Building Control in Japan

- Part D -

by HASEGAWA Tomohiro
日本の建築規制　長谷川知弘

Ver. 1910

Chapter 10 Structural Safety

10-1 Composition of the structural codes

(1) Basic idea

The basic idea concerning structural safety is that structures must be safe against:

(a) permanent load (dead load);
(b) imposed load (live load);
(c) snow load;
(d) wind pressure;
(e) seismic force; and
(f) Others

(2) Concepts

In concrete terms, technical requirements have been set on the basis of the following concepts:

(a) The permanent load and imposed load are safely supported, and cause no excessive deformation or vibration, which can interfere with the use of the building.
(b) The building does not sustain damage due to a rare medium-scale snowfall, windstorm, earthquake, or other event.
(c) The building does not collapse or otherwise fail due to an extremely rare large-scale snowfall, windstorm, earthquake, or other event.

(3) General Flow of Structural Design

(a) Structural Category of the buildings

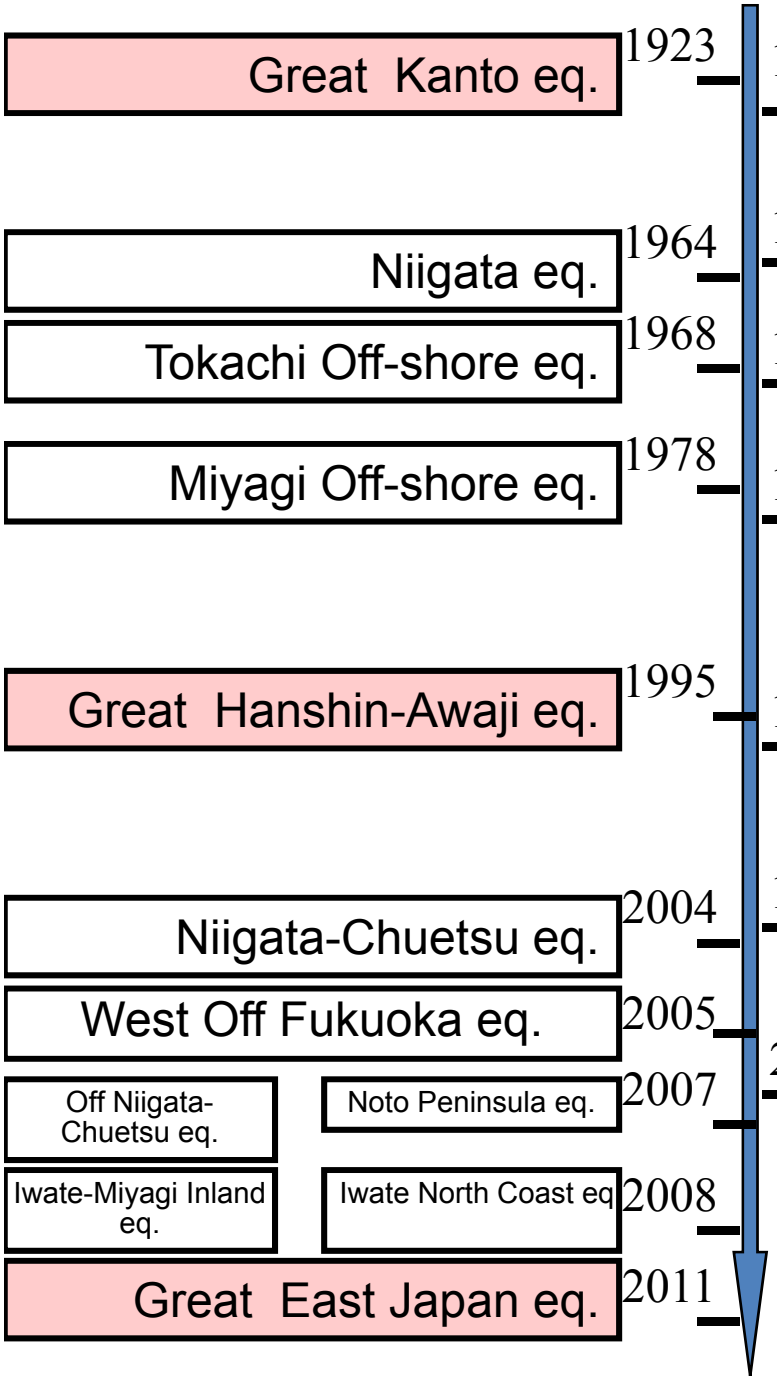
Every building is classified into one of the categories:

- Category I (high-rise buildings);
- Category II (large-seized buildings);
- Category III (medium-sized buildings); and
- Category IV (small buildings),

based on the structural type, height, and size of the building, as shown in the table of 'Structural Category of the Buildings'.

Trends in development of earthquake-resistance measures

《Major earthquakes》



1924 **Structural calculation regulation in considering seismic force (First such requirement in the world)**

1950 **Enactment of the Building Standard Law (BSL)**

1971 **Amendment of the BSL**

- Strengthening of RC standards

1981 **Amendment of the BSL (New Seismic Codes)**

- Not damaged by medium-scale earthquakes
- Not collapsed by large-scale earthquakes

1995 **Enactment of the Act on Promotion of Seismic Retrofitting of Buildings**

- Approval of seismic retrofitting plans

1998 **Amendment of the BSL**

- Building confirmation by private sector, introduction of interim inspection, performance-based standards

2006 **Amendment of the Act on Promotion of Seismic Retrofitting of Buildings**

- Making a plan for promoting seismic retrofitting by local government

Many buildings built before 1981 do not comply with the current seismic standard.

Structural Category of the Buildings

Categories (share)	Structure, height, and size of building	
	Wooden buildings	Buildings other than wooden buildings
(I) High-rise buildings (0.1 %)	Building height ＞ 60 m	
(II) Large-sized Buildings (2.5%)	- Building height ＞ 13m, or - Eave height ＞ 9m, other than (I)	Any of the buildings below other than (I): - Steel buildings with 4 or more stories (excluding basement); - RC or SRC buildings of 20m or more in height, and - Buildings stipulated by the Cabinet Order, such as steel buildings more than 13 m in height or more than 9 m in eave height,
(III) Medium-sized buildings (25%)	- Number of stories ＞3, or - Total floor area ＞500 m^2 other than (I) and (II)	- Number of stories ＞2, or Total floor area ＞200 m^2, and - Masonry structure, etc. that are more than 13m in height and that have eaves of more than 9m in height. other than (I) and (II)
(IV) Small buildings (over 70%)	Buildings other than (I), (II) and (III). It means wooden buildings that conform to: - Number of stories ≦2; - Total floor area ≦500 m^2; - Building height ≦13 m; and - Eave height ≦9 m.	Buildings other than (I), (II) and (III).

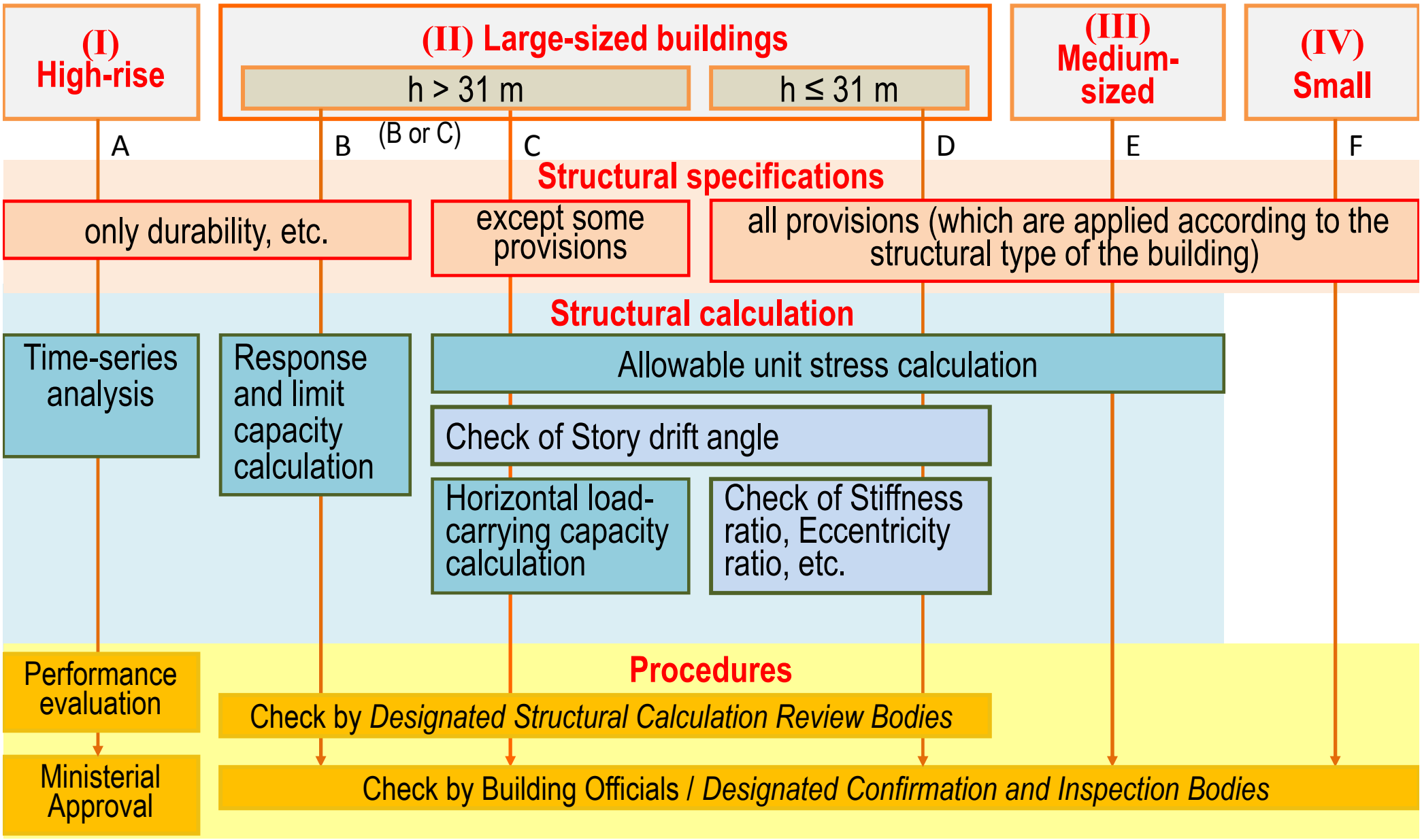
(b) Structural check responding to the Categories

There are 6 structural check combinations (**A** through **F**, as shown in the figure 'Structural check responding to the Categories'. The order of sophistication of the combinations is from **A** (the highest), down to **F**.

For each category, the possible combinations to confirm its structural safety are determined as shown in the figure. It is allowed to use more sophisticated combinations than the required combination.

Some requirements of structural specifications are not applied to the combinations of **A**, **B**, and **C**, because these specific requirements can be checked through structural calculations of **A**, **B**, or **C**. Structural calculation or check for roofing material, etc. is done in the all combinations.

Structural check responding to the Categories



The order of sophistication of the combinations is from A (the highest), down to F. It is allowed to use more sophisticated combinations than the required combination.

(i) **For Category IV (small buildings),** it is required to only comply with structural specifications. Structural calculations are not required. On the other hand, it is allowed to use other structural combinations. In case where the structural safety of the building was confirmed by combinations of **A** or **B**, only the structural specifications on durability, etc. are applied to the buildings.

(ii) **For Category II (large-sized buildings)** and **Category III (medium sized buildings)**, structural calculations are required. As same as Category IV (small buildings), in case where the structural safety of the building was confirmed by combinations of **A** or **B**, only the structural specifications on durability, etc. are applied to the buildings.

(iii) **For Category I (high-rise buildings)**, only the combination **A** is allowed to use, and performance evaluation by a *Designated Performance Evaluation Body* and Approval by the Minister are required.

10-2 Structural specifications

Structural specifications are provided according to ordinary structural types, namely:

- wooden structures;
- masonry structures;
- reinforced concrete block structures;
- steel structures;
- reinforced concrete structures;
- steel and reinforced concrete composite structures; and
- plain concrete structures.

In addition, for:

- special structural methods of ordinary structural types mentioned above (such as wood-frame structure); and
- structural types other than ordinary structural types mentioned above (such as membrane structure),

structural specifications are established and announced in the form of *MLIT Notifications*.

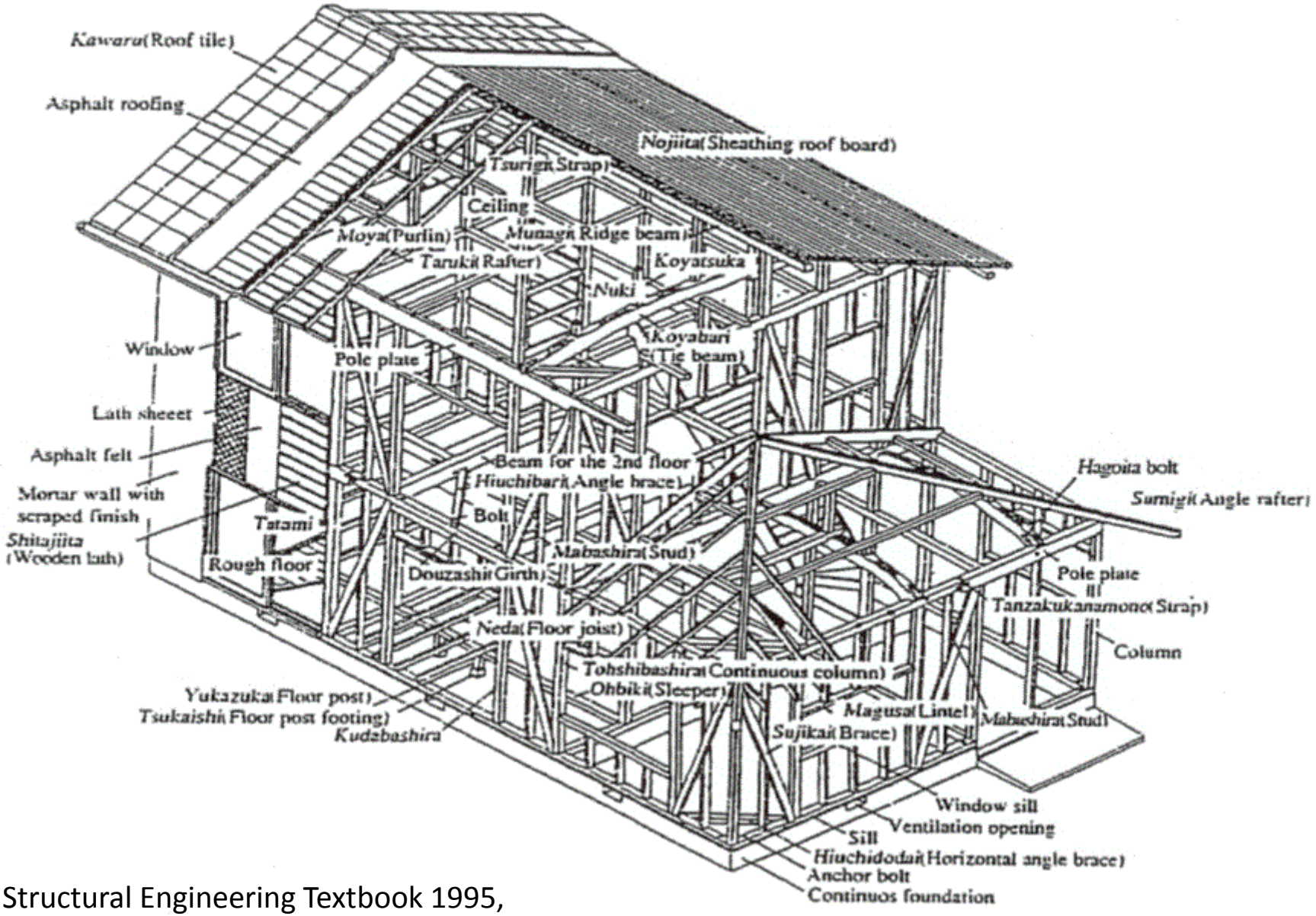
(1) Wooden Structure

Concerning wooden structures, regulations are prescribed for:

- structure of sills and foundations;
- size of posts;
- necessary strength and quantity of braces and structural frames;
- methods of using joints/connection;
- quality of preservative measures; and
- others.

