Comparative study on using of SNI 1726-2012 and SNI 1726-2019 for calculating of internal force magnitude of lecture building in D.I. Yogyakarta Province

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Abstract. The application of SNI 1726-2019 as a new standard has added and changed the scope of the procedure for calculating earthquakes to become wider so that it can keep up with the times. Earthquake loads can be analyzed statically or dynamically. Dynamic analysis using the response spectrum method. This study aims to compare the results of the calculation using the response spectrum based on SNI 1726-2012 and SNI 1726-2019 so that it can be seen whether buildings using the old rules are still safe or not. The building structure is modeled as an ordinary building and functions as a lecture building in the Province of D.I Yogyakarta with a total of 4 floors and a building height of 24.054 m. The results of the research prove that the forces acting on the building with modeling use the response spectrum of SNI 1726-2012 and SNI 1726-2019, the building structure scheme using the old standard is given a small safe limit, if a review is carried out using the new standard the structure of the building is required to be rehabilitated in preventing building construction failures. However, if a large safety limit is given in the planning using the old standard, if a review is carried out based on the new standard, it is possible that the building structure does not need to be rehabilitated if it meets the safety limit of the new standard.

1. Introduction
SNI 1726: 2012 earthquake scheme is determined with a probability of exceeding the magnitude of the age of the 50-year building structure by 2% or an earthquake with a return period of 2,500 years [1]. Since the issuance of the rules for Establishing Indonesian National Standard (SNI) 1726: 2019 Earthquake Resistance Planning Procedures for Building Structures and Buildings as a Revision of SNI 1726: 2012 Earthquake Resistance Planning Procedures for Structures and Buildings [2,3].

In this standard the scope is expanded considering the discovery of a national earthquake that is included in the 2017 Hazard. Many buildings have been established using SNI 1726: 2012 during the planning process, so it is necessary to evaluate an earthquake resistance assessment from SNI 1726: 2012 to SNI 1726: 2019 to find out which buildings are still safe to live in or need to be rehabilitated.

The search for earthquake resistance in buildings can be analyzed both statically and dynamically. In dynamic analysis, there are two analytical methods used, such as the response spectrum and time
history. The time history of the earthquake acceleration provides information about the magnitude of ground acceleration due to the earthquake during the duration or time of the earthquake [4].

2. Loadings
In this study, two types of loads are used, namely: i) gravitational loads which include dead and live loads, and ii) lateral loads which include earthquake loads.

2.1. Gravity load
The loads that work in this building include dead loads and live loads. Dead loads and live loads based on PPIUG 1983 & PPURG 1987 refer to SNI 2847-2013. Dead loads and live loads work as distributed loads in buildings. Dead loads are the weight of all parts of a fixed building, including everything that is not additional, discussed - completion, machinery and equipment that are an integral part of the building [5]. Based on SNI 1727-2013, the living load for the lecture building is 1.92 kN / m2 and 4.5 kN centrally

2.2. Lateral load
Lateral load in this study is earthquake load with response spectrum method between SNI 1726-2012 and SNI 1726-2019.

2.2.1. Design spectrum responses
Dynamic analysis for the design of earthquake-resistant structures is carried out if evaluation is more accurate in the seismic forces acting on the structure is needed, and to see the behavior of the structure due to the effects of the earthquake on multi-storey buildings with regular or irregular shapes.

Dynamic analysis can be carried out in an elastic or inelastic way, in which the elastic method is distinguished by Time History Modal Analysis, where this method requires recording the earthquake acceleration and analyzing the Spectrum Modal Variation (Response Spectrum Modal Analysis), where this method is the maximum response of each vibration which is obtained from the Plan Response Spectra [6].

Based on study by [7] the value of N-SPT around D.I Yogyakarta is 20.

Spectral response is a spectrum that is displayed in the form of a graph / plot between the vibrating period of the T structure, versus the maximum responses based on a particular earthquake and damping ratio [8].

The stages of the spectrum response design are as follows [8]:
- Determine the location of the building.
- Determine the acceleration parameter of the maximum earthquake response spectrum that takes into account the risk-targeted maximum \( M_{\text{CER}} \) (Maximum Considered Earthquake, Risk Targeted) for short periods of 0.2 seconds (\( S_S \)) and 1.0 seconds (\( S_I \)).
- Determine the mapped coefficient of 0.2 second spectral response period (\( C_{\text{rS}} \)) and 1 second spectral response period (\( C_{\text{rI}} \)).
- Determine the classification of soil types.
- Determine the amplification factor of the ground surface acceleration response spectrum for a short period (\( F_a \)) and a period of 1 second (\( F_v \)).
- Determines the response parameters of the acceleration spectrum (\( S_{MS} \) and \( S_{M1} \)).
  \[ S_{MS} = F_a \cdot S_S \]
  \[ S_{M1} = F_v \cdot S_I \]
- Defines the response parameters of the design acceleration spectrum (\( S_{DS} \) and \( S_{D1} \)).
  \[ S_{DS} = 2/3 \cdot S_{MS} \]
  \[ S_{D1} = 2/3 \cdot S_{M1} \]
- Create a design spectrum response
2.3 Internal force
Inner force is a force consisting of axial, latitude, and moment forces. When the earthquake force acts on the building it causes the building to exert internal forces, if the internal force exceeds the capacity of the building, the result is that the building will behave inelastically if the structure is ductile enough, but it will immediately collapse if it is not ductile enough [9].

