

SOSIALISASI LEBIH DALAM ISI SNI 1726  
**GeoTalk XIX 22**  
Zoom Webinar, 11-12 Juli 2022

## PERKEMBANGAN PETA GEMPA DAN PENERAPANNYA DALAM PERENCANAAN INFRASTRUKTUR DAN GEDUNG TAHAN GEMPA INDONESIA

Prof. Dr. Ir. Masyhur Irsyam\* dkk

- \*Ketua – Tim Pemutakhiran Peta Gempa Indonesia 2010 dan 2017
- \*Koordinator – Tim Struktur Bawah Revisi SNI 1726:2019
- \*Ketua Umum – Himpunan Ahli Teknik Tanah Indonesia (2011-2019)
- \*Koordinator – Akademi Ilmu Pengetahuan Indonesia AIPI

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## Cakupan Materi Bahasan:

1. Penyusunan Peta Sumber dan Bahaya Gempa Nasional Indonesia 2017
2. Aplikasi Peta Gempa dalam Perencanaan Infrastruktur Tahan Gempa Indonesia
3. Aplikasi Peta Gempa untuk Perencanaan Gedung dalam SNI 1726-2019

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### Percepatan Gempa: Parameter Penting untuk Perancangan Bangunan Tahan Gempa

Untuk perhitungan beban gempa,  
diperlukan parameter pergerakan tanah.  
Sesuai tingkat kesulitan dan akurasi:

Percepatan maksimum  
 $a_{\text{maximum}}$

Informasi kekuatan puncak

Respon spektra  
 $a_{\text{max}}$

Informasi tambahan frekuensi dan efek amplifikasi

Time histories percepatan

Informasi variasi besar beban gempa untuk setiap waktu

Parameter pergerakan tanah

3

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Response Spektra Percepatan

Gaya Gempa  
 $H = m \times a$

Motion at Building

Building characteristics  $\rightarrow T_{\text{structure}}$

Motion at Foundation

Soil Condition

Indonesian Hazard Maps

Motion at Bedrock

Earthquake source

Wave propagation from epicenter to bedrock surface

4

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### Seismic Hazard Analysis

Deterministic (DSHA)	Probabilistic (PSHA)
<ul style="list-style-type: none"> <li>- Analisis mudah difahami</li> <li>- Worst case scenario kondisi terjelek: <math>R_{min}</math> dan <math>M_{max}</math> dan nilainya 84% (mean+<math>\sigma</math>)</li> </ul>	<ul style="list-style-type: none"> <li>- Merupakan state-of-the-arts</li> <li>- Bukan hanya worst case scenario, tapi juga berbagai level dan kemungkinan dari seluruh area</li> <li>- Yang umum digunakan dalam perencanaan infrastruktur tahan gempa</li> </ul>

Saling melengkapi, cara terbaik dengan mengintegrasikan keduanya

DSHA mulai digunakan tahun 2010, umumnya digunakan untuk lokasi yang dekat sesar sebagai pembatas nilai PSHA

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### Total Probability Theorem

$$P_X(x) = \int_m f_M(m) \int_l f_{L,R}(l) \int_r P(X > x | m, r) f_{R|MLR}(r, m, l) dr dl dm$$

$f_M(m) = \frac{dP_M < m < M_{max}}{dm} \cdot m_{min} < m < M_{max}$

$P(X > x | M, R) = P(x^*)$

Fungsi distribusi kumulatif probabilitas jarak dalam 1 sumber di gambarkan sebagai probabilitas seragam

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### Team for Updating of Seismic Hazard Maps of Indonesia 2017

STEERING COMMITTEE

ADVISORY BOARD

TECHNICAL COMMITTEES  
Prof. Masyhur Irsyam  
Ir. Lutfi Faizal

GEOLOGY WORKING GROUP	GEODESY WORKING GROUP	SEISMOLOGY + INSTRUMENTATION WORKING GROUP	GMPE WORKING GROUP	CATALOG WORKING GROUP	SEISMIC HAZARD WORKING GROUP
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Dr. Benyamin Sapie Dr. Supartoyo Dr. Akhmad Solihin Dr. Mudrik Daryono Dr. Astyka Lumpuni Dr. Gayatri I. Marliyani Dr. Ma'ruf Mukti Subandriyo, M.Si	Prof. Hasnuddin Dr. Endra Gunawan Susilo, MT Dr. Daryono Arkadia R., MT Dr. N. Rahma Hanifa Dr. Dina A. Sarasito Awaluddin, MT Cecep Sulaeman, MSc Pandu A. Minarmo, ST	Prof. Nanang T Puspito Dr. Andri Dian Nugraha Dr. M. Ridwan Dr. Wahyu Triyoso Dr. Muzli Dr. Wandono Dr. Nurliah Sadikin H. Ash Shidiqji, M.Si Shindy Rosalia, ST Pepen Supendi	Dr. Wahyu Triyoso Dr. Winda Partono Prof. Wayan Sengara Sigit Pramono, M.Si Dr. Jaya Murjaya Prof. Wijoyo Prakoso Oriza Sativa, ST Fajri Spukur R., MT Fajar Budi Utomo, ST Requel Mikhail, MT	Dr. Andri Dian Nugraha Dr. M. Asrurifak Prof. Wayan Sengara Shindy Rosalia, ST Fahmi Aldimar, MT Pepen Supendi, MSI	Dr. M. Asrurifak Fahmi Aldimar, MT Amalfi Omang, M. Phil Desyanti, MT Dr. Hendriyawan Artadi Prita Sakti, M.Si Adhi Yudha Mulia, Meng Mahdi Ibrahim T., MT Imam Catur P, S.Si Rahayu Robiana, S.Si

Total members = 72 persons (from different institutions and technical background)

International Collaboration:  
GeoSciences&ANU-Australia, Global Earthquake Model-Italy, USGS-USA

Prof. Dr. Masyhur Irsyam (ITB-HATTI-PuSGeN)      Revisi SNI-1726:2018

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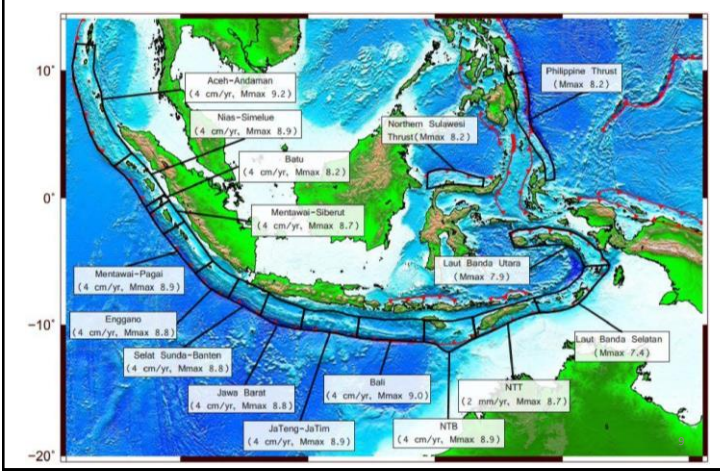
### Classification of Main Shocks Based on Type of Source

Shallow background  
Fault  
Background  
Subduksi Megathrust  
Benioff 1  
Benioff 2  
Benioff 3  
Benioff 4  
Subduksi Benioff  
Benioff Zone/ Deep BG

8

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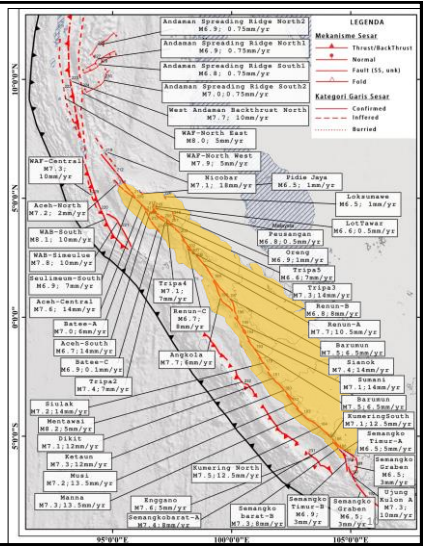
### Map of Earthquake Sources for Indonesia 2017 Subduction Megathrust



9

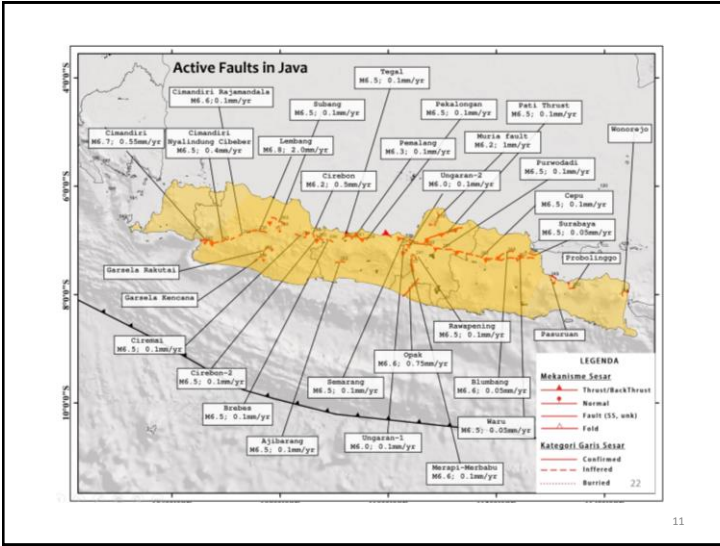
Penyempurnaan oleh Pakja Geologi dengan merevisi lokasi dari jalur sesar aktif yang sudah ditetapkan sebelumnya dan menambahkan banyak jalur-jalur sesar aktif yang belum diperhitungkan dalam peta 2010.

