INTRODUCTION TO SEISMIC DESIGN IN ACCORDANCE WITH MS EN 1998

28 OGOS 2020

Presented by :

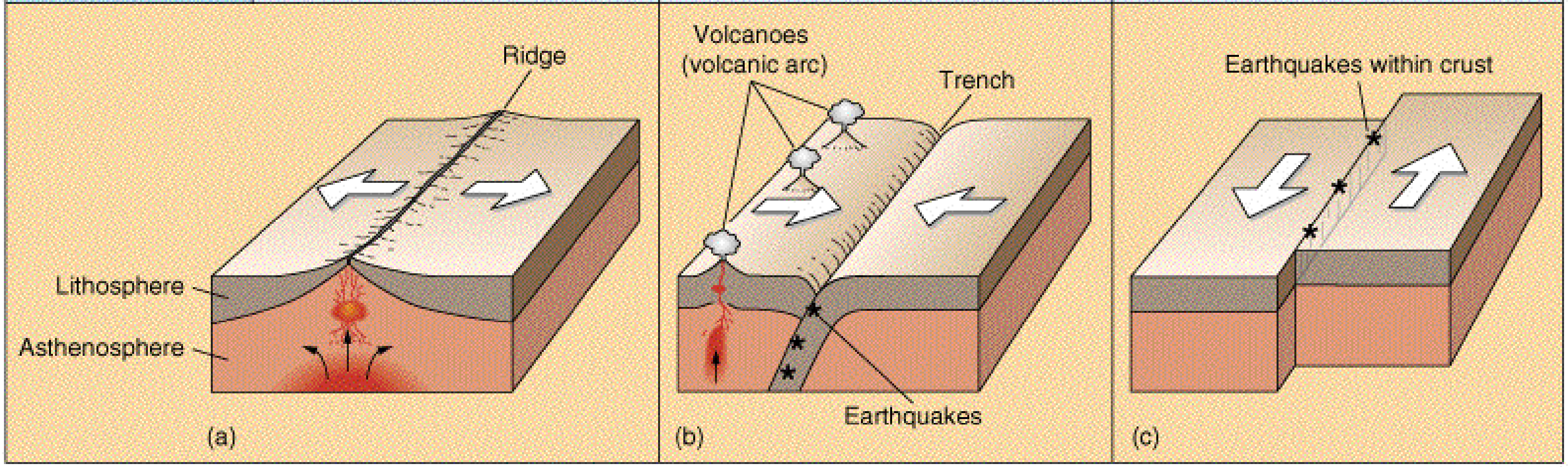
Ir. LEE CHOON SIANG
Jurutera Awam Penguasa
Cawangan Kejuruteraan Awam dan Struktur
Tingkat 1u, Block G
Ibu Pejabat JKR, Jalan Sultan Salahuddin, 50480 Kuala Lumpur.

Email: cslee.jkr@1govuc.gov.my

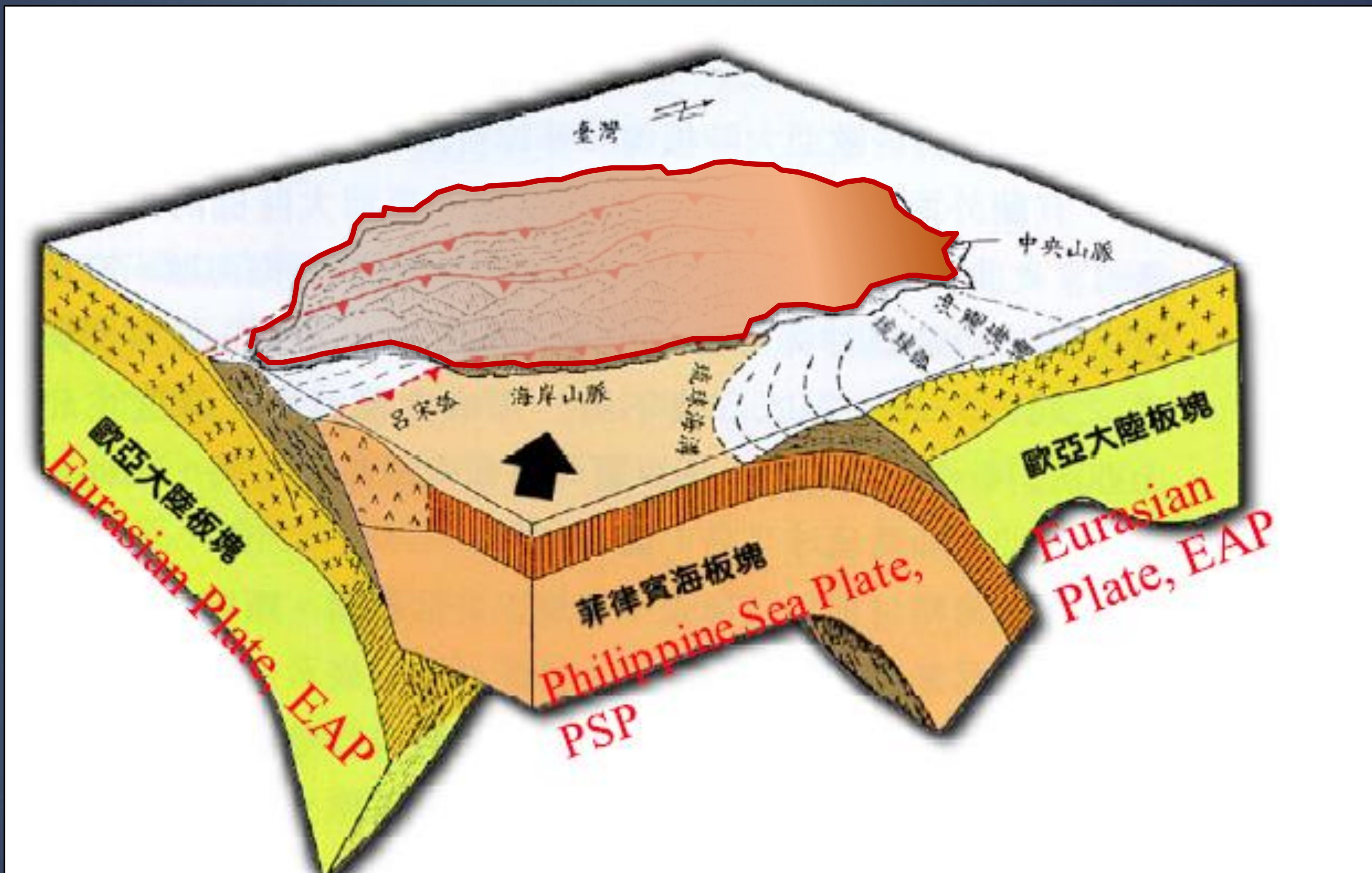
Civil Works & Structural Engineering Branch
Jabatan Kerja Raya Malaysia, Kuala Lumpur

