Sharing the Japanese experience towards Build Back Better Recovery and Reconstruction

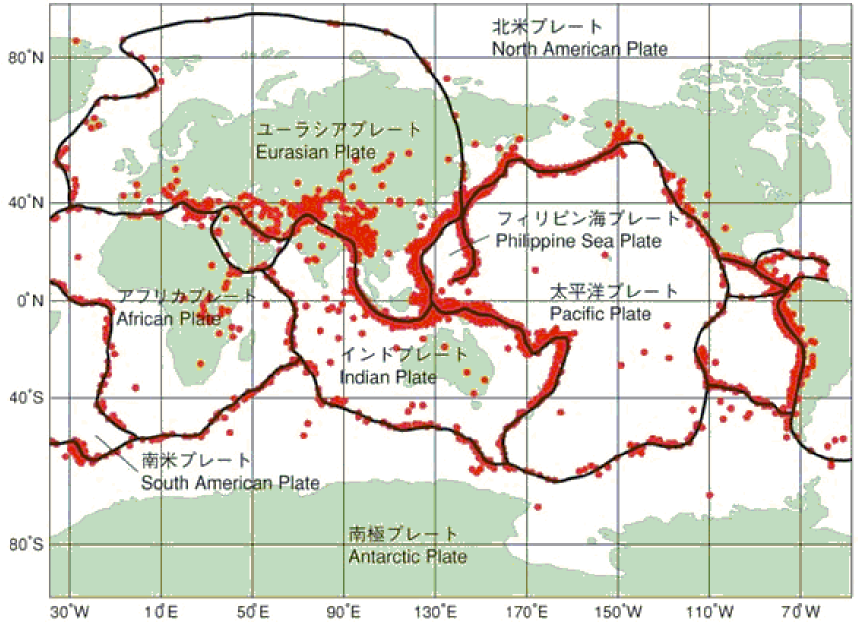
23 Jan. 2025@Port Vila Vanuatu

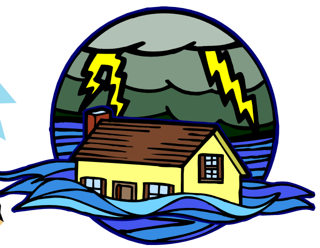
Satoru NISHIKAWA Ph.D
JICA Senior Advisor(Disaster Reduction Strategy)
Professor, Tohoku University IRIDeS

Japan International Cooperation Agency

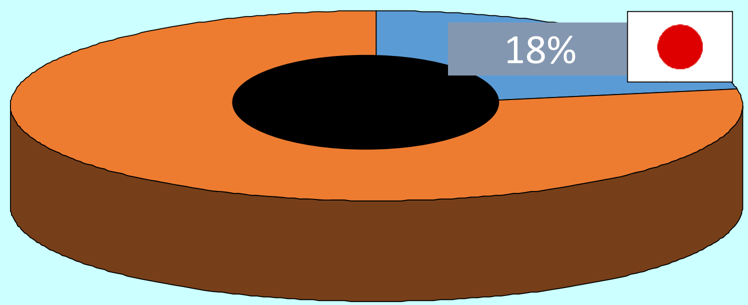
Mother Nature is not Gentle in Japan !

- **Earthquakes**
- **Tsunamis**
- **Volcanic Eruptions**
- **Typhoons**
  (July – October)
- **Heavy Monsoon Rains**
  (May – July)
- **Floods**
- **Landslides**
- **Snow Avalanches**





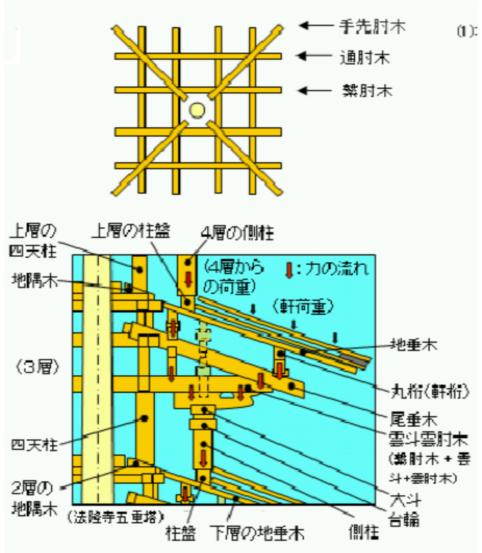
Number of earthquakes with magnitude of 6.0 or larger (2011-2020) Japan's Unfair Share



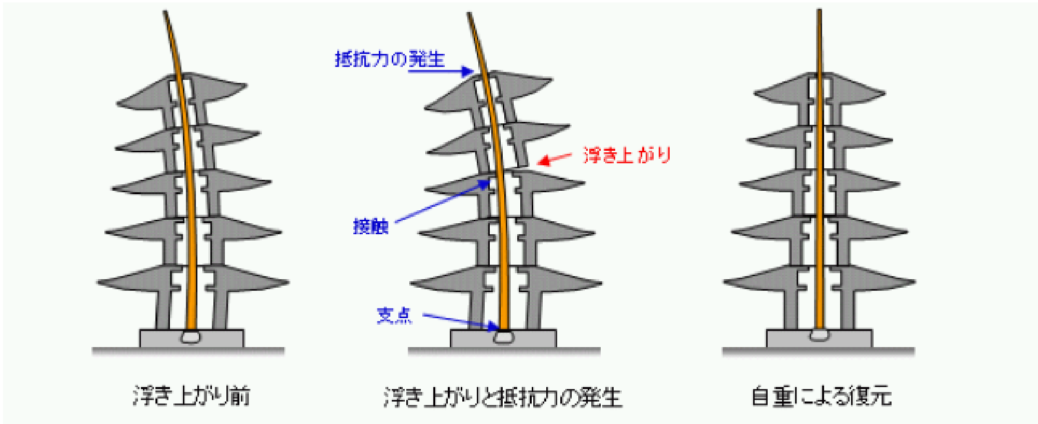
Pagoda of Horyuji Temple built 680A.D.
The Oldest Wooden "High-Rise" Building in Japan withstood numerous Earthquakes over the Centuries

5 layered, 32m high

Combination of semi-flexible timberwork joints and a central wooden pillar disperses and absorbs earthquake shocks



層の構造の詳細

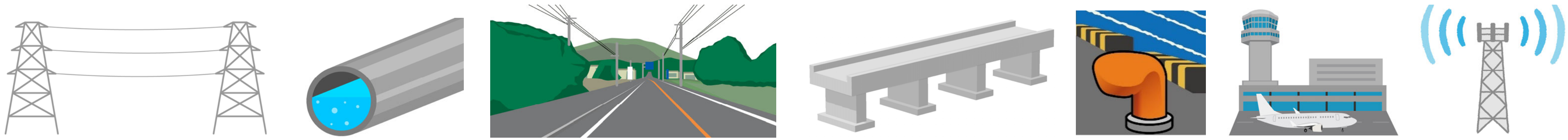


Traditional “UKIYOE” drawing after 1855 October Ansei-Edo Earthquake

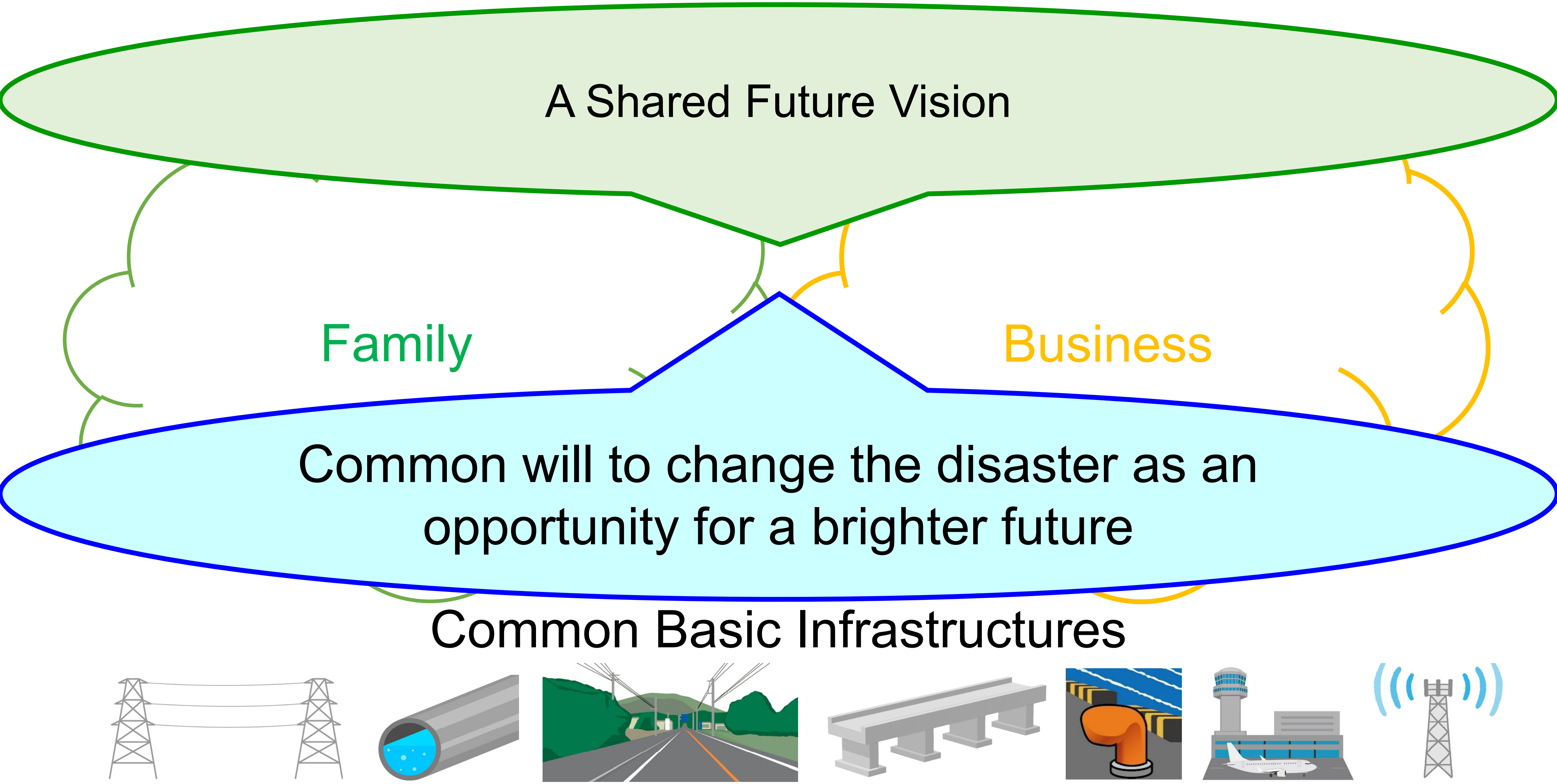
Edo (Old name of Tokyo) citizens beating the legendary Catfish Monster which was believed to cause earthquake

How can we Build Back Better?

Common Basic Infrastructures

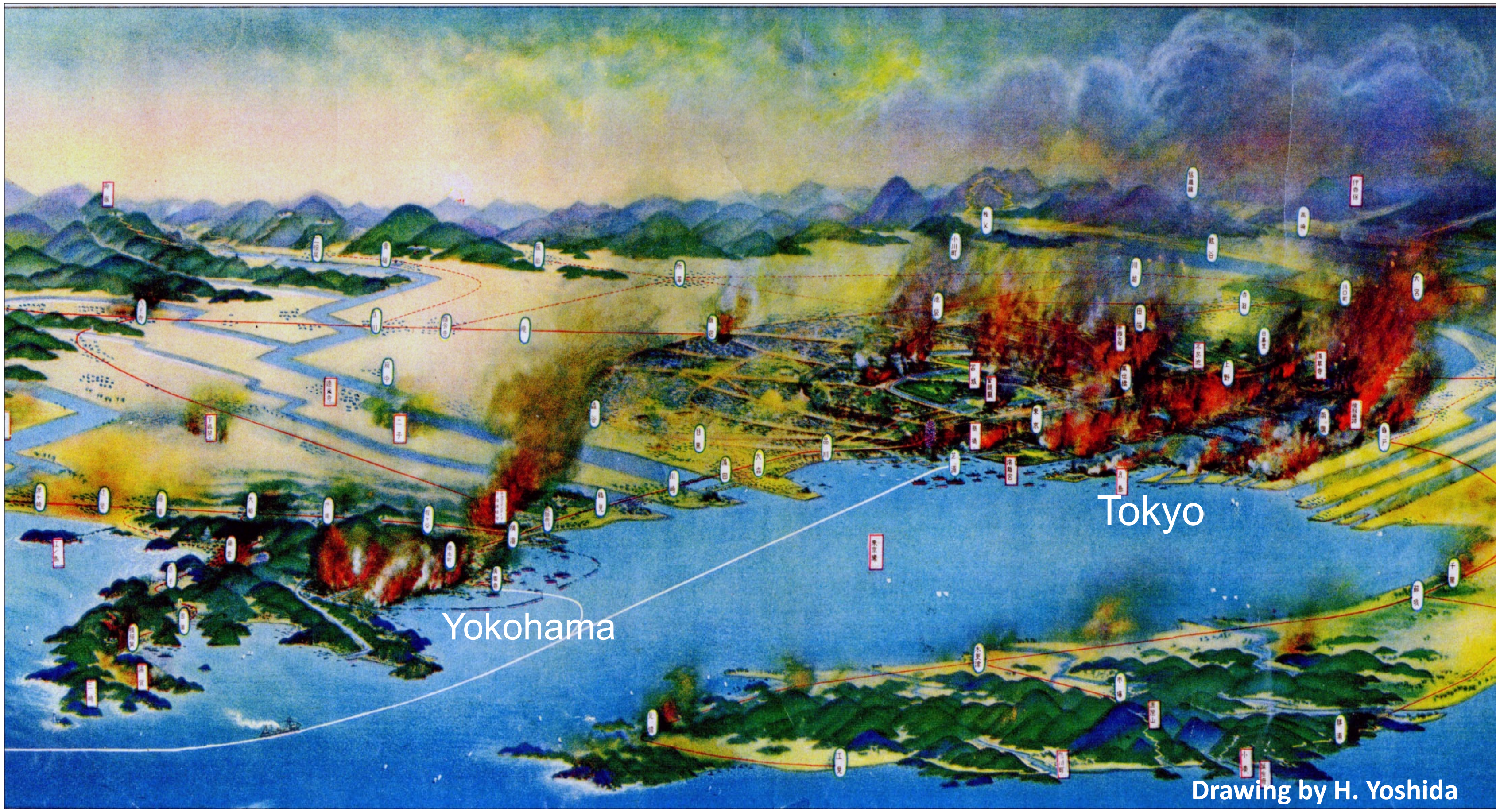


How can we Build Back Better?



1923 Great Kanto Earthquake destroyed Tokyo & Yokohama

M7.9 Sagami Trough Earthquake on 1 Sept. 1923



105,000 Casualties, approx.40% of GDP of Japan lost

Numerous City Fires resulted in Huge Casualties

fire whirlwinds at Honjo Hifukusho

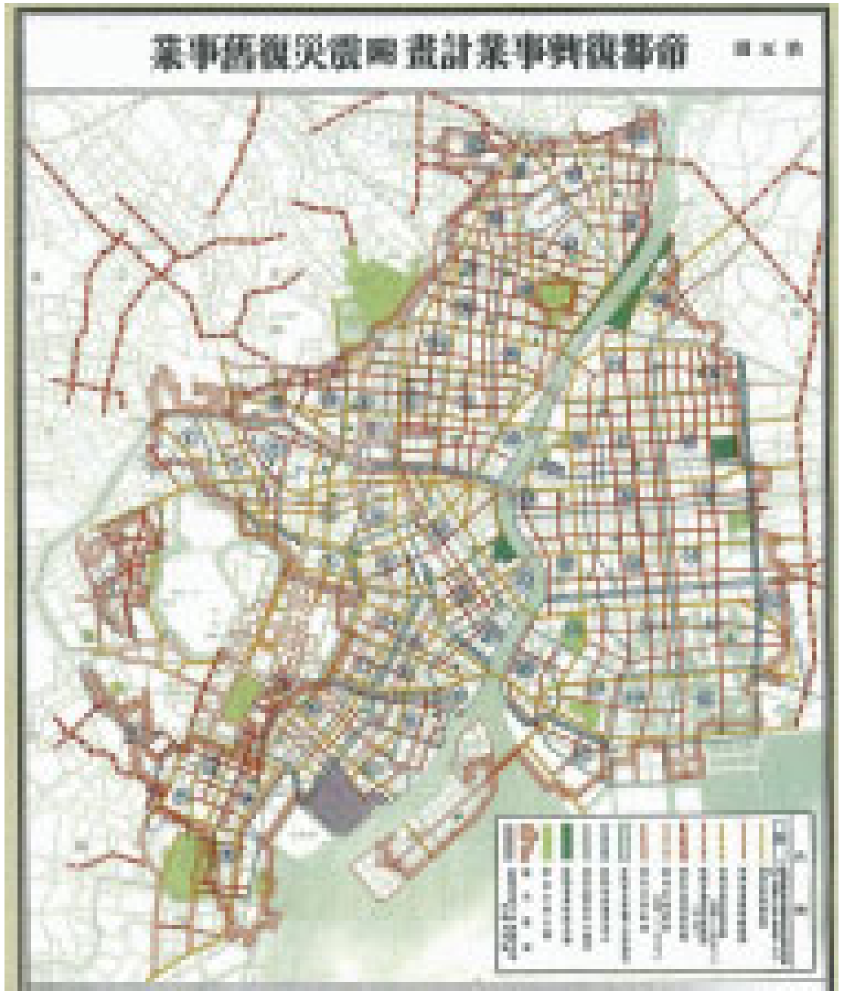
Why was Tokyo devastated by this Earthquake ?

In 1868, Edo became Tokyo, the new Capital of Japan, inheriting the old Edo feudal city structure, but the new concentration of population and industry resulted in a congested city sitting on soft ground without sufficient road infrastructure.

CBD of Tokyo before the Earthquake

Ginza, Nihonbashi, Kanda before the Earthquake, narrow winding roads, bare wooded houses densely built up.

