Seismic evaluation of the existing RC buildings in Japan

June 2017

Building Research Institute,
Japan

Matsutaro SEKI

Contents

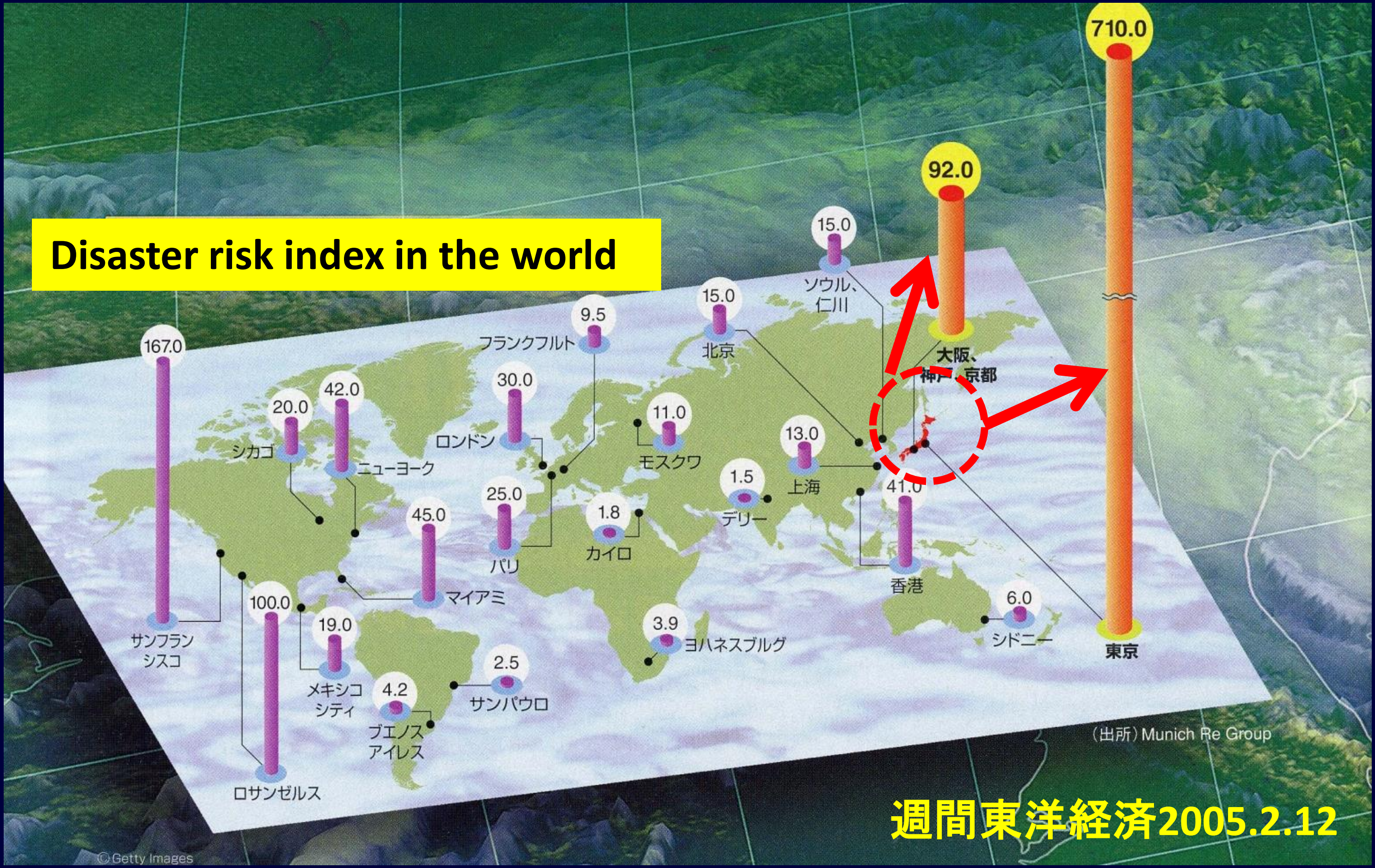
Earthquake damage and Japanese seismic code

1995 Hyogoken Nanbu (Kobe) earthquake, Japan

兵庫県南部地震、1995.1.1

Disaster Risk in the World

Disaster Risk in Japan is highest in the World: Tokyo, Osaka



Disaster risk index in the world

（出所）Munich Re Group

週間東洋経済2005.2.12

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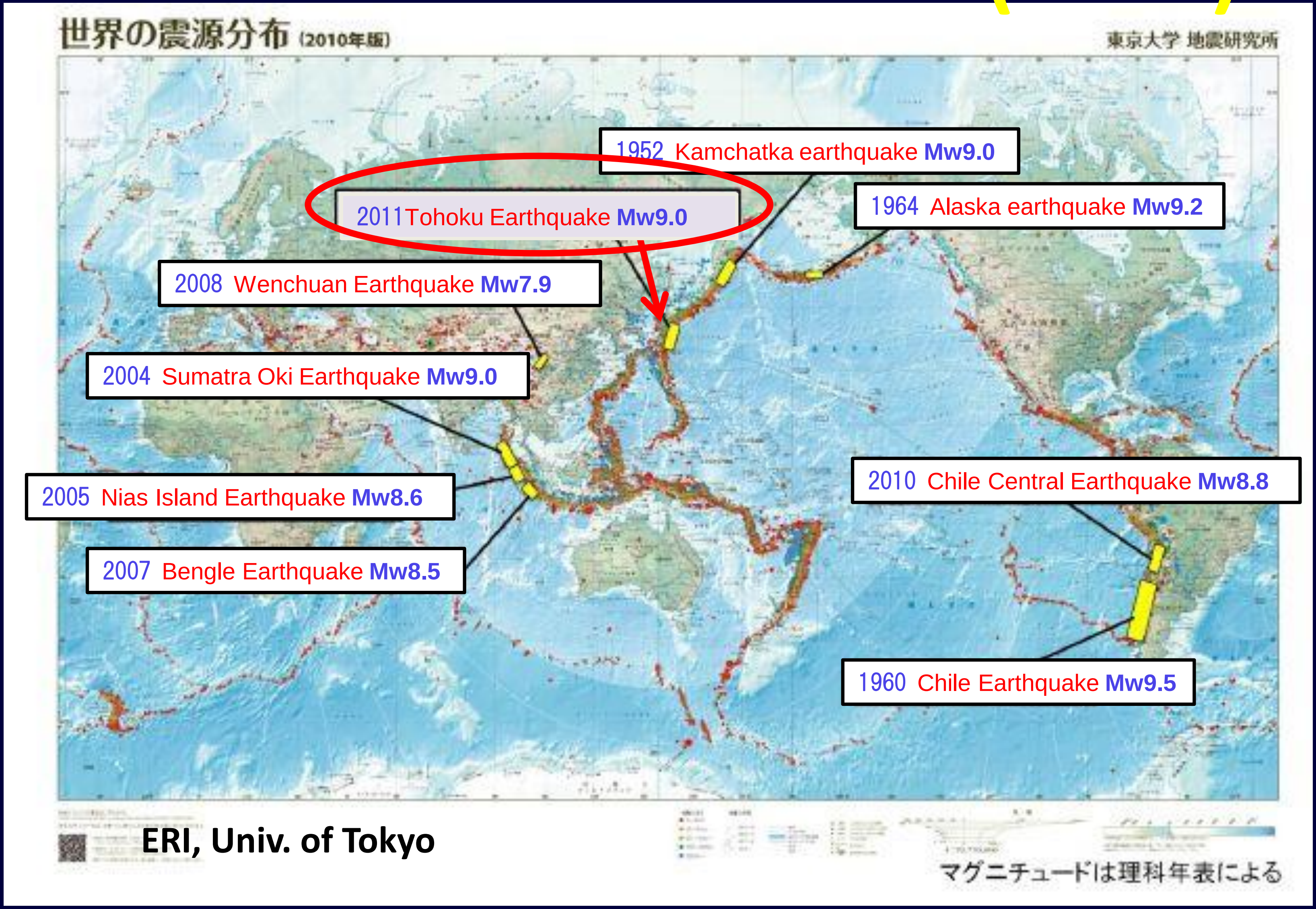
Recent Big Earthquakes higher than M.8 in the World (2010)



1952 Kamchatka earthquake **Mw9.0**

2011 Tohoku Earthquake **Mw9.0**

1964 Alaska earthquake **Mw9.2**

2008 Wenchuan Earthquake **Mw7.9**

2004 Sumatra Oki Earthquake **Mw9.0**

2005 Nias Island Earthquake **Mw8.6**

2010 Chile Central Earthquake **Mw8.8**

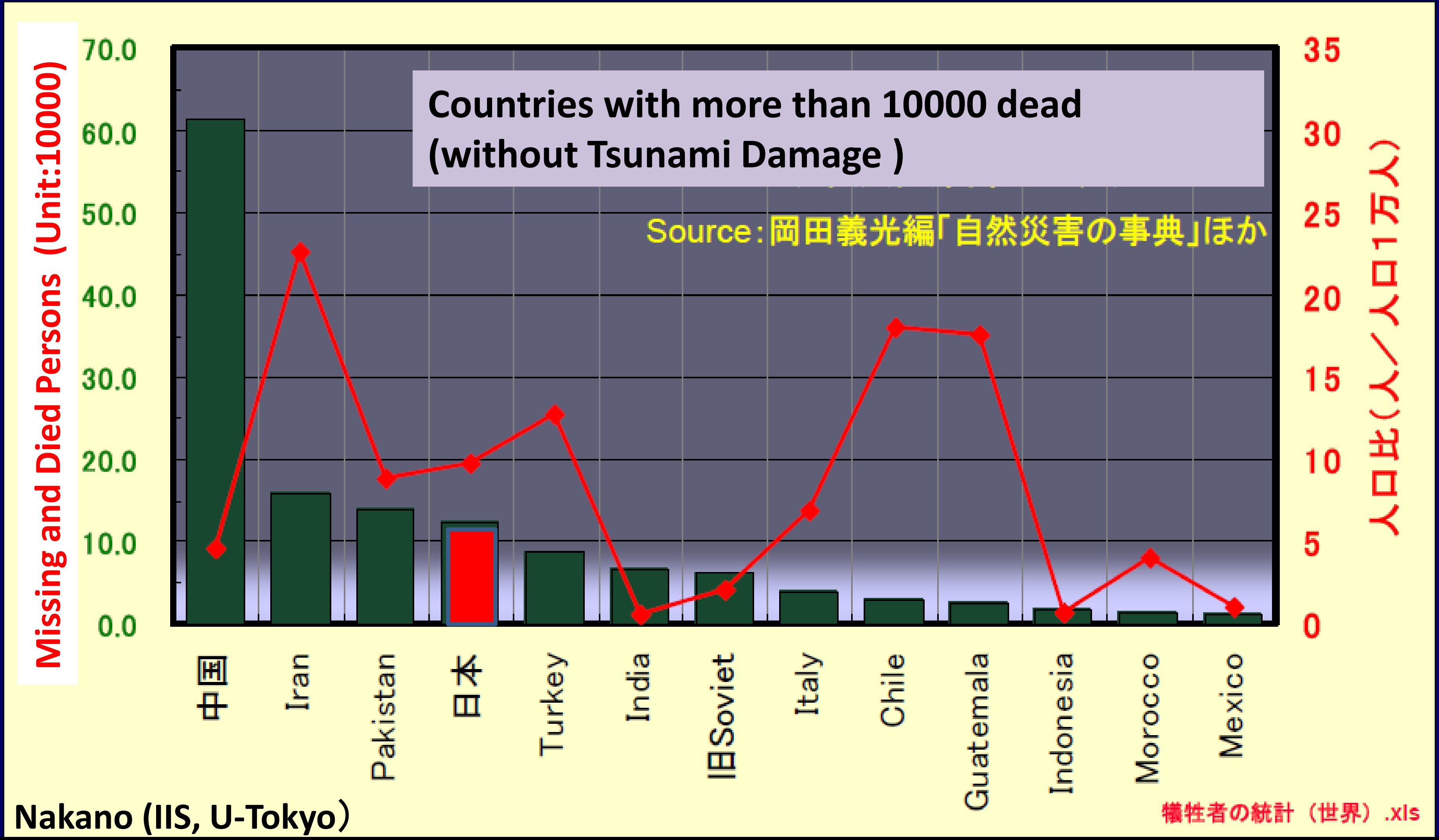
2007 Bengle Earthquake **Mw8.5**

1960 Chile Earthquake **Mw9.5**

ERI, Univ. of Tokyo

Casualties by Earthquakes in the World

(1990-2008.8)



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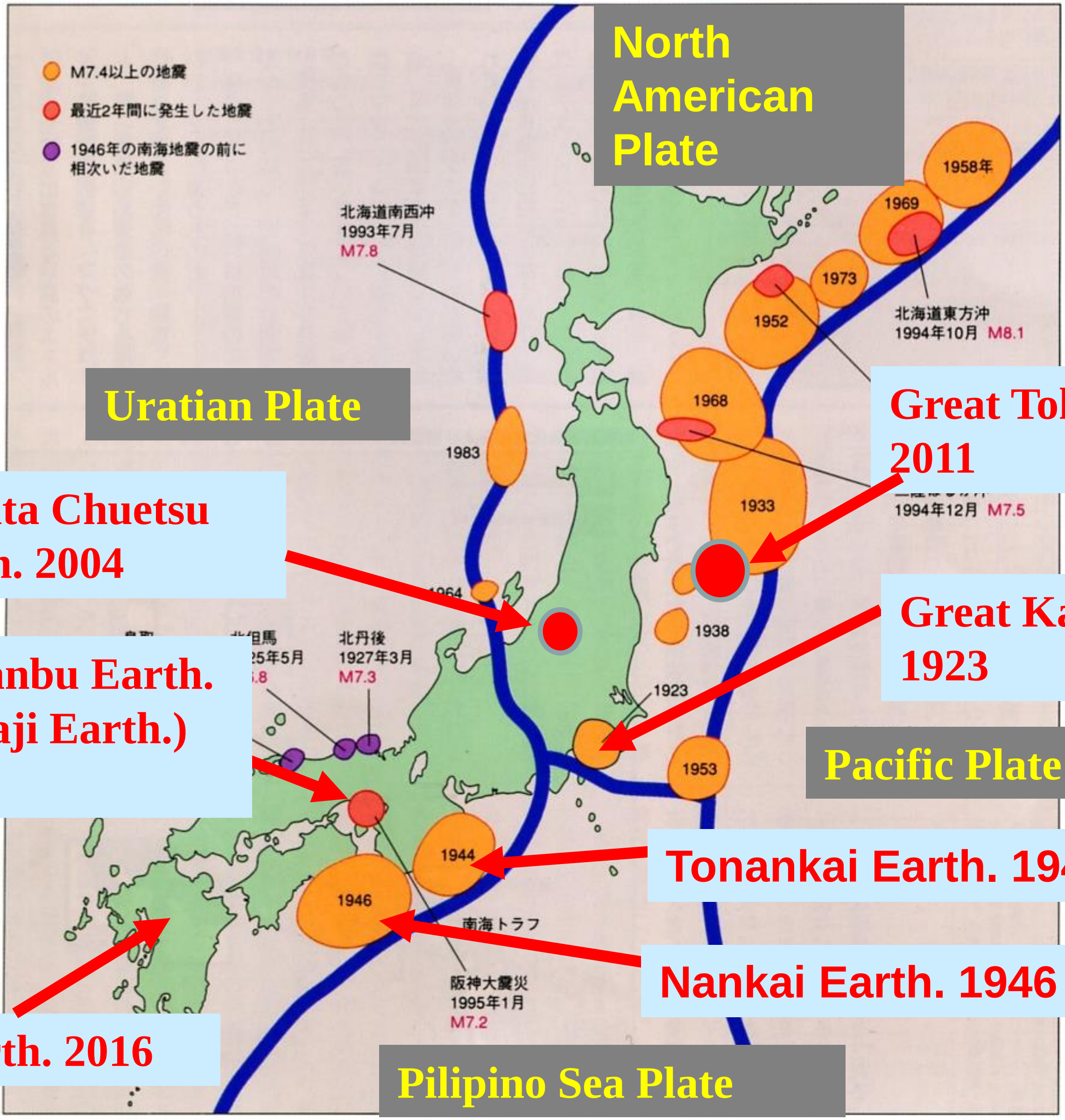
Earthquake Around Japan Island（1900-2017）

今世紀に日本周辺で起きた主な地震



North American Plate

Uratian Plate

Great Tohoku Earth. 2011

Niigata Chuetsu Earth. 2004

Great Kanto Earth. 1923

Hyogo ken Nanbu Earth.（Hanshin Awaji Earth.) 1995

Pacific Plate

Tonankai Earth. 1944

Nankai Earth. 1946

Kumamoto Earth. 2016

Pilipino Sea Plate

（『朝日新聞』1995年1月25日）

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Kanto Earthquake, 1923

Reinforced Concrete Building

http://research.kahaku.go.jp/rikou/namazu/03kanto/marunouti/marunouti.html

Kanto Earthquake, 1923

Damage of Masonry Building

http://research.kahaku.go.jp/rikou/namazu/03kanto/marunouti/marunouti.html

Lessons from Kanto Earthquake,1924

1. Horizontal seismic intensity: 0.1 was adopted for seismic design.
2. Damage of reinforced concrete buildings was small.
3. Damage of masonry buildings was big.
4. Discussion on the benefit of rigid structure and flexible structure was done. From then, the rigid structure was recommended.

Dynamic Time History Analysis and Super High Rise Buildings

1. In 1960, Computer was used for dynamic analysis.

2. Many Earthquake ground motions were recorded.

3. in 1968, the first high rise building was completed.

(H=147m, 36F, Steel structure)

Kasumigaseki building, Japan

Photo: Tsuneo Okada (2005)

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Tokachi-oki Earthquake, 1968

Shear Failure of Column (Brittle failure)

Hachinohe Technical High School

Photo; Tsuneo Okada

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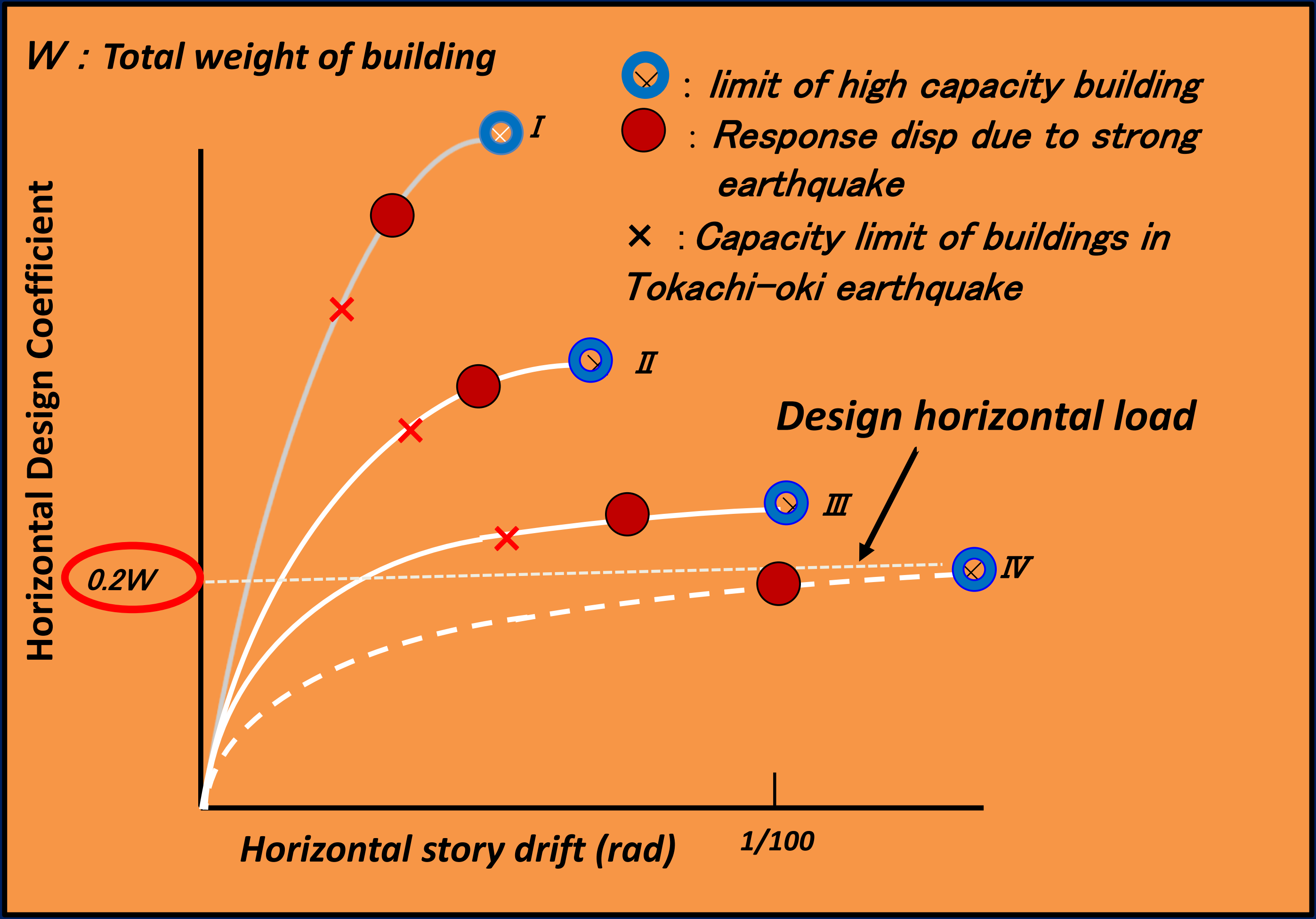
Lessons from Tokachi-oki Earthquake, 1968

1. There are lots of Shear Failure of RC Column
2. Lots of research works on Shear Failure were done from then.
3. Japanese seismic code was revised in 1971.
4. Hoop space was changed from 30 cm to 10 cm.
5. Seismic design was changed from shear failure to flexural failure.

Lessons from Tokachi-oki Earthquake, 1968

AIJ journal. January 1969

Load Deflection Curves of Various type Structures



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Japanese New Seismic Code (Required Horizontal Strength)

- ■ 1977: Draft of New Seismic Code

- ■ 1981: Issue of New Seismic Code

◆ Characteristics

1. Design force is calculated by linear response spectrum.
2. Required design strength can be reduced Based on the Ductility of Structure.