Hazard Maps 2010: 81 active fault lines  
Hazard Maps 2017: 295 active fault lines



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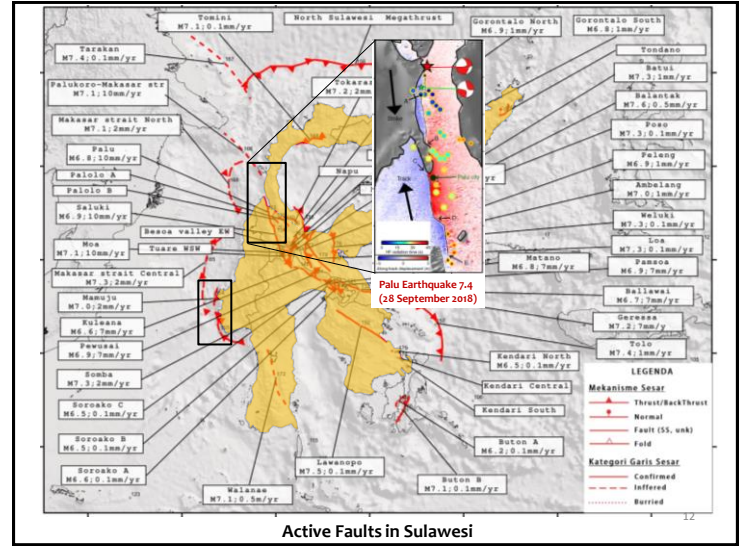
### Active Faults in Java



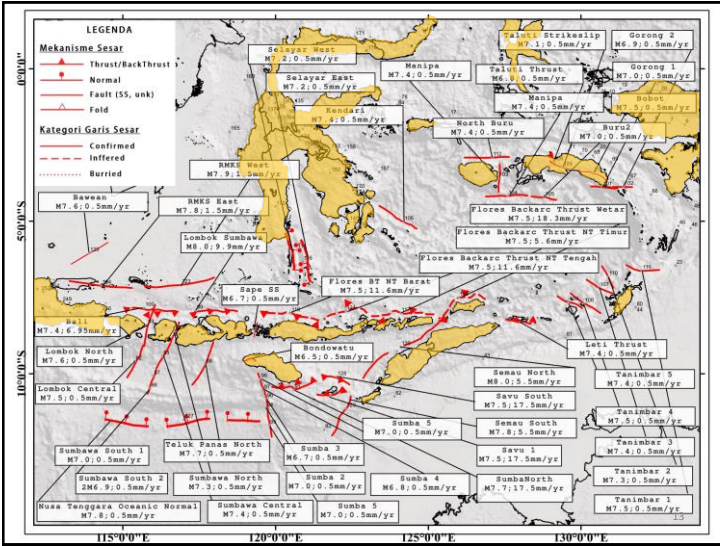
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Palu Earthquake 7.4  
(28 September 2018)