Reconstruction of Tokyo after 1923 Great Kanto Earthquake
Grand Master Plan by Dr. Shinpei GOTO



Criticized as "Big Mouth", "big pipe dreamer"

Wikimedia commons

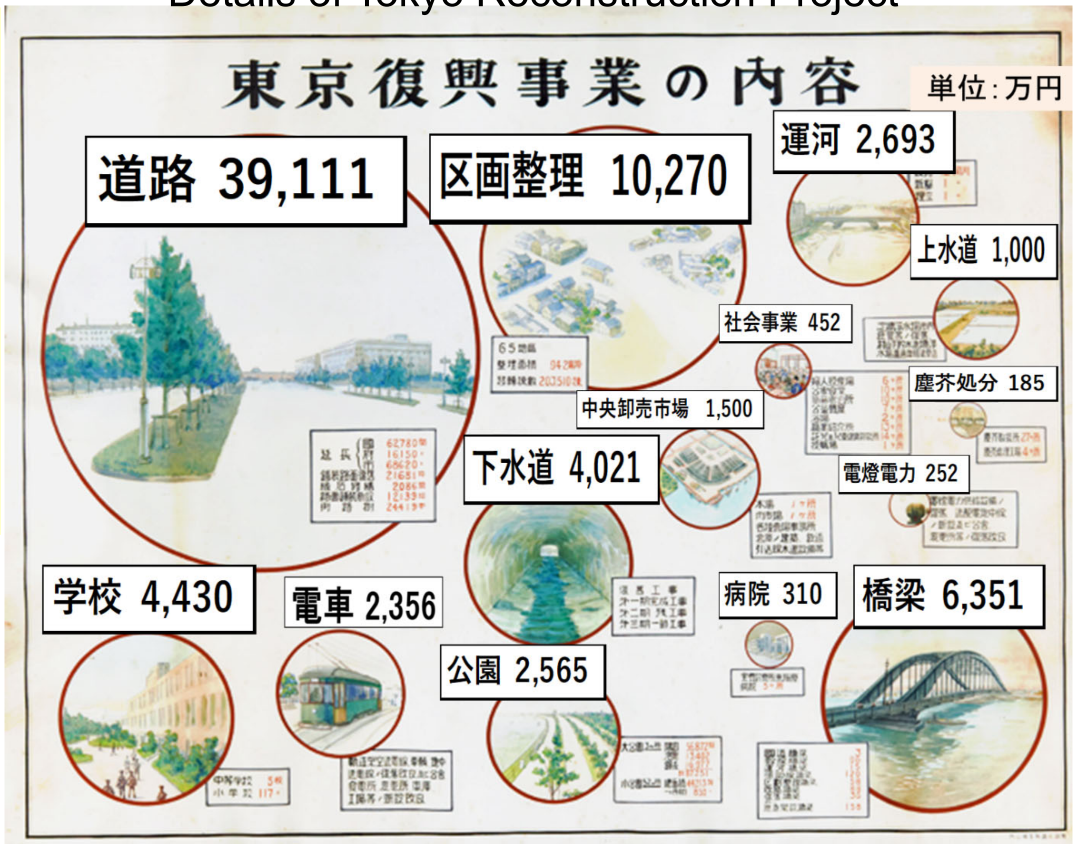
On 1 September 1923, the Cabinet was not formed due to political oppositions. Shinpei GOTO was one of the big political figure, a possible prime minister. However at the news of the devastation by the EQ, he immediately volunteered to assist the interim Cabinet and led the Imperial Capital Reconstruction Agency.
His plan was initially sharply criticized as "out scaled" "unrealistic" . His plan later served as the basic structure of Tokyo today.

The Imperial Capital Reconstruction Project (1924-1930)

Citizens of Tokyo rose up together with Shinpei GOTO, with the motto: “We do not want to suffer that misery ever again!”

Objective of the project: Create the city as the capital of Japan which the people can be proud of, while ensuring earthquake and fire resilience, prioritizing the public interest under the national consensus.

Details of Tokyo Reconstruction Project

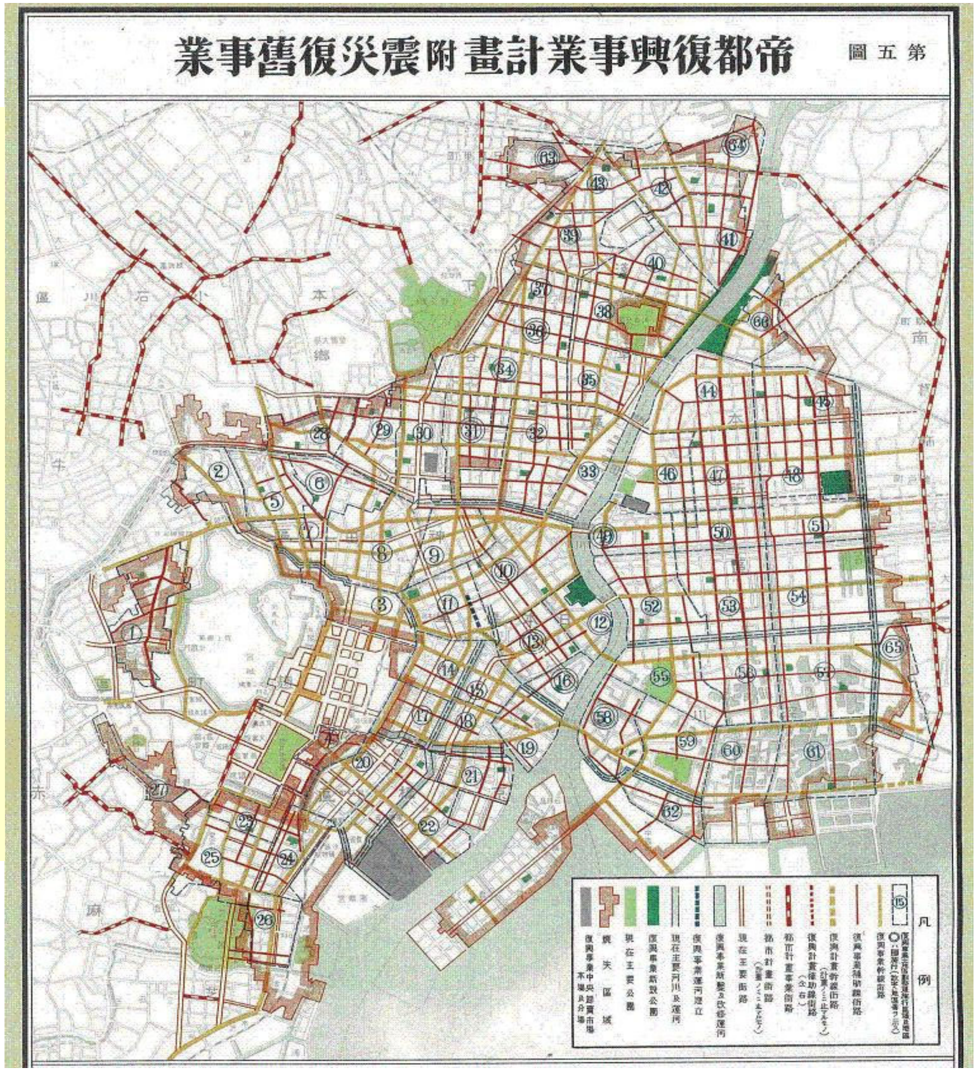


The total cost was about 724.5 million yen (about 4 trillion yen in current value)

From a poster on display at the Fukko Kinenkan (Great Kanto Earthquake Memorial Museum)explaining the details and costs of the Imperial Capital Reconstruction Project in Tokyo.

Land readjustment to secure safe streets and parks

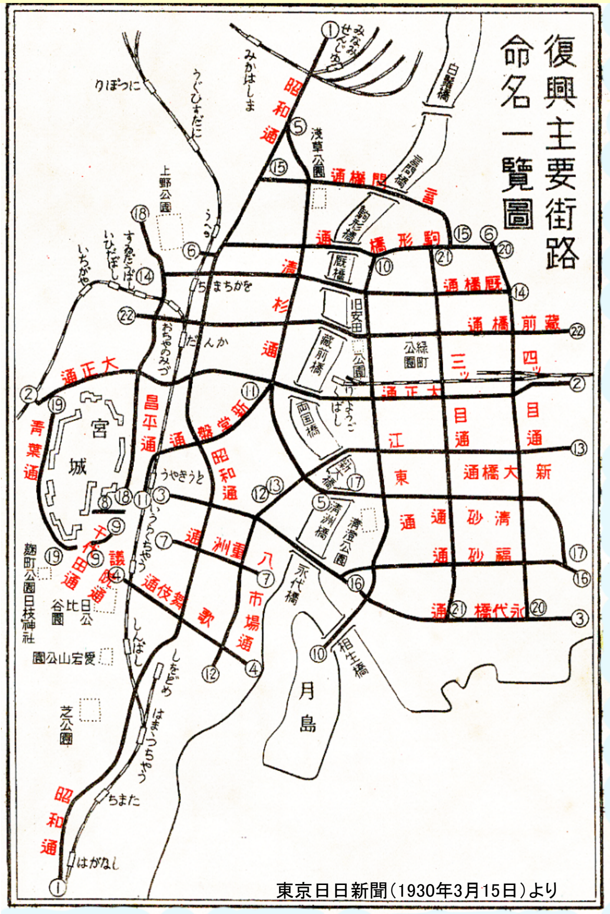
In order to avoid people having to move away from their communities, landowners were asked to donate 10% of their land.
Streets & parks were built using the donated land, and the remaining land was reallocated in proportion to the previous owned lots. If more than 10% of donation was required, the landowner was compensated for that amount.



Map of the Imperial Capital Reconstruction Project (City of Tokyo, March 1930)

Road Masterplan

National and arterial roads (>22m wide): 52 routes
Auxiliary roads in the City of Tokyo (<22m wide): 122 routes



22 major roads masterplan ←

Arterial road No. 1 Showa Dori Avenue → 44meters wide

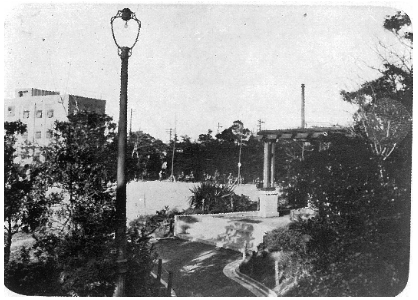
This Road Masterplan of 1924 is still the blueprint of modern Tokyo.

Construction of parks

Three major parks (Sumida, Kinshi, and Hamacho) were made by the national government and the City of Tokyo made 52 small parks.

Small parks were constructed next to elementary schools as a symbol of the community to solve the problem of limited space at elementary schools and to provide modern, recreational spaces for the general public to relax, when the children were not using them as playground.

Sumida Park (world-class riverfront park)



Small Parks (Tsukishima No. 1 and No. 2)

Hamacho Park and
Condor Memorial Tower

Japanese Cities faced various Disaster Risks by rapid population increase

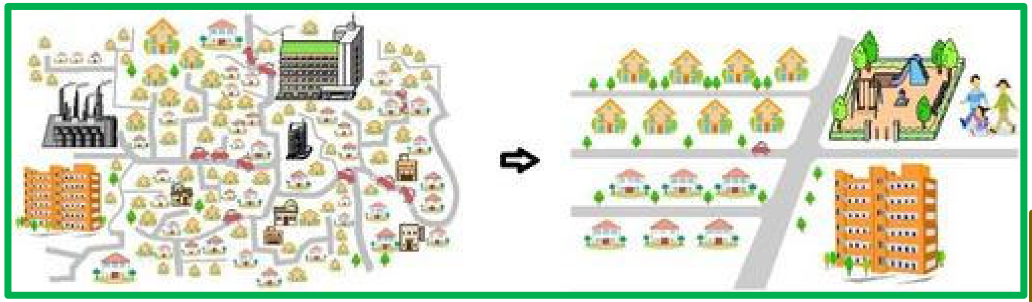
Massive densely populated area with wooden houses & narrow streets faced huge risk of urban fires.

Massive development of new housing by developers in Tokyo suburbs revealed numerous problems to environment and urban flooding in 1960s to 80s.

Sept.1974, Bank of Tama-river in Tokyo broke, 19 newly built houses washed away.

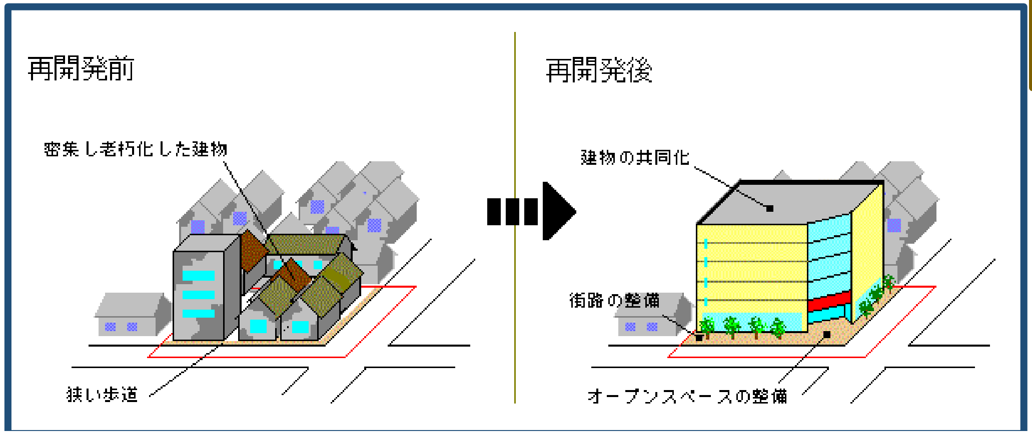
Disaster Reduction is a must for City Planning & Regional Development in Japan

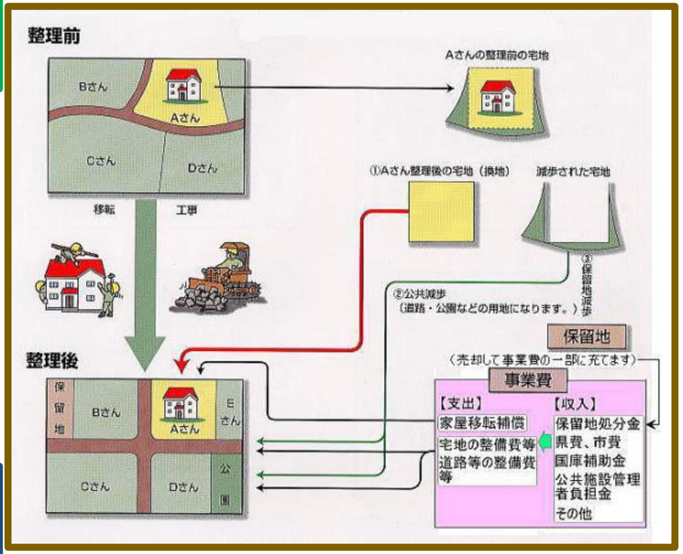
Efforts for better building control



City Ordinances for housing & land development are enforced to avoid disorderly neighborhoods.

Urban Redevelopment are implemented to secure safe space and better environment.





Land Readjustment are implemented to secure accessible streets and public space.

Severe Damage by Earthquakes(1945-1995)

Year	Earthquake (Magnitude)	Death Toll
1945	Mikawa Earthquake (M6.8)	2,306
1946	Nankai Earthquake (M8.0)	1,330
1948	Fukui Earthquake (M7.1)	3,769
1952	Tokachi-oki Earthquake (M8.2)	33
1960	Chile Earthquake & Tsunami (M8.5)	139
1964	Niigata Earthquake (M7.5)	26
1968	Tokachi-oki Earthquake (M7.9)	52
1974	Izu-hanto-oki Earthquake (M6.9)	30
1978	Izu-Oshima Kinkai Earthquake (M7.0)	25
1978	Miyagi-ken-oki Earthquake (M7.4)	28
1983	Nihonkai Chubu Earthquake & Tsunami (M7.7)	104
1984	Nagano-ken Seibu Earthquake (M6.8)	29
1993	Hokkaido Nansei-oki Earthquake & Tsunami (M7.8)	230
1995	**Hanshin-Awaji <Kobe> Earthquake (M7.3)**	**6,437**

Fukui Earthquake(M.7.1) 1948

3,769 casualties

内閣府防災災害教訓報告書

福井県資料

Wooden houses collapsed
caught fire

Tokachi-oki Earthquake(M7.9) 1968

52 Casualties

Collapsed RC buildings

Miyagi-ken-oki Earthquake(M7.4) 1978

Sendai City Experience

28 Casualties

Crashed concrete block wall

school children crushed to death

Pancake-collapsed building

Evolution of Japan's Anti-Seismic Building Code

1923 The Great Kanto Earthquake (M7.9: Tokyo devastated 105,000 dead)
1924 First Seismic Building Code
1948 Fukui Earthquake (M7.1: 3,769 dead)
1950 Building Standard Law
1968 Tokachi-oki Earthquake (M7.9: 52 dead)
1978 Miyagi-ken-oki Earthquake (M7.4: 28 dead)

1981Revision of Building Standard Law requirements:

- No damage against medium scale (JMA scale 5+) earthquakes,
- To be able to continue use after these medium earthquakes.
- No collapse & safety of people inside against large scale(JMA scale 6+ to 7) earthquakes

1995 Hanshin-Awaji(Kobe) Earthquake (M7.3: 6,347 dead)
1995 Revision of Building Standard (encourage metal reinforcement to wood joints)
2000 Revision of Building Standard (ground strength check made mandatory)

JMA scale 5+ ⇒ almost equivalent to Mercalli scale VII
JMA scale 6+ to 7 ⇒ almost equivalent to Mercalli scale VIII to IX

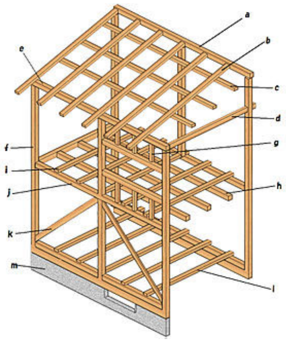
Enforcement of Building Safety Codes, How?

Inspection of Seismic Building Safety, Why Practiced in Japan?

Average worker needs long term housing loan to obtain his house. Approx. 5X of annual salary
Low interest loan by Government Housing Loan Corporation (established in 1950).
Aim of Government Housing Loan Corporation: to assist the improvement of housing quality.

Eligible for HLC loan or not: A big difference in loan interest.

Building Structure & Design Plan Inspection → Intermediate on-site Inspection → Final on-site Inspection → Certificate of Eligibility



Proof of Quality

Incentives to Build Houses according to Safety Codes

Condominiums for Sale in Japan

Inspected & HLC Eligible or not makes a big difference to consumers⇒Real Estate Developers will ask for Inspection

Seismic Building Standards + Policy Incentive

↓

Consumers to demand Seismic Building Standard fit Housing

↓

Create a Sense of Common Practice in the Housing Market

1995 Hanshin-Awaji (Kobe) Earthquake (M7.3)

Fire in a city center

Collapsed houses

Damaged office building

Damaged railway track

Collapsed viaducts of an expressway

6,437 Casualties

Old timber structure with heavy tile roofs collapsed, crushing residents to deaths, Blocked the streets.