Basic Concept of Japanese Required Horizontal Strength

Required horizontal strength (Qun)

$C = Qun/W = Co \cdot R_t \cdot Ds \cdot Fes$

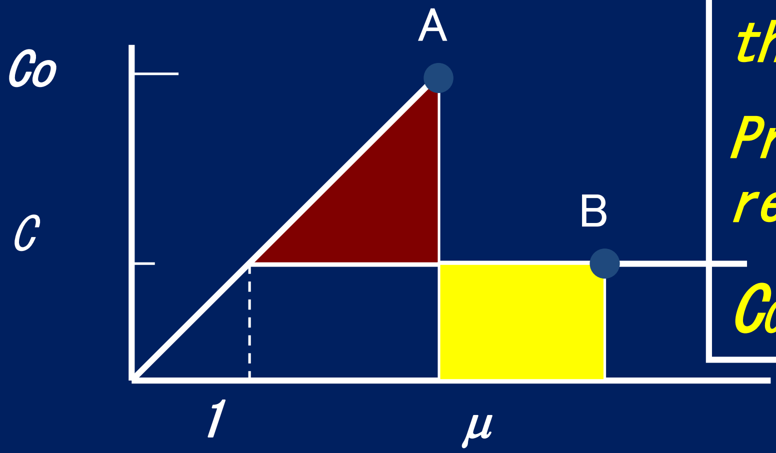
Co : Standard shear coefficient ≥ 1.0

R_t : Design spectral factor ≤ 1.0

Ds : Structural characteristic factor ≥ 0.25 (RC: ≥ 0.30)

Fes : Shape factor ≥ 1.0

W : Weight of building



Based on the energy constant theory after Newmark

Prediction of nonlinear response displacement

$$C_0 = C \times \sqrt{2\mu - 1}$$

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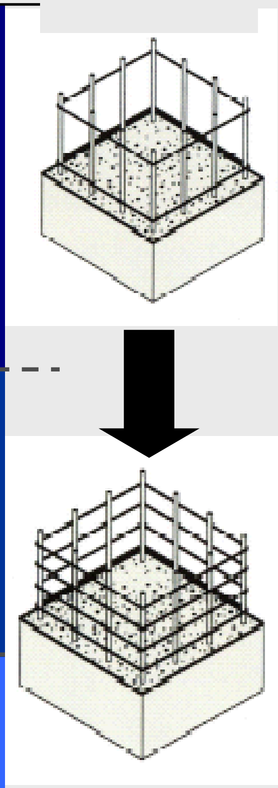
Transition of Japanese Seismic Code

1968 Tokachi oki Earth.	Old code	1971 Revised: Japanese seismic code	Allowable design
1978 Miyagiken oki Earth.	Shifting	1981 Revised: Japanese seismic code (New Seismic Code)	Ductility of Column
1995 Kobe Earth.	New code		2 steps design: (1) Small Earth. (2) Strong Earth.



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Hyogoken Nanbu Earthquake, January 1995

Column Designed by the Old Code

Column Designed by the New Code

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Hyogoken Nanbu Earthquake, January 1995

Columns collapsed (Designed by old Seismic Code)

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Hyogoken Nanbu Earthquake, January 1995

First Story Collapsed (designed by old code)

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Hyogoken Nanbu Earthquake, January 1995

Me

Medium Story Collapsed (Old code)

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Hyogoken Nanbu Earthquake, January 1995

Building collapsed on the Road

http://www.kobe-c.ed.jp/shizen/strata/equake/photo/index2.html

Hyogoken Nanbu Earthquake, January 1995

Residential House (Upper Structure has no damage)

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Hyogoken Nanbu Earthquake, January 1995

Top of the Piles were Damaged

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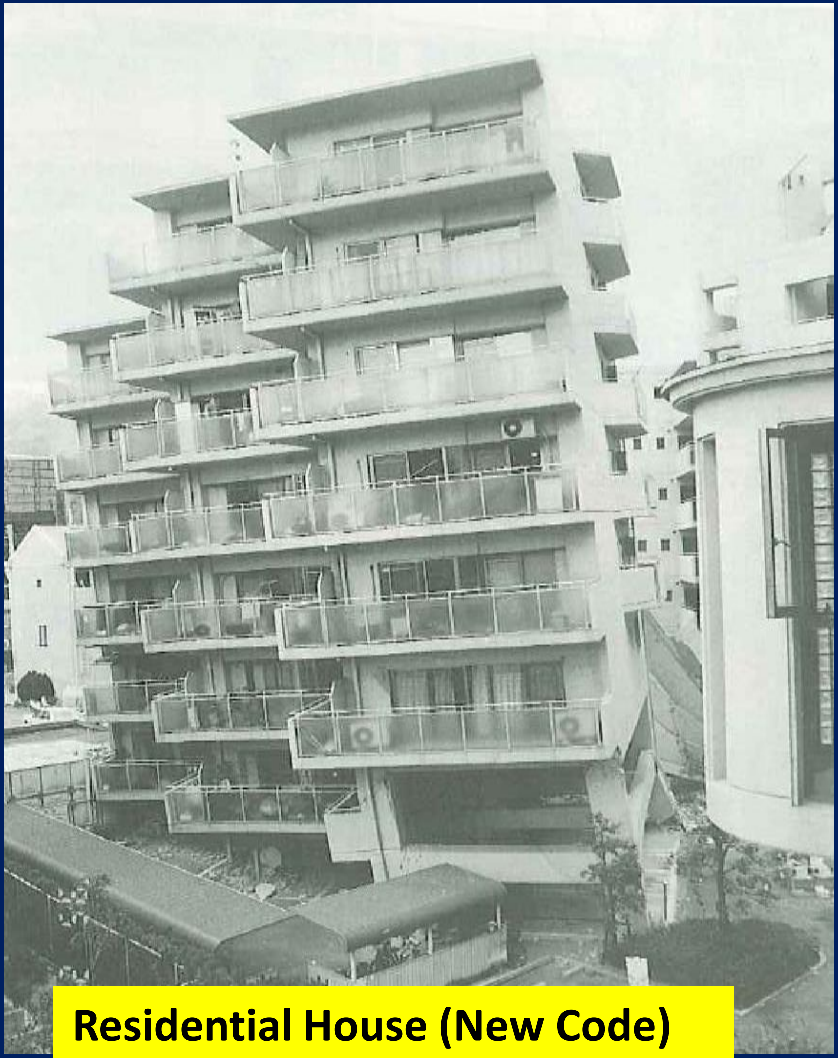
Hyogoken Nanbu Earthquake, January 1995



Residential House (New Code)

Failure of First Story (New Code)

被災した集合住宅・テツアドー出版1995

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Hyogoken Nanbu Earthquake, January 1995

Cracks of Beam Column Joint (New Code)

Failure of Beam (New Code)

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Hyogoken Nanbu Earthquake, January 1995

Fall of Windowpane

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Hyogoken Nanbu Earthquake, January 1995

Fall of Precast Concrete Panels

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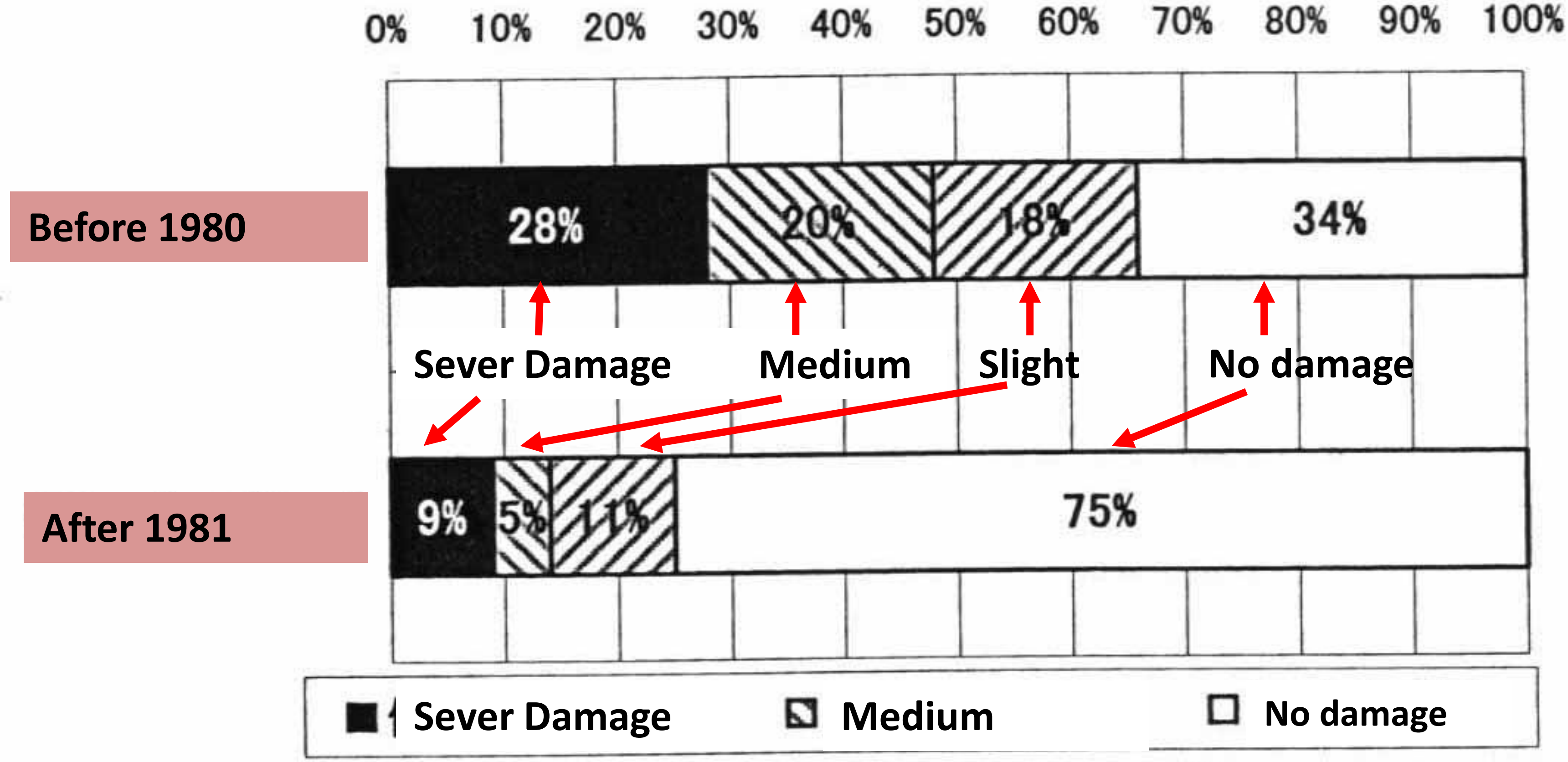
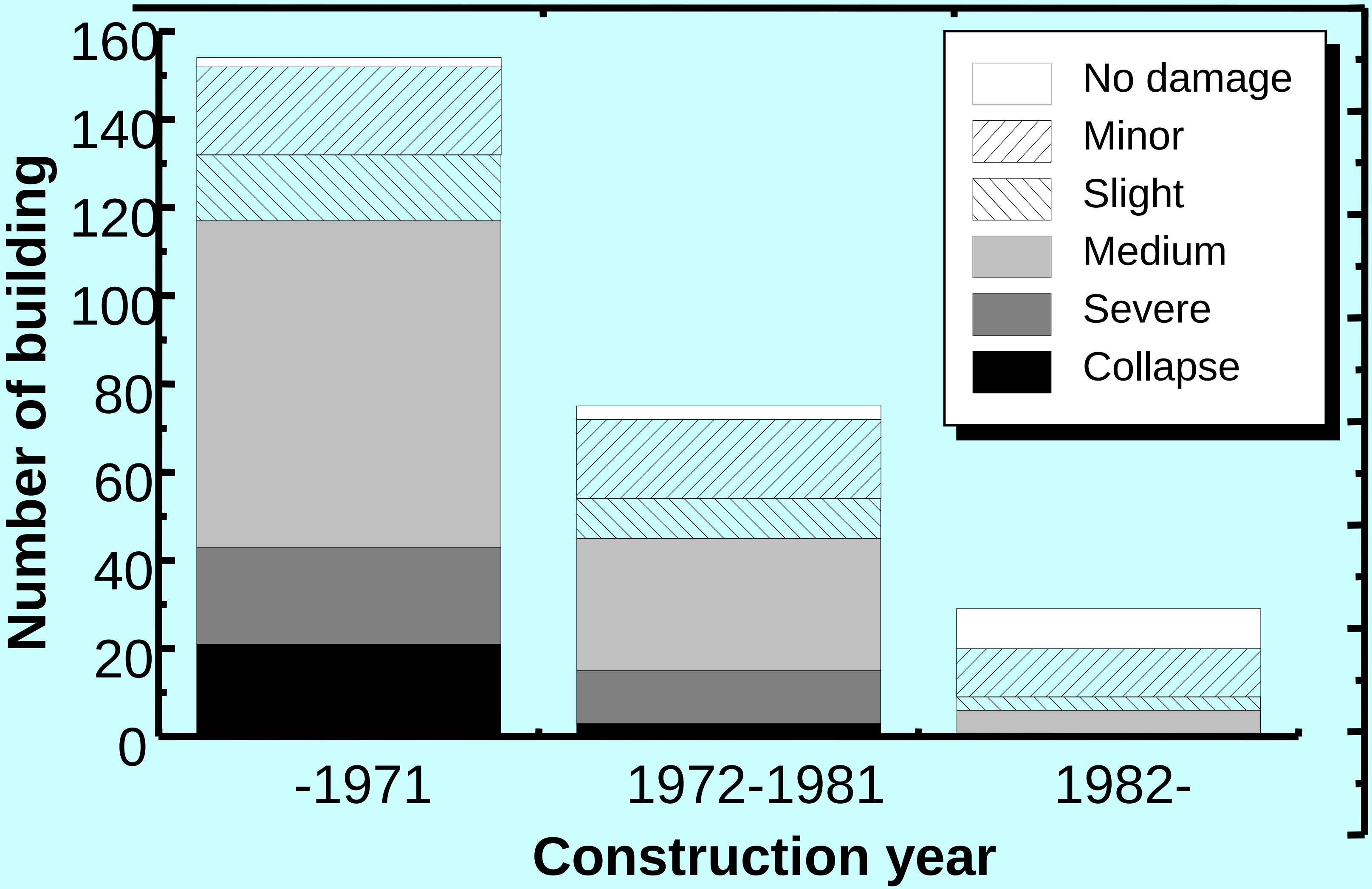
Hyogoken Nanbu Earthquake, January 1995
Conclusions(1)

Construction year ad Damage of buildings



神戸市中央区JR三宮駅付近の悉皆調査(923棟)
出典:平成7年阪神・淡路大震災建築震災調査委員会中間報告

Hyogoken Nanbu Earthquake, January 1995



Hyogoken Nanbu Earthquake, January 1995
Conclusions(2)

1. Lot of severe damaged buildings before 1980 code
2. Small number of damaged buildings after 1981 code.　 Small modification of 1981 seismic code was done.
3. If Seismic strengthening has been performed, there is little damage.

Tohoku Taiheiyo Earthquake, 3.11,2011

Story Collapse (Old Seismic Code)

Photo: Fukuyama H.

Tohoku Taiheiyo Earthquake, 3.11,2011

Photo: Fukuyama H. ,BRI

Column Failure (Old Seismic Code)

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Tohoku Taiheiyo Earthquake, 3.11,2011

東日本大震災；サンデー毎日増刊4月２日号

Damaged detached timer house by Tsunami

Tohoku Taiheiyo Earthquake, 3.11,2011

Liquefaction

BRI report

Sliding of Soil

JAAF, June 2011

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Tohoku Taiheiyo Earthquake, 3.11,2011

Fall of the Ceiling

BRI report

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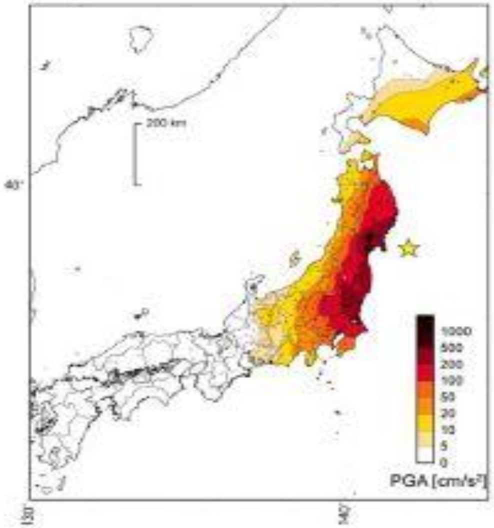
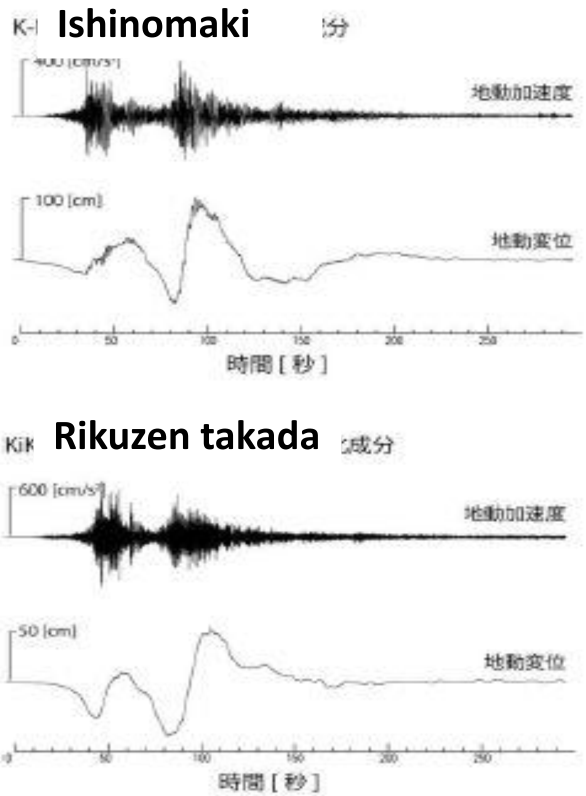
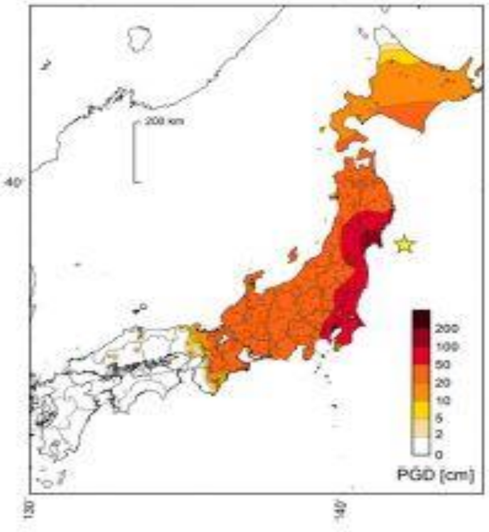
Tohoku Taiheiyo Earthquake, 3.11,2011

Furumura, Takemura; ERI. , Univ. of Tokyo

Observed strong ground motions



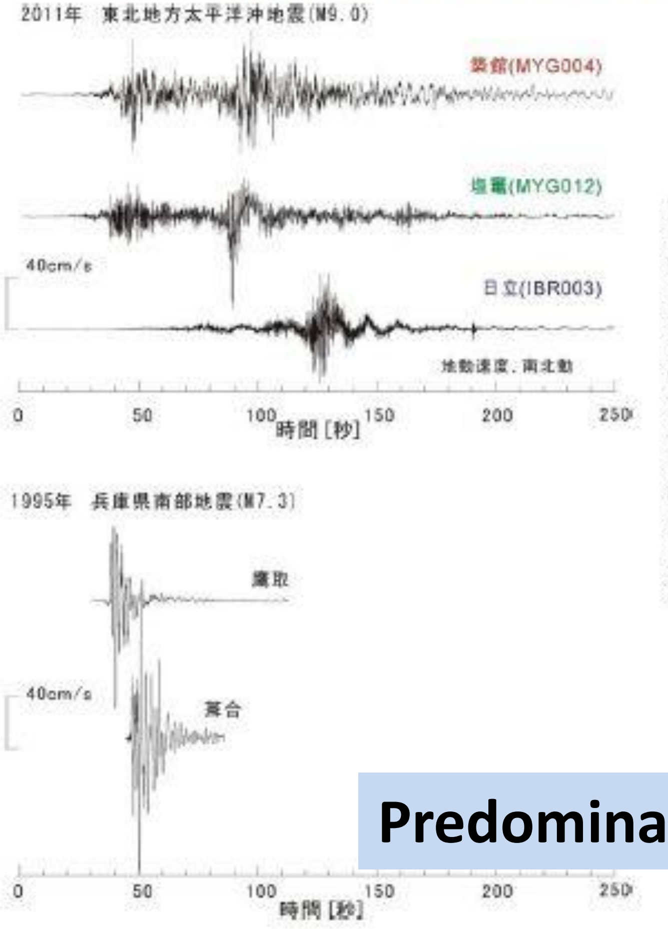




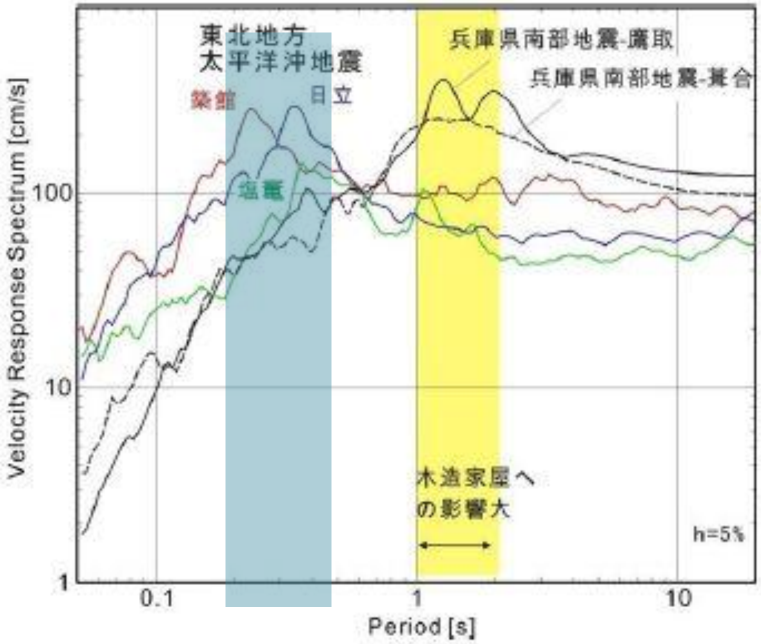
Long Duration Ground Motion (about 100 seconds)

Tohoku Taiheiyo Earthquake, 3.11,2011

Velocity time history and Velocity response spectrum



Furumura, ERI. Univ. of Tokyo



Predominant Periods of Ground Motions

Tohoku Taiheiyo Earthquake, 3.11,2011
Conclusions (1)

RC buildings

1. The Buildings constructed by 1980 old code were severely damaged but not so many buildings.
2. The retrofitted buildings showed the good performance.
3. The buildings constructed by 1981 new code were almost safe but small modification was performed.

Tohoku Taiheiyo Earthquake, 3.11,2011
Conclusions (2)

4. Other damages

① Serious Damage of non structural members
② Liquefaction of soil occurred and detached house suffered severely damaged.
③ The high rise buildings were affected by the long period dominated ground motion.
④ Tsunami did great damage to the lots of houses.

History of Seismic Evaluation Standard in Japan

1. Research work on seismic retrofit has started after 1968 Tokachi-oki earthquake
2. In 1977 seismic evaluation standard was issued by JBPA . It was only used for disaster mitigation in Shizuoka Prefecture, Japan
3. It was legislated as "Act for Promotion of Renovation for Earthquake- Resistant Structures of Buildings" just after 1995 Hyougoken Nanbu earthquake.
4. 2005: Revision of the Act; Enforcement of promotion
5. 2013: Revision of the Act; Mandatory for the special –use building

2001Revised version

Standard for Seismic Evaluation of Existing Reinforced Concrete Buildings, 2001

2001

The Japan Building Disaster Prevention Agency (JBDPA)

2001年改訂版

既存鉄筋コンクリート造建築物の

耐震診断基準

同解説

監修　国土交通省住宅局建築指導課
発行　財団法人　日本建築防災協会

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Basic Policy

JBDPA Seminar PPT

- Seismic Evaluation=In-situ investigation +Calculation
- Digitization of Capacity

1. Seismic Index of Structure : I_S
2. Seismic Index of Non Structural Element: I_N

- Judgement comparing Seismic Demand Index of Structure

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Flow from Seismic Evaluation to Seismic Retrofit

(1) Seismic Index : Is

(2) Seismic Demand Index: *Iso*

- *Is* $\geq$ *Iso* : OK -------------------------> END
- *Is* < *Iso* : Retrofit ----------------------> GO TO (3)

(3) Select of Retrofitting Methods

(4) Structural Design of Retrofit

(5) Judgment of Retrofitted Building

- *Is* $\geq$ *Iso* : OK

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Seismic Estimation Level

- 1st level evaluation (Failure of wall & column)
  - The simplest calculation. Strength of column and wall is calculated by section area and material strength.

