the building layout. Therefore they easily fall into panic typically at bottlenecks along evacuation routes. Evacuation planning for theaters has to make many precautions to secure smooth evacuation.

Sufficient Route and Capacity of Evacuation Route



The evacuation planning for the theaters has to secure;

- Evacuation route that can clearly and easily understood by visitors,
- Sufficient capacity of doors to eliminate any bottlenecks along the evacuation route,
- Sufficient spacing of seats to secure exit access routes in the seating area.

2.6	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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Theater (2/2)

2)Fire Prevention at the Stage

Principle: Stage and backstage areas are susceptible to fire by illumination, fire, and stage curtains for stage setting.

Typical requirements are to:

- Restrict use of fire on stage,
- Use noncombustible and fireproof materials for interior finish, curtains, and setting of the stage,
- Install sprinkler system above the stage,
- Install inlet of smoke exhaust system above the stage,
- Install fire shutters and drenchers to create fire separation between the stage and the seating area.

General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.7
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School

1) Safe Evacuation for Students

Schools have classrooms, lecture rooms, lecture halls, libraries, management rooms (or teachers' rooms), and canteens. Schools have large numbers of students, and students in lower grades have insufficient knowledge of fire.

On the other hand, schools have the advantages of;

- Habitable rooms and corridors with sufficient openings to the outside,
- Low-rise buildings for elementary, secondary, and high schools.

Typical points for evacuation planning are to:

- Have proper guidance by teachers and staff,
- Have an evacuation route that is the same as the path of daily use to prevent students from losing the correct routes to a public way.

2) Protection of Students from Injury in Normal and Emergency Conditions

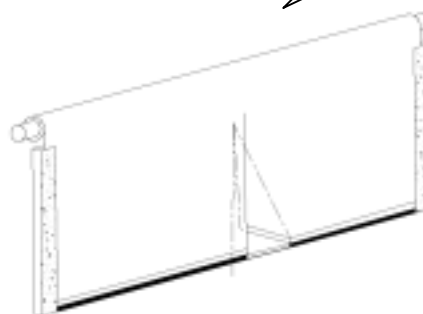
Principle: Students, especially in lower grades, are weak to protect themselves from accidents. The fire protection system must provide a fail-safe system against mischief and mis-operation by students.

For instance, typical points for fire shutters are to:

- Prevent accidents on students by their mischief and mis-operation,
- Provide reliability for fire separation and easy operation to pass through by students.

The L-shaped fire shutter is a suitable fire shutter for schools. It is made of heat-proof glass cloth and is lighter and softer than steel.

Dimension of L-shaped Fire Shutter



Screen with fire resistance and capable to walk through the L-shaped notch.

General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex	2.8
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Complex (1/2)

1) Simplification of Complexity

Complex buildings have special conditions of complexity;

- Buildings classified as office, hotel, department store, theater, etc,
- Building owners, operators, and users,
- Operation time.

Those special conditions have the disadvantages of:

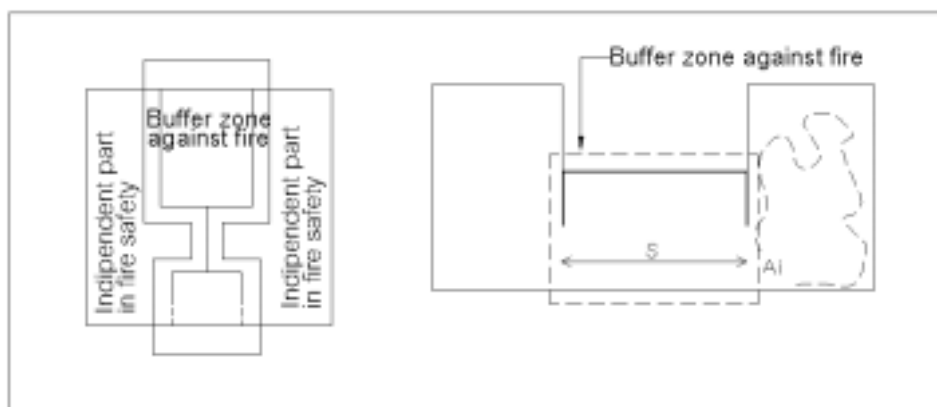
- Panic conditions in evacuation by intermixture of large number of various types of occupants,
- Complications for fire fighting.

Those disadvantages allow enlargement of fire. Typical points of fire prevention are to:

- Subdivide a building into blocks by classification, floor, and structure,
- Have self-reliance for fire protection system and service facilities in each block, such as;
 - i) Setting up fire and smoke separation between blocks,
 - ii) Setting up buffer zones with smoke control and fire fighting systems between blocks,
 - iii) Having independent service system of water supply, sanitary, power supply, and communication,
 - iv) Having independent fire protection system of fire fighting and evacuation,
 - v) Having an administration system in each block.
- Set up an appropriate safety level for each block.

Within the fire protection system, the subdivision of the evacuation and fire fighting system is important and should be well-coordinated with the administration system.

Zoning by Spatial Layout



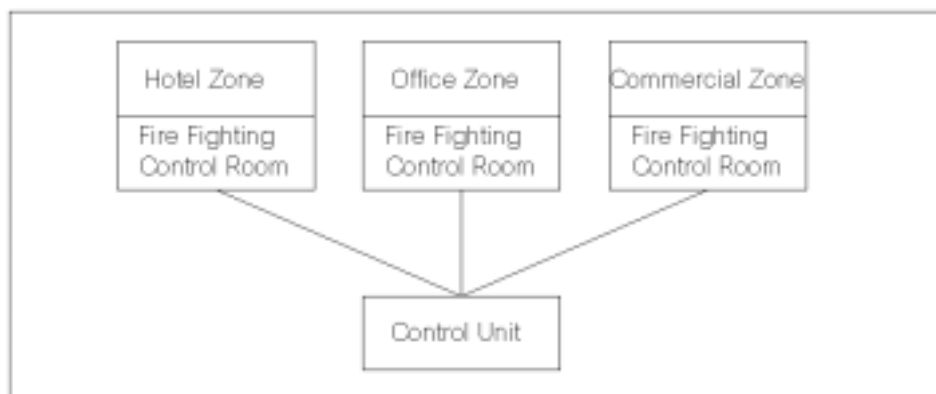
2.8	General	Office	Hotel	Housing	Hospital	Dept Store	Theater	School	Complex
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Complex (2/2)

2) Zoning by Operation and Management

Sub-fire fighting control room in each subdivided block is preferable to set up easy and efficient supervision system

Fire Fighting Control Room of Complex Building



Sub-fire fighting control room requires;

- Integration with main fire fighting control room,
- Supervising and operation system similar to the main fire fighting control room,
- Mutual communication system between sub and main centers,
- Information for outbreak of fire in other blocks.