International Journal of Innovative Research in Computer Science and Technology (IJIRCST)
ISSN (online): 2347-5552, Volume-10, Issue-5, September 2023
https://doi.org/10.55524/ijircst.2023.11.5.4
Article ID IRP1410, Pages 23-29
www.ijircst.org

Comparison of Design Response Spectra in SNI 1726:2012 and SNI 1726:2019

Irwan[1], and Samsul Abdul Rahman Sidik Hasibuan[2]

[1,2] Department of Civil Engineering, Universitas Medan Area, Medan, Indonesia

Correspondence should be addressed to Abdul Rahman Sidik Hasibuan; samsulrahman@staff.uma.ac.id

ABSTRACT- At the end of 2019, the Indonesian National Standards Agency issued new regulations regarding procedures for earthquake resistance planning in building and non-building structures or SNI 1726:2019. The existence of new regulations will certainly be one of the issues that need attention regarding the safety of buildings designed based on old regulations or SNI 1726:2012. This paper aims to compare spectral acceleration designs based on SNI 1726:2012 and SNI 1726:2019 for several cities in Indonesia, namely Medan, Banda Aceh, Bengkulu, Padang, Bandar Lampung, Yogyakarta, Surabaya, Palu, Ambon and Jayapura.

The comparison results show that in hard (SC) and medium (SD) soil conditions, almost all cities surveyed experienced increased spectral acceleration values except for Medan and Surabaya, where the values were the same. The increase in the spectral acceleration value in hard (SC) and medium (SD) soil conditions was very significant in the cities of Palu, Jayapura, and Bengkulu. However, in soft soil (SE), almost all survey cities experienced a decrease in spectral acceleration, except for Medan and Surabaya, where the spectral acceleration values were the same. Considering that the results of spectral design comparisons in several cities have increased, it is important to re-evaluate the existing building structures.

KEYWORDS- Earthquake, Spectrum Response, SNI 1726:2012, SNI 1726:2019.

I. INTRODUCTION

At the end of 2019, the Indonesian National Standardization Agency approved procedures for planning earthquake resistance for buildings and non-buildings or SNI 1726:2019 to refine procedures for planning earthquake resistance for buildings and non-buildings or SNI 1726:2012. According to Arfiadi, if researched, earthquake SNI is universal. SNI Earthquake 2012 (National Standardization Agency, 2012) refers to ASCE 7-10 (2010) [1]. ASCE 7-10 is a refinement of the ASCE 7-05 (2005) regulations [2]. In 2017, ASCE issued the latest regulations or standards, namely ASCE 7-16 (2017), to refine ASCE 7-10. In SNI 1726:2019 and SNI 1726:2012, the parameters Ss (acceleration of bedrock in a short period) and S1 (acceleration of bedrock in a period of 1 second) are determined respectively from the acceleration spectrum response of 0.2 seconds and 1 second in unit time. Seismic ground movement map with a probability of exceeding 2% in 50 years (MCER, 2% in 50 years) and expressed in decimal acceleration numbers due to gravity [3].

The 0.2 second and 1 second spectral response acceleration maps in this paper are based on the 2017 Indonesian earthquake and earthquake hazard source map with an attenuation ratio of 5% in bedrock with a probability of exceeding 2% in 50 years. With SNI 1726:2019, all new buildings to be designed must comply with these regulations, and all existing structures must be evaluated based on the latest existing regulations for the safety of human life [4]. This paper aims to compare spectral designs based on SNI 1726:2012 and SNI 1726:2019 in several cities in Indonesia, including Medan, Banda Aceh, Bengkulu, Padang, Bandar Lampung, Yogyakarta, Surabaya, Palu, Ambon, and Jayapura, by showing design comparisons. Spectral will certainly make this problem even more serious if it turns out that the difference in results is very significant.