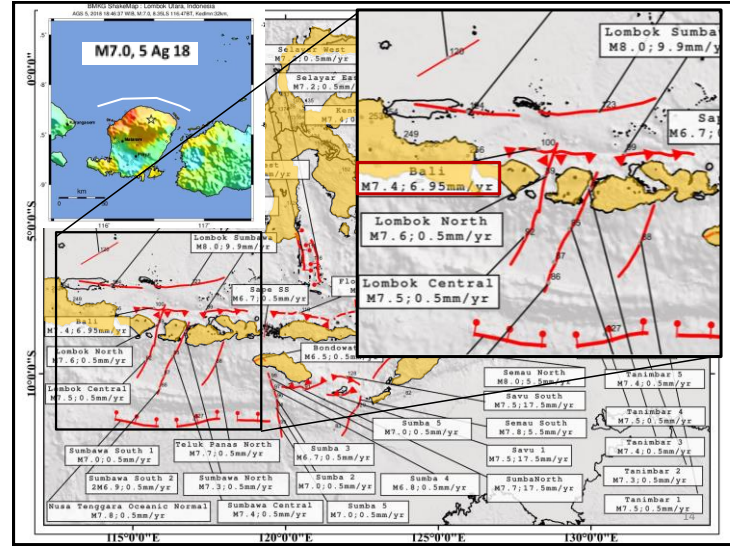
### Active Faults in Sulawesi



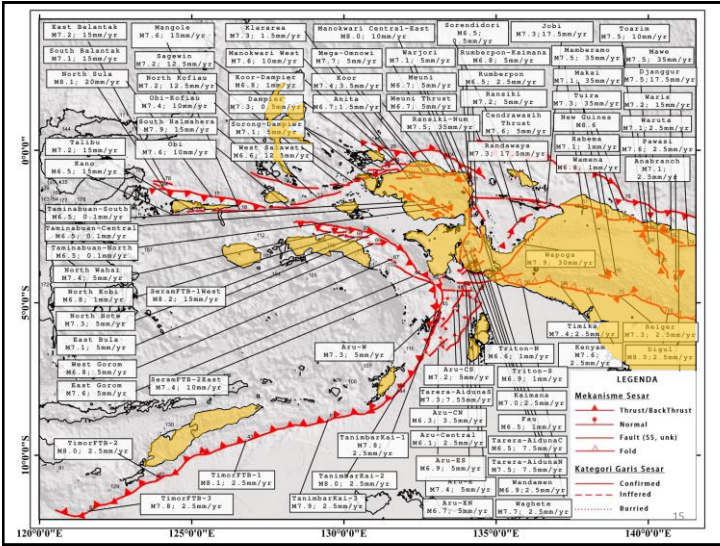
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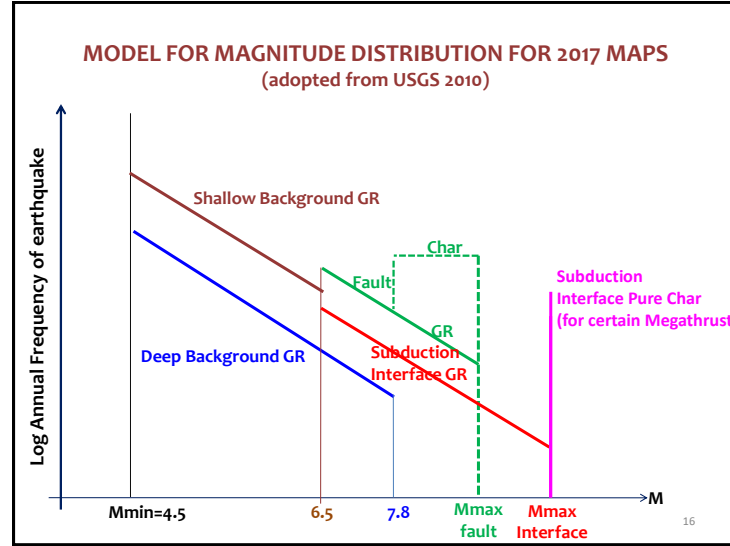
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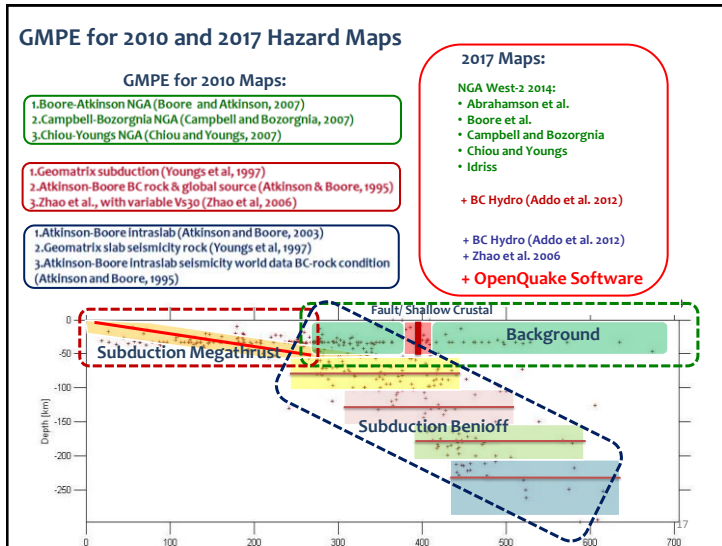
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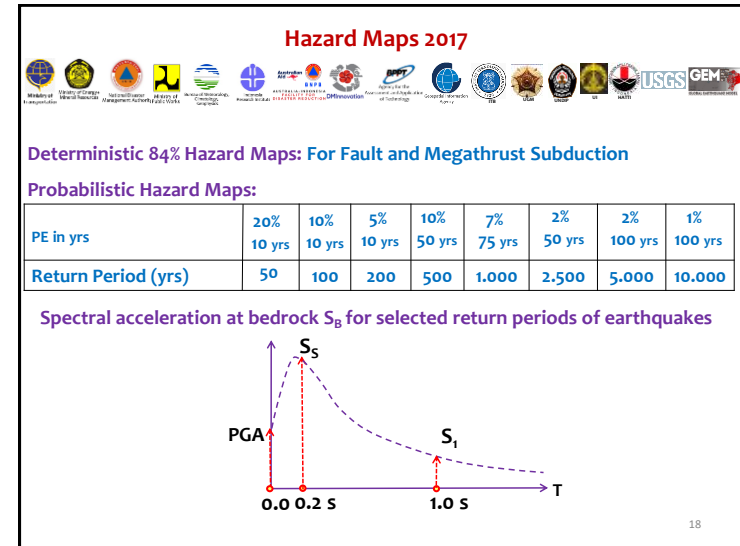
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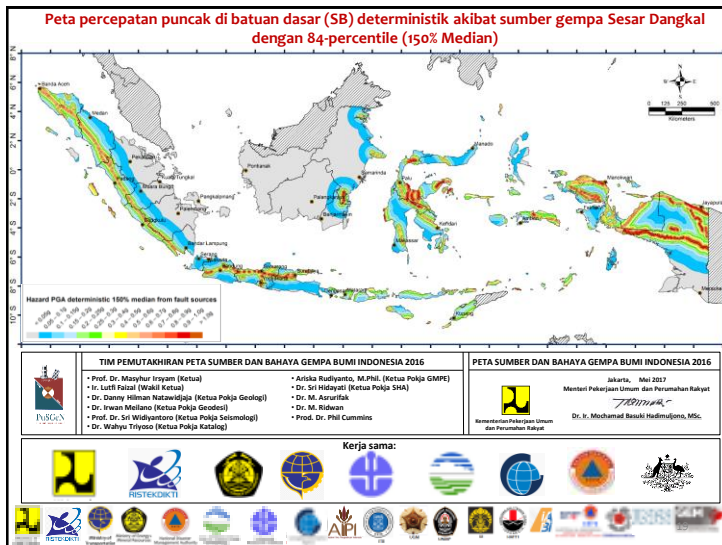
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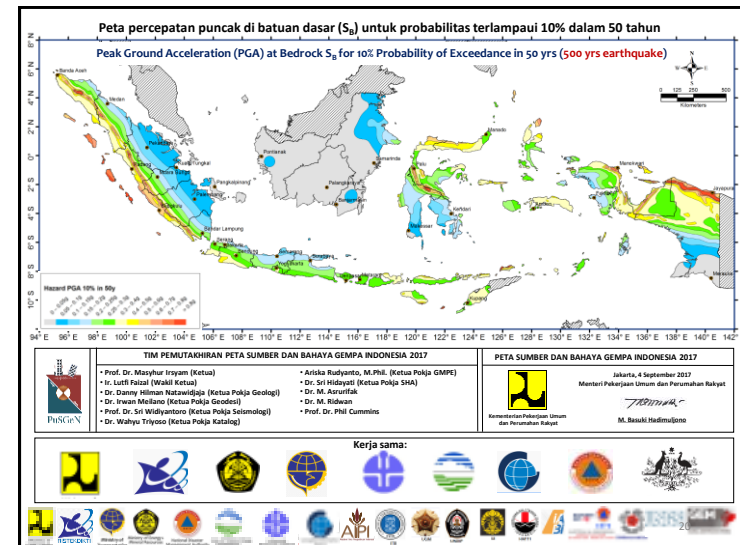
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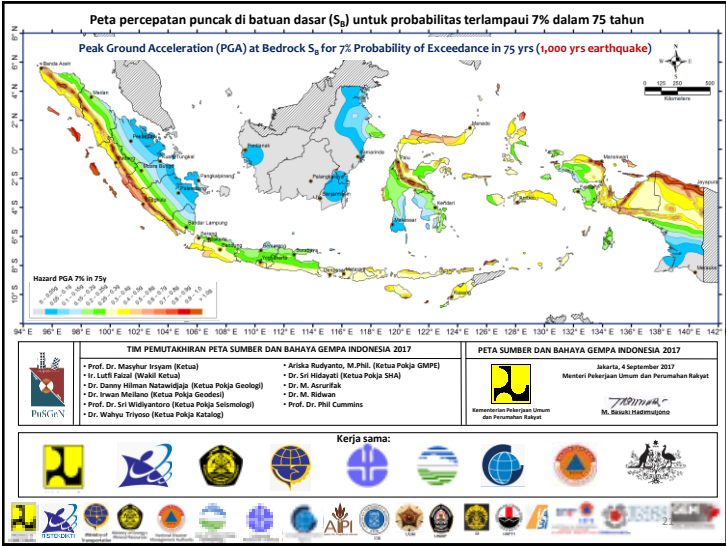
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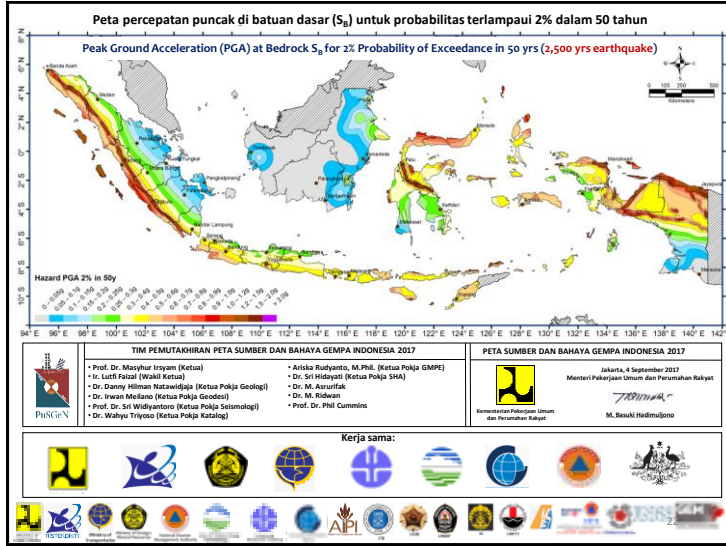
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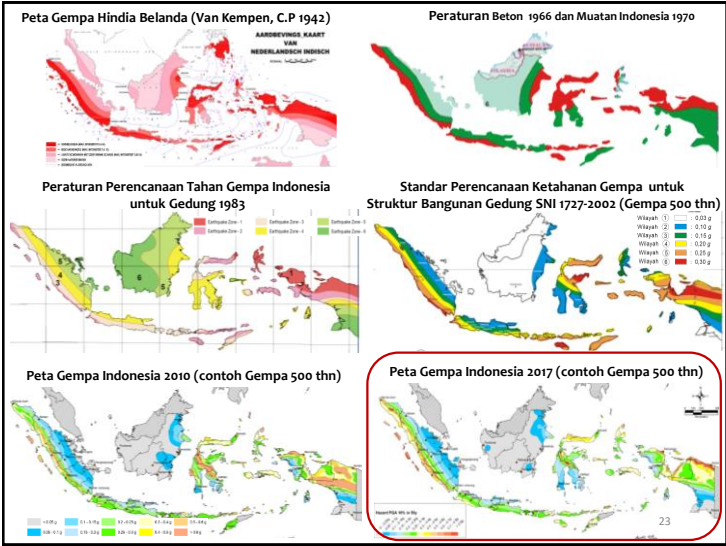
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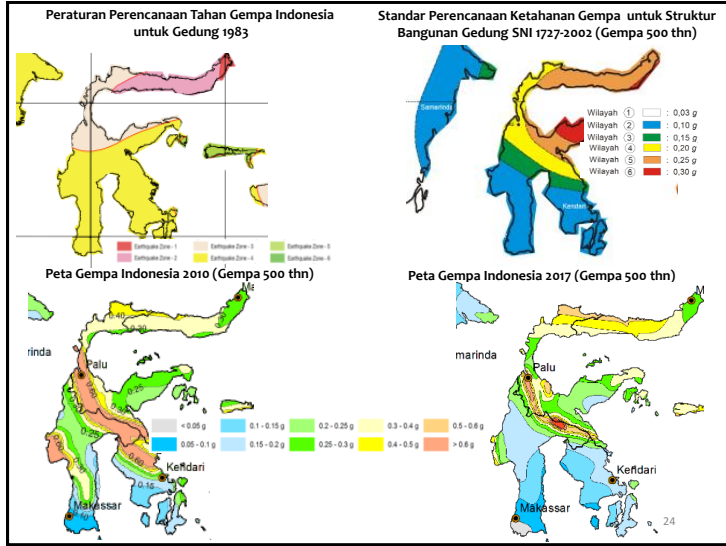
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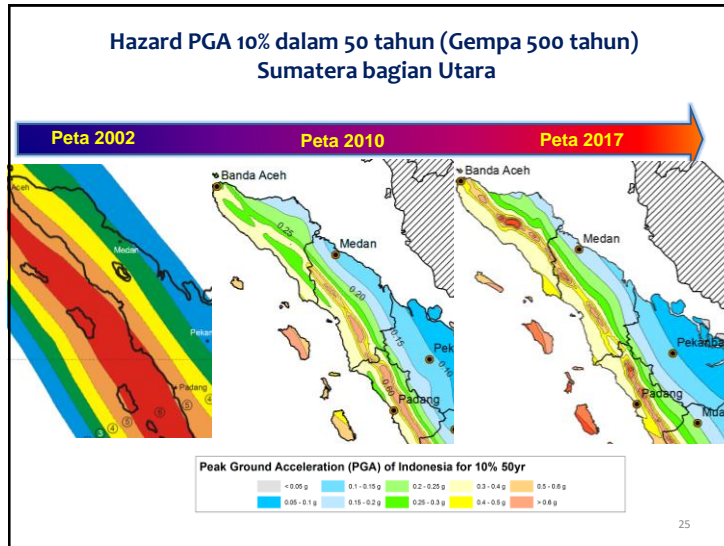
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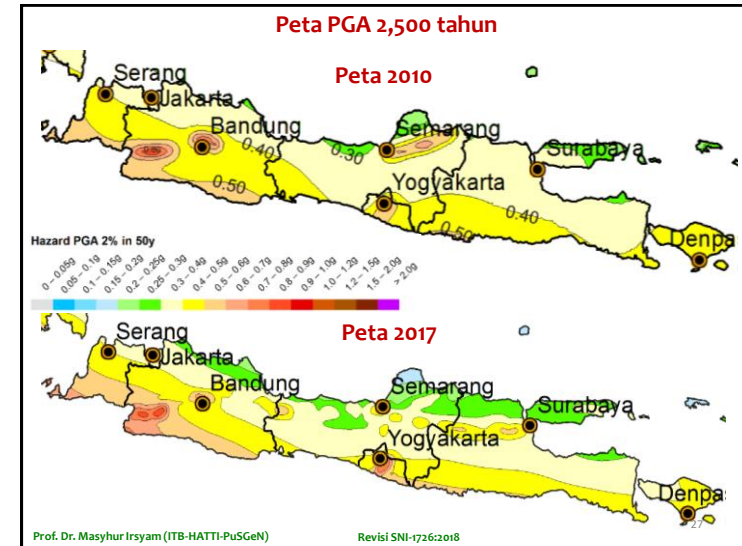
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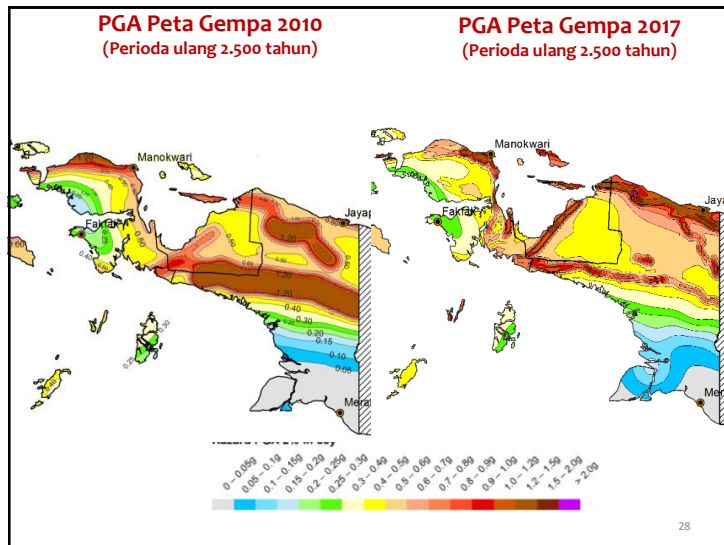
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GeoTalk 19 HATTI

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### Implementation of the Indonesian Hazard Maps 2010 in Earthquake Resistance Building and Infrastructure Design Codes

**Buildings**  
Return period of earthquake 2,500 yrs and 1% risk of collapse in 50 yrs

**Bridges**  
Return period of earthquake 1,000 yrs

**Metro Tunnels**  
1,000 yrs

**Dams:**  
OBE: 145 yrs  
SEE: 2,500 → 10,000 yrs or DSHA

**Offshore Platforms:** 2,500 yrs

**Railway Bridges:** 1,000 yrs

**Liquefaction for Runway Airport** 1,000 yrs

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**SNI GEOTEKNIK** **SNI 8460:2017**