- 2nd level evaluation (Failure of wall & column)
  - C index and F index of column and wall are calculated by member size , material, rebar, concrete, etc. Slab and beam are not considered in the estimation.

- 3rd level evaluation（Failure of beam)
  - The most complicated calculation. Beam and sla aere considered in the estimation.

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Material Property required for Seismic Evaluation

short ← Calculation time → long

		1st	2nd	3rd
Size of Members	**Column, Wall**	○	○	○
	Beam			○
Strength of Members	**Concrete**	○	○	○
	Rebar		○	○
Location of rebar			○	○

Column, Wall ——→ |

Column, Wall + Beam ——→ |

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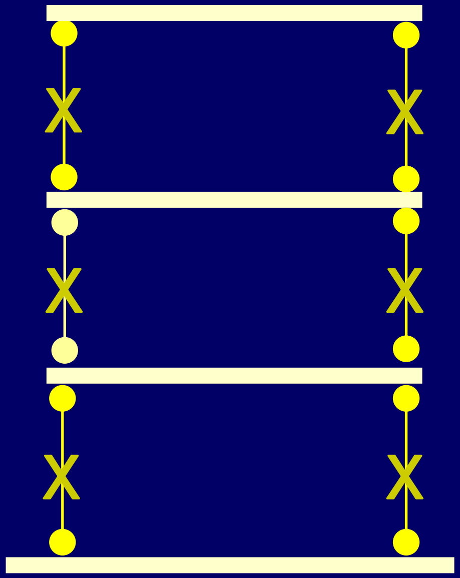
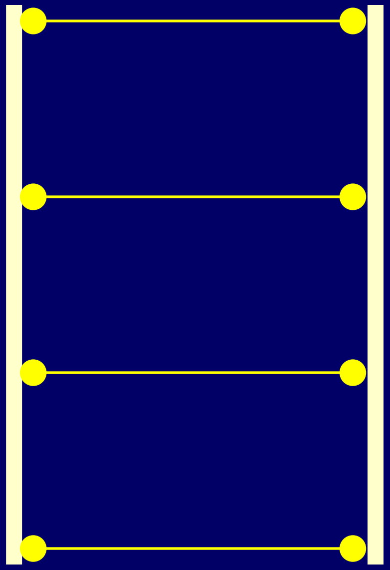
Failure Type



Column failure type



Beam failure type

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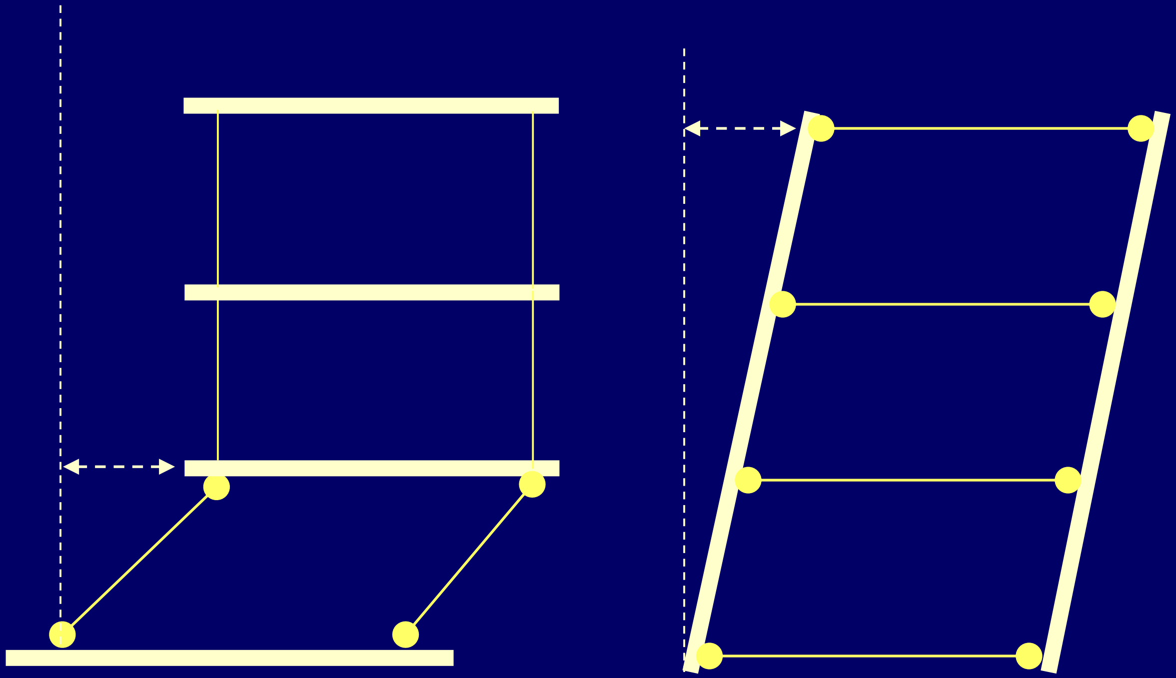
Failure Type



Column failure type

Beam failure type

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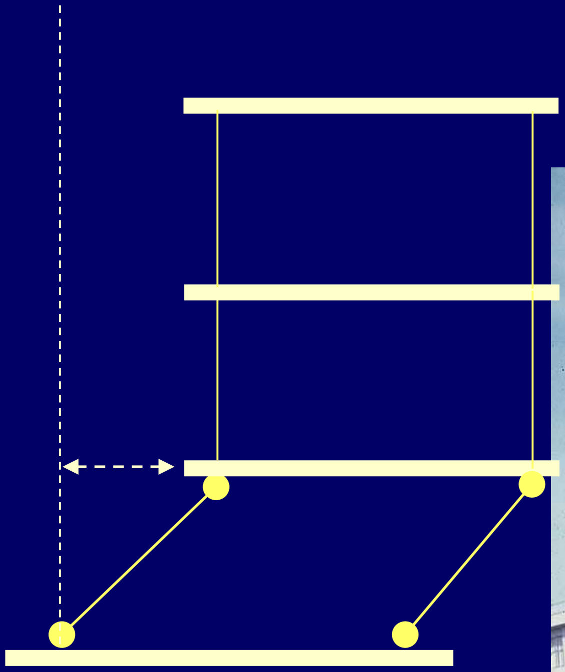
Example of column failure type



1968 Tokachi-oki Earth.（Hachinohe Technical High School)

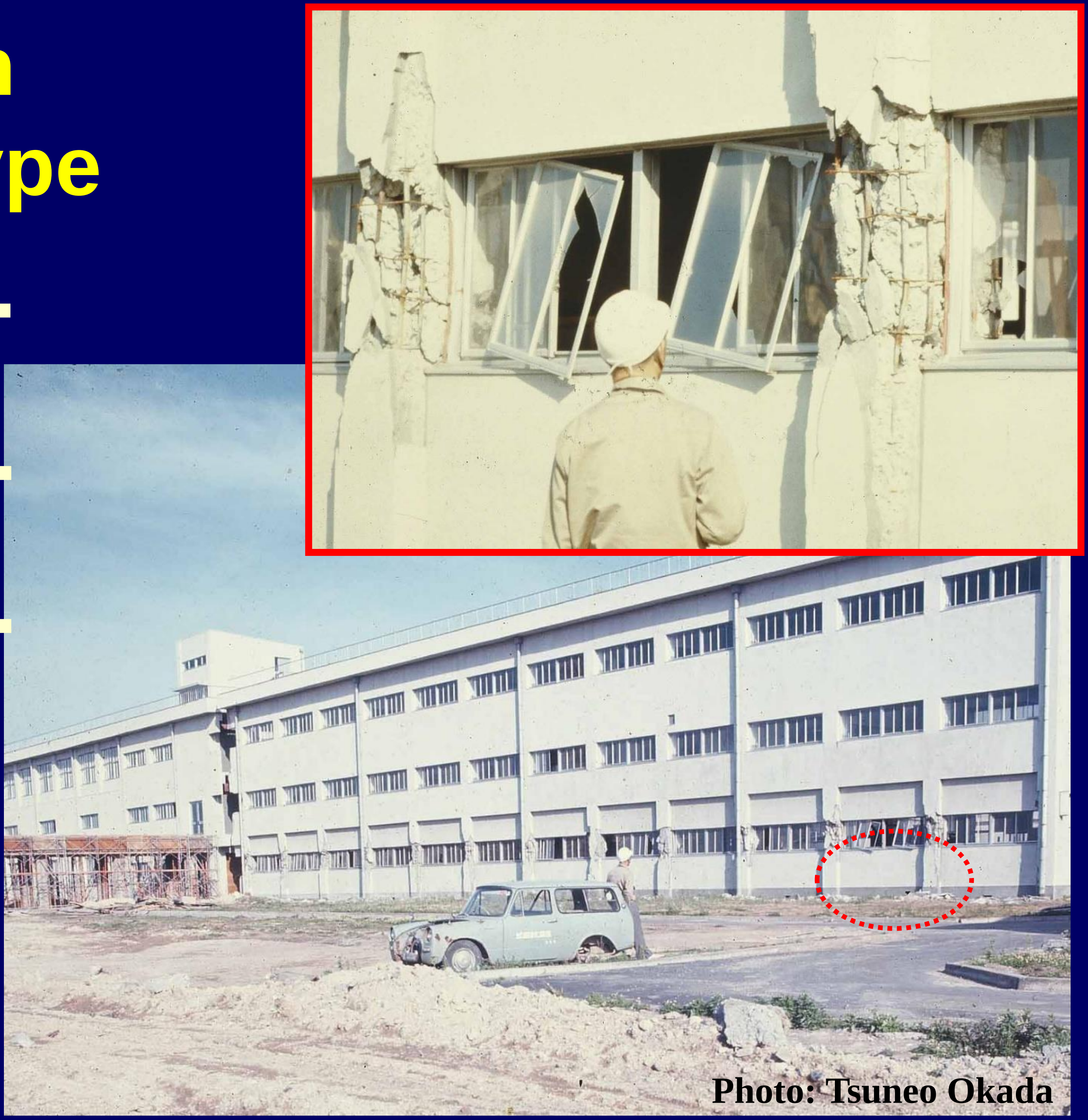


Photo: Tsuneo Okada

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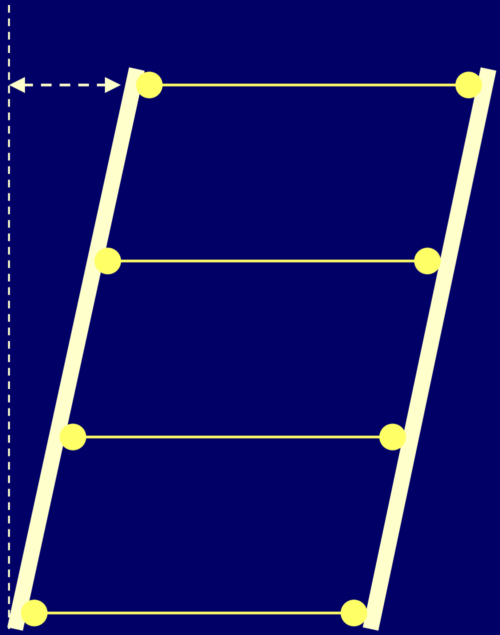
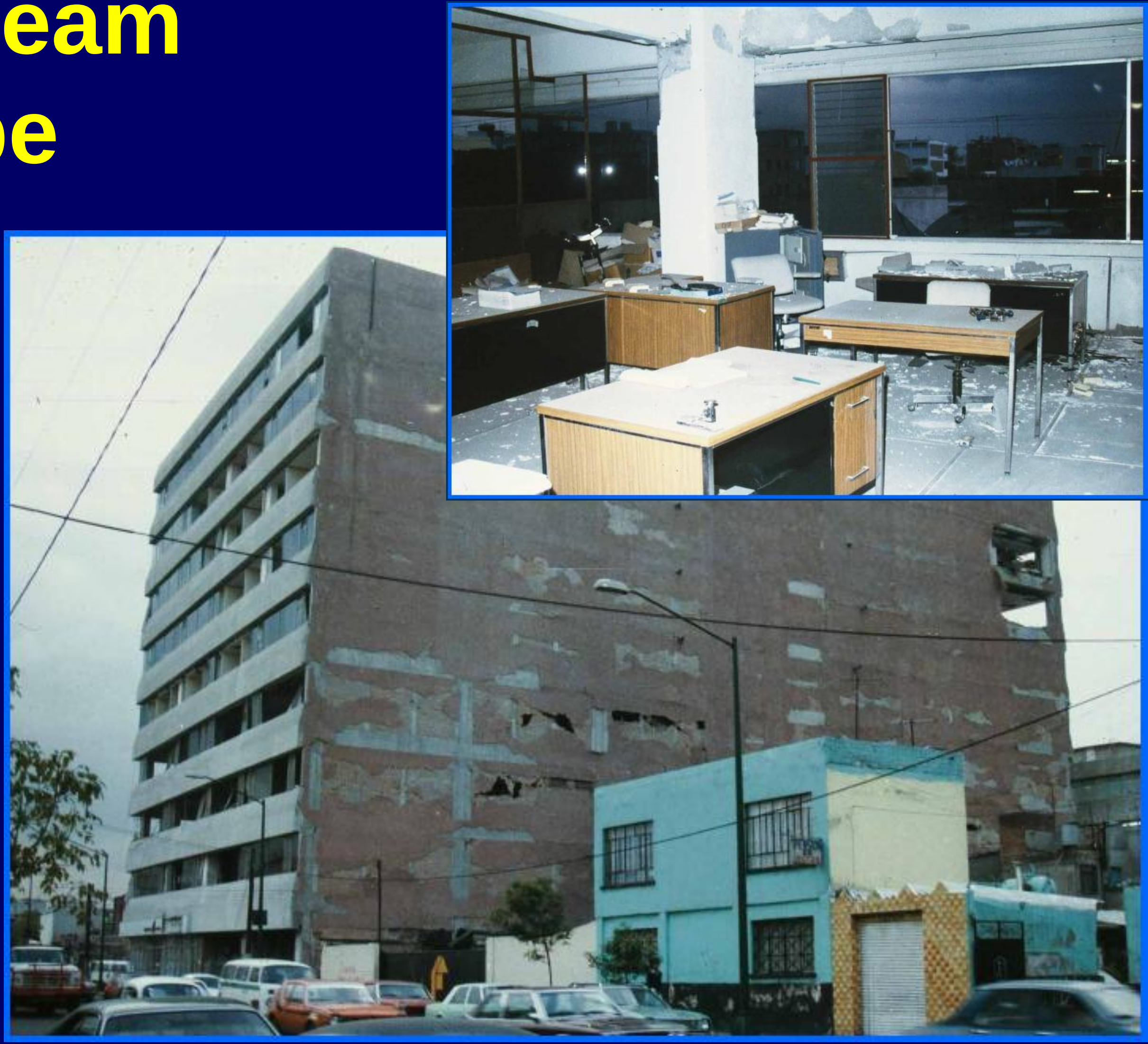
Example of Beam failure type





1985 Mexico Earthquake

Photo: Tsuneo Okada

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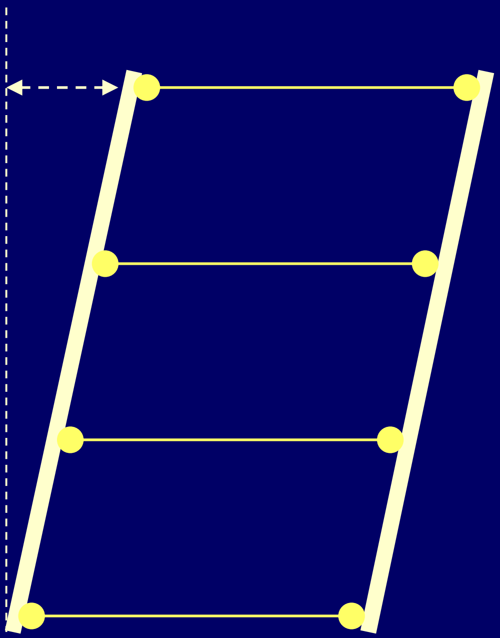
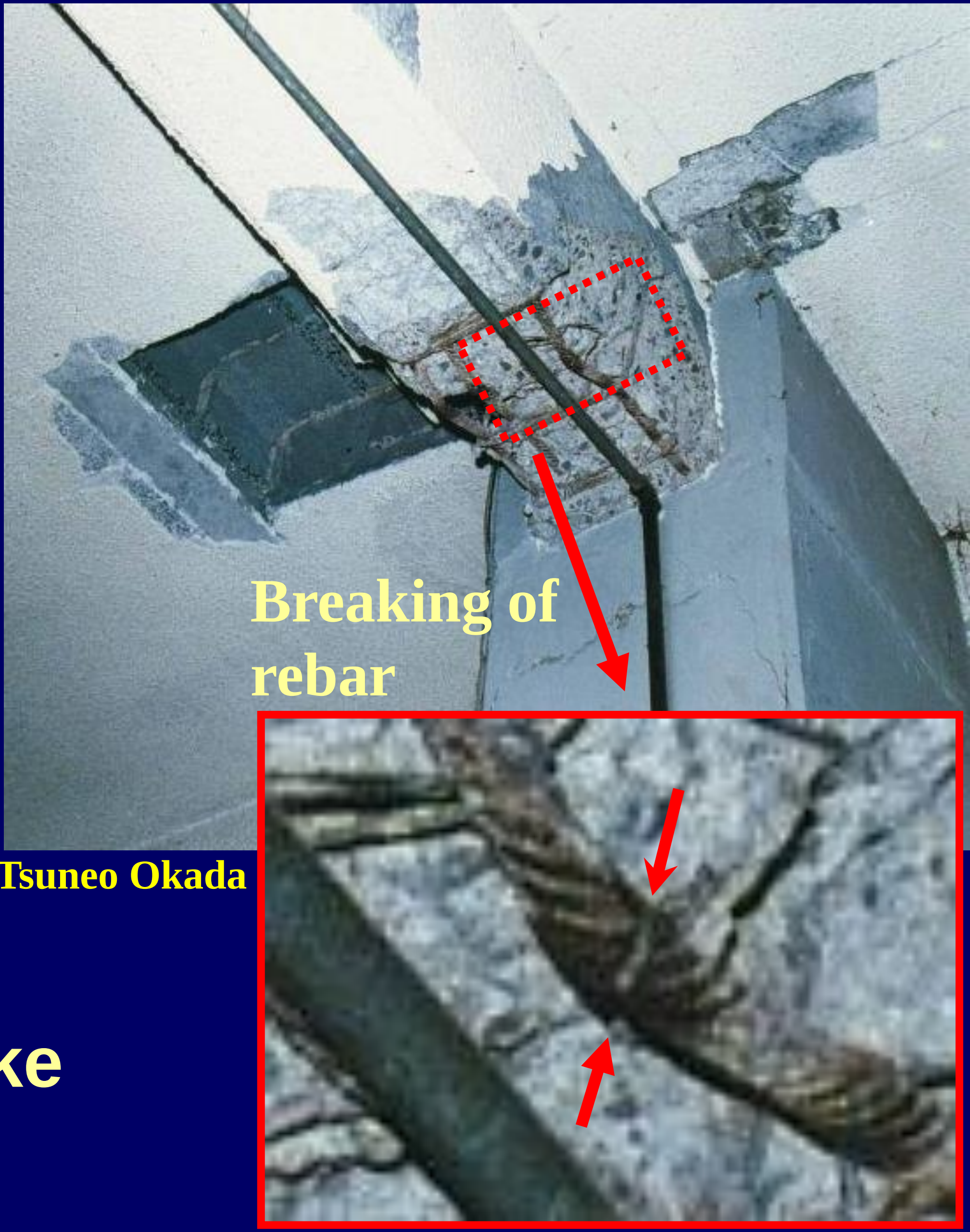
Example of Beam failure type





Breaking of rebar

Photo: Tsuneo Okada

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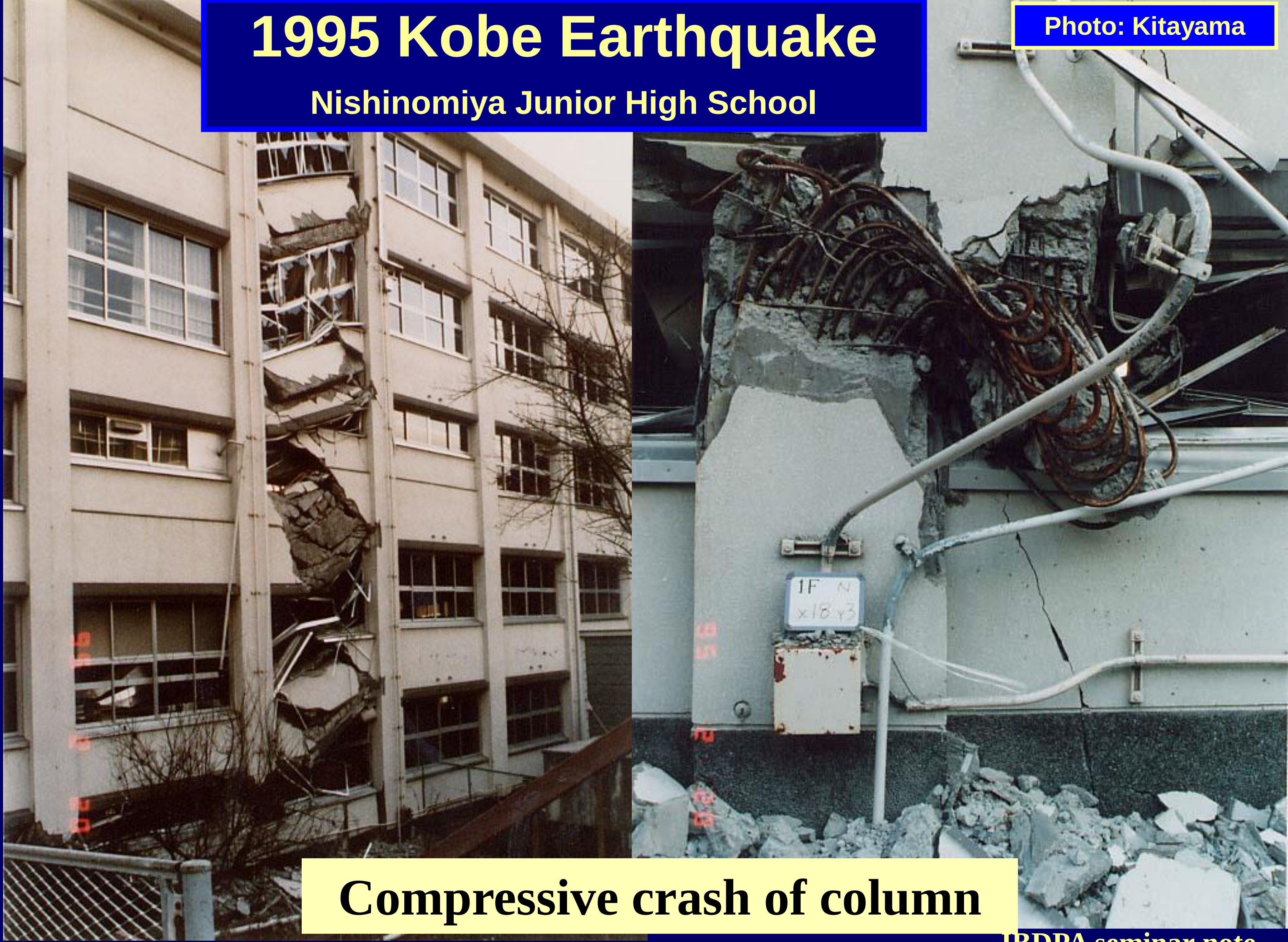
1985 Mexico Earthquake

1995 Kobe Earthquake

Nishinomiya Junior High School

Photo: Kitayama



Compressive crash of column

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2004 Niigata Chuetu Earth.

