Kyrgyz - Japan Workshop by the Japan Society of Seismic Isolation

Outline of Building Regulation and Earthquake-Resistant Measures in Japan

8th Feb. 2021

ISHIHARA Akihiko

Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

国土交通省

Japan's experience in Building Regulations for improving Building Safety

Shortage of human resources

- ✓ Start of regulation from a specific area and minimum required level
- ✓ Development of human resources
- ✓ Collaboration with the private sector

Building-related incidents & violations

- ✓ Enhancement of inspection and reporting system
- ✓ Strengthening crackdown on illegal construction

Building quality problems

- ✓ Establishment of quality specification
- ✓ Strengthening examination system
- ✓ Introduction of new qualification system

Large- scale disasters

- ✓ Refinement of building structural code
- ✓ Strengthening measures for existing buildings
- ✓ Quick risk assessment after disasters

Contents

Composition of the Building Standard Law of Japan

(Purpose)

Article 1. The purpose of the Building Standard Law (BSL) is to safeguard the life, health, and property of people by providing minimum standards concerning the site, construction, equipment, and use of buildings, and thereby to contribute to the furtherance of the public welfare.

Whole area of Japan

General Provisions

Administrative Provisions
Miscellaneous
Penalty

Building Codes

Structural Requirement
Fire Requirement
Equipment and Sanitary Requirement

City Planning Areas*

Planning Codes

Relation between Sited and Roads
Land-Use Zoning Regulation
Building Height
Restrictions in Fire Protection Zone

*City Planning Areas;
102,300 km², 27% of total land
(as of March 2018)

History of Building Regulation in Japan

(1) First Law System In 1920

The Japanese Government enforced the Urban Building Law.

(a) Covered area: Six largest cities at that time

(b) Building permission by the police of each prefecture for construction of certain buildings (depending on usage and size of the building).

(2) Building Standard Law In 1950

The Japanese Government repealed the Urban Building Law, and enforced the Building Standard Law.

(a) Covered area: Everywhere in Japan
(Zoning codes only apply city-planning area.)

(b) Building confirmation by local governments (building officials) for construction of every building.
(From 1999, designated private bodies also issue building confirmation as well as local governments)

Legislation documents

Provisions are provided in the documents in the table below.

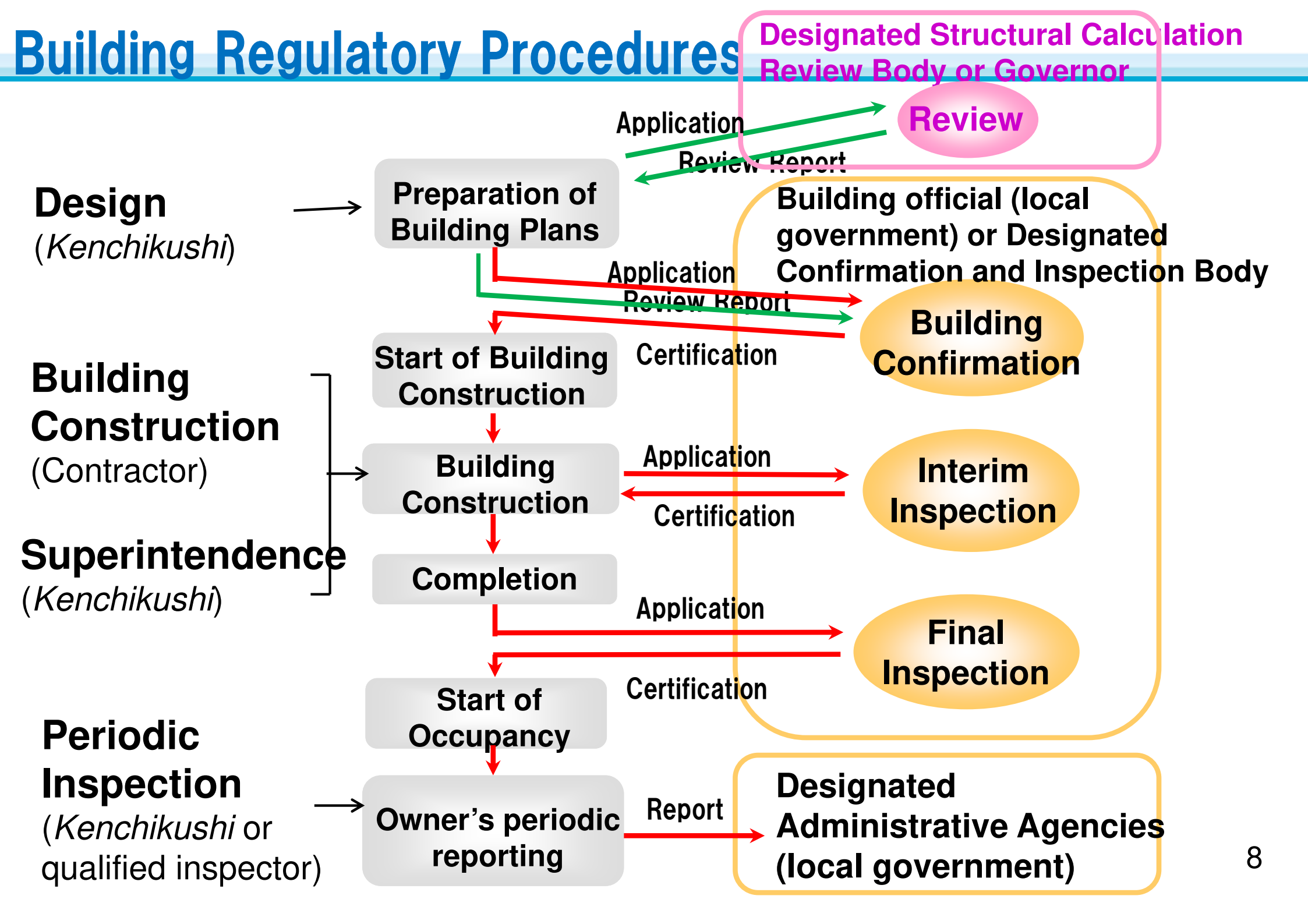
Authorities to issue		Documents	Main contents
Central Government	**National assembly**	The BSL (the Building Standard Law)	- Procedures, such as confirmation, permission, certification system - Penalties - Technical requirements (outline)
	Cabinet	The *Enforcement Order*	- Technical requirements
	MLIT	The *Enforcement Regulation of the Ministry*	- Procedures (Details, such as application forms)
	MLIT	*Notifications of the Ministry*	- Technical requirements (Details)
Local governments	**Local assembly**	Bye-laws	- Additional technical requirements in response to their local conditions.
	Governor or Mayor	Enforcement Regulations	- Procedures (Details) - Technical information, such as snow accumulation, etc.

Other standards related to the building regulations

The BSL is the primary law concerning building codes. Other laws concerning building codes and related fields are shown below.

Building codes items and related fields		Restrictive laws (Requirements are mandatory.)	Promotional laws
Fire safety	Fire extinguishing equipment, etc.	Fire Service Law	
	Fire- resistance, evacuation, etc.	**Building Standard Law**	
Structural safety			Seismic Retrofitting Law
Hygienic safety			Building Management Law
Accessibility		Barrier-free Law	
Energy saving		Building Energy Saving Law	

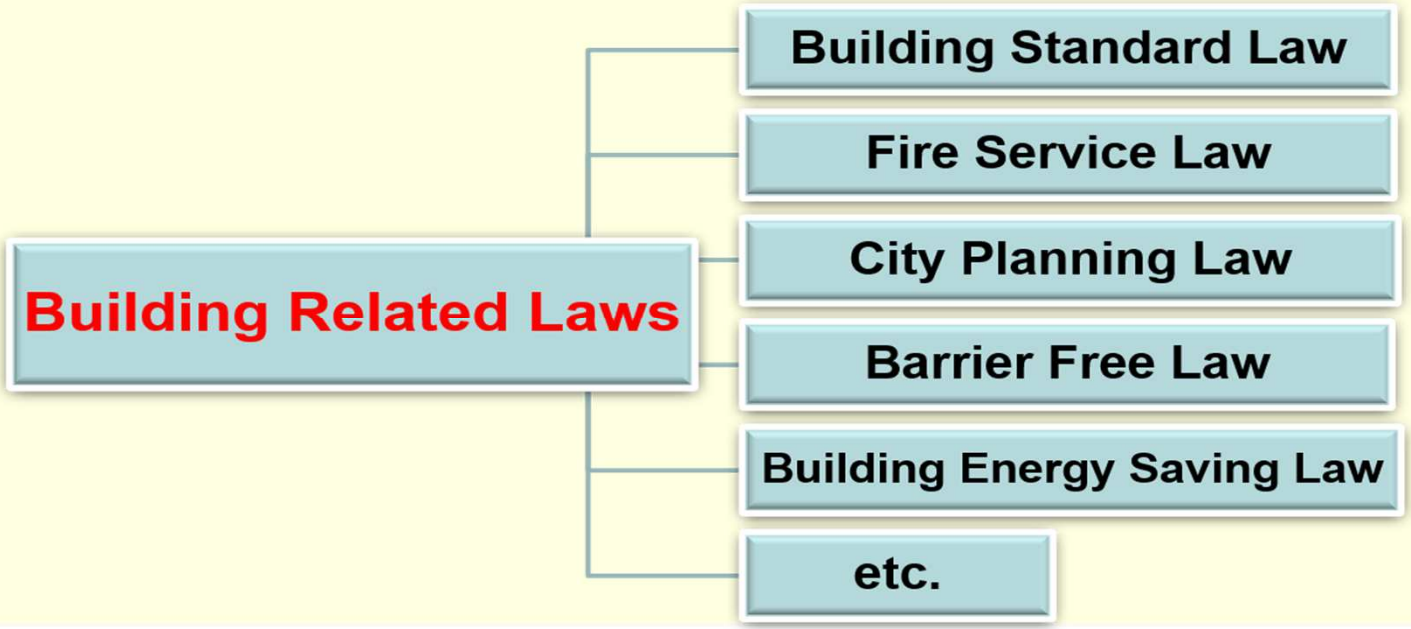
Building Regulatory Procedures



Building Confirmation

- Building Owner must apply for and receive **building confirmation** from a building official (or inspector in the designated building confirmation and inspection body) as to **whether the plan for the building is in conformity with provisions of Building Related Laws**.(the laws relating to the site and structure of the building, and the building equipment)

- Building construction work can only be started after the certification of building confirmation has been issued.



Special cases related to Building Confirmation

Small buildings designed by Kenchikushi

- For small buildings (such as detached houses) with 2 floors or less, in case Kenchikushi designed them, examination for structural regulations is omitted in the building confirmation.
- Regulations related to building site or zoning code are examined.

Type Approval of Buildings

- If (the part of) the building has been approved in advance as "conforming to a series of regulations such as structural strength and fire prevention and evacuation", the examination of the "series of regulations" is omitted in the building confirmation.
- However, it is necessary to verify whether the design specifications of the building conform to the approved model.

Inspection

Interim inspection

- Building owner must request inspection by building official (local government) or Designated Confirmation and Inspection Body, **when the process in A and B has been completed**, within 4 days from the date of completion.

  A : the process of installing steel bars of the second floor, and beams supporting the floor (of residential building with 3 or more floors)

  B : the processes stipulated by local government (the designated administrative agency) (such as “foundation reinforcement work”)

- If he do not pass this inspection, he will not be able to carry out subsequent construction.

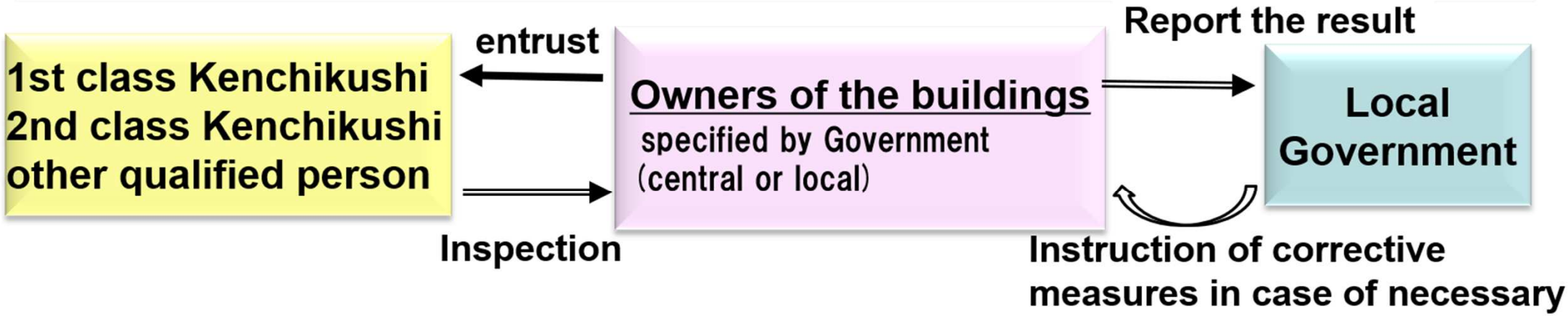
Inspection

Final inspection

- Within 4 days from the date of completion, building owner must request final inspection by building official (local government) or Designated Confirmation and Inspection Body
- Buildings that have undergone a completion inspection and have not been issued an inspection certificate cannot be used.
- Completion inspection rate is about 90% lately.