**Tabel 52 – Kriteria Perancangan Gempa Berdasarkan Peruntukan Infrastruktur**

Peruntukan	Periode ulang	Umur rencana	Probabilitas terlampaui	Kriteria keamanan	Referensi
Bangunan gedung dan non-gedung	2.500 Tahun	50 Tahun	2% Kemungkinan Terlampaui/ 1% Risiko Runtuh	-	SNI 1726:2012 SNI 1726:2019
Jembatan konvensional	1.000	75	7%	-	SNI 2833:2016 AASHTO (2012)
Dinding penahan abutmen jembatan	1.000	75	7%	-	-
Timbunan oprit	-	-	-	FK>1,1	-
Bendungan	10.000 Safety Evaluation Earthquake (SEE)	100	1%	FK-1,5 (terhadap geser saat mengalami beban statik) FK>2 (terhadap guling saat mengalami beban statik) FK>1,1 (terhadap beban pseudostatik)	WSDOT, FHWA-NI-2005-002
	145 Operating Basis Earthquake (OBE)	100	50%	-	-
Bangunan pelengkap bendungan	2500	50	2%	-	-
Terowongan	1.000 tahun	100	10%	-	ICOLD No 148, 2016, 31

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**Angkasa Pura | AIRPORTS** **PP** **CONSTRUCTOR & INVESTMENT**

**Untuk Perancangan Likuifaksi Runway Bandara Cengkareng-Jkt, Kulon Progo-Ygy, dan Ngurah Rai-Bali: 1,000 thn**

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### Updating of Bridge Design Standard in Indonesia

**Development in Indonesia:**  
Indonesia standard and technical guideline are revised to keep up with the International advancement

Referred to Department of transportation, California, 1976 (Report 579)

500 years return of period

Revision has been completed according to AASHTO 2012

- 1,000 years return of period (7% in 75 yrs)
- PGA and spectral response at 0.2 and 1.0 sec.

1992 → 2008 → 2013



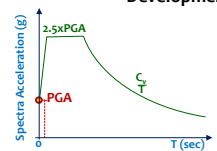
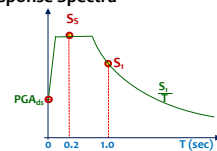
**Development in USA:**  
USA standard updated regularly to accommodate the reliability of the bridge, especially in term of seismic hazard analysis

1998 → 2005 → 2007 → 2010 → 2012-2013

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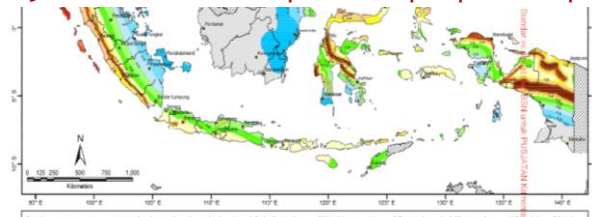
### SIGNIFICANT CHANGES OF BRIDGE CODE SNI-2833

SNI 2008	SNI 2016
<b>IBMS 1993</b>  AUSTRALIAN INTERNATIONAL DEVELOPMENT ASSISTANCE BUREAU FEBRUARY 1993	<b>AASHTO 2013</b>  2013 Interim Revisions to the AASHTO LRFD BRIDGE
<b>Partial Adoption from</b> 1 Maps 500 years: - PGA (Peak Ground Acceleration)	3 Maps 1,000 years: - PGA (Peak Ground Acceleration) - $S_2$ (Spectral Acceleration 0.2 sec) - $S_1$ (Spectral Acceleration 1.0 sec)
<b>Development of Design Response Spectra</b>	
	

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### SNI 2833:2016 Perencanaan jembatan terhadap beban gempa

Ada 3 Peta untuk Penentuan Percepatan dan Respon Spektra Percepatan



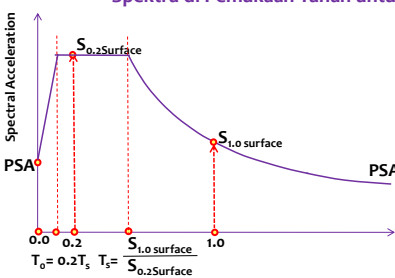
**Gambar 3 - Peta respon spektra percepatan 1 detik di batuan dasar untuk probabilitas terlampaui 7% dalam 75 tahun**

**Gambar 2 - Peta respon spektra percepatan 0.2 detik di batuan dasar untuk probabilitas terlampaui 7% dalam 75 tahun**

**Gambar 1 - Peta percepatan puncak di batuan dasar (PGA) untuk probabilitas terlampaui 7% dalam 75 tahun**

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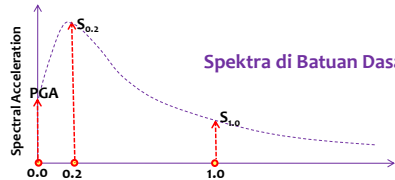
### Spektra di Permukaan Tanah untuk Perancangan Jembatan



$PSA = F_{pga} \times PGA$       $S_{0.2\text{Surface}} = F_a \times S_{0.2}$       $S_{1.0\text{Surface}} = F_v \times S_{1.0}$

$T_0 = 0.2T_s$       $T_s = \frac{S_{0.2\text{Surface}}}{S_{0.2}}$

### Spektra di Batuan Dasar $S_B$



Ground Surface

$F_{pga}$       $F_a$       $F_v$

Soil Type

PGA      $S_{0.2}$       $S_{1.0}$

Bedrock  $S_B$ <sup>36</sup>

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### PEDOMAN PEMBAHASAN PENYELENGGARAAN KEAMANAN JEMBATAN DAN TEROWONGAN JALAN DENGAN KOMISI KEAMANAN JEMBATAN DAN TEROWONGAN JALAN

**2.2 Penyelidikan Geoteknik untuk Jembatan**

(1) *Soil Investigation*

- Kedalaman lubang bor dihentikan apabila nilai N-SPT >60 tercapai 5 kali berturut-turut dengan interval uji 2 m;
- Untuk daerah yang pernah mengalami likuifaksi, maka uji N-SPT dilakukan dengan interval 1 m;
- Untuk daerah-daerah yang pernah mengalami longsor, *Undisturbed Sample (UDS)* dilakukan dengan interval 3 m;
- Pengambilan *Disturbed Sample (DS)* pada jenis *coarse soil* dapat diperoleh juga dari tabung SPT;
- Pengukuran Muka Air Tanah diperoleh dari *open standpipe piezometer*
- Posisi casing harus ditampilkan dalam *Bore Log* dan mengikuti standar dalam menampilkan deskripsi tanah sesuai nomenklatur dan menampilkan muka air tanah, serta nilai SPT.

(2) *Persyaratan khusus*

- Untuk jembatan, *soil investigation* dilakukan pada setiap titik rencana *pier* dan *abutment* dan profil tanah digambarkan sesuai dengan kaidah dalam penyajian profil;
- Untuk *elevated road* (struktur *pile slab*) *soil investigation* dilakukan setiap jarak 30 m dan profil tanah digambarkan sesuai dengan kaidah dalam penyajian profil.

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**Basic Performance for Existing Buildings**

**BPOE Performance Objective**

**Pre-Defined Seismic Hazard Levels**

- BSE-1E: 20%50 year hazard (capped at BSE-1N)
- BSE-2E: 5%50 year hazard (capped at BSE-2N)
- BSE-1N: matches ASCE 7 Design Earthquake
- BSE-2N: matches ASCE 7 Risk Targeted Maximum Considered Earthquake (MCE<sub>e</sub>)

**Structural Performance Levels**

- S1: Immediate Occupancy
- S2: Damage Control
- S3: Life Safety
- S4: Reduced Safety
- S5: Collapse Prevention

**Pre-Defined Performance Objectives**

- IMPERY: BPOE is the most common Performance Objective, intended to replicate traditional retrofit requirements. Nonstructural level must also be considered for BPOE for Risk Categories III and IV.
- Basic Performance Objective for Existing Buildings (BPOE)
- Enhanced Performance Objective
- Basic Performance Objective Equivalent to New Building Standards (BPN)
- Limited Performance Objectives

**Perioda ulang gempa 225 tahun**  
L.2. Peta persebaran gempa dengan magnitudo 5.0 dan lebih, berintensitas 20% dalam 50 tahun

**Perioda ulang gempa 975 tahun**  
L.3. Peta persebaran gempa dengan magnitudo 5.0 dan lebih, berintensitas 5% dalam 50 tahun

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**Tahun 2022: Penyusunan SNI Tata Cara Perancangan Infrastruktur Bawah Tanah Tahan Gempa**

**Perioda ulang Gempa:**  
-100 yrs: Fully operational  
-1000 yrs: Immediate occupancy

**Ground Response Analysis**

- NERA
- Output
- Displacement
- Acceleration
- Shear Stress
- Converged G

**Soil-Structure Interaction Analysis**

- JRSNAP
- JRBOX

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**Direktorat Jenderal SDA 2021:**

**PEDOMAN**  
Konsentrasi dan Bangunan SDA

**Studi Kegempaan untuk Penentuan Parameter Desain Gempa Bendungan**

**Volume I**  
Penelusuran Sumber Gempa

**Volume II**  
Analisis Bahaya Gempa

**For dam design,**  
Return period of earthquake: OBE is 145 yrs, SEE is DSHA or 5,00-10,000 yrs

Dr. Didiek Djarwadi  
Dr. M Asrurifak  
Dr. Danny Hilman Natawidjaja

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**SOSIALISASI LEBIH DALAM ISI SNI 1726**

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**PENERAPAN PETA GEMPA INDONESIA DALAM PERENCANAAN GEDUNG TAHAN GEMPA**


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**Tim Struktur Bawah dan Kontributor SNI 1726 :2019**



SNI 1726:2019


Tata cara perencanaan ketahanan gempa untuk Struktur bangunan gedung dan nongedung



CS 91.120.25; 91.080.01

1	Prof. Ir. Masyhur Irsyam, MSE., Ph.D.
2	Andhika Sahadewa ST., MSE., Ph.D.
3	Dr. Ir. M. Asrurifak, MT.
4	Prof. Dr. Ir. I Wayan Sengara
5	Ir. Sindhu Rudianto, MSCE.
6	Prof. Dr. Ir. Widjojo Adi Prakoso
7	Dr. Ir. Windu Partono, M.Sc
8	Hendriawan, ST., MT., Ph.D.
9	Dr. M. Ridwan
10	Andri Mulia, ST., MS.c
11	Ir. Bigman M. Hutapea, M.Sc. Ph.D.
12	Ir. Wahyu Wuryanti, MSC.
13	Simon Dertha Tarigan, ST., MT.
14	Dr. Endra Susila, MT.
15	Dr. Ir. Agus Darmawan Adi
16	Daniel Hutabarat, ST., M.Sc
17	Requel Mikhail, ST., MT.
18	Prof. Dr. Ir. Indra Jati Sidi
19	Dr. Ir. FX. Toha

