Comparison for Seismic Standard between Japan and Mongolia

Tadashi Sugano
Tomokazu Tateno

The Building Center of Japan

Outline

Japan

Design of ordinary buildings
・First design
(allowable stress)
・Second desing
(ultimate strength design)

Compare

Mongolia

Design of ordinary buildings

Design of high-rise building
・example of actual design
・・・・・ 2/1 explain
・Performance evaluation of high-rise building ・・・・・ 2/5 explain

Design of highrise building

?

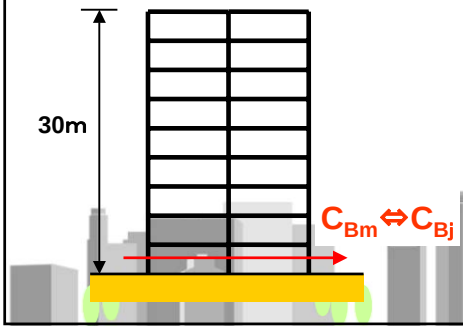
Outline

- In order to understand the difference in the seismic standard between Japan and Mongolia, the formula for design seismic force of a building is compared in the base shear coefficient.

Mongolia $C_{Bm} = \Sigma Sik/\Sigma Qk = Ki\ K\psi\ A\ \beta\ (\Sigma\ \eta ik\ Qi/\Sigma Qi)$

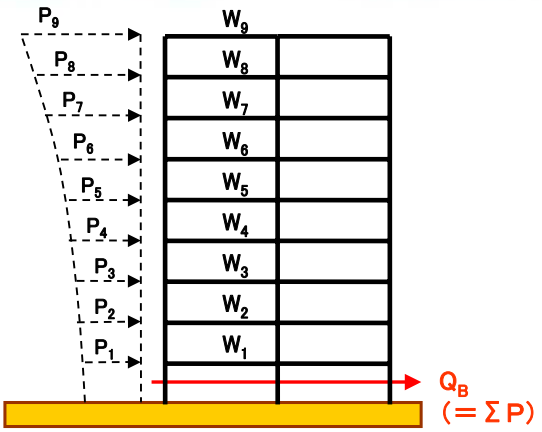
Japan $C_{Bj} = Ds\ Fes\ Z\ C_0\ Rt\ Ai$

- Comparison is made assuming that a 9-story high reinforced concrete apartment (height H=30 m) is designed in Tokyo and Ulan Bator



Outline of building	
Stories	9 stories
Height	30 m
Natural period	0.6s
Structural type	Reinforced concrete (RC)
Soil	Tokyo (Type 2 soil)
	Ulan Bator (Type 2 soil)

What is base shear coefficient?



What is base shear coefficient? Story shear force coefficient of one story. Shear force of one story divided by the total weight of the building

Base shear coefficient $C_B = Q_B / \Sigma W$

1. Comparison of Japan with Mongolia for Design Seismic Force Formula

Base shear coefficient in Mongolia

$C_{Bm} = \Sigma Sik/\Sigma Qk = Ki\ K\psi\ A\ \beta\ (\Sigma\ \eta ik\ Qi/\Sigma Qi)$

- Ki: Building coefficient (Damage level, configuration)
- $K\psi$, A, β: Seismic force coefficient (MSK7-9, soil, building importance)
- $\Sigma\ \eta ik\ Qi/\Sigma Qi$: Modal analysis coefficient

Almost equal

Base shear coefficient in Japan

$C_{Bj} = Ds\ Fes\ Z\ C_0\ Rt\ Ai$

- Ds: Building coefficient (Structural type, configuration)
- Fes, Z, C_0, Rt: Seismic force coefficient (JMA6+, region, soil)
- Ai: Modal analysis approximate coefficient

The design criteria for a building are that the building does not collapse against the Japan Meteorological Agency (JMA) Seismic Intensity Scale 6+ (equivalent to MSK9) considered to occur once in 500 years