Photo: Yoshiaki Nakano

Shear failure of column

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Focal points of the Standard

- **Objective of seismic evaluation**

1. **Digitization of seismic capacity**
2. **Grasp of the failure process of structural members**

↓

Importance of the appropriate analytical modeling of structure

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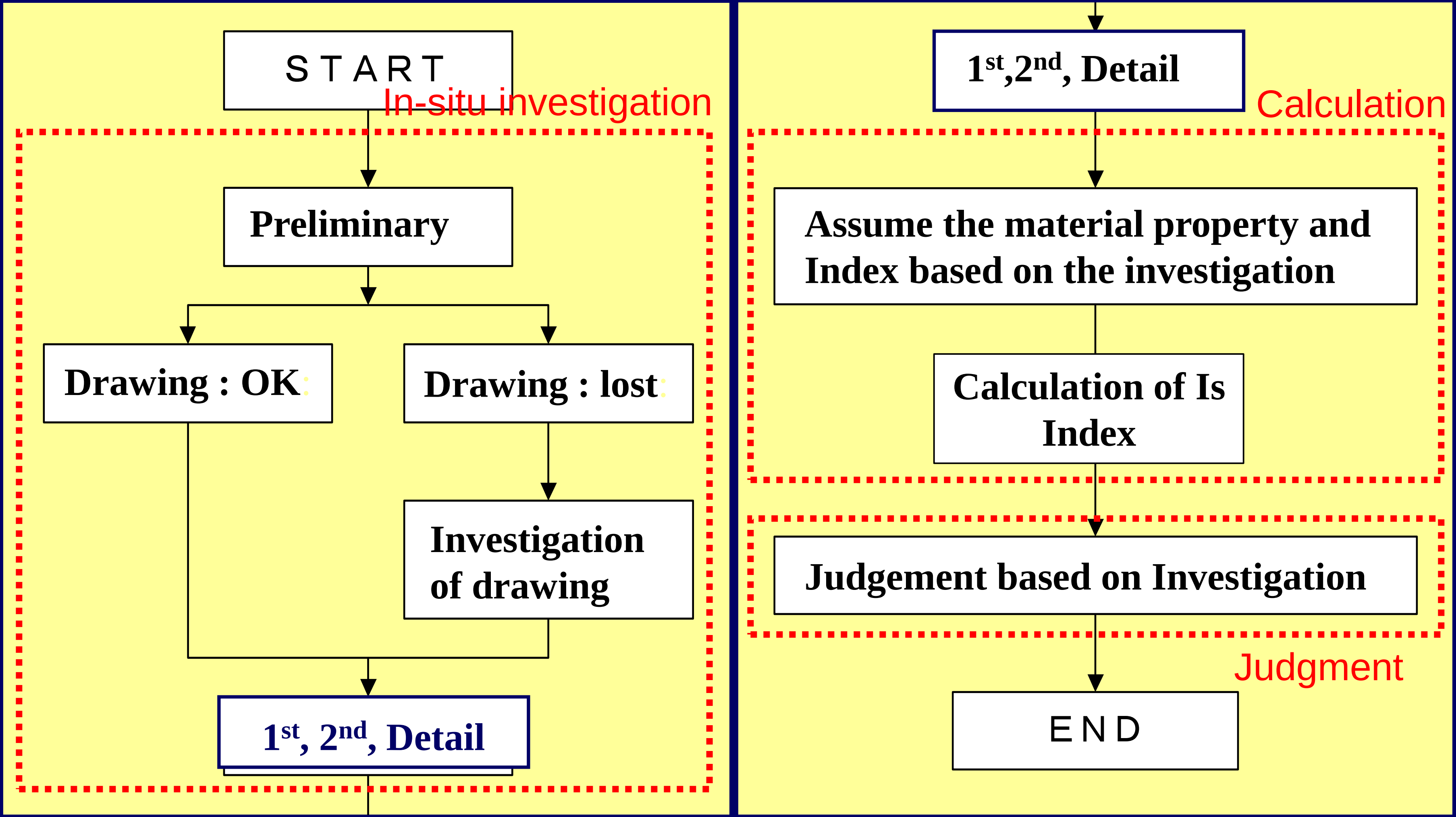
Importance of In-situ investigation



START

In-situ investigation

Preliminary

Drawing : OK

Drawing : lost

Investigation of drawing

1st, 2nd, Detail

1st,2nd, Detail

Calculation

Assume the material property and Index based on the investigation

Calculation of Is Index

Judgement based on Investigation

Judgment

END

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The Seismic index of structure (Is)

$$Is = Eo\ S_D\ T \qquad (1)$$

Is : Seismic index of structure

Eo : Basic seismic index of structure

S_D : Irregularity index

T : Time index

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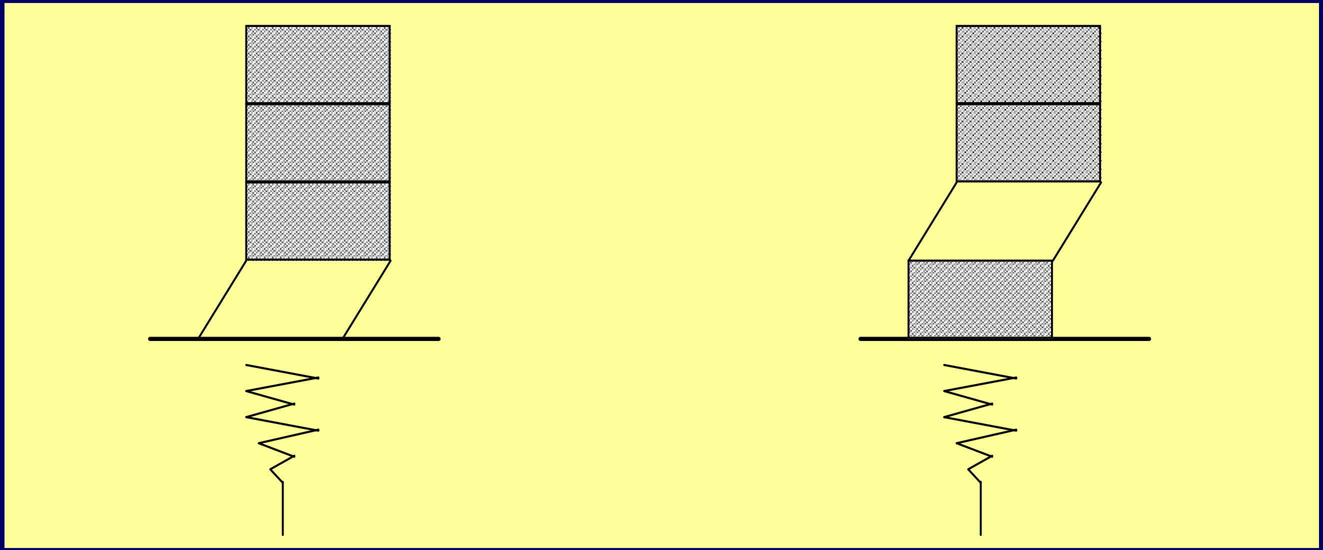
S_D index
Collapse（Soft Story Mechanism）



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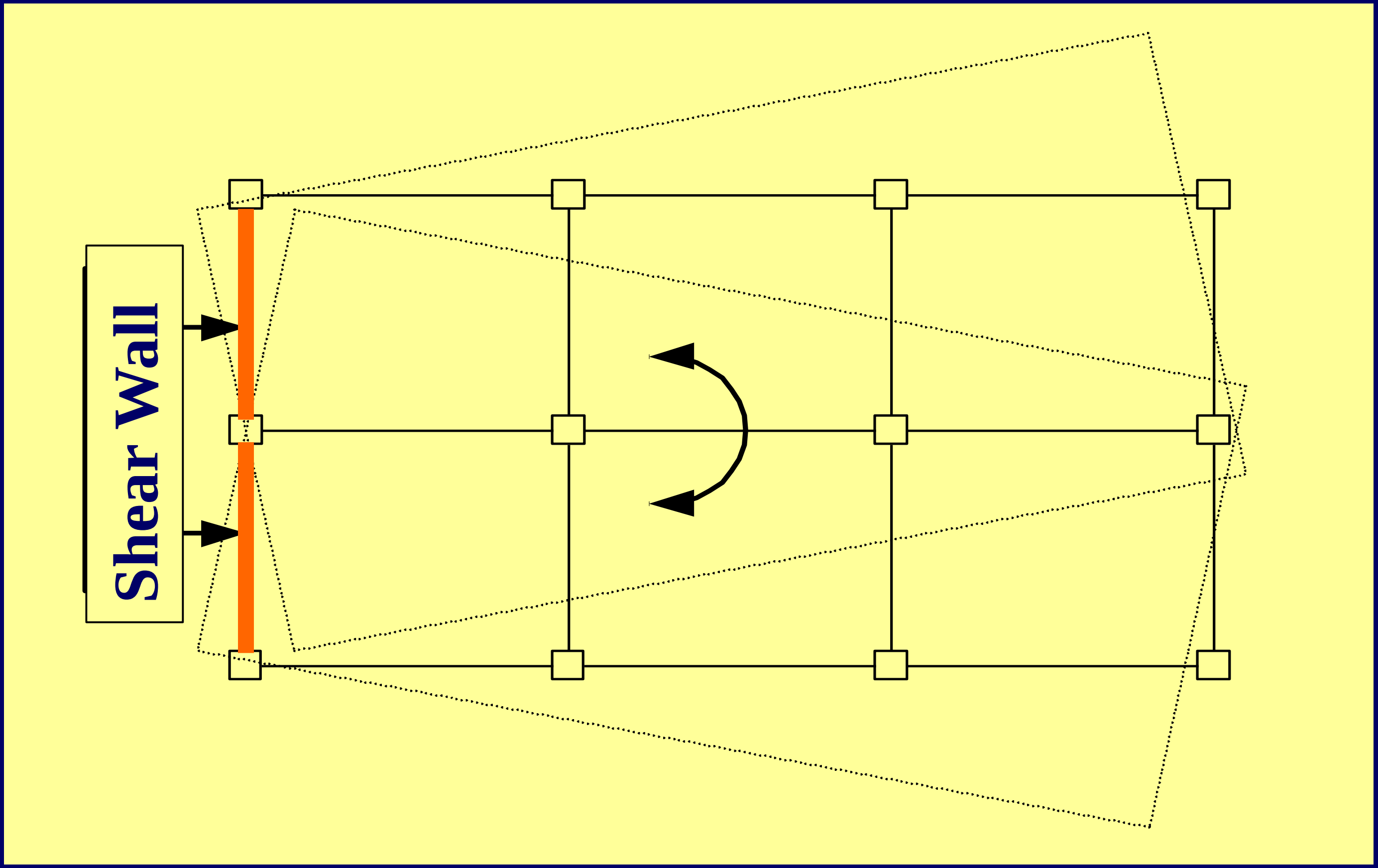
S_D index
Torsional vibration



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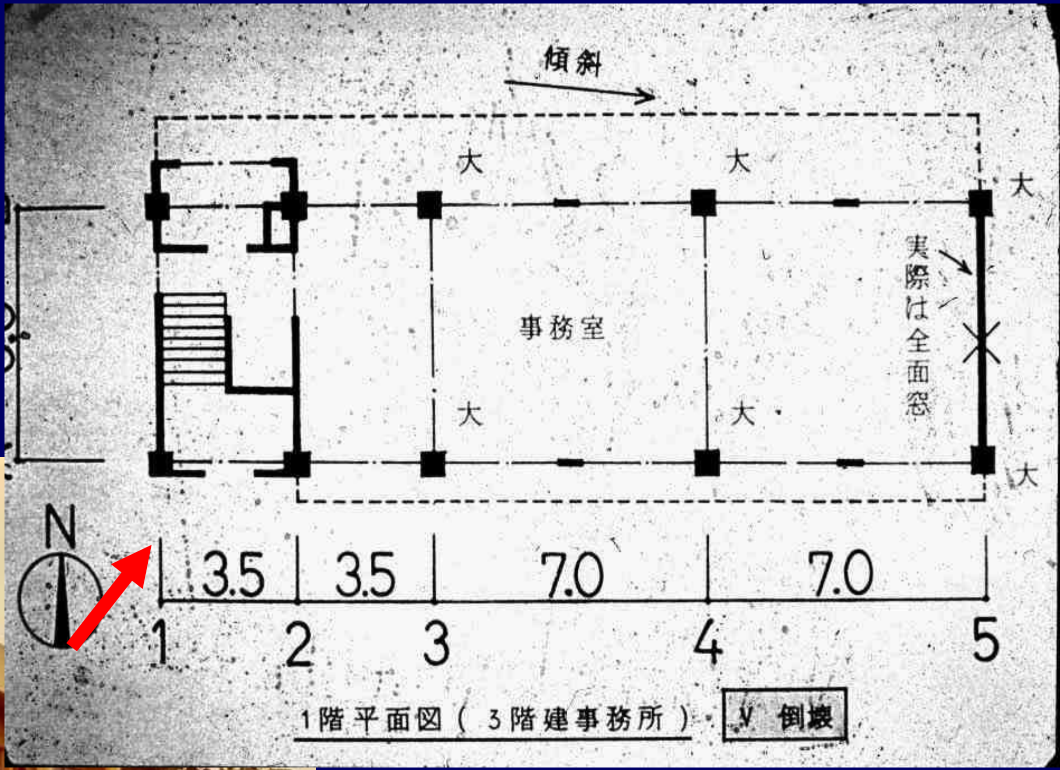
1978 Miyagiken- oki EQ.



Torsional vibration

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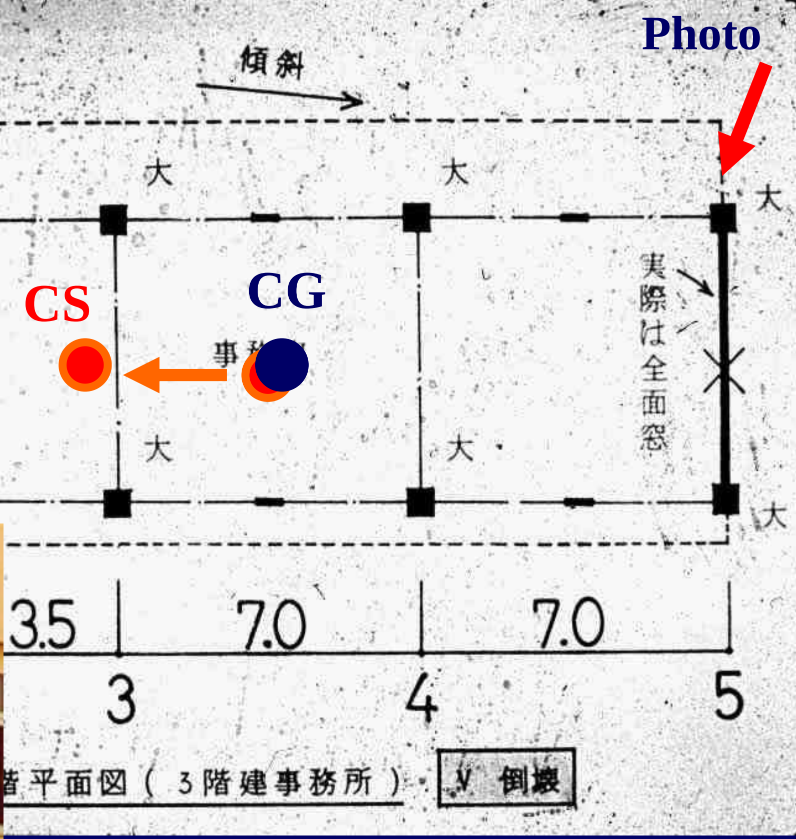
1978 Miyagiken- oki EQ.



Torsional vibration

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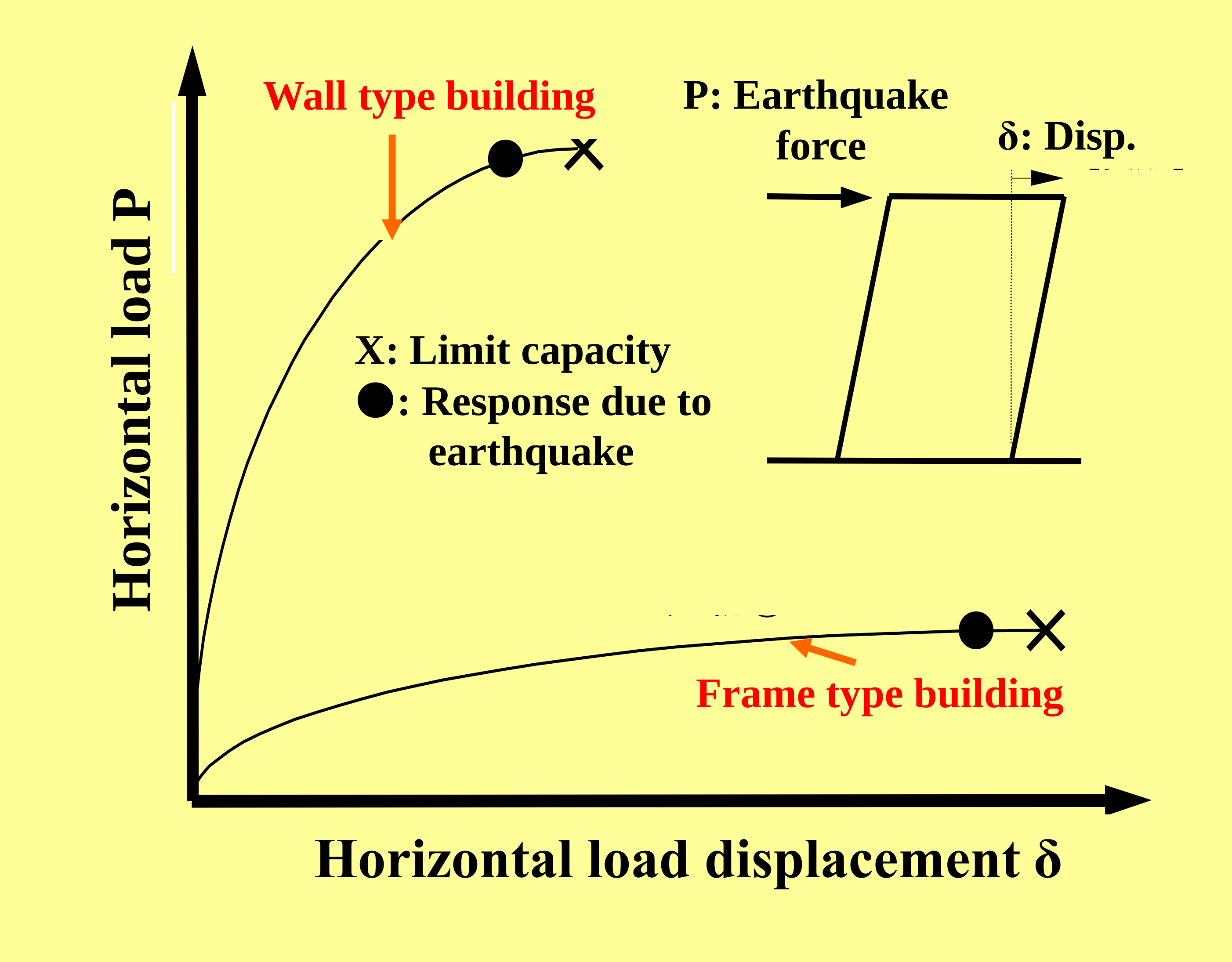
Load vs. Displacement



Wall type building

P: Earthquake force

δ: Disp.

X: Limit capacity

●: Response due to earthquake

Frame type building

Horizontal load P

Horizontal load displacement δ

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Basic seismic index (Eo)

Basic seismic index: *E_0*

$$E_0 = \frac{n+1}{n+i}\sqrt{E_1^2 + E_2^2 + E_3^2}$$

Eq. (4)

$$E_0 = \frac{n+1}{n+i}\left(C_1 + \sum_j \alpha_j C_j\right) \cdot F_1$$

Eq. (5)

α_j : Effective strength factor

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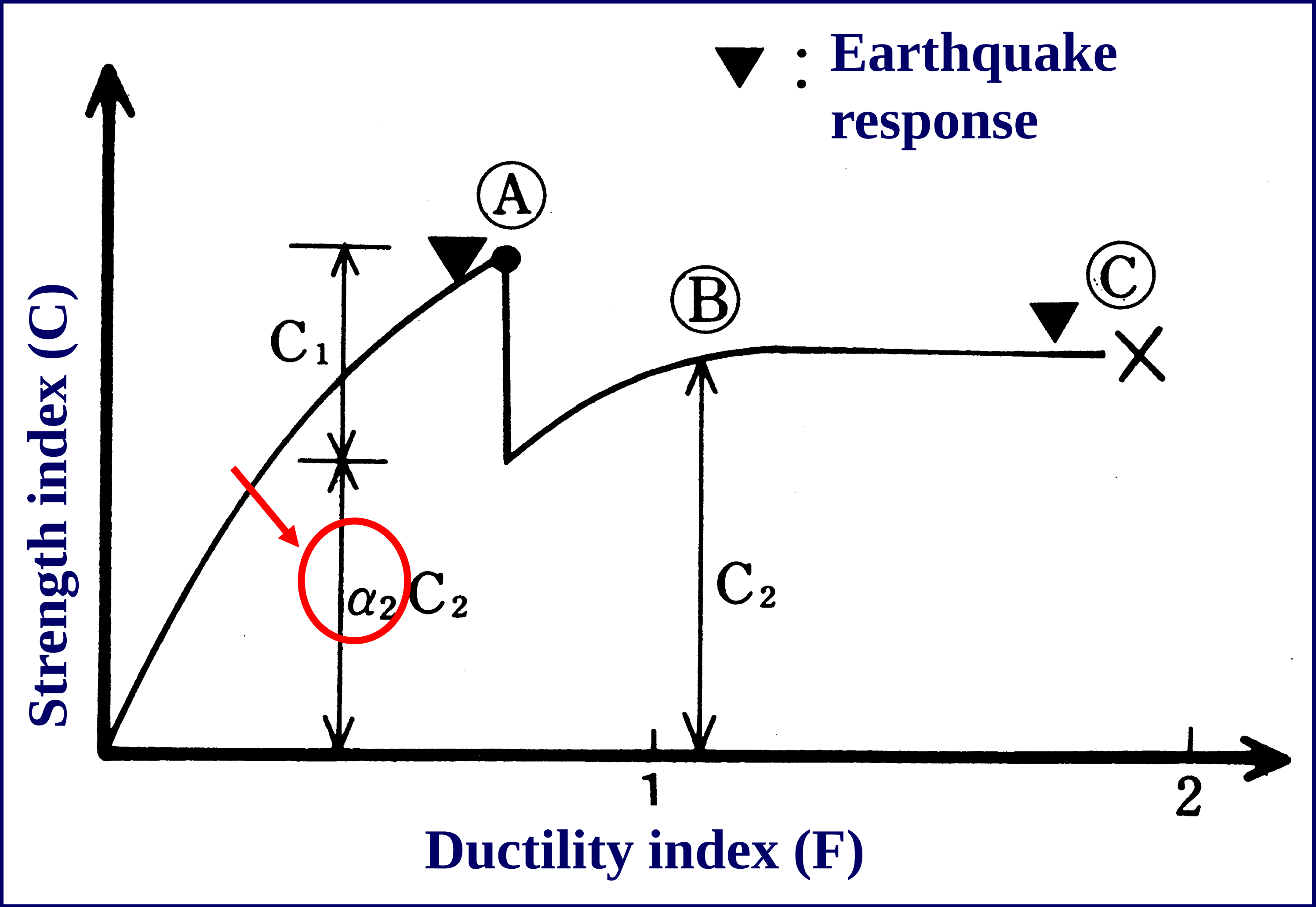
αj : Effective strength factor