Old RC structure condominiums built before 1981 collapsed

- Collapse of houses not only kills people inside,
- Loss of shelter,
- But also debris blocking streets & reconstruction
- Existence of debris depress the affected population.

Kobe Municipal Government Headquarter

Lesson1: Collapse of old houses built before 1981 standard was the main cause of death

5,520 direct deaths (+917 relevant deaths)

total 6,437 victims

83% immediately killed by building collapse

surgeon general's autopsy report

Prevention & Mitigation

Preparedness

Ensure Building Safety !

Public Awareness

Disaster Manager's Proper Action

1995 new Act on Seismic Retrofitting of Existing Buildings

Public awareness campaign on housing seismic safety

Public campaign on affixing furniture and room safety

更新

Act on Promotion of Seismic Retrofit of Buildings

Formulated and Revised based on bitter lessons from deadly earthquakes

1995 Hanshin-Awaji Earthquake ⇒1995 New legislation

2004 Niigata Chuetsu Earthquake ⇒2006 1st revision:

National Gov't to indicate policy target for seismic retrofitting, Local Gov'ts to formulate their own seismic retrofitting policy/plans

Enabled Sendai City to formulate Earthquake Resilience Policy in 2008

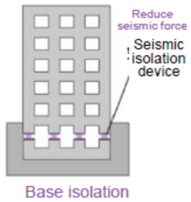
2011 Great East Japan Earthquake ⇒2013 2nd revision:

Mandatory Earthquake Resistance Analysis & Disclosure of Large Commercial & Public-use Buildings

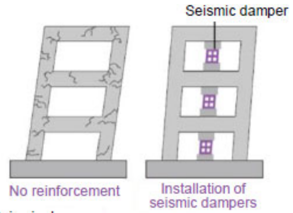
Seismic Retrofitting technology

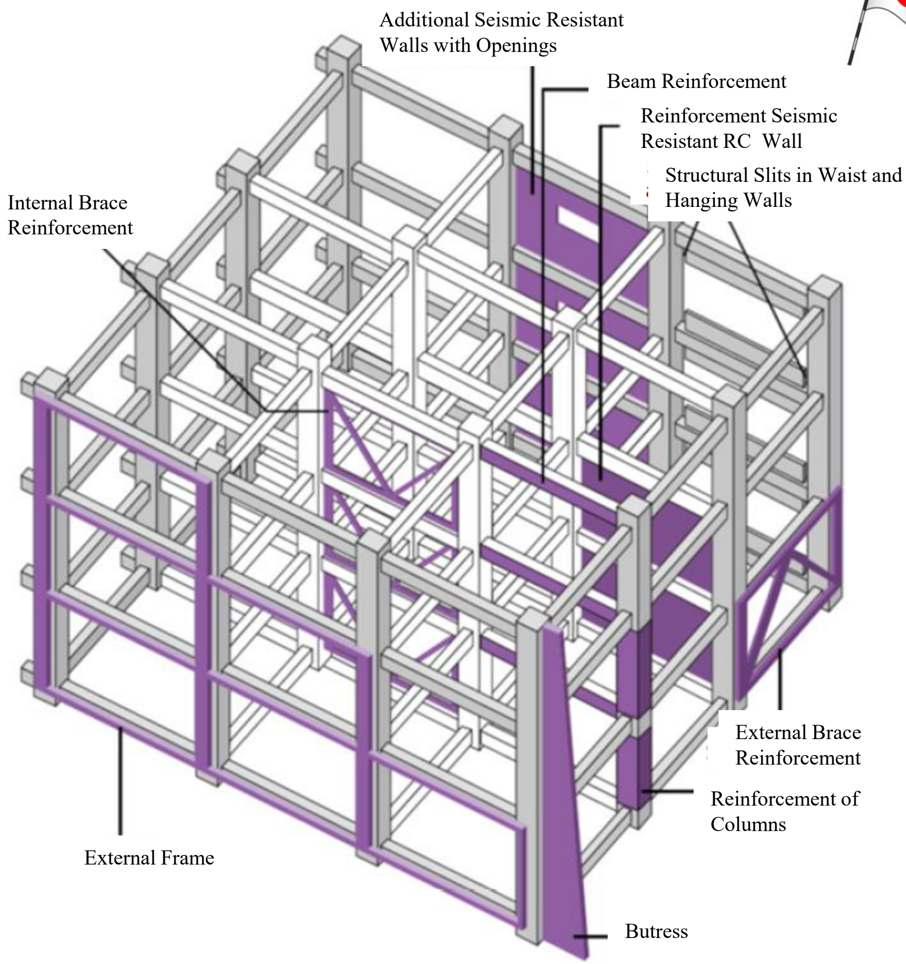
•<u>Seismic Reinforcement</u> is achieved by methods such as increasing the seismic resistance of walls, installing new external/ internal supports and frames, and reinforcing columns and beams.
+ Aditional Seismic Resistant Walls
+ Internal/ External Braces
+ Reinforcemtn of Columns/ Beams by Jacketing, Wrapping etc.
+ Adition of Butress/ External Frames
+ Structural Slits in Waist/ Hanging Walls
+ etc.

- <u>Seismic Isolation</u> reduces significantly the seismic force transmitted from the ground by installing seismic isolation devices below the foundations or on intermediate floors.



- <u>Seimic Vibration Control</u> reduces the seismic force transmitted to a building with damping devices, such as seismic dampers.





Based on the information by MLIT

Recent Ad of Wooden House Seismic Retrofit in Japan

Seismic Strength Joints

Vibration Control Damper

Lightweight & Tough Roof Tiles

Durable Outer Wall

Anti Termite Base Structure

Anti-Seismic Systematic Retrofit to withstand 6+ Scale Earthquake

People's Demand for Earthquake Safety Creates New Supply of Affordable Engineering Methods

Alternate methods for Seismic Retrofitting of Buildings

Great Need for Seismic Retrofitting of Existing Reinforced Concrete Buildings built before 1981 standard.

But

Many building owners do not have sufficient fund for rebuilding or full-speck seismic retrofitting.

Invention of new affordable retrofitting method

Taping and Banding RC columns with dense polyester bands

SRF retrofitting method

https://www.sqa.co.jp/english/index.html

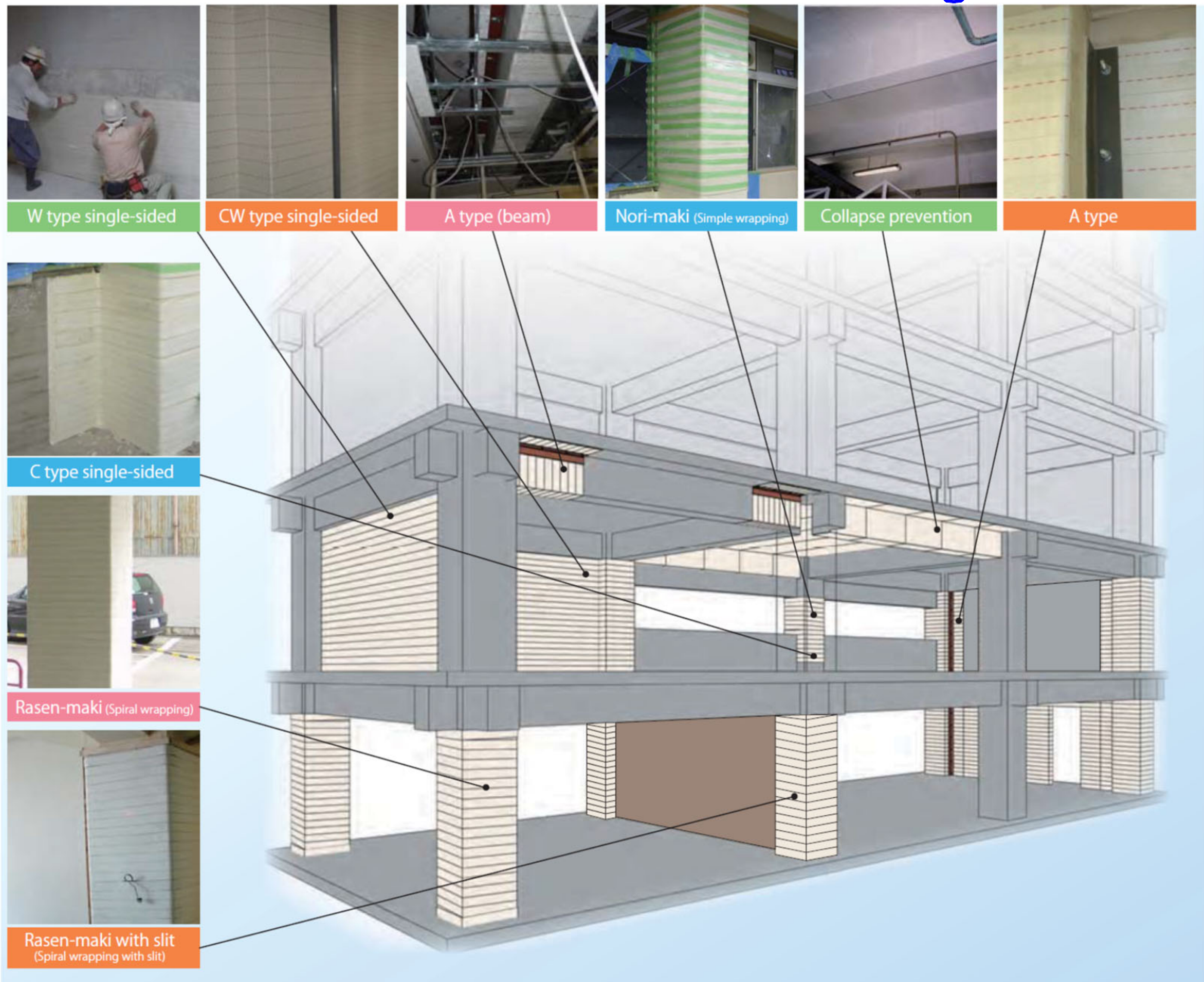
This high ductility material is made of polyester fibers which are woven together densely. There are various belts, tapes, and sheets as well as widths and thicknesses. For example, the thickness of 4 mm (0.15 inch) has 16 tons of horizontal strength. It is flexible and can be bent easily with the hands. In earthquakes, it follows the deformation of concrete and wooden materials while resisting cracks which invite collapse.

This high-toughness adhesive is solvent free, so there are no offensive odors. The high ductility material can be adhered as soon as the adhesive is applied, and construction is also simple and effective as it is a one-pack type. It contains no formaldehyde and has received a grade of F☆☆☆☆. It has the same durability and constructability as continuous fiber reinforcement. Unlike epoxy resin, its adhesive powers do not destroy the groundwork. It works together with the surroundings to support weight even if partially ripped off.

* It has JIS (Japanese Industrial Standards) recognition.

※ These materials are for concrete structures (SRF20).
Tube-type materials (SRF30) are used for joint connection of wooden structures.

Alternate methods for Seismic Retrofitting of Buildings



https://www.sqa.co.jp/english/index.html

Alternate methods for Seismic Retrofitting of Buildings

Case of SRF Reinforcement

Wrapping the main columns with SRF allows it to maintain its shape in spite of big transformations and also prevents collapse. While steel plate reinforcement, carbon fiber, and aramid fiber are realistically impossible, SRF prevents collapse and shows high-tensile strength even for short columns or columns exposed to a large compressive force (high axial force). It has been technically evaluated by The Japan Building Disaster Prevention Association.

Pasting strip-type SRF belts on shear walls provides elastic stability to cracks, absorbs large amounts of energy, and prevents collapse. Steel plates, carbon fiber, and aramid fiber resist the compression forces and eventually peel off easily, producing almost no effect at all. SRF elastically resists tensile forces and avoids compressive forces. It is the first to be able to achieve this reinforcement effect.

This reinforcement method is applied in Nepal for reinforcement of school building.
https://m.facebook.com/jhss4

https://www.sqa.co.jp/english/index.html

Damage to Kobe City Hall main building

Difficultly in Communication at HYOGO Prefecture Headquarter

Lesson 2:Delay of First Response due to lack of information at the direct hit Kobe city

- <u>Damaged Local Government Headquarter</u>
- <u>Local Government Command initially paralyzed</u>
- Destroyed almost all traffic system
- Telecommunication, even satellite telecommunication system were cut off due to power failure

⇒ It took three days to grasp the entire picture of damage

⇒ The bottom-up reporting system could not function

Gov't Buildings must be stronger than average

- Nationwide support system for local & regional emergency
- Appointment of Minister of State for Disaster Management
- High density seismometer network &
- Development of disaster damage estimation system (DIS)

Seismic Standards for public buildings (mandatory) in Japan:

For Building Structure

Severer ↑

Types	Examples	Required Performance: The building can be used after a ground shaking of I_{MM}=11~12		Required Level of Lateral Load
		Safety of lives	Functionality of Building	
I Important Primary Buildings for Disaster Response	Main Public Buildings for Disaster Response: Main Office Buildings of Ministries, HQ of Fire Department and Police Department etc, Hospitals for Disaster Response 		Sufficient functionality Required	**1.5** times of the required level of the Building Standard Law.
II Important Secondary for Disaster Response	Public Buildings for Disaster Response other then type I: Public Schools and Ordinary Public Hospitals etc. 	Required	Functionality Required	**1.25** times of the required level of the Building Standard Law.
III Other Public Buildings	Public buildings other than type I and II. 		Not required	**1.0** Equivalent to the Building Standard Law.

There are also classifications and regulations for non-structural members and building equipment in order to ensure the required functionality of buildings.

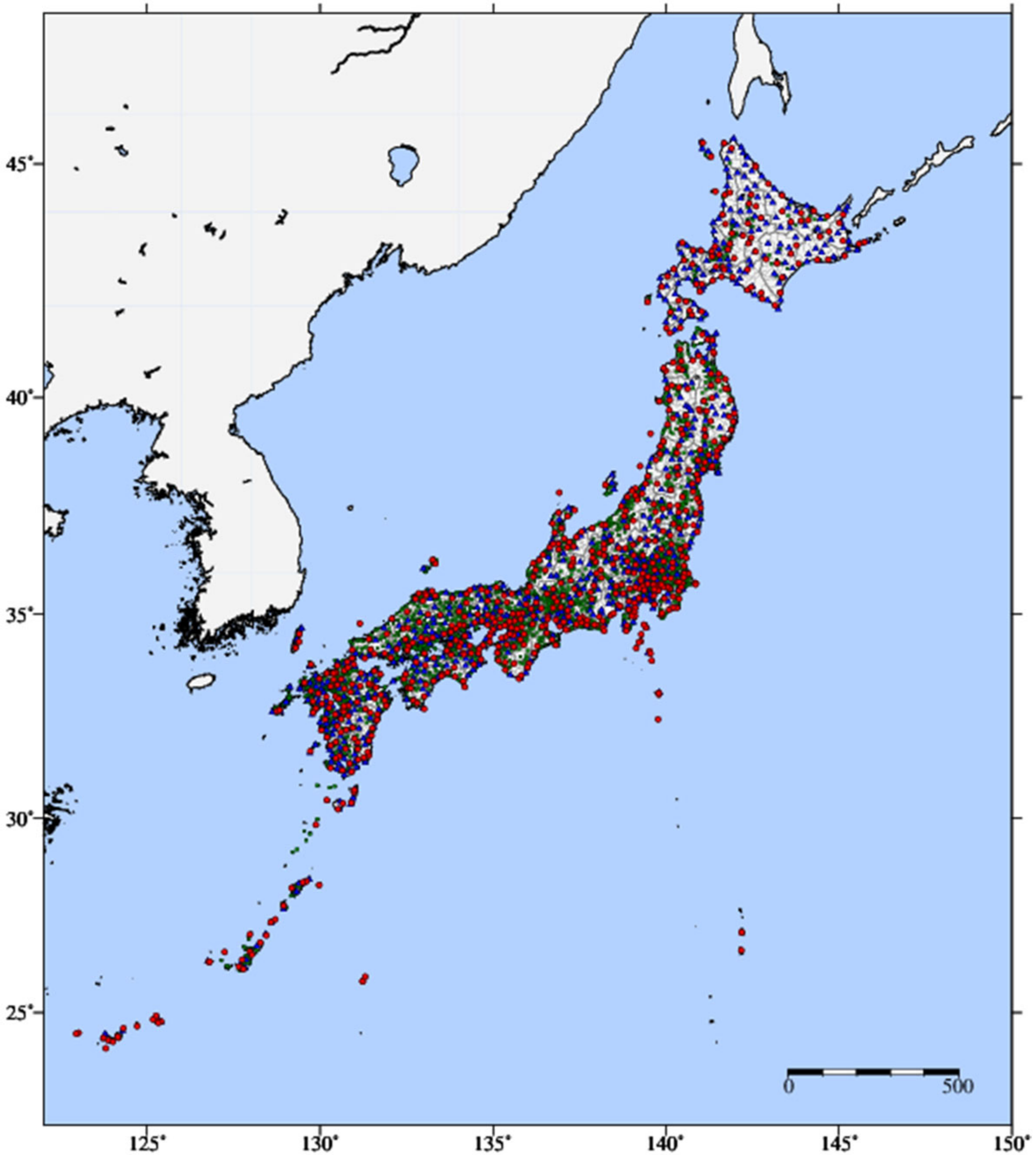
Ref.: "Comprehensive Seismic Planning Standards for Government Facilities"(MLIT, 2006)