A. *Design Response Spectra Based on SNI 1726:2012*

According to SNI 1726:2012, seismic amplification aspects are needed to determine the response of the MCER earthquake acceleration spectra at the ground surface at a period of 0.2 seconds and a period of 1 second. The amplification aspect includes the vibration amplification aspect related to acceleration, which represents short-period vibrations (Fa), and the acceleration-related amplification aspect, which means vibrations with a period of 1 second (Fv). The acceleration spectral response parameters in the short period (SMS) and 1 second period (SM1), adjusted for the effect of location classification, must be determined based on equations 1 and 2 [5-8].

$$S_{Ms} = F_a \times S_s \quad (1)$$

$$S_{M1} = F_v \times S_1 \quad (2)$$

Where Fa and Fv are determined based on Table 1 and Table 2, Ss is the MCER earthquake acceleration spectra response parameter mapped in a short period, and S1 is the MCER earthquake acceleration spectra response parameter mapped in a 1 second period. The design spectral acceleration parameter for a short period (SDS) and 1 second period (SD1) must be determined based on equations 3 and 4. For periods greater than Ts, the design acceleration spectral response, Sa, is calculated according to equation 5,6, dan 7.

$$S_{ds} = \frac{2}{3} \times S_{Ms} \quad (3)$$

$$S_{d1} = \frac{2}{3} \times S_{M1} \quad (4)$$

$$S_a = \frac{S_{d1}}{T} \quad (5)$$

$$T_0 = 0{,}2 \frac{S_{d1}}{S_{ds}} \quad (6)$$

$$T_S = \frac{S_{d1}}{S_{ds}} \quad (7)$$

Table 1: Site coefficient, Fa

Site class	Response parameters from the earthquake acceleration spectra (MCER) targeting the maximum risk considered to be mapped in a short period, T = 0.2 seconds, Ss				
	Ss ≤ 0.25	Ss = 0.5	Ss = 0.75	Ss = 1.0	Ss ≥ 1.25
SA	0.8	0.8	0.8	0.8	0.8
SB	1.0	1.0	1.0	1.0	1.0
SC	1.2	1.2	1.1	1.0	1.0
SD	1.6	1.4	1.2	1.1	1.0
SE	2.5	1.7	1.2	0.9	0.9

Table 2: Site coefficient, Fv

Site class	Response parameters from the earthquake acceleration spectra (MCER) targeting the maximum risk considered to be mapped in a long period, T = 1 seconds, S1				
	Ss ≤ 0.25	Ss = 0.5	Ss = 0.75	Ss = 1.0	Ss ≥ 1.25
SA	0.8	0.8	0.8	0.8	0.8
SB	1.0	1.0	1.0	1.0	1.0
SC	1.2	1.2	1.1	1.0	1.0
SD	1.6	1.4	1.2	1.1	1.0
SE	2.5	1.7	1.2	0.9	0.9

B. Design Response Spectra Based on SNI 1726:2019

According to SNI 1726:2019, the short period (SMS) and 1-second period (SM1) acceleration spectrum response parameters, adjusted for the effect of location classification, must be determined based on equations 1 and 2. However, to determine Fa and Fv it is determined based on Table 3 and Table 4. Ss is the response parameter of the MCER earthquake acceleration spectra, which is mapped in a short period, and S1 is the response parameter of the MCER earthquake acceleration spectra, which is mapped in a period of 1 second [9-11]. The design spectral acceleration parameter for a short period (SDS) and 1 second period (SD1) must be determined based on equations 3 and 4.

Table 3: Site coefficient, Fa

Site class	Response parameters from the earthquake acceleration spectra (MCER) targeting the maximum risk considered to be mapped in a short period, T = 0.2 seconds, Ss				
	Ss ≤ 0.25	Ss = 0.5	Ss = 0.75	Ss = 1.0	Ss ≥ 1.25
SA	0.8	0.8	0.8	0.8	0.8
SB	0.9	0.9	0.9	0.9	0.9
SC	1.3	1.3	1.2	1.2	1.2
SD	1.6	1.4	1.2	1.1	1.0
SE	2.4	1.7	1.3	1.1	0.9

Table 4: Site coefficient, Fv

Site class	Response parameters from the earthquake acceleration spectra (MCER) targeting the maximum risk considered to be mapped in a long period, T = 1 seconds, S1				
	Ss ≤ 0.25	Ss = 0.5	Ss = 0.75	Ss = 1.0	Ss ≥ 1.25
SA	0.8	0.8	0.8	0.8	0.8
SB	0.8	0.8	0.8	0.8	0.8
SC	1.5	1.5	1.5	1.5	1.5
SD	2.4	2.2	2.0	1.9	1.8
SE	4.2	3.3	2.8	2.4	2.2

II. METHOD

The analysis method is done numerically by calculating based on the equations in each regulation. The first step is determining the Ss and S1 values from the sources and the 2017 Indonesian earthquake hazard map. In more detail, the analysis flowchart is shown in Figure 1.

