Study on the Application of Earthquake Resistant Standards (SNI 1726: 2019) Against Building in Yogyakarta City

Muhammad Syarif[1], Sri Astika[2] and Arkas Viddy[2]
[1]Enggineering, Politekinik Negeri Nunukan, Jl. Limau Sedadap, Nunukan, Indonesia
[2]Department of Administration Business, Politeknik Negeri Nunukan, Jl. Limau Sedadap, Nunukan, Indonesia

Keywords: Earthquake Load, Internal Force, Seismic Bottom Shear Force, Return Period.

Abstract: The load-bearing structure is made from a Special Moment Bearer Frame Structure. The structure is planned against earthquake loads in accordance with the Indonesian National Standard 1726: 2019 (Earthquake Resistance Planning Standards for Building Structures), which is based on an earthquake plan with a return period of 2,500 years. The earthquake load analysis uses the response spectrum method based on the Earthquake Resistance Planning Procedure for Building and Non-Building Structures (Indonesian National Standard- 726: 2012 and Indonesian National Standard 1726: 2019). This study aims are to make a comparison between the two procedures in terms of changes in seismic bottom shear forces, and to examine of the performance of the building structure in terms of the inter-level drift that occurs. The results of dynamic analysis obtained using the ETABS v.19.0.0 program showed an increase in seismic bottom shear force by 133%, both in the X direction and in the Y direction. The result directions also compared by using the 2012 Indonesian National Standard. Judging from the terms of deviation between levels, the building structure does not exceed the provisions, either according to the 2012 or 2019 Indonesian National Standard.

1 INTRODUCTION

Yogyakarta is an area prone to earthquakes. Failure of building structures can be caused, among others, by miscalculations in planning, inadequate planning with the implementation of work in the field, changes in building functions, natural disasters such as strong earthquakes and others (Chock, 2016). Evaluation of the performance of building structure can be done by analyzing the performance of ultimate limits and the performance of the service limits based on the Indonesian National Standard, earthquake loads based on the Indonesian National Standard (SNI) 1726: 2012 and the Indonesian National Standard 1726: 2019 which contains guidelines for earthquake resistance planning procedures for building structures. and non-building which is a revision of the Indonesian National Standard 1726: 2012 (Nasional, 2012).

The Indonesian National Standard Guidelines 1726: 2019 have used the latest earthquake history maps since 2017 so that buildings built before 2017 need a structural evaluation to determine the safety of the structure according to the new standard. Differences in building planning guidelines for earthquake resistance The Indonesian National Standard 1726: 2012 and the Indonesian National Standard 1726: 2019, namely the design of the earthquake spectral acceleration of the Indonesian National Standard 1726: 2019 in several regions of Indonesia experienced an increase in site class types of medium soil and hard soil and a decrease in type of soft ground site class (Indonesia, 2013). The building that will be the object of research in this study is a building that has 8 floors using a concrete structure. The purpose of this study is to determine the performance of the building with story drift / deviation between levels and the story shear of the building. The calculation of the structure is based on the earthquake loading of the Indonesian National Standard 1726: 2012 and the Indonesian National Standard 1726: 2019. The building is located on medium and hard ground areas.

Syarif, M., Astika, S. and Viddy, A.
Study on the Application of Earthquake Resistant Standards (SNI 1726: 2019) Against Building in Yogyakarta City.
DOI: 10.5220/0011729600003575
In *Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2022)*, pages 148-153
ISBN: 978-989-758-619-4; ISSN: 2975-8246

2 LITERATUR REVIEW

2.1 Deviation Between Floor

2.1.1 Based on SNI 1726: 2012

Deviation between floors based on SNI 1726: 2012 article 7.8.6, is calculated as the deflection of the center of mass at the top and bottom levels under review. The deflection of the center of mass at the x level must be determined by the equation (Farlianti, 2020).

$$\delta_x = \frac{C_d \delta_{xe}}{I_e} \qquad (1)$$

Information:
Cd = deflection amplication factor.
δ_x = deflection at the required location determined by elastic analysis.
Ie = the earthquake priority factor, namely 1. To meet the performance requirements the ultimate limit of deviation between floors must not exceed 0.02 times the level height.

2.1.2 Based on SNI 1726: 2019

Deviation between floors based on SNI 1726: 2019 article 7.8.6, is calculated as the deflection of the center of mass at the top and bottom levels under review. The deflection of the center of mass at the x level must be determined by the equation (Siswanto, 2018).

$$\delta_x = \frac{C_d \delta_{xe}}{I_e} \qquad (2)$$

Information:
Cd = deflection amplication factor
δ_x = deflection at the required location determined by elastic analysis.
Ie = the priority factor of the earthquake, namely 1. To meet the performance requirements of the ultimate limit of deviation between floors, it must not exceed 0.02 times the level height.

3 RESEARCH OBJECTIVES

3.1 Response Spectrum of the 2012 Indonesian National Standard Design for Earthquake

The design response spectrum (Sa) in the 2012 Indonesian National Earthquake Standard is taken as shown in the figure below.

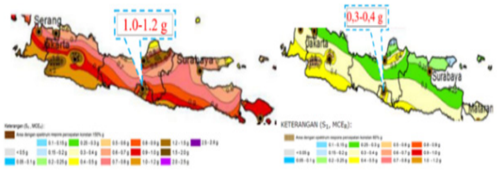

Figure 1: S1 and SS values based on the 1726: 2019 Indonesian National Standard earthquake map.

