ProtaStructure®
ProtaSteel®
ProtaDetails®
ProtaBIM®

ProtaStructure Design Guide

SNI 1726:2019 – Indonesia Seismic Code

Version 1.0 27 Sep 2022

Please contact us for your training and technical support queries

asiasupport@protasoftware.com

globalsupport@protasoftware.com

PROTA

Limitation of Responsibilities

Prota shall not be held responsible for any losses caused by documentation, software, or usage errors.

In addition to Prota License Agreement Terms, it is the responsibility of the user

- to check of results generated by documentation and software,
- make sure that the users of the software and their supervisors have adequate technical capabilities,
- make sure that the software is properly used per the reference manual and documentation,

Intellectual Property

ProtaStructure is a registered trademark of **Prota Software Inc.** and all intellectual property rights belong to **Prota Software Inc**. Documentation, training, and reference manuals and any program component can not be copied, distributed, and used in violation of the license agreement.

Trademarks

ProtaStructure®, **ProtaDetails®**, **ProtaSteel®** ve **ProtaBIM®** are registered trademarks of Prota Software Inc. Prota logo is a trademark of Prota Software Inc.

Table of Contents

Introduction 4
Calculation of Elastic and Design Response Spectrum 4
Design Earthquake 4
Risk Categories and Importance Factors 4
Site Classification 5
Mapped Spectral Acceleration 5
Site Coefficients and Spectral Response Parameters 6
Design Spectral Acceleration 6
Elastic Response Spectrum 7
Design Response Spectrum 8
Calculation of Period 8
Maximum Value of Period 8
Equivalent Static Load Method 9
Base Shear Calculation 9
Base Shear Storey Distribution 10
Mode Superposition Analysis 10
Notations: 10
Analysis Method 10
Cumulative Mass Participation 10
RSA – Equivalent Static Base Shear Comparison 10
Inter-storey Drift Scaling 11
Relative Storey Drift Check 11
Modelling and Analysis 11
Cracked Sections 11
Load Combinations 12
Combinations for Ultimate Limit State Design (Cl. 4.2.2) 12
Combinations for Allowable Stress Design (Cl. 4.2.3) 12
Combination of EQ Load (Cl. 7.4.2.3 and Cl. 7.4.3) 12
Thank You… 14

Introduction

Aim of this document is to summarize the clauses in SNI1726:2019 and the scope implementation scope in ProtaStructure.

The Indonesian seismic code is very similar to IBC and so, ASCE07-10.

Calculation of Elastic and Design Response Spectrum

Design Earthquake

Reference Clause(s): 4.1.1

Elastic and Design spectrum is calculated for MCE (2% probability of exceedance in 50 years)

Risk Categories and Importance Factors

Reference Clause(s): 4.1.2

Choose Risk Categories I, II, III or IV from **Table 1**

Choose Importance Factor from **Table 2**

Risk category	Importance factor of earthquake, I_e
I or II	1,0
III	1,25
IV	1,50

Site Classification

Reference Clause(s): 5.3

Table 3

<table>
<tr><th>Site Class</th><th>$\overline{V}_s$ (m/s)</th><th>$\overline{N}$ or $\overline{N}_{ch}$</th><th>$\overline{S}_u$</th></tr>
<tr><td>SA (Hard Rock)</td><td>> 1500</td><td>N/A</td><td>N/A</td></tr>
<tr><td>SB (Rock)</td><td>750 to 1500</td><td>N/A</td><td>N/A</td></tr>
<tr><td>SC (Hard Soil,
Very Solid Soil and
Very Soft Rock)</td><td>350 to 750</td><td>> 50</td><td>≥ 100</td></tr>
<tr><td>SD (Medium Soil)</td><td>175 to 350</td><td>15 to 50</td><td>50 to 100</td></tr>
<tr><td>SE (Soft Soil)</td><td>< 175</td><td>< 15</td><td>< 50</td></tr>
<tr><td></td><td colspan="3">Soil Profile Type SE also includes any soil profile with more than 3.0 m of soft clay with:
Plasticity Index PI > 20
Moisture Content w_{mc} ≥ 40%
Undrained Shear Strength $\bar{S}_u$ < 25 kPa</td></tr>
<tr><td>SF
(Special soil requiring site-specific evaluation. See section 6.10.1)</td><td colspan="3">Each profile of soil layer having one or more following characteristics:
Soils vulnerable to potential failure or collapse under seismic loading, such as liquefiable soils, quick and highly sensitive clays, and collapsible weakly cemented soils
Peats and/or highly organic clays, where the thickness of peat or highly organic clay exceeds 3 m.
Very high plasticity clays with a plasticity index, PI > 75, where depth of clay exceeds 7.5 m
Very thick soft/medium stiff clays, where the depth of clay exceeds 35 m with $\bar{S}_u$ < 50 kPa</td></tr>
</table>

Mapped Spectral Acceleration

S_s = Bedrock acceleration at short period (0.2 s)

S_1= Bedrock acceleration at 1 sec.