Plate Boundaries

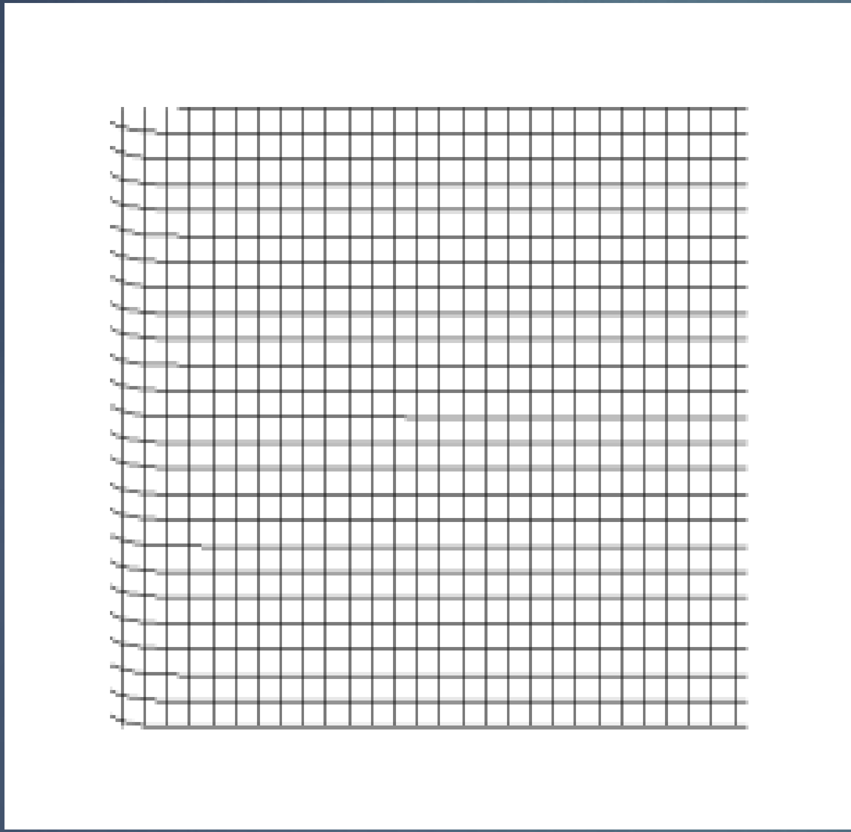
Type of Margin	Divergent	Convergent	Transform
Motion	Spreading	Subduction	Lateral sliding
Effect	Constructive (oceanic lithosphere created)	Destructive (oceanic lithosphere destroyed)	Conservative (lithosphere neither created or destroyed)
Topography	Ridge/Rift	Trench	No major effect
Volcanic activity?	Yes	Yes	No



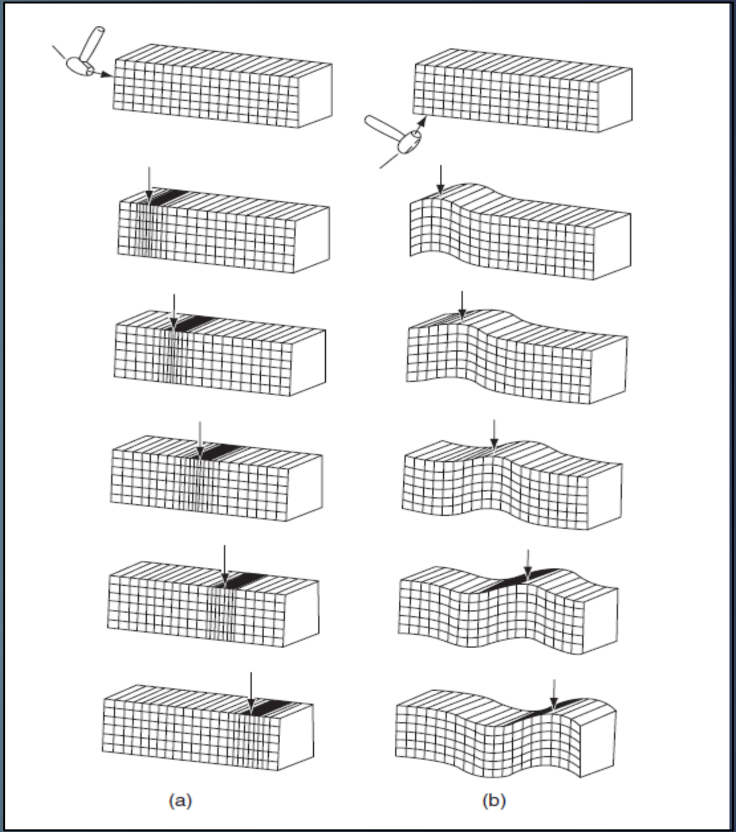
Taiwan Plate Boundaries



Surface Body Waves



S- Wave in action



Questions

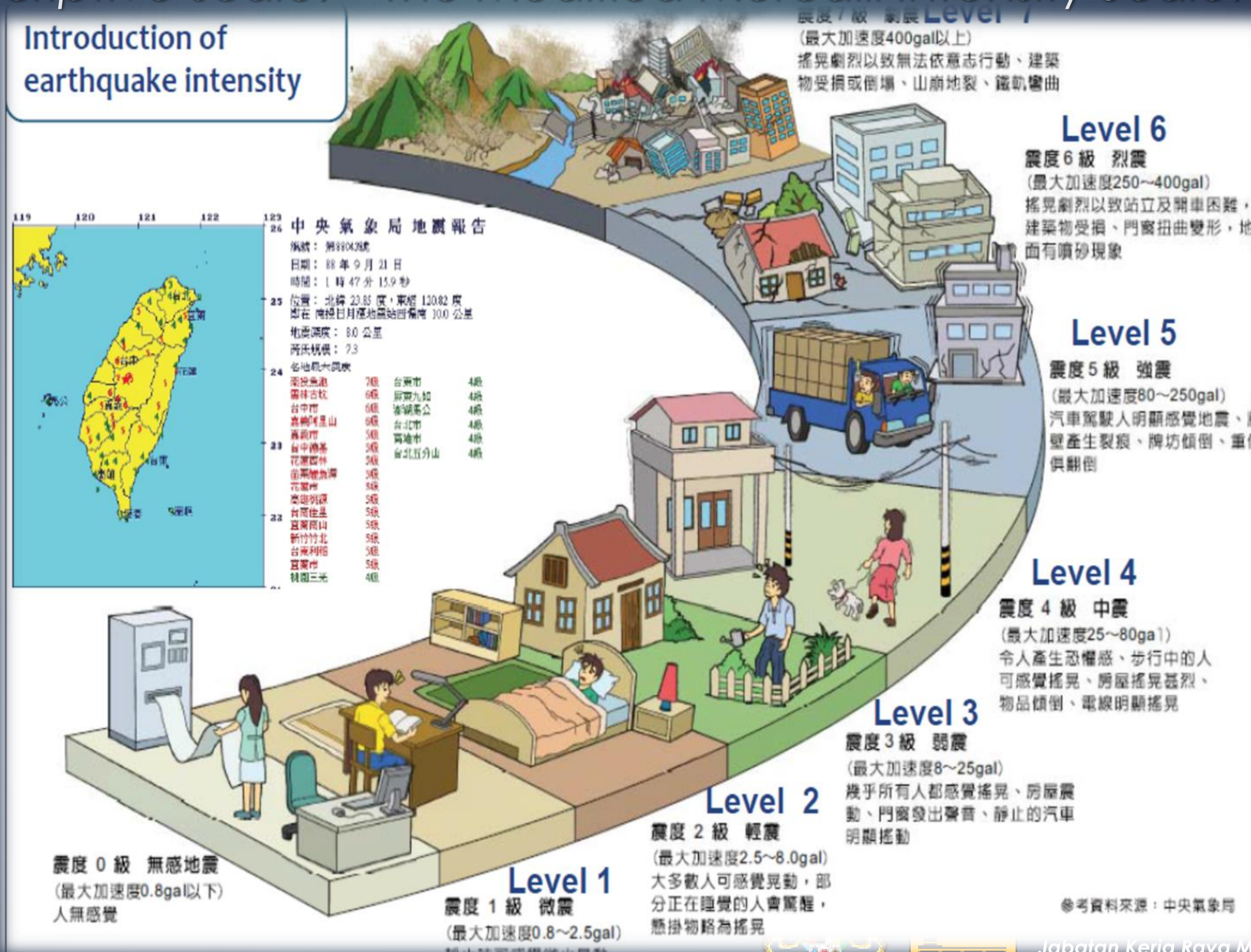
How do we measure earthquake?

By Richter scale?

What is the engineering measurement units for earthquake?

Intensity:

The severity of earthquake shaking is assessed using a *descriptive* scale. – The Modified Mercalli Intensity Scale.