Periodic Report System

After starting to use the buildings, the owners of the buildings specified by Government (central or local) must have qualified person **inspect** their buildings, elevators, etc. and must **report** the results of inspections to the Local Government periodically.



	Target	Report time
Buildings	Theaters, hotels, hospitals, department stores, etc.	every half a year to 3 years specified by the local government
Elevators and escalators		every half a year to 1 year specified by the local government
Building facilities Fire protection facilities	Ventilating facilities, fire doors, etc.	every half a year to 1 year specified by the local government

Structural Calculation Review

Size of buildings	Structural Calculation Method	Procedures
High-rise buildings (h > 60m)	Time History Analysis	Certification by the Minister + Building Confirmation
Large size buildings (Wooden: h > 13m) (RC: h > 20m) , etc.	Limit Strength Calculation Horizontal Load-carrying Capacity Calculation Allowable Stress Design+	**Structural Calculation Review** + Building Confirmation
Medium size buildings (Wooden: h < 13m) (RC: h < 20m) ,etc.	Allowable Stress Design	Building Confirmation
Small size buildings (Wooden ≦2 stories,500㎡) (RC ≦ 1 story,200㎡)	(No need to calculate)	Building Confirmation

Structural Calculation Review and Building Confirmation

- In the **Structural Calculation Review**, the **Designated Structural Calculation Review Body** or the **Prefectural governor** examine such as :

  - ✓ there are no abnormalities or unnatural elements in the structural design drawing,
  - ✓ whether the method of applying the calculation formula are appropriate,
  - ✓ whether the method of inputting data corresponding to a special building shape / topography are appropriate,
  - ✓ (when using the approved calculation program) re-enter the data and recalculate, and examine that there are no error messages.

- **Building official** or **Designated Confirmation and Inspection Body** will make a final examination based on the result of the Structural Calculation Review.

The System of Building Confirmation and Inspection

(1) Local government in Japan

There are two levels of local governments

(a) Prefectures 47

(b) Cities, Towns and Villages 1,741

(as of July 2015)

(2) Designated Administrative Agency

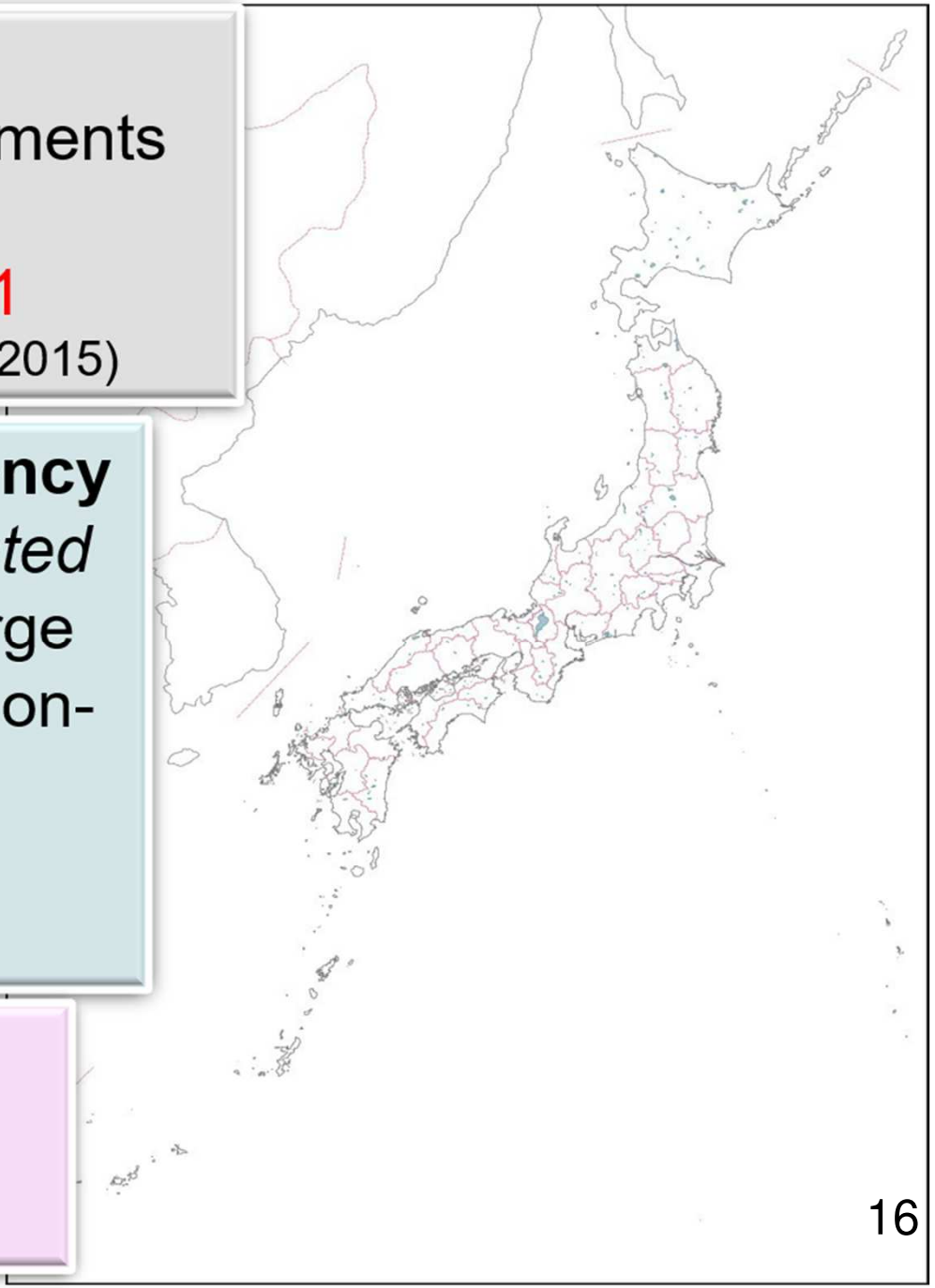
Building officials under the *Designated Administrative Agencies* are in charge of (i) building confirmation; and (ii) on-site inspections.

(a) Prefectures 47

(b) Cities, Towns and Villages 404

(3) Designated Confirmation and Inspection Body

132 in Japan (as of Apr 2017)



Building Regulatory Authorities

Confirmation and inspection work has been opened to private sector since 1999.

Building officials		Designated Confirmation and Inspection Bodies
Prefectural or municipal officials (Prefectures and specific cities with populations of over 250,000)	**Attributes**	Private (either profit or non-profit)
451 local authorities (as of May, 2017) 1,484 building officials (as of 2015)	**Staff (organiza -tions)**	132 organizations (as of April 2017) 3,217 private building inspectors (as of 2015)

Designated Confirmation and Inspection Bodies

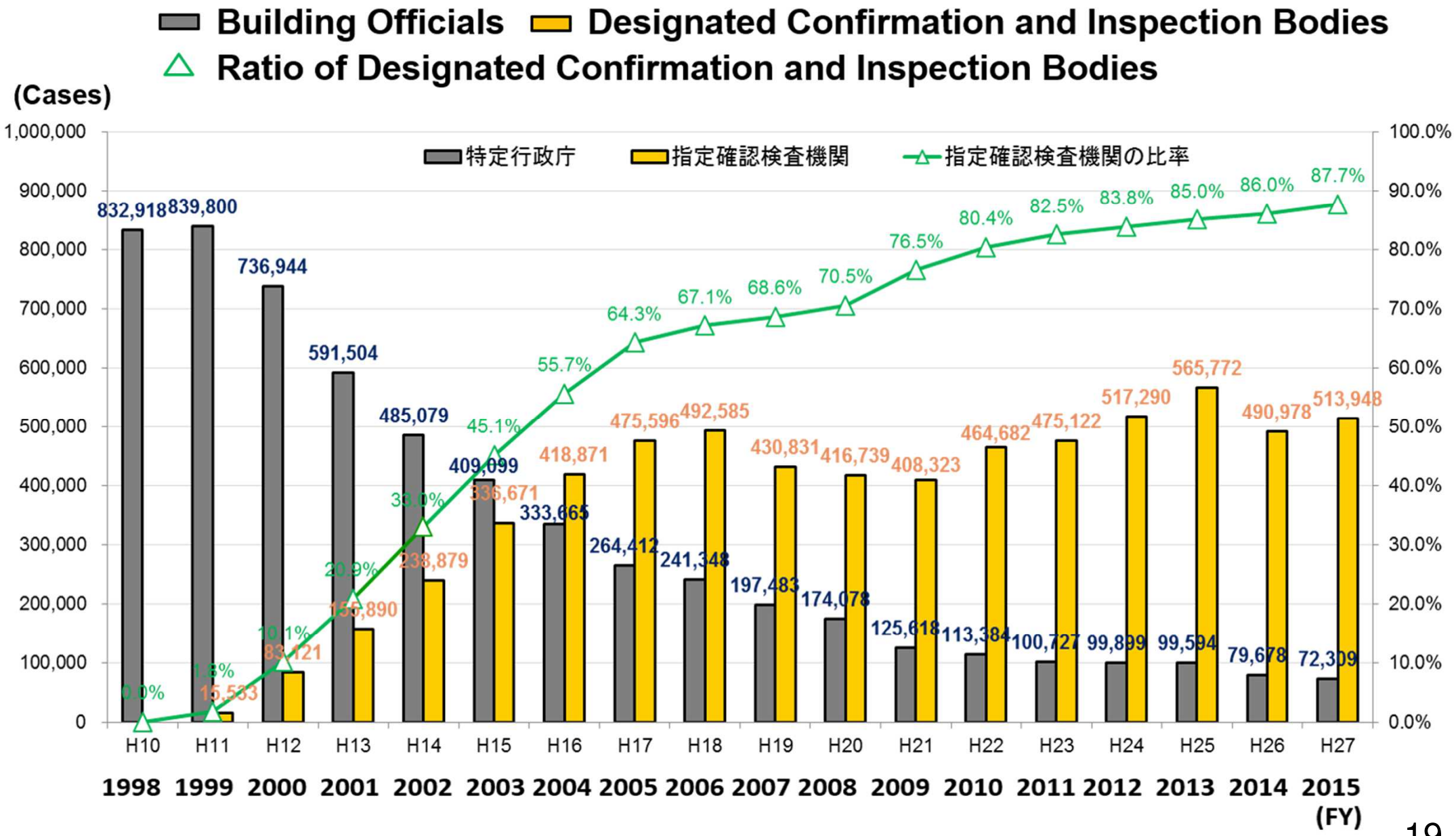
■ 3 types of **Designated Confirmation and Inspection Bodies**

- 24 are designated by Minister of MLIT
- 40 are designated by Director of Regional Development Bureau of MLIT
- 68 are designated by Prefectural Governors (2017.4)

■ Designation criteria of **Designated Confirmation and Inspection Bodies**

- A sufficient number of confirmation inspectors are secured according to the number of confirmation inspections.
- The organizational structure necessary for the implementation of fair confirmation inspection work is in place.
- Sufficient financial basis
- Composition of officers and staff that does not affect the fair implementation of business
- etc.