S_s and S_1 must be determined from Map for **MCE=2% in 50 years**.

Site Coefficients and Spectral Response Parameters

SNI1726 2019 - Table 6: Site Coefficients, Fa

Site class	Earthquake spectral acceleration response parameter (MCE_R) mapped to short period, T=0.2 seconds, S_s					
	$S_s \leq 0.25$	$S_s = 0.5$	$S_s = 0.75$	$S_s = 1.0$	$S_s = 1.25$	$S_s \geq 1.5$
SA	0.8	0.8	0.8	0.8	0.8	0.8
SB	0.9	0.9	0.9	0.9	0.9	0.9
SC	1.3	1.3	1.2	1.2	1.2	1.2
SD	1.6	1.4	1.2	1.1	1.0	1.0
SE	2.4	1.7	1.3	1.1	0.9	0.8
SF	Site-specific response analysis required, see Cl. 6.10.1					

SNI1726 2019 Table 7: Site Coefficient, Fv

Site class	Earthquake acceleration spectral response parameter (MCE_R) mapped to period of 1 seconds, S_1					
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 = 0.5$	$S_1 \geq 0.6$
SA	0.8	0.8	0.8	0.8	0.8	0.8
SB	0.8	0.8	0.8	0.8	0.8	0.8
SC	1.5	1.5	1.5	1.5	1.5	1.4
SD	2.4	2.2	2.0	1.9	1.8	1.7
SE	4.2	3.3	2.8	2.4	2.2	2.0
SF	Site-specific response analysis required, see Cl. 6.10.1					