Unit Measurements:

Earthquake size is a quantitative measure of the size of the earthquake at its source.-The Richter Magnitude Scale.

Richter Sacle	Acceleration (g)	Velocity (cm/s)	Perceived shaking	Potential damage
I	< 0.0017	< 0.1	Not felt	None
II–III	0.0017 – 0.014	0.1 – 1.1	Weak	None
IV	0.014 – 0.039	1.1 – 3.4	Light	None
V	0.039 – 0.092	3.4 – 8.1	Moderate	Very light
VI	0.092 – 0.18	8.1 – 16	Strong	Light
VII	0.18 – 0.34	16 – 31	Very strong	Moderate
VIII	0.34 – 0.65	31 – 60	Severe	Moderate to heavy
IX	0.65 – 1.24	60 – 116	Violent	Heavy
X+	> 1.24	> 116	Extreme	Very heavy

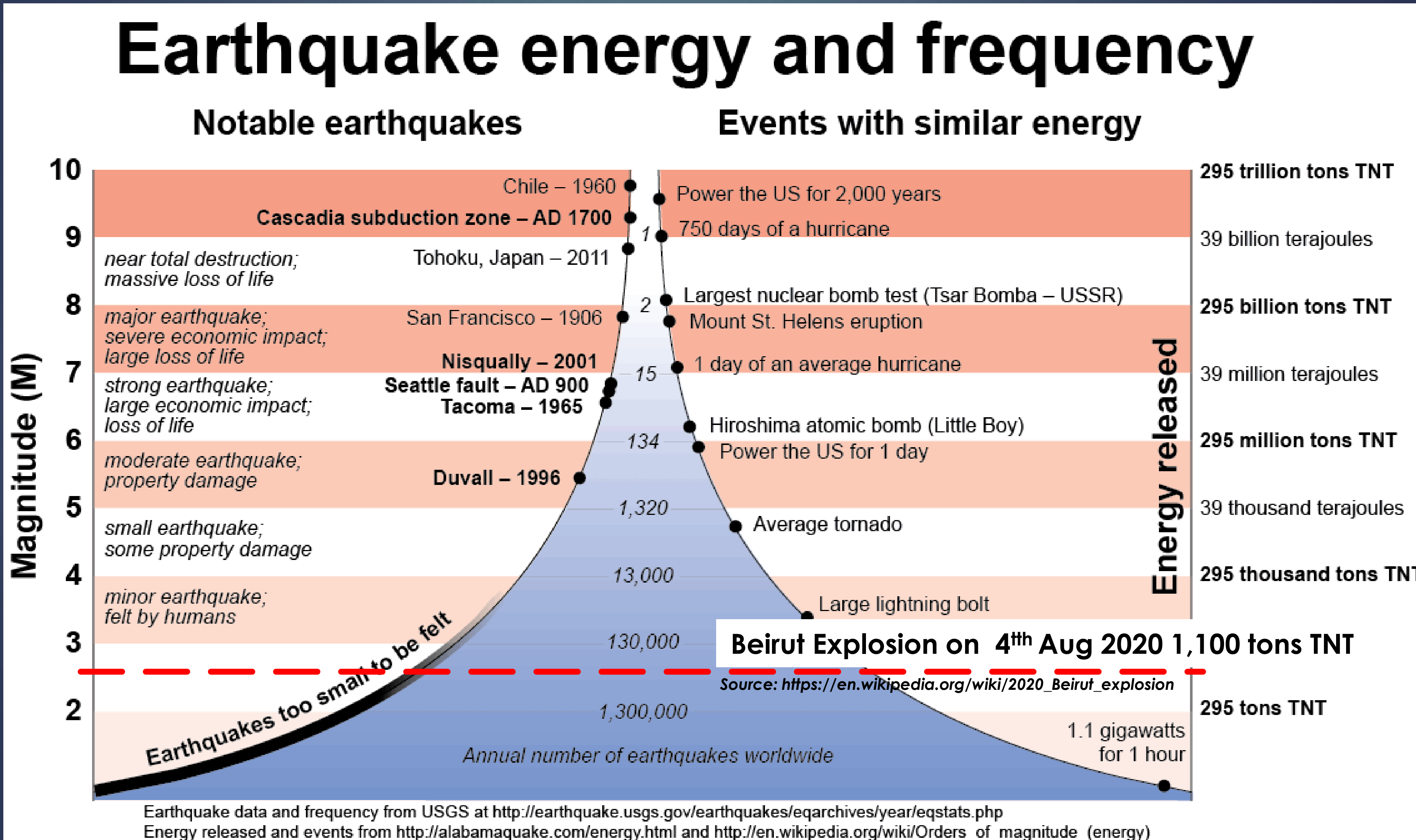
Peak Ground Acceleration(PGA)

- Peak ground acceleration (PGA) is the maximum ground acceleration that occurred during earthquake shaking at a location.

• Peak ground acceleration (PGA)	Richter and moment magnitude scales
Measures how hard the earth shakes at a given geographic point.	Ritcher scale measures Intensity (Amount of Energy Releases)
PGA is measured by instruments, such as accelerographs. can be correlated to macroseismic intensities on the Mercalli scale but these correlations are associated with large uncertainty.	The Mercalli intensity scale based on personal reports and observations to measure earthquake intensity
Measured in unit of m/s^2, g_o or gal	Unitless

Base value	(Gal, or cm/s^2)	(ft/s^2)	(m/s^2)	(Standard gravity, g_0)
1 Gal, or cm/s^2	1	0.0328084	0.01	0.00101972

Earthquake Energy:



Probability of Exceedance

ASCE Specification

Performance level	Description	Mean return period (years)	Annual probability of exceedance (%)
Operational	Frequent	25	4.0% in 50 years
Immediate occupancy	Occasional	72	1.4% in 50 years
Life-safety	Rare	250–800	0.12–0.4% in 50 years
Collapse prevention	Maximum Considered (MCE)	800–2500	0.04–0.12% in 50 years

