Seismic Risk Evaluations of Buildings in Japan

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What is going on in Japan

Standards, Regulations

S1- Standards for **Seismic Evaluation and Retrofit** of **Existing** Buildings
(Structure and Non-structural Components)
S2- **Post-Earthquake Temporary** Risk Evaluation of **Damaged** Buildings
S3- Standards for **Damage Evaluation** and Guidline of **Repair Technology of Earthquake Damaged** Buildings
[The Japan Building Disaster Prevention Association (JBDPA)]

S4- **Housing Performance** Indication System (Based on Housing Quality Assurance Act)
[Ministry of Land, Infrastructure, Transportation and Tourism of Japan (MLITT)]

What is going on in Japan - Continued

Guidelines

G1- Seismic Evaluation of **Brick Structure**
[Hokkaido Building Engineering Association]

G2- Sesmic Evaluation of **Reinforced Concrete Block Structure**
[Fukuoka-Pref Building Seismic Evaluation Committee]

G3- Guideline for Avoiding Collapse of **Ceiling**
[Architectural Institute of Japan (AIJ), MLITT]

What is going on in Japan - Contiued

Methodorogy

M1- **PML**
[Private Consultant firms, Insurance Companies]

M2- **High-rise Building** : Seismic Response Analysis with **Revised Earthquake Motions** and Seismic Upgrades
[Consultant firms, MLITT, BCJ]

S1- Standards for **Seismic Evaluation and Retrofit** of Existing Buildings **(Structure and Non-structural Components)**
[The Japan Building Disaster Prevention Association (JBDPA)]

1977 Published
1990 Revised
2001 Revised

- Especially for the buildings designed and constructed before 1981 when Seismic Design Standards changed to New Standards

- 1st, 2nd and 3rd Evaluation Methods

- I_S : Seismic Index of Structure

I_N : Sesmic Index of Non-structural Component
Deformation Ability More Deformable the better
Impact to Public Less Impact the better

***S1*- Standards for Seismic Evaluation and Retrofit of Existing Buildings (Structure and Non-structural Components)**
[The Japan Building Disaster Prevention Association (JBDPA)]

(1) 構造耐震指標（I_s）は建物の各階の梁間及び桁行方向それぞれについて(1)式により算定する。ただし、T指標及び第１次診断法におけるS_D指標については、階位置及び方向による区別をしない。

$$I_s = E_0 \cdot S_D \cdot T \quad (1)$$

ここで、E_0 ：保有性能基本指標（3.2 節による）
S_D ：形状指標（3.3 節による）
T ：経年指標（3.4 節による）

$$E_0 = \frac{n+1}{n+i}\sqrt{E_1^2 + E_2^2 + E_3^2} \quad (4)$$

ここで、E_1 ：$C_1 \cdot F_1$
E_2 ：$C_2 \cdot F_2$
E_3 ：$C_3 \cdot F_3$
C_1 ：第１グループ（F指標が最も小さいグループ）のC指標
C_2 ：第２グループ（F指標が中間のグループ）のC指標
C_3 ：第３グループ（F指標が最も大きいグループ）のC指標
F_1 ：第１グループのF指標
F_2 ：第２グループのF指標
F_3 ：第３グループのF指標

$$E_0 = \frac{n+1}{n+i}\left(C_1 + \sum_j \alpha_j C_j\right) \cdot F_1 \quad (5)$$

ここで、α_j ：第１グループ（靭性指標F_1）の終局強度時変形（R_1）における第jグループの強度寄与係数で、表３および表３の注によることができる。

強度指標C

靭性指標F

- Seismic Index of Structure

Is ＝ E0 ・ SD ・ T

E0 : Retained Basic Seismic Capacity Index
SD : Shape Factor
T : Time Factor

- E0 is calculated as representing Seismic Enegy Capacity which the building retains, with C and F

Strength Factor C
Ductility Factor F

***S1*- Standards for **Seismic Evaluation and Retrofit** of Existing Buildings**
(Structure and Non-structural Components)
[The Japan Building Disaster Prevention Association (JBDPA)]