$$S_{MS} = F_a S_s \quad (5)$$

$$S_{M1} = F_v S_1 \quad (6)$$

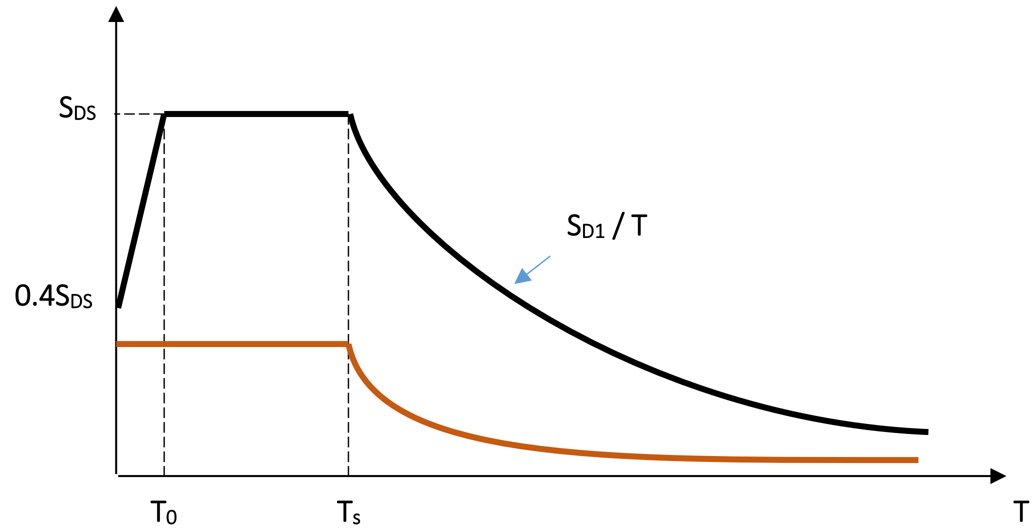
Design Spectral Acceleration

$$S_{DS} = \frac{2}{3} S_{MS} \quad (7)$$

$$S_{D1} = \frac{2}{3} S_{M1} \quad (8)$$

Elastic Response Spectrum

Reference Clause(s): 6.4

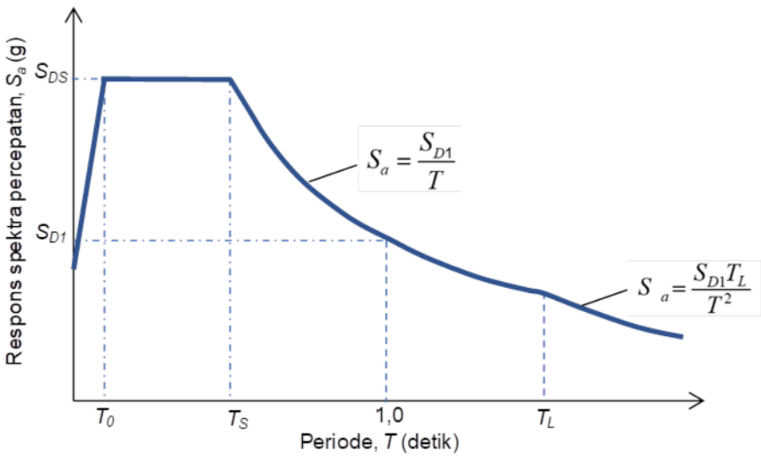


$$T < T_0 \Rightarrow S_a = S_{DS}\left(0.4 + 0.6\frac{T}{T_0}\right)$$

$$T_0 < T < T_s \Rightarrow S_a = S_{DS}$$

$$T > T_s \Rightarrow S_a = \frac{S_{D1}}{T}$$

$$where\ T_0 = 0.2\frac{S_{D1}}{S_{DS}}\ and\ T_s = \frac{S_{D1}}{S_{DS}}$$



Design Response Spectrum

Reference Clause(s): 7.8.1.1

$$T < T_s \Rightarrow C_s = \frac{S_{DS}\, I_e}{R}$$

$$T > T_s \Rightarrow C_s = \frac{S_{D1}\, I_e}{R\, T}$$

$$C_s \geq 0.044 S_{DS} I_e \geq 0.01$$

$$If\ S_1 \geq 0.6g \Rightarrow C_S \geq \frac{0.5 S_1}{\left(\frac{R}{I_e}\right)}$$

Calculation of Period

Vibration modes are automatically determined using eigenvalue analysis.

Maximum Value of Period

Reference Clause(s): 7.8.2

Condition 1:

$$T \leq C_u T_a$$

Table 14: Upper boundary of the calculated period

S_{D1}	Coefficient C_u
≥ 0.4	1.4
0.3	1.4
0.2	1.5
0.15	1.6
≤ 0.1	1.7

Condition 2:

$$T \leq T_a = C_t h_n^x$$

C_t and x values will be provided in the FED file. If they are empty, this check can be ignored.

Types of structure	C_t	x
Steel MRF	0.0724[a]	0.8
RC MRF	0.0466[a]	0.9
Steel MRF with Eccentric Brace	0.0731[a]	0.75
Steel MRF with Buckling Restrained Brace	0.0731[a]	0.75
All of other structures	0.0488[a]	0.75

Condition 3:

$$T \leq T_a = 0.1N$$

This is valid if structural system is **RC** or **Steel MRF** with **N ≤ 12** storeys and **Storey Height ≤ 3 m**

Equivalent Static Load Method

Notation:

F_x: Design Lateral Force Applied to Floor x
W_x: Total Dead Load Part of the structure on floor x
V: Base Shear
W: Seismic Weight of Structure
C_s: Seismic Response Coefficient
R: Behaviour Factor
I_e: Importance Factor
n: Live Load Participation Factor (0.25)

Base Shear Calculation

Reference Clause(s): 7.7.2

$$V = C_s W$$

W = G + n.Q (n = 0.25)

Cs will be taken directly from provided Design spectrum by using the period of dominant mode.

Base Shear Storey Distribution

$$F_x = C_{vx} V$$

$$C_{vx} = \frac{w_x h_x^k}{\sum_{i=1}^{n} w_i h_i^k}$$

Notation:

C_{vx}: Vertical distribution factor
V: Total base shear
w_i or w_x: Effective Seismic Weight
h_i or h_x: Height of storey from bottom
k: Exponent that depends on structure period

$$T \leq 0.5\ sec\ \Rightarrow k = 1$$

$$T \geq 2.5\ sec \Rightarrow k = 2$$

$$0.5 < T \leq 2.5 \Rightarrow k = Interpolate\ between\ 1\ and\ 2$$

Mode Superposition Analysis

Notations:

V: Base Shear Calculated by Equivalent Static Method
V_t: Base Shear by Mode Superposition
C_s: Seismic Response Coefficient

Analysis Method

Standard eigenvalue analysis and mode superposition method is used which is already implemented in PSSolver, the analysis engine of ProtaStructure.

Cumulative Mass Participation

Reference Clause(s): 7.9.1.1

Total mass participation must be at least 90%. If less than 90% a warning message will appear.