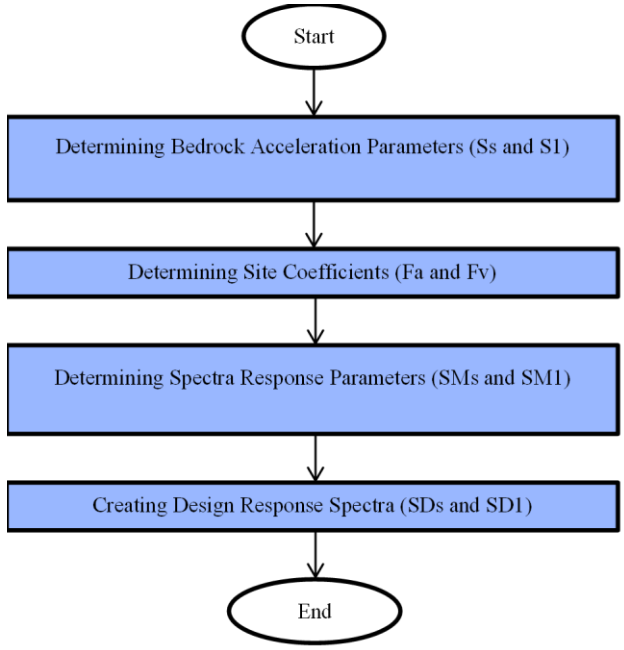


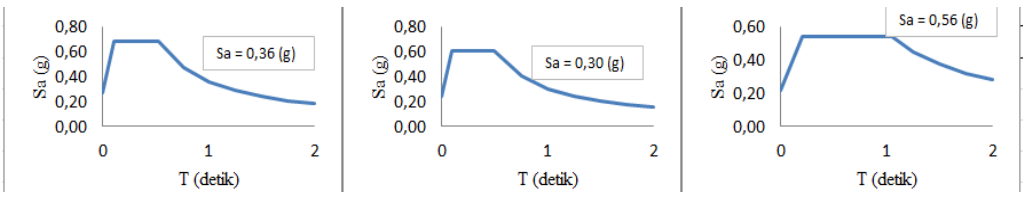
Figure 1: Pervasive wireless grid

III. RESULT

In this paper, the Sa value is taken when T = 1 second, with the help of the 2017 Indonesian earthquake and hazard source map with an attenuation ratio of 5% in the bedrock for a probability of exceeding 2% in 50 years, the Fa and Fv values are obtained, for T0 and Ts calculated based on equations 5 and 6. In cities such as Banda Aceh, Padang, Palu, and Jayapura, which have Ts values greater than 1 second, the design acceleration spectra value when T = 1 second is the same as SDS. Next, the spectral response design results based on SNI 1726:2012 and SNI 1726:2019 in several selected cities in Indonesia are displayed.

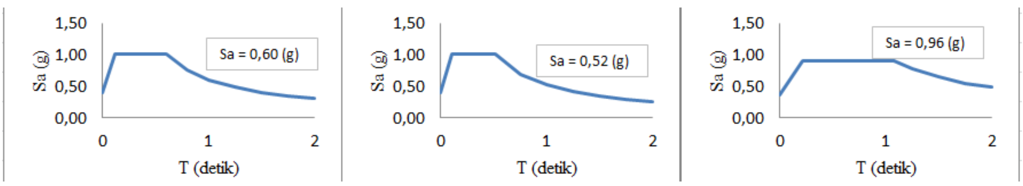
A. Design Response Spectra Based on SNI 1726:2012

Figures 2-11 respectively show the results of the design response spectra in selected cities such as Medan, Banda Aceh, Bengkulu, Padang, Bandar Lampung, Yogyakarta, Surabaya, Palu, Ambon, and Jayapura.