- Seismic Index of Structure Is

0.6 : Possibility of Collapse is little in case of Very Rare Occurance Earthquake

Very Rare Occurance Earthquake corresponds to Level-2 Design Load in the Latest Seismic Design defined in Building Law of Japan

For Government Building
Critical Buildings – No Damage, Functionable
: Is = 0.90 or more

Important Buildings – Repairable Damage, Funtionable
: Is = 0.75 or more

S2- **Post-Earthquake Temporary** Risk Evaluation of **Damaged** Buildings
[The Japan Building Disaster Prevention Association (JBDPA)]

[Post-evaluation placard:]

1980	Algeria Earthquake Southern Italy Earthquake	
1981		The Ministry of Construction of Japan started the project "The project for advanced repair technology for earthquake damaged buildings" for five years.
1985	Mexico Earthquake	The Ministry of Construction applied the draft of quick inspection method for damaged buildings, and ensured its appropriateness.
1986		The Ministry of Construction compiled "the manual of repair technology for damaged buildings" as the fruit of the project.
1989	Loma Prieta Earthquake in the U.S.A.	The U.S. compiled a manual of postearthquake safety evaluation of buildings, "ATC-20".
1991		"The standard of damage evaluation and the guidance of repair technology for the buildings hit by an earthquake" was published. *Each local government promoted the establishment of the quick inspection system.
1994	Northridge Earthquake in the U.S.A.	
1995	Great Hanshin-Awaji Earthquake (Earthquake in Southern Hyogo Prefecture)	The Ministry of Construction, local governments and private construction organizations cooperated with each other to implement the quick inspection of damaged buildings for the first time in Japan. The number of inspected buildings: 46,610 *Each prefectural government established and adopted the quick inspection system and the support system rapidly.

Temporary Risk Evaluation Separated in 1998

Damage Evaluation and Repair Tech. Revised in 2001

***S3*- Standards for **Damage Evaluation** and Guidline of **Repair Technology of Earthquake Damaged** Buildings**
[The Japan Building Disaster Prevention Association (JBDPA)]

1991 Published
2001 Revised
2014 Revision being prepared

- R (Remained Seismic Capacity)
  = Is (Seismic Index of Original Structure)
  / $_{D}$Is (Seismic Index of Damaged Structure)

Slight Damage	: R 95%
Little Damage	: 80% R 95%
Moderate Damage	: 60% R 80%
Serious Damage	: R 60%
Collapse	: R neary= 0 Totally or Partially Collapse

S4- **Housing Performance** Indication System (Based on Housing Quality Assurance Act)
[Ministry of Land, Infrastructure, Transportation and Tourism of Japan (MLITT)]