1.1 Comparison for Seismic Force Coefficient

Base shear coefficient in Mongolia

$C_{Bm} = \Sigma Sik/\Sigma Qk = Ki\ K\psi\ A\ \beta\ (\Sigma\ \eta ik\ Qi/\Sigma Qi)$

Seismic force coefficient (MSK7-9, soil, building importance)

Base shear coefficient in Japan

$C_{Bj} = Ds\ Fes\ Z\ C_0\ Rt\ Ai$

Seismic force coefficient (JMA6+, region, soil)

Comparison for seismic force coefficient

1.1 Comparison for Seismic Force Coefficient

■ When a 9-story building (height = 30 m, natural period T = 0.6s) apartment structured with reinforced concrete is to be designed in Ulan Bator

$$C_{Bm} = Ki\ K\psi\ A\ \beta\ (\Sigma\ \eta ik\ Qi / \Sigma\ Qi)$$

Seismic force coefficient in Mongolia

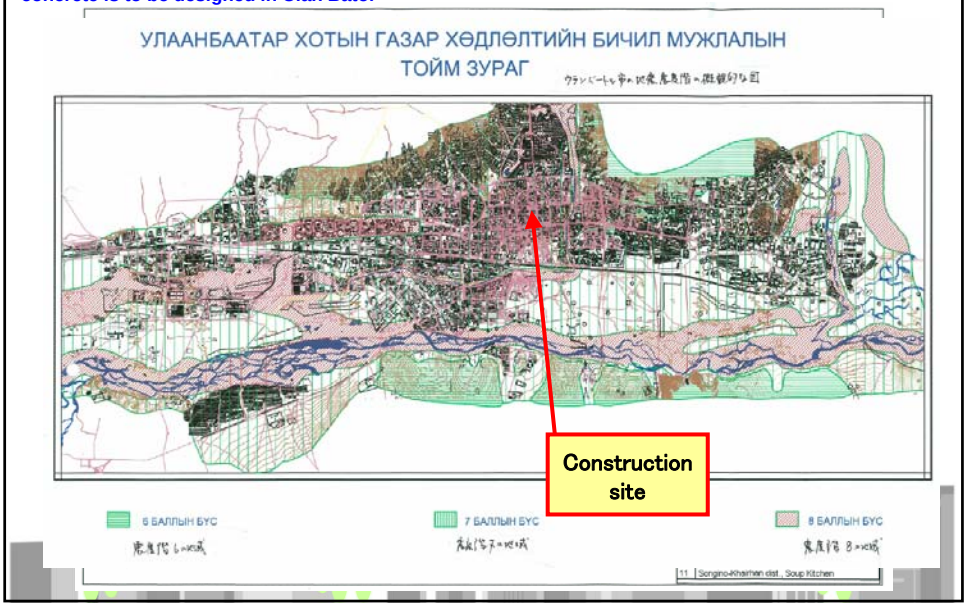
種類	地　盤	地域の地震度		
		7	8	9
1	全ての種類の岩石地盤で、風化していないもの、風化の少ないもの 強固に凍結した永久凍土	6	7	8
2	岩石地盤で、風化したもの、強く風化したもの 砂利土壌で、密度の高いもの。 粘土質土壌で、IL≦0.5 間隙比がe<0.9の粘性土 とe<0.7の砂質土のもの。	7	8	9
3	湿度、粒度に関わり無く、締め固まっていない砂 粘土質土壌で、IL≦0.5 間隙比がe<0.9の粘性土 とe<0.7の砂質土のもの。	8	9	10

建築特別仕様	計算震度		
	7	8	9
1.　本規準の2・5条に属していない共同住宅、事務所工場の建物	7	8	9
2.　特別に重要な建物	8	9	9**
3.　破壊すると大きな被害を受ける可能性のある建物（大きな鉄道の駅、スタジアムなど）	7**	8**	9***
4.　地震が発生し、被害を受けたとき、復旧するために必要な建物（中央郵便局、消防署、発電所、水道設備等）	7***	8***	9***
5.　人の生命に関係ない、大事な機械のない、停止しても影響のない建物（倉庫、工場のクレーン設備と修理設備、鉄骨製作工場、仮設宿舎等）	地震応力を計算しない		