Here, the wooden structure refers to the post and beam structure, which is the conventional method of construction in Japan (see the next page), while the wood-frame structure comes under a different set of structural specifications. Structural specifications also exist for large wooden structures with posts and beams with large sectional size.

Structure of Conventional JapaneseWooden Houses



Source: Structural Engineering Textbook 1995,
Architectural Institute of Japan

(2) Masonry Structure

Concerning masonry structures, such as the brick structure and the stone structure, regulations are prescribed for:

- foundation structures;
- necessary length and thickness of walls;
- wall-girder structures;
- limitations on the size of openings;
- methods of construction work; and
- others.

(3) Reinforced Concrete Block Structure

This method of construction involves reinforcing bars passing through concrete blocks. Various regulations are provided for:

- foundation structures;
- necessary length and thickness of walls;
- size and arrangement of reinforcing bars;
- wall-girder structures;
- method of construction work;
- structural parts of fences; and
- others.

(4) Steel Structure

Regulations concerning the steel structure are provided for:
- effective slenderness ratio of members;
- foundation structures;
- methods of making joints and connections; and
- others.

(5) Reinforced Concrete Structure

Reinforced concrete structures are governed by regulations prescribing:
- quality of concrete materials;
- connections and arrangement of reinforcing bars;
- strength of concrete;
- method of curing;
- structure of columns, floor slabs, beams, and bearing walls;
- depth of concrete cover above steel bars; and
- others.

(6) Steel and Reinforced Concrete Composite Structure

Concerning steel and reinforced concrete composite structures, regulations for both steel structures and reinforced concrete structures are applied correspondingly, as the occasion demands.

(7) Plain Concrete Structure

Concerning plain concrete structures, regulations for both reinforced concrete structures and masonry structures are applied correspondingly, as the occasion demands.

(8) Other Structural Types

Technical standards for structural types other than those listed above are announced in the *MLIT Notifications*. Some of the technical standards have been announced for:

- wood-frame structures;
- pre-stressed concrete structures;
- box-frame type reinforced concrete structures; and
- others.

10-3 Structural calculation methods

(1) Two-phase seismic design

Seismic codes revised in 1981 feature a two-phase seismic design for earthquakes.

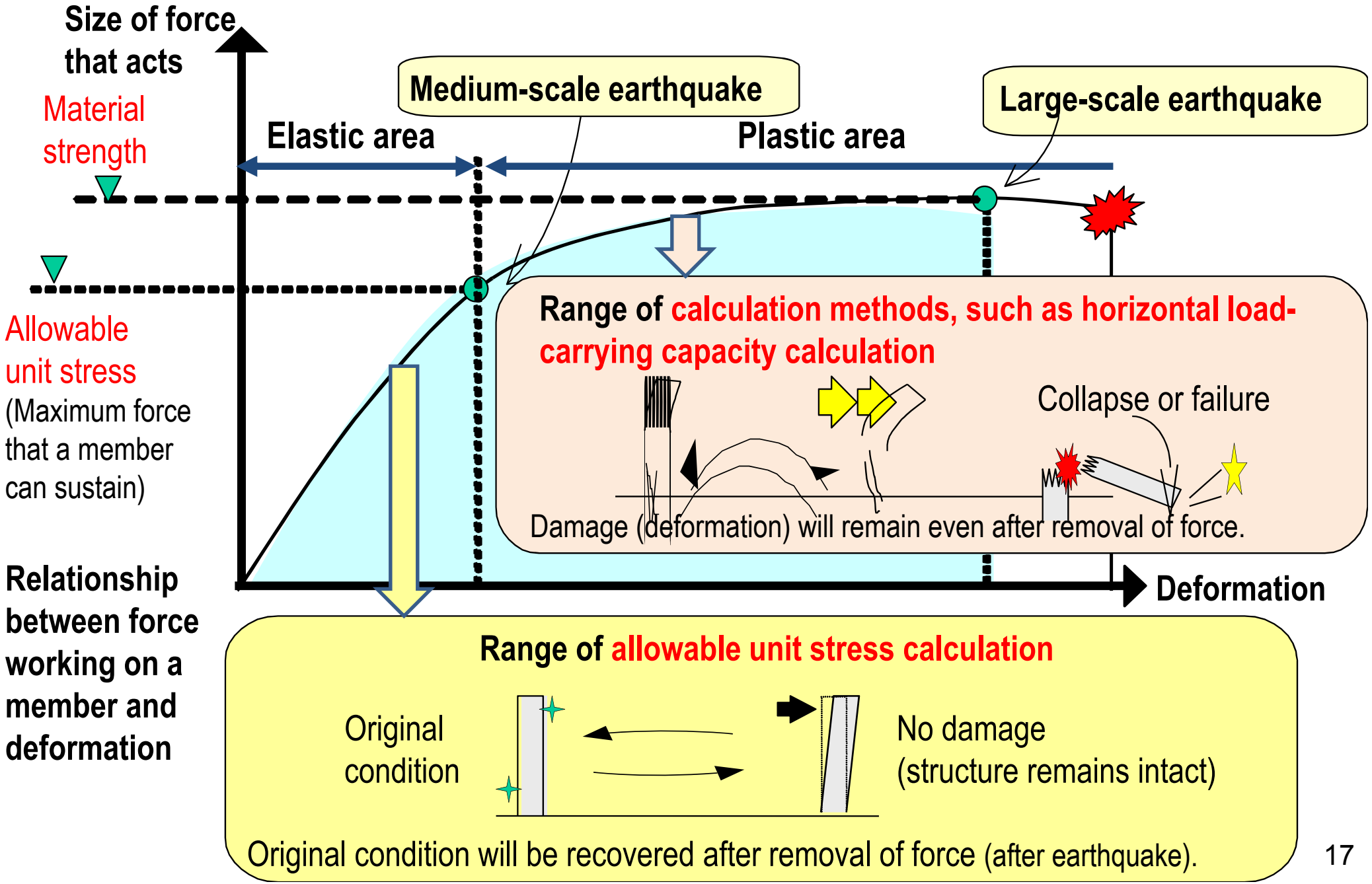
(a) Primary seismic design

- For **medium-scale earthquake** motions (**Standard shear coefficient $C_0 \geq 0.2$)**
  Strong earthquakes which could occur several times during the life time of the building
- **Working stress < Allowable stress**
  Not basically changed from the seismic design method before 1981)
- For **both superstructure and foundation**

(b) Secondary seismic design

- For **large-scale earthquake** motions (**Standard shear coefficient $C_0 \geq 1.0$)**
  Extraordinary earthquakes which could occur once in the life time of the building
- It requires **additional checking of several aspects** of the building that has been proportioned by the primary seismic design
- For **superstructure only**

Allowable unit stress calculation and other calculation methods



(2) Allowable unit stress calculation

(a) Calculation

Stresses acting upon the sections of elements necessary for structural resistance must be calculated by the formulas in the following table in cases both:

- sustained loads (for calculation considering normal time); and
- temporary loads (for calculation considering snow season, storm, or earthquake).

Kind of force	Possible conditions regarding loads and external forces	Loads and external forces, which must be included	
		General area	Heavy snow area
Force due to sustained loads	Normal time	G+P	G+P
	Snow season		G+P+0.7S
Force due to temporary loads	Snow season	G+P+S	G+P+S
	Storm	G+P+W	G+P+W
			G+P+0.35S+W
	Earthquake	G+P+K	G+P+0.35S+K

In this table, *G*, *P*, *S, W* and *K* represent the following loads and forces:

G: Permanent load (dead load);
P: Imposed load (live load);
S: Snow load;
W: Wind pressure; and
K: Seismic force.

(b) Confirmation

It shall be confirmed that sustained or temporary stresses do not exceed the allowable unit stresses in cases both sustained load and temporary load.

$$\text{Calculated stress} \leqq \text{Allowable unit stress}$$

Values of allowable unit stress are available for common materials, such as timber, steel, concrete, etc. These values are specified for both sustained loads and temporary loads.

Examples are shown in the next page. “Material strength” mentioned in the table is values of strength, which are used for calculations, such as horizontal load-carrying capacity calculation.

Examples of values of allowable unit stress and material strength

Concrete

		Compression	Tension
Allowable unit stress (Values of stress, which are used for allowable unit stress calculation)	Sustained load	F/3	F/30
	Temporary loads	F/3 × 2	F/30 × 2
Material strength (Values of strength, which are used for calculations, such as horizontal load-carrying capacity calculation)		F	F/10

F represents a specified design strength of concrete (unit: Newton/mm2), which is compressive strength to be set up in designing, and confirmed by the test of specimens.

Structural stainless steel

		Compression	Tension
Allowable unit stress (Values of stress, which are used for allowable unit stress calculation)	Sustained load	F/1.5	F/1.5
	Temporary loads	F	F
Material strength (Values of strength, which are used for calculations, such as horizontal load-carrying capacity calculation)		F	F

F represents a value of specified design strength (unit: Newton/mm2), which is specified by the Minister according to the kinds and quality of steel, etc.

(3) Loads and External Forces

Loads and external forces as factors for structural calculation vary, depending upon the location of the building and its use. Of these forces, at least five must be checked. They are:

- permanent load (dead load);
- imposed load (live load);
- snow load;
- wind pressure; and
- seismic force.

Depending upon the conditions, checks must also be performed for other external forces such as:

- ground pressure;
- water pressure;
- vibration; and
- shock.

(a) Permanent load (Dead load)

The permanent load is the load of each of the components of the building, including building equipment. It depends on the structural type of the building, finishing material of the components, etc. Various values are provided in the *Enforcement Order* for general cases. For special cases, the permanent load is determined according to the actual conditions.

(b) Imposed load (Live load)

The imposed load is the load of furniture, occupants, etc. It depends on the use of the building. Various values are provided in the *Enforcement Order* for general cases. For special cases, the imposed load is determined according to the actual conditions.

(c) Snow load

The snow load is determined by the method of calculation, below. Snow accumulation varies greatly from region to region in Japan because of the various meteorological conditions. Therefore, the *Designated Administrative Agencies* issue regulations to specify values, based on criteria specified by MLIT.

$S = H \cdot R$

S: Snow Load (N/m^2)

H: Deepest snow fall in the region (cm), which is specified by regulation, issued by the *Designated Administrative Agency*

R: Unit snow load, which is 20 $N/m^2/cm$, or the value specified by regulation, issued by the *Designated Administrative Agency*

The snow load used in calculations, however, can be decreased by increasing the degree of the roof slope. It can also be decreased in regions where snow is customarily removed from roofs.

(d) Wind pressure

The wind pressure that acts on a building depends on the shape and the height of the building. It is calculated by the velocity pressure multiplied by the wind force coefficient. The velocity pressure is generally calculated by the following formula:

$q = 0.6\ E\ Vo^2$

- q: Velocity pressure (N/m^2)
- E: Coefficient calculated using a method stipulated by the Minister, reflecting the roof height of the building and its surrounding environment
- Vo: Standard wind velocity (m/s), as determined by the Minister

Wind force coefficients that are available for general cases are specified in the *MLIT Notification*.

(e) Seismic force

The seismic force is determined by calculating the inertial force that is generated through the movement of both the ground and the building. That is, horizontal force (seismic shear force) generated in the building. It is calculated by Formula A and Formula B below, incorporating the vibration characteristics of the building, the conditions of the ground, and other conditions.