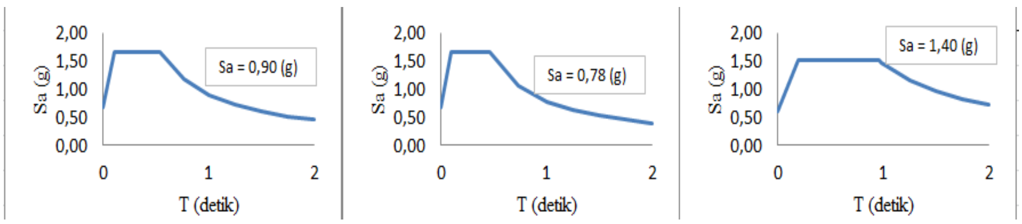
Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 2: Design response spectra in Medan City



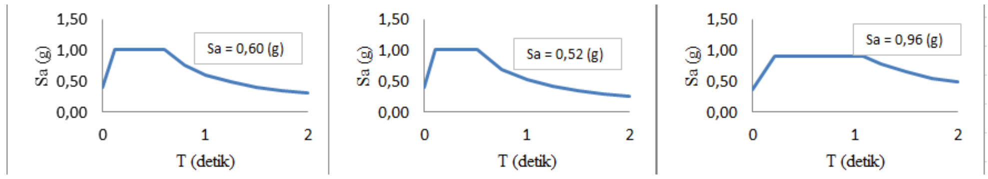
Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 3: Design response spectra in Banda Aceh City



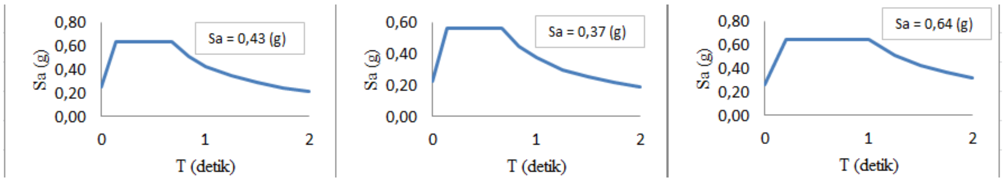
Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 4: Design response spectra in Bengkulu City



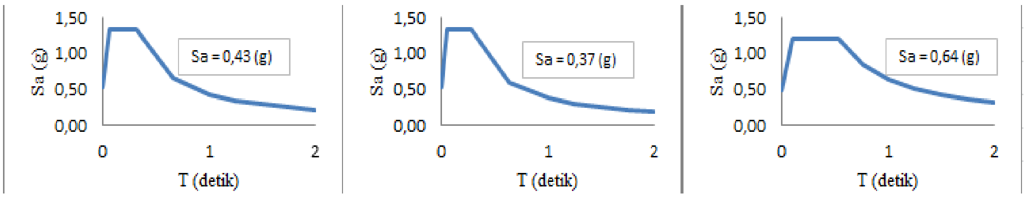
Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 5: Design response spectra in Padang City



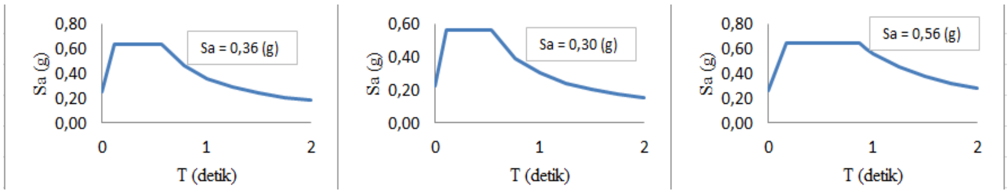
Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 6: Design response spectra in Bandar Lampung City



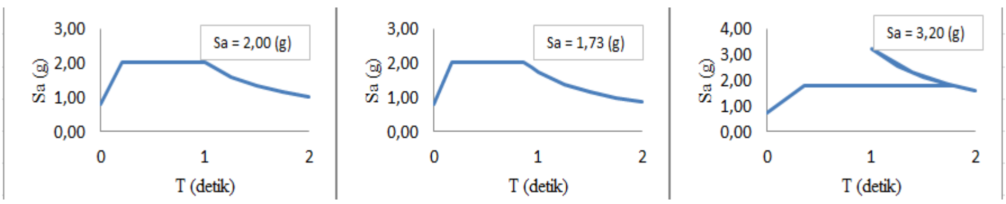
Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 7: Design response spectra in Yogyakarta City



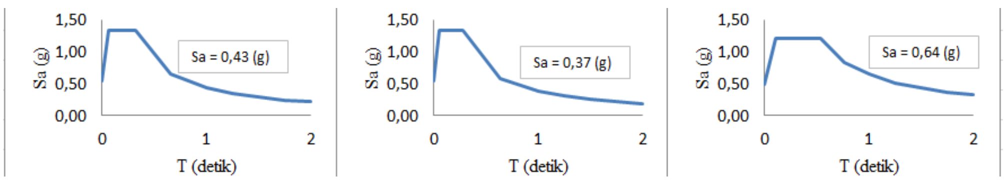
Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 8: Design response spectra in Surabaya City