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Basic seismic index *Eo*

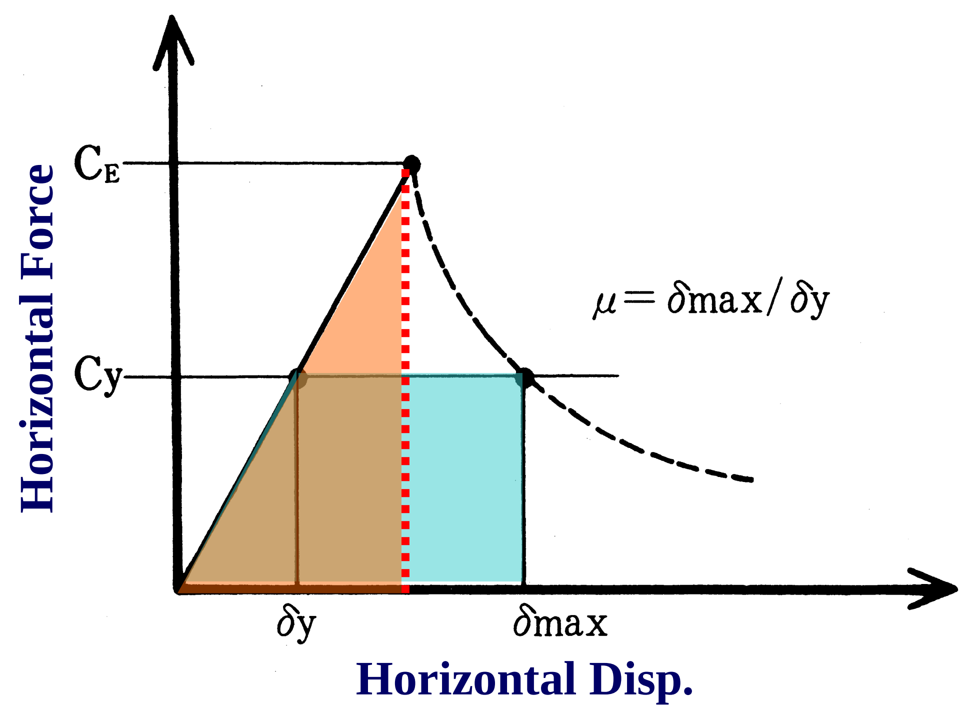
$Is = Eo \times S_D \times T$

$Eo = C \times F$

- Basic seismic index: *Eo*

$$Eo = C\ [\text{strength index}] \times F\ [\text{ductility index}]$$

$$cf. \quad Ce = Cy \times \sqrt{2\mu - 1}$$



Newmark:

Energy constant theory

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Japanese Seismic Design & Seismic Index (Is, Iso)

$$C_E \leqq C_Y \times \sqrt{2\mu - 1}$$

Seismic Design	Demand Capacity	Yield Strength (Ds)	Ductility Factor (μ)
(Ex.	1.0	0.3	6.0)

Seismic Evaluation	Demand Index (Iso)	Strength Index (C)	Ductility Index (F)
(Ex.	0.6	0.3	2.0)

Basic Seismic Index: Eo = C x F

Seismic Index : $Is = Eo \times S_D \times T$

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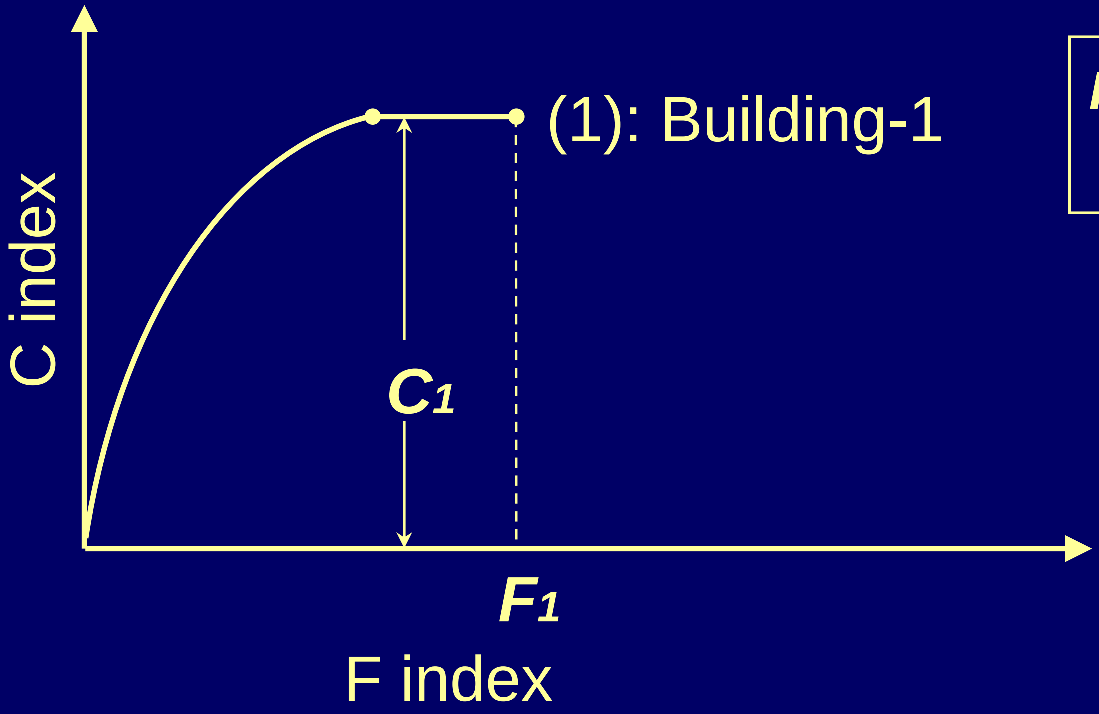
Eo index (1) One type of member



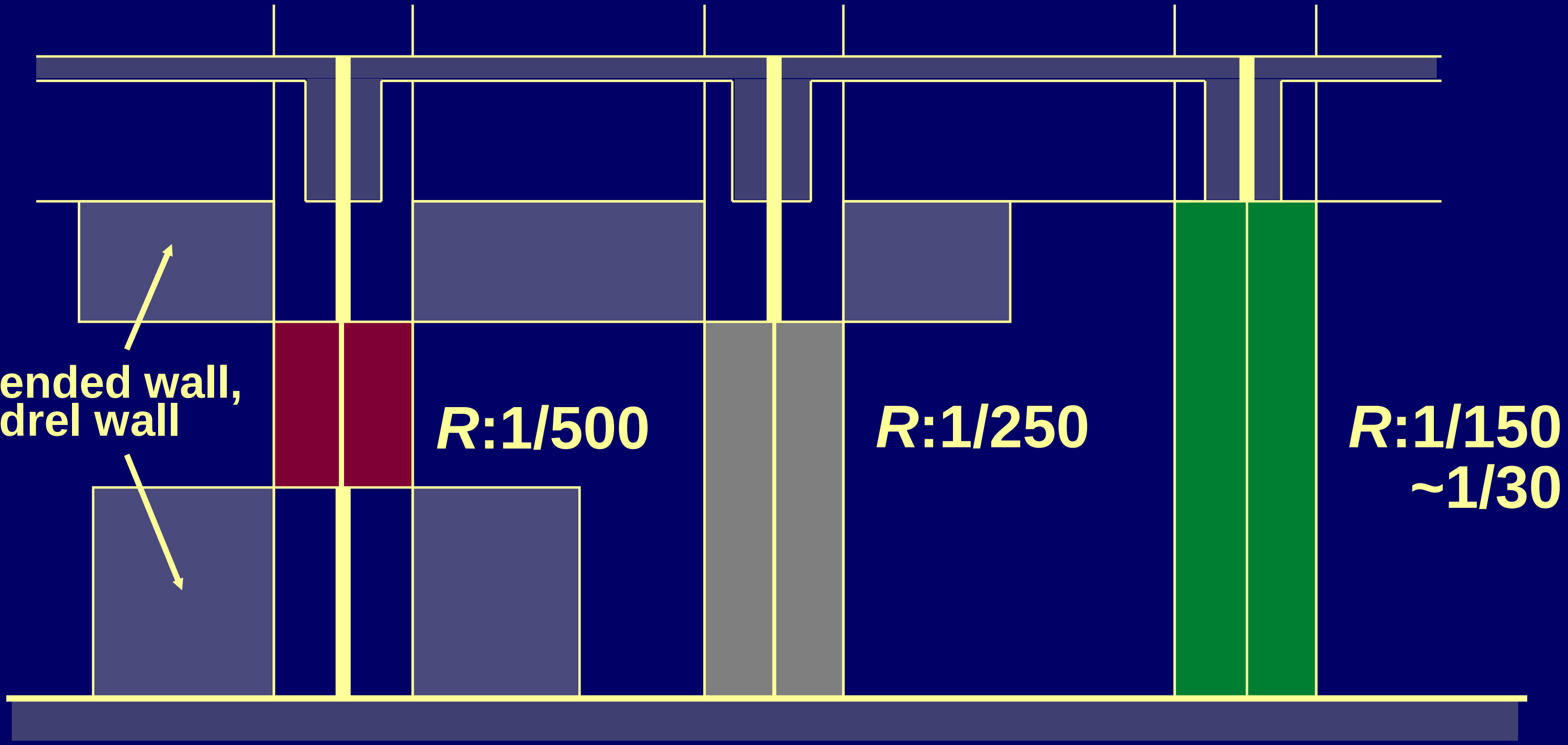
$Is = Eo \times S_D \times T$

$Eo = C \times F$

E_0 index of Building-1: $E_{01}(1) = C_1 \times F_1$

JBDPA seminar note

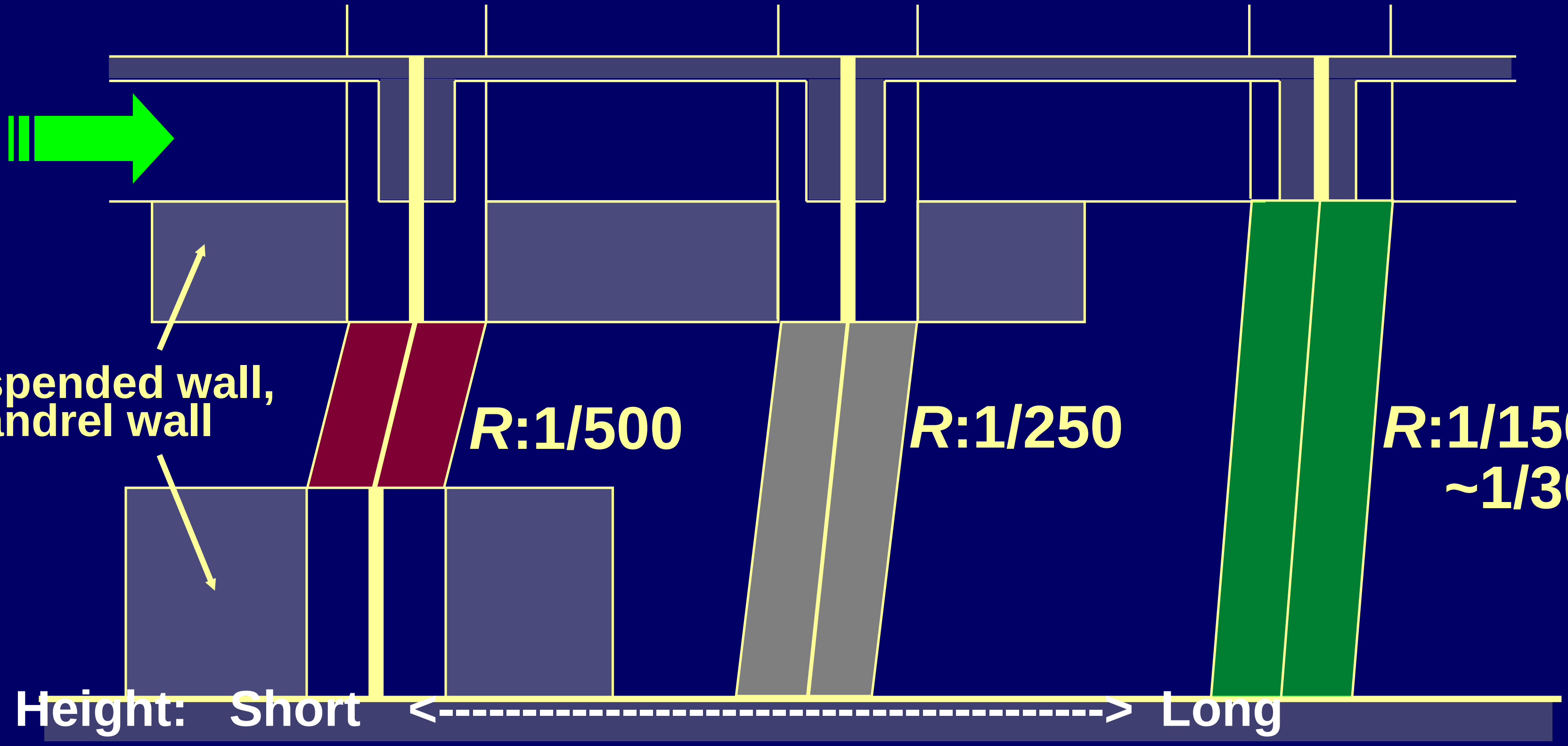
Ductility



Height of column: **short <--> long**

JBDPA seminar note

Ductility



Suspended wall,
Spandrel wall

***R*:1/500**

***R*:1/250**

***R*:1/150**
~1/30

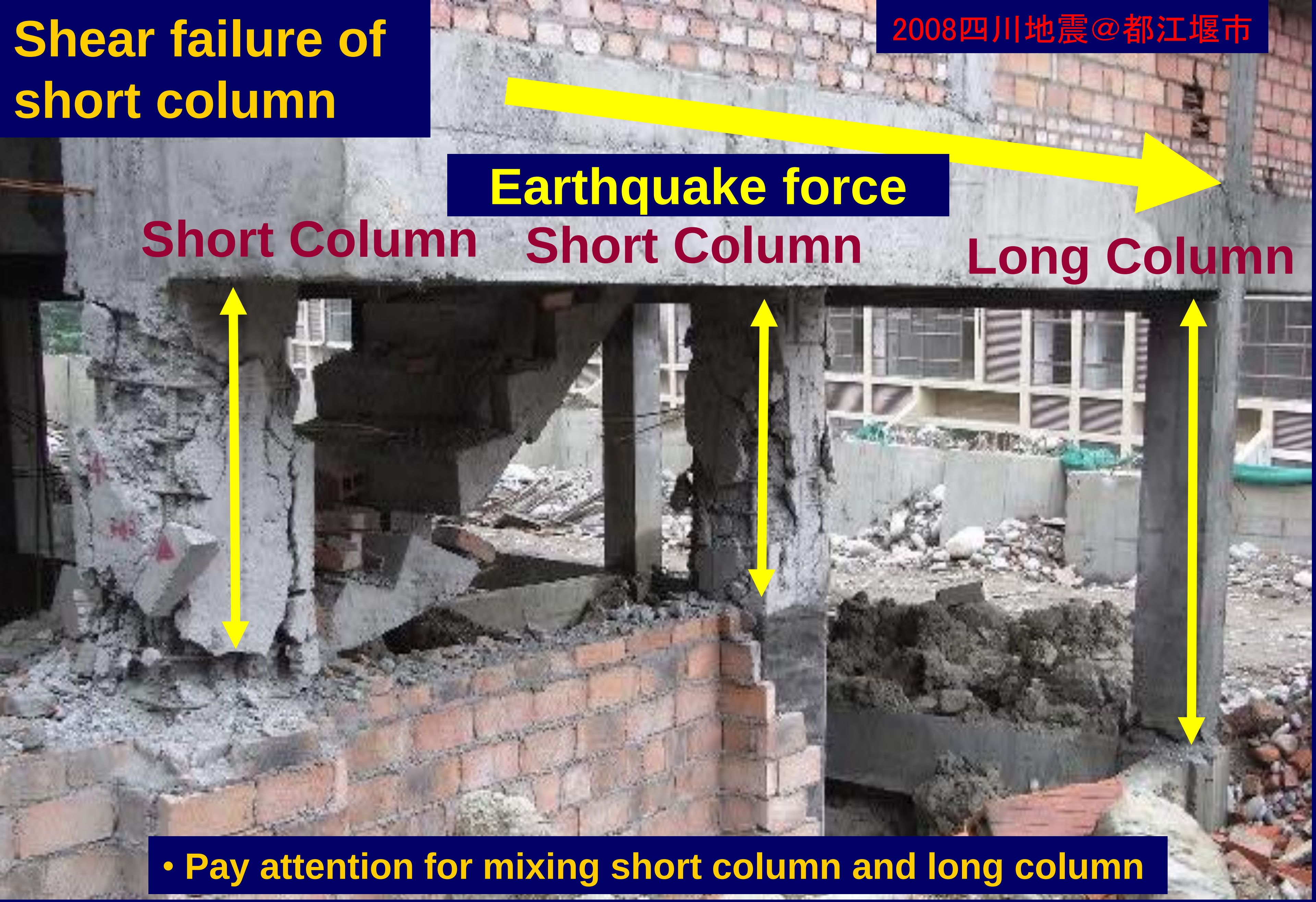
Height: Short <--> Long

Failure mode: Extremely brittle brittle Ductile

Extreme brittle column shear column flexural column

JBDPA seminar note

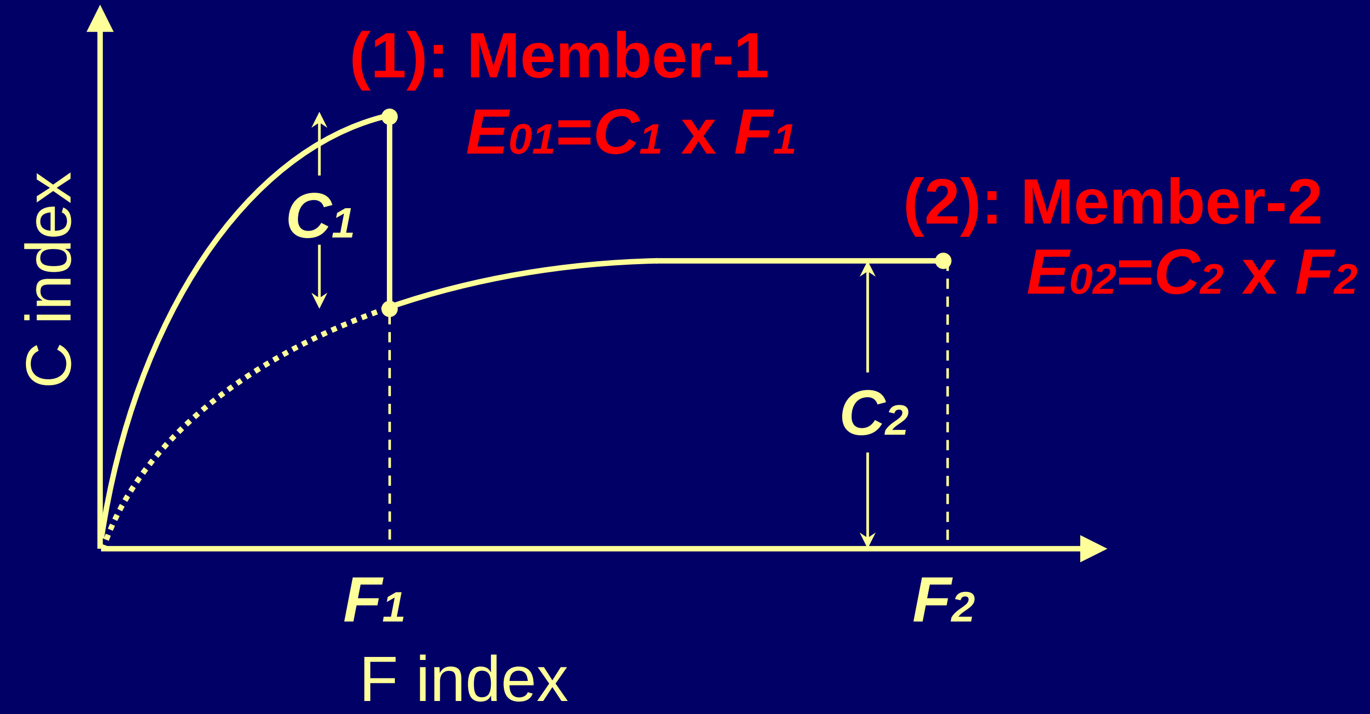
Shear failure of short column



- Pay attention for mixing short column and long column

JBDPA seminar note

Eo index (2) Two types of members



Q . *E_0 index of the building???*

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Eo index (3)   Two types of members

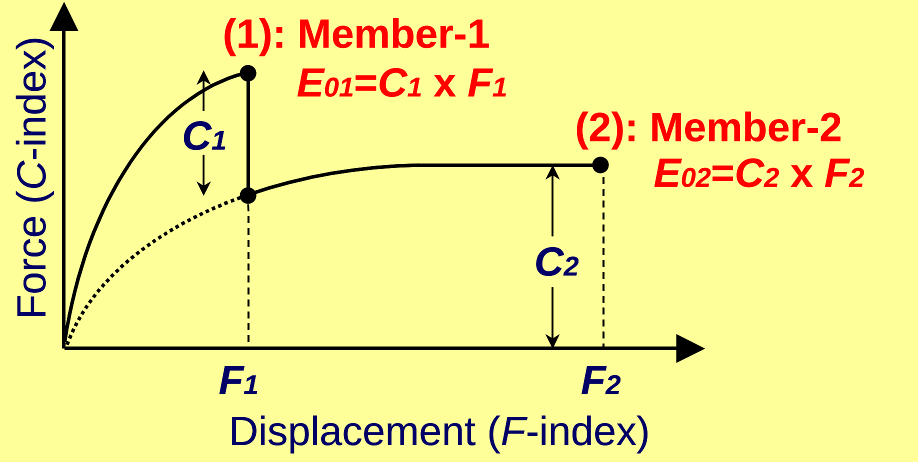
Q: E_0 index of the building？？？

$E_0 = C_1 \text{ x } F_1$ or $C_2 \text{ x } F_2$ [= E_{01} or E_{02}]   : under estimate

$E_0 = (C_1 \text{ x } F_1) + (C_2 \text{ x } F_2)$ [=$E_{01} + E_{02}$] : over estimate

↓

A: $E_0 = \sqrt{(C_1 \text{ x } F_1)^2 + (C_2 \text{ x } F_2)^2}$



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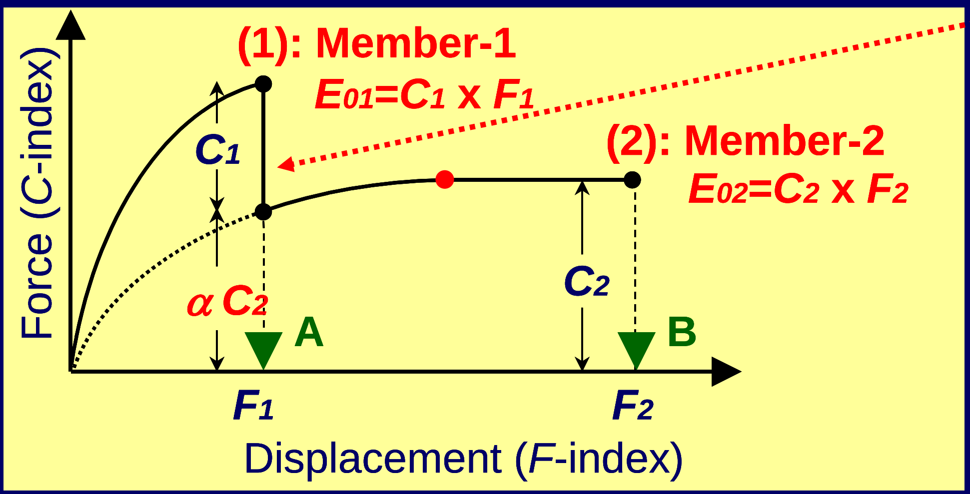
Eo index (4) Local failure vs. safety



- $E_{0A} = (C_1 + \alpha C_2) \times F_1$
- $E_{0B} = \sqrt{(C_1 \times F_1)^2 + (C_2 \times F_2)^2}$

α :Strength effective factor

Allowable of failure of member-1 ➔ $E_0 = \max(E_{0A}, E_{0B})$

Not allowable ➔ $E_0 = E_{0A}$

JBDPA seminar note

Seismic demand index

$Is \geqq Iso$ (37)

$Iso = Es \cdot Z \cdot G \cdot U$ (38)

$C_{TU} S_D \geqq 0.3 \cdot Z \cdot G \cdot U$ (39)

C_{TU} : Cumulative strength index at ultimate deformation

S_D : Irregularity index

Es : Basic demand index $Es_1 = 0.8$, $Es_{2,3} = 0.6$

Z : Zone index, G : Ground index, U : Usage index

JBDPA seminar note

Seismic demand index

1st level estimation $I_{so} = 0.8$（$Z\ G\ U = 1.0$）

1968 Tokachi-oki EQ

2nd level estimation $I_{so} = 0.6$（$Z\ G\ U = 1.0$）

1968Tokachi-oki EQ、1978Miyagiken-oki EQ, etc.