Formula A: For seismic Force above the ground level

Qi=Wi•Ci

Ci=Z•Rt•Ai•Co

Qi: the seismic shear force of point “i” (the height from ground level)

Ci: the seismic shear coefficient of point “i”

Wi: permanent load added to imposed load above point “i” (+ snow load, in heavy snow areas, as designated by the *Designated Administrative Agency*)

Z: the seismic zone factor (from 0.7 to 1.0)

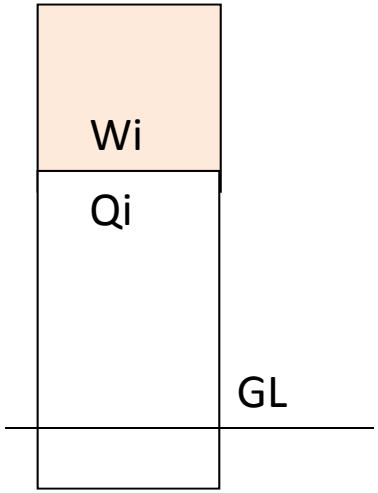
Rt: vibration characteristic factor

Ai: vertical distribution factor

Co: the standard shear coefficient

(a) In general cases, not less than 0.2 (not less than 0.3 within areas designated as soft ground areas)

(b) For calculating *required horizontal load-carrying capacity*, not less than 1.0



Formula B: For seismic force of the below-ground portion

Qb=Wb•k

Qb: the seismic shear force

k: the seismic coefficient

$k \geq 0.1\ (1-H/40)\ z$

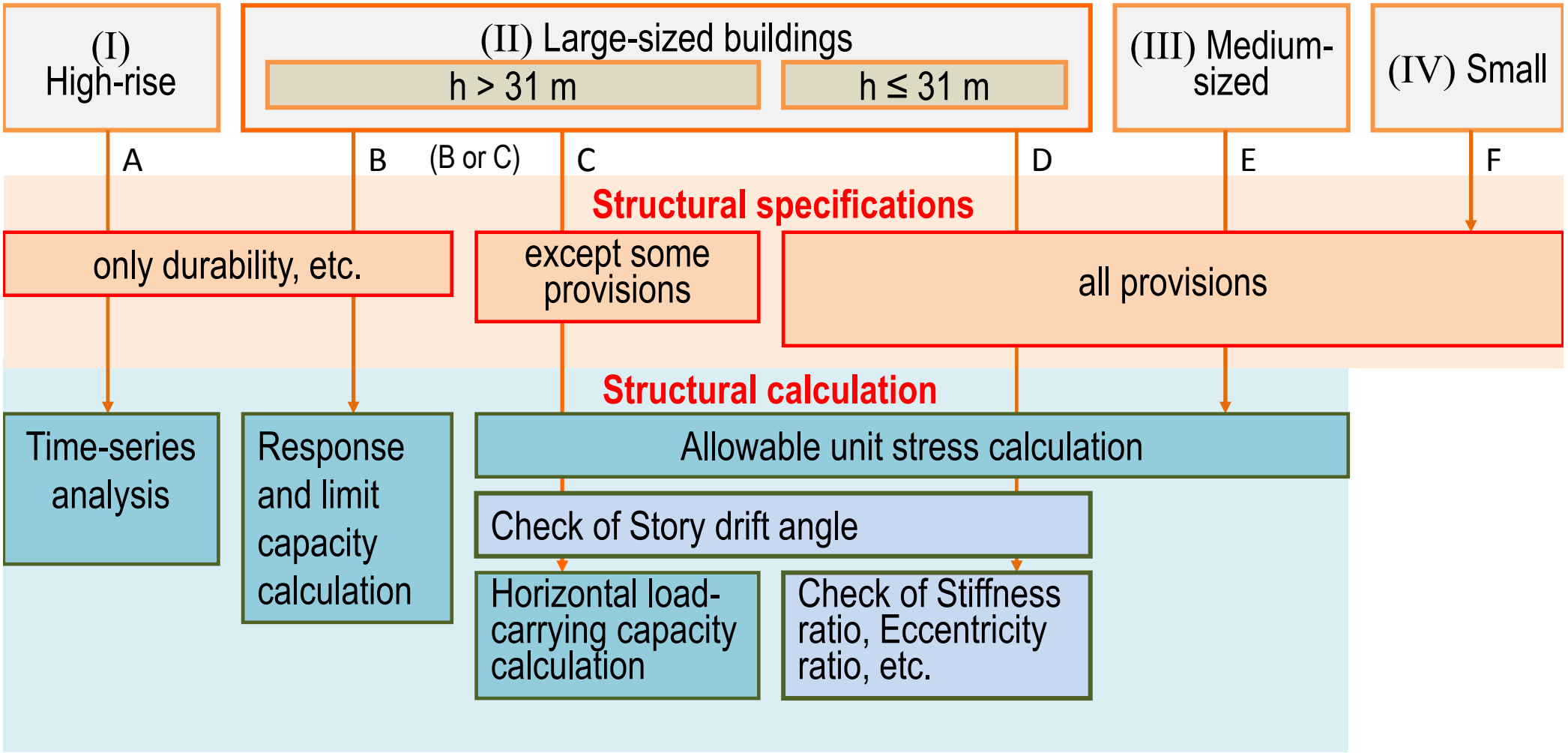
H = the depth of the portion below ground level (m) ($H \leq 20$)

z = the seismic zone factor (from 0.7 to 1.0)

Wb: permanent load added to imposed load above the portion

(4) Structural calculation methods other than Allowable unit stress calculation

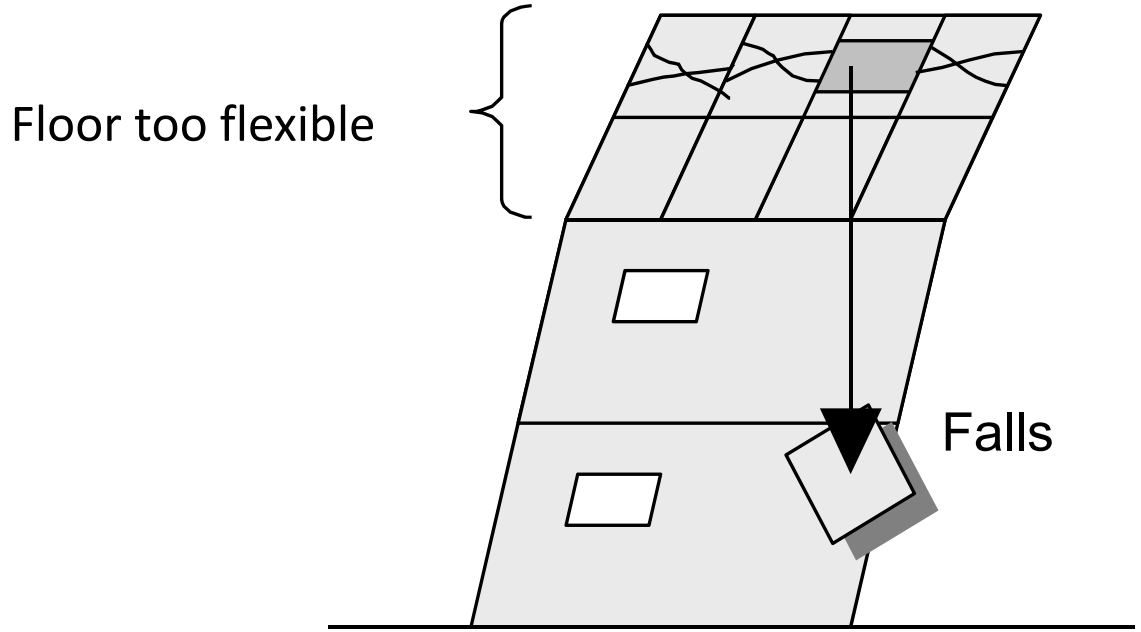
High-rise buildings and large-sized buildings must be confirmed to be structurally safe through structural calculation methods shown in this part.



The order of sophistication of the combinations is from A (the highest), down to F. It is allowed to use more sophisticated combinations than the required combination.

(a) Story drift angle

This is to check that, during a mid-sized earthquake, **the horizontal deformation in each floor** (cross-section) is within the scope wherein no external components become detached and fall from the building (in principle, within 1/200, or 1/120 in cases where there is no fear of significant damage).

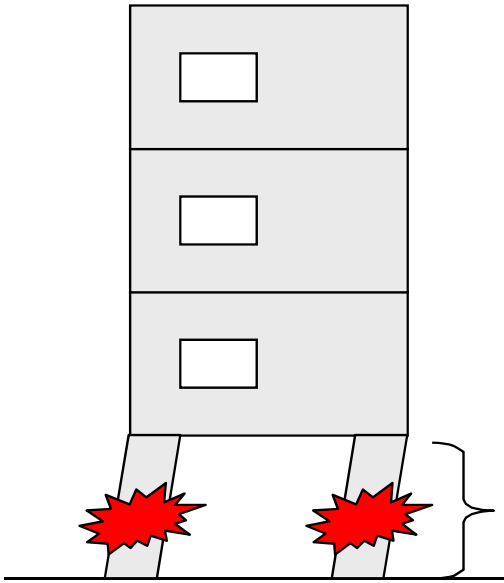


(b) Stiffness ratio and Eccentricity ratio

Stiffness ratio
Indicator of balance of hardness on each floor of building

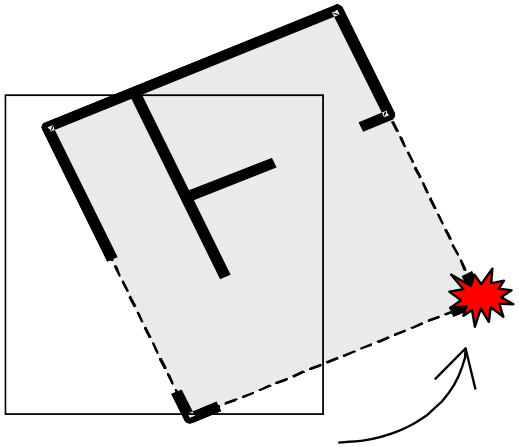
Eccentricity ratio
Indicator of balance of horizontal hardness on each floor

《Vertical diagram》



Damage concentrated on weaker floors

《Horizontal diagram》



Deformation concentrated on specific pillar due to shift in position

These calculations allow confirmation that the building's balance is within the scope that will not result in significant structural weakness

(c) Horizontal load-carrying capacity calculation

$$Q_u \geq Q_{un} \qquad Q_{un} = D_s \cdot F_{es} \cdot Q_{ud}$$

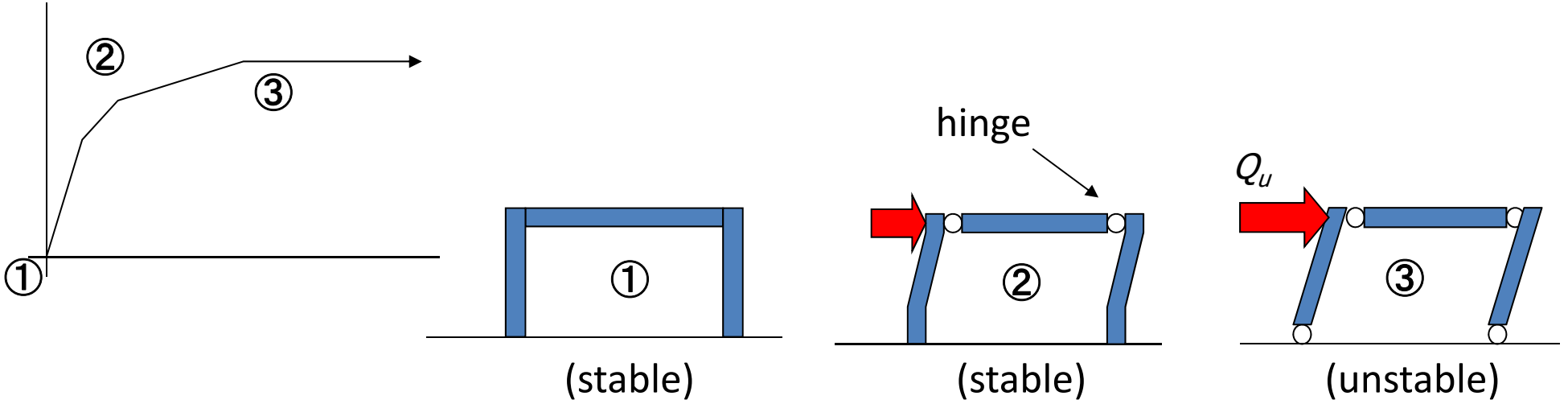
Q_u : Horizontal load-carrying capacity of each story (unit: kilo-Newtons)

Q_{un} : **Required value** of horizontal load-carrying capacity of each story (unit: kilo-Newtons)

Ds: **Structural characteristics factor**, considering damping characteristics and ductility of each story

Fes: **Shape factor**, representing stiffness ratio and eccentricity ratio (up to 3.0 for irregular structure).

Qud: **Horizontal force** acting upon each story due to seismic force ($C_0 \geq 1.0$) (unit: kilo-Newtons)



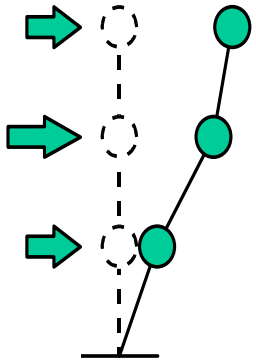
(d) Time-series analysis

(i) To continuously clarify forces and deformation in each part of a building under loads and external forces, such as ground vibration caused by a large-scale earthquake, through the computer simulations.

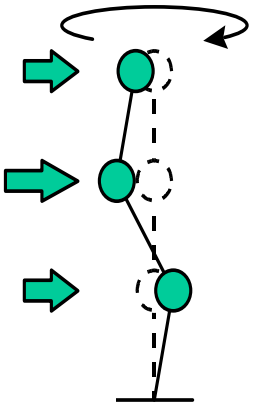
(ii) To confirm that forces and deformation clarified in (i) do not exceed the structural strength and deformation limit of each part of the building.

(iii) To confirm that roofing materials, exterior finishing materials, and curtain walls facing the exterior are safe from the perspective of structural capacity due to wind pressure, earthquake, and other vibration and impacts.

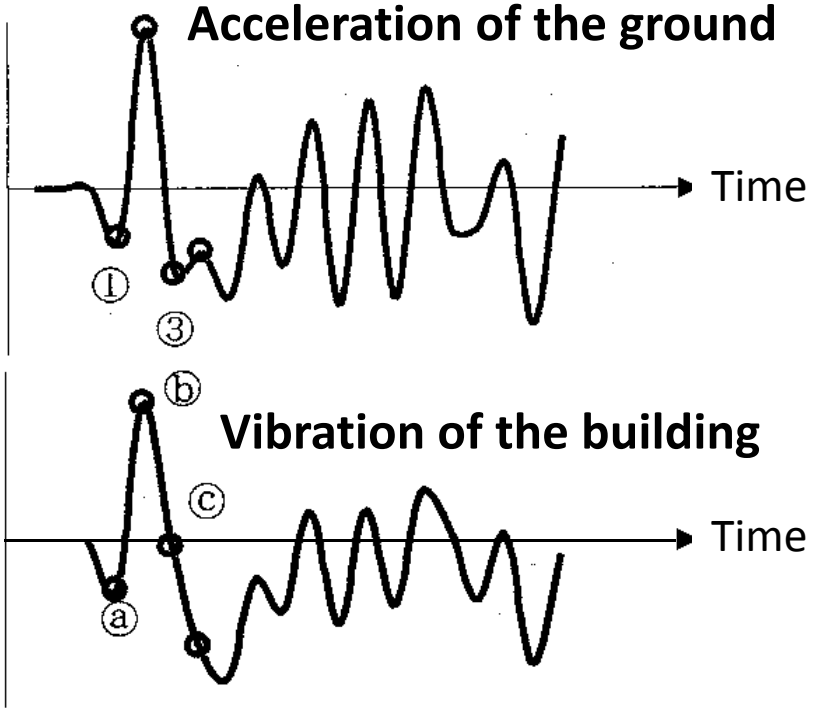
(iv) Others



Ordinary analysis
Direction of deformation is always the same as that of external force .