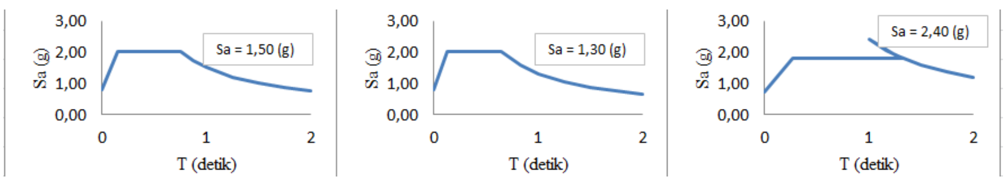
Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 9: Design response spectra in Palu City



Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 10: Design response spectra in Ambon City



Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 11: Design response spectra in Jayapura City

B. Design Response Spectra Based on SNI 1726:2019

For periods greater than Ts but smaller than or equal to TL, the design acceleration spectral response, Sa, is calculated based on equation 4. Where T is the fundamental vibration period of the structure, in this paper, the value of Sa is taken when T = 1 second, with the help of a map of hazard sources and Indonesian earthquakes with an attenuation ratio of 5% in bedrock for a probability of exceeding 2% in 50 years obtained Fa and Fv values, for T0 and Ts calculated based on equations 5 and 6. In cities such as Palu and Jayapura, which have higher Ts values from 1 second, the design acceleration spectrum value at time T = 1 second is taken to be the same as SDS. Figures 11-21 respectively show the results of the design response spectra in selected cities such as Medan, Banda Aceh, Bengkulu, Padang, Bandar Lampung, Yogyakarta, Surabaya, Palu, Ambon, and Jayapura.