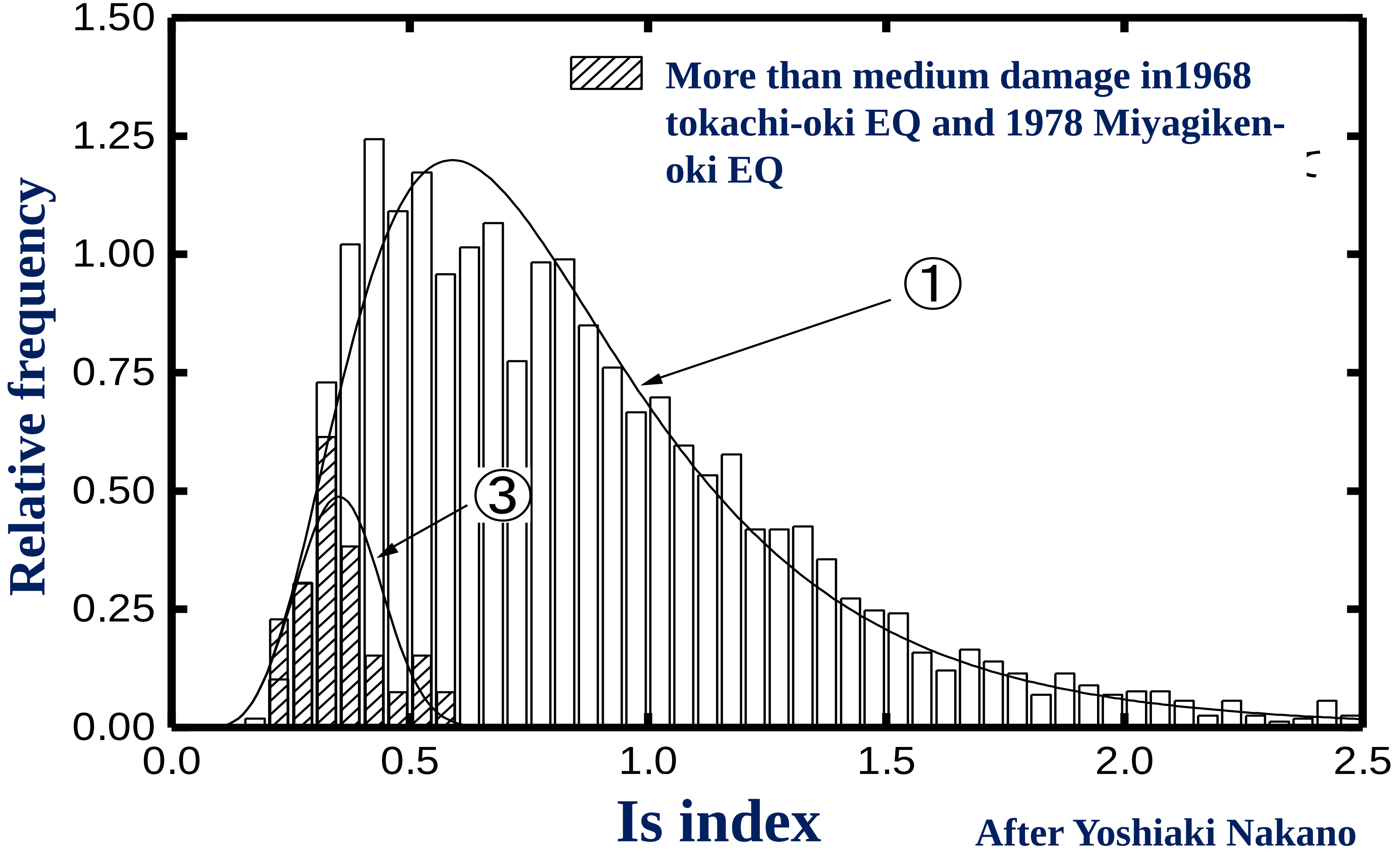
Not deterministic （Damage ratio: about 10%）

$C_{TU}\ S_D \geqq 0.3\ Z\ G\ U$

Correspond to D_s (Japanese seismic code)

JBDPA seminar note

Damage ratio due to the strong earthquake in Japan



After Yoshiaki Nakano

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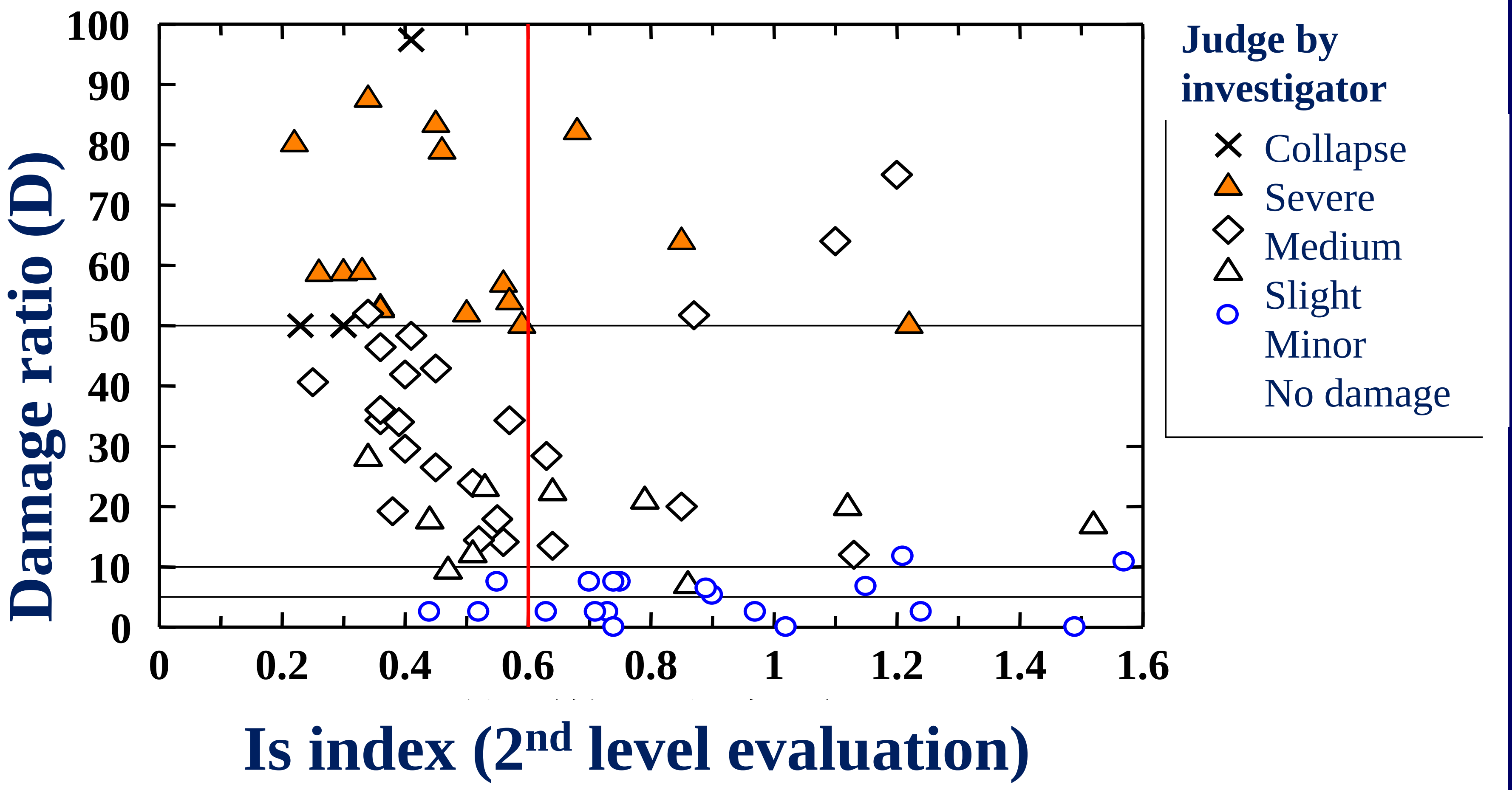
Damage ratio due to 1995 Kobe EQ



AIJ report

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Is index doesn’t directly cover the following items;

1. Usability after earthquake

Is it possible to keep using or not?

2. Repairbility after damaged

Does the capacity recover rapidly after repairing or not?

3. Durability in the future

Is it possible to keep using and safety in the future or not?

↓

The investigator should inform them to the owner of buildings.

JBDPA seminar note

Post Earthquake Quick Inspection of Damaged Buildings

(Reinforced concrete buildings)

The content of this document is quoted from Manual of Postearthquake Quick Inspection of Damaged Building, Japan Building Disaster Prevention Association (JBDPA), Japan Council for Quick Inspection of Earthquake Damaged Building, January 1998, and the Brochure for Postearthquake Quick Inspection of Damaged Buildings, Japan Council for Quick Inspection of Earthquake Damaged Buildings, December 2001.

February 2011

Japan Building Disaster Prevention Association

Matsutaro Seki

I. Outline of Postearthquake Quick Inspection of Damaged Buildings

1. What is the postearthquake quick inspection of damaged buildings?

◆The aim of the quick inspection is to prevent the secondary disaster, regarding the life of people by inspection of damaged building through the evaluation of risk for collapse of building, fall of window glass and exterior walls and overturn of building equipments that may be occurred by the aftershocks.

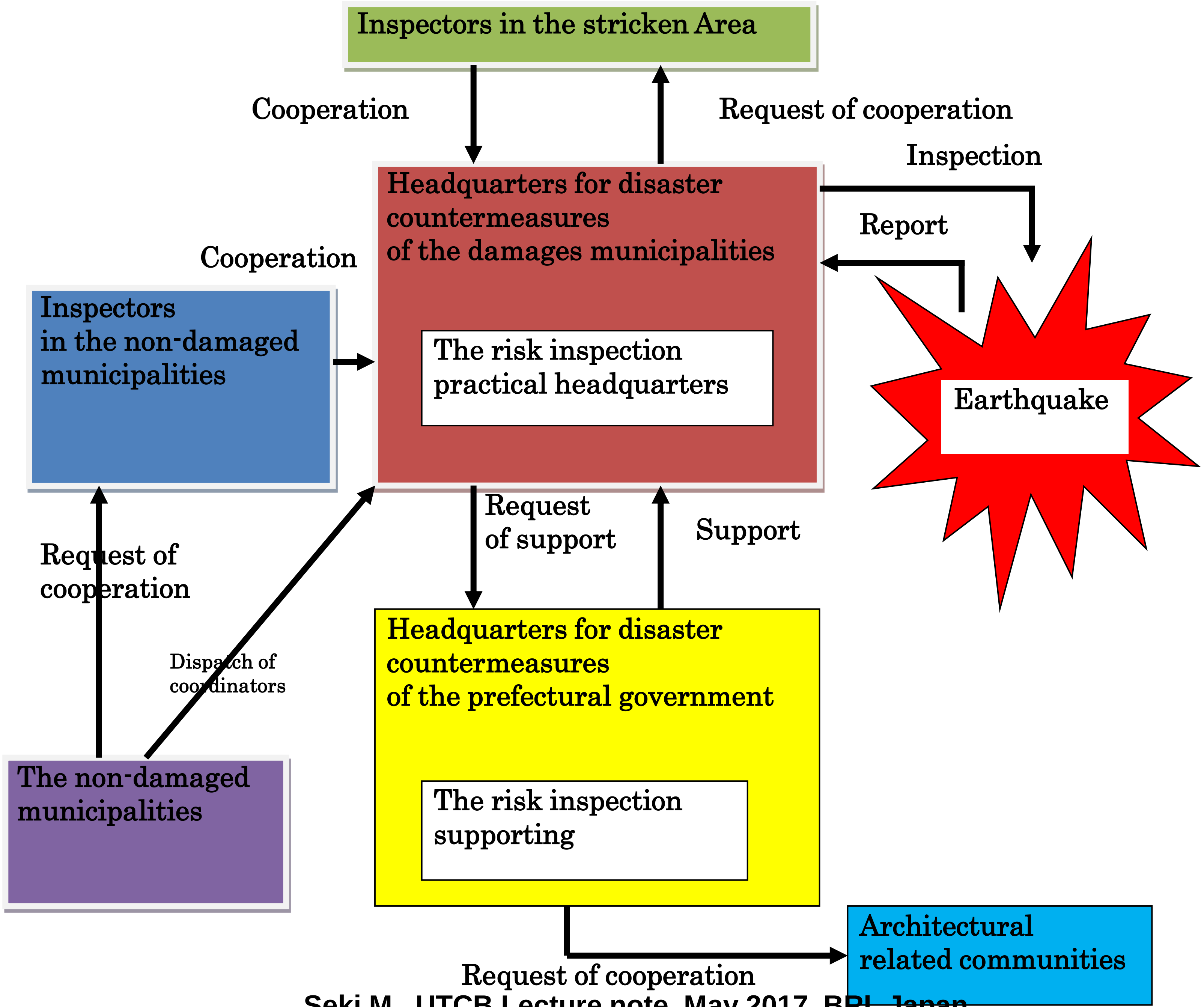
◆The placards evaluated should be put clearly on the building. This placards system informs the predicted risk of building to the owners and the pedestrians.

◆The evaluated placards are classified into three categories; "Inspected", "Limited Entry" and" Unsafe".

2. Who is responsible for the safety management of damaged buildings?

◆Generally the owners and managers are responsible for keeping the buildings safe.

◆Municipality carry out the quick inspection as the part of its emergent measures just after the earthquake. Prefectural government must support the activities of municipality.



Inspectors in the stricken Area

Cooperation

Request of cooperation

Headquarters for disaster countermeasures of the damages municipalities

The risk inspection practical headquarters

Inspection

Report

Earthquake

Cooperation

Inspectors in the non-damaged municipalities

Request of support

Support

Request of cooperation

Dispatch of coordinators

Headquarters for disaster countermeasures of the prefectural government

The risk inspection supporting

The non-damaged municipalities

Architectural related communities

Request of cooperation

Inspectors

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応急危険度判定結果

調査済

INSPECTED

◆この建築物の被災程度は小さいと考えられます
◆建築物は使用可能です

建築物名称

注記：

整理番号

判定日時　月　日　午前・午後　時現在

災害対策本部　電話　－

応急危険度判定結果

要注意

LIMITED ENTRY

◆この建築物に立ち入る場合は十分注意して下さい
◆応急的に補強する場合には専門家にご相談下さい

建築物名称

注記：

整理番号

判定日時　月　日　午前・午後　時現在

災害対策本部　電話　－

応急危険度判定結果

危険

UNSAFE

◆この建築物に立ち入ることは危険です
◆立ち入る場合は専門家に相談し、応急措置を行った後にして下さい

建築物名称

注記：

整理番号

判定日時　月　日　午前・午後　時現在

災害対策本部　電話　－

Evaluated Placards

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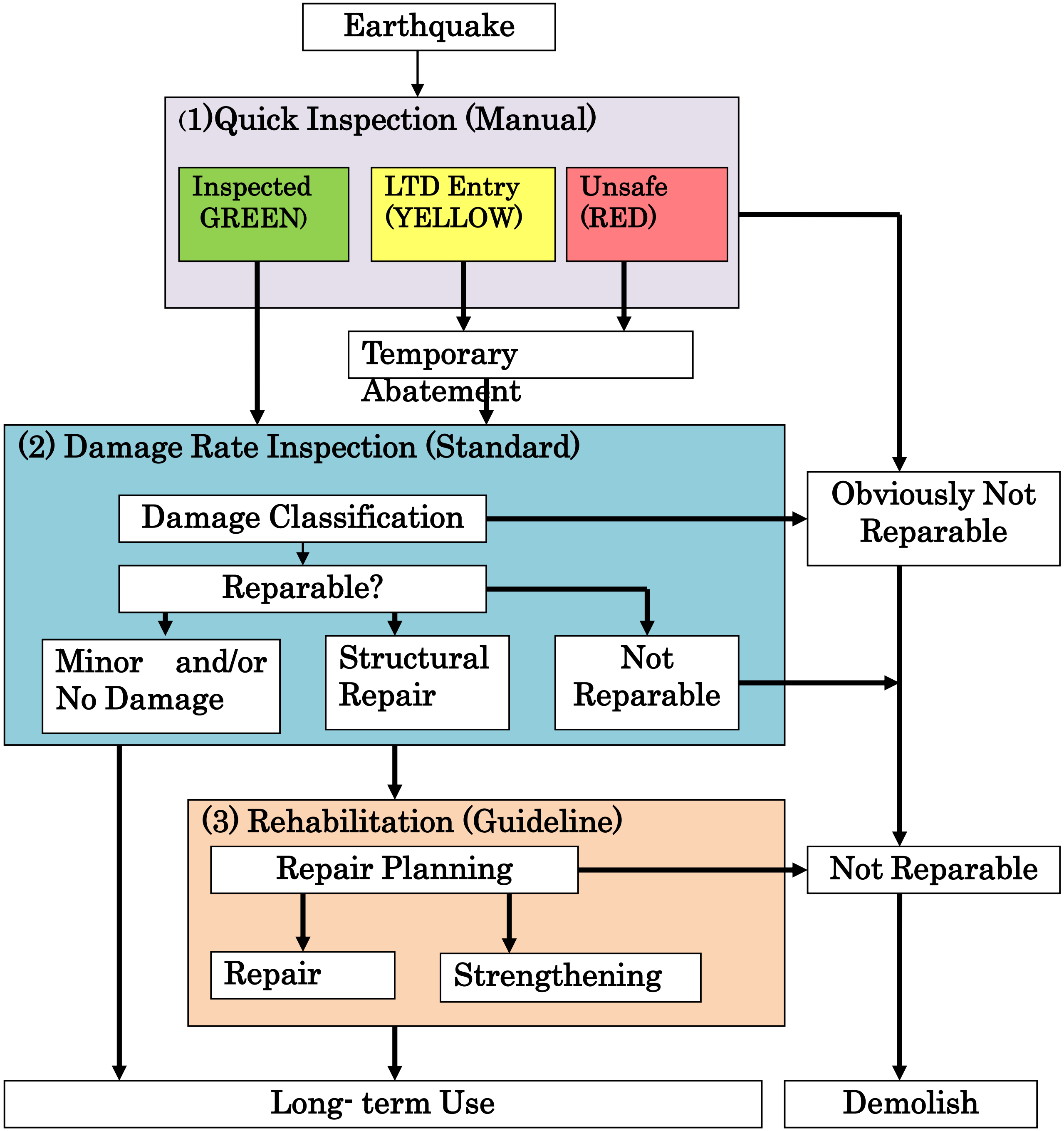
再使用の可能性を判定し、復旧するための

震災建築物の
被災度区分判定基準
および復旧技術指針

監修　国土交通省住宅局建築指導課
発行　財団法人　日本建築防災協会

Standard for Damage Rate Inspection, Japan Building Disaster Prevention Association, Jan. 2001 (in Japanese)



Earthquake

(1)Quick Inspection (Manual)

Inspected GREEN)

LTD Entry (YELLOW)

Unsafe (RED)

Temporary Abatement

(2) Damage Rate Inspection (Standard)

Damage Classification

Reparable?