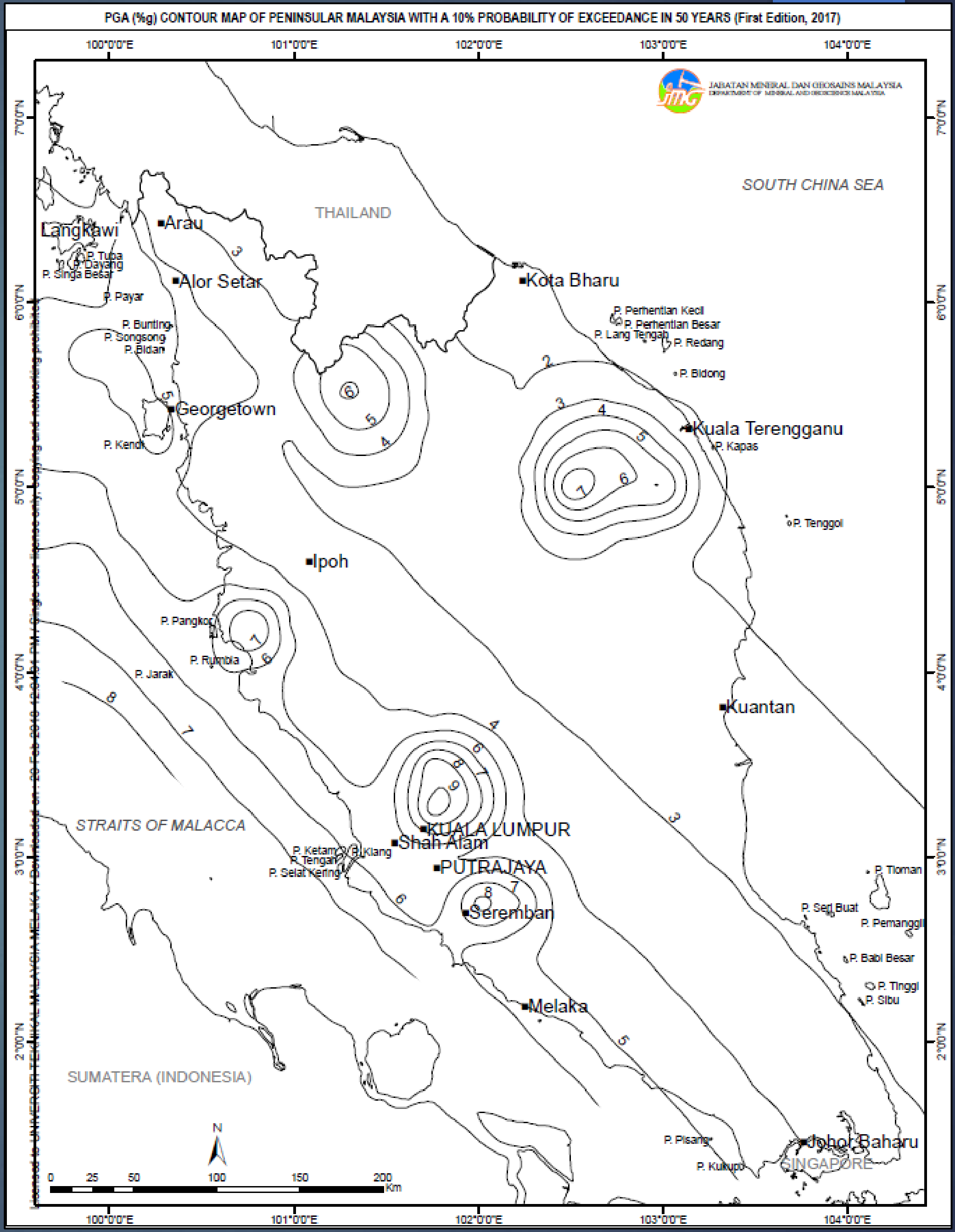
EN 1998-1

Performance Requirements	Description	Mean return period (years)	Annual probability of exceedance (%)
No-collapse	Rare	475	10% in 50 years
Damage limitation	Occasional	95	10 %in 10 years

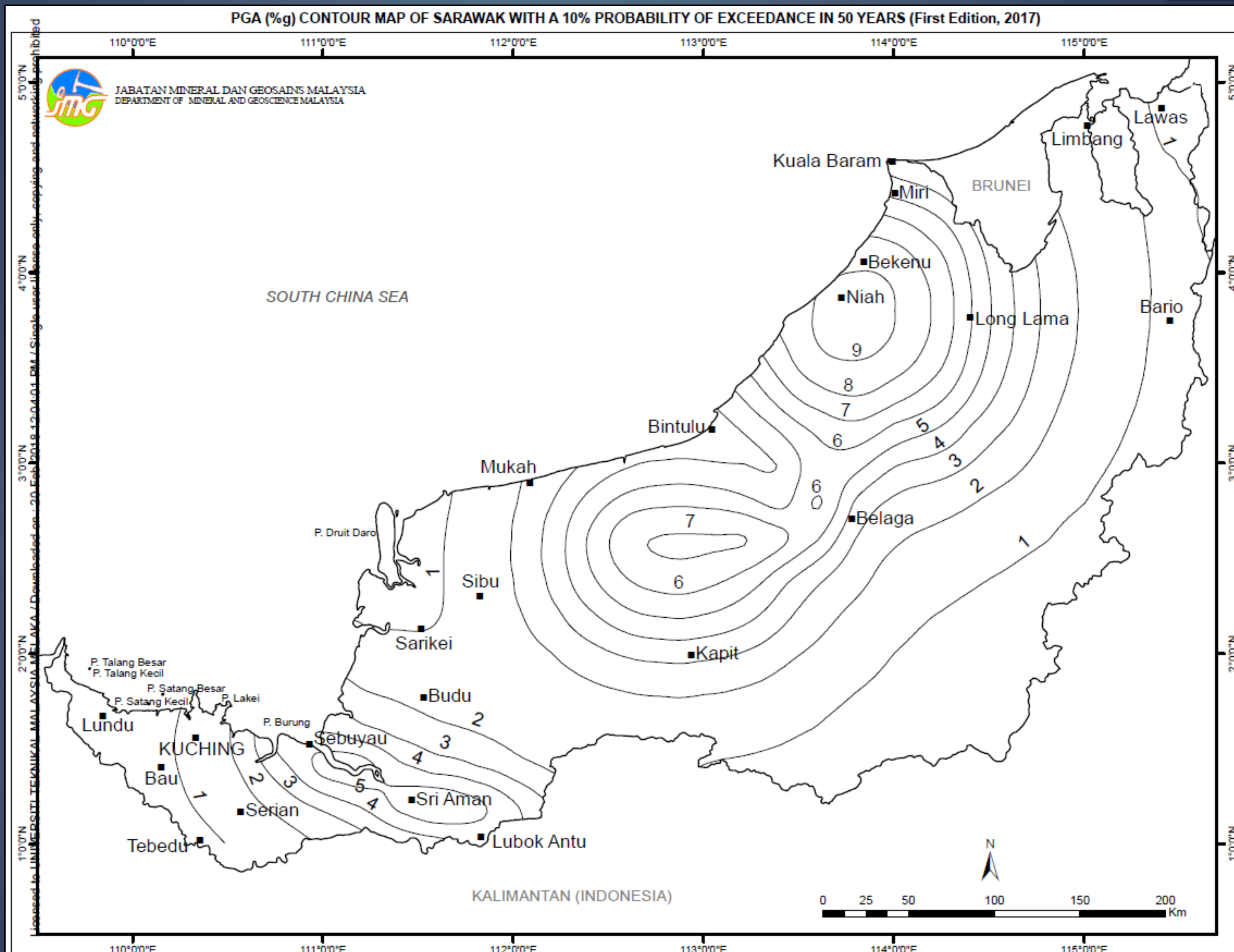
NA MS EN 1998-1

Performance Requirements	Description	Mean return period (years)	Annual probability of exceedance (%)
No-collapse	Rare	475	10% in 50 years
Damage limitation	Occasional	95	10% in 10 years