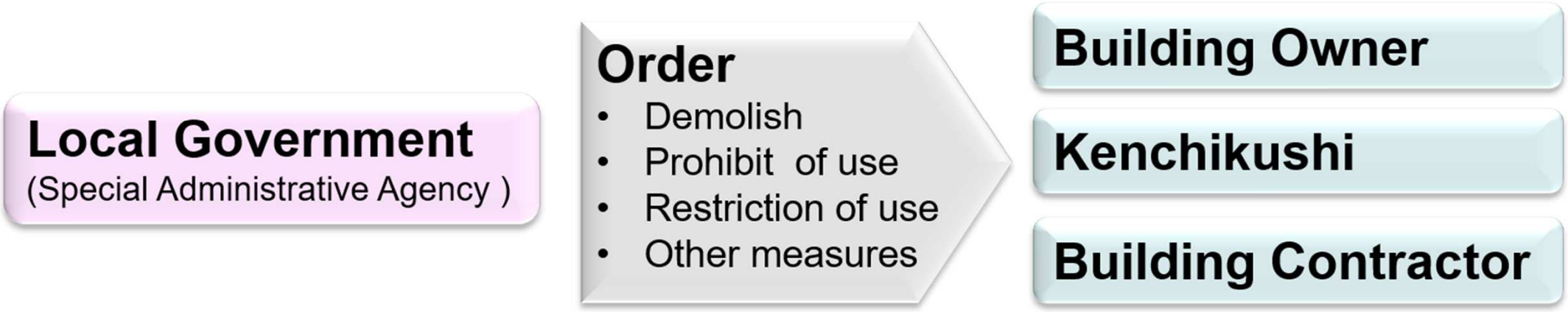
Transition of the number of Building Confirmation



Regulation of buildings in violation

In order to **rectify buildings in violation** of Building Standard Law, or orders and ordinances based upon it, local government (Special Administrative Agency) is empowered with the **necessary measures**.

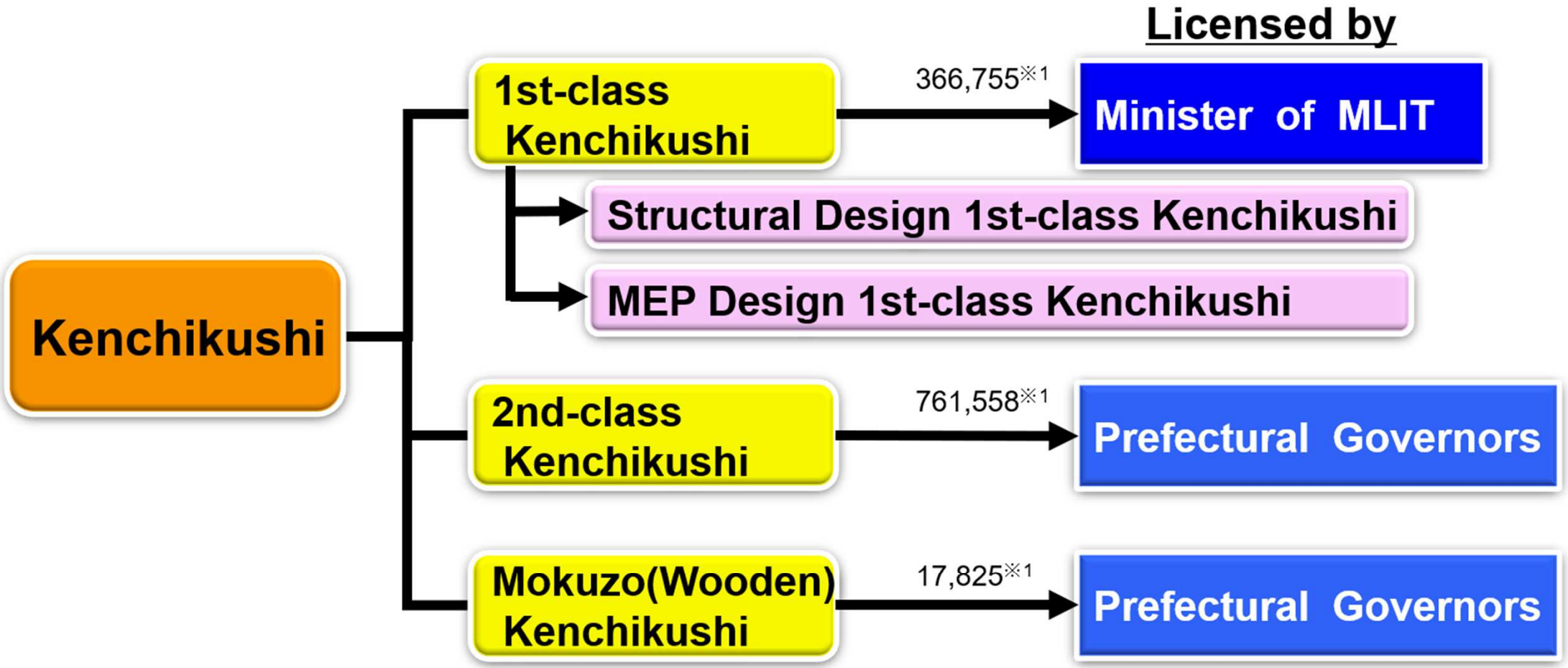
< In case of violation of BSL >



In cases where such action is not carried out by building contractor or building owner, executive action will be performed in accordance with the Law for Administrative Execution by Proxy.

Kenchikushi (Architect and Building Engineer)

Only a **Kenchikushi** shall engage in the design or the superintendence of related construction work (Kenchikushi Law Article3～Article3-3)



※1 Number as of April 2017

Scope of Activity by Type of Kenchikushi

<table>
<tr><th colspan="2" rowspan="3">Height and structure
Total floor area
(S: m2）</th><th colspan="5">height of building ≦ 13 m and
Height of eave ≦ 9 m</th><th rowspan="3">Height of building＞13 m, or
Height of eave ＞9 m</th></tr>
<tr><th colspan="3">wooden</th><th colspan="2">Non-wooden</th></tr>
<tr><th>1 story</th><th>2 story</th><th>3 story</th><th>Up to 2 stories</th><th>3 stories or more</th></tr>
<tr><td colspan="2">S ≦ 30</td><td colspan="3" rowspan="2">Anyone can engage in this.</td><td>Anyone</td><td rowspan="3"></td><td rowspan="5"></td></tr>
<tr><td colspan="2">30 ＜ S ≦100</td><td rowspan="2">1st, 2nd, or Mokuzo may engage in this.</td></tr>
<tr><td colspan="2">100 ＜ S ≦ 300</td><td rowspan="2"></td></tr>
<tr><td colspan="2">300 ＜ S ≦ 500</td><td colspan="3" rowspan="2">Only 1st–class or 2nd-class may engage in this.</td><td rowspan="3"></td></tr>
<tr><td rowspan="2">500 ＜S ≦ 1,000</td><td></td><td rowspan="3"></td></tr>
<tr><td>Special-purpose buildings</td><td rowspan="3">Only 1st-class may engage in this.</td></tr>
<tr><td rowspan="2">1,000 ＜ S</td><td></td><td>1st, 2nd</td></tr>
<tr><td>Special-purpose buildings</td><td colspan="4"></td></tr>
</table>

Note: *Special-purpose buildings* refer to schools, hospitals, theaters, cinemas, grandstands, public halls, assembly halls with auditoriums, and department stores.

Pathway to Kenchikushi qualification (a standard case)

Graduate from a 4- year university in the faculty of architecture

↓ **Practical experiences (e.g. design) of at least 2 years ※**

1st-class *kenchikushi* examination

Examination subjects

Subjects: I. Planning II. Environment / MEP systems
III. Related laws and regulations IV. Structure
V. Construction work

Drafting & design

Results (2017)

Candidates	Successful	Pass rate
31,061	3,365	10.8%

Successful candidates

1st-class *kenchikushi*

※ Practical experience after passing the examination has also been recognized recently.

Structural Design 1st-class Kenchikushi

- **Objective**: A system that involves Kenchikushi with specialized knowledge and skills in structural design to ensure the safety of buildings of a certain size or larger that require advanced structural design

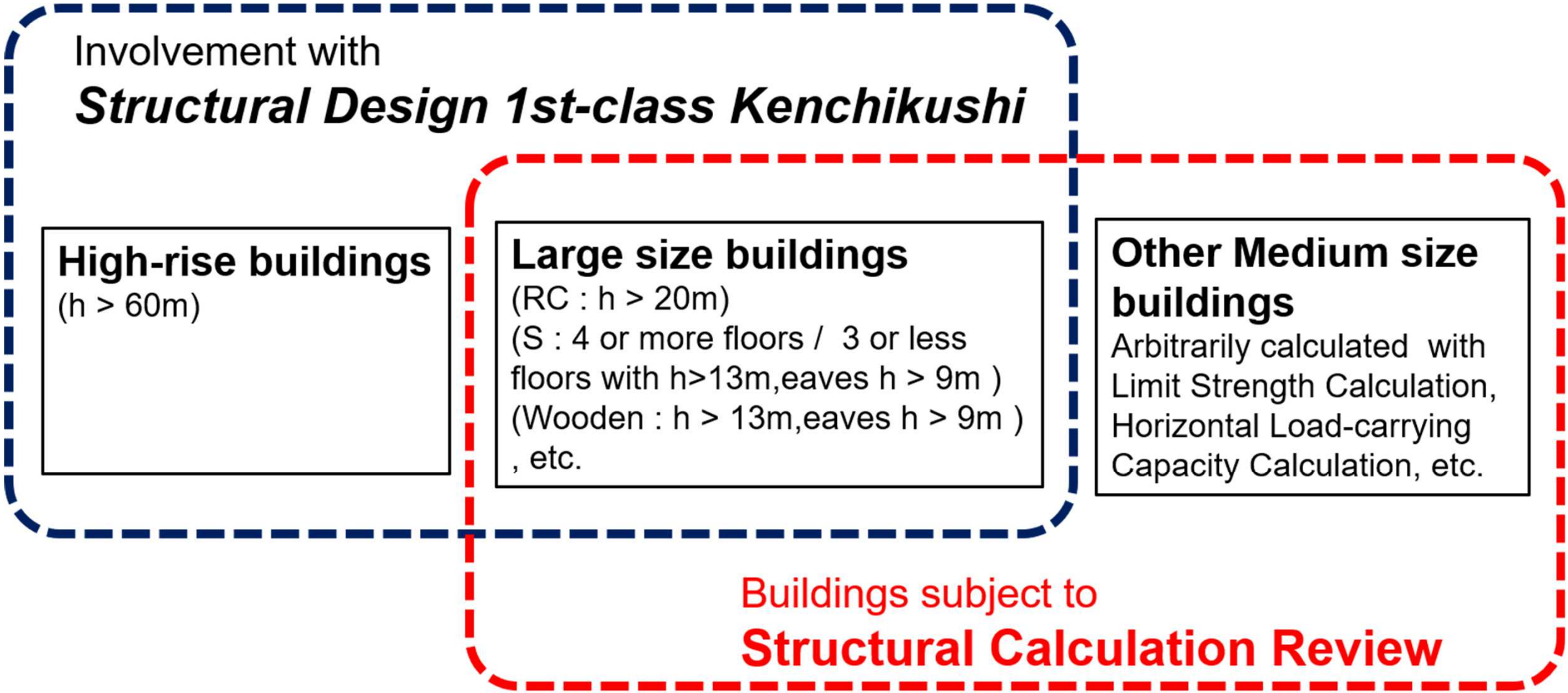
- **Qualification requirements for *Structural Design 1st-class Kenchikushi***: After engaging in structural design for more than 5 years as a 1st-class Kenchikushi, it is necessary to complete the Training course (lecture on structural design and legal compliance confirmation, completion examination).

- **Target building**: RC : Height over 20m
  Steel : 4 or more floors / 3 or less floors with a height of 13 m or an eave height of more than 9 m
  Wooden : Height over 13m or eaves height over 9m , etc.

- **Involvement**:
  Structural Design 1st-class Kenchikushi designs by himself
  or
  When other 1st-class Kenchikushi perform structural design, it is required that legal compliance confirmation by ***Structural Design 1st-class Kenchikushi.***

Structural Design 1st-class Kenchikushi

Buildings subject to involvement with ***Structural Design 1st-class Kenchikushi***, and buildings subject to **Structural Calculation Review**



MEP Design 1st-class Kenchikushi

- **Objective**: A system that involves Kenchikushi with specialized knowledge and skills in MEP design (mechanical, electrical and plumbing) to ensure the safety of buildings of a certain size or larger that require advanced MEP design

- **Qualification requirements for *MEP Design 1st-class Kenchikushi***:
  After engaging in MEP design for more than 5 years as a 1st-class Kenchikushi, it is necessary to complete the Training course (lecture on MEP design and legal compliance confirmation, completion examination).

- **Target building**: 3 or more floors with total floor area of more than 5,000㎡

- **Involvement**:
  MEP Design 1st-class Kenchikushi designs by himself
  or
  When other 1st-class Kenchikushi perform MEP design, it is required that legal compliance confirmation by ***MEP Design 1st-class Kenchikushi***.