Design seismic activity 7 → A = 0.1

1.1 Comparison for Seismic Force Coefficient

■ When a 9-story building (height = 30 m, natural period T = 0.6s) apartment structured with reinforced concrete is to be designed in Ulan Bator

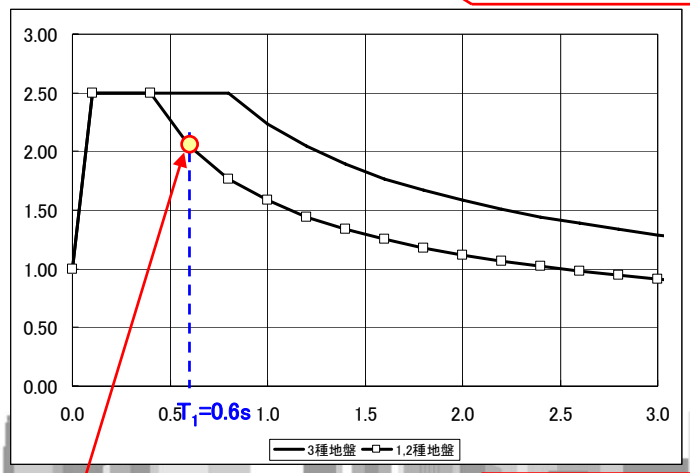


1.1 Comparison for Seismic Force Coefficient

■ When a 9-story building (height = 30 m, natural period T = 0.6s) apartment structured with reinforced concrete is to be designed in Ulan Bator

C_{Bm} = Ki Kψ A β (Σ η ik Qi/ Σ Qi)

Seismic force coefficient in Mongolia



β = 2.04

Aβ = 0.1 x 2.04 = 0.204

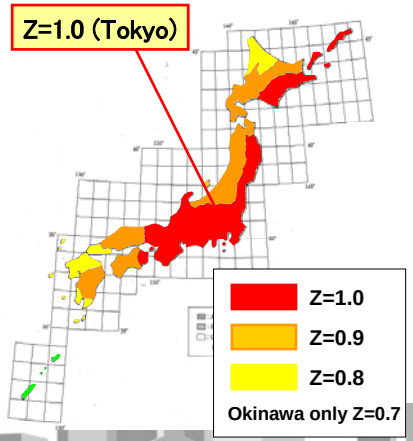
1.1 Comparison for Seismic Force Coefficient

■ When a 9-story building (height = 30 m, natural period T = 0.6s) apartment structured with reinforced concrete is to be designed in Ulan Bator

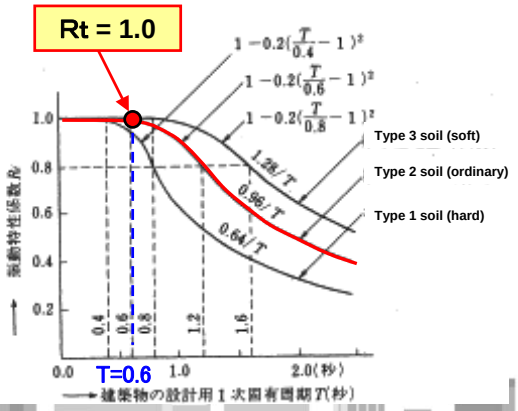
C_{Bj} = Ds Fes Z C_0 Rt Ai

Seismic force coefficient in Japan

Z=1.0 (Tokyo)



Rt = 1.0



C_0 Z Rt = 1.0 x 1.0 x 1.0 =1.0

1.1 Comparison for Seismic Force Coefficient

Mongolia

C_{Bm}=Ki Kψ A β (Σ η ik Qi/ Σ Qi)

A
A value equivalent to design seismic force
Design seismic force MSK7-9 is assumed
depending on the region, type of soil
and importance of the building and the
A value may be 0.1, 0.2, or 0.4 respectively.

β
Seismic response spectrum.
There are two spectra depending
on the type of soil.