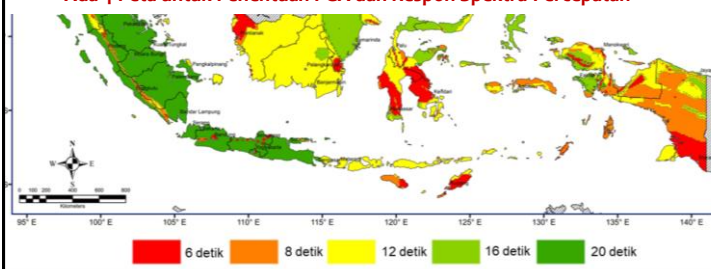
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SNI 1726:2019

**Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan nongedung**

**Ada 4 Peta untuk Penentuan PGA dan Respon Spektra Percepatan**



Gambar 20 - Peta transisi periode panjang,  $T_L$ , wilayah Indonesia

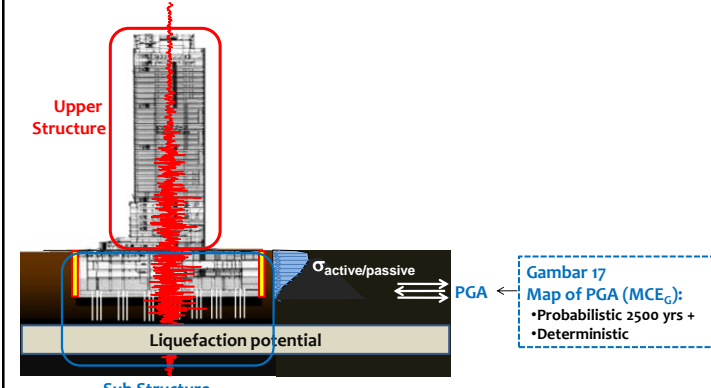
Gambar 16 - Parameter gerak tanah,  $S_T$ , gempa maksimum yang dipertimbangkan risiko-tertarget (MCE<sub>a</sub>) wilayah Indonesia untuk spektrum respons 1,0 detik (redaman kritis 5%)

Gambar 15 - Parameter gerak tanah  $S_u$ , gempa maksimum yang dipertimbangkan risiko-tertarget (MCE<sub>a</sub>) wilayah Indonesia untuk spektrum respons 0,2-detik (redaman kritis 5%)

Gambar 17 -  $PGA$ , Gempa maksimum yang dipertimbangkan rata-rata geometrik (MCE<sub>o</sub>) wilayah Indonesia

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**Application of Earthquake Maps in SNI 1726:2019/ ASCE 2016**



Gambar 17  
Map of PGA (MCE<sub>o</sub>):  
• Probabilistic 2500 yrs +  
• Deterministic

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Prof. Dr. Masyhur Irsyam, MSE. (ITB-AIPI-PuSGeN)

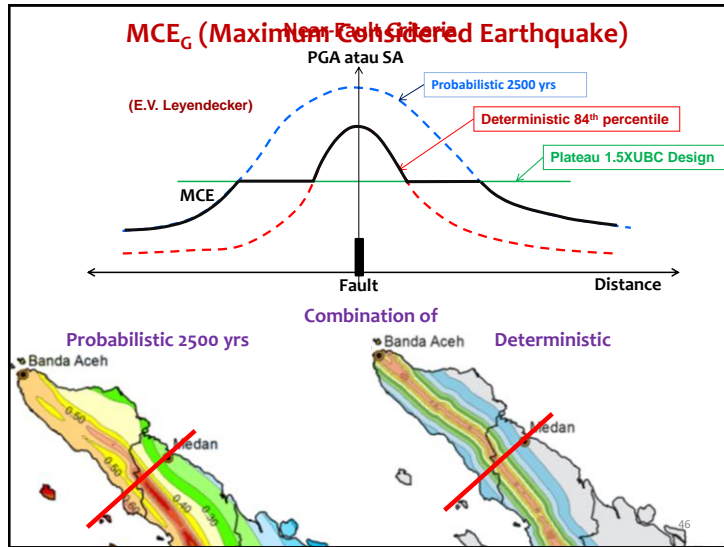
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**SIGNIFICANT CHANGES OF BUILDING CODE SNI-1726**

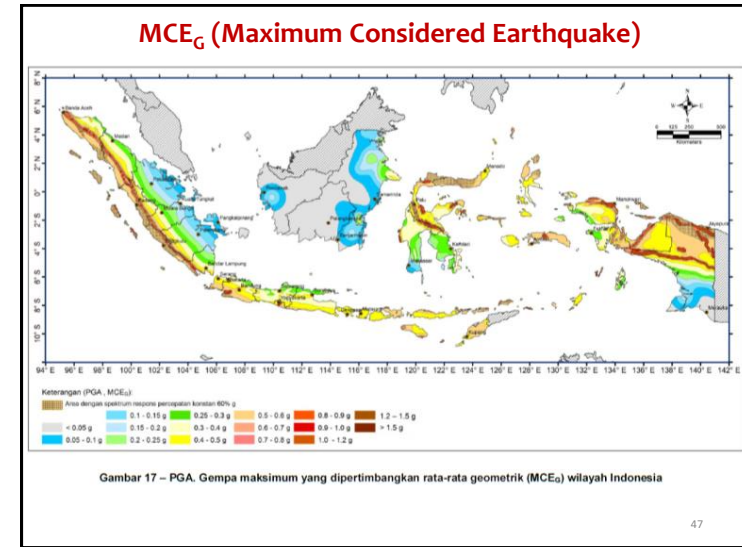
SNI 2002	SNI 2012	SNI 2019
Gambar 2.1	Gambar 11	Gambar 17
<b>Criteria for PGA Maps</b>		
<ul style="list-style-type: none"> <li>• Probabilistic: 10% PoE in 50 yrs (500 yrs)</li> </ul>	<ul style="list-style-type: none"> <li>• Probabilistic: 2% PoE in 50 yrs (2,500 yrs)</li> <li>• Deterministic 84% PGA</li> </ul>	<ul style="list-style-type: none"> <li>• Probabilistic: 2% PoE in 50 yrs (2,500 yrs)</li> <li>• Deterministic 84% PGA</li> </ul>

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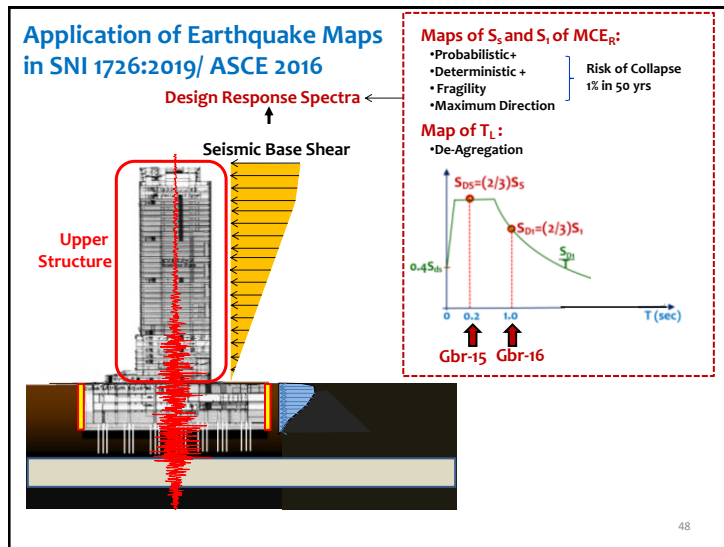
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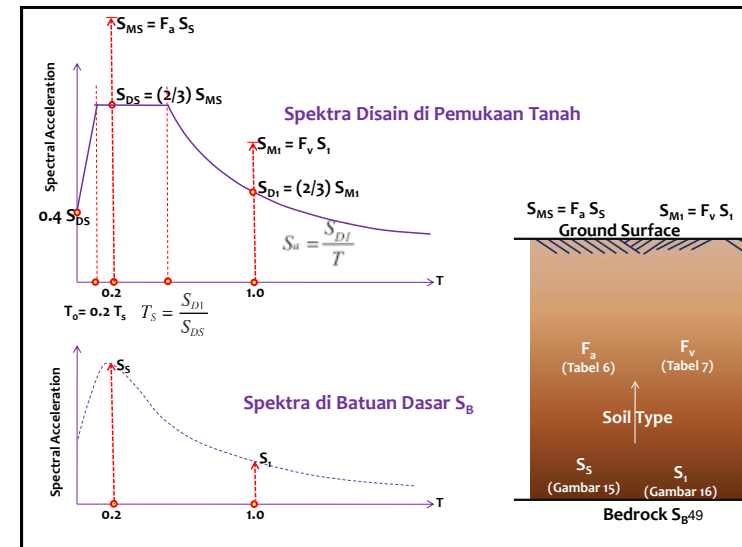
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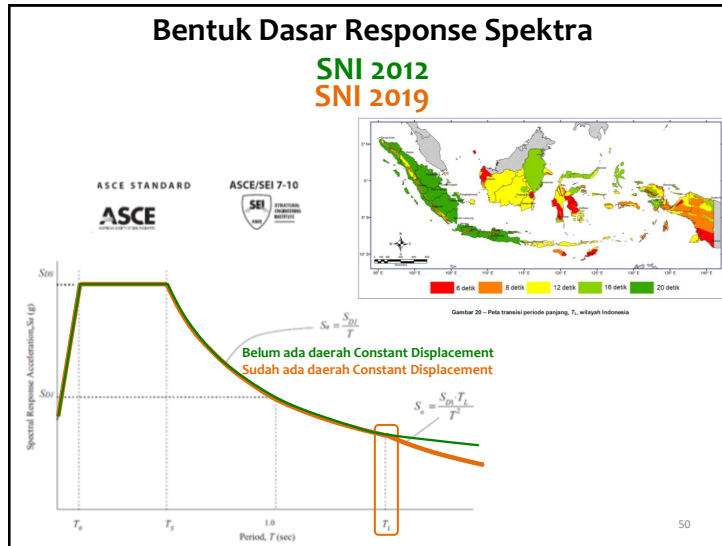
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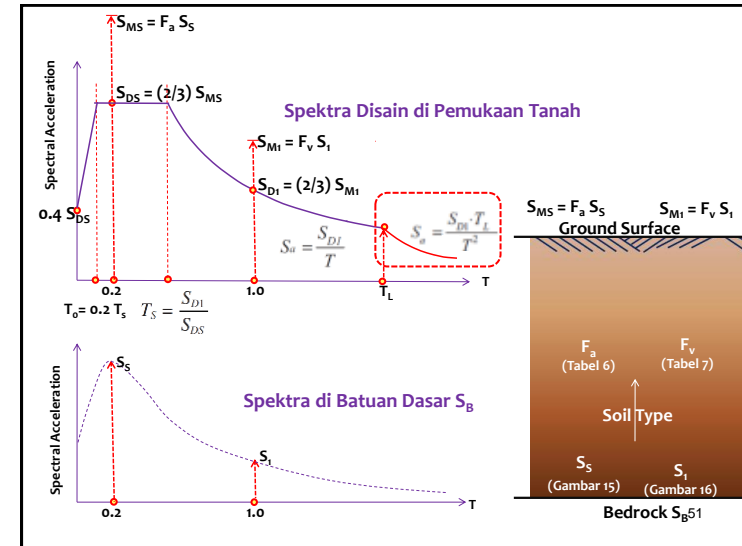
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### Short-Period Site Coefficient $F_a$ (Tabel 6, Pasal 6.2)