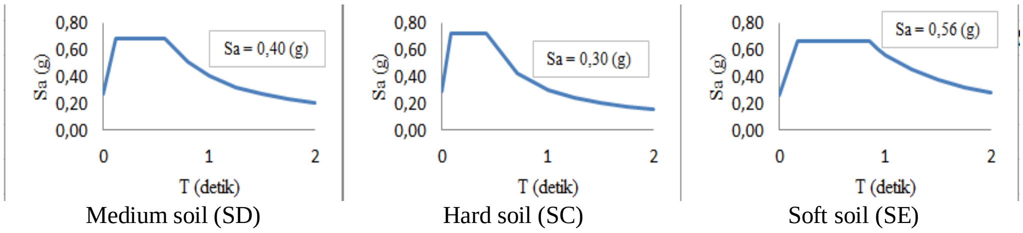


Figure 12: Design response spectra in Medan City

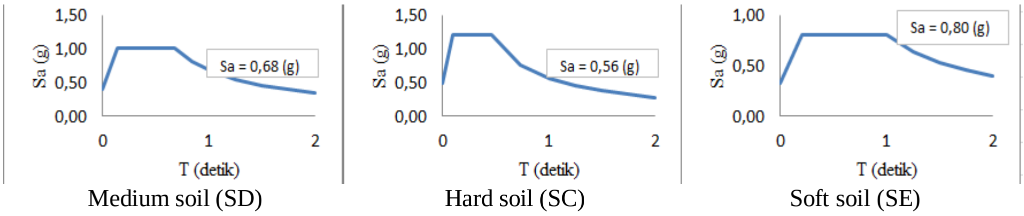


Figure 13: Design response spectra in Banda Aceh City

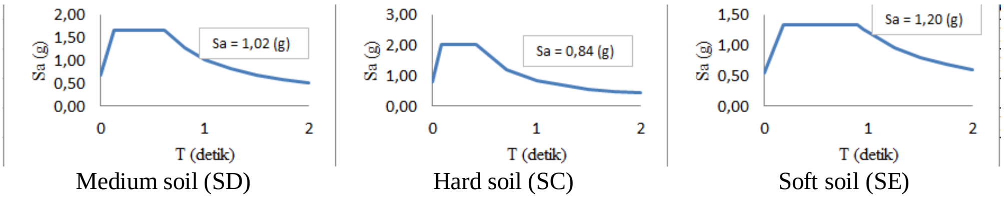


Figure 14: Design response spectra in Bengkulu City

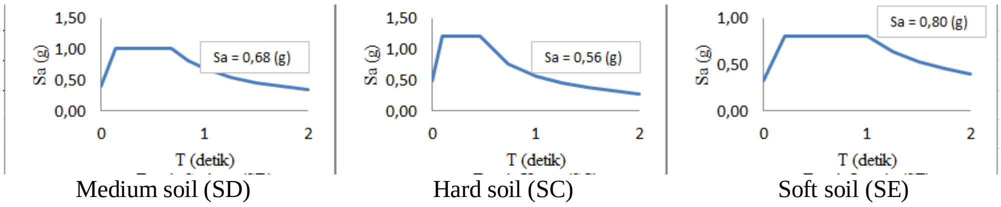


Figure 15: Design response spectra in Padang City

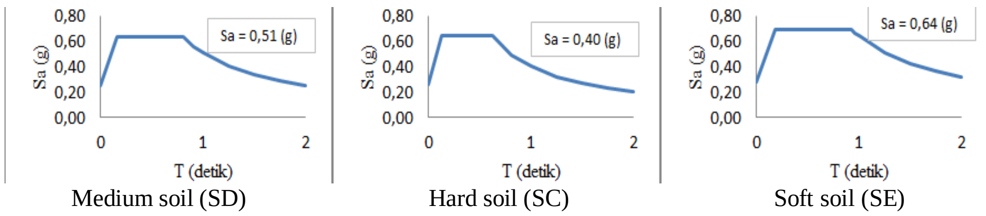


Figure 16: Design response spectra in Bandar Lampung City

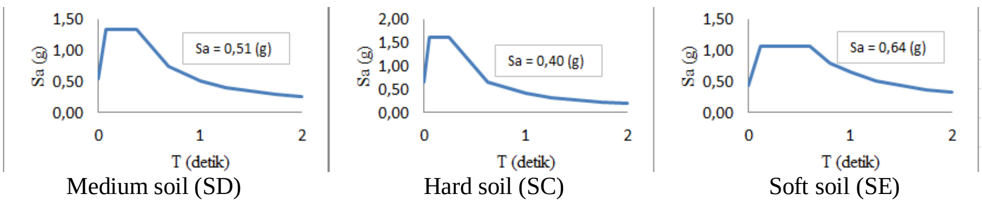
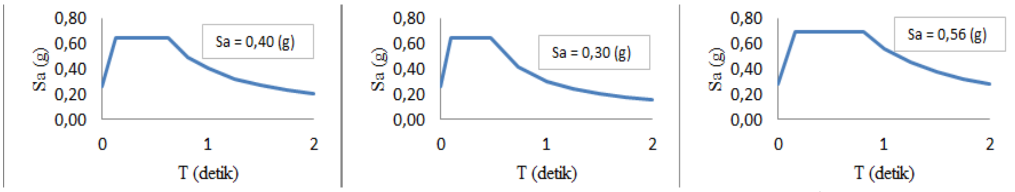
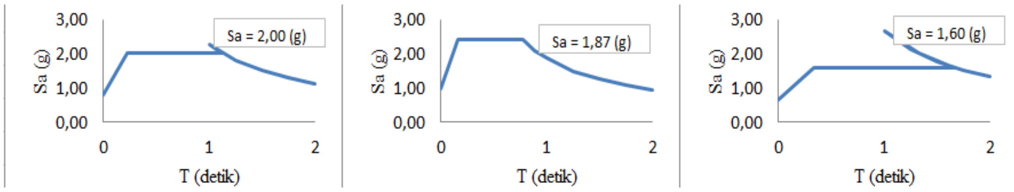


Figure 17: Design response spectra in Yogyakarta City



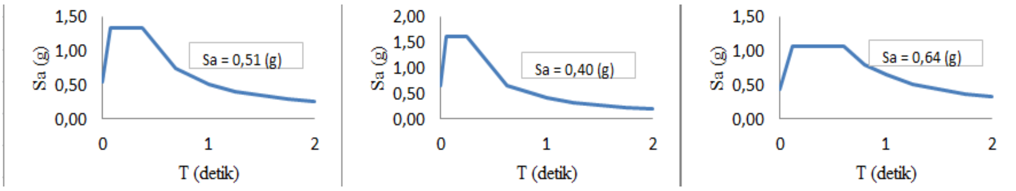
Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 18: Design response spectra in Surabaya City