9-story RC building Aβ = 0.204

Japan

C_{Bj} = Ds Fes C_0 Z Rt Ai

C_O (standard shear coefficient)
C_O value equivalent to design seismic force.
Assuming JMA6+ (equivalent to MSK9),
C_O shall be 1.0 anywhere in Japan.

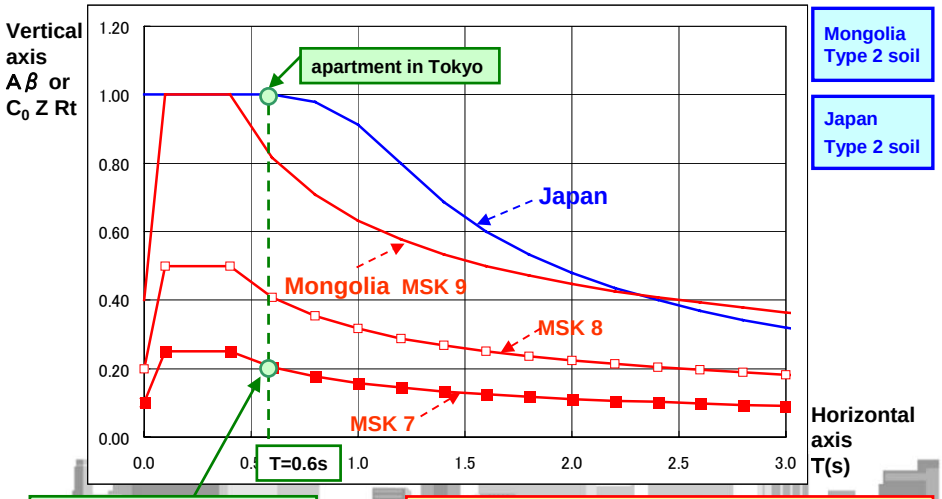
Z (seismic regional coefficient)
Depending on the region, the coefficient ranges from 0.7 to 1.0, but the majority throughout Japan is Z=1.0.

Rt (Vibration property coefficient)
A value equivalent to seismic response spectrum.
There are three spectra depending on the type of soil.

9-story RC building C_OZRt=1.0

1.1 Comparison for Seismic Force Coefficient

CBm=Ki Kψ A β (Σ η ik Qi/ Σ Qi) CBj = Ds Fes C_0 Z Rt Ai



JMA6+ is assumed throughout Japan
MSK7-9 is assumed in Mongolia, having a great gap.

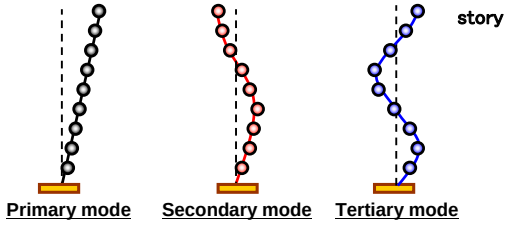
1.2 Comparison for Modal Analysis Coefficient

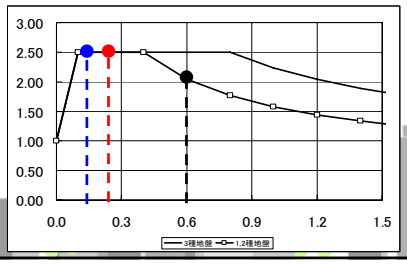
■ When a 9-story building (height = 30 m, natural period T = 0.6s) apartment structured with reinforced concrete is to be designed in Ulan Bator

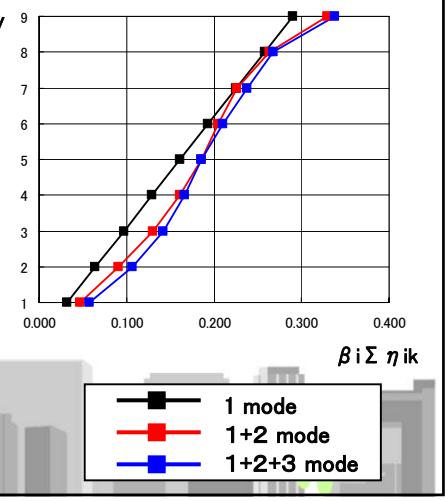
$C_{Bm} = Ki\ K\psi\ A\ \beta\ (\Sigma\ \eta ik\ Qi/\Sigma\ Qi)$