**SNI 2019 follows PEER 2013**

Site Class	$S_s < 0.25$			$S_s = 0.5$			$S_s = 0.75$		
	SNI 2012	ASCE 7-16	PEER	SNI 2012	ASCE 7-16	PEER	SNI 2012	ASCE 7-16	PEER
A	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
B	1.0	0.9	0.9	1.0	0.9	0.9	1.0	0.9	0.9
C	1.2	1.3	1.3	1.2	1.3	1.3	1.1	1.2	1.2
D	1.6	1.6	1.6	1.4	1.4	1.4	1.2	1.2	1.2
E	2.5	2.4	2.4	1.7	1.7	1.7	1.2	1.3	1.3

Site Class	$S_s = 1.0$			$S_s = 1.25$			$S_s > 1.5$		
	SNI 2012	ASCE 7-16	PEER	SNI 2012	ASCE 7-16	PEER	SNI 2012	ASCE 7-16	PEER
A	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
B	1.0	0.9	0.9	0.9	0.9	0.9	1.0	0.9	0.9
C	1.0	1.2	1.2	1.2	1.2	1.2	1.0	1.2	1.2
D	1.1	1.1	1.1	1.0	1.0	1.1	1.0	1.0	1.0
E	0.9	SS	1.1	0.9	SS	0.9	0.9	SS	0.8

SS: Site Specific Response Analysis

Prof. Dr. Masyhur Irsyam (ITB-HATTI-PuSGen) Sosialisasi Peta Sumber dan Bahaya Gempa Indonesia 2017 dan Revisi SNI-1726:2019

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### Long-Period Site Coefficient $F_v$ (Tabel 7, Pasal 6.2)

**SNI 2018 follows PEER 2013**

Site Class	$S_i < 0.1$			$S_i = 0.2$			$S_i = 0.3$		
	SNI 2012	ASCE 7-16	PEER	SNI 2012	ASCE 7-16	PEER	SNI 2012	ASCE 7-16	PEER
A	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
B	1.0	0.8	0.8	1.0	0.8	0.8	1.0	0.8	0.8
C	1.7	1.5	1.5	1.6	1.5	1.5	1.5	1.5	1.5
D	2.4	2.4	2.4	2.0	2.2	2.2	1.8	2.0	2.0
E	3.5	4.2	4.2	3.2	SS	3.2	2.8	SS	2.8


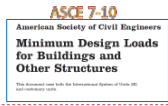

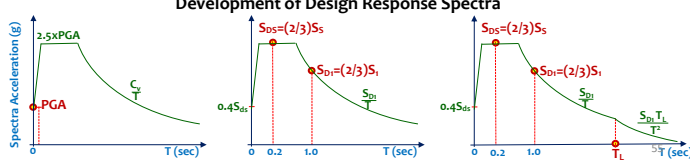
  

Site Class	$S_i = 0.4$			$S_i = 0.5$			$S_i > 0.6$		
	SNI 2012	ASCE 7-16	PEER	SNI 2012	ASCE 7-16	PEER	SNI 2012	ASCE 7-16	PEER
A	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
B	1.0	0.8	0.8	1.0	0.8	0.8	1.0	0.8	0.8
C	1.4	1.5	1.5	1.3	1.5	1.5	1.3	1.4	1.4
D	1.6	1.9	1.9	1.5	1.8	1.8	1.5	1.7	1.7
E	2.4	SS	2.4	2.4	SS	2.2	2.4	SS	2.0

SS: Site Specific Response Analysis

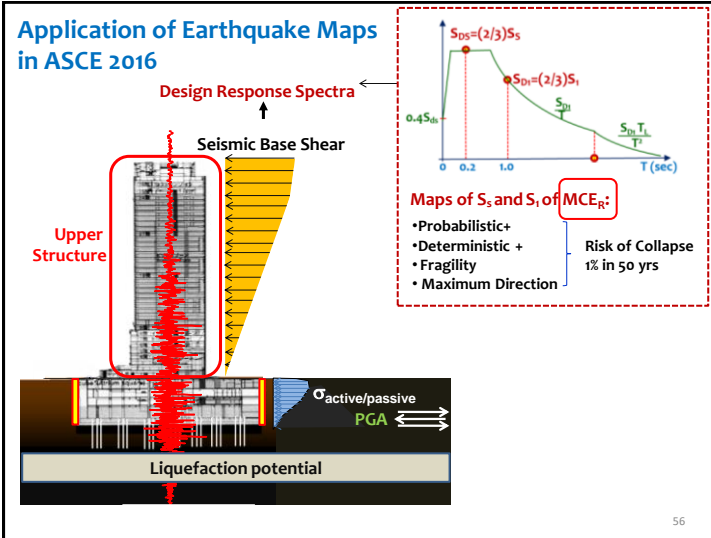
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### SIGNIFICANT CHANGES OF BUILDING CODE SNI-1726

SNI 2002	SNI 2012	SNI 2019
 <p><b>1997 UBC</b> UNIFORM BUILDING CODE</p>	<p>Partial Adoption from</p>  <p><b>ASCE 7-10</b> American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures</p>	 <p><b>ASCE 7-16</b> Minimum Design Loads and Associated Criteria for Buildings and Other Structures</p>
<p><b>1 Maps:</b></p> <ul style="list-style-type: none"> <li>- PGA (Peak Ground Acceleration)</li> </ul>	<p><b>3 Maps:</b></p> <ul style="list-style-type: none"> <li>- PGA (Peak Ground Acceleration)</li> <li>- S<sub>0.2</sub> (Spectral Acceleration 0.2 sec)</li> <li>- S<sub>1</sub> (Spectral Acceleration 1.0 sec)</li> </ul>	<p><b>4 Maps:</b></p> <ul style="list-style-type: none"> <li>- PGA (Peak Ground Acceleration)</li> <li>- S<sub>0.2</sub> (Spectral Acceleration 0.2 sec)</li> <li>- S<sub>1</sub> (Spectral Acceleration 1.0 sec)</li> <li>- T<sub>L</sub> (Long-Period Transition Periods)</li> </ul>
<p><b>Development of Design Response Spectra</b></p> 		

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### Application of Earthquake Maps in ASCE 2016



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### MCE<sub>R</sub> Risk-Targeted Ground Motion

ASCE-2010 and 2016: 1% Risk of Collapse in 50 yrs (= 1/5000 per yr)

Generic fragility curve equation:

$$\Phi \left[ \frac{\ln a - (\ln RTGM + 1.28 \times \beta)}{\beta} \right]$$

**RTGM**

$P_f$

Risk/probability of collapse = 1/5000

$= \int_0^\infty H(a) \frac{dP_f(a)}{da} da$

Hazard

Fragility Curve (Conditional probability of failure)

Capacity


$$\frac{1}{a\beta\sqrt{2\pi}} \exp \left[ -\frac{(\ln a - (\ln(RTGM) + 1.28\beta))^2}{2\beta^2} \right]$$

Structural Capacity

Luco, 2009

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### Teleconference dengan Dr Nico Luco USGS tentang Risk Map, 22 Januari 2018



Generic fragility curve equation:

$$\Phi \left[ \frac{\ln a - (\ln RTGM + 1.28 \times \beta)}{\beta} \right]$$

Fragility Curve (Conditional probability of failure)

-Prof. Indra Jati

-Prof. Wayan Sengara

SNI 2012

$\beta = 0.70$

$\beta$  Minimum untuk site specific analysis = 0.65

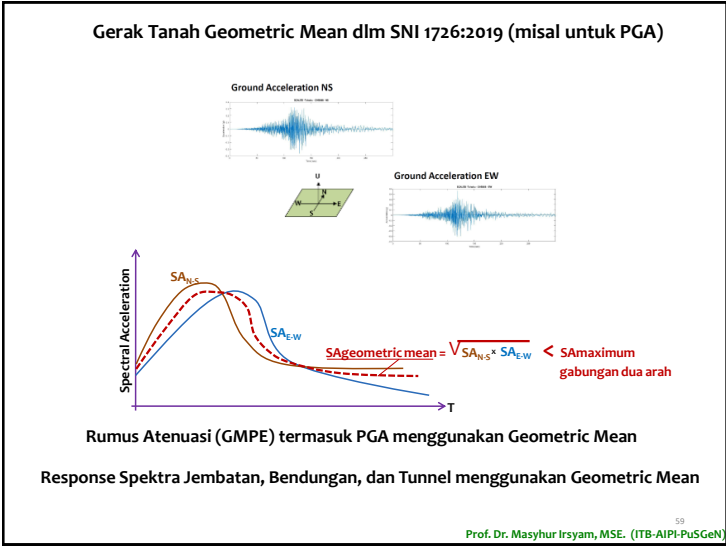
SNI 2019

$\beta = 0.65$

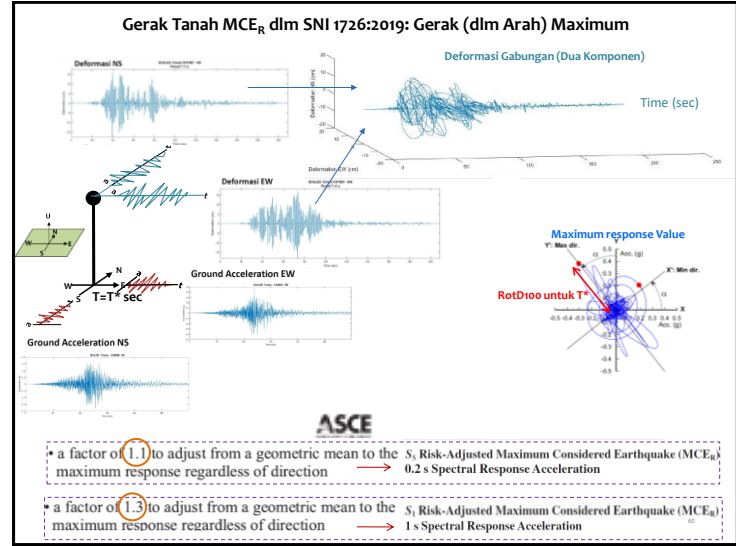
$\beta$  Minimum untuk site specific analysis = 0.55