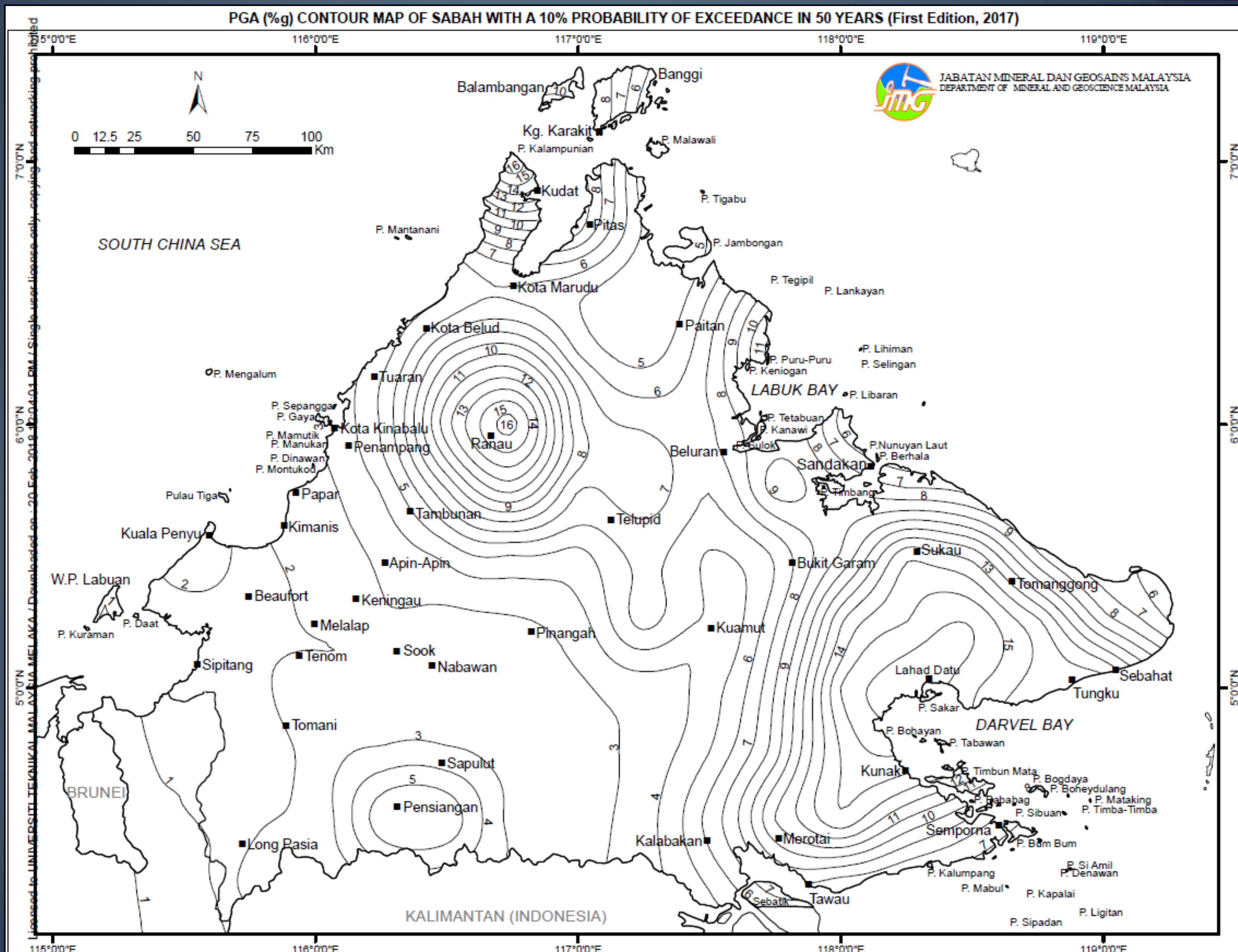
PGA Contour Map of Peninsular Malaysia With A 10% Probability of Exceedance in 50 Years



PGA Contour Map of Sarawak With A 10% Probability of Exceedance in 50 Years



PGA Contour Map of Sabah With A 10% Probability of Exceedance in 50 Years



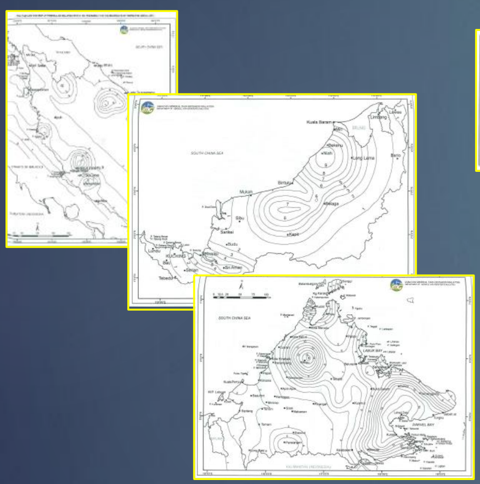
Seismic Load & Design Approach

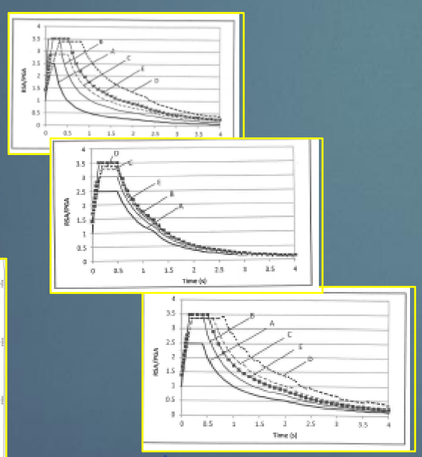
Seismic Load

Recorded Ground motion

Macrozonation Map

Response Spectrum





Analysis, Design & Assessment

Analysis, Design & Assessment

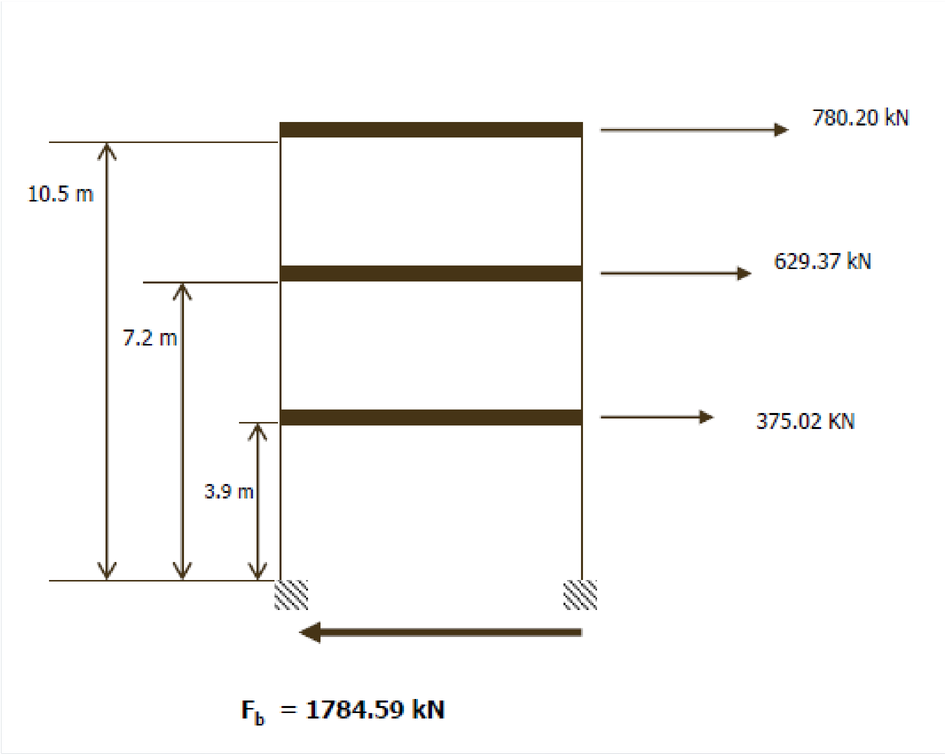
- Static Analysis
  - Equivalent Static (Lateral Force Method)
  - Non-Linear Analysis (Push Over)
- Dynamic Analysis
  - Modal & Response Spectral
  - Incremental Dynamic with Time History

Methods of Analysis

1) Lateral Force Method of Analysis (Equivalent Static)
2) Modal Response Spectrum Analysis
3) Non-Linear (Push Over Analysis)
4) Time History Analysis

Equivalent Static (Lateral Force Method)

1. Acquire Design Ground acceleration from Macrozonation map according to performance requirements (return period)
2. Determine importance Factor, γ_I according to the importance class
3. Determine Ground Type for Soil Investigation
4. Specify building type and height
5. Calculate the fundamental period of vibration, T_1
6. Calculate the seismic base shear F_b
7. Distribution of the horizontal Seismic Force
8. Modelling and analysis