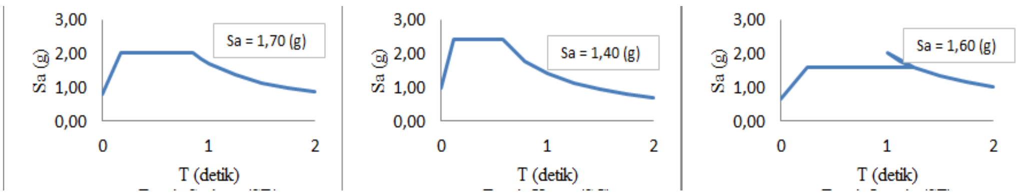
Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 19: Design response spectra in Palu City



Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 20: Design response spectra in Ambon City



Medium soil (SD) Hard soil (SC) Soft soil (SE)

Figure 21: Design response spectra in Jayapura City

C. Comparison Design Response Spectra SNI 1726:2019 and SNI 1726:2019

The Ss and S1 values shown in Tables 1 and 2 for SNI 1726:2012 and Tables 3 and 4 for SNI 1726:2019 appear to have differences where SNI 1726:2019 adds a greater Ss value equal to 1.5 and a greater S1 equals 0.6 while in SNI 1726:2012 Ss is only reviewed up to 1.25 and S1 is 0.5. The site coefficients for Fa and Fv for each site class contained in SNI 1726:2019 also experience a change in value, causing the value of Sa in several selected cities to increase. The following shows a comparison of the value of Sa in Figure 22.

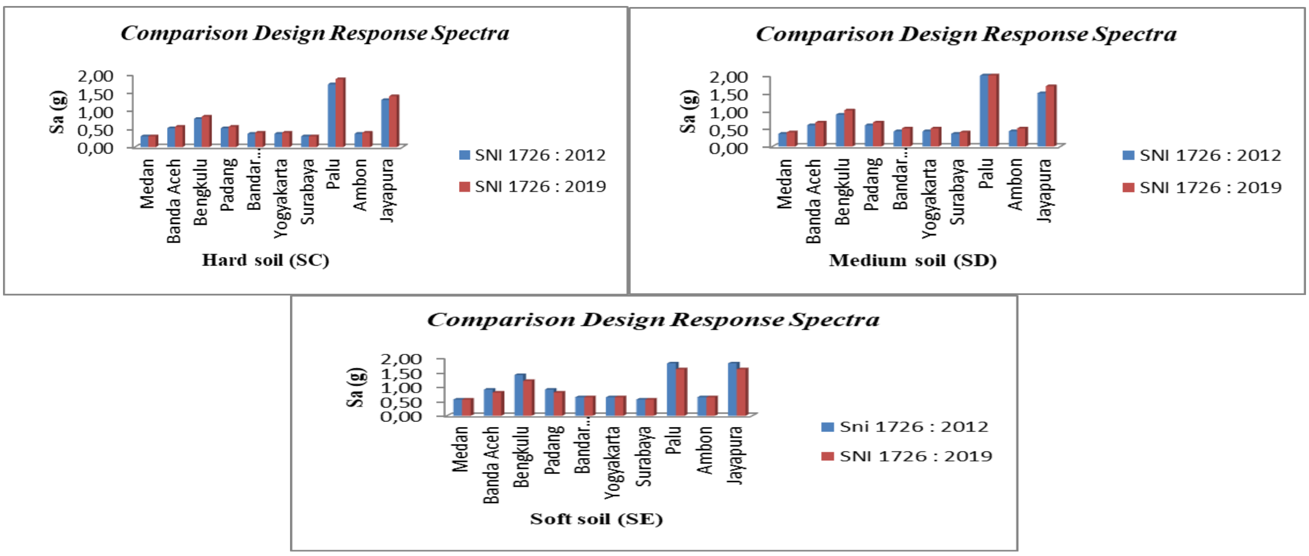


Figure 22: Comparison design response spectra SNI 1726:2019 and SNI 1726:2019

Figure 22 for hard soil (SC) shows that in SNI 1726:2019, the value of Sa experienced a significant increase in the cities of Palu, Jayapura, and Bengkulu with successive differences of 0.14 (g), 0.10 (g), and 0.06 (g), greater than the Sa value in SNI 1726:2012. For medium soil (SD) in SNI 1726:2019, the Sa value has increased significantly in the cities of Jayapura and Bengkulu with a difference of 0.20 (g) and 0.12 (g) greater than the Sa value in SNI 1726:2012. For soft soil (SE) in SNI 1726:2019, the Sa value has decreased by 0.20 (g) from the Sa value in SNI 1726:2012 in Palu, Jayapura, and Bengkulu.