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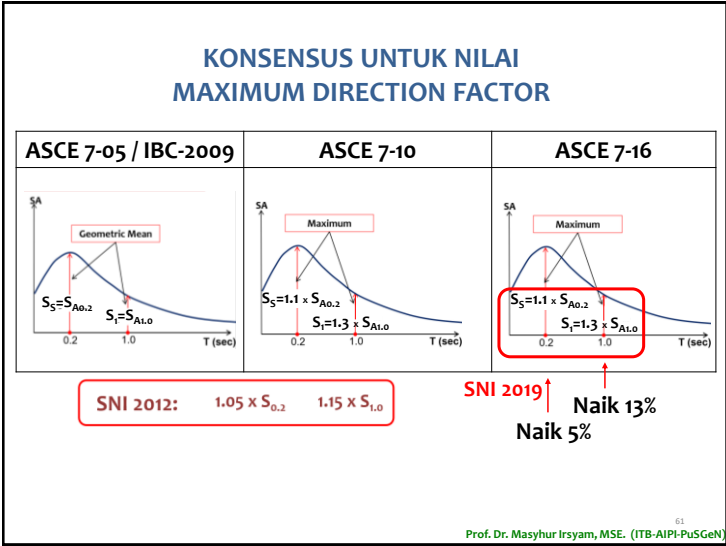
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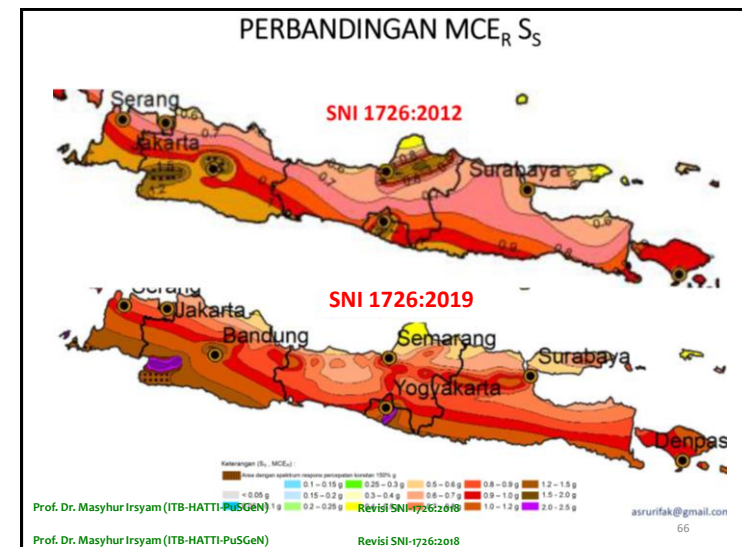
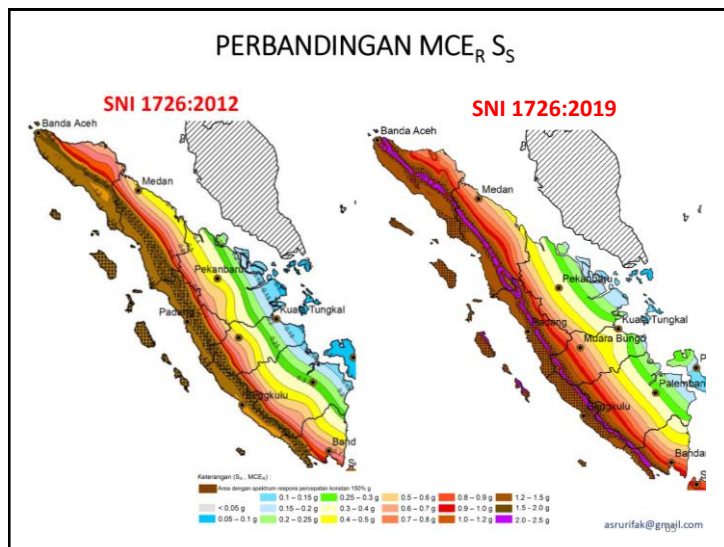
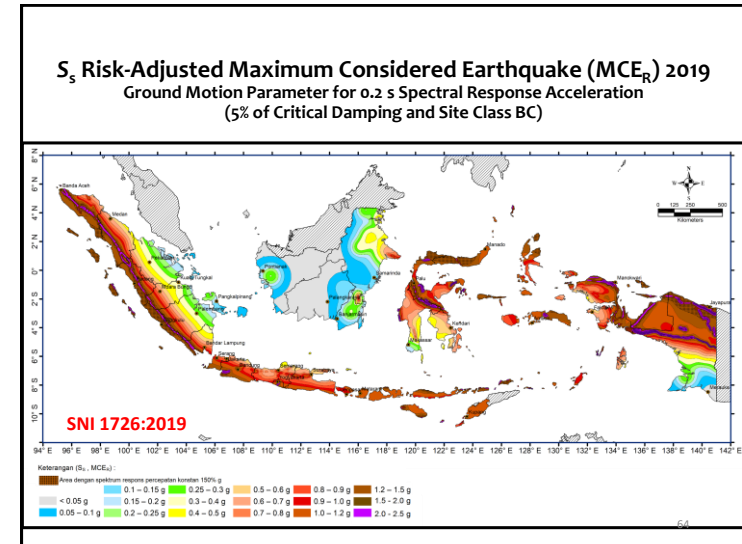
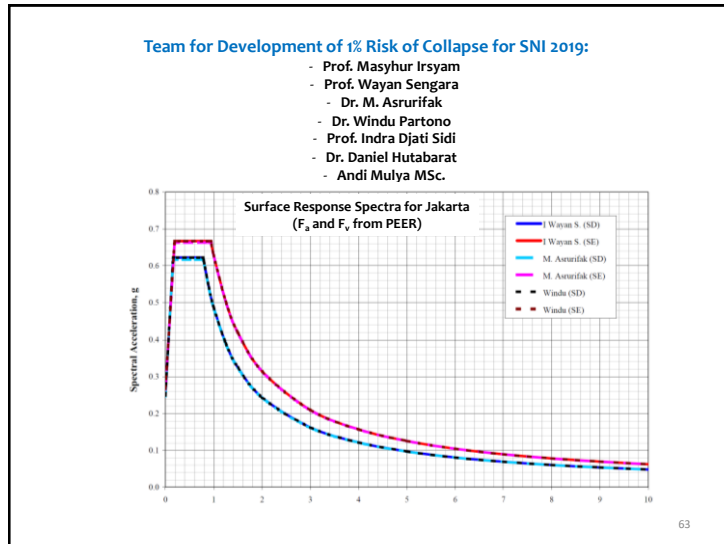


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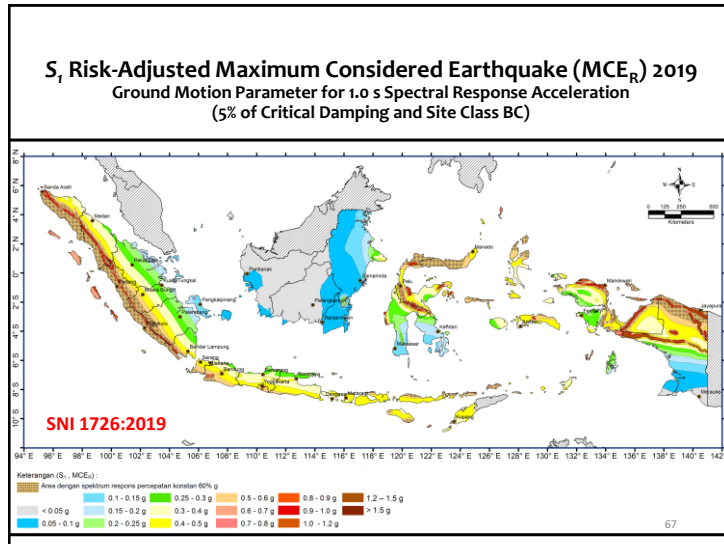
### SIGNIFICANT CHANGES OF BUILDING CODE SNI-1726

SNI 2002	SNI 2012	SNI 2019
Criteria for Seismic Maps for Development of Design Response Spectra		
10% Probability of Exceedance in 50 yrs	1% Risk of Collapse in 50 yrs	1% Risk of Collapse in 50 yrs
	↑ Developed based on	
	Seismic Hazard / Risk Analysis	
- Probabilistic SHA	- Probabilistic SHA - Deterministic SHA - Fragility function ASCE	- Probabilistic SHA - Deterministic SHA - Fragility function ASCE - De-Aggregation (for $T_L$ )
	Fragility Function	
No fragility function	ASCE generic fragility curve equation $\beta = 0.70$	$\beta = 0.65$
	Directivity Factors for Maximum Directions	
- No directivity factor	- 1.05 for $S_5$ - 1.15 for $S_1$ (average of UBC 2009 + ASCE 2010)	- 1.10 for $S_5$ - 1.30 for $S_1$ (follows ASCE 2010, 2016)
	Increase in $S_5 = 5\%$ Increase in $S_1 = 43\%$	