Time-series analysis
Direction of deformation is not always the same as that of external force.



Chapter 11 Fire Safety

11-1 Composition of the fire codes

The BSL and the Fire Service Law provide various technical requirements to secure fire safety in buildings. The examples of technical requirements provided by each of the BSL and the Fire Service Law are shown in the next page responding to the viewpoints of fire safety measures.

Technical requirements provided by the BSL and the Fire Service Law

Fire safety measures	**Examples of technical requirements**	
	The BSL (Regulates the basic structure and facilities of buildings)	**The Fire Service Law** (Regulates facilities and equipment from a fire safety viewpoint)
Prevention of the spread of fire from adjacent buildings	- Fire-resistance of roofing materials - Fire-resistance of external walls	
Prevention of outbreak of fire	- Fire-resistance of interior finishing materials	- Flame retardant curtains - Restrictions on appliances that operate with a flame
Fire detection		- Fire alarms
Evacuation	- Evacuation facilities, such as escape stairs - Smoke control systems	- Escape facilities, such as escape ladders
Fire extinguishment and rescue	- Emergency elevators - Rescue access	- Fire extinguishing equipment, such as automatic sprinkler systems and standpipe systems
Prevention of spread of fire within a building	- Fire compartments	
Prevention of structural collapse	- Fire-resistance of principal building parts	

11-2 Definitions

Definitions related to fire safety in the BSL are as below.

(1) *Noncombustible materials* (hereafter referred to as **NC**);
(2) *Quasi- noncombustible materials* (hereafter referred to as **Q-NC**); and
(3) *Fire retardant materials* (hereafter referred to as **FR**);
are building materials that conform to requirement (*1) during the time range shown in the next page, and that are either stipulated in the MLIT Notifications or that have been approved by the Minister on an individual basis.

(*1) Requirement for NC, Q-NC, and FR

When being heated with the heat of a normal fire, the material must satisfy the essential conditions in the following items (for those used as external finishing of the building, (a) and (b)) for the time as shown in **Table 12** after the beginning of the heating:

(a) It must not cause burning.
(b) It must not cause deformation, melting, cracking, or other damage detrimental to fire prevention.
(c) It must not generate smoke or gas that is detrimental to evacuation.

NC, Q-NC, and FR

Material	Duration after heat is applied	Examples of materials deemed to satisfy the requirements for NC, Q-NC or FR
(1) **NC**	20 minutes or more	- Concrete, Mortar, and Lime plaster; - Bricks; - Pottery tile and Ceramic tile; - Steel and Aluminum; - Glass; and - Gypsum board with a thickness of 12 mm or more, and with a paper covering of a thickness of 0.6 mm or less
(2) **Q-NC**	10 minutes or more	- NC; - Gypsum board with a thickness of 9 mm or more, and with a paper covering of a thickness of 0.6 mm or less; and - Wood wool cement board with thickness of 15 mm or more
(3) **FR**	5 minutes or more	- NC and Q-NC; and - Gypsum board with a thickness of 7 mm or more, and with a paper covering of a thickness of 0.5 mm or less

NC: *Noncombustible materials*
Q-NC: *Quasi- noncombustible materials*
FR: *Fire retardant materials*

(4) *Parts liable to catch fire* are parts of a building within a distance of 3 m for the first floor, or 5 m for the second or higher floors, from any of the following:

(a) the boundary line with the adjacent land lot;

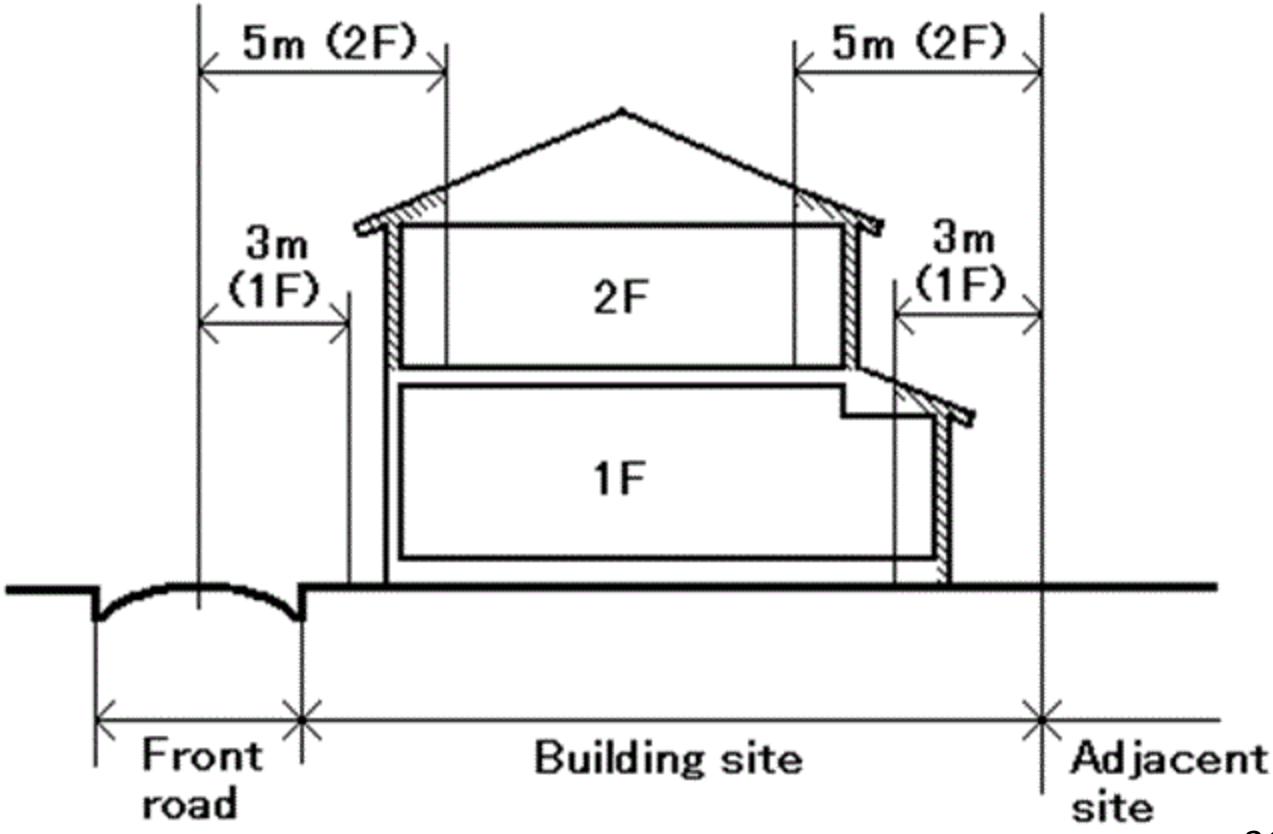
(b) the center line of the road;

(c) the center line between exterior walls of two or more buildings on the same site (two or more buildings with an aggregate total floor area not exceeding 500 m^2 are regarded as one building).

(see the figure on the right)

However, any part facing an open space or a water area that is effective for fire safety, such as a park, public square, river, or facing walls of fire-resistive construction, or the like, are not considered *parts liable to catch fire*.

Parts liable to catch fire



(5) ***Fire-resistive buildings*** are defined as buildings:

(a) of which ***principal building parts*** (namely, those walls, posts, beams, roofs, and stairways that are important from the viewpoint of fire prevention):

(i) come under *fire-resistive construction* (see **(6)**); or

(ii) are constructed using a solution that has been confirmed to be capable of withstanding fire and heat until the end of a fire through:

- *Fire-resistance Verification Method* (see **4-2 (3)**); or
- Approval from the Minister; and

(b) of which openings in *parts liable to catch fire* are equipped with certain *fire-preventive assemblies*.

(6) ***Fire- resistive construction*** is defined as a building part, such as walls, columns, beams and floors, which conforms to technical criteria of ***fire-resistive performance*** **(*1),** and:

(a) Which uses **construction methods established by the Minister (*2);** or

(b) Which is **approved by the Minister (*3)**.

(*1) ***Fire-resistive performance***

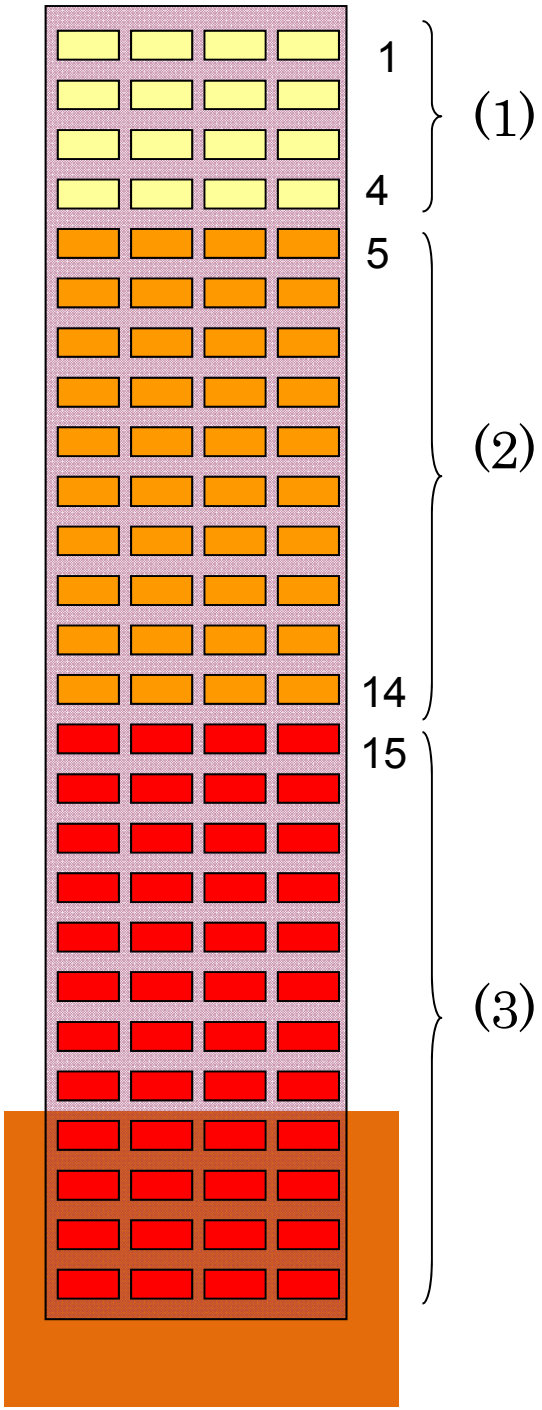
Technical criteria *of fire-resistive performance* are shown in the table of the next page (with some other requirements). Building parts of fire-resistive construction must not be deformed, melted, cracked, or undergo any other damage detrimental to structural resistance during the times as listed in the table after the heating begins, when they are heated with heat produced by a normal fire.

(*2) Construction methods established by the Minister

Common construction methods of building parts of *fire-resistive construction* have been specified by the Minister. They are deemed to have *fire-resistive performance* during the times as listed in the table. Their examples of reinforced concrete structure are shown in the table of the page after the next.

(*3) Approval by the Minister

Other than the common construction methods, construction methods of building parts, which the Minister approved that they have *fire-resistive performance,* may be used as *fire-resistive construction.*

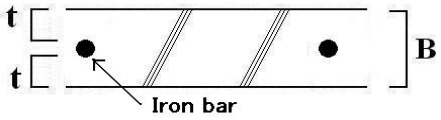
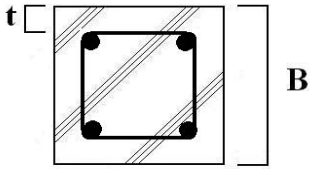
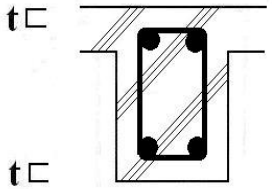
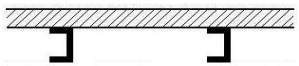
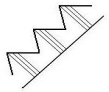


Technical criteria of *Fire-resistive performance* required on the building parts of *fire resistive construction*

Parts \ Story	(1) Uppermost story and second to fourth stories from the uppermost story	(2) Fifth to fourteenth stories from the uppermost story	(3) Fifteenth story or more from the uppermost story
Load bearing walls	1 hour	2 hours	2 hours
Columns	1 hour	2 hours	3 hours
Floors	1 hour	2 hours	2 hours
Beams	1 hour	2 hours	3 hours
Roofs	0.5 hour		
Stairs	0.5 hour		

Example of building parts of *fire-resistive construction* (in case of reinforced concrete structure)

In case of steel structure, fire-preventive covering is required.

	Required times (*)	Required conditions, such as depth of concrete cover above steel bars	
Load bearing walls	60		B≧ 70 mm, t≧30 mm
	120		B≧100 mm, t≧30 mm
Columns	60		t≧30 mm
	120		B≧250 mm, t≧30 mm
	180		B≧400 mm, t≧30 mm
Floors	60		B≧ 70 mm, t≧20 mm
	120		B≧100 mm, t≧20 mm
Beams	60		t≧30 mm
	120		t≧30 mm
	180		t≧30 mm
Roofs	30	 RC structure 	Roof covered with concrete finish
Stairs	30	 RC structure  Steel structure	

(*) Minutes, which are required on each building part (See the preceding page.)

(7) ***Quasi fire-resistive buildings*** are defined as buildings:

(a) of which construction method meets any of following:

(i) Principal building parts come under *quasi fire-resistive construction*

Type of quasi fire-resistive construction (see **Figure of Type A**)

Type of 1-hour quasi fire-resistive construction

(ii) Buildings are constructed using a construction method specified in the *MLIT Notification.*

Type of fire-resistive external walls (see **Figure of Type B-1**)

Type of NC (Noncombustible materials) (see **Figure of Type B-2**)

(iii) Buildings are constructed through a solution approved by the Minister.