Seismic Intensity Observation Points Increased

as of Oct. 2016

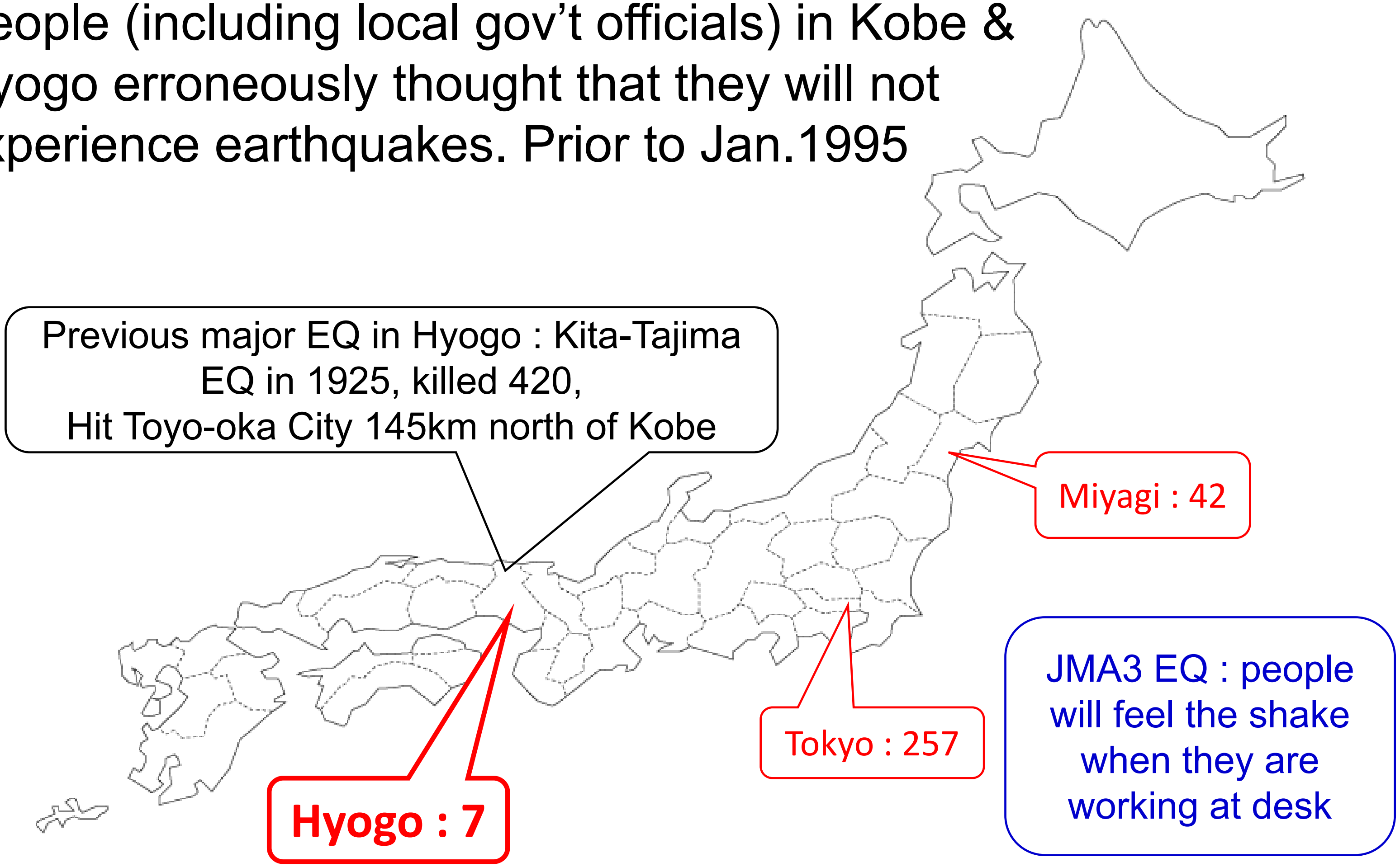
JMA: 672 points
Local Govt.: 2931 points
NIED: 785 points
total: 4388 points

(before the 1995 earthquake
JMA 150points)



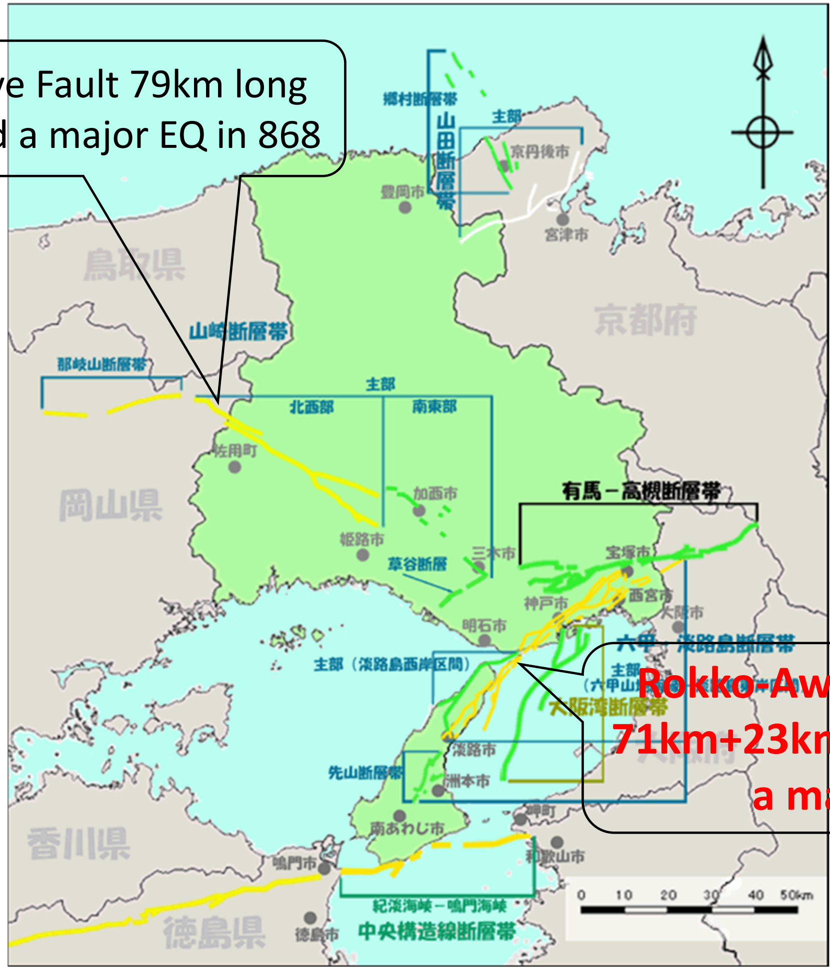
Biggest Lesson: Lack of Earthquake Awareness in Kobe & Hyogo

People (including local gov't officials) in Kobe & Hyogo erroneously thought that they will not experience earthquakes. Prior to Jan.1995



Number of EQs greater than JMA3 felt in 1985-1994

Existence of Active Faults in Hyogo were known to only a limited number of scientists



Yamazaki Active Fault 79km long which triggered a major EQ in 868

Rokko-Awajishima Active Fault 71km+23km long which triggered a major EQ in 1596

http://www5d.biglobe.ne.jp/~kabataf/katudansou/hyougo/hyougo.htm

Lack of EQ Awareness meant
Lack of Preventive Measures & Preparedness

Human Sufferings & Slow Response

Recollection by Mr. Sadao Tsunematsu, Principal Director of Reconstruction Hyogo Prefecture, in 2005 "Kindai-Shobo 2005 Vol 527, pp24-31"

- The previous experience of an earthquake in Hyogo was the "Kita-Tajima EQ in 1925" far to the north of Kobe, it was said that there is a slight possibility of an earthquake by Yamazaki fault in the western part of Hyogo, so, a strong earthquake in Kobe was a big surprise. Since Kobe has the Rokko mountains in the north, and the previous experience of 1938 Great Hanshin Flooding, we were thinking of flooding and landslides.
- Therefore, Hyogo prefecture government did not have 24/7 duty officer, we had procedure to increment emergency response according to weather forecast, so this system did not function in sudden onset earthquake.
- Since the Hyogo Prefecture Gov't was located midst of the disaster site, we were in "blackout of information" at noon of 17 January, we were aware of only 200 casualties.

Reconstruction of Kobe (residential & commercial)

Land Readjustment Projects in Kobe for Build Back Better

•Matsumoto, Kobe

•Matsumoto Street W=17m

Rokkomichi St. North, Kobe

六甲道駅北

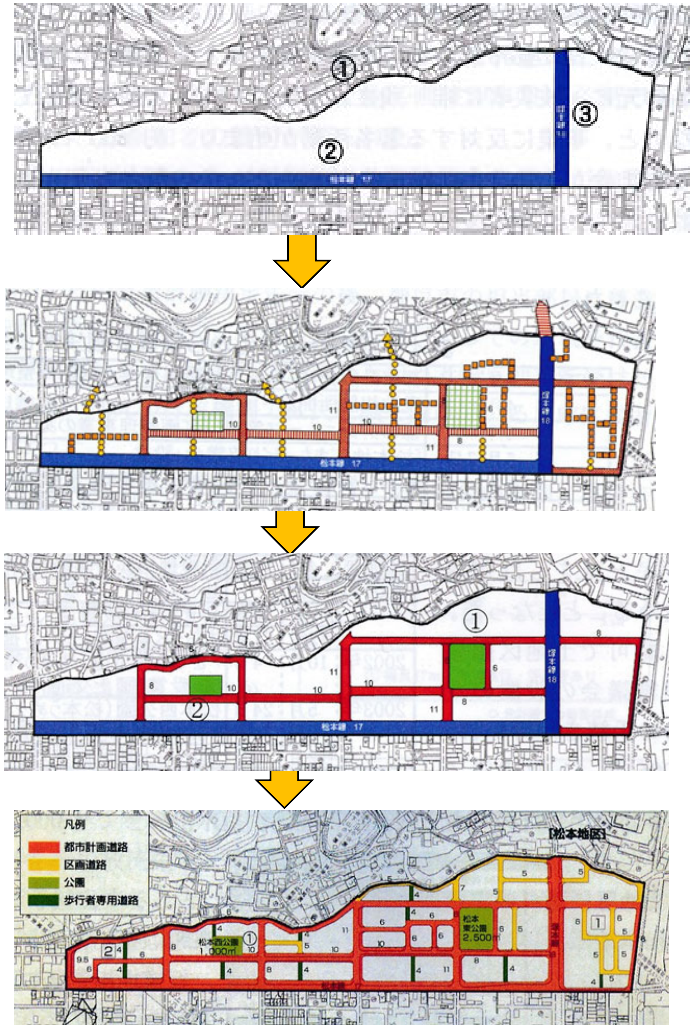
Pictures from Kobe City

Rokko-machi Street W=17m

六甲町線 幅員17m

Two Stages Urban Planning for L.R. Projects

Matsumoto Area



City Planning in the **1st Stage**: 17 Mar 1995 (2 months after the Eq.) Decision of the area of the L.R. Project and City Planning Roads

Contents of the Community Development **Proposal by Community** Development Conference: 10 Dec.1995

City Planning in the **2nd Stage**

(1) Alteration and Addition in City Planning: 27 Mar.1996

- **Additional City Planning Roads**
- **Decision of City Planning Parks**

(2) Approval of the L.R. Project: 26 Mar. 1996

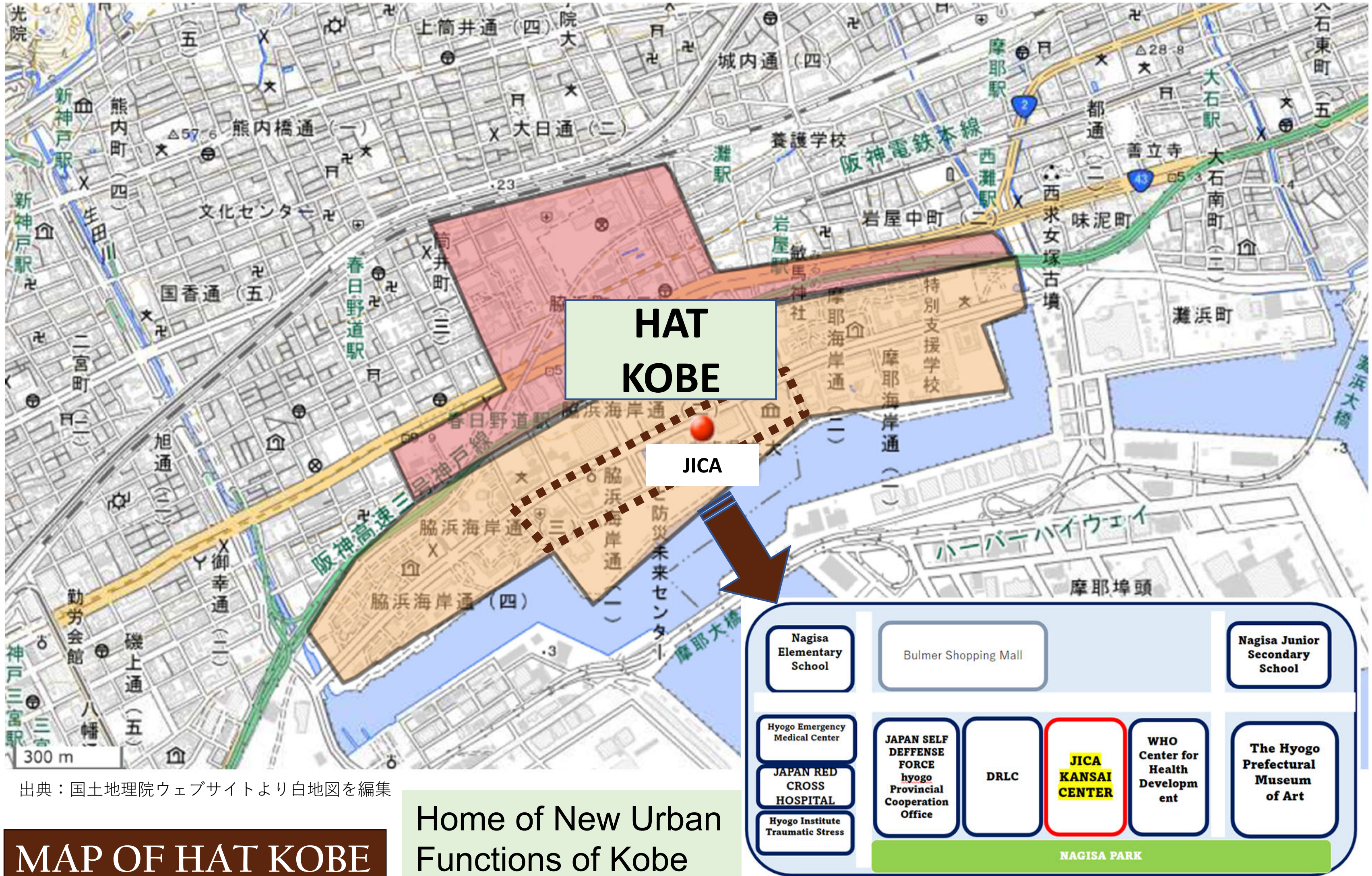
Dramatic Transformation of Kobe in the Build Back Better Process

Kobe was the home of heavy industries, ex: Kobe Steel, Ltd

factories closed ⇒ converted to new urban functions

The Main Factory of Kobe Steel converted to “Hat Kobe”

Home of EQ Memorial Museum, ADRC, JICA Kansai and Univ. of Hyogo etc



出典：国土地理院ウェブサイトより白地図を編集

MAP OF HAT KOBE

Home of New Urban Functions of Kobe

HAT KOBE in 2023

Kobe EQ Museum
（ADRC、UNDRR、Univ. of Hyogo etc）

JICA Kansai

WHO Kobe

Hyogo Museum of Art

Damage Example of Port Facilities in Kobe Port

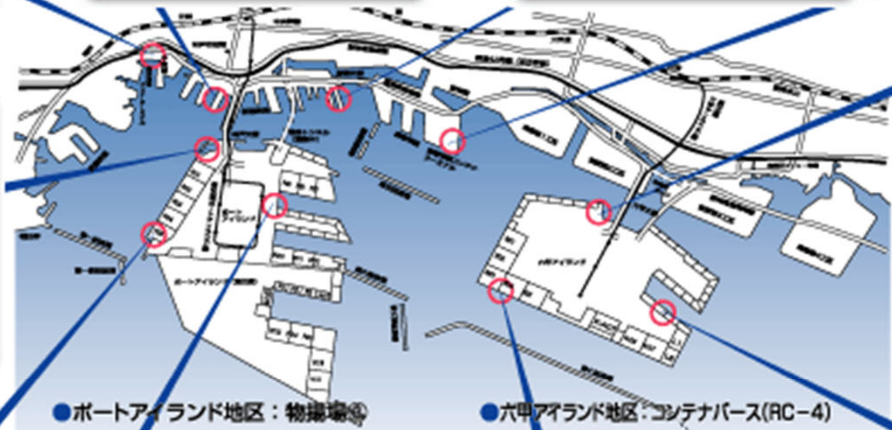
- -5.5m Berth

- New port area

- New port area

- -12m Berth

- Port island berth



- Rokko island berth

- Container berth

●ポートアイランド地区：物揚場⑥

●六甲アイランド地区：コンテナバース(RC−4)

- Rokko island -12m berth

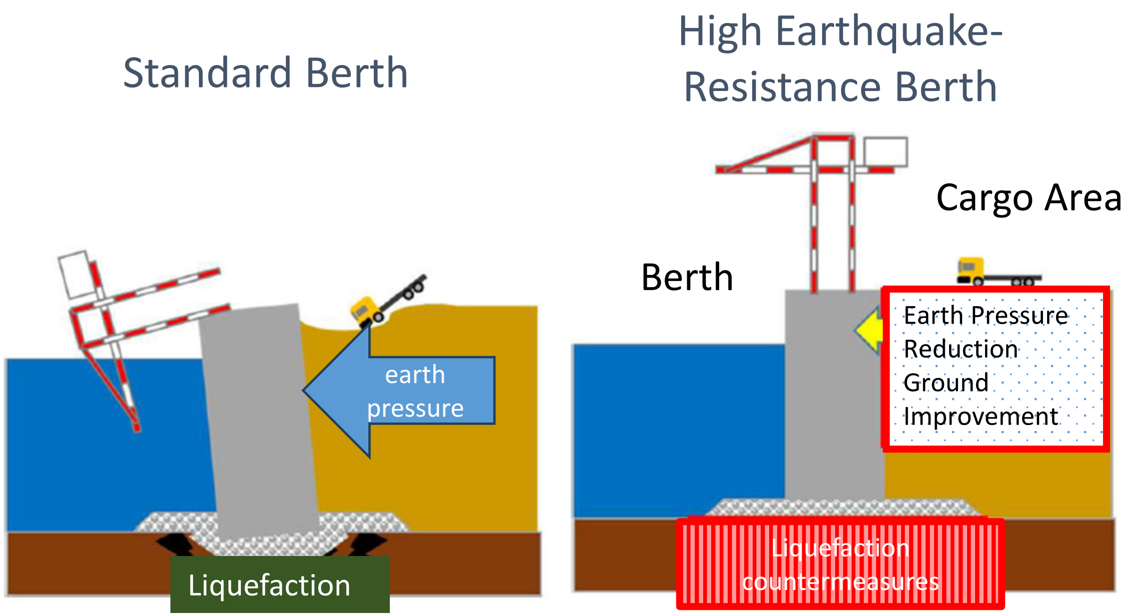
Source: MLIT, Japan, JICA Study Team

Reconstruction Example of Port Facilities in Kobe Port

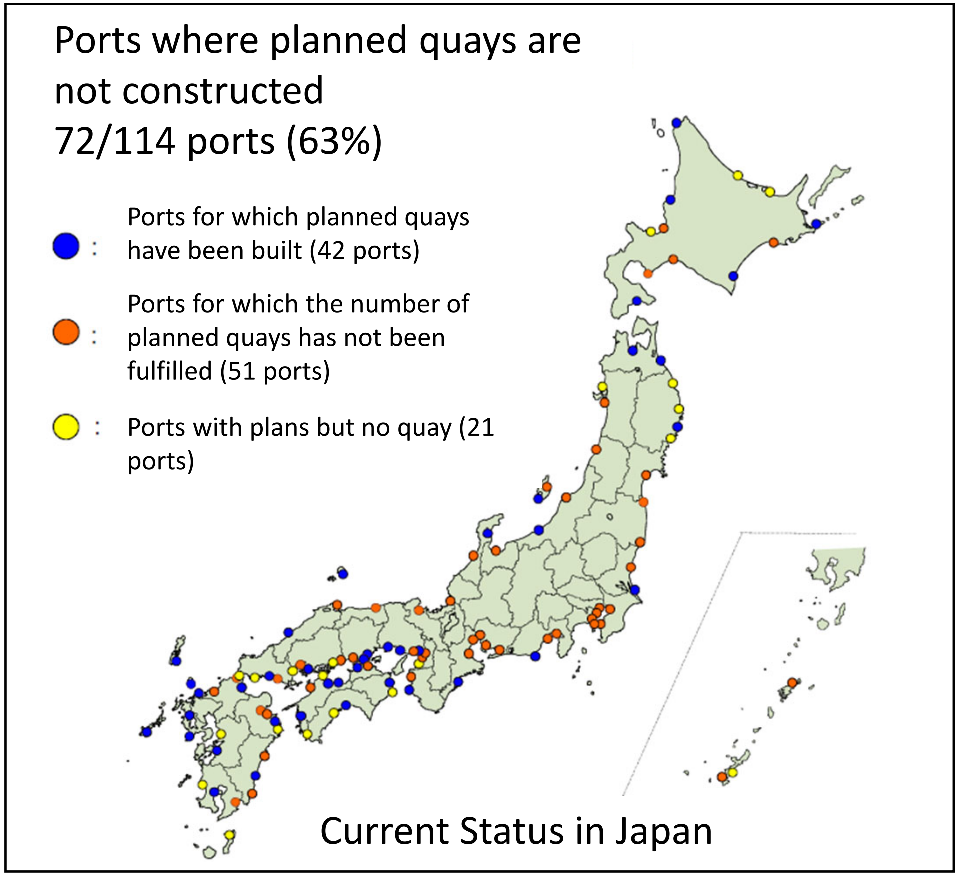
Source: MLIT, Japan, JICA Study Team

High Earthquake-Resistance Berth

A high Earthquake-resistance berth is a mooring facility with enhanced seismic resistance to prepare for large-scale earthquakes, so called "Level 2 Earthquake". It plays a crucial role in transporting emergency supplies and maintaining economic activities through import and export during earthquakes."