Coefficient against seismic force in Mongolia

$\beta_i \Sigma\ \eta_{ik} = \sqrt{(\beta_1 \eta_{i1})^2 + (\beta_2 \eta_{i2})^2 + (\beta_3 \eta_{i3})^2 + \cdots}$







1.3 Comparison for Building Coefficient

Base shear coefficient in Mongolia

$C_{Bm} = \Sigma\ Sik/\Sigma\ Qk = Ki\ K\psi\ A\ \beta\ (\Sigma\ \eta ik\ Qi/\Sigma\ Qi)$

Building coefficient (Damage, configuration)

Base shear coefficient in Japan

$C_{Bj} = Ds\ Fes\ Z\ C_0\ Rt\ Ai$

Comparison for building coefficient

Building coefficient (Structural type, configuration)

1.3 Comparison for Building Coefficient

■ When a 9-story building (height = 30 m, natural period T = 0.6s) apartment structured with reinforced concrete is to be designed in Ulan Bator

$C_{Bm} = Ki\ K\psi\ A\ \beta\ (\Sigma\ \eta ik\ Qi / \Sigma\ Qi)$

Building coefficient in Mongolia

建築の種類	Kiの値
1. 構造に破壊と傷、つまり、塑性変形をしてはいけない建築物	1
2. 構造に破壊と傷と変形が起こるが破壊により使用に問題がないような設備と人々の安全を保護できるように建物を下記の構造で作る	
■ プレキャストコンクリート(パネル造)	0. 22
■ 鉛直方向に接続、耐震壁のない鉄骨造	0. 25
■ 鉛直方向に接続、耐震壁のある鉄骨造	0. 22
■ 鉛直方向に接続、耐震壁のないRC造	0. 35
■ 鉛直方向に接続、耐震壁のあるRC造	0. 25
■ 石とレンガ造の壁	0. 35
3. 構造に亀裂や変形が起こると部材の破壊、傷のせん断のため短期間、使用禁止して人々の安全を保護出来る建築物	0. 12

建築特別仕様	Kψの値
1. 高層建物(塔、煙突、エレベーターシャフト)ピロティー構造の1階と1階以上の層との弾性比率が0. 25と等しいか小さい場合	1. 5
2. 壁を作る材料が構造を変形させないような建物	1. 3
3. 加水分解技術建物以外で1・2に示されていない建物	1. 0

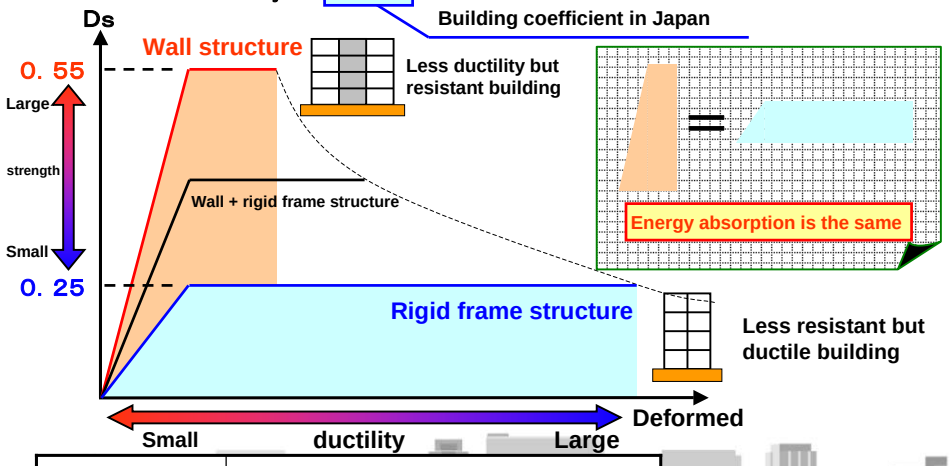
Ki x Kψ = 0.35 x 1.0 = 0.35

1.3 Comparison for Building Coefficient

■ When a rigid frame structured reinforced concrete building is to be designed in Tokyo