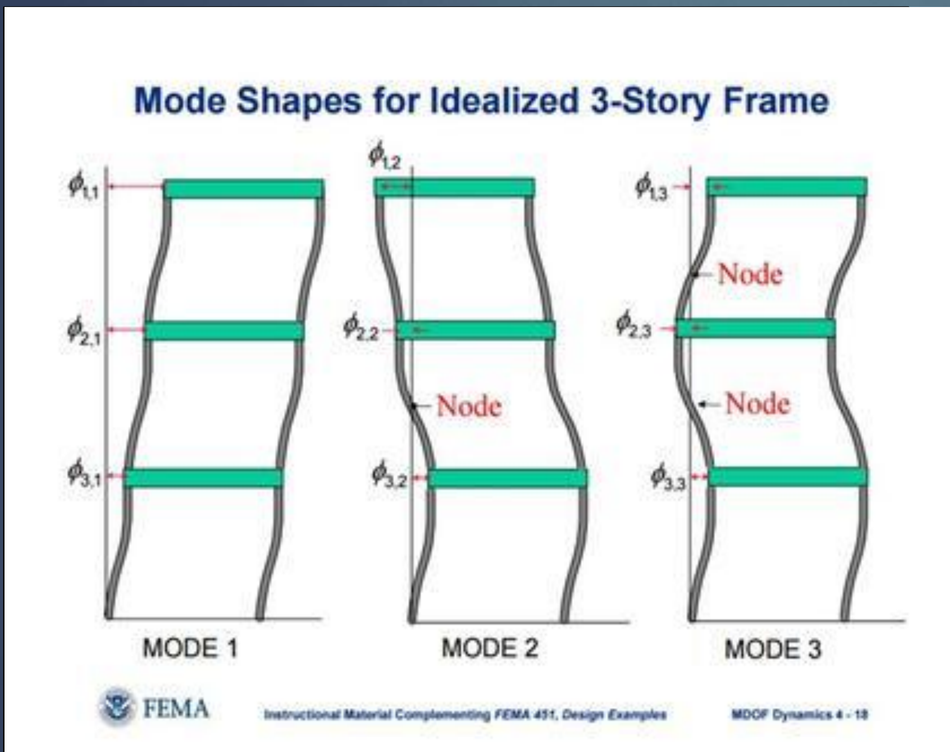


Modal & Response Spectral Analysis

Steps

1. Develop Acceleration Response Spectrum diagram according to MS EN 1998-1
2. Check minimum mass Participation factor>90%
3. Check Base Shear

Acceleration Response Spectrum

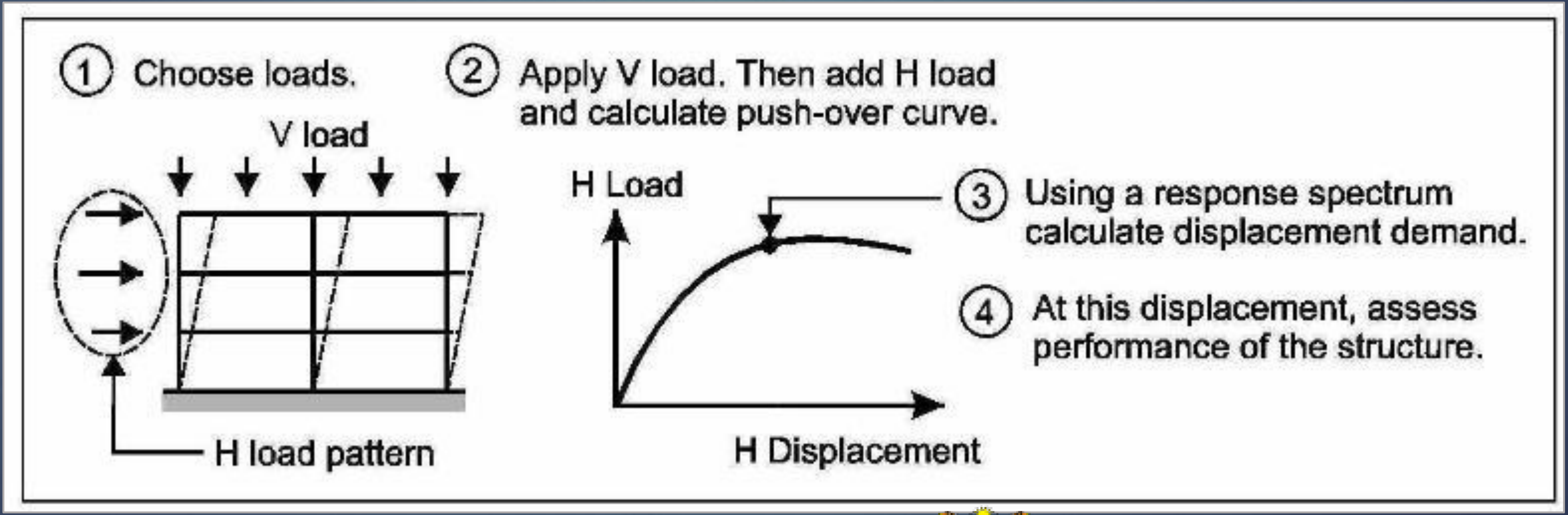


Mass Participation

MODE	MASS PART. -TRANSLATION (%)			SUMM-X	SUMM-Y	SUMM-Z	MASS PART. ROTATION (%)		
	X	Y	Z				X	Y	Z
1	0	0	81.58	0	0.003	81.577	0	0	0
2	0.22	0	0	0.224	0.003	81.577	0.64	0	0
3	81.48	0	0	81.708	0.003	81.577	232.46	0	0
4	0	0.08	9.48	81.708	0.085	91.06	0	0	0
5	0	0.04	0	81.708	0.121	91.062	0	0	0
6	0	2.53	0.01	81.708	2.65	91.067	0	0	0
7	0	6.21	0.02	81.708	8.858	91.084	0	0	0
8	0	4.85	0	81.708	13.708	91.085	0	0	0
9	0.04	0	0	81.746	13.708	91.085	0.11	0	0
10	0.02	0	0	81.765	13.708	91.085	0.05	0	0
11	9.43	0	0	91.19	13.708	91.085	26.77	0	0
12	0	0	0	91.191	13.708	91.085	0	0	0
13	0.03	0	0	91.216	13.708	91.085	0.07	0	0
14	0.01	0	0	91.221	13.708	91.085	0.01	0	0
15	0	1.9	0.01	91.221	15.604	91.097	0	0	0

Push-Over Analysis

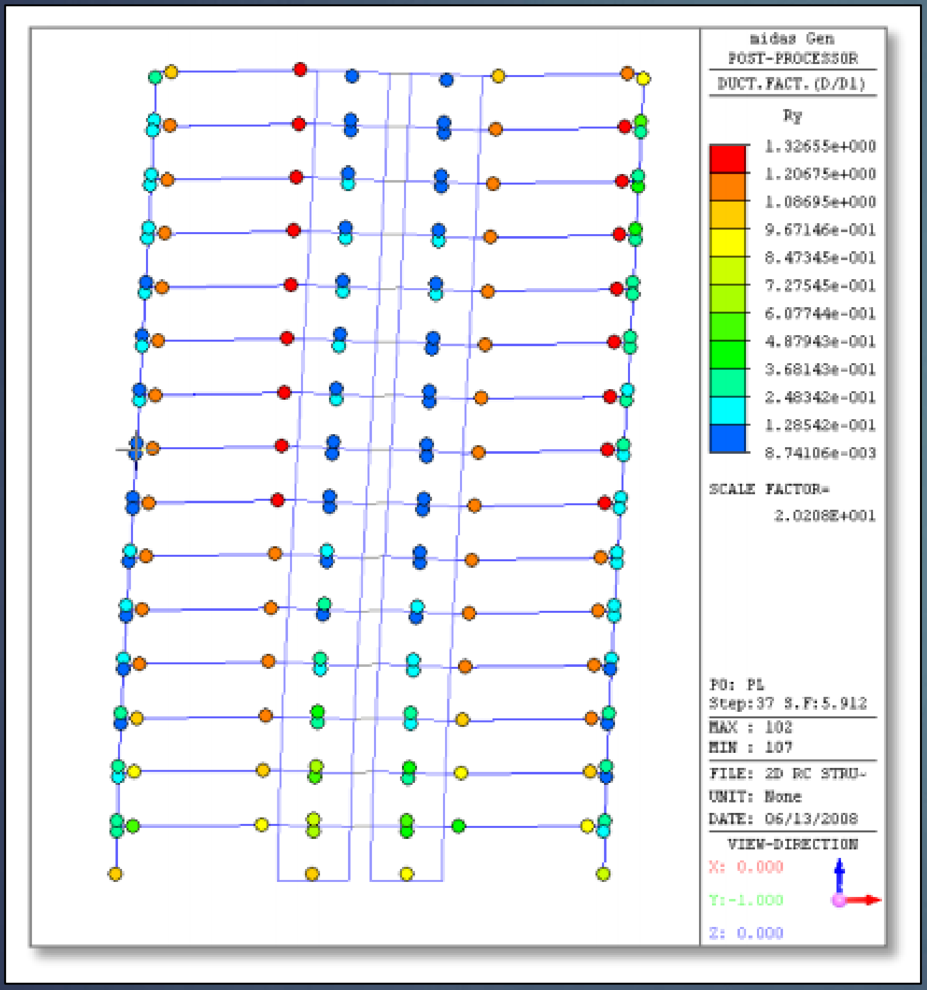
- Simplified nonlinear analysis methods, referred to as Nonlinear Static Analysis Procedures which includes the capacity spectrum method that uses the intersection of the capacity (pushover) curve and a reduced response spectrum to estimate maximum displacement.