Level 1 ← Seismic motion → Level 2
High ← Probability of occurrence → Low
Small ← Seismic motion → Large



Paradigm shift after 1995 Hanshin-Awaji (Kobe) Earthquake

Most of the initial search & rescue done by family members and neighbors.

→ How can we encourage disaster preparedness at community level?

Importance of building safety re-recognized.

→ *Who owns the houses and buildings?*
Who can take care of safety inside the house or in the office?

Business Continuity Planning is important for reducing economic loss.

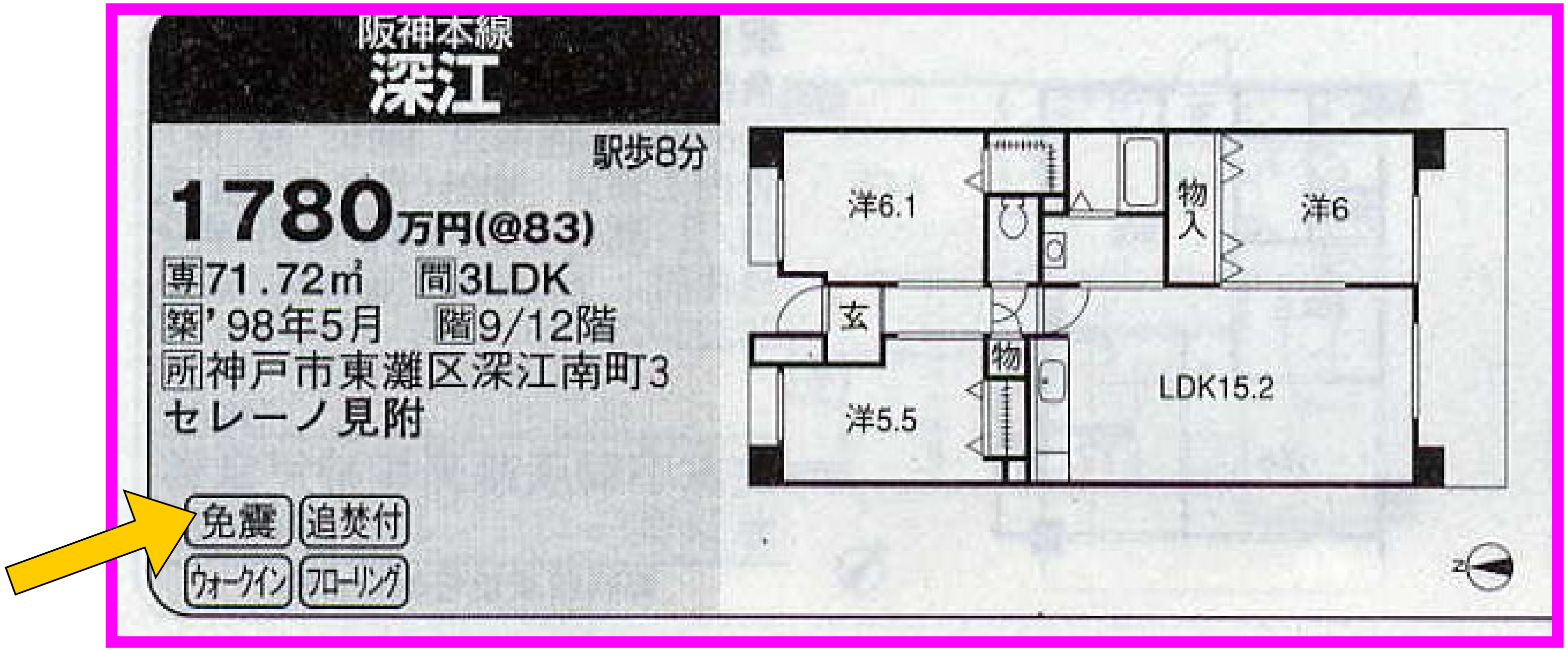
→ Who decides on BCP of companies?

Importance of Pre-disaster measures re-recognized.

→ Pre-assessment for each possible large scale earthquakes & floods.
Disaster reduction strategy based on pre-assessments.

Government centered disaster reduction → Multi-stakeholder approach to disaster risk reduction

Consumer's Awareness changes
Advertisement of Condominium



"This condominium has seismic base isolation structure"

One of the 4 important sales points!

2004 Niigata-Chuetsu Earthquake (M6.8)

Epicenter was shallow 13km => Strong Ground Motion

40 Direct Deaths+11Relevant Deaths
4,801 Injured 117,000 Houses damaged

Reminded the necessity of seismic retrofit of buildings

2,800 Houses Collapsed

Collapse of houses built before 1981

Baby boy rescued after 5 days

Nishikawa was dispatched as the Gov't on-site coordinator to Niigata

A very worrisome comment from a Niigata Prefectural Government Director

The Niigata earthquake of June 1964 occurred 40 years ago, and by October 2004, the prefecture staff working at that time had already retired. Thus, the institutional memory of the earthquake was lost in Niigata prefecture.

出典：新潟地震
誌昭和41年11月

1964 Photo of RC apartments tilted by Ground Liquefaction

The real challenge for Build Back Better starts after the mass media has left

Mayor of City of Nagaoka, Mr. Tamio MORI
Later became the President of all Japan Mayor's Association.
Has former experience as a bureaucrat at Ministry of Construction.

Former Mayor of Yamakoshi-village (merged to City of Nagaoka in 2005) acted as local leader in reconstruction process.
Decided to evacuate all the villagers (2,167) from Yamakoshi-village and came back after 3years and 2 months.
Later elected as National Parliament member from Niigata.

The fortune of Niigata-Chuetsu Eq reconstruction owes to a capable mayor and a local leader. (National Government support stays behind the scenes. The local leaders highlighted.)

Role of local leader : Foster the solidarity & consensus and unite the residents towards better future.

The successful local leader needs to be paid due respect.

Physical reconstruction of Yamakoshi

羽黒トンネル池谷側　震災直後

羽黒トンネル池谷側　復旧後　2007年9月

池谷集落内　震災直後

池谷集落内　復旧後　2007年9月

Physical reconstruction of Yamakoshi

木篭集落　震災直後

木篭集落　復旧後　2006年11月1日

宇賀地橋　震災直後

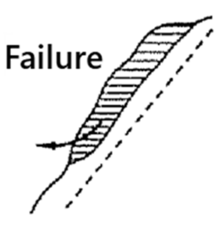
新宇賀地橋　復旧後 2006年11月1日

Technologies to Prevent Slope Failures / Landslides

Patterns of Landslide Disasters on Cut Slopes

In general, the patterns of landslide failure of cut slope slopes occurring in Japan can be classified into (1) surface failure, (2) moderate surface failure, (3) deep failure, and (4) rockfall as follows.

Pattern	Surface failure
Fig.	

Pattern	Moderate surface failure	Deep failure	Rockfall
Fig.			

Source: Handbook of Road Earthquake Countermeasures (Earthquake Disaster Restoration Edition), 2022, Japan Road Association

Methodology list for Slope Failures/Land slides prevention

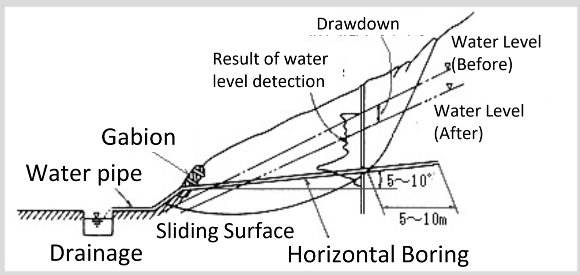
Surface Water Drainage Works • Channel Works: Channels are installed to drain surface water and prevent infiltration that can cause landslides. • Infiltration Prevention Works: Waterproof sheets or concrete are used to prevent surface water from infiltrating into the ground.
Groundwater Drainage • Horizontal Boring Works: Horizontal boring is performed to remove groundwater, reducing the risk of landslides. • Collection Well Works: Wells are excavated to collect groundwater, lowering the groundwater level. • Drainage Tunnel Works: Tunnels are dug underground to remove groundwater, preventing landslides.
Earth Removal Works • Removing soil that causes landslides to reduce the risk of landslides.
Counterweight Embankment Works • Embankments are constructed at the toe of the landslide to increase the resisting force against the sliding force.
Piling Works • Piles are driven into the ground to add resisting force against the sliding force of the landslide.
Ground Anchor Works • Anchors are installed in the ground to add resisting force against the sliding force of the landslide.
Shotcrete Concrete Works • Concrete is sprayed onto slopes to prevent landslides from occurring.

Source: MLIT, Japan and JICA Study Team

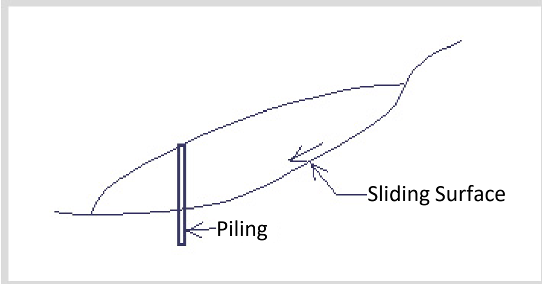
Technologies to Prevent Slope Failures / Landslides

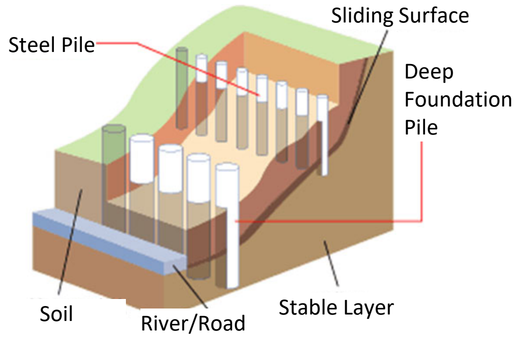
Representative Methodologies

Horizontal Boring

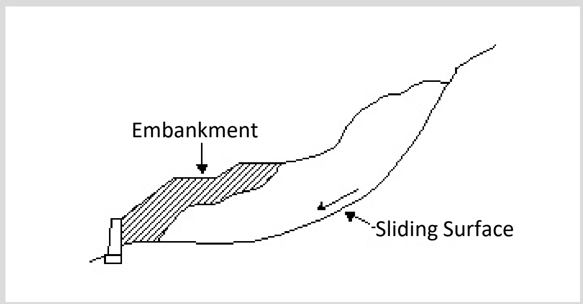


Piling



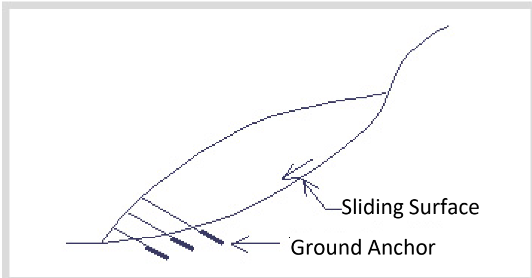


Counterweight



Reference:
Geotextile Reinforced Earth Wall

Ground Anchor



Frame work + Anchor work

Source: MLIT, Japan Bosai Platform, JASDiM "Japan Association for Slope Disaster Management" and JICA Study Team

Technologies to Prevent Slope Failures / Landslides

Representative Methodologies

Rock fall prevention

Pocket type rockfall prevention net work

Wire rope hanging work

Source: MLIT, Japan Bosai Platform, JASDiM ”Japan Association for Slope Disaster Management”

The former Yamakoshi-village (presently merged to the city of Nagaoka) is world famous for the breeding of Colored Carps (swimming jewels) and export.

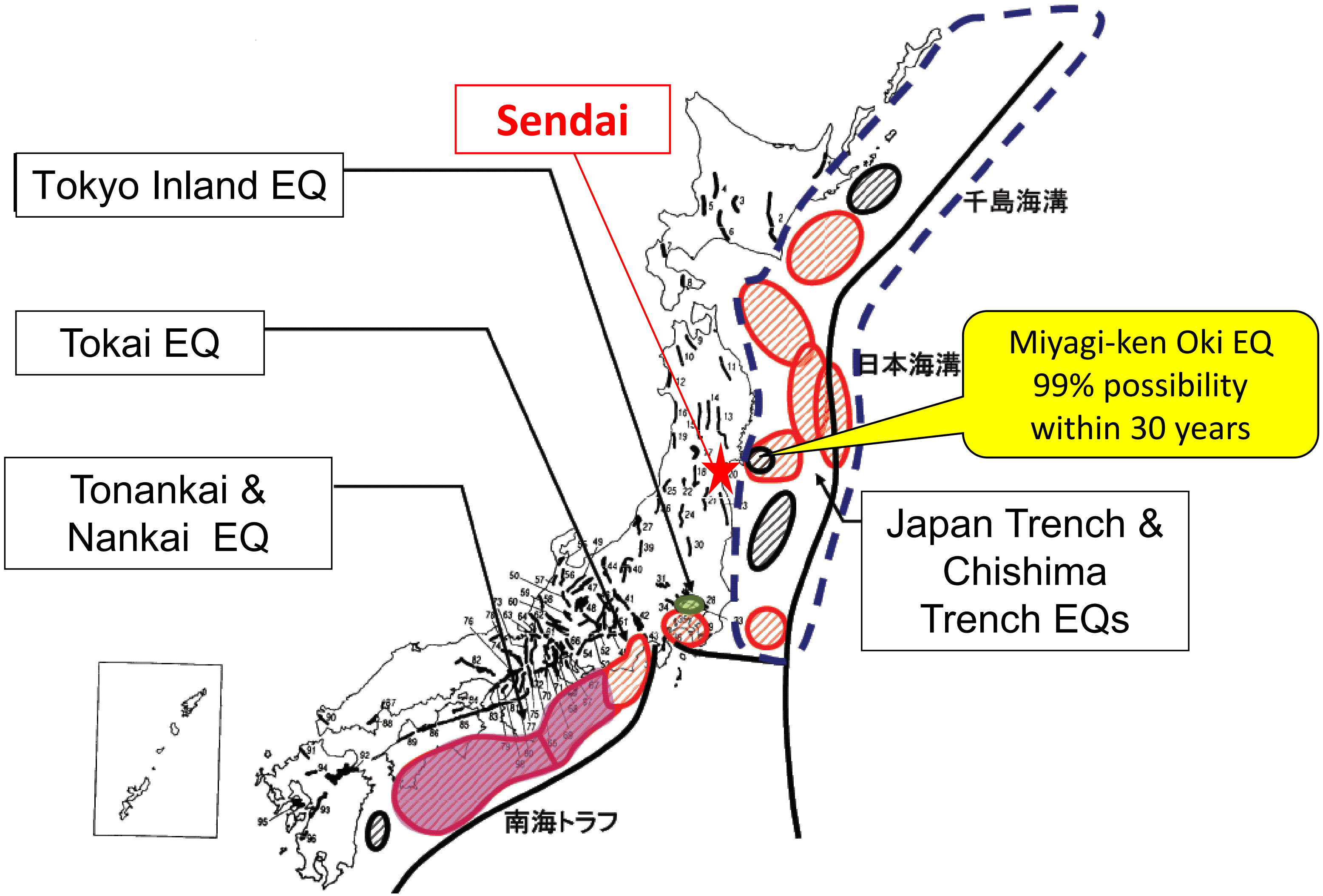
The rice paddies are revived (with support of volunteers), renowned as the most delicious rice.