$C_{Bj} = Ds\ Fes\ Z\ C_0\ Rt\ Ai$

Building coefficient in Japan



Ds value	Ductile building – Resistant building
Reinforced concrete structure	0. 30 – 0. 55
Steel structure	0. 25 – 0. 50

Ds=0.3

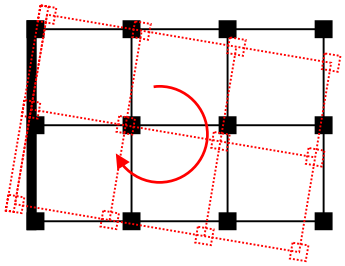
1.3 Comparison for Building Coefficient

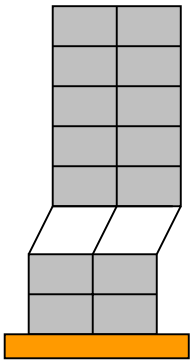
■ When a rigid frame structured reinforced concrete building is to be designed in Tokyo

C_{Bj} = Ds Fes Z C_0 Rt Ai

Building coefficient in Japan

Fes=Fe × Fs





Fe=1.0～1.5
Torsion correction coefficient

Fs=1.0～2.0
Rigid modulus correction coefficient

In principle, design to have less biased rigidness and torsion

Fes=1.0

1.3 Comparison for Building Coefficient

Mongolia

C_{Bm} = Ki Kψ A β (Σ η ik Qi/ Σ Qi)

Ki (building damage coefficient)
- Specially important building 1.0
- RC building 0.25 – 0.35
- Steel structure 0.22 – 0.25

K Ψ (building configuration coefficient)
- Configuration correction coefficient 1.0 – 1.5

9-story RC building Ki Kψ =0.35

0.22 – 0.35 for an ordinary building
Depending on the importance this varies about 4 times

Japan

C_{Bj} = Ds Fes C_0 Z Rt Ai

Ds (structural property coefficient)
- RC building 0.30 – 0.55
- Steel structure 0.25 – 0.50

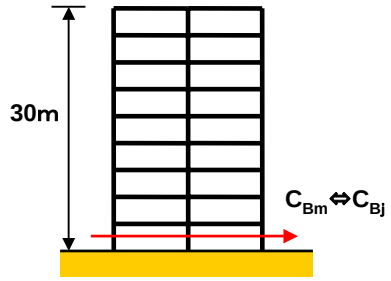
Fes (configuration property coefficient = Fe x Fs
- Torsion correction coefficient Fe=1.0 – 1.5
- Rigid modulus correction coefficient Fs=1.0 – 2.0

9-story RC building DsFes=0.30

0.25 – 0.55 for an ordinary building
Less resistant but ductile building is small
Resistant but less ductile building is large

2. Summary

■ When a 9-story building (height = 30 m, natural period T = 0.6s) apartment structured with reinforced concrete is to be designed in ・・・



in Ulan Bator

CBm = Ki Kψ A β (Σ η ik Qi/ Σ Qi)
= 0.35 x 1.0 x 0.1 x 2.04 x 0.93 = 0.0664

in Tokyo

CBj = Ds Fes C_0 Z Rt Ai
= 0.3 x 1.0 x 1.0 x 1.0 x 1.0 x 1.0 = 0. 3

About 4 times difference

2. Summary

■ Comparison of Japan with Mongolia for Design Seismic Force Formula

Mongolia C_{Bm} = Σ Sik/ Σ Qk = Ki Kψ A β (Σ η ik Qi/ Σ Qi)