Periodic Regular Training Session for Kenchikushi

- **1st-class Kenchikushi, 2nd-class Kenchikushi,** and **Mokuzo Kenchikushi** who belong to kenchikushi-office are required to take **periodic regular training courses** based on the Kenchikushi Law **every 3 years**.
- Kenchikushi who do not take the course within the course deadline, will be subject to a reprimand or suspension of business for two months.
- Periodic regular training courses are provided by **Registered Training Organization**.
- 10 Training Organizations are registered now.

<Contents of Periodic Regular Training Session for Kenchikushi>

Subjects		Hour
Lectures	Laws and Regulations	5 hours
	Design and Superintendence	
Completion Examination		1 hour

Periodic Regular Training Session for Structural Design 1st-class Kenchikushi, MEP Design 1st-class Kenchikushi

- **Structural Design 1st-class Kenchikushi, and MEP Design 1st-class Kenchikushi** is required to take **periodic regular training courses** based on the Kenchikushi Law **every 3 years.**
- They are obliged, regardless of whether they belong to an Kenchikushi office or not.
- They who do not take the course within the course deadline, will be subject to a reprimand or suspension of business for two months.
- Periodic regular training courses are provided by **Registered Training Organization**.
- 2 Training Organizations are registered now.

<Contents of Periodic Regular Training Session for Structural Design 1st-class Kenchikushi>

Subjects		Hour
Lectures	Structural regulations	5 hours
	Structural design	
Completion Examination		1 hour

Registration of Kenchikushi's office

Registration of the Kenchikushi's office is required for any Kenchikushi to undertake design, construction management, etc. in business.

- Registration with the governor of the prefecture where the office will be established
- Registration requires renewal every 5 years.

Number of registered Kenchikushi's offices (as of April, 2017)

Classification of *kenchikushi*'s offices	All *kenchikushi*'s offices			
		1st-class *kenchikushi*	2nd-class *kenchikushi*	*Mokuzo kenchikushi*
Number of offices	104,016	77,425	26,334	257

1. Regulatory System
2. **Building Code**
3. Seismic Retrofitting
4. Disaster Prevention and Ensuring the Continuation of Building Functions

Sophistication of seismic code in Japan

(a) In 1923, Great Kanto Earthquake hit Tokyo and surrounding regions, and caused:

- 254,000 buildings collapsed or severely damaged;
- 447,000 buildings destroyed by fire, and
- More than 105,000 persons dead or missing.

Great Kanto Earthquake (1923)

(b) In 1924, the Japanese seismic codes were revised to require **structural calculation in considering seismic force.** This was the first such requirement in the world.

(c) Learning the damages of earthquakes**,(Niigata earthquake in 1964, Tokachi Off-shore earthquake in 1968, and Miyagi Off-shore earthquake in 1978**), and developing the seismic technology, structural calculation methods as well as specific structural provisions stated in the seismic codes have been sophisticated.

(d) Current seismic codes are based on **the codes enforced in 1981**.

Trends in development of earthquake-resistance measures

《Major earthquakes》

- 1923 **Great Kanto eq.**
- 1964 Niigata eq.
- 1968 Tokachi Off-shore eq.
- 1978 Miyagi Off-shore eq.
- 1995 **Great Hanshin-Awaji eq.**
- 2004 Niigata-Chuetsu eq.
- 2005 West Off Fukuoka eq.
- 2007 Off Niigata-Chuetsu eq. / Noto Peninsula eq.
- 2008 Iwate-Miyagi Inland eq. / Iwate North Coast eq.
- 2011 **Great East Japan eq.**
- 2016 Kumamoto eq.

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

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

1995 **Enactment of the Act on Promotion of Seismic Retrofitting of Buildings (APSRB)**

- 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 APSRB**

- Making a plan for promoting seismic retrofitting by local government

2013 **Amendment of the APSRB**

- **Mandatory seismic assessment of large-scale hospitals, department stores, hotels and schools, etc.**

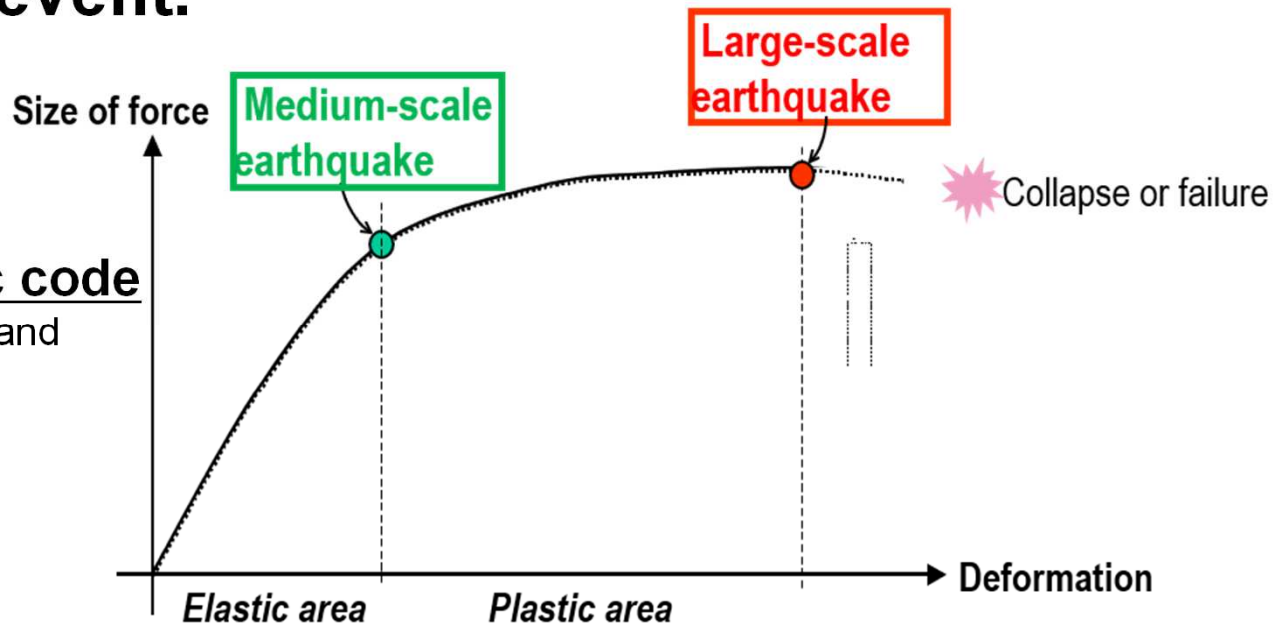
Structural Requirement in Current Code

(1) 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.

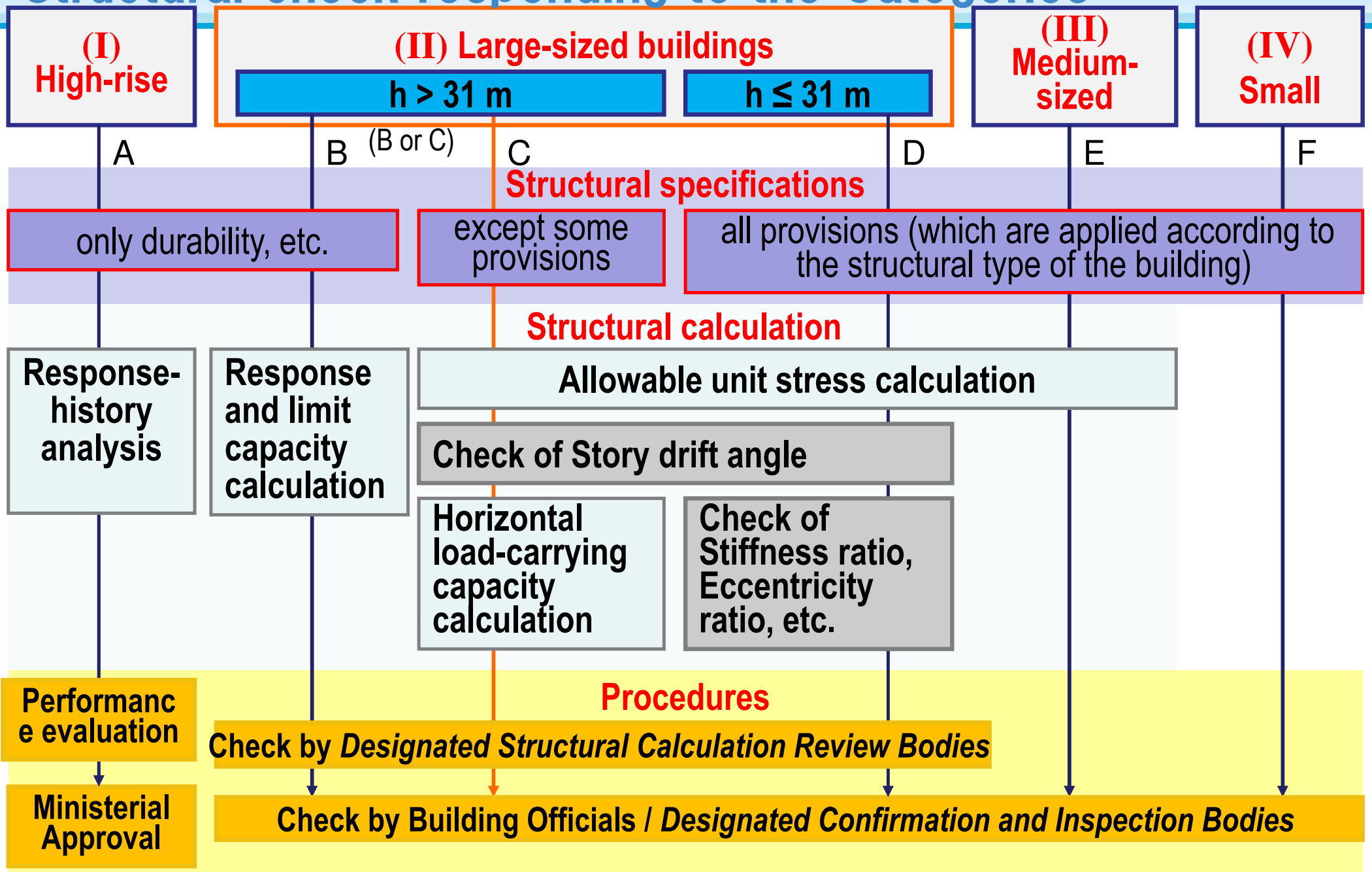
(2) The building does not sustain damage due to a rare medium-scale snowfall, windstorm, earthquake, or other event.

(3) The building does not collapse or otherwise fail due to an extremely rare large-scale snowfall, windstorm, earthquake, or other event.

Image of current seismic code
(Relationship between force and deformation at earthquakes)



Structural check responding to the Categories



Ensuring the Quality of Building Materials

Designated building materials

BSL requires quality of the important building materials (such as steel, concrete, rebar etc.) used for principal building parts (column, beam, bearing wall, floor slab, etc.), to be assured.

Designated building materials	Quality Requirement
Steel, Bolt, Rebar, Concrete, Structural Cable, etc.	**Need to conform to the JIS or JAS. Those that don't conform to JIS or JAS standard need to be certified.**
Seismic isolation devices, Membrane materials, etc.	**Need to be certified as conform to the quality standard of MLIT.**

JIS: the Japanese Industrial Standard
JAS: the Japanese Agricultural Standard

Quality of Seismic Isolation Devices

Ensuring of quality of Seismic isolation devices (Bearing devices, Damper)

Seismic isolation devices need to be **approved** by the Minister of Land, Infrastructure, Transportation, and Tourism as conforming to technical criteria concerning the quality necessary for safety, fire prevention, etc. (BSL § 37)

Contents of the Technical Criteria (Notification No.1446(Y2000))

① Quality criteria
② Examination method
③ Precision and performance of the Examination equipment
④ Quality, inspection, and storage of the Products
⑤ Other technical manufacturing conditions necessary for the maintenance of quality

Approval of Special Building Materials and Construction Method

BSL provides the **minimum standards** to which specific building materials and construction methods must conform.

Rapid progress in construction techniques makes it possible that newly developed methods, although having adequate performance, cannot be evaluated properly under the current provisions.

Article 38 of BSL provides for approval of the Minister of MLIT which enables special or unique materials and construction methods to be used while recognizing them as having performance equal to or better than that provided in BSL.

Performance-based codes

(1) The Building Standard Law had a provision that the Minister could issue approval to make it possible to use building materials/products/construction-methods/design, which did not satisfy one of the specifications provided by the prescriptive provisions, from its establishment of 1950.