Minor and/or No Damage

Structural Repair

Not Reparable

Obviously Not Reparable

(3) Rehabilitation (Guideline)

Repair Planning

Repair

Strengthening

Not Reparable

Long- term Use

Demolish

General Flow of Quick Inspection, Damage Rate Inspection and Rehabilitation in Japan (Manual, Standard, Guide line)

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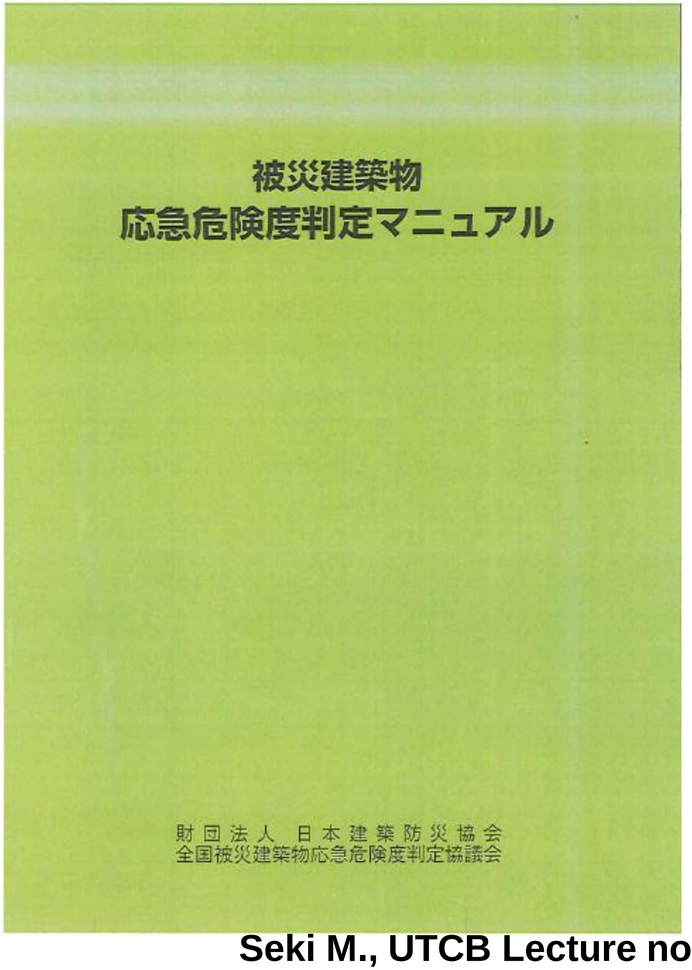
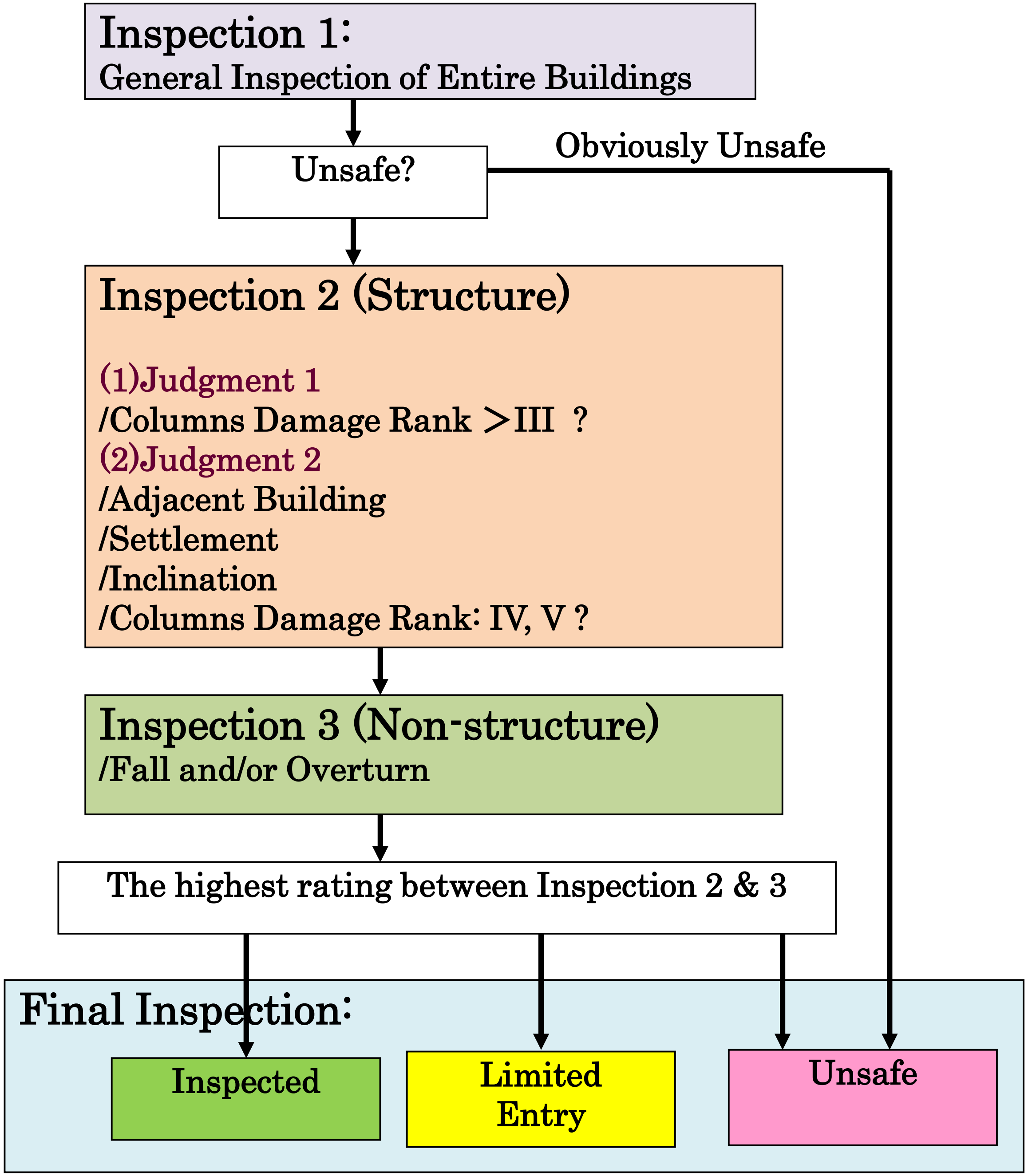
II.　Manual of Postearthquake Quick Inspection of Damaged Building



被災建築物
応急危険度判定マニュアル

財団法人　日本建築防災協会
全国被災建築物応急危険度判定協議会

Manual of Postearthquake Quick Inspection, Japan Building Disaster Prevention Association, Jan., 1998(in Japanese)



Inspection 1:
General Inspection of Entire Buildings

Unsafe?

Obviously Unsafe

Inspection 2 (Structure)

(1)Judgment 1
/Columns Damage Rank >III ?
(2)Judgment 2
/Adjacent Building
/Settlement
/Inclination
/Columns Damage Rank: IV, V ?

Inspection 3 (Non-structure)
/Fall and/or Overturn

The highest rating between Inspection 2 & 3

Final Inspection:

- Inspected
- Limited Entry
- Unsafe

Postearthquake Quick Inspection Flow (Reinforced Concrete Buildings)

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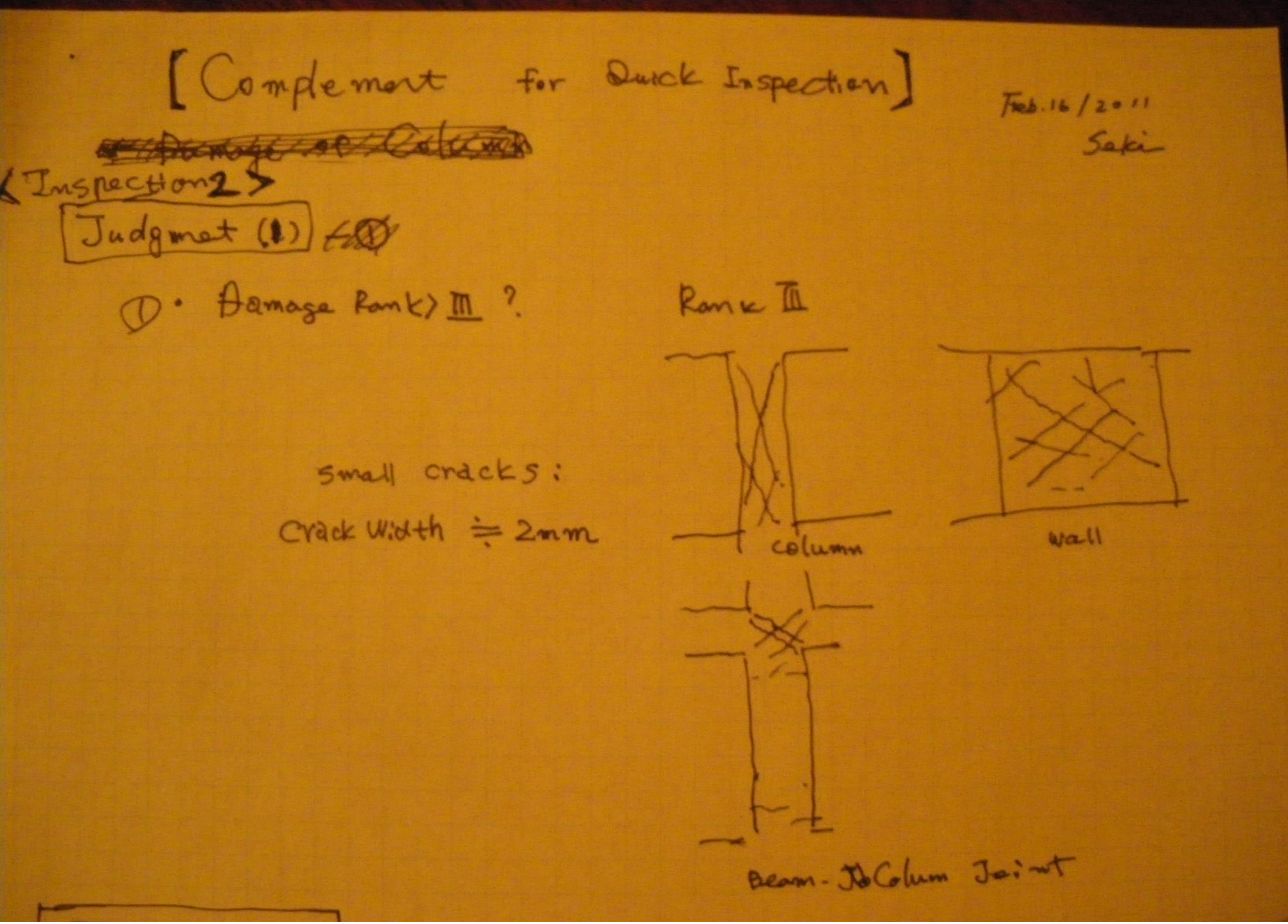
Quick Inspection Training

Carried out on 16th,Feburay in Talca、Chile by JICA program

TwoBuildings
①Public Office Building
②School Building



[Complement for Quick Inspection]

Feb.16/2011
Seki

~~Damage of Column~~

<Inspection 2>

Judgmet (1) ← ①

① · Damage Rank > III ?

Rank III

small cracks:

Crack Width ≒ 2mm

column

wall

Beam-~~Jo~~Colum Joint

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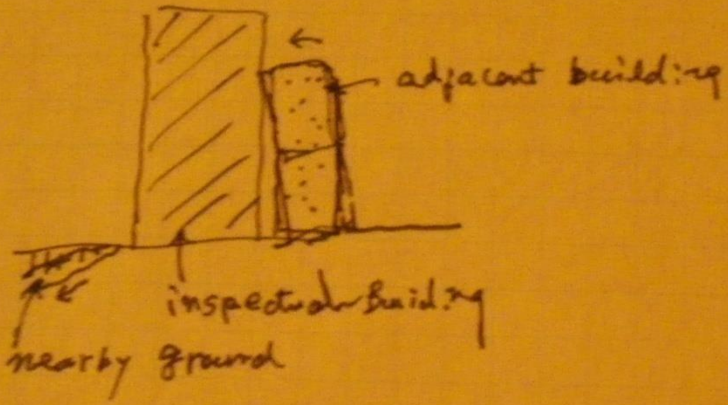
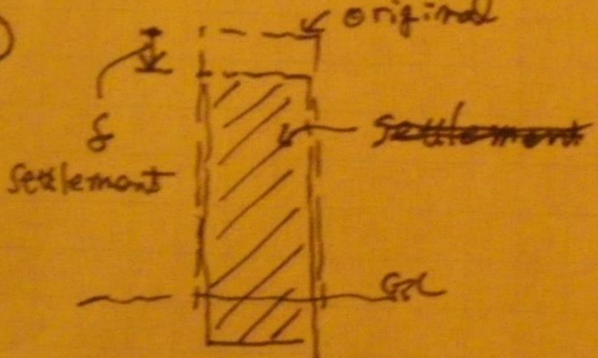
Beam - To Colum Joint

Judgment (2)

②



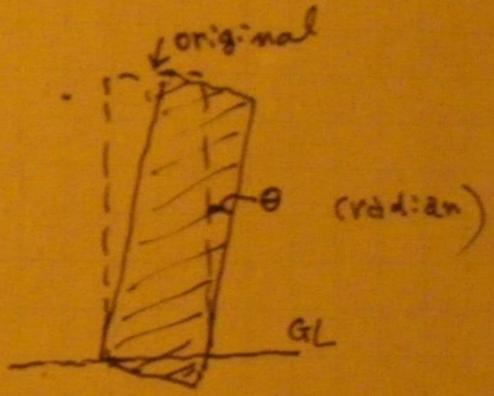
③



(settlement)

$\delta < 0.2m$, ..., $\delta > 1.0m$

④



(Inclination)

$\theta < 1/60$, ..., $\theta > 1/30$

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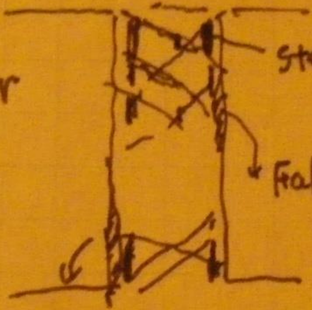
〈Damage of Column〉

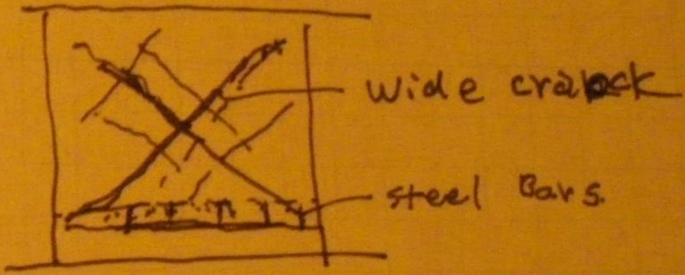
- Most serious damge floor, → (F)
(and. Direction)

⑤ Damage Rank Ⅳ ?

- NO. Settlemat of Floor

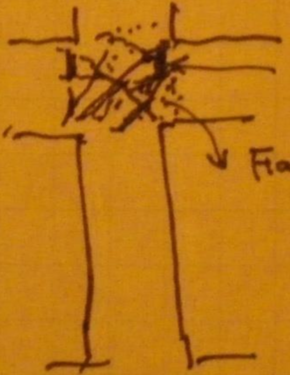


Column



wall

- $\text{Damage Ratio} = \dfrac{\text{Number of Damage columns}}{\text{Number of Inspected Columns}}$



Beam-Column Joint

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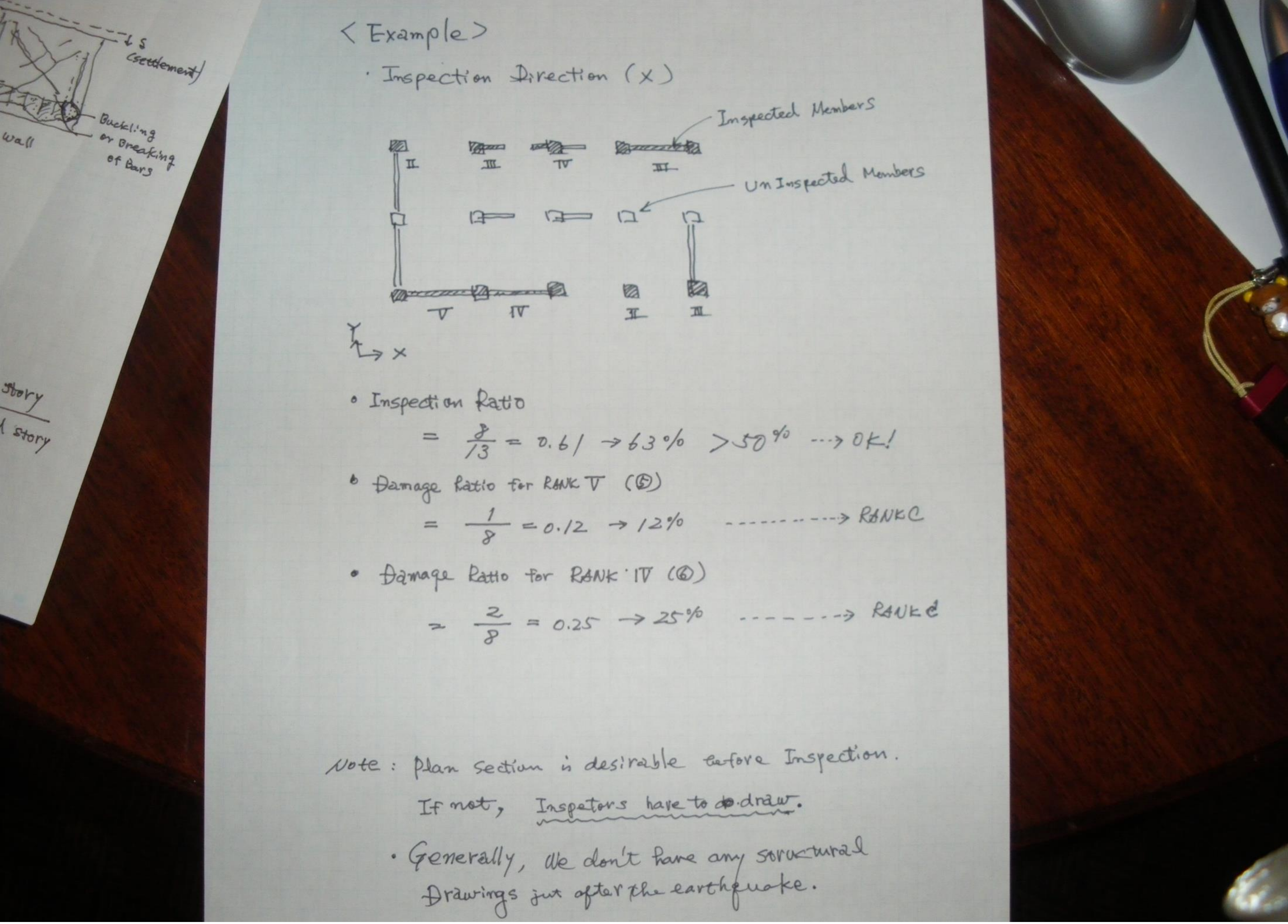

< Example >

- Inspection Direction (X)

- Inspection Ratio

  = 8/13 = 0.61 → 63% > 50% ---> OK!

- Damage Ratio for RANK V (⑤)

  = 1/8 = 0.12 → 12% ---------> RANK C

- Damage Ratio for RANK IV (⑥)

  = 2/8 = 0.25 → 25% -------> RANK d

Note : Plan section is desirable before Inspection.

If not, Inspetors have to ~~do~~ draw.

- Generally, We don't have any structural Drawings just after the earthquake.

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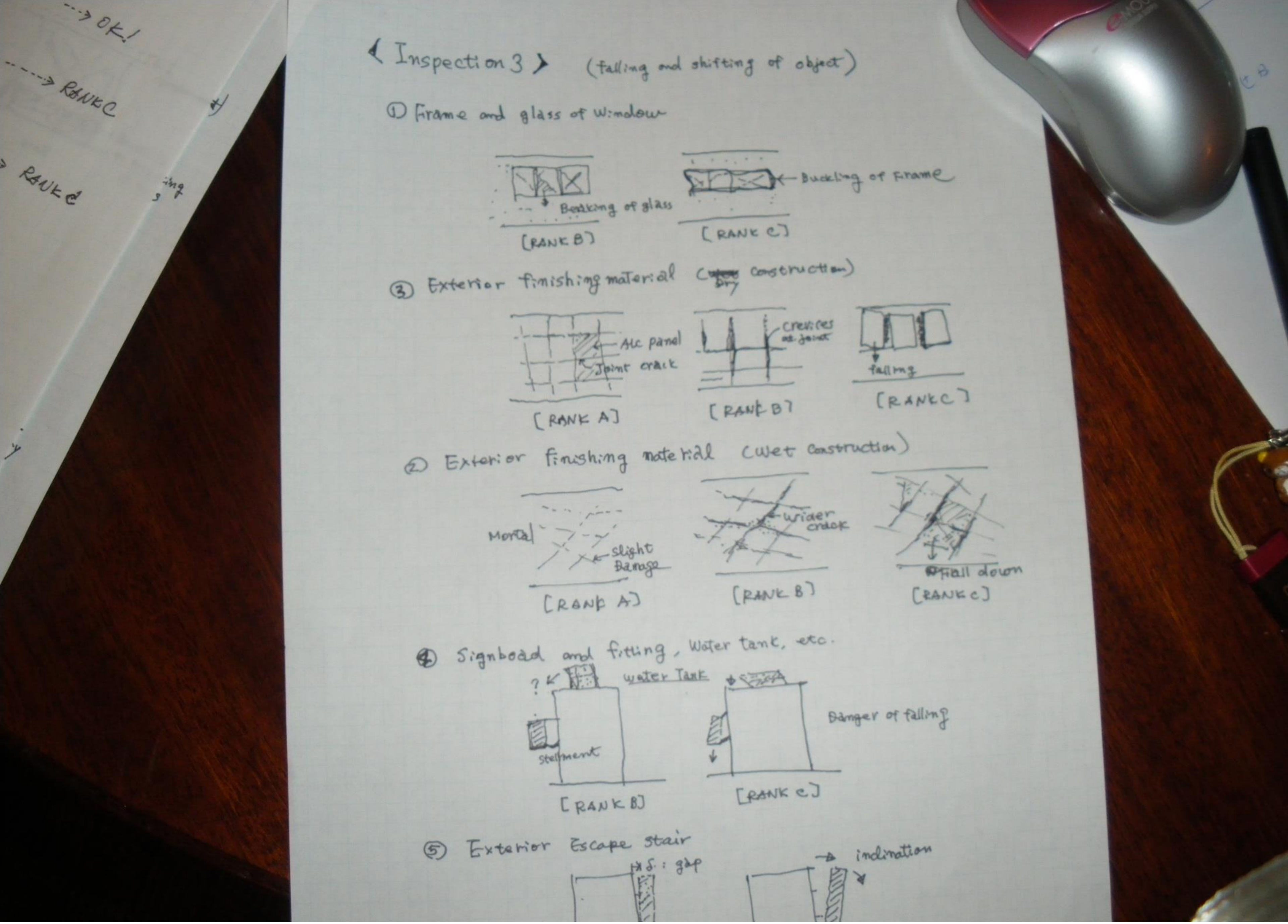

《Inspection 3》 (falling and shifting of object)

① Frame and glass of Window

Breaking of glass

Buckling of Frame

[RANK B] [RANK C]

③ Exterior finishing material (~~[illegible]~~ Dry construction)

ALC panel

Joint crack

Crevices at joint

falling

[RANK A] [RANK B] [RANK C]

② Exterior finishing material (Wet construction)

Mortal

Slight Damage

wider crack

Fall down

[RANK A] [RANK B] [RANK C]

④ Signboad and fitting, Water tank, etc.