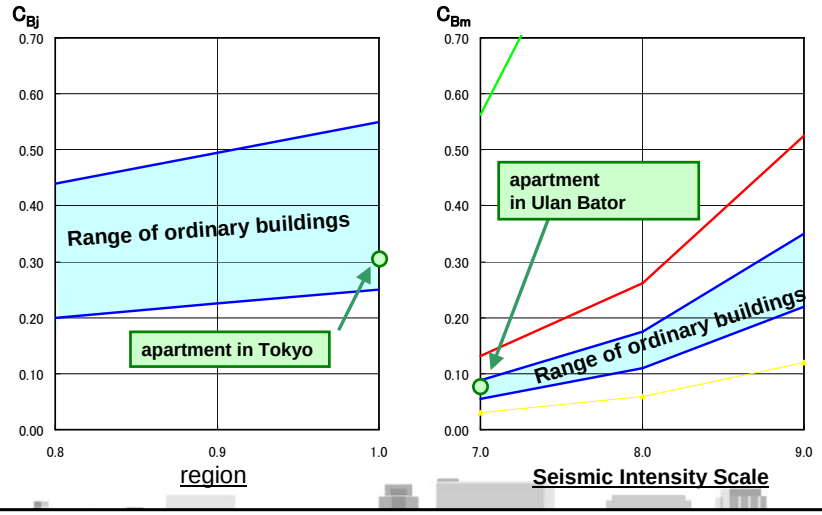
Japan C_{Bj} = Ds Fes Z C_0 Rt Ai

1. Seismic force coefficient –Aβ and C_0 Z Rt
   - JMA intensity 6+ (equivalent to MSK9) is assumed throughout Japan
   - MSK7 to MSK9 is assumed depending on the region in Mongolia with a difference of about 1/4 times in seismic force.

2. Building coefficient –Ki KΨ and Ds Fes
   - 0.25 – 0.55 for an ordinary building in Japan (change in resistance and ductile)
   - 0.22 – 0.35 for an ordinary building in Mongolia
   - About 3-fold safety rate is taken at most depending on the configuration in Japan.
   - About 6-fold safety rate is taken at most depending on the importance and configuration in Mongolia.

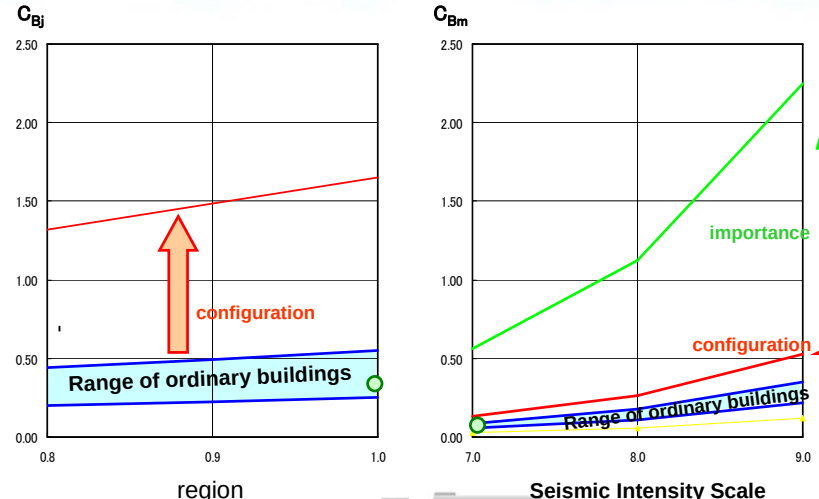
3. Modal analysis coefficient – (Σ η ik Qi/ Σ Qi) and Ai
   - The concept in Japan and in Mongolia is almost the same

2. Summary



■ Ordinary building
- The earthquake resistant performance in Mongolia is smaller than that of Japan.
- Depending on the region, MSK7 to MSK9 is assumed with a difference in seismic force of about 1/4 times.

2. Summary



■ Important building and peculiar building in configuration
- About 3-fold safety rate is taken at most depending on the configuration in Japan.
- About 6-fold safety rate is taken at most depending on the importance and configuration in Mongolia.