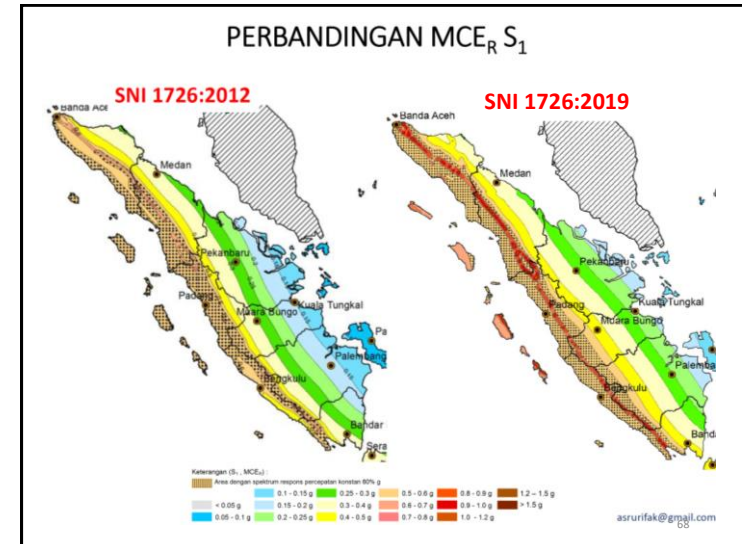
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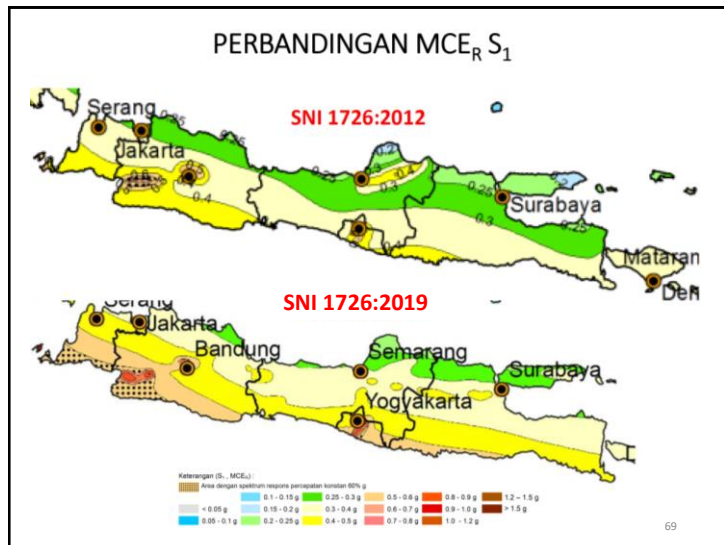




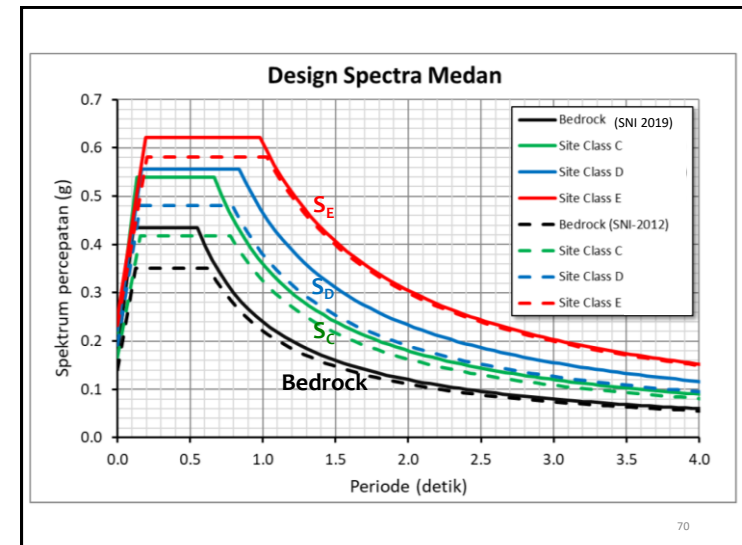
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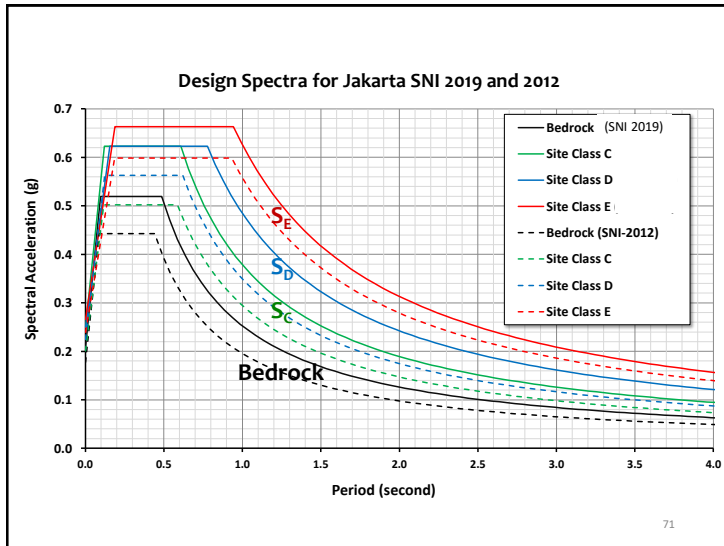
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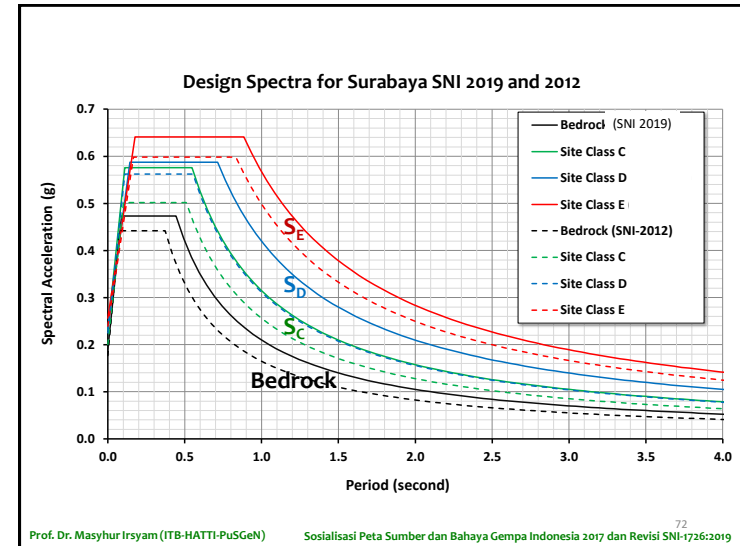
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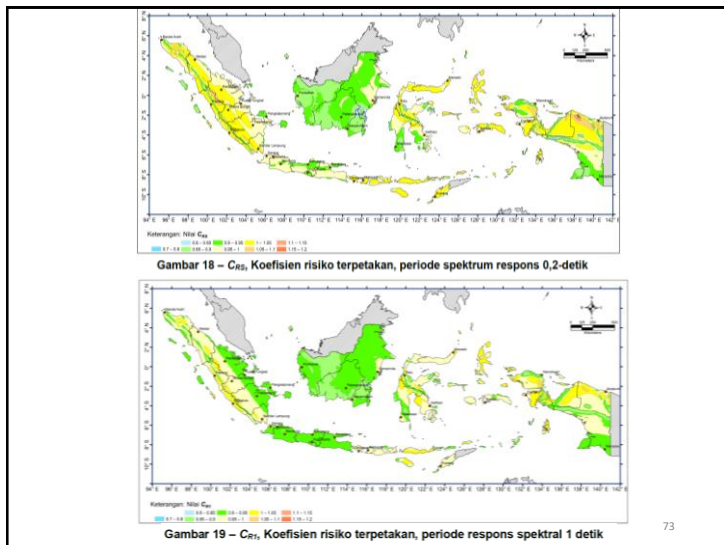
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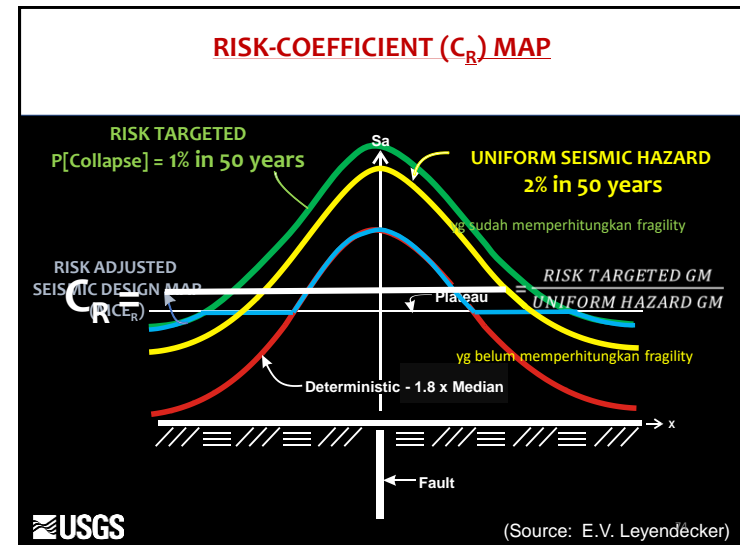
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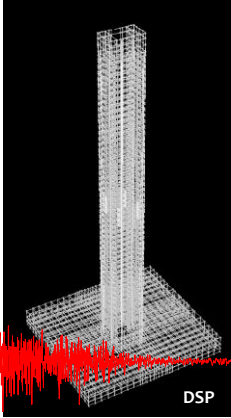


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**GROUND MOTIONS REQUIRED FOR NON-LINEAR RESPONSE TIME HISTORY ANALYSIS ACCORDING TO SNI 1726:2019**



**SNI**  
Standar Nasional Indonesia

SNI 8899:2020

Tata cara pemilihan dan modifikasi gerak tanah permukaan untuk perencanaan gedung tahan gempa

ICS 91.120.25, 91.080.01

**BSN** BADAN STANDARISASI NASIONAL

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**PENYUSUNAN PETA DEAGREGASI NASIONAL UNTUK BERBAGAI JENIS SUMBER GEMPA, PERIODA ULANG, DAN PERIODA GETAR UNTUK PEMILIHAN DAN MODIFIKASI GROUND MOTIONS**



**ITS**

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The National Research Center for Earthquake

**ITS**

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**PENGEMBANGAN METODE PEMILIHAN DAN MODIFIKASI GROUND MOTION YANG TEROTOMASI & TERINTEGRASI DENGAN DATABASE RAMPING UNTUK EVALUASI DAN PERANCANGAN GEDUNG DI KOTA-KOTA BESAR DI INDONESIA**



**ITS**

**PuSGeN**  
The National Research Center for Earthquake

**ITS**

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Dr. Ir. M. Asrurifak, MT.  
Dr. Hendriyawan ST., MT.

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**Thankyou for the continuous support from:**



**PuSGeN**  
The National Research Center for Earthquake

Ministry of Public Works, RISTEKDIKTI, Ministry of Energy & Mineral Resources, Ministry of Transportation, National Disaster Management Authority, Bureau of Meteorology, Climatology, Geophysics, Indonesia Research Institute, Geospatial Information Agency, AIPI, University of Gajah Mada, University of Diponegoro, Universitas Indonesia, DMinnovation, USGS, GEM, ITS, ITS, ITS

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