- Housing Quality Assurance Act enforced in 2000

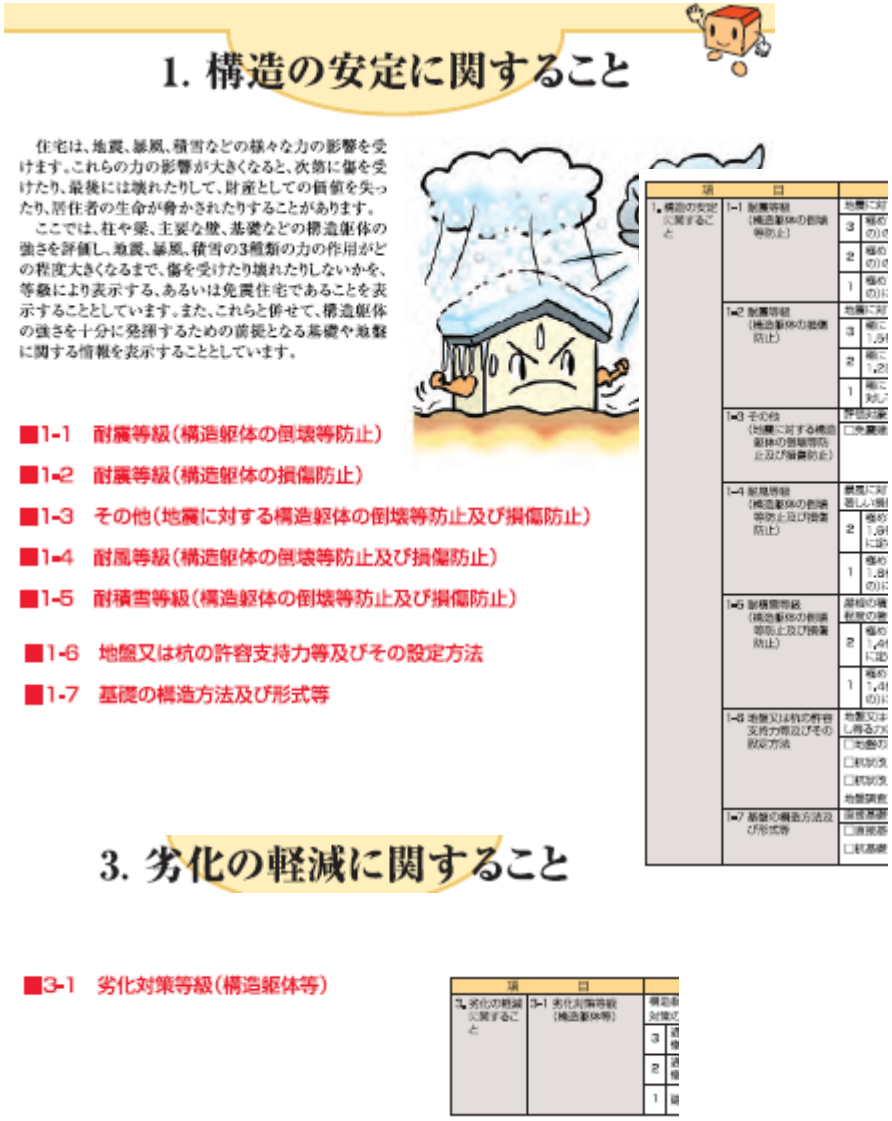
① 構造の安定に関すること
② 火災時の安全に関すること
③ 劣化の軽減に関すること
④ 維持管理・更新への配慮に関すること
⑤ 温熱環境に関すること
⑥ 空気環境に関すること
⑦ 光・視環境に関すること
⑧ 音環境に関すること
⑨ 高齢者等への配慮に関すること
⑩ 防犯に関すること

10 Fields in Housing Performance Indication System

1. Structure Stability
2. Fire Safety
3. Durability
4. Maintenance & Renovation
5. Heat & Cool Cercumstances
6. Air Cercumstances
7. Lighting Cercumstances
8. Sound Cercumstances
9. Elderly Concerns
10. Security

Evaluation Certificate Sign

S4- **Housing Performance** Indication System (Based on Housing Quality Assurance Act)
[Ministry of Land, Infrastructure, Transportation and Tourism of Japan (MLITT)]



Structure Stability

1-1 Seismic Evaluation for Level 2 Earthquake
1-2 Seismic Evaluation for Level 1 Earthquake
1-3 Seismic Isolation
1-4 Rating for Wind Load
1-5 Rating for Snow Load
1-6 Supporting Capacity of Foundation
1-7 Foundation System

Durability

3-1 Durability Rating

G1- Seismic Evaluation of **Brick Structure**
[Hokkaido Building Engineering Association]

2012 Published

1．無筋の煉瓦造を対象としている。建物の診断は耐震性能の判定（Ｉｓ値、ｑ値の算定）までとし、補強設計は対象外とする。また壁体の面外耐力の診断も行う。
2．建物の規模は、建築基準法や日本建築学会の設計規準で想定している通常の規模（小～中規模まで）とし、特殊な規模や構造の煉瓦造は対象としていない。
3．「歴史的組積造建築物の耐震診断法に関する基礎研究」（日本建築学会北海道支部研究報告集No70・1997 年）によれば、２階以上の床に鉄筋コンクリート造床を設けた煉瓦造建物は、被害の規模・程度が小さかった（図１）。