The population of Yamakoshi
Before the EQ: 2100

As of 2024: 750

New challenges to increase "affiliated population"

Recognized Possibilities of large-scale M8 earthquakes and tsunamis in Japan (pre-2011)



M9 Earthquake & Tsunami Came ! 2011 March

写真出典仙台市復興五年記録誌

Tohoku was prepared for a Miyagi-ken Oki EQ of M7.6-M8.2,
but what came was M9 EQ & Tsunami

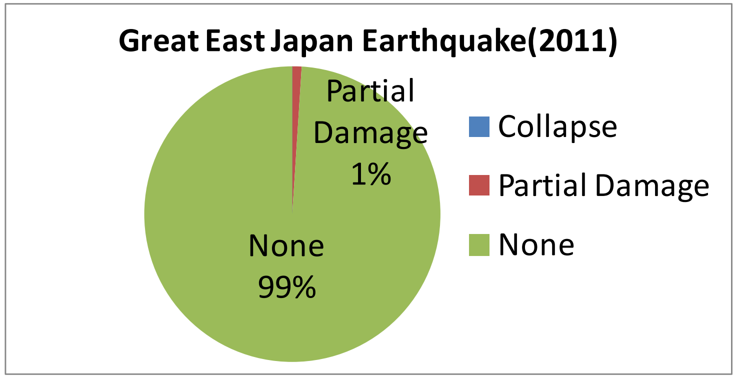
Energy of M9 earthquake is 32 times stronger than M8 earthquake

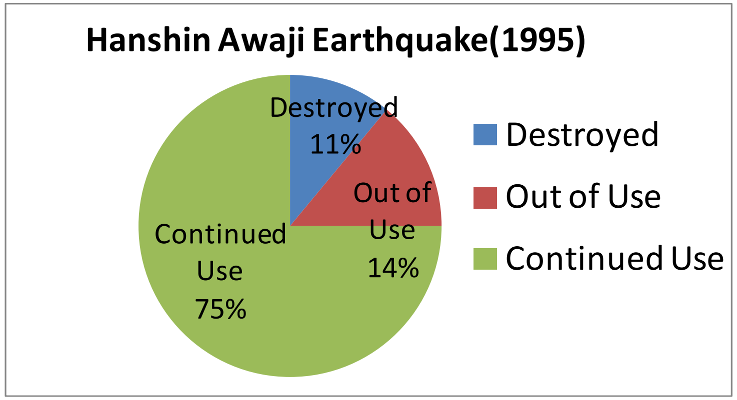
Enormous Destruction by the Tsunami !

Preventive Approach 1 Japanese building codes showed its strength against M9 earthquake

The M9 Great East Japan Earthquake hit Sendai City, but there was no structural collapse of buildings.

Office building in Sendai, photo by Satoru Nishikawa, Apr 15 2011

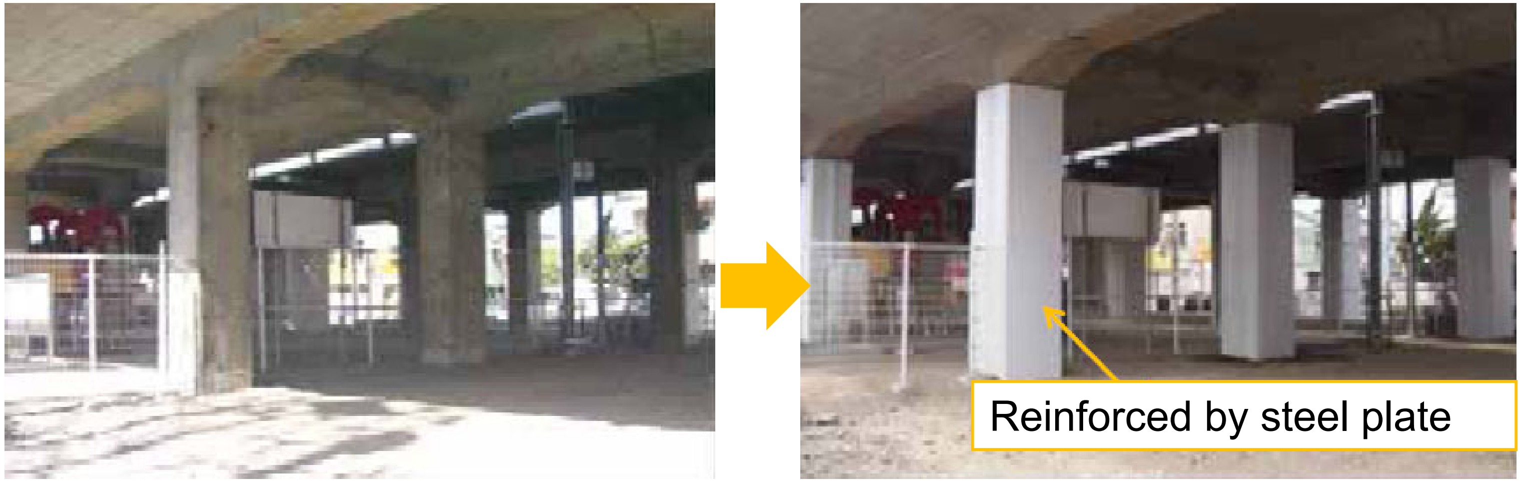




Source: CBRE Consulting "Impact of Great East Japan Earthquake on Japan Real Estate Market"

Preventive Approach 2 Structural reinforcement of important infrastructures showed value.

* Reinforced Shinkansen bullet train elevated rail bed columns



These reinforcements based on the bitter lessons of 1995 Hanshin-Awaji Earthquake and 2004 Niigata-Chuetsu Earthquake

Derailment of Joetsu Shinkansen in 2004

History of Bridge Seismic Design in Japan

< Flow of Infrastructure Earthquake Resistance >

Infrastructure damaged by earthquake → Development of Technical Standards → Development of Construction Technology

< Case Study on Bridges in Japan >

Many bridges were damaged in the 1995 Great Hanshin-Awaji Earthquake.

→ Shifted from the conventional design up to level 1 earthquake (1980 standard) to design considering level 2 earthquake (1996 standard)

Research on seismic design against level 2 earthquakes took 10 years (the standard revise took 15 years).

→ Based on new construction technology, seismic reinforcement technology is provided by the government as a standard (Reference material on seismic reinforcement in 1997).

The construction method was provided by the government, which established a standard construction method.

Continuously updating standard.

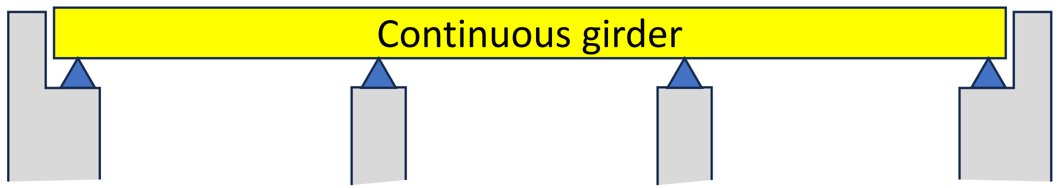
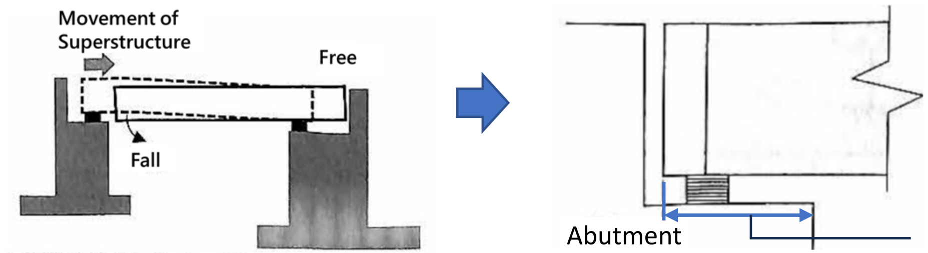
- 2011.3 Great East Japan Earthquake

- 2016.4 Kumamoto earthquake

Source: MLIT, Japan, JICA Study Team

Technologies for Seismic Design of Bridges

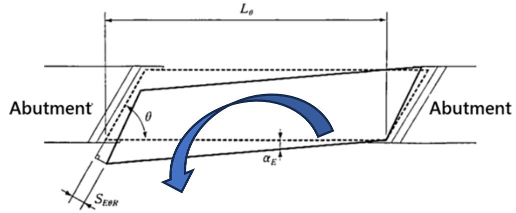
Representative Methodologies

Superstructure		
	Continuation of main girder Connecting girders to distribute the concentration of loads on the bearings.	
Substructure		
	Widening bearing seat Secure enough length of bearing seat even bearing collapsed.	
	Reinforcement of bridge piers Wrap by RC or Steel plate or Carbon fiber sheet.	 

Source: MLIT, Japan, JICA Study Team

Technologies for Seismic Design of Bridges

Representative Methodologies

Others		
	Prevention of superstructure rotation - Geometry check for rotation - Lateral displacement restraining structure	Geometry check   Stop lateral displacement
	Bridge fall prevention devise (generally bridges of 2 spans or more)	
	Consideration of liquefaction	
	Isolation Bearing/Dumper: Use for Special Bridge or Long viaducts.	

Source: MLIT, Japan, JSCE, JICA Study Team

Preventive Approach 3

Risk is identified! What Next?

Awareness ⇒ Policy & Investment

Hints from the Sendai City Experience.

Sendai City： population 1,046,000 (2010 census)

Previous experience of 1978(M7.4), 2003(M7.0), 2005(M7.2) earthquakes

Probability of another Miyagi-ken Oki EQ estimated as 99% within 30 years !

Risk is imminent! ⇒ Policy & Action by Sendai City

Nov. 1999 "Sendai City Building Assets Seismic Safety Target"

Sept. 2005 "Sendai Disaster Reduction Expo" with Cabinet Office of Japan

April 2008 "Sendai City Earthquake Resilience Policy"

Examples of Action

- Seismic Retrofit of Schools
- Seismic Retrofit of Sendai City Hall
- Seismic Retrofit of Fire Stations
- Subsidy to Earthquake Resistance Analysis of Private Housing
- Subsidy to Earthquake Retrofitting of Private Housing & more

⬇

Minimized human casualties by the Great East Japan EQ (M9.0)

The Sendai Disaster Reduction Expo in 2005

Co-organized by Sendai City, Cabinet Office and the DR week promotion committee

Exhibition booths at Sendai Terminal Hall

Vice-Minister of Cabinet Office Disaster Management

President of Japanese Red Cross Society

Mayor of Sendai City

Various Demonstrations

Opportunity to boost citizen's awareness and propagate the Nation-Wide Movement at local level.
Laid the foundation for Sendai City DR Policy Implementation.

Seismic Retrofit of Sendai City Hall

Sendai City Hall built in 1965 (before the 1981 seismic standard)
Earthquake Resistance Analysis done in 1996 ⇒necessity for seismic retrofit
Seismic retrofit work done in 2007 to 2008

Seismic Brace with vibration damper inserted.

Seismic Brace & Seismometer installed on ground floor hall.

M9 Earthquake Came ! 11 March 2011

Structural safety of City Hall confirmed in 1 hour.
City hall served as temporary shelter for stranded commuters & visitors.

Photo by Tobishima Cooperation

Seismic Retrofit of Schools

Seismic retrofit of schools based on
Sendai City Earthquake Resilience Policy April 2008

Progress of school seismic retrofitting : 99.6% done by April 2010

M9 Earthquake Came ! 11 March 2011

No structural damage to Sendai schools.
Not a single child killed in Sendai school.

Seismic Retrofit of Fire Stations

Seismic Retrofit of Sendai City Fire Stations based on
Nov. 1999 “Sendai City Building Assets Seismic Safety Target”
April 2008 “Sendai City Earthquake Resilience Policy”

M9 Earthquake Came ! 11 March 2011

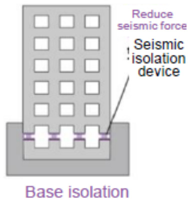
None of the Fire Stations structurally damaged by earthquake.
Functioned as Emergency Operation base.

Promotion of Seismic Retro-fitting of Non-conforming Existing Buildings

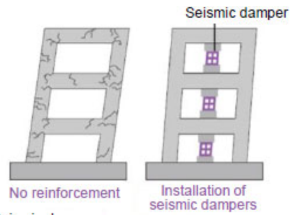
Seismic Retrofitting technology

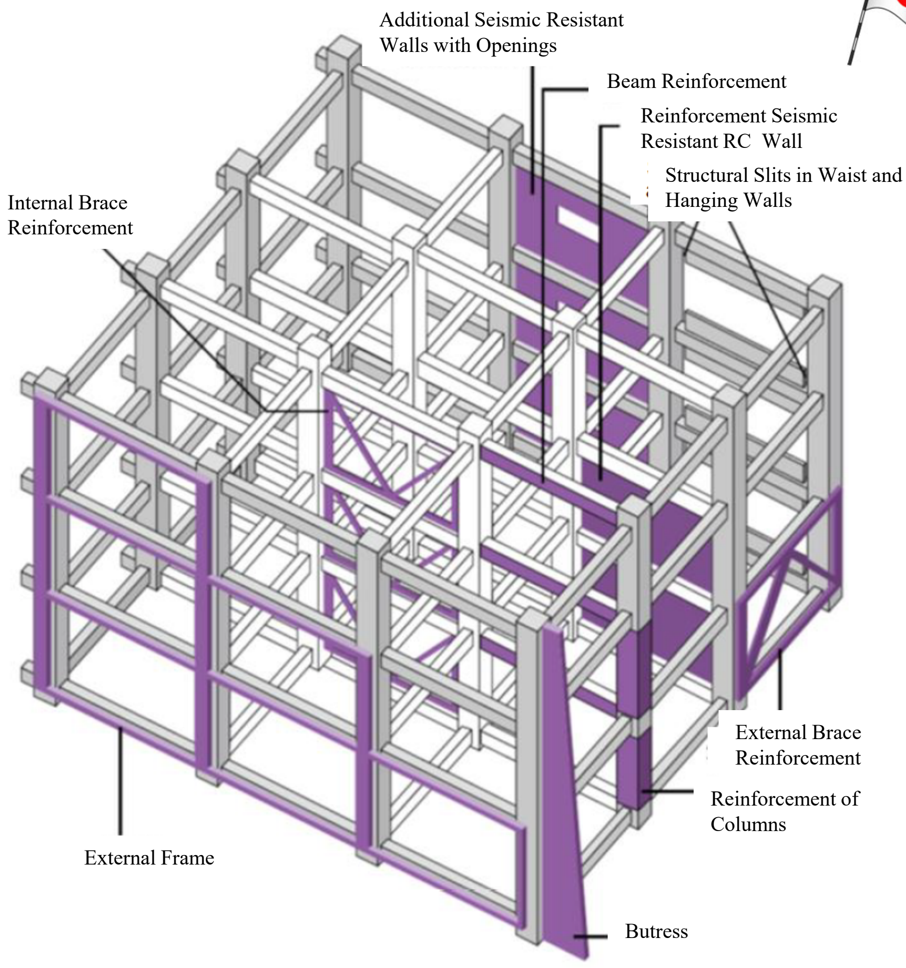
- Seismic Reinforcement is achieved by methods such as increasing the seismic resistance of walls, installing new external/ internal supports and frames, and reinforcing columns and beams.
  + Aditional Seismic Resistant Walls
  + Internal/ External Braces
  + Reinforcemtn of Columns/ Beams by Jacketing, Wrapping etc.
  + Adition of Butress/ External Frames
  + Structural Slits in Waist/ Hanging Walls
  + etc.

- Seismic Isolation reduces significantly the seismic force transmitted from the ground by installing seismic isolation devices below the foundations or on intermediate floors.



- Seimic Vibration Control reduces the seismic force transmitted to a building with damping devices, such as seismic dampers.





Based on the information by MLIT

Alternate methods for Seismic Retrofitting of Buildings

Great Need for Seismic Retrofitting of Existing Reinforced Concrete Buildings built before 1981 standard.
But
Many building owners do not have sufficient fund for rebuilding or full-speck seismic retrofitting.

Invention of new affordable retrofitting method
Taping and Banding RC columns with dense polyester bands
SRF retrofitting method

https://www.sqa.co.jp/english/index.html

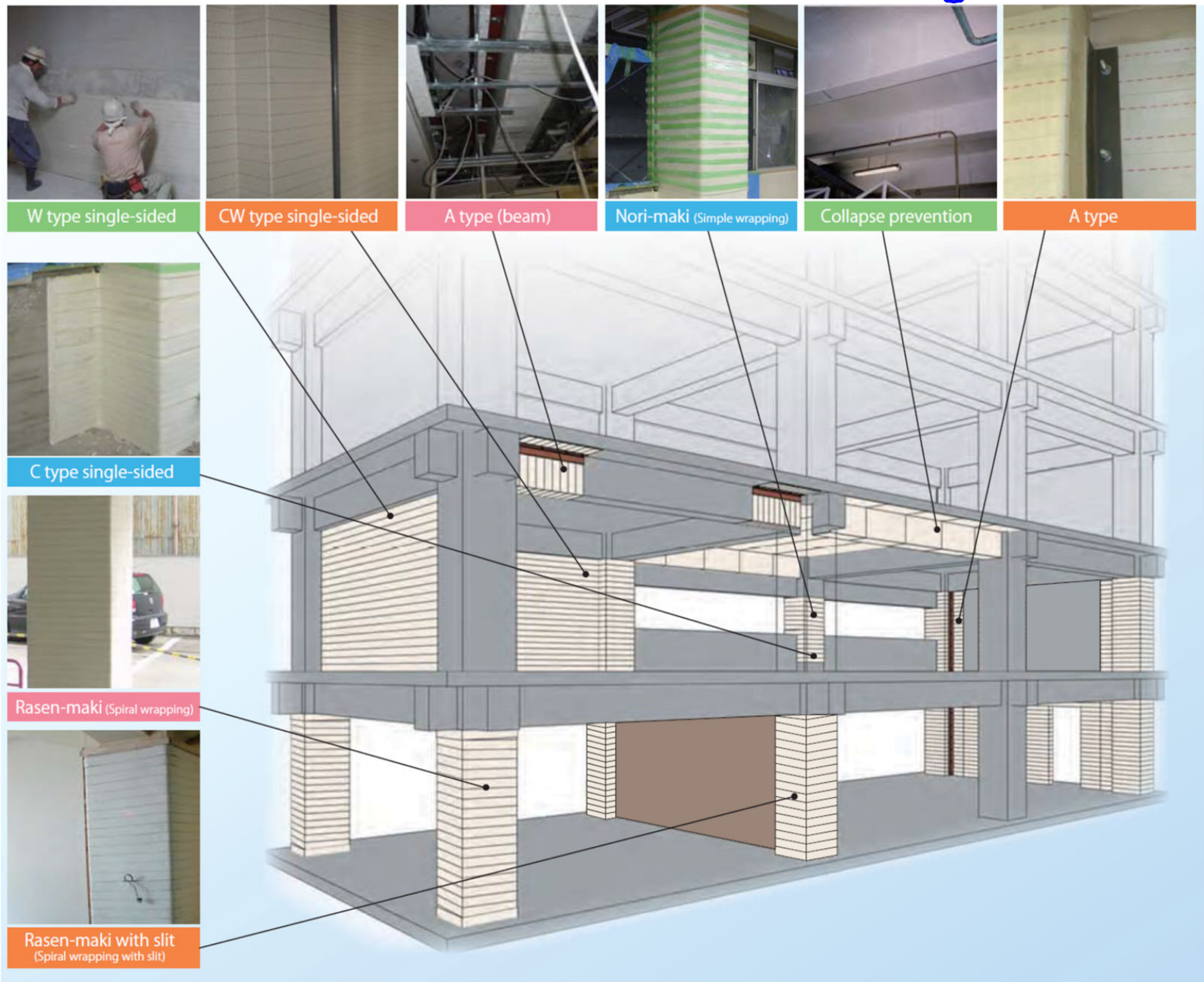
This high ductility material is made of polyester fibers which are woven together densely. There are various belts, tapes, and sheets as well as widths and thicknesses. For example, the thickness of 4 mm (0.15 inch) has 16 tons of horizontal strength. It is flexible and can be bent easily with the hands. In earthquakes, it follows the deformation of concrete and wooden materials while resisting cracks which invite collapse.