(2) The *process* was revised from the viewpoint of **Performance-based codes** in 1998, and enforced **in 2000.**
The revised codes provide **performance requirements** for some technical requirements. The new *process* requires **the evaluation by the *Designated Performance Evaluation Body*** prior to the application for the approval by the Minister.

※ ***Designated Performance Evaluation Body***
30 bodies (28 bodies located in Japan and 2 bodies located in foreign countries) have been designated by the Minister, as of 2020.

Performance Evaluation and Certification of building materials

Performance evaluation

Designated Performance Evaluation Bodies conduct technical evaluation to confirm the performance of building materials or structural method which was applied for the evaluation

Certification

Based upon the Performance Evaluation Sheet issued by the Designated Performance Evaluation Bodies, **the Minister of Land, Infrastructure, Transport and Tourism certify the performance**

Housing Performance Indication System

Legislation

Based on “Housing Quality Assurance Act” enforced in 2000.

Purpose

- Assurance of housing quality
- Protection of the interests of housing purchasers
- Prompt and appropriate resolution of disputes related to housing

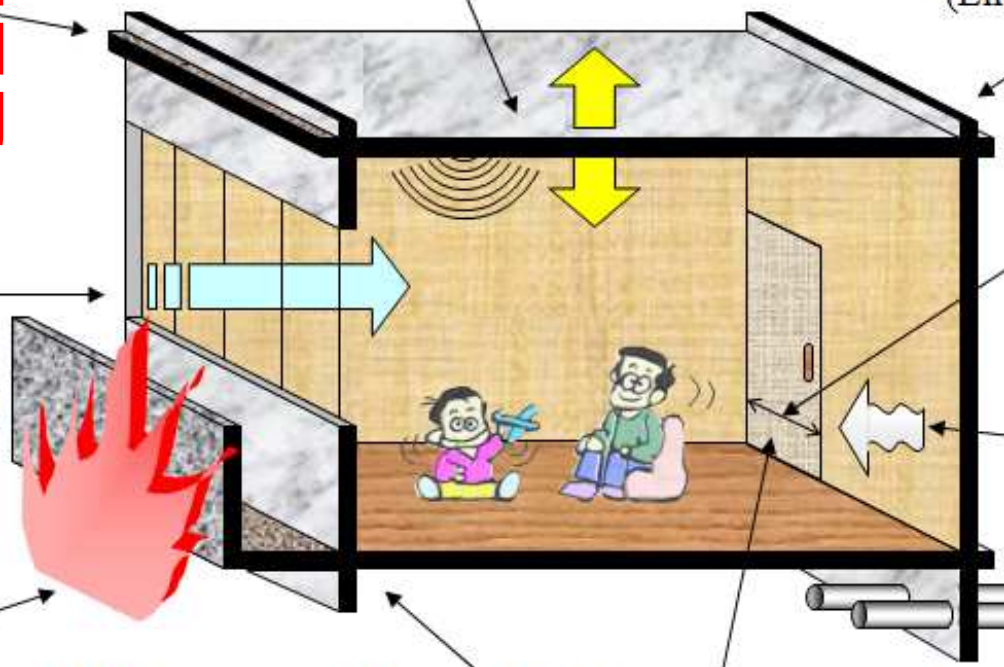
Feature

- It is a **voluntary** system
- It covers **10 fields**
- **Evaluating services by independent bodies** are available

Mark of Performance Evaluation Report

10 fields of Housing Performance Indication System

● Indications of Housing Performance



① **Structural Stability**
(Earthquake-resistance, Grade ○, etc.)

⑧ **Acoustic Environment**
(Sound control of heavy impact on floor, Grade ○, etc.)

⑤ **Energy Consumption Thermal Environment**
(Energy efficiency, Grade ○)

⑨ **Consideration for the Aged & Others**
(Consideration for the aged and others, Grade ○, etc.)

⑦ **Luminous and Visual Environment**
(Simple opening ratio, ○%, etc.)

⑥ **Indoor Air Environment**
(Formaldehyde control measures, Grade ○, etc.)

② **Fire Safety**
(Fire-resistance, Grade ○, etc.)

③ **Mitigation of Degradation**
(Anti-degradation measures, Grade ○)

④ **Consideration for Maintenance and Remodeling**
(Consideration for maintenance, Grade ○, etc)

⑩ **Security against Intrusion**
(Performance of openings)

Evaluation Standard for Structural Stability in Housing Performance Indication System

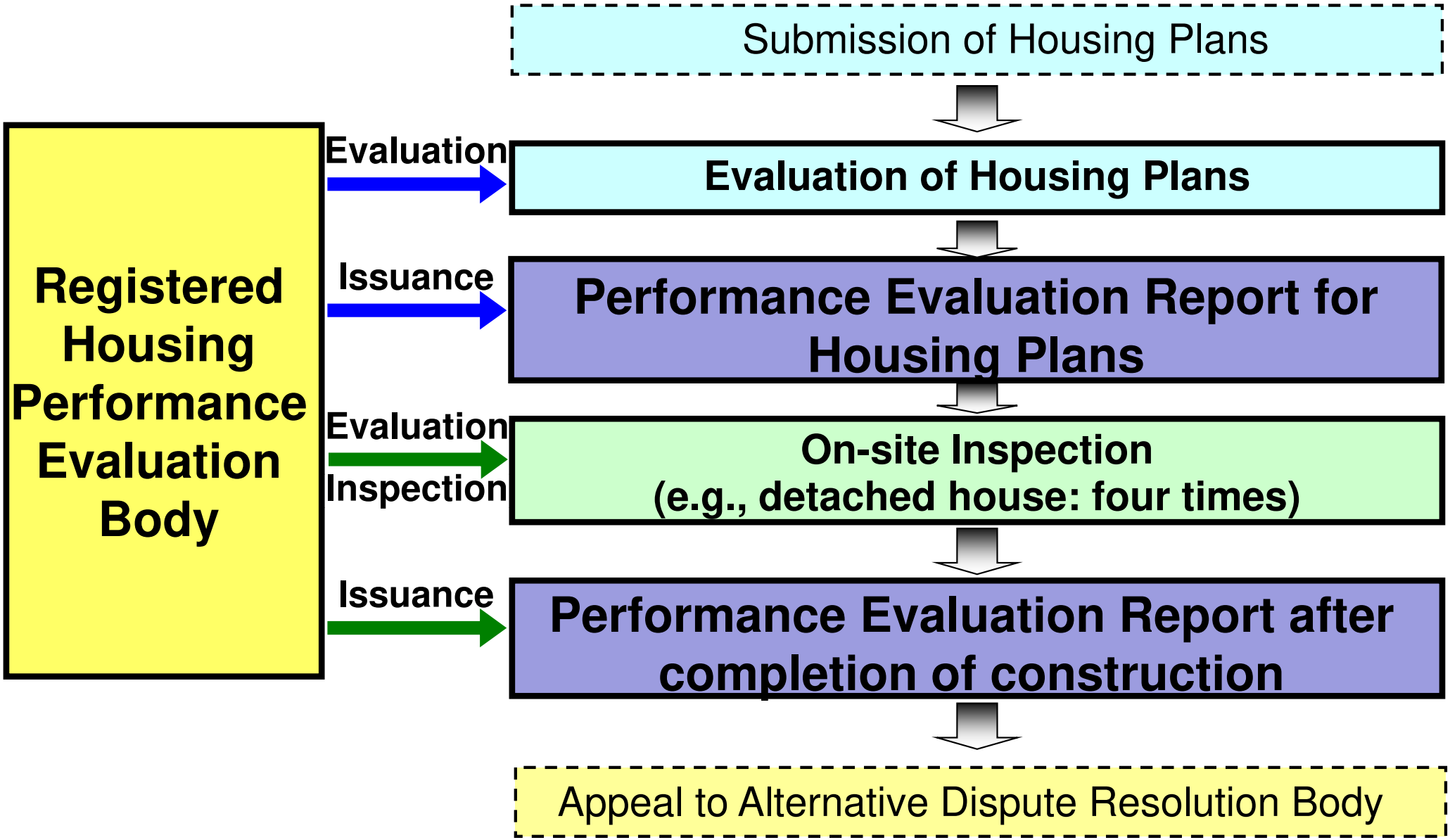
◆ Earthquake Resistant Grade

Item	Grade	Evaluation Standard
Earthquake Resistant Grade (Prevention of the collapse)	**3**	Not to collapse by **1.5 times** the force of extremely rare large scale earthquake
	2	Not to collapse by **1.25 times** the force of extremely rare large scale earthquake
	1	Not to collapse by the force of extremely rare large scale earthquake
Earthquake Resistant Grade (Prevention of the damage)	**3**	Not to sustain damage by **1.5 times** the force of rare medium scale earthquake
	2	Not to sustain damage by **1.25 times** the force of rare medium scale earthquake
	1	Not to sustain damage by the force of rare medium scale earthquake

◆ Windstorm, or Snowfall Resistant Grade

Item	Grade	Evaluation Standard
Windstorm Resistant Grade (Prevention of the collapse or damage)	**2**	Not to collapse by **1.2 times** the force of extremely rare large scale windstorm (once in 500 years), and Not to sustain damage by **1.2 times** the force of rare medium scale windstorm (once in 50 years)
	1	Not to collapse by the force of extremely rare large scale windstorm, and Not to sustain damage by the force of rare medium scale windstorm
Snowfall Resistant Grade (Prevention of the collapse or damage)	**2**	Not to collapse by **1.2 times** the force of extremely rare large scale snowfall (once in 500 years), and Not to sustain damage by **1.2 times** the force of rare medium scale snowfall (once in 50 years)
	1	Not to collapse by the force of extremely rare large scale snowfall (once in 500 years), and Not to sustain damage by the force of rare medium scale snowfall (once in 50 years)

Evaluation services by independent bodies for Housing Performance Indication System



1. Regulatory System
2. Building Code
3. **Seismic Retrofitting**
4. Disaster Prevention and Ensuring the Continuation of Building Functions

For improving and maintaining earthquake resistance of buildings

1) Improve earthquake resistance of new buildings

- Building standards
- Improvement and maintenance of building technology (Design / Construction)
- Examination and inspection system

2) Improve earthquake resistance of existing buildings

- Assessment of earthquake resistance based on the latest standard (seismic diagnosis)
- Promotion of seismic retrofitting according to diagnostic results

Seismic Retrofitting

(a) Seismic retrofitting of old buildings became an important issue in Japan, while building regulation does not require buildings, which were constructed with old codes, to meet current codes other than the cases of extension of a building, etc.

(b) In 1995, Great Hanshin-Awaji Earthquake hit Kobe city and surrounding regions,

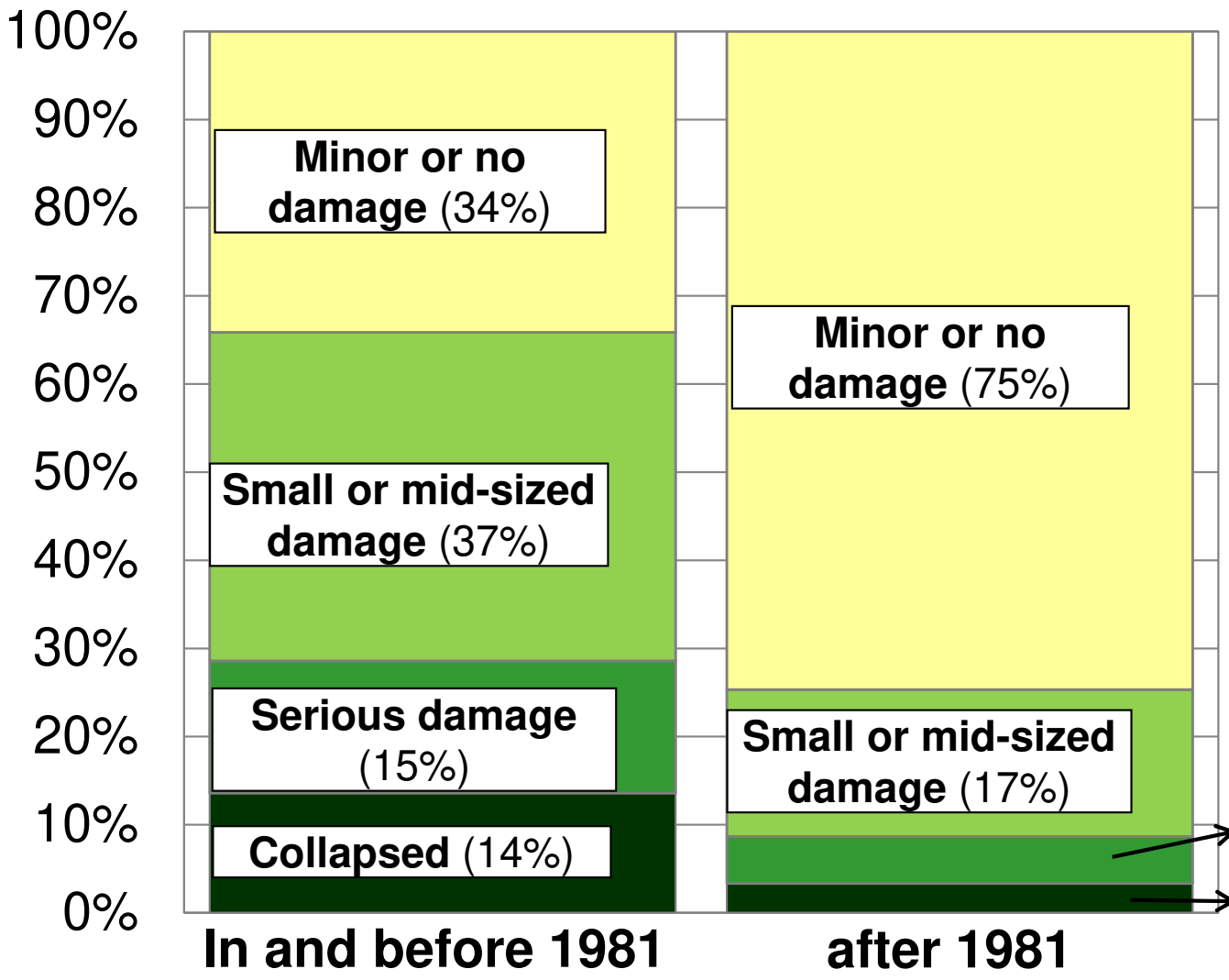
- 249,000 buildings collapsed or severely damaged
- 6,433 persons dead or missing.