3. Method
This study aims to assess and evaluate changes in the response spectrum in lecture buildings that are still using SNI 1726-2012 planning and compared with SNI 1726-2019, after calculating the response spectrum, continue by running the model in modeling application software with the Dynamic method (Response Spectrum). Then compare the internal strength values such as Mu, Pu, and Vu. Build modeling using 3D in structural modeling application software.

Based on the established methodology, the study can be explained as below:

1) Initial data collection related to the needs of response spectrum analysis as follows:
   - Building data
     Location: D.I Yogyakarta Province
   - Structure data
     Fc Concrete: 25 Mpa
     Plain Reinforcement steel $f_y = 240 \text{ Mpa (BJTP - 24)}$
     Deformation Reinforcement Steel $f_y = 400 \text{ Mpa (BJTD - 40)}$
     Bolt = HTB A 325 X
     Las = E 60 XX
2) The load for the lecture building structure uses the standard combination of the SNI 2847-2013 load structure and the load data that works on the building structure is obtained as follows:

- Live Load in the classroom: 1.92 kN/m²
- Live load on the roof: 0.96 kN/m²
- Dead Load on floors with brick walls: 2.452 kN/m²
- Dead load on floors without brick walls: 1.392 kN/m²
- Dead load on the roof (joint point): 22.867 kN/m³

3) To get the Spectrum Response graph using the earthquake response spectrum response standards SNI 1726-2012 and SNI 1726-2019, and obtained the following data:

\[\begin{array}{|c|c|c|}
\hline
\text{SNI 1726-2012} & \text{SNI 1726-2019} \\
\hline
S_{MS} & \text{Fa} \cdot S_1 & \text{Fa} \cdot S_1 \\
S_{MI} & \text{Fv} \cdot S_1 & \text{Fv} \cdot S_1 \\
S_{DS} & \frac{2}{3} S_{MS} & \frac{2}{3} S_{MS} \\
S_{DI} & \frac{2}{3} S_{MI} & \frac{2}{3} S_{MI} \\
T_0 & 0.2 \cdot \frac{S_{DI}}{S_{DS}} & 0.2 \cdot \frac{S_{DI}}{S_{DS}} \\
T_s & \frac{S_{DI}}{S_{DS}} & \frac{S_{DI}}{S_{DS}} \\
T_a & C_T \cdot h_a^3 & C_T \cdot h_a^3 \\
T & \text{Ta} & \text{Ta} \\
S_a & \frac{S_{DS}}{0.4+0.6 \cdot (T/T_0)} & \frac{S_{DS}}{0.4+0.6 \cdot (T/T_0)} \\
S_a & S_{DS} & S_{DS} \\
S_a & \frac{S_{DI}}{T} & \frac{S_{DI}}{T} \\
T_L & - & \text{Based on the transitional map} \\
& & \text{of the long period of} \\
& & \text{Indonesian territory} \\
\hline
\end{array}\]

4) Structural analysis uses a 3-dimensional structure modeling software application. When analyzing, one frame is taken to be used as a 2D model to make it easier to review. Modeling and frame taking can be seen in Figures 3 and 4.

5) Then do a comparative analysis of the results between the SNI 1726-2012 response spectrum loading method and SNI 1726-2019 to see the ability of the lecture building structure to withstand earthquakes when compared to the SNI 1726-2019 response spectrum method.