- Reference to Basic Research on Seismic Evaluation of Historical Masonry Buildings

4．保有水平耐力（Qu）の算定
保有水平耐力は（７）式により算定する。
$Qu = \alpha \cdot Aw \cdot \tau w$ 〔N〕 （７）
ここで、Aw：各階各方向の壁の水平断面積〔mm^2〕
τw：壁の水平断面積当りのせん断耐力〔N/mm^2〕（５条 表２参照）
α ：壁の高さと幅の比率による低減係数で①～③による
①開口部の高さと壁の幅の比が２以下：α＝1.0
②開口部の高さと壁の幅の比が３以上：α＝0.0
③上記①と②の間は直線補間による
壁の両側の開口部高さが異なる場合は両者の平均の高さとする。
また、端部の壁は煉瓦の積み高を片側の開口部高さと見なす。

- Horizontal Shear Capacity

$Qu = \alpha \cdot Aw \cdot \tau w$

Aw : Sectional Area of Wall
τw : Shear Strength
α : Coefficient related to Height / Width

G2- Sesmic Evaluation of **Reinforced Concrete Block Structure**

[Fukuoka-Pref Building Seismic Evaluation Committee]

2013　Published

- Included in Manual for Building Seismic Evaluation and Retrofit
- Reference to
  Design Codes for Reinforced Concrete Block Structure [AIJ]
  Strength Evaluation Methods of Existing Reinforced Concrete Block Structure Schools [Ministry of Education, Culture, Sports, Science and Technology of Japan]

- Seismic Index　(Basically same as Standards for **Seismic Evaluation and Retrofit** of Existing Buildings)

$I_S = E_0 \cdot S_D \cdot T$

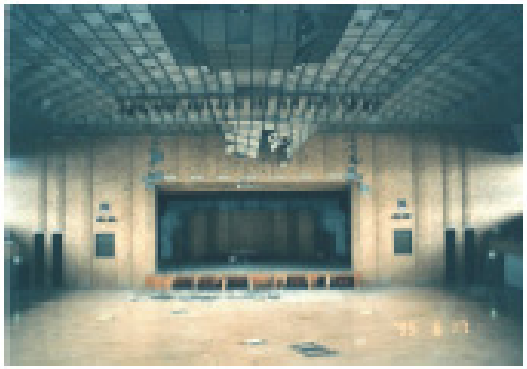
E_0 : Retained Basic Seismic Capacity Index
Shear Strength 0.32 – 0.45 N/mm^2 ,　Ductility Fasctor F = 1.0, 1.5

S_D : Shape Factor

T　: Time Factor

G3- Guideline for Avoiding Collapse of **Ceiling**
[Architectural Institute of Japan (AIJ), MLITT]