This high-toughness adhesive is solvent free, so there are no offensive odors. The high ductility material can be adhered as soon as the adhesive is applied, and construction is also simple and effective as it is a one-pack type. It contains no formaldehyde and has received a grade of F☆☆☆☆. It has the same durability and constructability as continuous fiber reinforcement. Unlike epoxy resin, its adhesive powers do not destroy the groundwork. It works together with the surroundings to support weight even if partially ripped off.

* It has JIS (Japanese Industrial Standards) recognition.

※ These materials are for concrete structures (SRF20).
Tube-type materials (SRF30) are used for joint connection of wooden structures.

Alternate methods for Seismic Retrofitting of Buildings



https://www.sqa.co.jp/english/index.html

Alternate methods for Seismic Retrofitting of Buildings

Case of SRF Reinforcement

Wrapping the main columns with SRF allows it to maintain its shape in spite of big transformations and also prevents collapse. While steel plate reinforcement, carbon fiber, and aramid fiber are realistically impossible, SRF prevents collapse and shows high-tensile strength even for short columns or columns exposed to a large compressive force (high axial force). It has been technically evaluated by The Japan Building Disaster Prevention Association.

Pasting strip-type SRF belts on shear walls provides elastic stability to cracks, absorbs large amounts of energy, and prevents collapse. Steel plates, carbon fiber, and aramid fiber resist the compression forces and eventually peel off easily, producing almost no effect at all. SRF elastically resists tensile forces and avoids compressive forces. It is the first to be able to achieve this reinforcement effect.

This reinforcement method is applied in Nepal for reinforcement of school building.
https://m.facebook.com/jhss4

https://www.sqa.co.jp/english/index.html

Revised Act on Promotion of Seismic Retrofit of Buildings enables Investment for Seismic Safety

Since 2013, all the Hotels & Department Stores & Cinemas etc. in Japan built before 1981 are obliged to do their Earthquake Resistance Analysis and disclose the results to the public.

Do tourists want to stay in a fragile hotel? Probably NO.

Major Cities have prepared subsidy programs for seismic retrofitting of hotels built before 1981. (incl. Sendai City)

Incentives for Investment in Earthquake Resilience !

Side Effect of the
Act on Promotion of Seismic Retrofit of Buildings

400 year long established Department Store built in 1953 in Nagoya forced to close in 2018

Photo: Nikkei Newspaper

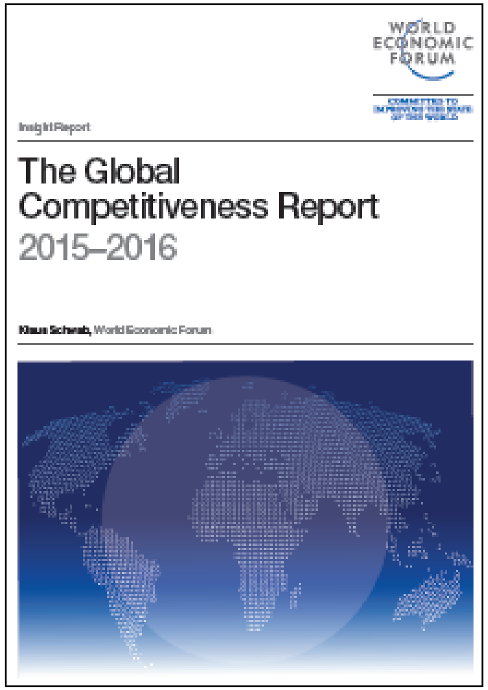
The Japanese society accepted to invest for resilience.

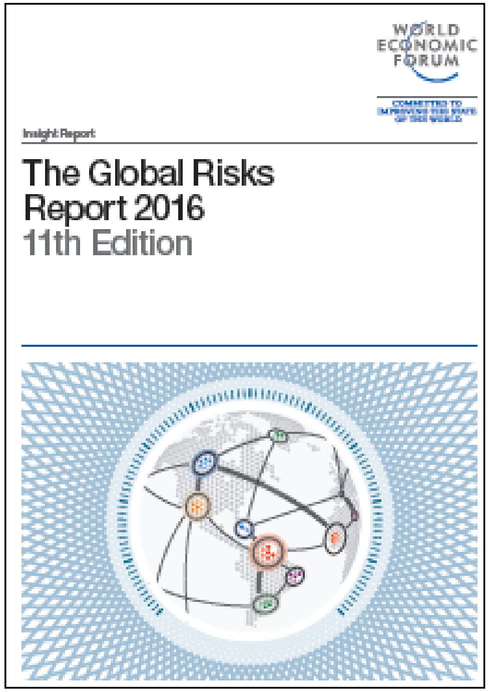
The oldest Hot Spring Spa in Japan: Dogo Hot Spring Undergoing Seismic Renovation

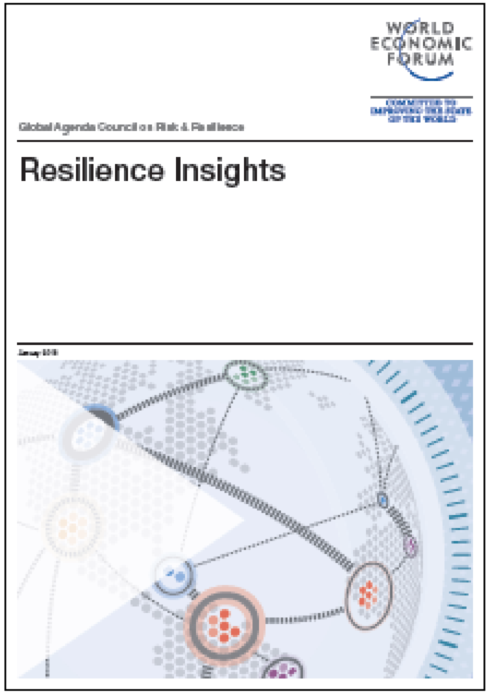
https://matsuyama-sightseeing.com/topics/1-2/

Some traditional hotels in Japan were forced to close their business since they could not afford the investment for seismic retrofitting.

Risk and Resilience is the Key for International Investment Decisions







The 2011 Thailand Floods reminded international capitals about risk & resilience in investments when selecting locations.

Business leaders are more acute on risks than 20 years ago.

Noto Peninsula Earthquake & Tsunami 2024 Jan.


JICA北陸高野撮影


JICA北陸 高野撮影


地震の影響で斜面が崩落した住宅地（2日午前8時2分、金沢市）=共同


能登町の道路被害　JICA三尾撮影

Noto Peninsula Earthquake & Tsunami

白煙が上がる石川県能登町。海岸に流出したとみられる家屋などが見
える（2日午前8時43分）=共同

JICA北陸高野撮影

https://www.hrr.mlit.go.jp/press/2023/1/240111honkyoku1.pdf

Noto Peninsula Earthquake & Tsunami

Landslides, Liquefaction, Ground Upheaval

https://www.hrr.mlit.go.jp/press/2023/1/240111honkyoku1.pdf

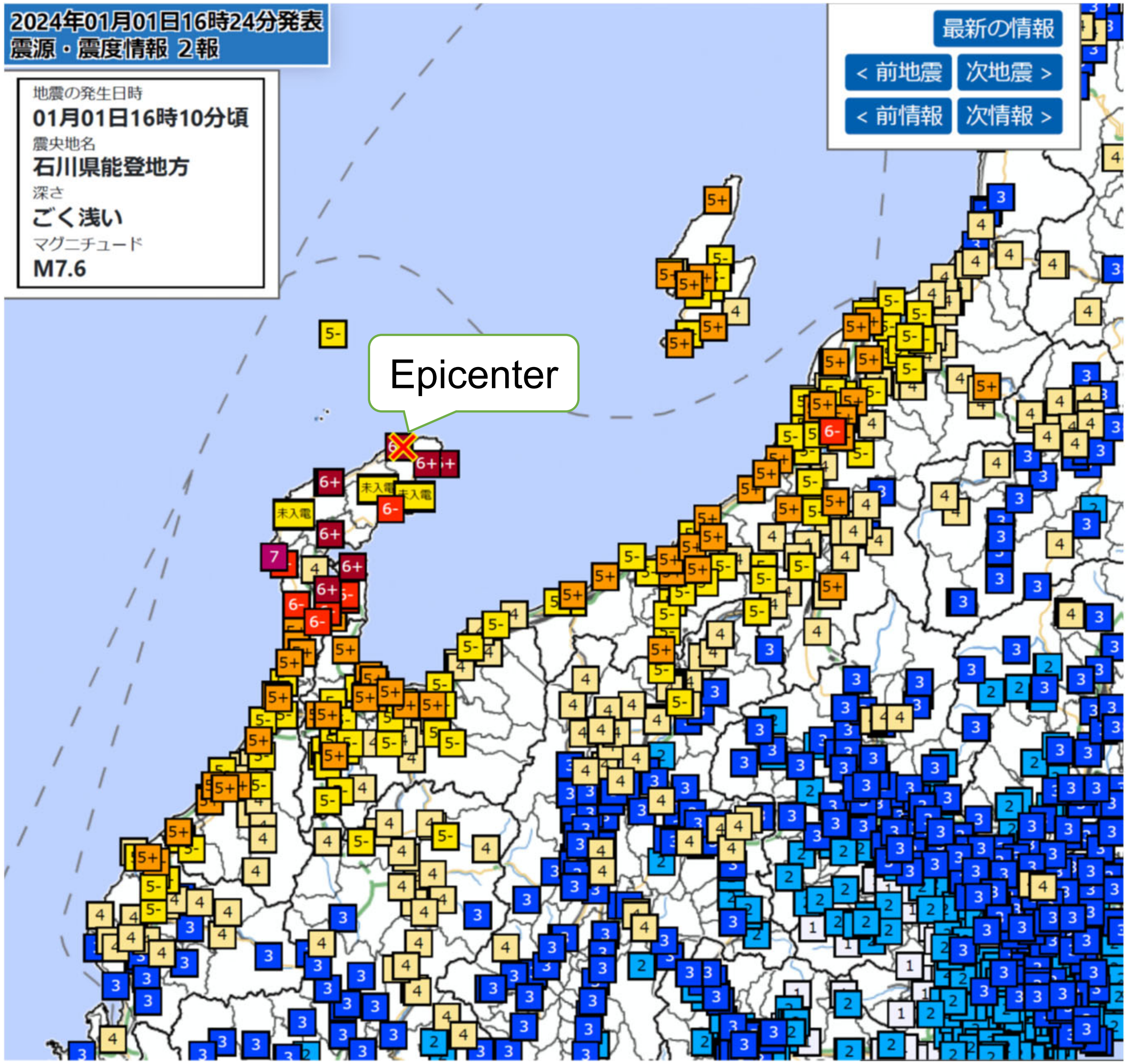
Manhole popped up by ground liquefaction
JICA北陸高野撮影

Port Warf rose 4m by ground upheaval

鹿磯漁港の防潮堤に固着した生物遺骸が示す隆起の様子。人が持っている標尺の長さは5 m

Upheaval of sea bottom brought dry port

Noto Peninsula Earthquake & Tsunami



Main Shock

16:10 January 1, 2024

Mj 7.6 : Mw7.5

Very Strong

Epicenter

Depth 16km(very shallow)

Max. PGA 27.3m/s^2

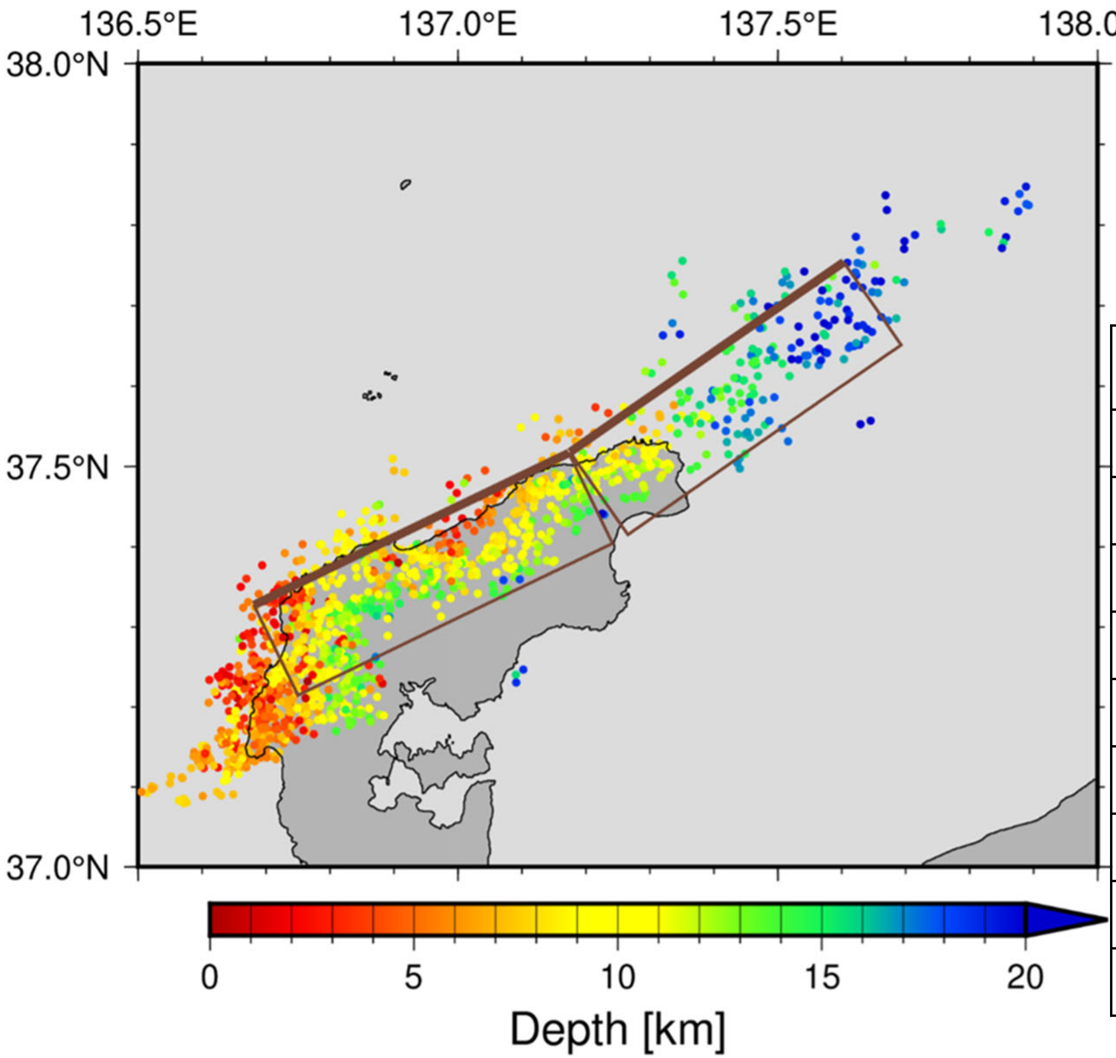
(K-NET Fuki)

Max. PGV 1.59m/s

(K-NET Anamizu)

JMA Scale	approx. MMI Scale
7 震度７	X～XII
6+ 震度６強	IX
6- 震度６弱	VIII
5+ 震度５強	VII
5- 震度５弱	VI
4 震度４	V～VI
3 震度３	IV～V
2 震度２	III～IV
1 震度１	II～III

Noto Peninsula Earthquake & Tsunami



https://www.gsj.jp/hazards/earthquake/noto2024/noto2024-03.html

Active Faults on the Land-Sea Border of Noto Peninsula were the sources. Numerous shocks observed.