Type of Ministerial approval

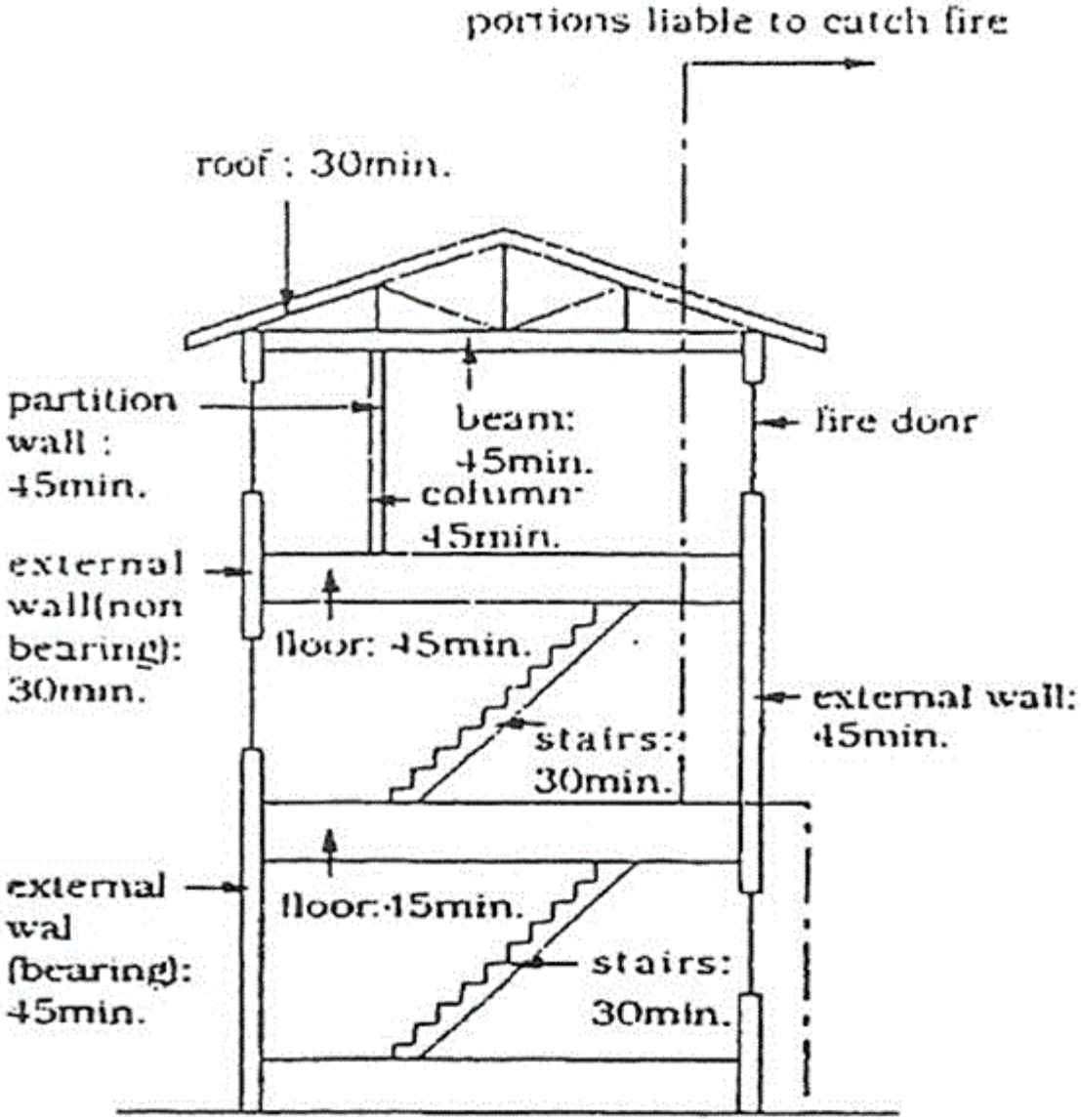
and

(b) of which openings in *parts liable to catch fire* are equipped with certain *fire-preventive assemblies*.

Remark: The definition of *quasi fire-resistive buildings* does not include *fire-resistive buildings*.

Quasi fire-resistive building

Type of quasi fire-resistive construction (Type A)



Remarks:

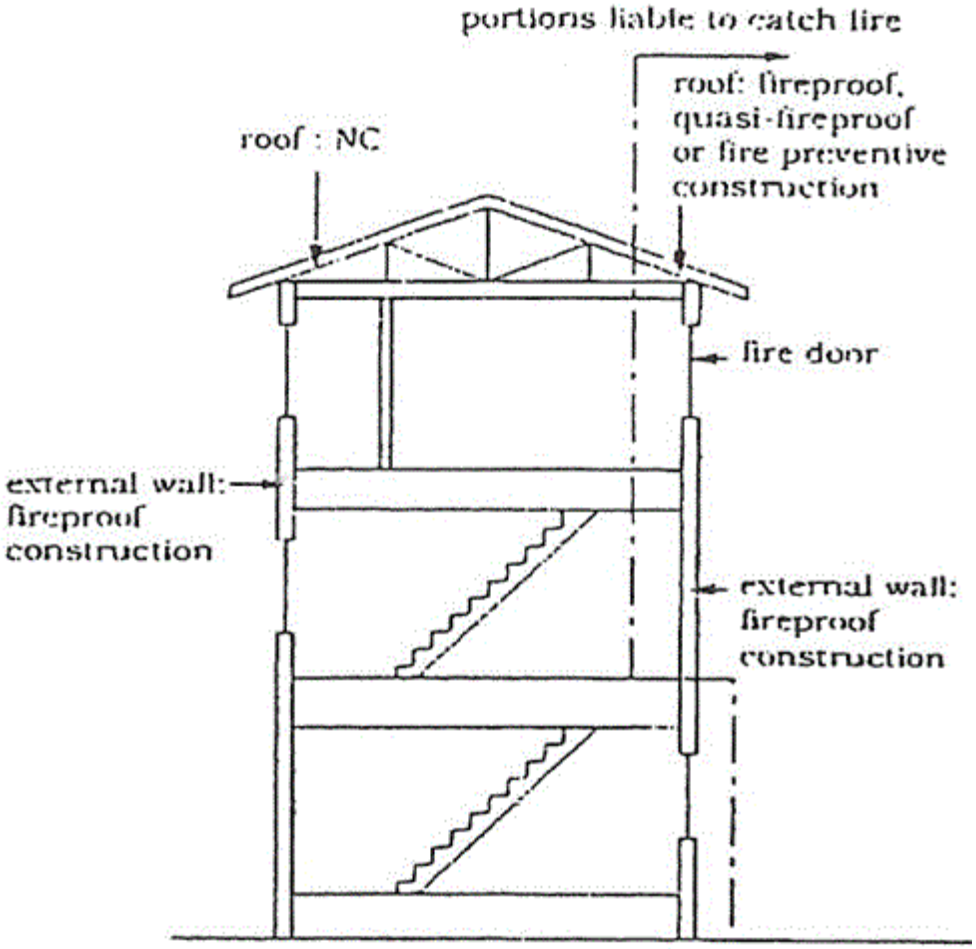
(1) NC: *Noncombustible material*

(2) Q-NC: *Quasi-noncombustible material*

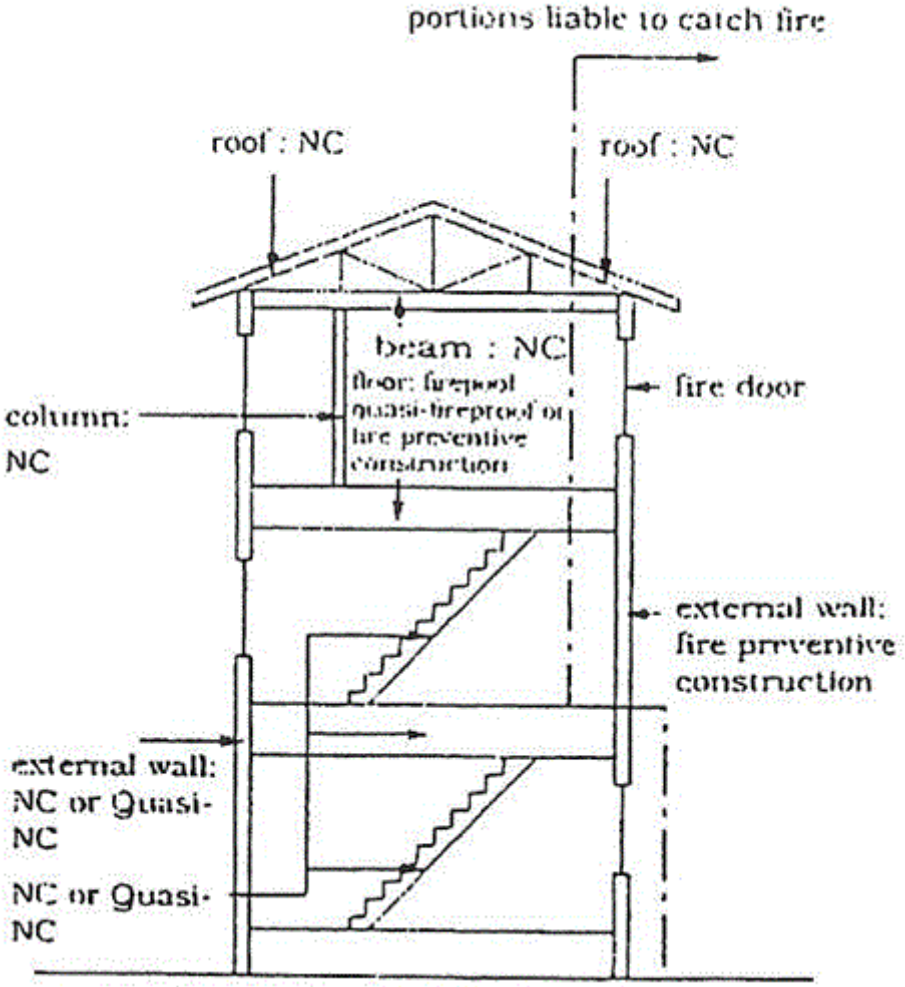
(3) Time shown in the figures indicates the duration of time for which components of quasi fire-resistive buildings must be able to withstand fire.

Quasi fire-resistive building

Type of fire-resistive external walls (Type B-1)

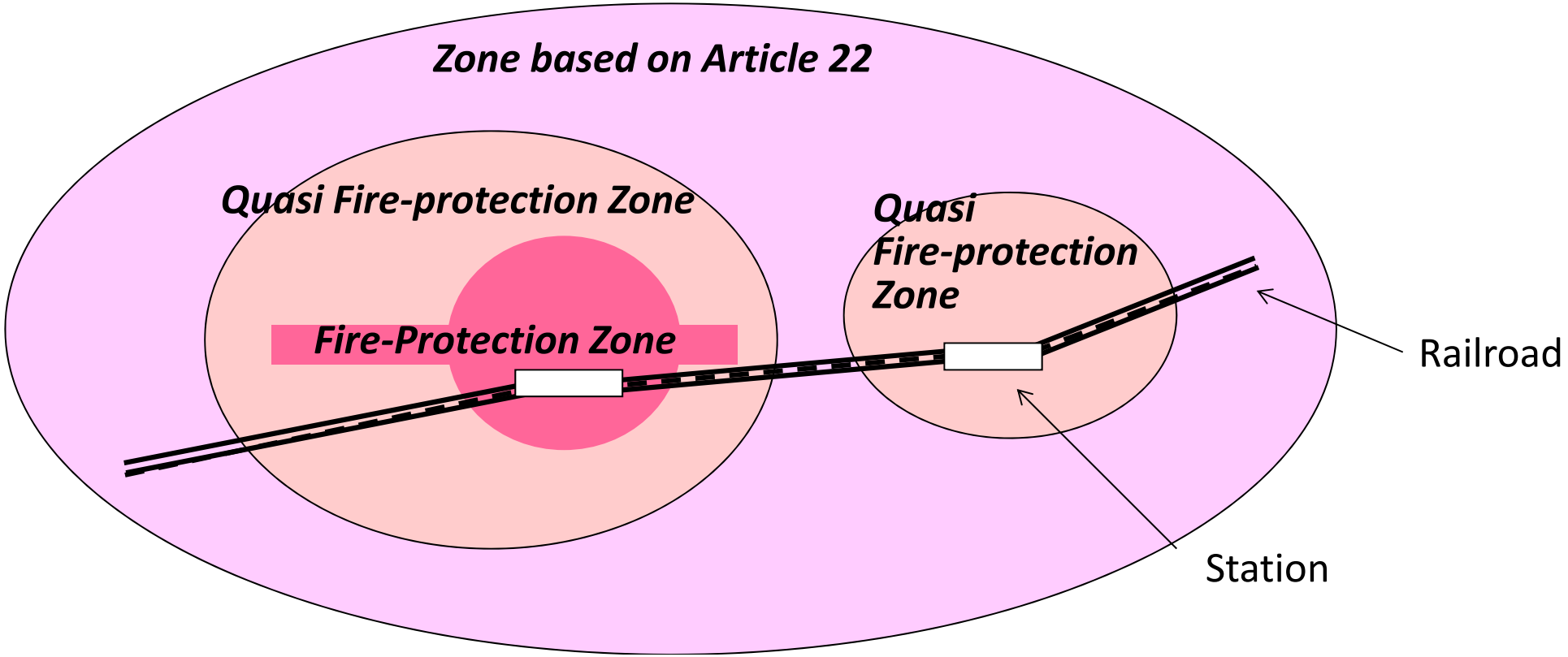


Type of NC (Noncombustible materials) (Type B-2)



(8) *Fire-protection Zone* and *Quasi Fire-protection Zone* are zoning systems provided by the City Planning Law. These zones are designated in urban areas in order to prevent the spread of fire from building to building. In the major cities of Japan, these zones are designated over a large area. Extensive measures for fire safety are required in the designated zones by the BSL.

(9) *Zone based on Article 22* are the urban areas designated by the *Designated Administrative Agencies*, based of Article 22 of the BSL for the purpose of prevention of the spread of fire in urban areas.