IV. CONCLUSION

The design response spectra and response spectra acceleration values have been displayed and discussed for selected cities in Indonesia. Based on the results of the comparison between SNI 1726:2012 and SNI 1726:2019 that have been presented, it is concluded that for the hard soil (SC) and medium soil (SD) site classes, the Sa value has increased in almost all review cities except Medan and Surabaya, which have the same value. However, for soft soil (SE), almost all cities experienced a decrease in Sa values except for Medan and Surabaya, which experienced the same Sa values.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

[1] Y. Arfiadi, "Perbandingan Spektra Desain Beberapa Kota Besar Di Indonesia Dalam SNI Gempa 2012 dan SNI Gempa 2002," In Konferensi Nasional Teknik Sipil 7 (Konteks 7), 2013, Hal. 299–306.

[2] ASCE 7-10, Minimum Design Loads For Buildings And Other Structures. Reston, Virginia: American Society Of Civil Engineers, 2010.

[3] Pusgen, Peta Sumber Dan Bahaya Gempa Indonesia, 1 Ed. Jakarta, 2017.

[4] Team Teaching Teknik Gempa, Respon Spektra Gempa Desain SNI 1726-2019. Mataram, 2019.

[5] SNI 1726, Tata Cara Perencanaan Ketahanan Gempa Untuk Struktur Bangunan Gedung Dan Non Gedung. Jakarta: Bsn, 2012.

[6] M. S. Meassa, "Studi Perbandingan Respon Spektra Kota Tarutung Berdasarkan SNI 03-1726-2002 dan SNI 1726:2012 Untuk Evaluasi Pelaksanaan Bangunan Tahan Gempa," In Konferensi Nasional Teknik Sipil 7 (Konteks 7), 2013, Hal. 24–26.

[7] F. Sari, "Respon Spektra Gempa Desain Berdasarkan SNI 03-1726-2012 Untuk Wilayah Kota Palembang," Teknika, Hal. 50–61, 2014.

[8] D. N. Afriandini, B & Saputro, "Analisis Gaya Geser Dasar Seismik Berdasarkan SNI-03-1726- 2002 dan SNI 1726:2012 Pada Struktur Gedung Bertingkat," Techno, Vol. 19, No. 2, Hal. 95–102, 2018.

[9] SNI 1726, Tata Cara Perencanaan Ketahanan Gempa Untuk Struktur Bangunan Gedung dan Non Gedung. Jakarta: Bsn, 2019.

[10] Sari, F., "Perhitungan Respon Spektra Percepatan Gempa Kota Palembang Berdasarkan SNI 1726;2019 Sebagai Revisi Terhadap SNI 1726;2012," Teknika, Vol. 6, No. 2, Hal. 167–177, 2019.

[11] Rizcha, T., "Perbandingan Desain Respon Spektra Pada Permukaan Tanah Di Tempat Evakuasi Kota Banda Aceh Berdasarkan SNI 1726-2002 dan SNI 1726-2012 Dengan Peta Bahaya Gempa 2017," J. Pendidik. Geos., Vol. Iii, No. 2, Hal. 31–40, 2018.

ABOUT THE AUTHORS

Irwan was born in Medan, Indonesia in 1959. He obtained his B.Eng. in Civil Engineering from Universitas Sumatera Utara, Indonesia, the M.Eng. in Civil Engineering from Institut Teknologi Bandung, Indonesia. Since 1990, he has been a faculty member at the Department of Civil Engineering, Faculty of Engineering, Universitas Medan Area. His research interests include modeling of concrete behavior, steel structure, materials in cement and concrete.

Samsul Abdul Rahman Sidik Hasibuan was born in Dili, Timor Leste in 1997. He obtained his B.Eng. in Civil Engineering from Universitas Teknologi Yogyakarta, Indonesia, and the M.Eng. in Civil Engineering from Universitas Atma Jaya Yogyakarta, Indonesia. Since 2021, he has been a faculty member at the Department of Civil Engineering, Faculty of Engineering, Universitas Medan Area. He is the author of more than 30 articles. His research interests include modeling of concrete behavior, earthquake assessment, special concrete, use of wastes and recycled materials in cement and concrete.