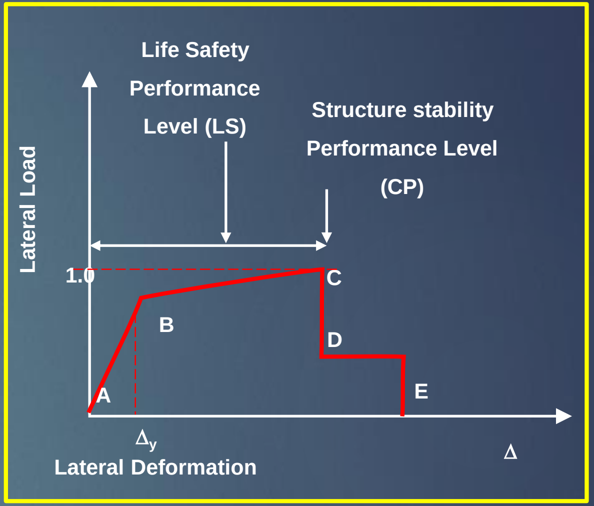


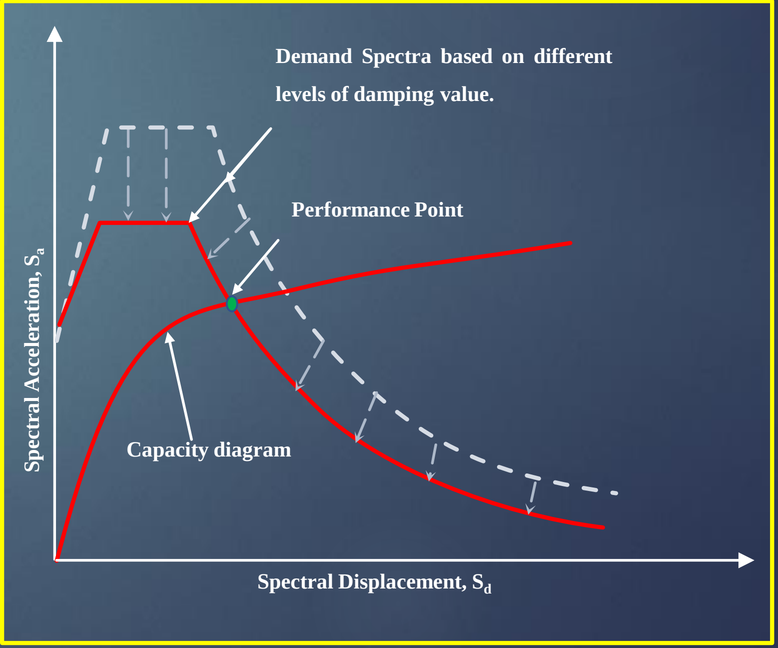
Non Linear Push-Over Analysis

- To obtain the maximum shear strength of the structure, and the collapse mechanism
- To evaluate the structure's collapse mechanism without exhausting the plastic rotation capacity of the members
- To obtain the monotonic displacement and global ductility capacity of the structure
- To estimate the concentration of damage and IDI (Inter-storey Drift Index) that can be expected during the non-linear seismic response.