11-3 Fire resistance

In order to:

- secure the time for evacuation,
- prevent collapse, and
- prevent catching fire,

fire resistance is required on buildings from three characteristics of buildings as follows:

(1) Scale of the buildings;

(2) Use of the buildings; and

(3) Location of the buildings.

(1) Restrictions on Large-scale *Buildings*

In case of buildings,

(i) which are more than 13 m in building height, more than 9 m in eave height, or more than 3000 m2 in total floor area, and

(ii) of which bearing walls, posts, or beams are made of combustible materials, such as wood and plastic,

their safety of fire resistance must be confirmed by:

(i) using materials that the Minister approved as *fire-resistive construction*; or

(ii) using solution that has been confirmed to be capable of withstanding fire and heat until the end of a fire through:

- *Fire-resistance Verification Method* (see **4-2 (3)**); or
- Approval by the Minister.

Some construction methods, of which structural members are wood covered by gypsum boards, have been approved by the Minister as *fire-resistive construction,* which is considered to be able to undergo the fire for one hour.

(2) Restrictions on Construction of *Special Buildings*

Special buildings are defined as, but not limited to:

(a) buildings that are intended to be used by many and unspecified people, such as theaters, grandstands and department stores; and

(b) as buildings where many people sleep, such as apartment houses, hotels and hospitals.

It is prescribed that certain sizes of these *special buildings* must be *fire-resistive buildings*, and other certain sizes of these *special buildings* must be either *fire-resistive buildings* or *quasi fire-resistive buildings*. (see the following four pages)

Fire Resistance of Special Buildings (1/3)

Use \ Grade of building required		*Fire-resistive building* (in case of (1) or (2))		*Fire-resistive building or Quasi fire-resistive building*
		(1)	(2)	
1	-Theaters - Movie theaters - Entertainment halls	The main floor is not on the 1st floor	Seating space is 200 m^2 or more. (In case of open-air stand, 1,000 m^2)	-
	-Grandstands -Public halls - Assembly halls	Third or higher floors is used for any of these uses.		
2	-Hospitals -Clinics (limited to those having patient accommodation facilities) -Hotels/inns -Boarding houses -Apartment houses -Dormitories - *Welfare facilities*(*1)	The third floor or higher is used for any of these uses. (*2)	-	Floor area for the use on the 2nd floor is 300 m^2 or more. (For hospitals, this only applies to buildings which have patient accommodation facilities on the 2nd floor.)

Fire Resistance of *Special Buildings* (2/3)

Use		Grade of building required: *Fire-resistive building* (in case of (1) or (2)) (1)	*Fire-resistive building* (in case of (1) or (2)) (2)	*Fire-resistive building or Quasi fire-resistive building*
3	- Schools - Gymnasia - Museums, Art museums - Libraries - Bowling alleys, Indoor ski slopes, Skating rinks, Swimming pools, Sports practice facilities	The third floor or higher is used for any of these uses.	-	The total floor areas for the use is 2,000 m^2 or more.
4	- Department stores, Markets - Exhibition halls - Cabarets, Cafes, Night clubs, Bars, Dance halls, Amusement halls - Public bathhouses - *Machiai*, Restaurants, Dining facilities, - Stores engaged in commodity sales (excluding those with a floor area of 10 m^2 or less)	The third floor or higher is used for any of these uses.	The total floor areas for the use is 3,000 m^2 or more.	The floor area for the use on the 2nd floor is 500 m^2 or more.

Fire Resistance of *Special Buildings* (3/3)

Use \ Grade of building required		*Fire-resistive building* (in case of (1) or (2))		*Fire-resistive building or Quasi fire-resistive building*
		(1)	(2)	
5	- Warehouses	-	Total floor areas for the use on the 3rd floor or higher is 200 m^2 or more.	Total floor areas for the use is 1,500 m^2 or more.
6	-Automobile garages -Automobile repair shops -Movie studio - Television studio	The third floor or higher is used for any of these uses.	-	Total floor areas for the use is 150 m^2 or more.
7	- Storage or treatment facilities for hazardous materials of more than a specified value	-	-	All cases

(*1) Welfare facilities include:

- childrens' welfare facilities;
- maternity clinics;
- rehabilitation facilities for physically disabled persons (excluding prosthetic appliances manufacturing facilities and information centers for the visually/hearing impaired);
- social rehabilitation facilities for mentally disordered persons;
- protective institutions (excluding medical protective institutions);
- protective facilities for women;
- facilities for people with intellectual disabilities;
- welfare facilities for the elderly;
- fee charging homes for the elderly; and
- maternal and child health facilities.

(* 2) Three-story apartment houses can be of *quasi fire-resistive construction* when all of the following conditions exist:

- the area is not in a Fire Protection Zone;
- the structure has 1-hour or more *quasi fire-resistive performance*; and
- all other necessary measures are implemented from the viewpoint of fire prevention.

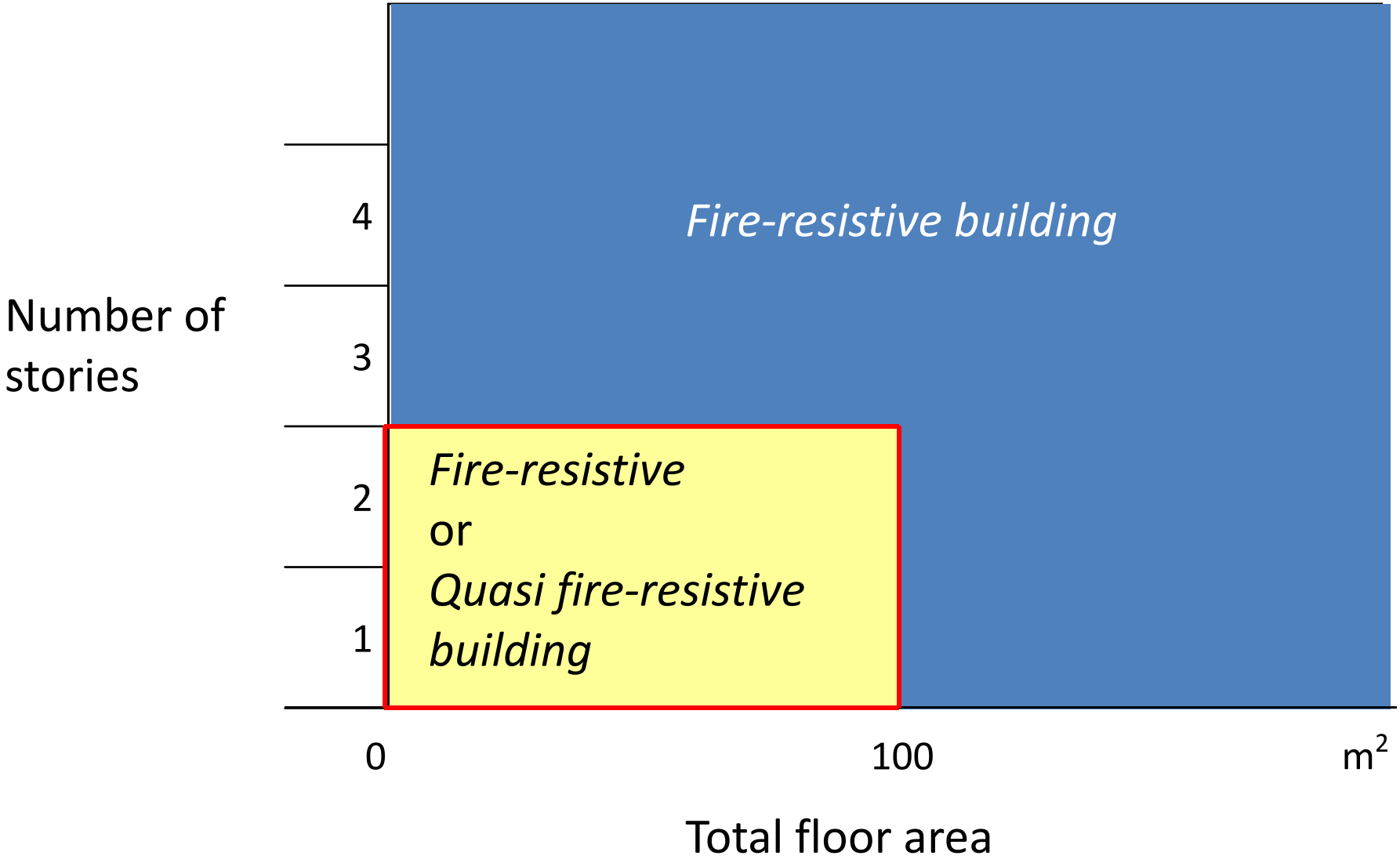
(3) Restrictions on buildings in *Fire-protection Zones* and *Quasi Fire-protection Zones*

Buildings in *Fire-protection Zones* or *Quasi Fire-protection Zones* must follow the requirements as shown in the following two pages.

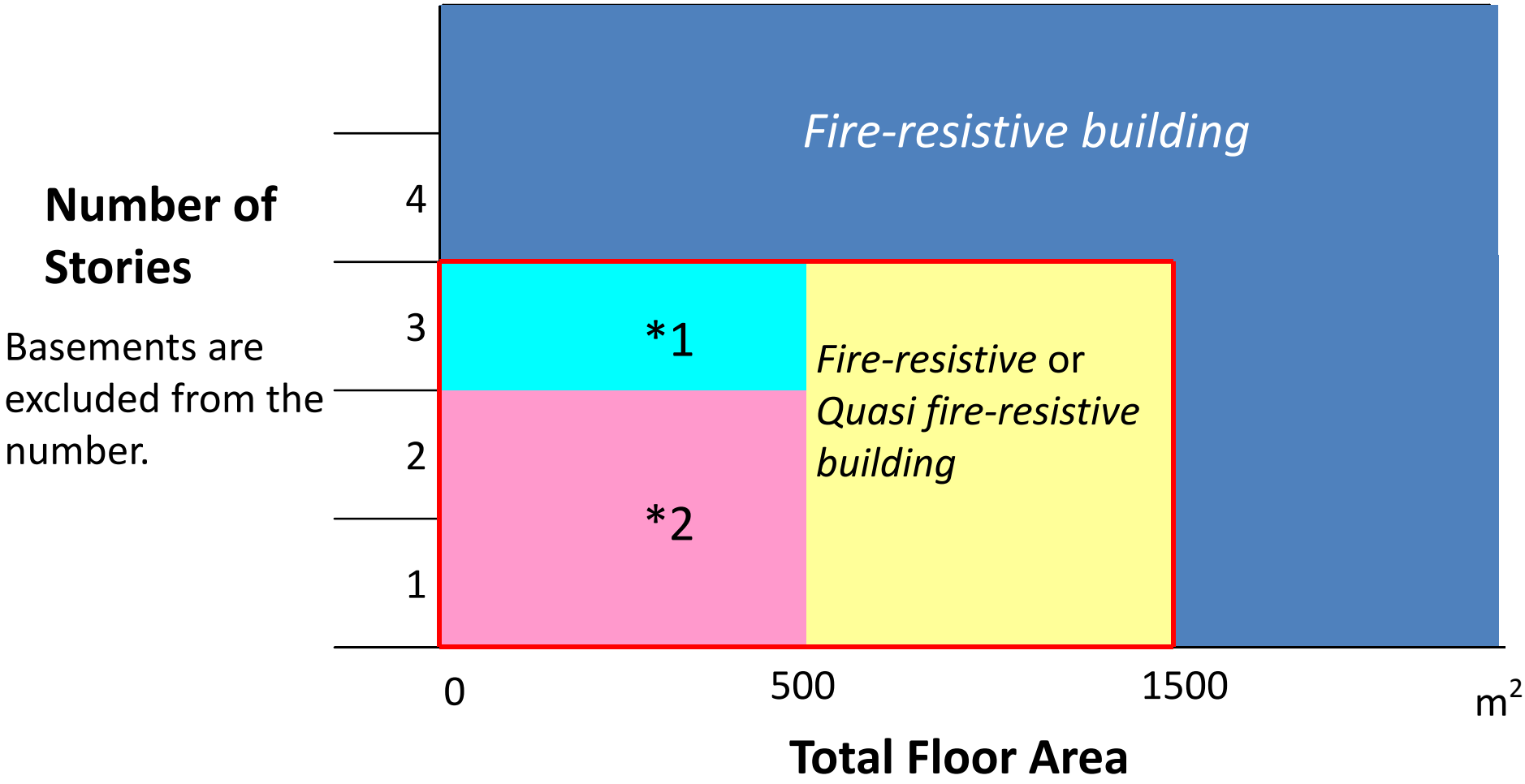
<Exceptions> Small annexed buildings, etc. are exceptions.

If buildings are located in either *Fire-protection Zones* or *Quasi Fire-protection Zones*, openings located in *parts liable to catch fire* must be fitted with certain *fire-preventive assemblies*.

Restriction on Buildings in *Fire-protection Zone*



Restriction on buildings in *Quasi Fire-protection Zone*



*1:*Fire-resistive building*, *Quasi fire-resistive building*, building stipulated in Article 136-2 of the BSL Enforcement Order

*2:*Fire preventive construction* for the external walls and soffits liable to catch the fire of wooden buildings

11-4 Fire compartment

Fire-resistive buildings, etc. must be separated into fire compartments with, but not limited to:

(a) floors or walls of *fire-resistive construction*, etc.; and

(b) fire doors.

These fire compartments have the following categories.

(1) Area separations

Area separations are arranged to prevent the horizontal spread of fire within a building. They have walls and floors of *fire-resistive construction*, fire doors, and so on. (see the following three pages)

In addition, wooden buildings with a floor area of more than 1,000 m^2 must be effectively divided with fire walls into areas of no more than 1,000 m^2, unless they are *fire-resistive buildings* or *quasi fire-resistive buildings*.

<table>
<tr><th colspan="3">Buildings/parts of buildings</th><th>a. Maximum allowable floor area of each fire compartment
b. Methods of separation</th></tr>
<tr><td colspan="3">Buildings whose principal building parts are of fire-resistive construction</td><td rowspan="2">a. 1,500 m^2 (*1)
b. Floors and walls: 1-hour quasi fire-resistive construction
Openings: Specified fire-preventive assembly (*2)</td></tr>
<tr><td rowspan="3">Quasi fire-resistive buildings</td><td colspan="2">Voluntary Quasi sire-resistive buildings</td></tr>
<tr><td rowspan="2">Obligated Quasi fire-resistive buildings</td><td>- Type of 1-hour quasi fire-resistive construction
- Type of NC</td><td>a. 1,000 m^2 (*1)
b. Ditto (*2)</td></tr>
<tr><td>- Type of quasi fire-resistive construction
- Type of fire-resistive external walls</td><td>a. 500 m^2 (*1)
b. Floors and walls: 1-hour quasi fire-resistive construction
Openings: Specified fire-preventive assembly
Partition walls: Partition walls in the key locations are of quasi fire-resistive construction. (*3)</td></tr>
</table>

Remark: Each type of Quasi fire-resistive buildings are explained in 6-2.