![Figure 3. 3D models in modeling software application](image)
4. Result and discussion

4.1. Calculation of earthquake loading with SNI 1726-2012 and SNI 1726-2019.

The spectrum response graph is obtained based on the spectrum response method specified in SNI 1726-2012 and SNI 1726-2019, the value obtained is then entered into the modeling application software to obtain a spectrum response graph that used to determine the earthquake resistance of a building.

| Value               | SNI 1726-2012 | SNI 1726-2019 |
|---------------------|---------------|---------------|
| $S_{DS}$            | 0.5           | 0.6           |
| $S_{D1}$            | 1             | 1             |
| $T_0$               | 0.1           | 0.12          |
| $T_s$               | 0.5           | 0.6           |
| $T_a$               | 0.815         | 0.815         |
| $T$                 | 0.815         | 0.815         |
| $S_a = S_{DS} (0.4 + 0.6 x(T/T_0))$ | 5.29         | 4.475         |
| $S_a = S_{DS}$      | 1             | 1             |
| $S_a = S_{D1}/T$    | 0.613         | 0.736         |
| $T_L$               | -             | 20            |

From the SNI 1726-2012 and SNI 1726-2019 methods, the response spectrum graphs are obtained in Figures 5 and 6.
Based on the graphic image above, there is a difference in the length of the period between the two, where the SNI 1726-2019 response spectrum graph has a longer period due to the increased consideration of earthquake calculations because the Indonesian earthquake region has different fault structures. In addition, there are differences in the parameter of values in short-period spectrum acceleration (SDS) due to the discovery of new earthquake faults which cause the SDS value to increase in size in SNI 1726-2019. This change causes the T0, TS and Sa values at SNI 1726-2012 to change significantly in SNI 1726-2019. To clarify the changes that occur in the inner style (Mu, Pu, Vu) of the lecture building structure, comparison data of SNI 1726-2012 and SNI 1726-2019 will be presented as follows.

From the table above shows that the force in the structure of a lecture building which is reviewed based on SNI 1726-2012, some of the data exceeds the internal force that works based on SNI 1726-2019, proving that planning using SNI 1726-2012 tends to be able to withstand earthquake loads based on SNI 1726-2019 so that the structure of the lecture building is still suitable for use, even if there are only minor rehabilitation correction.

The earthquake resistance of the lecture building structure with the planning of SNI 1726-2012 is calculated to be able to withstand earthquake loads using the latest SNI 1726-2019 standards, although there are differences in earthquake faults position found. This is inversely proportional to previous findings where other buildings if they still use old planning such as the SNI 1726-2002 method must receive rehabilitation so that they are able to withstand loads based on the SNI 1726-2012 method [10,11,12].
Based on the facts found, it can be seen that there is a correlation of changes between the updating of the earthquake map data and the resistance of the building structure where usually if the building structure planning uses the old standard which gives too small a safe limit, then if the new standard planning is applied, recommendations for rehabilitation are usually given because the building is considered incapable to withstand the forces that occur based on the new standard. If the building planning with the old standard is given a greater safe limit, when a review is applied using the new standard, rehabilitation usually does not need to be carried out considering the resilience of the building structure has met the new standard.

5. Conclusions.
Based on the above discussion, it can be concluded that the building structure scheme using the old standard is given a small safe limit, if a review is carried out using the new standard, the building structure is required to be rehabilitated to prevent building construction failure. However, if a large safety limit was given in the planning using the old standard, then review is carried out based on the new standard, it is possible that the building structure does not need to be rehabilitated if it meets the safety limit of the new standard.