Mj	Seismic Intensity	Time & Date
5.5	5+	16:06 Jan.1
7.6	**7**	**16:10 Jan.1**
6.1	5+	16:18 Jan.1
5.8	5+	16:56 Jan.1
4.6	5+	17:13 Jan.2
4.9	5+	02:21 Jan.3
5.6	5+	10:54 Jan.3
5.4	5+	05:26 Jan.6
4.3	6-	23:20 Jan.6

Major Shocks as of 6 Jan.

https://www.jma.go.jp/jma/menu/20240101_noto_jishin.html

Noto Peninsula Earthquake & Tsunami

Lessons Learnt from Previous Earthquakes & Tsunamis

2016 Kumamoto EQ:	Municipal Office Collapse
2011 Great East Japan EQ:	Tsunami Casualties
2004 Niigata Chuetsu EQ:	Village Isolation by Landslide
1995 Hanshin-Awaji(Kobe) EQ:	Building Collapse & Urban Fire

Reflected in Mitigation, Preparedness, Response and Recovery

能登町避難所での炊き出し（JICA三尾撮影)

https://www.hrr.mlit.go.jp/press/2023/1/240108honkyoku.pdf

https://www.jrc.or.jp/domestic_rescue/pdf/20240114-a93d1787b633a0e2459c1152b6f3a49be8df20b5.pdf

Noto Peninsula Earthquake & Tsunami

Lessons Learnt from Previous Earthquakes & Tsunamis

Wooden houses built according to the 2000 standard showed its strength

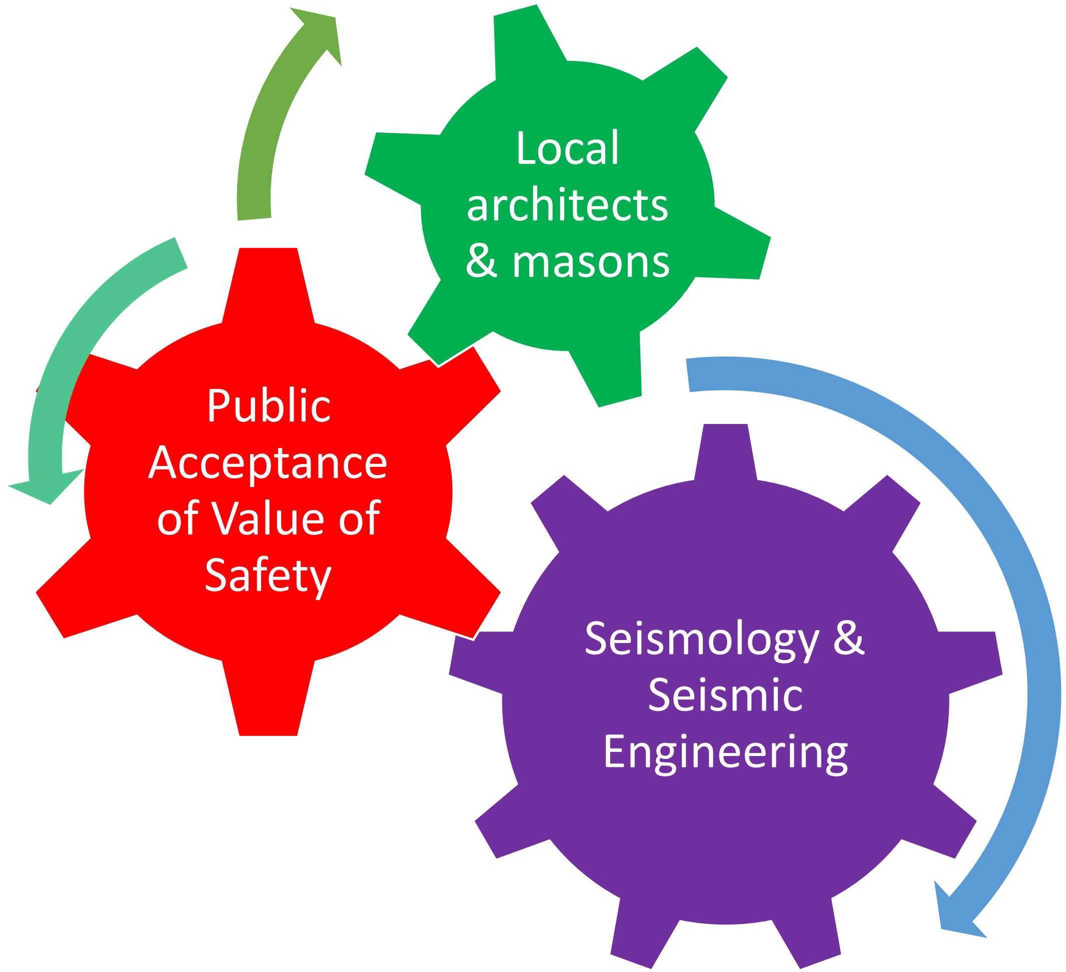
Built according to the 2000 standard

Built before the 2000 standard

Comparison of two neighboring wooden houses in Suzu City.

Survey by Takuya Nagae, Nagoya University

Some elements for earthquake safety of housing



What if Building Standard is cheated in Japan?

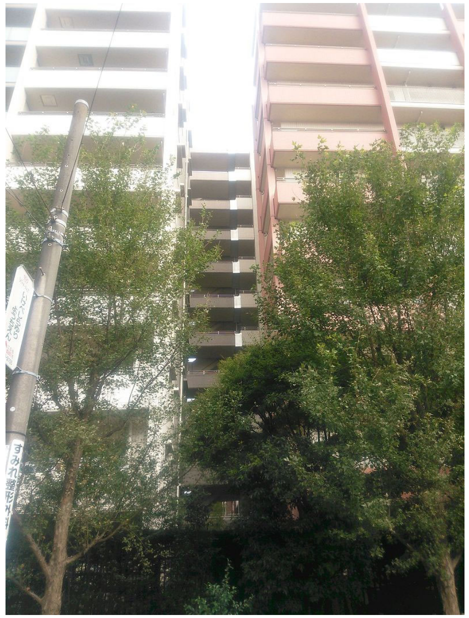
2007 A brand new large condominium complex with 705 housing units completed in Yokohama.

2014 Residents noticed a 2cm gap in the corridor!
Residents found that the condominium was slightly tilted!
Real Estate Developer denied and said no problem.

2015 Residents questioned the real estate developer. Why is this tilted?
Real estate developer initially insisted that it must be because of the Great East Japan Earthquake of 2011.
Residents were not satisfied with this explanation.
Residents demanded structural investigation!

Photo by Nikkei News

Photo by 妖精書士 - 投稿者自身による著作物, CC 表示-継承 4.0,



What if Building Standard is cheated in Japan?

2015 Residents raised this issue to the City of Yokohama.

Real estate developer investigated and found that ground piles were short and did not reach the solid base rock.

City of Yokohama and MLIT jointly pointed out that this ground pile shortage is violation of Building Standard Law.

This was reported in the newspaper.

Numerous criticism to the real estate developer.

Real estate developer was forced to announce that they are willing to totally rebuild the condominium at their own cost.

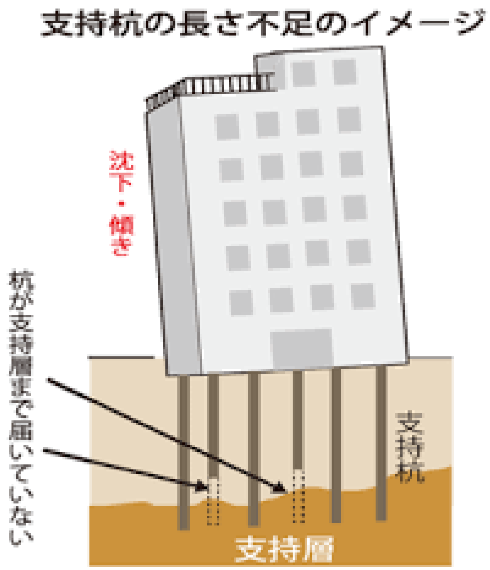
2016 Residents union decides to accept the rebuilding plan. Each resident was offered 3million yen compensation for the inconvenience of the temporally removal.

Residents were offered free alternate rooms.

2017 Reconstruction started.

2021 Reconstruction completed. Residents back.

Lawsuit over 46 billion yen cost of reconstruction and compensation among the real estate developer, construction company, pile work company continues.



https://www.shinsei-h.biz/blog/%E3%82%B9%E3%82%BF%E3%83%83%E3%83%95%E6%97%A5%E8%A8%98/764/

What if Construction Quality Control is cheated in Japan?

札幌市で建築中の高層ビルで精度不良などが発覚した。組み上がった鉄骨を解体して建て直す異例の事態に（写真:共同）

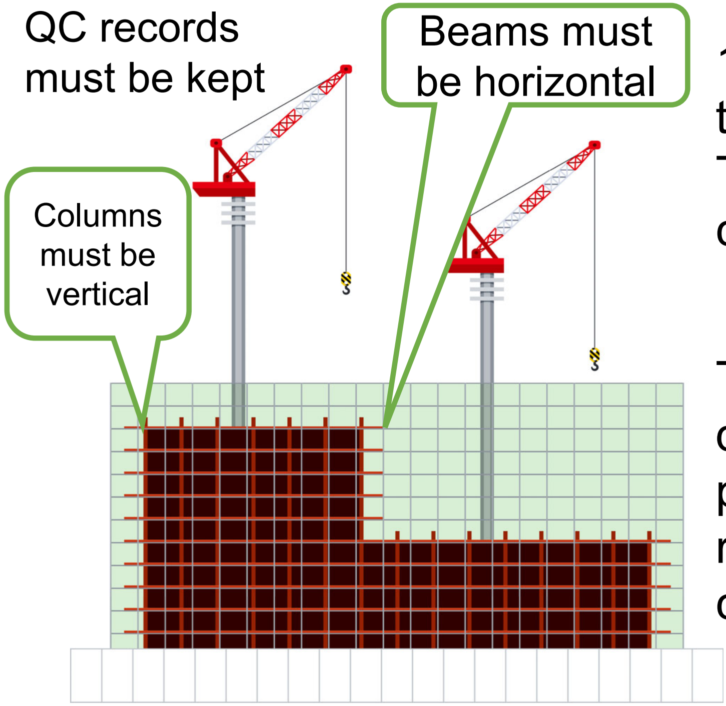
In Jan. 2023, at the construction site of a large hotel/office/commercial complex (26 stories above, 2 stories underground) in Sapporo, the client company's in-house engineer noticed that the holes for the bolt joints are distorted and smaller than what they should be.

The steel pillars and beams were already assembled up to the 15 floor.

He pointed out to the on-site construction project office that there must be something wrong with the structure.

The construction company HQ quality control office was called to inspect the assembled structure regarding accuracy of each steel column, beams and floors and reported that 77 points in the steel structure were found to exceed the tolerance by 21mm maximum, 245 points were found to exceed the tolerance of concrete floor slab thickness.

What if Construction Quality Control is cheated in Japan?



The structure already assembled up to the 15th floor, it was no longer possible to correct the distortion.
The construction company did not follow their construction quality control process.

The construction company was forced to dismantle the 15 story steel structure (lower part already with concrete slab floors) and reconstruct the steel structure at their own cost.

The hotel/office/commercial complex was originally planned to be completed in Feb. 2024, but is rescheduled to June 2026.
The construction company architectural department Executive Officer had to voluntarily resign, the cost of the reconstruction is huge but not reported.

The keen eyes enforces the quality control & safety of buildings !

Some elements for earthquake safety of housing

Explosion of Emotional Words

Surprise,
Unexpected,
Tragedy,
Horror,
Sorrow,
Despair,

Rescue,
Relief,
Heartwarming,
Rest,
Calm,

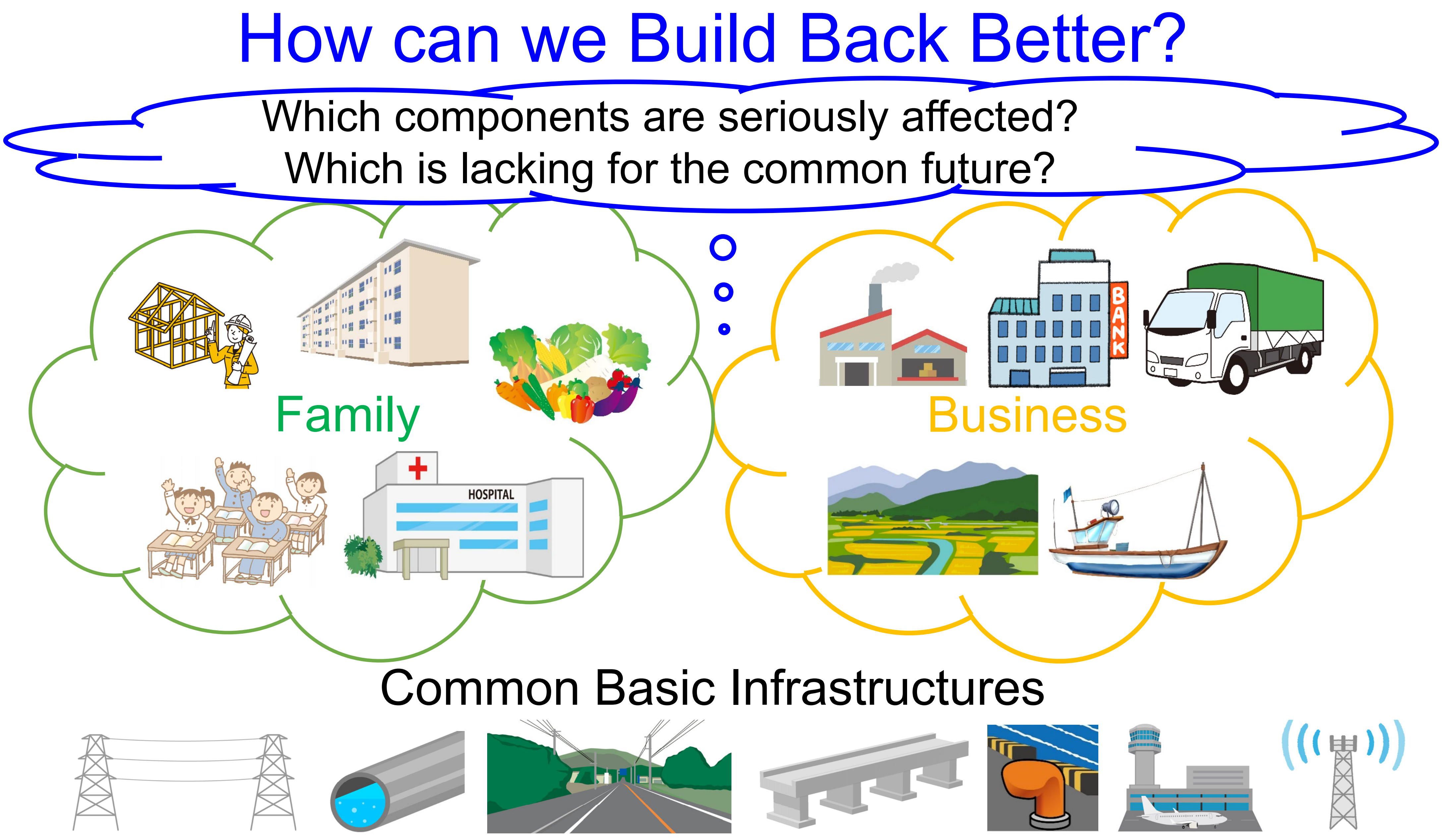
Disappointment,
Frustration,
Agony,
Grief,
Irritation,

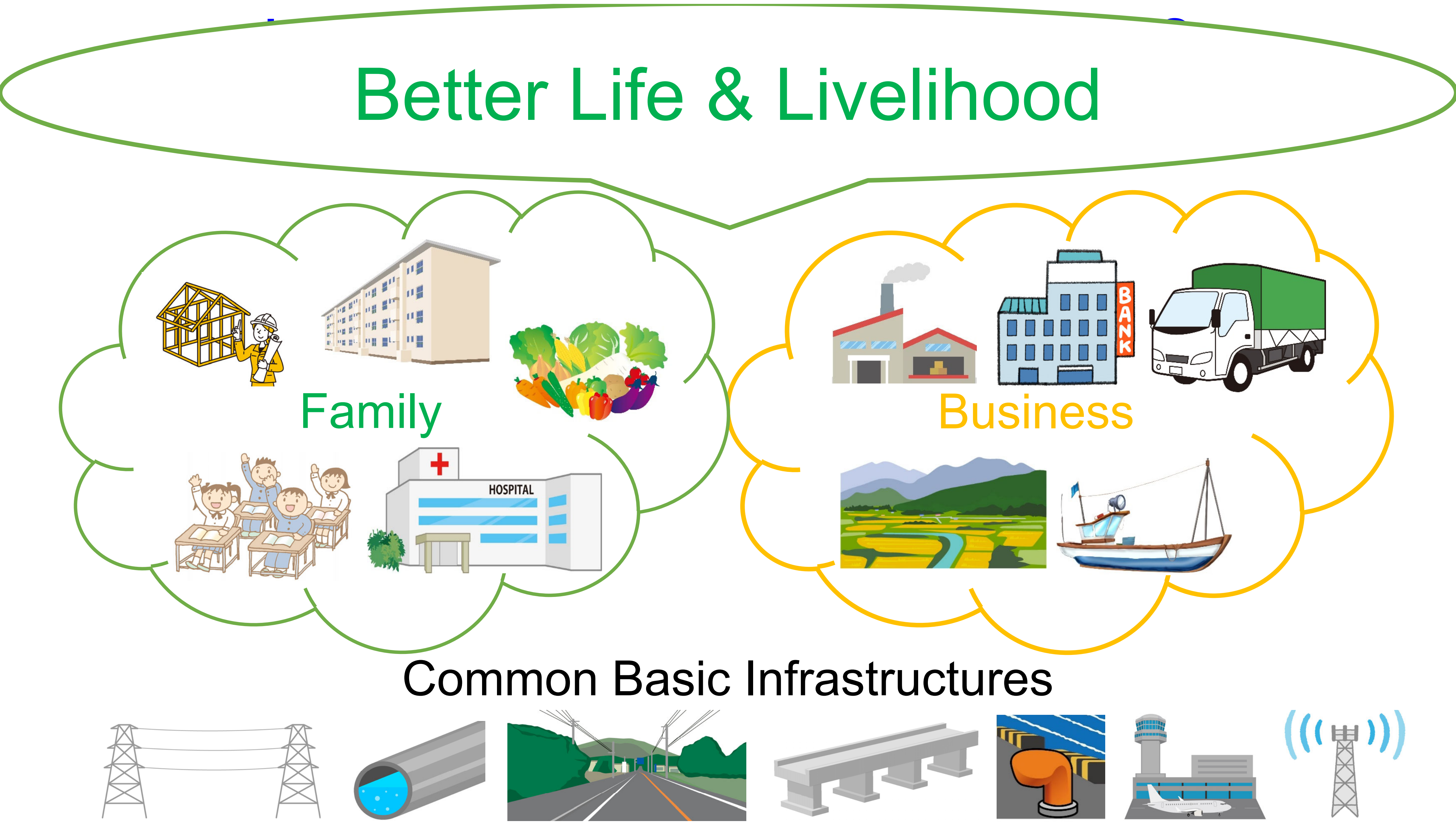
It is no use crying over spilt milk !

Positive,
Revive,
Forward,
Innovation,
Wish,
Will,

Criticism,
Non-sense,
Bi-partisan,
Opposition,
Unrealistic,

Solidarity, Consensus & Mutual Appreciation + Strong Will to enable "Build Back Better"


How can we Build Back Better?
Which components are seriously affected?
Which is lacking for the common future?
Family
HOSPITAL
Business
BANK
Common Basic Infrastructures


Better Life & Livelihood
Family
HOSPITAL
BANK
Business
Common Basic Infrastructures

People Centered and Resilient Recovery

How can you convince the community leaders about disaster risk in their localities ?

1923 Great Kanto Earthquake Monument in Yokotsuna park in Sumida-ku Tokyo where 38,000 people perished by fires.

1933 Tsunami Stone Monument in Miyako City

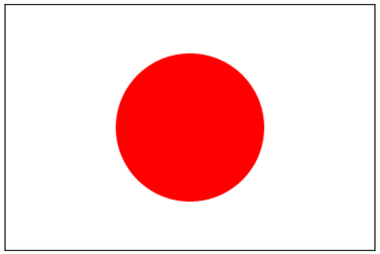
Why did our ancestors leave these historical assets for us ?

Proverb by Japanese Physics Scientist
Dr. Torahiko TERADA (1878-1935)
who investigated the damage by
1923 Great Kanto Earthquake

「天災は忘れた頃にやってくる」

“Natural Disasters will hit us by the Time people have forgotten about it”

How to foster & inherit the Culture of Prevention



Thank you for your attention!