Non Linear Component

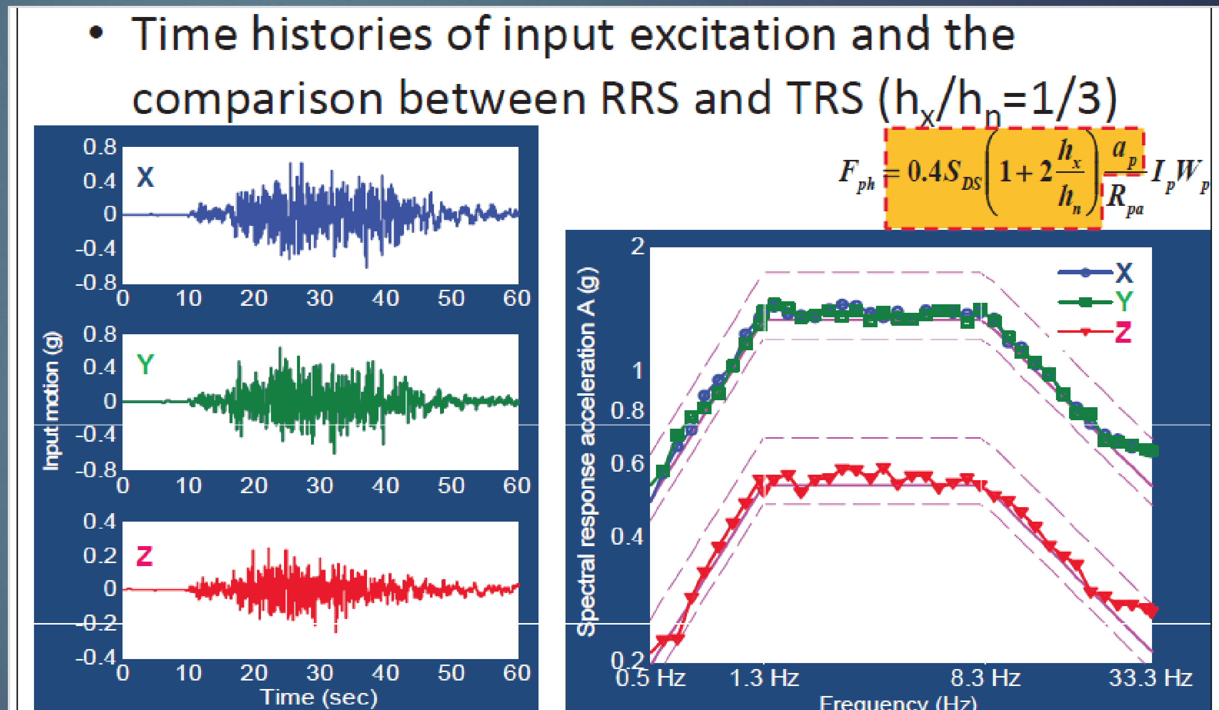






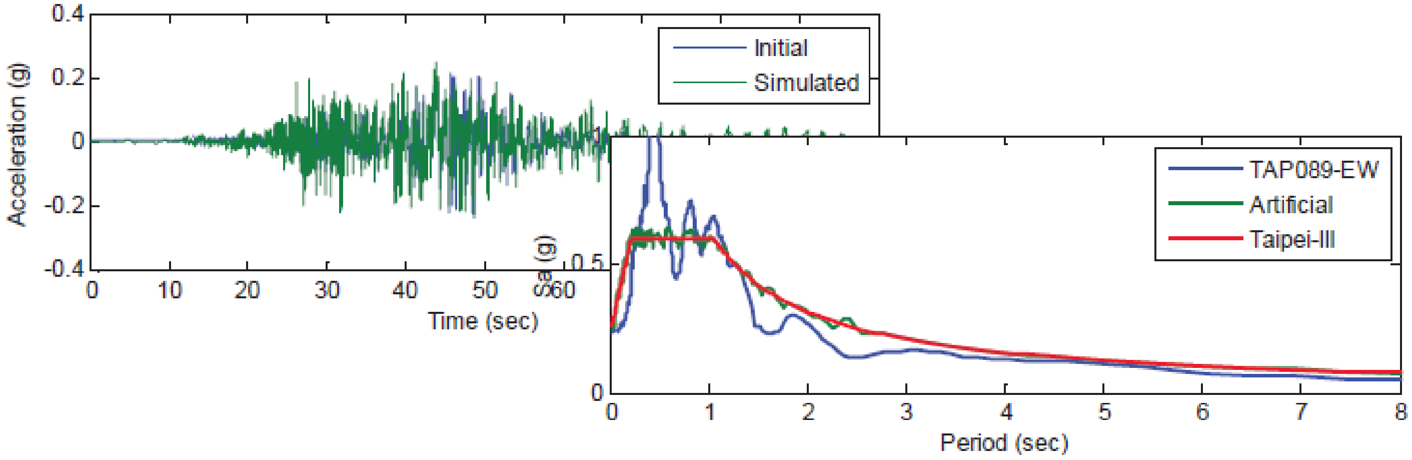
Time History Analysis

- Time history analysis is used to determine the seismic response of a structure under dynamic loading of representative earthquake.



Response History Procedure

- Not fewer than three simulated ground motions
- Selected from recorded events near site consistent with design basis (or maximum considered) earthquake
- If at least seven simulated ground motions, average value is used for design
- If fewer than seven simulated ground motions, maximum value is used for design



Fundamental Period Of Vibration

MS EN 1998-1

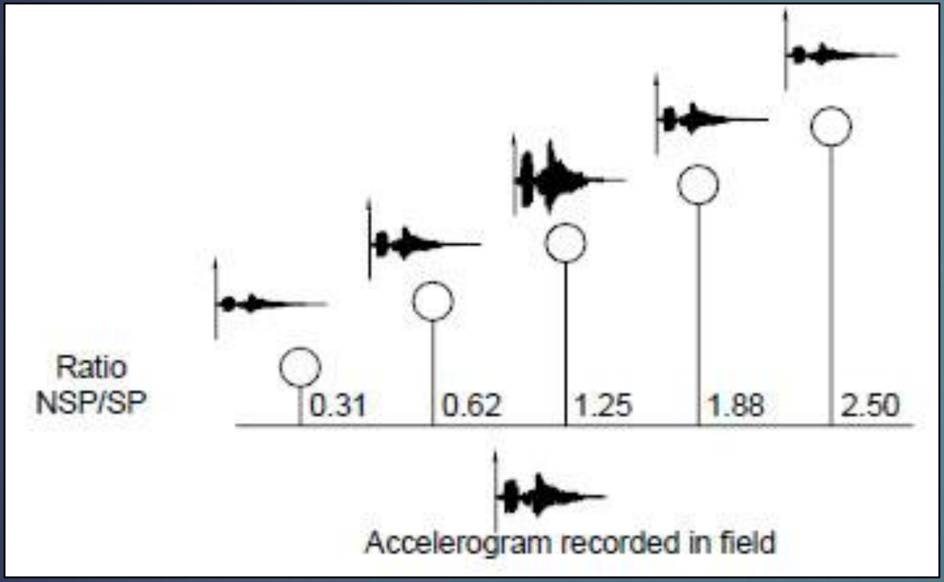
$$T_1 = C_t \cdot H^{3/4} \tag{4.6}$$

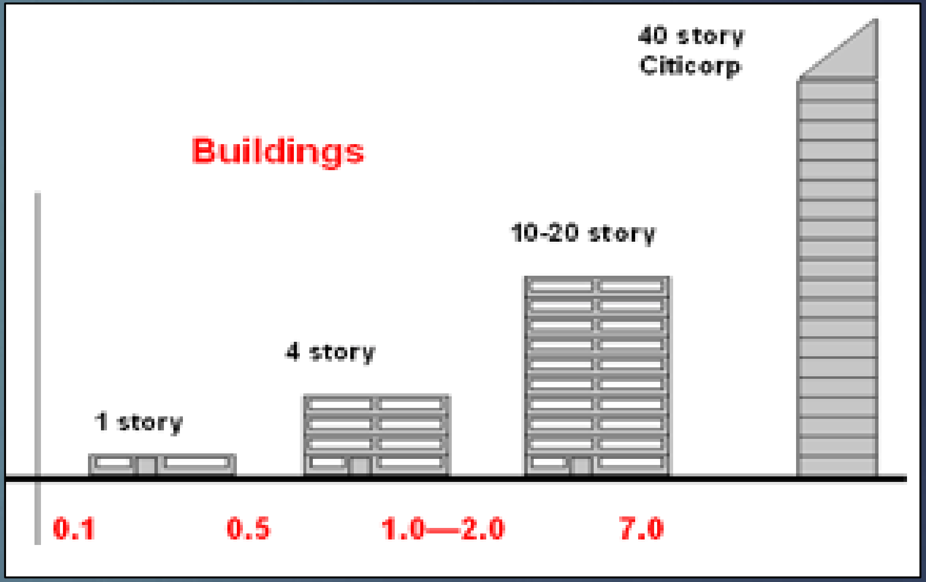
where

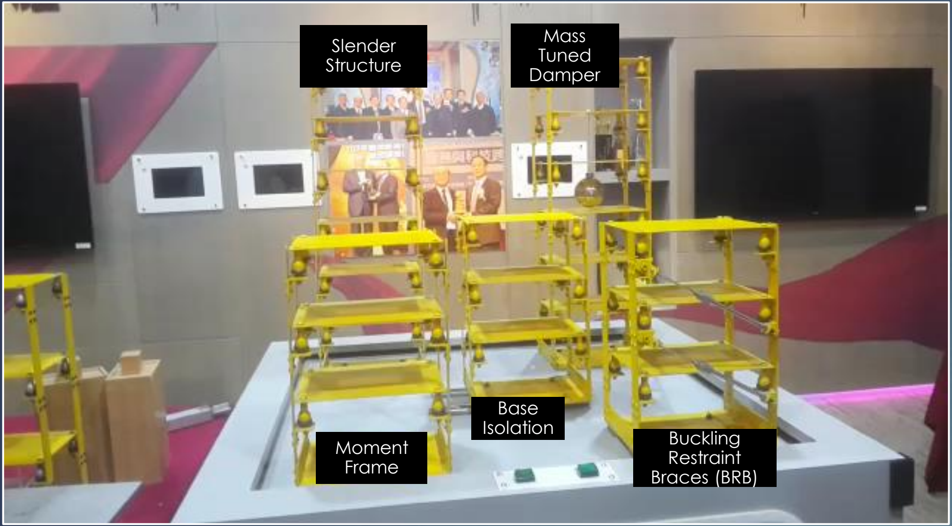
C_t is 0,085 for moment resistant space steel frames, 0,075 for moment resistant space concrete frames and for eccentrically braced steel frames and 0,050 for all other structures;

H is the height of the building, in m, from the foundation or from the top of a rigid basement.

Buildings Fundamental Period vs Height







Buildings Response Under High Frequency Of Vibration

Buildings Response Under Low Frequency Of Vibration