It is estimated that **80 % of the deaths** were due to **falling buildings or furniture**.

(c) Most of the collapsed buildings were those which were constructed **before 1981**, when the new seismic building regulations were enforced.

(d) Japan established **the Act on Promotion of Seismic Retrofitting of Buildings** in 1995. Seismic retrofitting of old buildings are promoted with various administrative measures, such as subsidies.

Difference of damages due to the construction year - the Great Hanshin-Awaji Earthquake (1995) -



→ **Around 90 % of victims were killed due to falling buildings or furniture.**

→ **Damage to buildings was mostly concentrated in buildings that were constructed in and before 1981.**

Source: Interim report of the Construction Damage Investigation Committee Relating to the 1995 Great Hanshin-Awaji Earthquake

Act for Promotion of Seismic Retrofitting of the Buildings

National Government's Policies
Basic policies, Numerical targets

Local Governments' Promotion Plans
Action Plan, Numerical Targets, Designation if emergency roads

Restrictive Measures

- Guidance, Advice
- Instruction, Announcement
- **Mandatory seismic assessment , Publication of seismic assessment results**

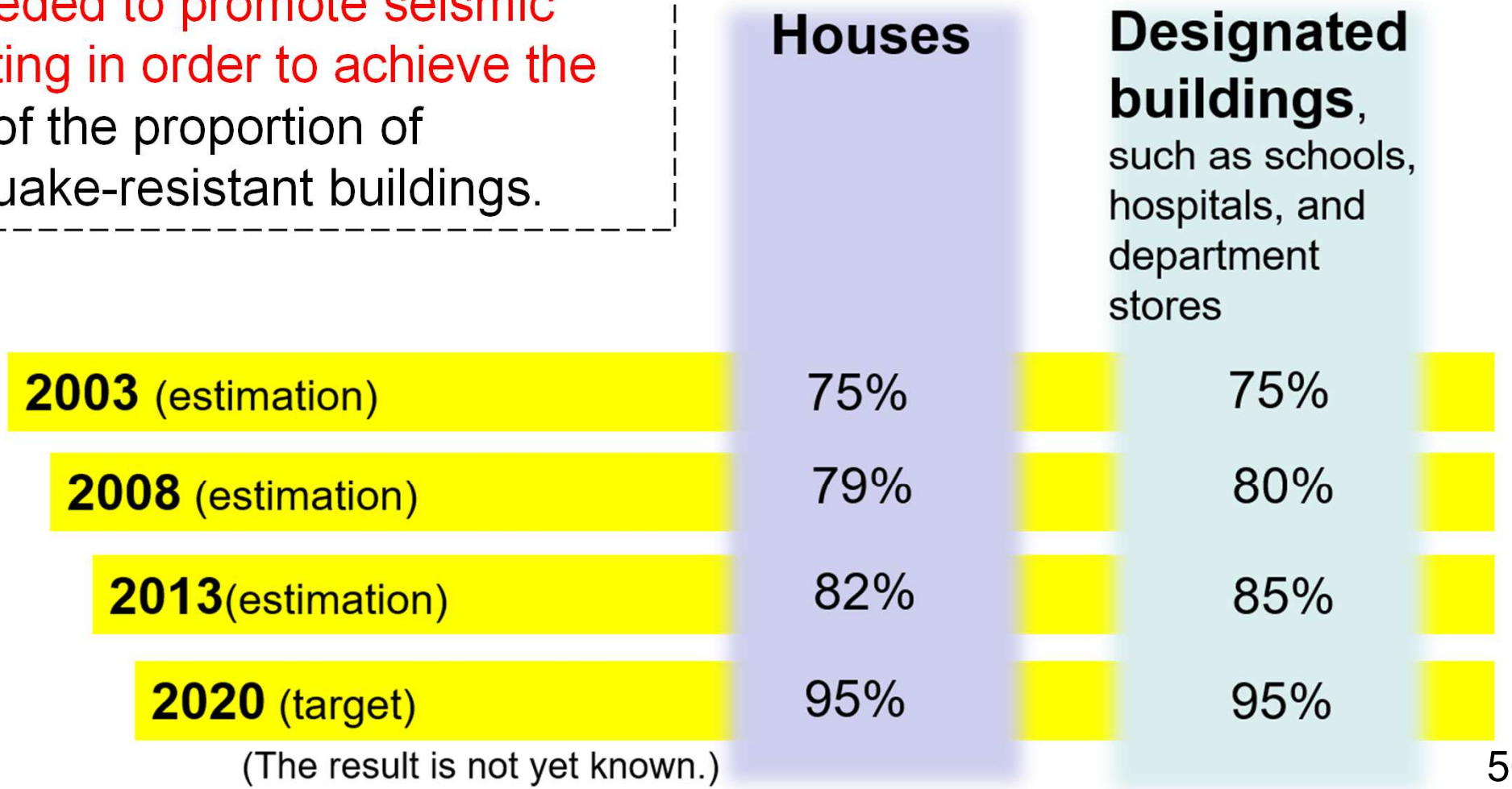
Promotional Measures

- Certification of the Seismic Retrofitting Plan (Special Measures of FAR, BAR, etc.)
- Indication System regarding Earthquake Resistance Performance
- Seismic Retrofitting Support Center

Promotion of earthquake-resistant buildings

Earthquake-resistant buildings
("Earthquake-resistant" represents "meeting to seismic code of 1981".)
It is needed to promote seismic retrofitting in order to achieve the target of the proportion of earthquake-resistant buildings.

Target and goals for proportion of earthquake-resistant buildings



(The result is not yet known.)

Points of recent amendment of the Act for Promotion of Seismic Retrofitting of Buildings

- ✓ **Mandatory seismic assessment**
- ✓ **Publication of seismic assessment results**

Target buildings of seismic assessment	**Deadline of seismic assessment**
(A) Large buildings used by **many unspecified people**, such as **hospitals**, **department stores**, and **hotels** (B) Large buildings used by **underprivileged people for evacuation**, such as **elementary schools**, **junior-high schools**, and **home for the aged**	Until the end of 2015
(C) **Tall buildings along the designated emergency roads** (D) Buildings used for a **disaster prevention center**	Until the date determined by the local government

Subsidy to Promote Seismic Assessment and Seismic Retrofitting

Objective buildings of seismic assessment	Subsidy for seismic assessment	Subsidy for seismic retrofitting
(A) Large buildings used by **many unspecified people**, such as **hospitals**, **department stores**, and **hotels** (B) Large buildings used by **underprivileged people for evacuation**, such as **elementary schools**, **junior-high schools**, and **home for the aged**	**Max;10/10** <1/3>	**2/3** <11.5%>
(C) **Tall buildings along the designated emergency roads** (D) Buildings used for a **disaster prevention center**		**4/5** <->

<Remark>

1. **Ratio in the table** indicates subsidy ratio in case where National Government and the local government jointly give subsidy. They pay half each.
2. **Ratio in the angle bracket** indicates subsidy ratio in case where National Government only gives subsidy, and the local government does not give subsidy.

Tax Incentive and Loan System to Promote Seismic Retrofitting

	Object	Content
Tax Incentive	**Houses**	・Deduction of 10% of seismic retrofit cost from Income Tax ・Partial reduction of Property Tax (1/2 for 1 year)
	Buildings (※1)	・Special depreciation of 25% of the acquisition price from Income Tax ・Partial reduction of Property Tax (1/2 for 2 years)
Loan System	**Houses**	・Low interest loan of 10 million yen from JHF**(※2)** (For individuals) ・Low interest loan of 5 million yen for each houses from JHF (For apartment management association)

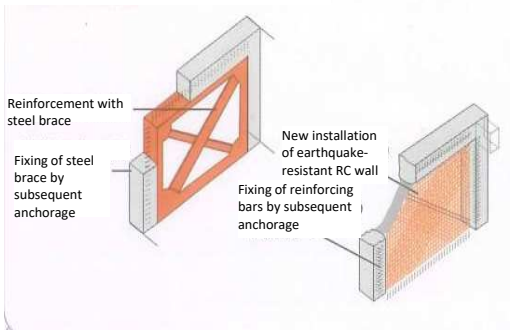
※1 Buildings that require seismic assessment
※2 Japan Housing Finance Agency

Seismic retrofitting methods for structures

Seismic strengthening

Addition of seismic walls, new construction of braces, reinforcement of columns and beams

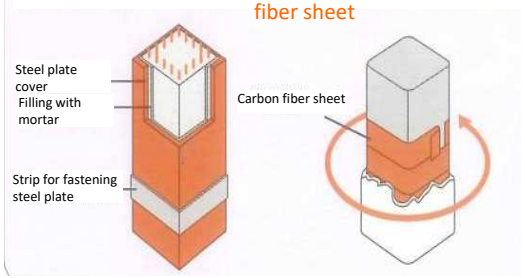
Reinforcement of walls



Reinforcement of columns

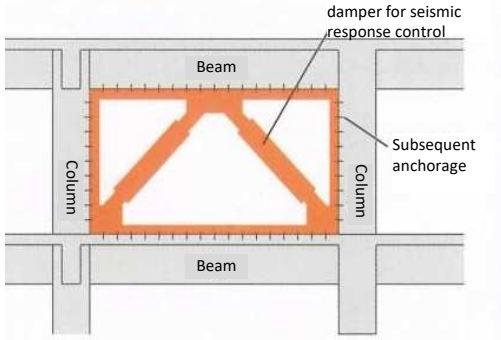
Reinforcement by covering with steel plate

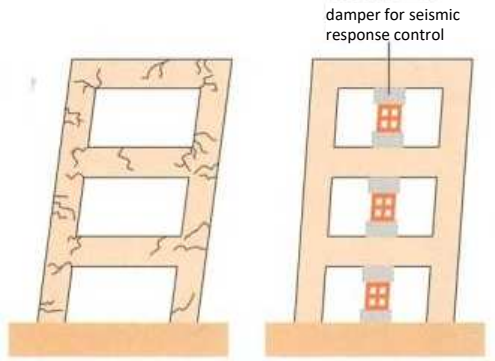
Reinforcement by wrapping with continuous carbon fiber sheet



Seismic response control

Installation of dampers for seismic response control, etc. to reduce propagation of seismic force to structures