?

water Tank

stellment

Danger of falling

[RANK B] [RANK C]

⑤ Exterior Escape stair

δ : gap

inclination

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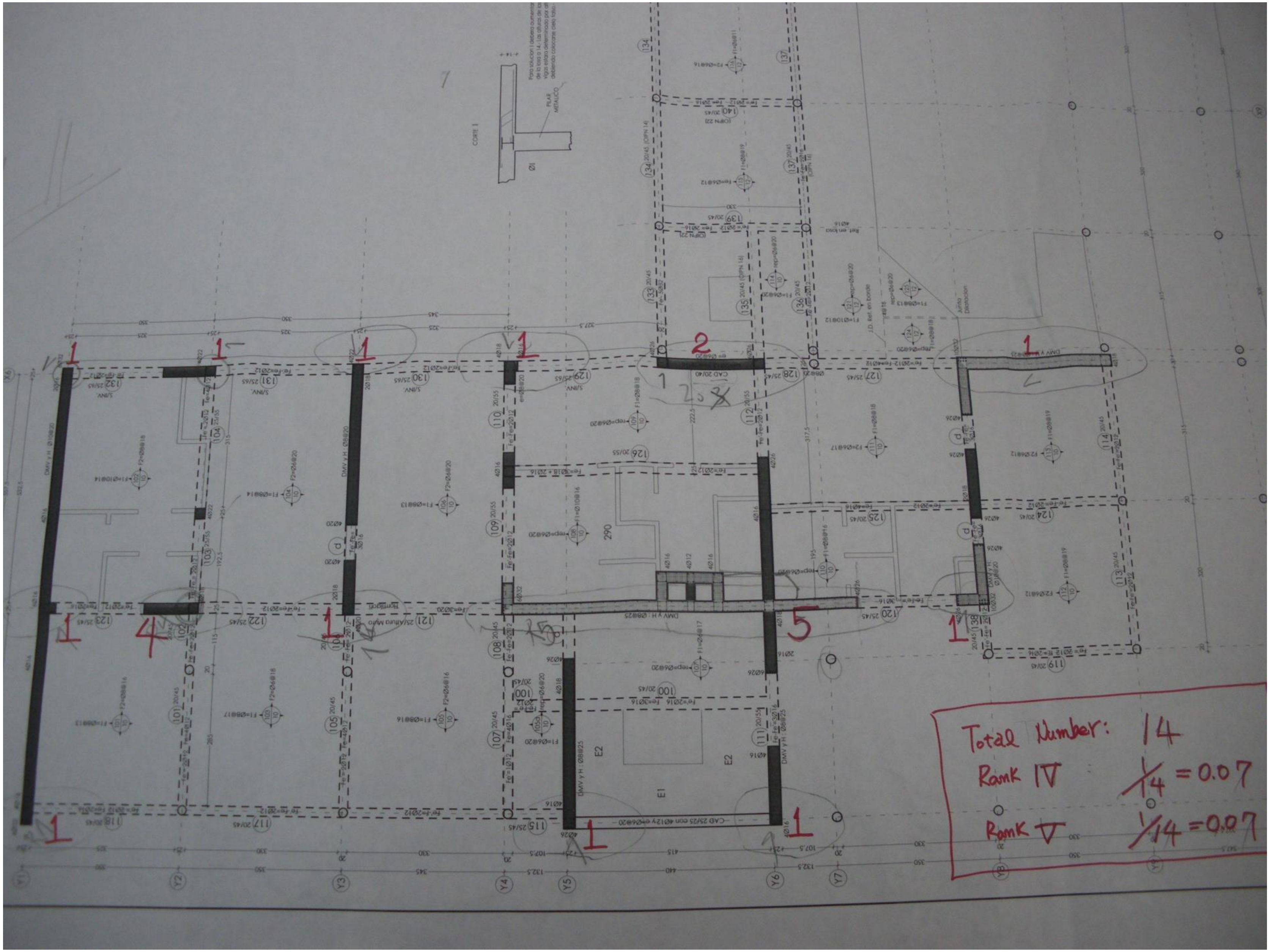

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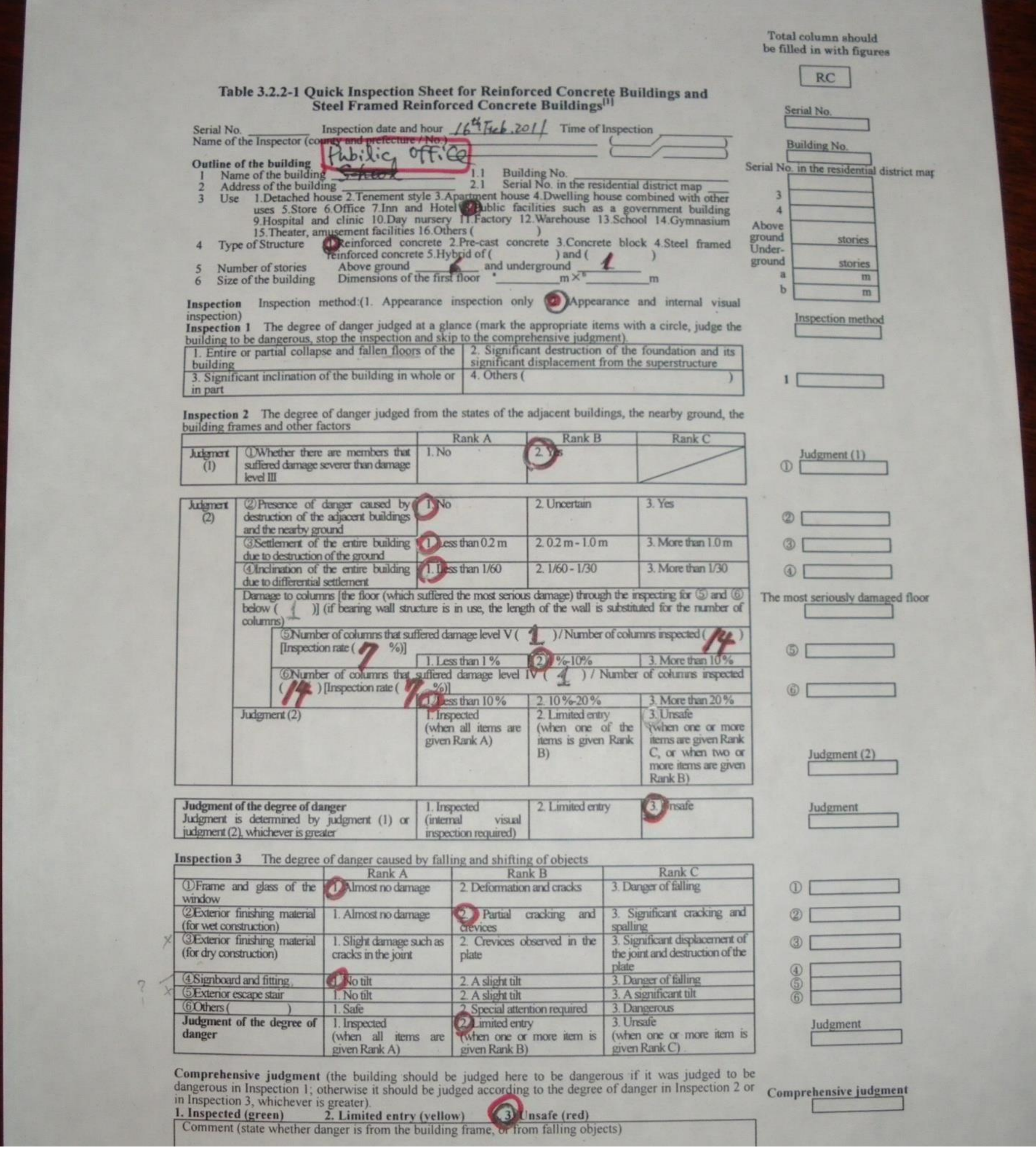

Total column should be filled in with figures

RC

Table 3.2.2-1 Quick Inspection Sheet for Reinforced Concrete Buildings and Steel Framed Reinforced Concrete Buildings[1]

Serial No. ________ Inspection date and hour 16th Feb.2011 Time of Inspection ________

Name of the Inspector (county and prefecture / No.) ________ (________) (________)

Outline of the building

1 Name of the building Pubilic Office ~~School~~ 1.1 Building No. ________

2 Address of the building ________ 2.1 Serial No. in the residential district map ________

3 Use 1.Detached house 2.Tenement style 3.Apartment house 4.Dwelling house combined with other uses 5.Store 6.Office 7.Inn and Hotel [✓ 8.Public facilities such as a government building] 9.Hospital and clinic 10.Day nursery 11.Factory 12.Warehouse 13.School 14.Gymnasium 15.Theater, amusement facilities 16.Others ( )

4 Type of Structure [✓ 1.Reinforced concrete] 2.Pre-cast concrete 3.Concrete block 4.Steel framed reinforced concrete 5.Hybrid of ( ) and ( )

5 Number of stories Above ground [illegible] and underground 1

6 Size of the building Dimensions of the first floor a ________ m × b ________ m

Inspection Inspection method:(1. Appearance inspection only [✓ 2. Appearance and internal visual inspection])

Inspection 1 The degree of danger judged at a glance (mark the appropriate items with a circle, judge the building to be dangerous, stop the inspection and skip to the comprehensive judgment).

1. Entire or partial collapse and fallen floors of the building	2. Significant destruction of the foundation and its significant displacement from the superstructure
3. Significant inclination of the building in whole or in part	4. Others ( )

Inspection 2 The degree of danger judged from the states of the adjacent buildings, the nearby ground, the building frames and other factors

		Rank A	Rank B	Rank C
Judgment (1)	①Whether there are members that suffered damage severer than damage level III	1. No	[✓ 2. Yes]	

Judgment (2)	②Presence of danger caused by destruction of the adjacent buildings and the nearby ground	[✓ 1. No]	2. Uncertain	3. Yes
	③Settlement of the entire building due to destruction of the ground	[✓ 1. Less than 0.2 m]	2. 0.2 m - 1.0 m	3. More than 1.0 m
	④Inclination of the entire building due to differential settlement	[✓ 1. Less than 1/60]	2. 1/60 - 1/30	3. More than 1/30
	Damage to columns [the floor (which suffered the most serious damage) through the inspecting for ⑤ and ⑥ below (1)] (if bearing wall structure is in use, the length of the wall is substituted for the number of columns)			
	⑤Number of columns that suffered damage level V (1) / Number of columns inspected (14) [Inspection rate (7 %)]	1. Less than 1 %	[✓ 2. %-10%]	3. More than 10 %
	⑥Number of columns that suffered damage level IV (1) / Number of columns inspected (14) [Inspection rate (7 %)]	[✓ 1. Less than 10 %]	2. 10 %-20 %	3. More than 20 %
	Judgment (2)	1. Inspected (when all items are given Rank A)	2. Limited entry (when one of the items is given Rank B)	3. Unsafe (when one or more items are given Rank C, or when two or more items are given Rank B)

Judgment of the degree of danger Judgment is determined by judgment (1) or judgment (2), whichever is greater	1. Inspected (internal visual inspection required)	2. Limited entry	[✓ 3. Unsafe]

Inspection 3 The degree of danger caused by falling and shifting of objects

	Rank A	Rank B	Rank C
①Frame and glass of the window	[✓ 1. Almost no damage]	2. Deformation and cracks	3. Danger of falling
②Exterior finishing material (for wet construction)	1. Almost no damage	[✓ 2. Partial cracking and crevices]	3. Significant cracking and spalling
x ③Exterior finishing material (for dry construction)	1. Slight damage such as cracks in the joint	2. Crevices observed in the plate	3. Significant displacement of the joint and destruction of the plate
? ④Signboard and fitting	[✓ 1. No tilt]	2. A slight tilt	3. Danger of falling
x ⑤Exterior escape stair	1. No tilt	2. A slight tilt	3. A significant tilt
⑥Others ( )	1. Safe	2. Special attention required	3. Dangerous
Judgment of the degree of danger	1. Inspected (when all items are given Rank A)	[✓ 2. Limited entry (when one or more item is given Rank B)]	3. Unsafe (when one or more item is given Rank C)

Comprehensive judgment (the building should be judged here to be dangerous if it was judged to be dangerous in Inspection 1; otherwise it should be judged according to the degree of danger in Inspection 2 or in Inspection 3, whichever is greater).

1. Inspected (green) **2. Limited entry (yellow)** [✓ **3. Unsafe (red)**]

Comment (state whether danger is from the building frame, or from falling objects)

Serial No. ☐

Building No. ☐

Serial No. in the residential district map ☐

3 ☐

4 ☐

Above ground ☐ stories

Under-ground ☐ stories

a ☐ m

b ☐ m

Inspection method ☐

1 ☐

Judgment (1)

① ☐

② ☐

③ ☐

④ ☐

The most seriously damaged floor ☐

⑤ ☐

⑥ ☐

Judgment (2) ☐

Judgment ☐

① ☐

② ☐

③ ☐

④ ☐

⑤ ☐

⑥ ☐

Judgment ☐

Comprehensive judgment ☐

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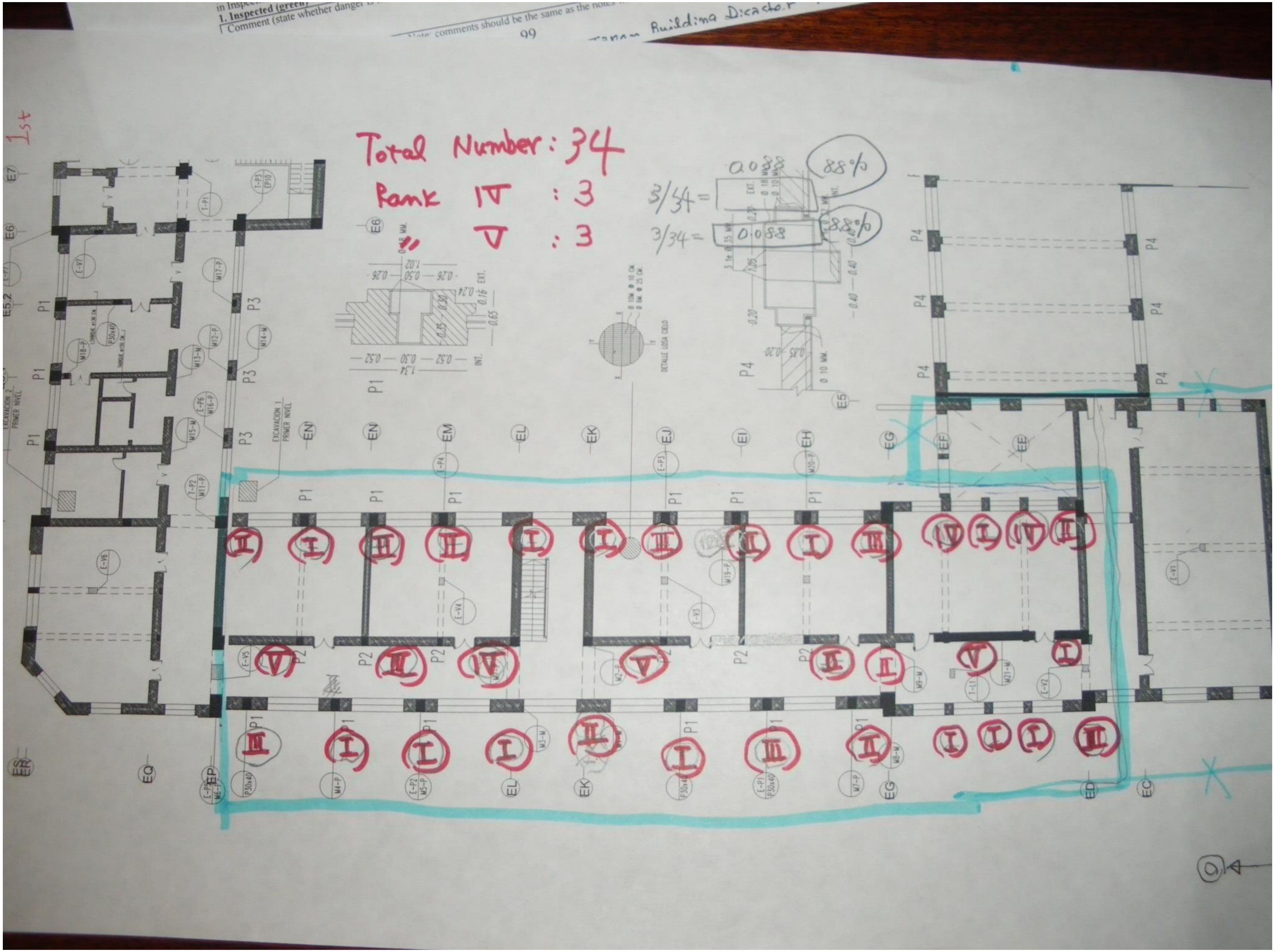

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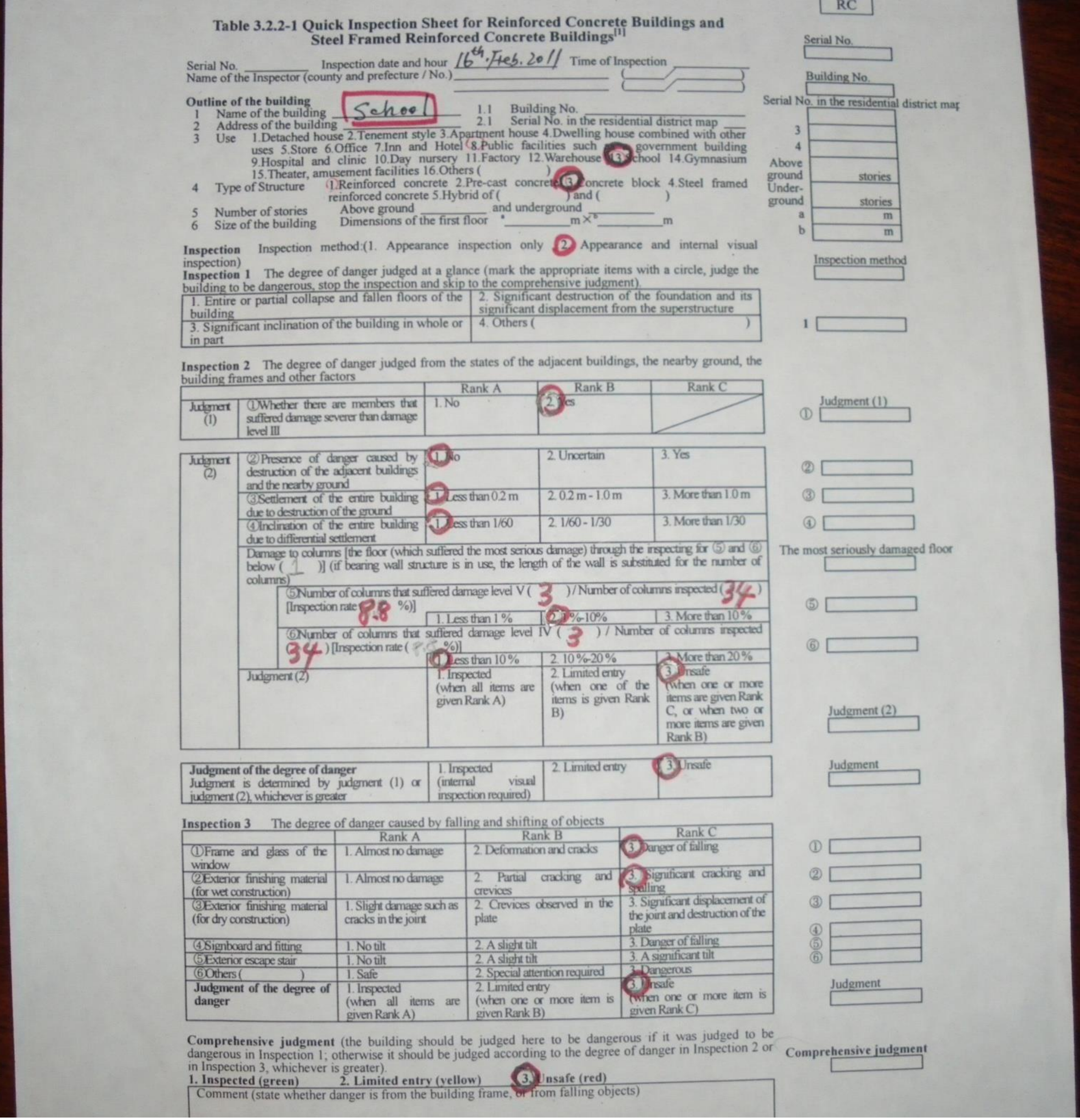

RC

Table 3.2.2-1 Quick Inspection Sheet for Reinforced Concrete Buildings and Steel Framed Reinforced Concrete Buildings[1]

Serial No. ________ Inspection date and hour 16th.Feb.2011 Time of Inspection ________
Name of the Inspector (county and prefecture / No.) ________ (________) ________

Outline of the building
1 Name of the building School 1.1 Building No. ________
2 Address of the building ________ 2.1 Serial No. in the residential district map ____
3 Use 1.Detached house 2.Tenement style 3.Apartment house 4.Dwelling house combined with other uses 5.Store 6.Office 7.Inn and Hotel 8.Public facilities such as government building 9.Hospital and clinic 10.Day nursery 11.Factory 12.Warehouse [✓ 13.School] 14.Gymnasium 15.Theater, amusement facilities 16.Others ( )
4 Type of Structure [✓ 1.Reinforced concrete] 2.Pre-cast concrete [✓ 3.Concrete block] 4.Steel framed reinforced concrete 5.Hybrid of ( ) and ( )
5 Number of stories Above ground ________ and underground ________
6 Size of the building Dimensions of the first floor a________m × b________m

Inspection Inspection method:(1. Appearance inspection only [✓ 2. Appearance and internal visual inspection)

Inspection 1 The degree of danger judged at a glance (mark the appropriate items with a circle, judge the building to be dangerous, stop the inspection and skip to the comprehensive judgment).

1. Entire or partial collapse and fallen floors of the building	2. Significant destruction of the foundation and its significant displacement from the superstructure
3. Significant inclination of the building in whole or in part	4. Others ( )

Inspection 2 The degree of danger judged from the states of the adjacent buildings, the nearby ground, the building frames and other factors

		Rank A	Rank B	Rank C
Judgment (1)	①Whether there are members that suffered damage severer than damage level III	1. No	[✓ 2. Yes]	

Judgment (2)	②Presence of danger caused by destruction of the adjacent buildings and the nearby ground	[✓ 1. No]	2. Uncertain	3. Yes
	③Settlement of the entire building due to destruction of the ground	[✓ 1. Less than 0.2 m]	2. 0.2 m - 1.0 m	3. More than 1.0 m
	④Inclination of the entire building due to differential settlement	[✓ 1. Less than 1/60]	2. 1/60 - 1/30	3. More than 1/30
	Damage to columns [the floor (which suffered the most serious damage) through the inspecting for ⑤ and ⑥ below (1)] (if bearing wall structure is in use, the length of the wall is substituted for the number of columns)			
	⑤Number of columns that suffered damage level V (3) / Number of columns inspected (34) [Inspection rate (8.8 %)]	1. Less than 1 %	[✓ 2. 1%-10%]	3. More than 10 %
	⑥Number of columns that suffered damage level IV (3) / Number of columns inspected (34) [Inspection rate (8.8 %)]	[✓ 1. Less than 10 %]	2. 10 %-20 %	3. More than 20 %
	Judgment (2)	1. Inspected (when all items are given Rank A)	2. Limited entry (when one of the items is given Rank B)	[✓ 3. Unsafe (when one or more items are given Rank C, or when two or more items are given Rank B)]

Judgment of the degree of danger Judgment is determined by judgment (1) or judgment (2), whichever is greater	1. Inspected (internal visual inspection required)	2. Limited entry	[✓ 3. Unsafe]

Inspection 3 The degree of danger caused by falling and shifting of objects

	Rank A	Rank B	Rank C
①Frame and glass of the window	1. Almost no damage	2. Deformation and cracks	[✓ 3. Danger of falling]
②Exterior finishing material (for wet construction)	1. Almost no damage	2. Partial cracking and crevices	[✓ 3. Significant cracking and spalling]
③Exterior finishing material (for dry construction)	1. Slight damage such as cracks in the joint	2. Crevices observed in the plate	3. Significant displacement of the joint and destruction of the plate
④Signboard and fitting	1. No tilt	2. A slight tilt	3. Danger of falling
⑤Exterior escape stair	1. No tilt	2. A slight tilt	3. A significant tilt
⑥Others ( )	1. Safe	2. Special attention required	3. Dangerous
Judgment of the degree of danger	1. Inspected (when all items are given Rank A)	2. Limited entry (when one or more item is given Rank B)	[✓ 3. Unsafe (when one or more item is given Rank C)]

Comprehensive judgment (the building should be judged here to be dangerous if it was judged to be dangerous in Inspection 1; otherwise it should be judged according to the degree of danger in Inspection 2 or in Inspection 3, whichever is greater).
1. Inspected (green) **2. Limited entry (yellow)** [✓ **3. Unsafe (red)**]

Comment (state whether danger is from the building frame, or from falling objects)

Serial No. ☐
Building No. ☐
Serial No. in the residential district map
3 ☐
4 ☐
Above ground ☐ stories
Underground ☐ stories
a ☐ m
b ☐ m
Inspection method ☐
1 ☐
Judgment (1)
① ☐
② ☐
③ ☐
④ ☐
The most seriously damaged floor ☐
⑤ ☐
⑥ ☐
Judgment (2) ☐
Judgment ☐
① ☐
② ☐
③ ☐
④ ☐
⑤ ☐
⑥ ☐
Judgment ☐
Comprehensive judgment ☐

Seki M., UTCB Lecture note, May 2017, BRI, Japan

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Training Video in Chile

Conclusions

1. Japan has already performed the seismic evaluation for the huge number of existing buildings such as RC, steel and timer structures.

2. For the public building, most of buildings are finished, but for the private office and residential building are still on the way.

3. Just after the earthquake, the quick inspection and more detail inspection and retrofit should be done immediately.

Thank you for your attention!