Relaxation (*1):

- In cases where automatic fire extinguishing equipment (such as sprinklers) is provided, the maximum allowable floor area of each fire compartment can be doubled.

Exceptions (*2):

- Seating space in theaters, movie theaters, entertainment halls, grandstands, public halls, assembly halls, and space for gymnasia, factories, etc.
- Staircases, hoistways (elevator shafts) including passenger lobbies partitioned to constitute fire compartments.

Exceptions (*3):

- Space for gymnasia, factories, etc. with NC or Q-NC for interior finishes.
- Staircases or hoistways (elevator shafts) including passenger lobbies with NC or Q-NC for interior finishes partitioned to constitute fire compartments.

Area Separations for high-rise buildings

Buildings/parts of buildings		a. Maximum allowable floor area of each fire compartment (*1) b. Methods of separation
11th floor, or higher	Interior finish and base lined with NC	a. 500 m^2 b. **Floors and walls**: *Fire-resistive construction* **Openings**: *Specified fire-preventive assembly* (*2)
	Interior finish and base lined with Q-NC	a. 200 m^2 b. Ditto (*2)
	Other than above	a. 100 m^2 b. **Floors and walls**: *Fire-resistive construction* **Openings**: *Fire-preventive assembly* (*2)

Relaxation (*1):

- In cases where automatic fire extinguishing equipment (such as sprinklers) is provided, the maximum allowable floor area of each fire compartment can be doubled.

Exceptions (*2):

- Staircases and hoistways (elevator shafts) including passenger lobbies, corridors or other evacuation spaces, or housing units in apartment houses not exceeding 200m^2, where these are partitioned to provide fire compartments.

(2) Shaft enclosures

Vertical spaces, such as staircases, hoistways (elevator shafts), pipe spaces, wellholes, etc. that pass through two stories or more, must be, in principle, separated from other spaces with:

(a) floors or walls of *quasi fire-resistive construction*; or

(b) *fire-preventive assemblies* as stipulated in Article 2 Item (9-2) (b) of the BSL.

(3) Mixed-use separations

In *special buildings* (see **6-3**) of complex uses, parts of different use categories must be separated from each other with:

(a) floors or walls of *1-hour quasi fire-resistive construction*; or

(b) *specified fire-preventive assemblies* defined in Article 112 paragraph 1 of the *Enforcement Order*.

11-5 External finishing

In order to prevent buildings from catching fire, restrictions are placed on external finishes for roofs, soffits, external walls, and openings.

(1) Fire prevention restrictions for roofs

For buildings which:

(a) have a total floor area in excess of 1000 m^2 ; or

(b) are located in certain areas (*Fire-protection Zones*, *Quasi Fire-protection Zones*, or *Zones based on Article 22*),

roofs must be made in such a way that they do not catch fire, melt, or undergo splitting, etc. from sparks caused by fires.

(2) Restrictions for external walls and soffits located in *parts liable to catch fire*

External walls and soffits of wooden buildings located in *parts liable to catch fire* must be of *fire-preventive* or *quasi fire-preventive construction*, for example, walls that are finished with mortar or laminated with gypsum board, in accordance with:

- the use of the building;
- the total floor area; and
- the zone in which it is located.

(see the next page)

Remarks:

If a building stands in two (or more) of the above zones, the stricter (or strictest) provisions of the restrictions in the zones are applied to the whole building.

Fire-preventive construction of *parts liable to catch fire* on the external walls and soffits of buildings, such as wooden buildings

Areas	Building type	Parts	Construction
In *Quasi Fire-protection Zones*	All buildings	External walls and soffits in *parts liable to catch fire*	*Fire-preventive construction*
in the *Areas based on Article 22 of the BSL*	1 Schools, theaters, movie theaters, entertainment halls, grandstands, public halls, assembly halls, markets, or public bathhouses 2 Automobile garages (only applied in cases where aggregate of floor areas for the said use exceeds 50 m^2) 3 Department stores, apartment houses, dormitories, hospitals, or warehouses (only applied in cases where the number of stories is two and the total floor area for the said use exceeds 200 m^2)	External walls and soffits in *parts liable to catch fire*	*Fire-preventive construction*
	4 Other uses	External walls in *parts liable to catch fire*	Structure satisfying *quasi fire-preventive performance*
All areas	Buildings whose total floor area (aggregate of total floor areas in case of 2 or more wooden buildings on the same site) is more than 1,000 m^2	External walls and soffits in *parts liable to catch fire*	*Fire-preventive construction*

11-6 Internal finishing

Finishing materials for ceilings and walls of the buildings are restricted in accordance with their:

- use;
- scale;
- construction types; and
- etc.

for the purpose of retarding the initial growth of fire, ensuring safe evacuation in the initial stage of fire, for instance, controlling the amount of smoke generated with the spread of fire, so as not to obstruct the way for evacuation.

The ceilings and walls of buildings subject to those restrictions must be finished, according to fire safety properties required of the part concerned, with:

- NC (noncombustible materials);
- Q-NC (quasi-noncombustible materials); or
- FR (fire retardant materials).

(see **Annex 3**)

11-7 Fire evacuation

Codes relating to the arrangement and the specification of evacuation measures such as:

- escape stairs;
- smoke exhaust equipment;
- lighting apparatus for emergency use;
- entrances for emergency use;
- elevatory equipment for emergency use;
- etc.

are provided in order to safely evacuate people to ground or to back up fire fighting and rescue.

Where evacuation safety has been verified using *Verification Method for Evacuation Safety*, etc., some Specific *Provisions* may not be applied to the building. (see **4-2(4)**)

(1) Through Stairs (Direct Stairs)

For prompt escape from upper floors or from the basement, *through stairs*, which connect directly to the evacuation floors that have exits to the ground, must be provided in such a way that the walking distance from any part of the rooms to the *through stairs* be within a certain distance.

Furthermore, large buildings or certain *special buildings* must have two or more *through stairs* for emergency, in case when one of them cannot be used. In this case, two or more stairs must be arranged as well as can be so that people can escape in different directions. (The overlap of the walking distances leading to the two or more *through stairs* must not be more than half of the length of the required walking distance.)

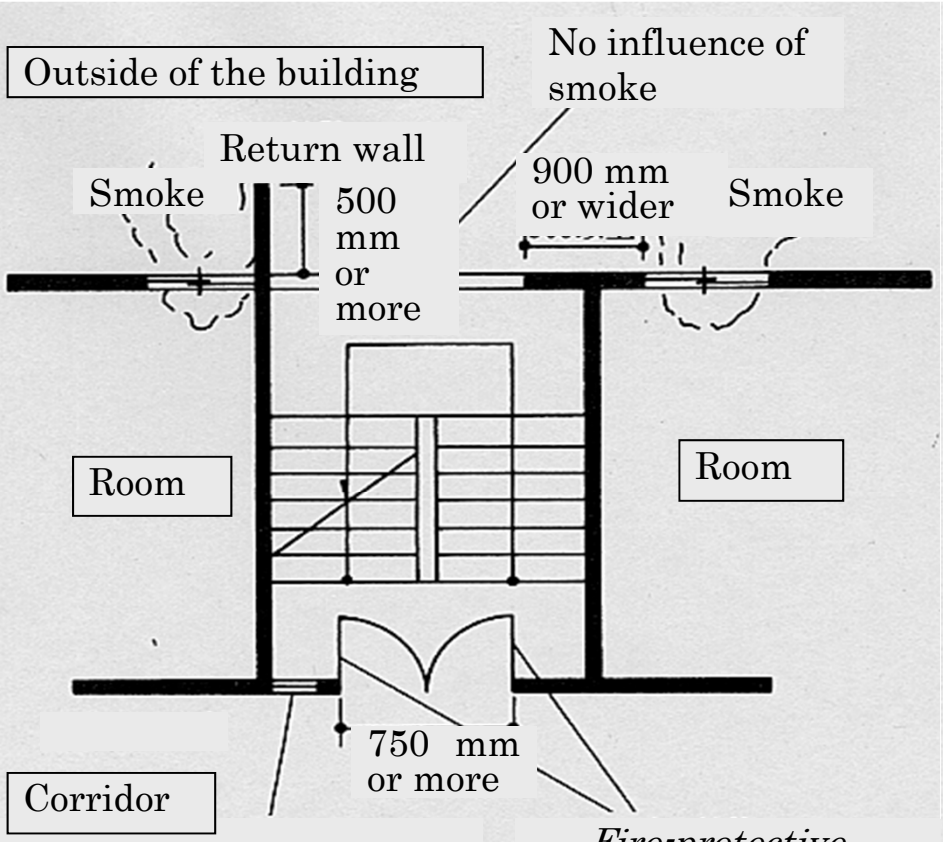
(2) *Escape Stairs* and *Special Escape Stairs*

In:

- high-rise buildings;
- buildings with basement floors; or
- buildings used by many people, such as department stores;

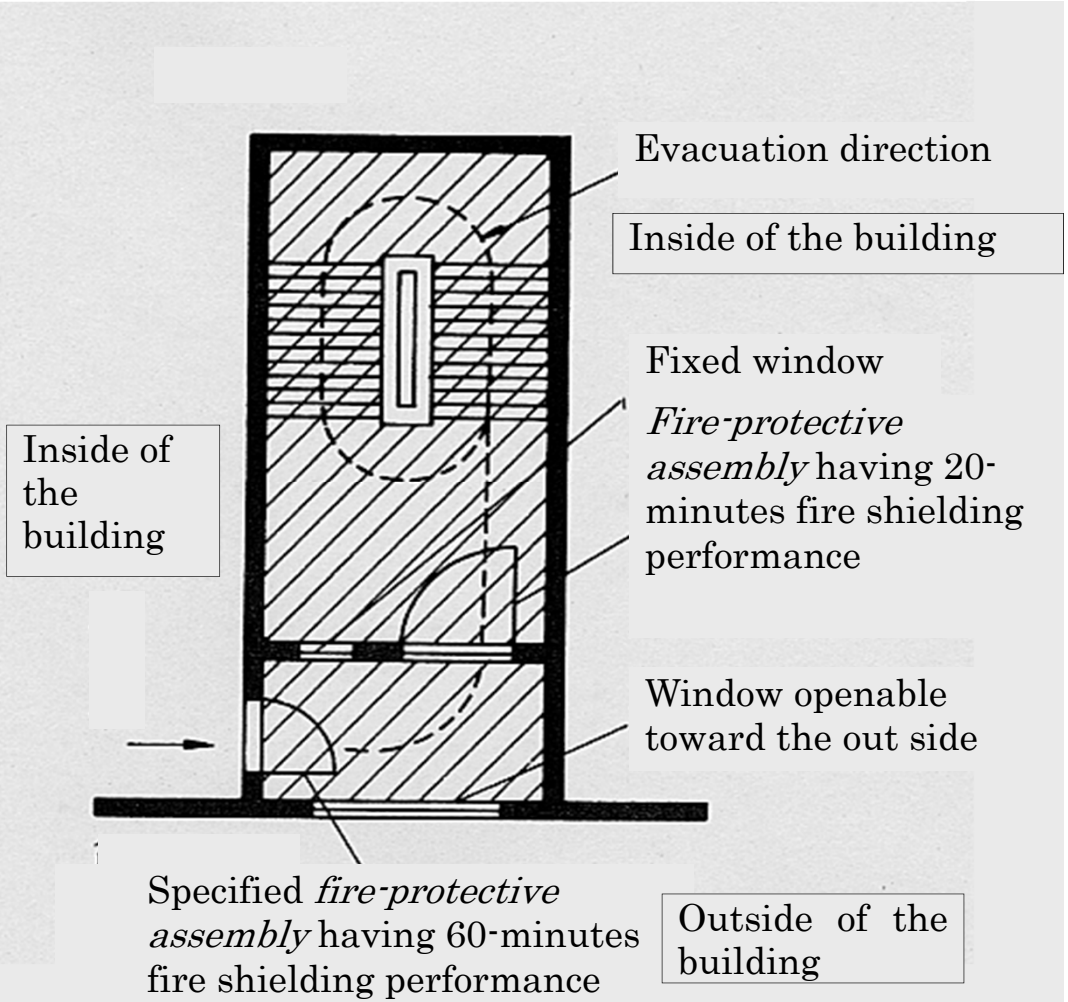
ordinary *through stairs* may not be enough to ensure safe evacuation. So, such buildings must have *escape stairs* or *special escape stairs* that have safer performance against fire and smoke than ordinary *through stairs*. (see the next page)

Escape Stairs (Example)



Window must be a *fire-protective assembly* having 20-minutes fire shielding performance, be fixed, and have an open area of less than 1 m^2.

Special Escape Stairs (Example)



(3) Exits on the Evacuation Floor

Regarding the evacuation floors, there is a limit to the walking distance both:

- from a room to the exits; and
- from *through stairs* to the exits.

(4) Passageways within a Building-site

A passageway within the building-site must be provided from an exit to an open space, such as a roadway, park or public square. This passageway must have a width of 1.5 m or more (3 m or more, in principle, in the case of large wooden buildings).

(5) Smoke Exhaust Equipment

Smoke exhaust equipment must be provided in *special buildings* and large buildings in order to effectively eliminate smoke and gas generated from combustible materials, thus ensuring a safe evacuation.

(6) Lighting Apparatus for Emergency Use

Lighting apparatus for emergency use must be provided according to the size of buildings, in order to ensure safe evacuation during a power failure.

(7) Elevatory Equipment for Emergency Use and Entrances for Emergency Use

Buildings with a height exceeding 31 m must, in principle, have elevatory equipment for emergency use for fire fighters. Also buildings must be provided with emergency entrances (elevator equipment, a balcony, or a window through which fire fighters can enter the building) on every floor, beginning with the third floor, up to 31 m in height, so that rescue work and fire fighting activities can be carried out smoothly.