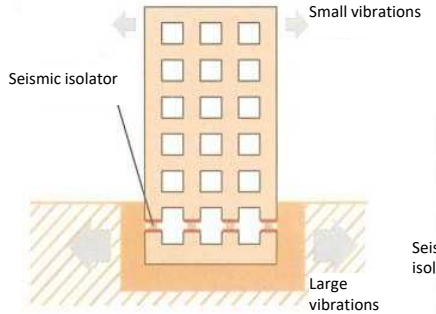


Not reinforced

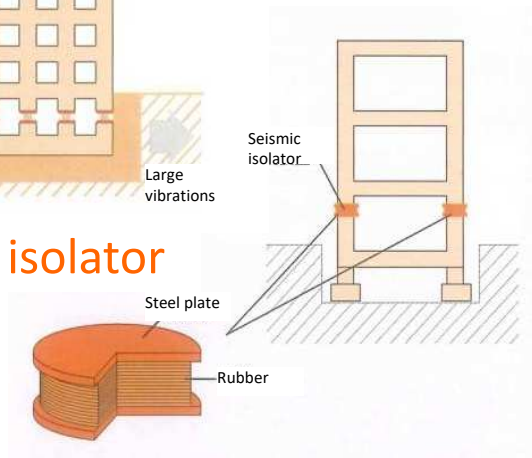
Reinforced

Seismic isolation system

Installation of seismic isolators under foundation or on intermediate floors to drastically reduce propagation of seismic force from the ground to structures



Seismic isolator



1. Regulatory System
2. Building Code
3. Seismic Retrofitting
4. **Disaster Prevention and Ensuring the Continuation of Building Functions**

Improvement of Earthquake Resistant Performance of Buildings and Disaster Prevention Measures

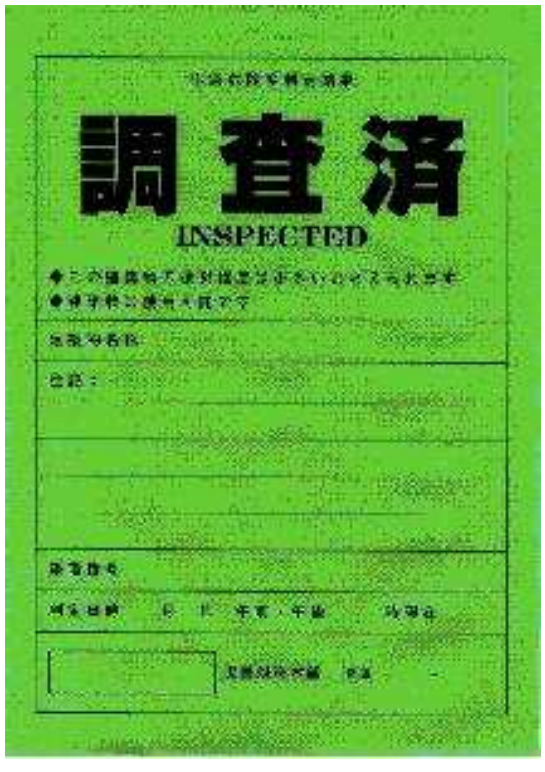
- **Before Disaster (Risk Reduction)**
  - Earthquake resistant design in new buildings
  - Seismic diagnosis and seismic retrofitting of existing buildings

- **Immediately After Disaster (Emergency Responses)**
  - Emergency risk assessment of damaged buildings
    （prevention of secondary disaster）
  - Securing of living environment of the refugees

- **After Disaster (Recovery and Reconstruction)**
  - Damage analysis
  - Review of seismic codes

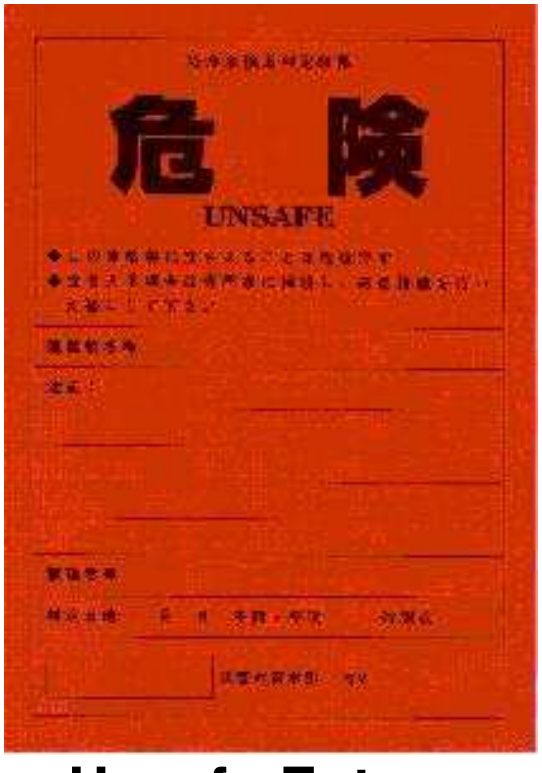
Emergency Risk Assessment of Damaged Buildings

Protection of people from a **secondary disaster** due to aftershocks or damage from first strike



Inspected: Usage possible

Limited Entry: Caution needed



Unsafe:Entry prohibited

(Example) Great East Japan Earthquake in 2011

Unsafe	11,699 cases (12%)
Limited Entry	23,191 cases (24%)
Inspected	60,491 cases (63%)

Procedures of Emergency Risk Assessment of Damaged Buildings

- Public sector organizes seminars to train Kenchikushi inspectors and registers them as volunteers.
- Inspectors evaluates the damaged buildings in a very short time soon after an earthquake strikes, inspecting exterior appearances of the damaged buildings.
- Then stick placards on the damaged buildings, indicating “Unsafe”, “Limited Entry”, “Inspected”.

(Source : Japan Council for Quick Inspection of Earthquake Damaged Buildings)

Review with consideration of building damages in the Great East Japan Earthquake 2011

(1) **Seismic damages to structural elements of buildings**

Some of the buildings, which were designed before 1981 with the old seismic design method, suffered from major seismic damage, mainly because of shear failure of columns. **Current seismic codes basically worked well.**

(2) Seismic damages to non-structural elements of buildings

Damages to non-structural elements, such as suspended ceilings, were observed.
The MLIT reviewed previous regulations on suspended-ceilings to strengthen the requirements.

Fall of suspended ceilings

(3) Seismic damages to high-rise buildings (long-period seismic motions)

Some high-rise buildings swung with large lateral displacement because of the long-period seismic motions. Then, it caused damages, such as trapping people in the elevators and clacks at many places.
The MLIT is reviewing countermeasures in structural calculation for high-rise buildings and base-isolated buildings, such as **using earthquake motion including elements of long-period seismic motions**, in reference to the earthquake motion records of the Great East Japan Earthquake.

(4) Tsunami-induced damages to buildings

(a) Many **wooden houses** were washed away by tsunami.

(b) On the other hand, some **RC buildings** withstood tsunami wave, and helped the people to vertically evacuate.

(c) **”Structural Design Method from the Viewpoint of Structural Safety against Tsunami”** was reviewed based on the lessons of the Great East Japan Earthquake. The structural design method will be utilized for:

- Designation of **tsunami evacuation building**, and
- Structural requirements to the buildings in the **tsunami hazardous areas**.

Tsunami evacuation building that withstood tsunami

- 200m from the coast
- Flood water depth was more than 13m.

Technology Development for Continuing the functions of the buildings

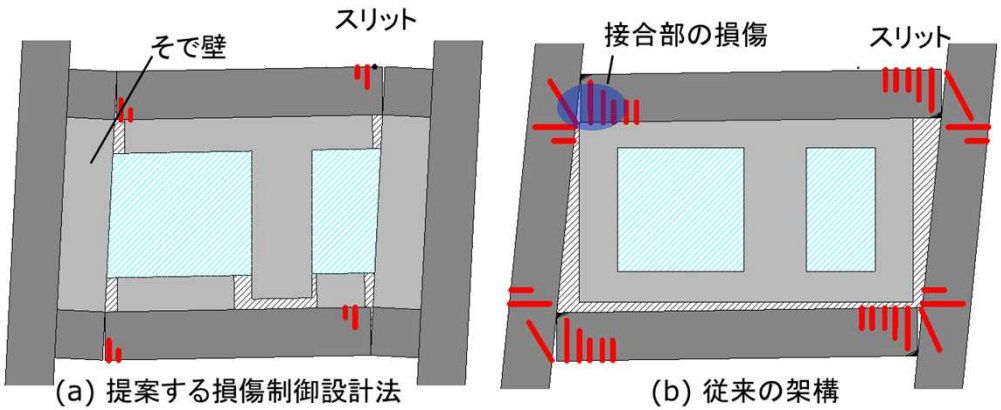
In the Great East Japan Earthquake(2011), some local government buildings suffered severe damages caused by earthquakes and tsunamis.

⇒

MLIT conducted the General Technology Development Project, to develop technologies that enable **buildings to serve as a base for an emergency disaster response center** such as local government office buildings.

Minami-sanriku town government building damaged by Tsunami

◆ Structural Design Method for suppression the deformation of the frame(Utilize the walls around the openings to increase the rigidity of the building)



(a)Frame Image by Damage Control Design
(b)Frame by traditional design

Loading test of a full size 5-floor RC building using walls to reduce damage during earthquakes

◆ Tsunami-Resistant Structural Design by considering falling off the outer wall

Runoff of outer wall of lower floor by tsunami

Falling off the wall in hydraulic experiment

Guideline for Continuing the Functions of Buildings for Disaster Bases

In the Kumamoto Earthquake(2016), some buildings, which were not destroyed or toppled , suffered partial but **serious functional damages** caused by seismic vibration.

Damaged Local Government building in Kumamoto

Based on these experiences, MLIT drew up the **Guideline for Continuing Functions of Buildings for Disaster Bases** .

<Some Disaster Bases examples>

Anan city hall

Iwaki city disaster prevention center

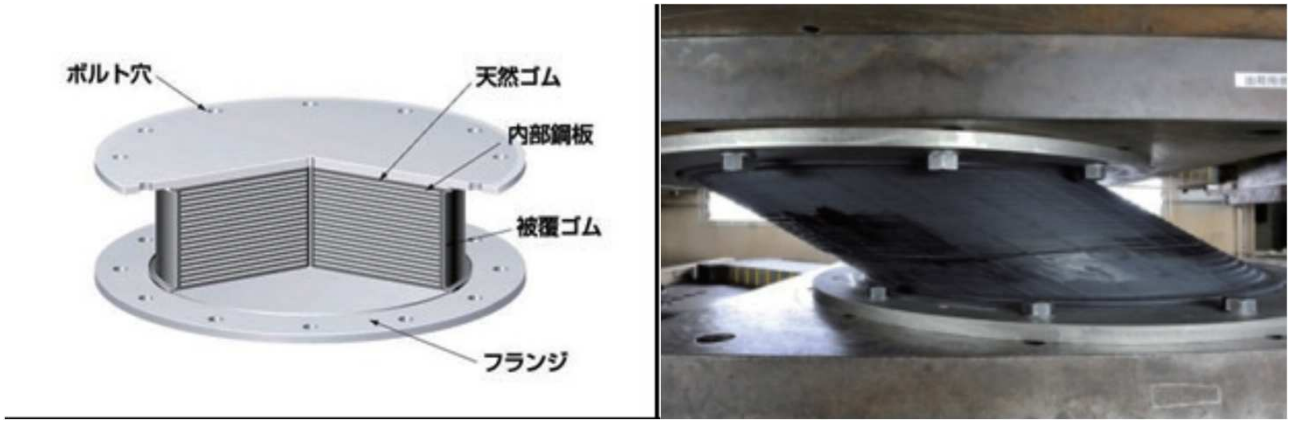
Guideline for Continuing the Functions of Buildings for Disaster Bases (Example of Content)

Item	Examples of Content
Location Planning	・To select the site with lower risk of large-scale earthquake.
Architectural Planning	・To assure necessary room, facilities, etc. ・To allocate Disaster Emergency Room on the floor with small risk of functional problem.
Structural Planning	**・To keep the deformation of structural frame within the specific range. Seismic isolation structure is effective .** **・To make the non-structural elements follow to the deformation of the structural frame.**
Equipment Planning	・To make the building equipment follow to the deformation of the structural frame. ・To assure the energy supply, water supply, improve the correspondence with temporary power supply.
Preparation from normal times	**・To make clear the procedure of inspection and judgment of availability of the building.** ・To make clear the procedure of operation of alternative equipment, connection with temporary power supply, water supply, etc. and make them known to users of the building. **・Considering to adopt Structural Health Monitoring System**

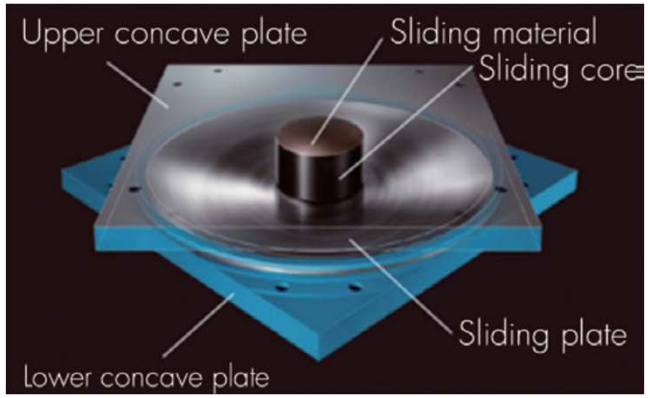
Seismic Isolation Devices ① Isolator

In Japan, there are many types of **isolators**, such as **laminated rubber-bearing** , **spherical slider** and **roller bearing** .
Some types of isolators have damping function, such as lead rubber-bearings, high-damping rubber bearings and sliders.