2013 Published
Special Research Committee on Safety Evaluation and Avoiding collapse of Non-structural Components



Ceiling collapse in Hanshin-Awaji Eq. 1995

Ceiling collapse in Non-earthquake ocasion

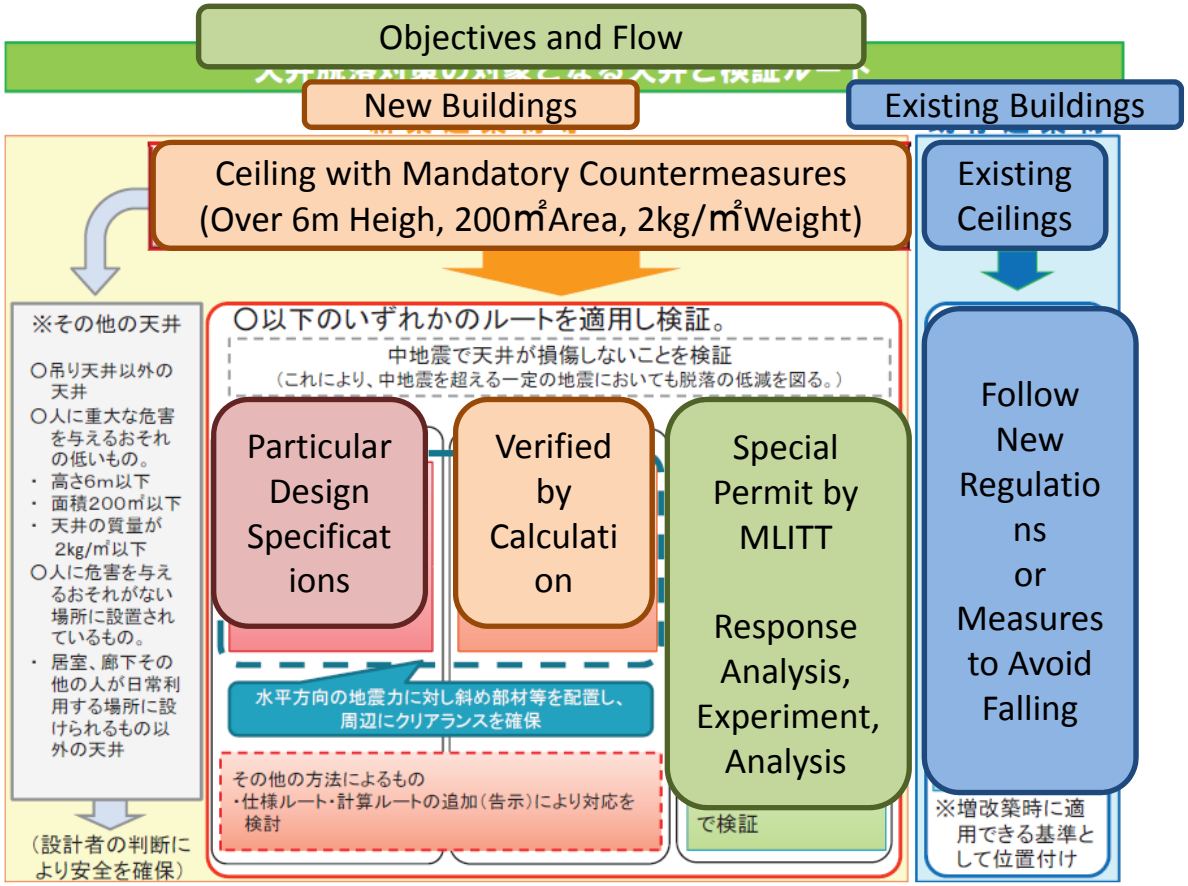
Acoustic elements collapse in Hanshin-Awaji Eq. 1995