RSA – Equivalent Static Base Shear Comparison

Reference Clause(s): 7.9.2.5.2

$$Scale\ Factor = 1.0\ \frac{V}{V_t}$$

The scale factor coefficient (1.0) can be overridden by the user for regular and irregular cases.

Inter-storey Drift Scaling

Reference Clause(s): 7.9.4.2

$$if\ V_t < C_s W \Rightarrow Drift\ Scale\ Factor = \frac{C_s W}{V_t}$$

$$where\ C_S = \frac{0.5 S_1}{\left(\frac{R}{I_e}\right)}$$

Relative Storey Drift Check

Relative horizontal drift check is done in accordance with clause 7.8.6.

The limits are specified in clause 7.12.1 Table 20. These limits are similar to ones specified in ASCE7-16.

Modelling and Analysis

Cracked Sections

Reference Clause(s): 7.7.3.a, ASCE 12.7.3

Properties of concrete and brick element stiffnesses should consider the cracked section properties.

There is no mention of cracked section modifier values. Hence, ACI318-14 values are included here (ACI318 6.6.3.1.1)

Table 6.6.3.1.1(a)—Moment of inertia and cross-sectional area permitted for elastic analysis at factored load level

Member and condition		Moment of Inertia	Cross-sectional area
Columns		$0.70I_g$	$1.0A_g$
Walls	Uncracked	$0.70I_g$	
	Cracked	$0.35I_g$	
Beams		$0.35I_g$	
Flat plates and flat slabs		$0.25I_g$	

Load Combinations

Combinations for Ultimate Limit State Design (Cl. 4.2.2)

1) 1.4D
2) 1.2D + 1.6L + 0.5 (Lr or R)
3) 1.2D + 1.6(Lr or R) + (L or 0.5W)
4) 1.2D + 1.0W + L + 0.5(Lr or R)
5) 1.2D + 1.0E + L
6) 0.9D + 1.0W
7) 0.9D + 1.0E

Combinations for Allowable Stress Design (Cl. 4.2.3)

1) D
2) D + L
3) D + (Lr or R)
4) D + 0.75L + 0.75(Lr or R)
5) D + (0.6W or 0.7E)
6) D + 0.75 (0.6W or 0.7E) + 0.75L + 0.75 (Lr or R)
7) 0.6D + 0.6W
8) 0.6D + 0.7E

Combination of EQ Load (Cl. 7.4.2.3 and Cl. 7.4.3)

Basic Combination for Strength Design

Combinations 5 and 7 will be replaced as follows:

$0.2S_{DS}D$: Vertical EQ effect
ρ: Redundancy Factor (Will be input by the user)
Q_E: Internal force caused by EQ
Ω_0: Overstrength Factor (From Structural System Type)

With redundancy factor:

5) $(1.2 + 0.2S_{DS})D + \rho Q_E + L$
7) $(0.9 - 0.2S_{DS})D + \rho Q_E + 1.6H$

OR

With Overstrength Factor

5) $(1.2 + 0.2S_{DS})D + \Omega_0 Q_E + L$
7) $(0.9 - 0.2S_{DS})D + \Omega_0 Q_E + 1.6H$

Basic Combination for Allowable Stress Design

Combinations 5,6 and 8 will be replaced as follows:

With Redundancy Factor:

5) $(1.0 + 0.14S_{DS})D + H + F + 0.7\rho Q_E$
6) $(1.0 + 0.1S_{DS})D + H + F + 0.525\rho Q_E + 0.75L + 0.75(L_r\ or\ R)$
8) $(0.6 - 0.14S_{DS})D + 0.7\rho Q_E + H$

With Overstrength Factor

5) $(1.0 + 0.14S_{DS})D + H + F + 0.7\Omega_0 Q_E$
6) $(1.0 + 0.105S_{DS})D + H + F + 0.525\Omega_0 Q_E + 0.75L + 0.75(L_r\ or\ R)$
8) $(0.6 - 0.14S_{DS})D + 0.7\Omega_0 Q_E + H$

Thank You...

Thank you for choosing the ProtaStructure Suite product family.

It is our top priority to make your experience excellent with our software technology solutions.

Should you have any technical support requests or questions, please do not hesitate to contact us at all times through globalsupport@protasoftware.com and asiasupport@protasoftware.com

Our dedicated online support center together with our responsive technical support team is available to help you get the most out of Prota's technology solutions.

The Prota Team

ProtaStructure®
ProtaSteel®
ProtaDetails®
ProtaBIM®