Tabel 2. Comparison of internal force between SNI 1726-2012 and SNI 1726-2019

| Element | Pu | Vu | Mu |
|---------|----|----|----|
| SNI 1726-2012 | SNI 1726-2019 | SNI 1726-2012 | SNI 1726-2019 | SNI 1726-2012 | SNI 1726-2019 |
| 81 | 265.608 | 245.849 | 5.439 | 4.186 | 19.6839 | 15.9392 |
| 82 | 131.503 | 122.125 | 5.622 | 4.998 | 12.8747 | 11.7317 |
| 83 | 37.678 | 31.712 | 4.18 | 3.676 | 11.0287 | 11.7405 |
| 84 | 133.037 | 129.71 | 1.158 | 1.145 | 2.5919 | 2.4607 |
| 85 | 711.774 | 725.739 | 102.23 | 96.856 | 647.7351 | 609.2082 |
| 86 | 536.705 | 550.383 | 81.771 | 76.732 | 240.5892 | 226.6869 |
| 87 | 360.093 | 371.996 | 46.99 | 45.238 | 245.2921 | 229.4355 |
| 88 | 210.213 | 254.593 | 19.548 | 27.31 | 348.5734 | 314.6005 |
| 89 | 515.417 | 505.742 | 9.877 | 6.398 | 32.2188 | 21.4484 |
| 90 | 262.601 | 313.871 | 7.123 | 5.389 | 14.7145 | 11.6848 |
| 91 | 86.202 | 78.195 | 7.048 | 5.873 | 41.427 | 21.2716 |
| 92 | 116.551 | 106.447 | 13.343 | 9.15 | 167.2302 | 144.5331 |
| 93 | 401.55 | 377.853 | 4.247 | 2.583 | 10.7041 | 6.5653 |
| 94 | 275.841 | 246.055 | 4.662 | 3.097 | 9.5168 | 6.4449 |
| 95 | 147.466 | 162.989 | 2.626 | 1.852 | 6.5482 | 3.2714 |
| 96 | 64.815 | 63.229 | 0.625 | 0.613 | 1.4434 | 1.4482 |
| 397 | 1.033 | 0.67 | 44.605 | 25.147 | 20.1024 | 20.5782 |
| 398 | 0.863 | 0.664 | 31.166 | 22.439 | 29.5395 | 16.8054 |
| 399 | 0.757 | 0.765 | 15.602 | 12.683 | 11.3779 | 25.0615 |
| 400 | 5.721 | 4.716 | 163.967 | 160.586 | 433.808 | 444.6622 |
| 401 | 4.592 | 3.296 | 70.247 | 28.097 | 136.3227 | 67.5081 |
| 402 | 1.932 | 2.262 | 65.822 | 62.49 | 103.6859 | 101.7579 |
| 403 | 10.142 | 7.412 | 48.381 | 43.707 | 77.7397 | 61.7793 |
| 404 | 19.652 | 14.092 | 64.063 | 71.534 | 396.5608 | 413.8705 |
| 405 | 2.266 | 2.126 | 53.36 | 28.907 | 62.8964 | 24.4007 |
| 406 | 1.152 | 0.972 | 29.038 | 18.308 | 28.9968 | 11.0181 |
| 407 | 1.197 | 0.839 | 41.966 | 35.548 | 51.4256 | 40.389 |
| 408 | 2.837 | 2.901 | 13.538 | 11.757 | 48.8497 | 41.3103 |
References

[1] Sungkono, K. K. D. 2019. Yogyakarta, Surakarta and Semarang City earthquake responds based on the 2012 SNI earthquake map and the 2017 earthquake map JUTEKS: Journal of Civil Engineering, 4(1), 39-44. (In Bahasa)

[2] Badan Standar Nasional. 2012. Indonesian national standard 1726-2012. national standard agency: Jakarta. (In Bahasa)

[3] Badan Standar Nasional. 2019. Indonesian national standard 1726-2019. national standard agency: Jakarta. (In Bahasa)

[4] Baehaki, Soelarso dan Fitria, N. 2018. Analysis of structural behavior in a 9-floor apartment dual system using time history analysis method according to regulation SNI 1726: 2012. Journal of the Foundations, 7 (1), 74-86. (In Bahasa)

[5] Pratama, A., Amandani, J. O. B., Wibowo, H., and Sabdono, P. 2018. Planning of lecture building structure, Faculty of Economics, Unnes Semarang. Journal of Civil Engineering Works, 7(1), 176-188.

[6] Priyono, A., Budi, A. S., and Supardi. 2014. Performance evaluation of 10-storey building structures with spectrum response analysis reviewed by padadrift and displacement using etabs software. e-Journal of Civil Engineering Matrix, 534-541(In Bahasa)

[7] Hatmoko, J. T dan Suryadharman, H. 2013. Prediction of soil liquefaction due to earthquake in Yogyakarta Special Region. National Conference of Civil Engineering 7 (KoNTekS 7). (In Bahasa)

[8] DS, Kurniawan. K. 2019. Yogyakarta, Surakarta and Semarang City earthquake response spectra based on the 2012 sni earthquake map and the 2017 earthquake map JUTEKS - Journal of Civil Engineering, IV (1), 39-44. (In Bahasa)

[9] Kalalo, G. H., Tenda, R., and Dappas, S. O. 2014. Effect of eccentricity of mass center of reinforced concrete building on structural response due to earthquake load. Jurnal Sipil Static, 2(6), 292-300. (In Bahasa)

[10] Hastono, B., & Syamsudin, R. 2018. Comparison of earthquake resistance SNI 03-1726-2002 & SNI 03-1726-2012 on building planning in Aceh City. Ge-STRAM: Journal of planning and civil engineering, 1 (1), 1-7 (In Bahasa)

[11] Soelarso, S., & Baehaki, B. 2016. Comparative analysis of horizontal inversion (drift) in earthquake resistant building structures with 3) using lateral acquires (bracing) based on SNI 03-1726-2002 and SNI 03-1726-2012. Journal of Foundation, 5(1). (In Bahasa)

[12] Purnijanto, B., Wiwoho, M., & Crista, N. H. 2014. Comparison of analysis of the structure of the USM psychology faculty building (four floors of the T building) using earthquake SNI 03-1726-2002 with earthquake SNI 03-1726-2012. Teknika, 9(2), 12-22. (In Bahasa)