Lighting facilities collapse in Niigata Eq. 2004

G3- Guideline for Avoiding Collapse of **Ceiling**

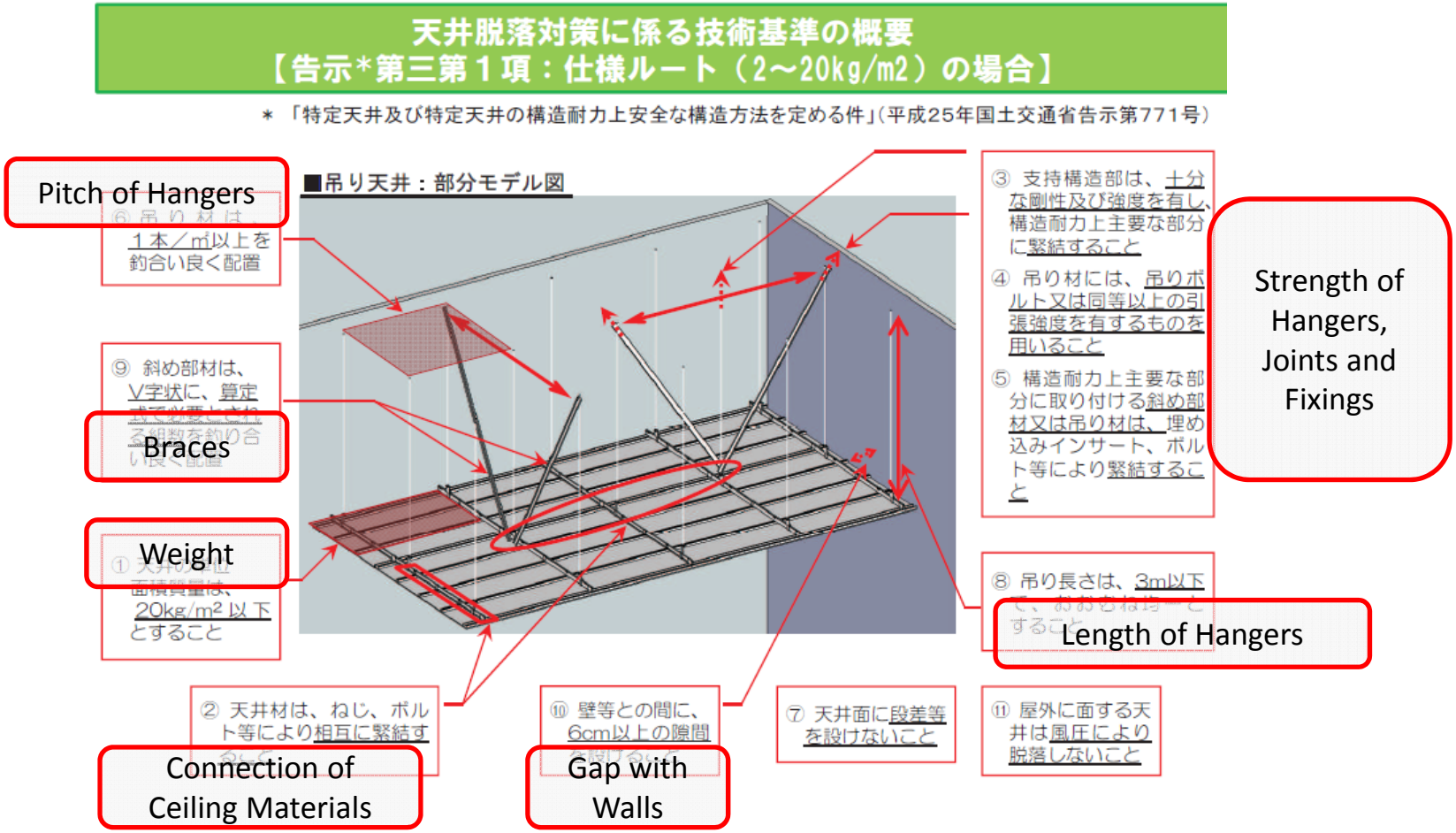
[Architectural Institute of Japan (AIJ), MLITT]

Regulations on Countermeasures for Avoiding Collapse of Ceilings, enforced in 2014



G3- Guideline for Avoiding Collapse of **Ceiling**

[Architectural Institute of Japan (AIJ), MLITT]