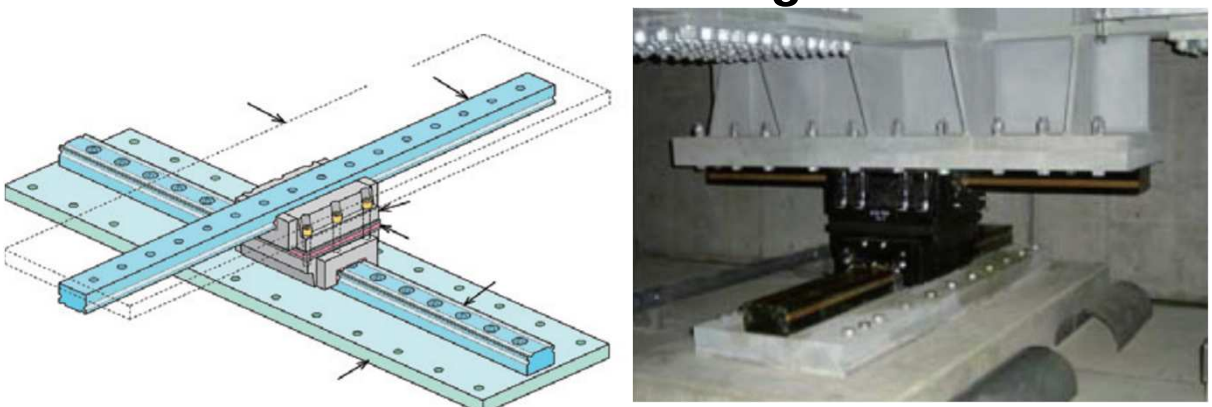
Laminated rubber-bearing



spherical slider



Roller bearing

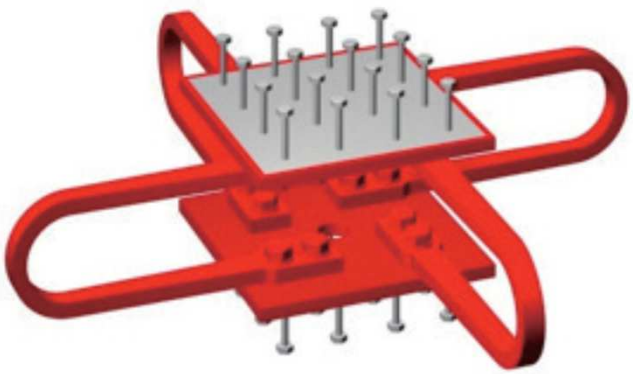


(Japan Society of Seismic Isolation)

Seismic Isolation Devices ② Damper

Dampers are typically metallic devices of steel or lead , fluid dampers, using soft, sticky (viscous) fluid, such as oil , and friction dampers.

Steel damper



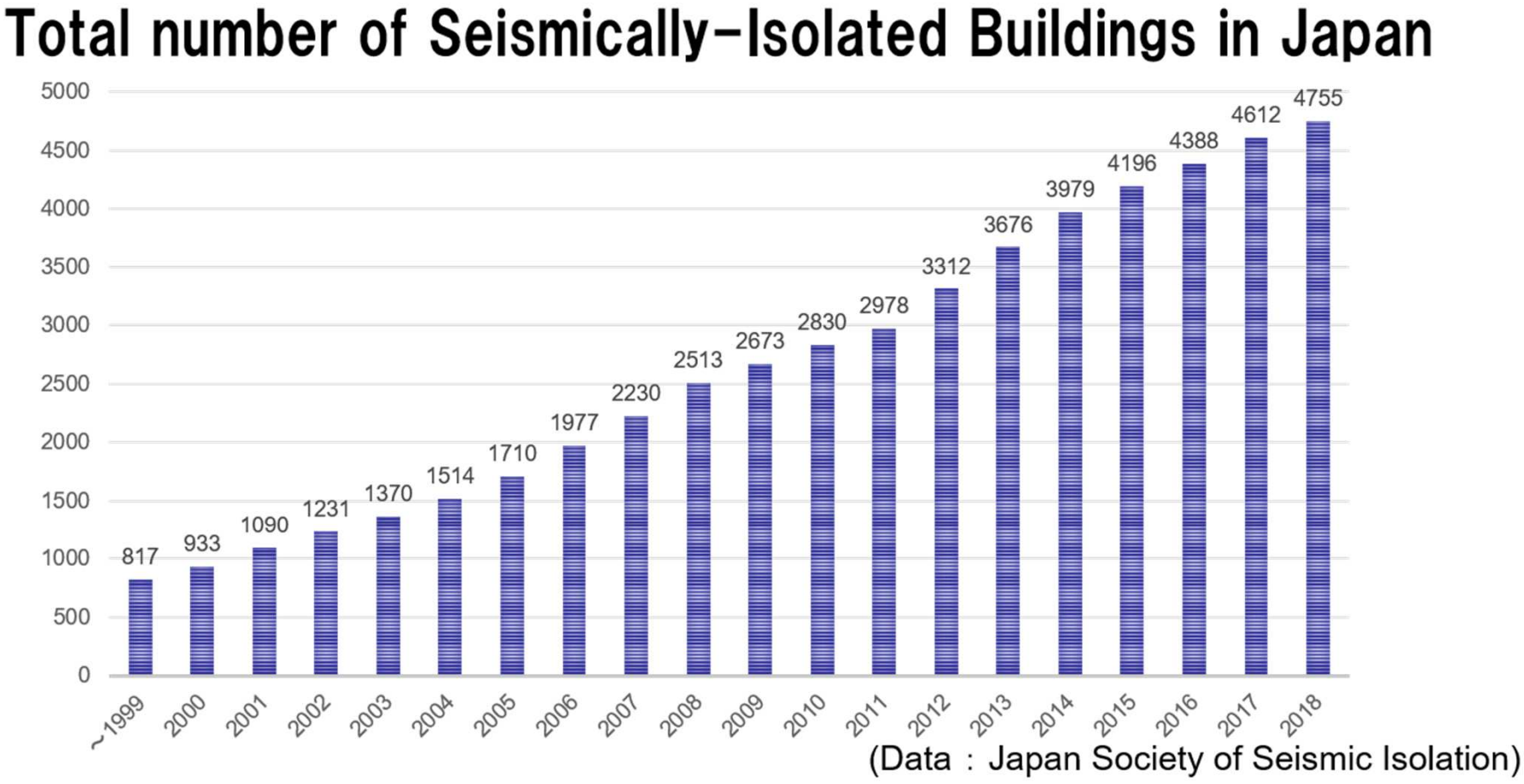
Lead damper

Oil damper

(Japan Society of Seismic Isolation)

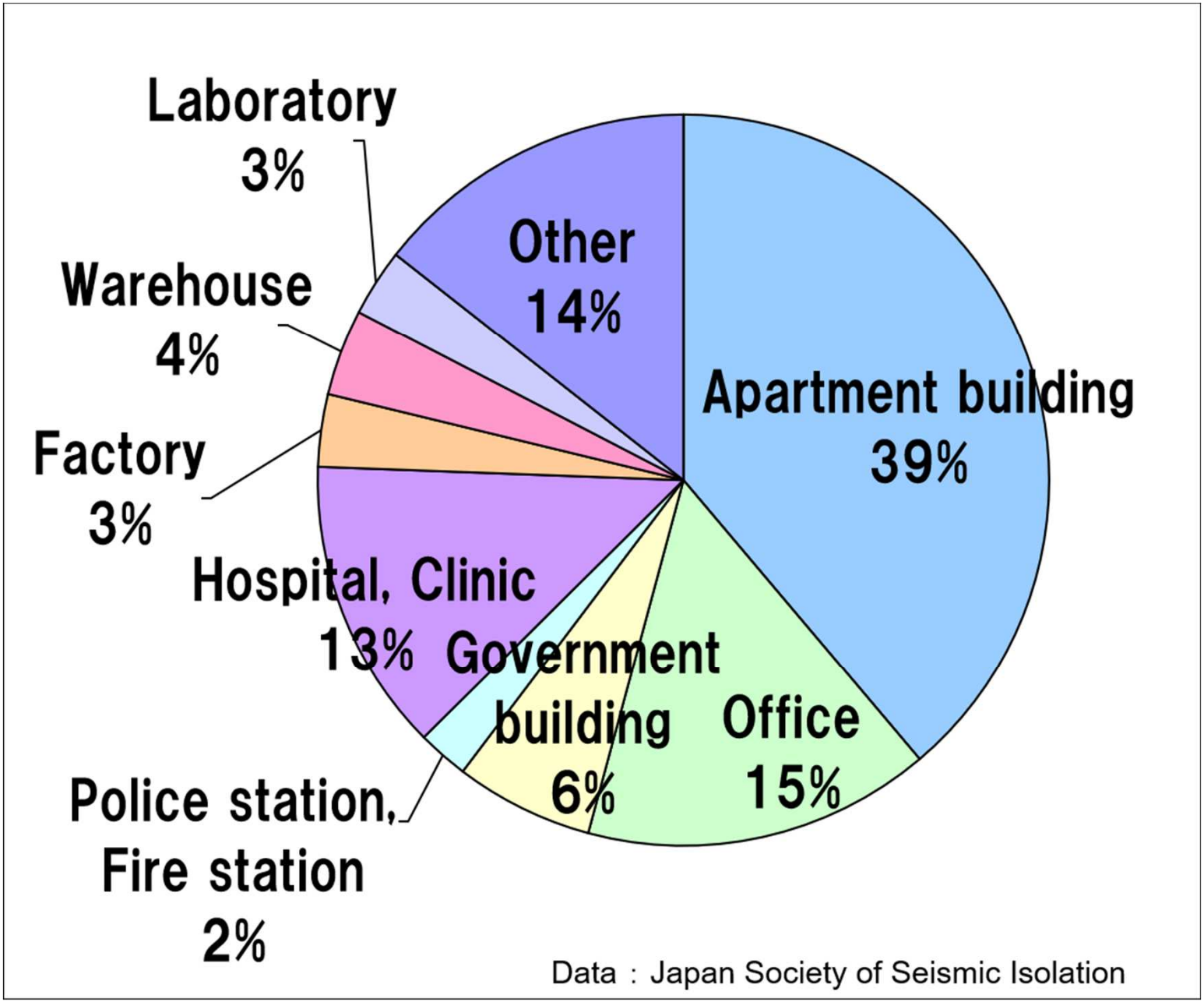
Increase in Seismically Isolated Buildings

Seismic isolation system has become more widespread in recent years in Japan, including as **retrofits of existing building**, and in a wide variety of different applications for new buildings.



Variety of application of Seismically Isolated Buildings

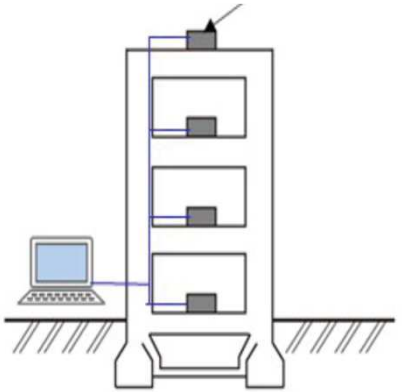
Percentage of Seismically-Isolated Buildings in use



Structural Health Monitoring of Buildings

Structural Health Monitoring System

Analyzing the damages of buildings with the information given by **accelerometers** installed in the buildings, the system will provide information on the damage status and seismic safety of buildings by quickly grasping the shaking and deformation amount of the building.



Earthquake occurs

Accelerometers measure the shaking of building

Analyze damage status

Diagnose the damage situation of the building

Building manager can help determine the necessity of evacuation after the disaster and whether the building can be used continuously.

Thank you for your attention

ありがとうございます

Рахмат сага