Chapter 12 Accessibility

See Chapter 7 of Part C.

Chapter 13 Energy Conservation

Under construction

Chapter 14 Other Aspects for Building Safety and Amenity

14-1 Building sites

(1) Ground level

Ground level of a building site must be higher than the border of adjacent roads and adjacent land lots, in principle.

(2) Improvement of ground

Fills, an improvement of ground or other measures necessary for sanitation or safety must be taken if necessary.

(3) Drainage

Sites of buildings must have proper sewer pipelines, sewer channels, manholes and other facilities for the purpose of draining and disposing of rainwater and wastewater.

(4) Countermeasures against landslides

If buildings are likely to be damaged by landslides, etc., construction of retaining walls or other appropriate measures for safety must be taken.

14-2 Environmental sanitation

(1) Natural Lighting of Habitable Rooms

A habitable room is a space that is continuously used for living, working, meetings, amusement, and so on, and that includes a living room or bedroom in a house, an office room, a meeting room, a theater auditorium, a hall, etc.

Requirements for natural lighting are prescribed from the viewpoint of environmental sanitation. The following habitable rooms must, in principle, have windows and other openings for natural lighting, and the ratio of the effective area thereof to the floor area must be more than a specified ratio for, but not limited to, the following spaces:

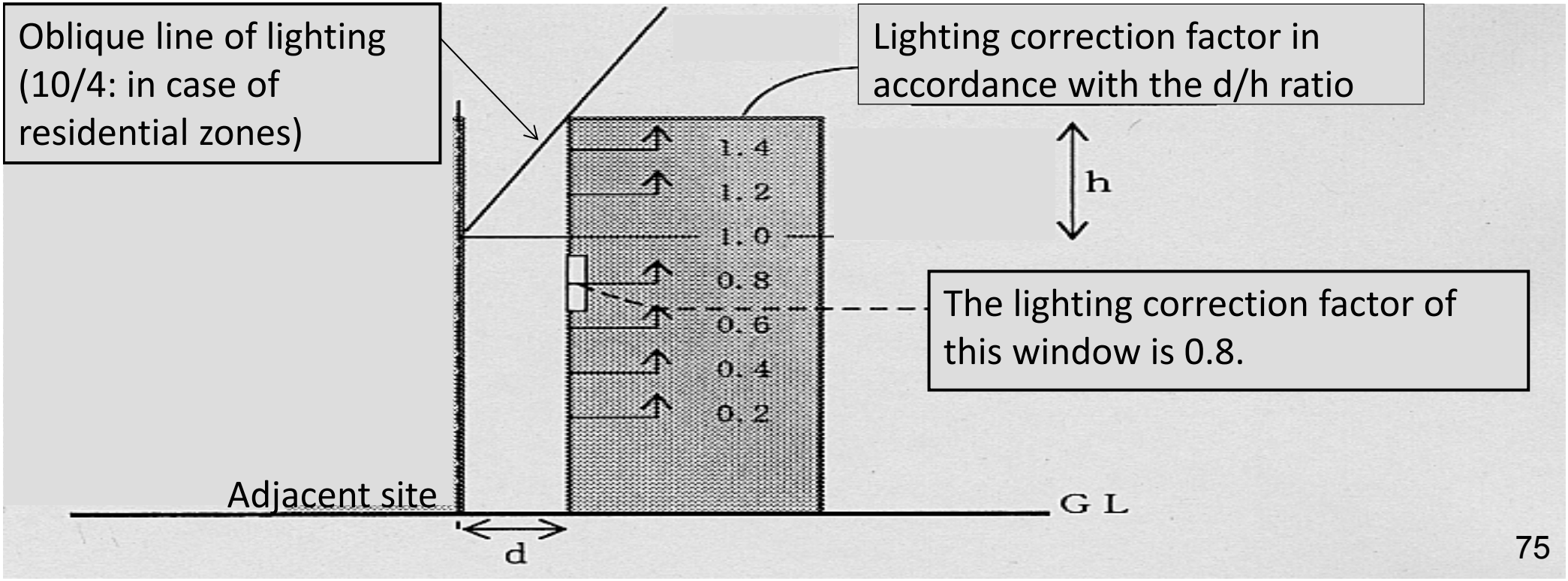
- habitable rooms in houses;
- classrooms in schools;
- wards in hospitals or clinics;
- guestrooms in boarding houses; and
- sleeping areas in dormitories.

Calculation of “effective natural lighting”

(a) Opening section area in habitable room x Lighting correction factor
(b) Floor area of habitable room x 1/7 (**1/7: In case of a residence**)
(c) Confirmation of (1)≧(2)

lighting correction factor

A lighting correction factor is determined by the height of the opening section and the distance from the border with the neighboring land, etc. The figure increases if the opening section is higher or the border is farther.



(2) Ventilation of Habitable Rooms

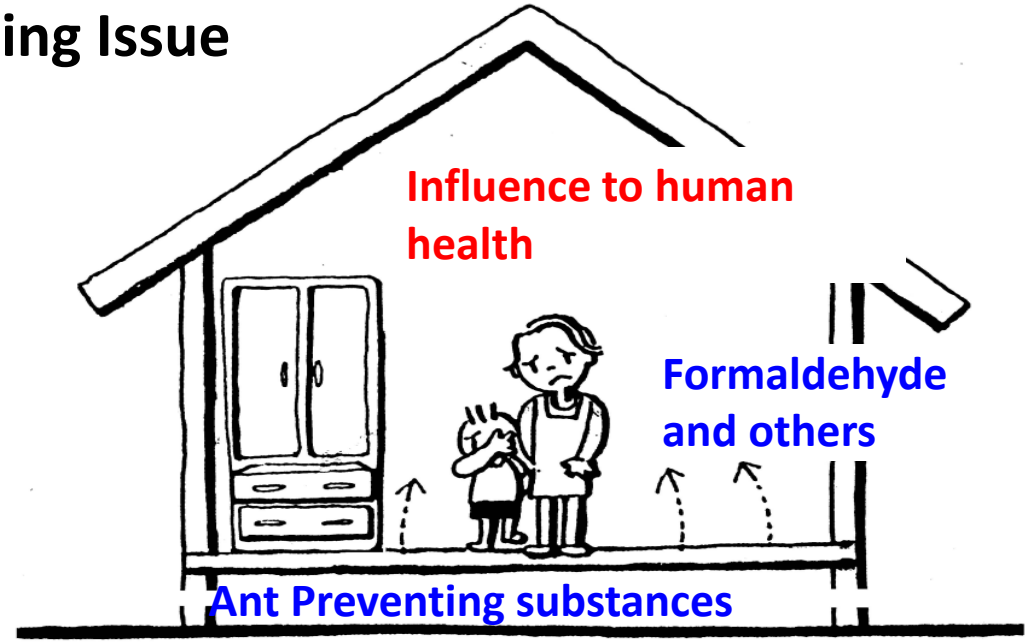
Ventilation equipment must be installed in:

- habitable rooms in theaters and movie theaters; and
- rooms having equipment that uses a flame, such as kitchens, bathrooms, etc.

There is another requirement of installation of mechanical ventilation equipment for habitable rooms as a countermeasure against chlorpyrifos emitted from furniture, etc. (see **(3)**)

(3) Countermeasures against Sick Building Issue

There are some requirements in order to prevent harm to human health by the scattering of asbestos or by emissions of other harmful substances from buildings materials.



(a) It is prohibited to add asbestos to building materials.

(b) It is prohibited to use the following building materials:

- sprayed asbestos; and
- sprayed rock wool that contains more than 1 % in weight of asbestos;

excluding those approved by the Minister as those do not cause the scattering or emission of asbestos particles.

(c) In a building with habitable rooms,

- It is prohibited to use building materials that might emit chlorpyrifos, an insecticide for termites;
- It is restricted to use of building materials that might emit formaldehyde; and
- It is required to install mechanical ventilation equipment, except in traditional wooden houses that have lower air tightness.

(4) Others

The following regulations are also provided with respect to the environmental sanitation and safety in the daily use of buildings.

(a) Height of the ceilings of habitable rooms

The height of the ceilings of habitable rooms must be 2.1 m or more (on average in each room).

(b) Height of floors from the ground and methods of damp proofing in habitable rooms

In principle, the first floor of wooden buildings must be 45 cm high, from the ground, or more, and must be provided with ventilation under the floor.

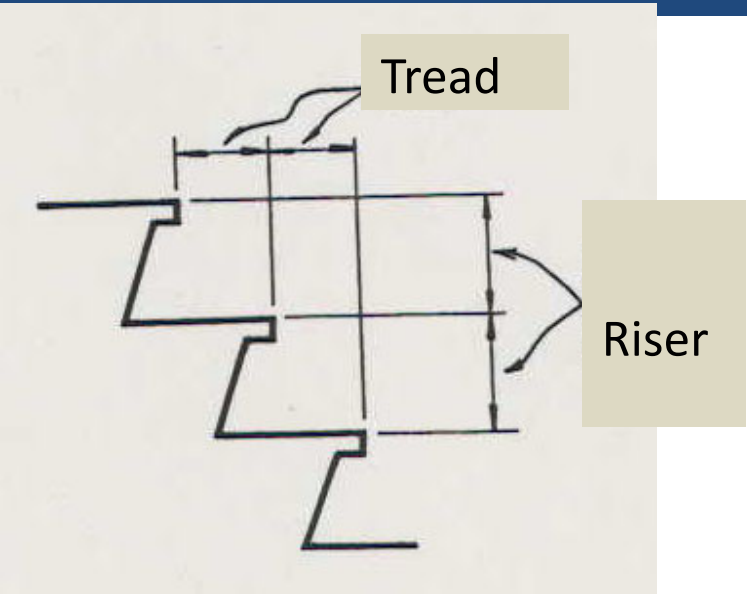
(c) Sound blocking of the separation walls

Separation walls between each unit of row houses or apartment houses must be of a structure that has effective sound insulation.

14-3 Structure of stairway

Some regulations are provided for stairs and for slope-ways (*) from the viewpoint of ensuring safety in daily situations.

(*) If a slope-way is provided as an additional exit route, and therefore not required in the BSL, these regulations are not applied to such slope-ways.



(1) Size of width, riser and tread of stairway

Type of stairway	Width of stairway and landing	Riser	Tread
Stairway for children in elementary school	≧140 cm	≦16 cm	≧26 cm
Stairway in junior high school, high school, store, theatre, movie theatre or other public facilities	≧140 cm	≦18 cm	≧26 cm
Stairway in residence (excluding public space in housing complex)	≧75 cm	≦23 cm	≧15 cm

(2) Handrails

A stairway is requited to have handrails. In case either side of stairway and landing has no handrail, it is required to install a side wall.

(3) Landings

Concerning stairway in elementary, junior high or high school, department store, theatre, etc. it is required to build a landing for every 3m height or less in case the height of the stairway exceeds 3m. For other cases, it is required to build a landing for every 4m height or less.

(4) Slope-ways

The slope of slope-ways in place of stairs must not exceed 1/8.

(1) Sewage

(a) In regions where wastewater can be treated at a final disposal plant, it is required to have flush toilet for which sewage pipes are directly connected to the sewage system.

(b) In case of discharging waste from toilet to other than the sewage system, it is required to install **a septic tank**. In areas other than districts planned for sewage treatment, it must be **a combined septic tank (a combined kitchen waste and toilet sewage treatment tank)** as per the Purification Tank Act.

(2) Plumbing Facilities (Water Supply and Drainage)

(a) Sanitary criteria for plumbing facilities

- Not to directory connect plumbing facilities for drinking water and other plumbing facilities.
- To install drain traps, etc. For plumbing facilities for drainage.

(b) Criteria for plumbing facilities in general (It is necessary to design plumbing facilities considering different aspects such as structure, fire prevention and hygiene.)

- To avoid a piercing arrangement that would cause a problem in the aspect of structural load-bearing capacity.
- To take countermeasure against corrosion according to the material in case there is a risk of corrosion, such as being buried in concrete.
- To use incombustible materials for duct, dust chute, etc. in case of being installed in a three-story or higher building.

(3) Elevatory equipment

Elevatory equipment must be constructed for safe operation. In addition, hoistways must not become channels for the spread of fire.

Elevatory equipment installed in buildings is classified into the following:

(a) **Elevators**: elevatory equipment (*) that:

- transports people;
- transports people and articles; or
- transports articles, whose cage has a horizontally projected area exceeding 1 m^2, and whose ceiling height exceeds 1.2 m.

(*) excluding escalators

(b) **Escalators**

(c) **Elevatory equipment exclusively for small objects**: elevatory equipment used to transport articles, and whose cage has a horizontally projected area of 1 m^2 or less, and whose ceiling height is not more than 1.2 m.

The requirements for each items are as shown in the next page.

For special elevators, such as elevators in a dwelling, some requirements are replaced by the Ministerial notification.

(a) Elevators

Cages and principal structural parts of elevators (parts to support or suspend cages) must either:

- meet the construction methods specified by the Minister; or
- have their safety confirmed through the **elevator strength verification method**; or
- be constructed by a construction method approved by the Minister.

Requirements on other parts, such as drive units, machine rooms, and safety devices, are also provided.

(b) Escalators

The slope must be no more than 30 degree. The width of the steps must be no more than 1.1 m. Steps and principal structural parts of escalators (parts to support or suspend steps) must either:

- meet the construction methods specified by the Minister; or
- have their safety confirmed through the **escalator strength verification method**; or
- be constructed by a construction method approved by the Minister.

Requirements on other parts, such as drive units, trapping prevention systems, and handrail structures, are also provided.

(c) Elevatory equipment exclusively for small objects

The regulations for elevators are partially applied, as necessary.

14-5 Structures and amusement facilities

The BSL applies to:

(1) Structures, such as:

(a) chimneys exceeding 6 m in height (including any supporting frame or stay wire, but excluding stove chimneys);

(b) advertisement towers, advertisement billboards, decorative towers, and memorial towers exceeding 4 m in height;

(c) elevated water tanks, silos, and observation towers exceeding 8 m in height; and

(d) retaining walls exceeding 2 m in height.

(2) Amusement Facilities, such as:

(a) elevated amusement facilities such as water chutes, and roller coasters; and

(b) rotating amusement facilities that use motors such as merry-go-rounds, Ferris wheels, octopus rides, and aero-towers.

The BSL and its related documents provide requirements for the abovementioned in order to secure safety.