Particular Design Specifications

M1- PML

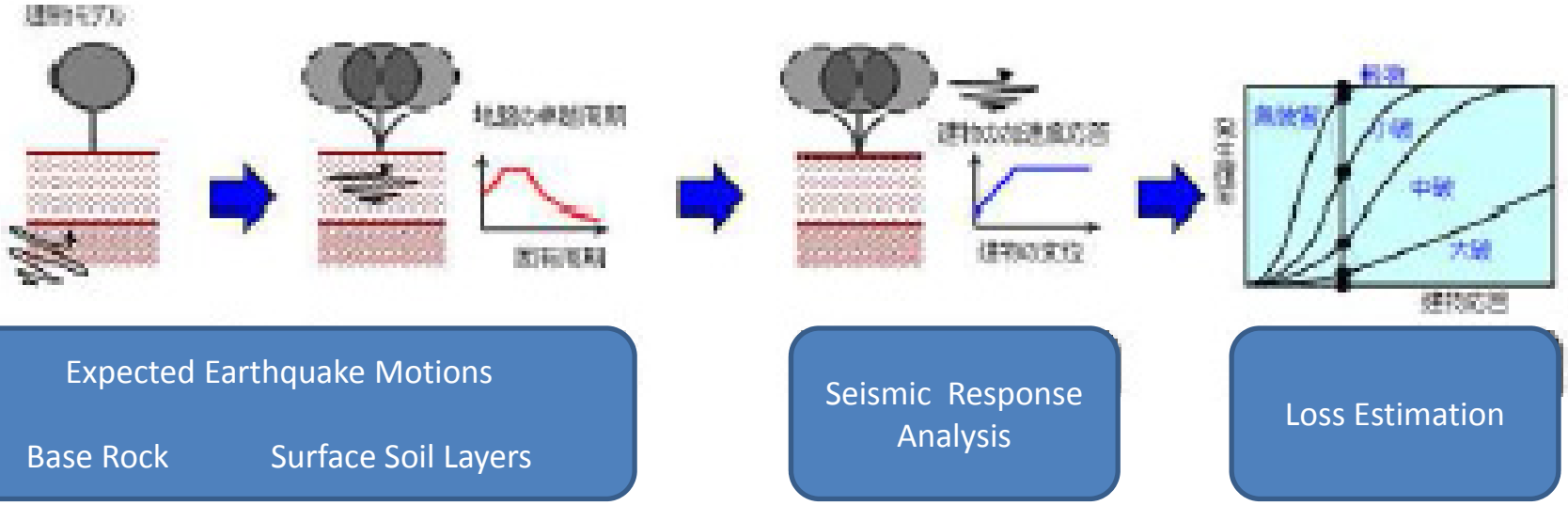
[Private Consultant firms, Insurance Companies]

PML Index

=

(Probable Maximum Loss Cost)

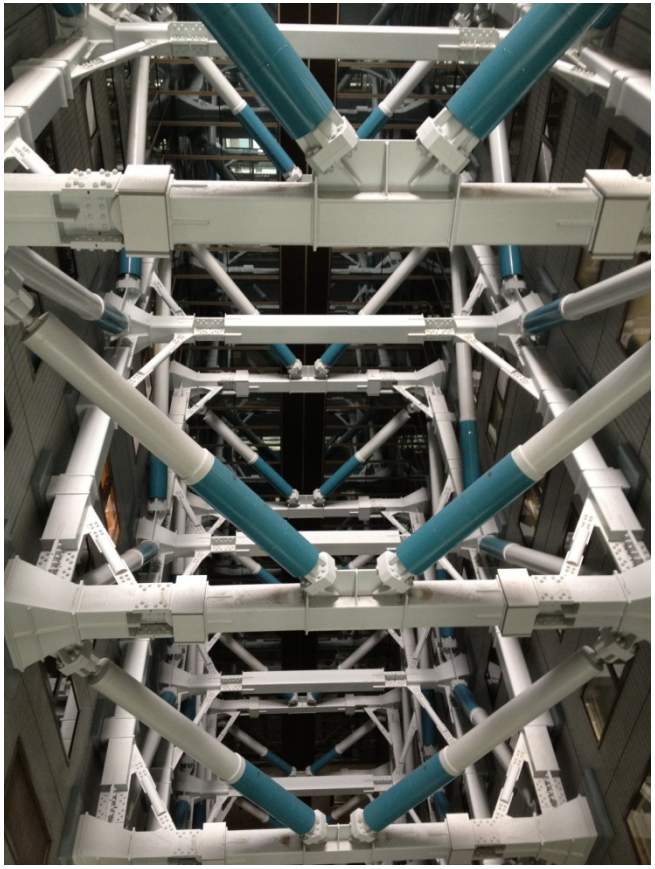
/ (Cost for Re-Procurement)



M2- **High-rise Building** : Seismic **Response Analysis** with **Revised Earthquake Motions** and Seismic **Upgrades**
-[Consultant firms, MLITT, BCJ]

Latest Concerns in Earthquake Motions
- Long Period Earthquake
- Jointly-Colapsing Fault Earthquake

Retrofit
- Vibration Control Devices
- Energy Dissipating Devices



Oil Dampers and Aditional Frames

Maybe more topics concerning Seismic Risk in Japan?

Thank you for Listening.