The results of the analysis from the PUSKIM website obtained tables, graphical response spectra and data of the design value of the acceleration response spectra obtained, among others: Hard soil, bedrock acceleration value 0.2 seconds (Ss) = 0.708 g, bedrock acceleration 1 second (S1) = 0.306 g, the acceleration response spectrum in the short period (SMS) = 0.873 g, the acceleration response spectrum for the 1 second period (SM1) = 0.547 g, the design spectral acceleration for the short period (SDS) = 0.582 g, the design spectral acceleration for the 1 second period (SD1) = 0.365 g, Period (Ts) = 0.626 s and Period (To) = 0.125 s.

3.2 Response Spectrum for 2019 Earthquake SNI Design

The design response spectrum (Sa) in SNI for Earthquake 2012 is taken as shown in the figure below.

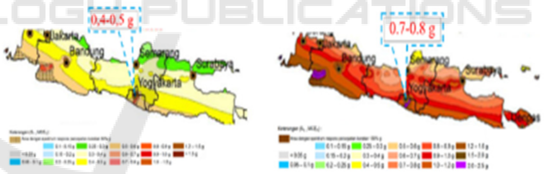

Figure 2: S1 and SS values based on the SNI 1726: 2019 earthquake map.

4 ANALYSIS AND DISCUSSION

4.1 Structural Modeling

Initial modeling was carried out with the ETABS program. The dimensions of the structure are then estimated in determining the initial dimensions which will later get the dimensions of the structure according to the forces that are obtained. Column with dimensions 800 x 800 mm, Beams with dimensions 400 x 800 mm and plate 125 mm.

The following are plans and 3D images of the designed building model.

4.2 Dynamic Response Spectra Earthquake Loading

The hard and medium soil spectral parameters of Yogyakarta City based on the Indonesian Spectra Design web are:

Table 1: Spectra Parameters.

PARAMETER	SNI 2019	SNI 2012
Ss	1.209	1.304
S1	0.530	0.471
Fa	1.200	1.000
Fv	1.470	1.529
Sms	1.451	1.304
Sm1	0.779	0.720
Sds	0.967	0.869
Sd1	0.520	0.480
T0	0.107	0.110
Ts	0.537	0.552
TL	8	8

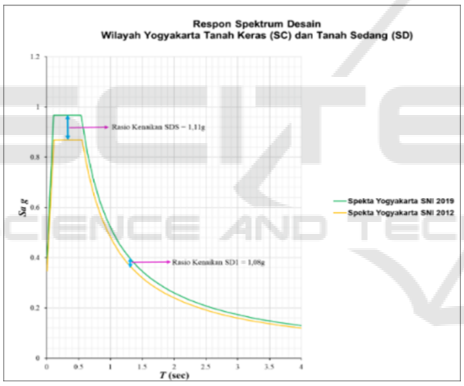

Figure 3: Comparison of Yogyakarta Regional Design Spectrum Curves.

4.3 Relation of Static Earthquake Load – Dynamic

Based on SNI 1726: 2012, the dynamic earthquake load must not be less than 85% of the static earthquake load, or in other words VDYNAMIC ≥ 0.85VSTATIC, if these conditions are not met then the dynamic earthquake load must be multiplied by a scale factor of. While SNI 1726: 2019 dynamic earthquake load must not be less than 100% static earthquake load, or in other words VDYNAMIC / VSTATIC, if these conditions are not met then the dynamic earthquake load must be multiplied by a scale factor of.

4.3.1 Sliding Force

Figure 4: Story Shear graphics on hard and medium soils.

Building Lateral Style

The lateral earthquake force of the design of each floor is obtained from the shear force of each floor of the design results of the previous analysis. The earthquake force on a floor is the difference between the shear forces between the floors, so that the respective values can be seen in the table below.

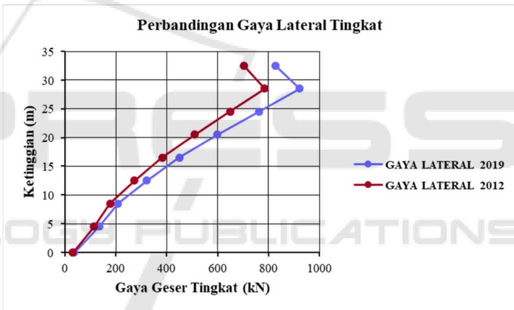

Figure 5: Lateral Force.

4.3.2 Image Lateral Force

Service Limit Performance Analysis

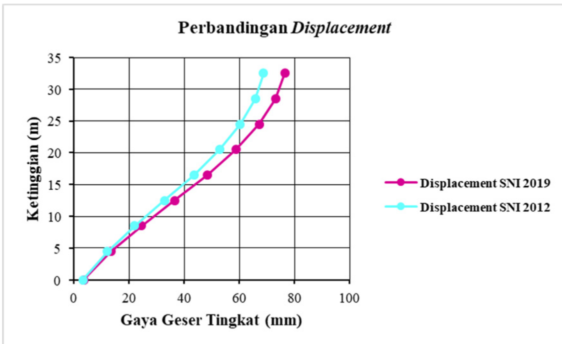

Figure 6: Displacement.

4.4 Design Control

Structural design control is carried out on checking the deviation limits between floors as regulated in articles 7.8.6 and 7.12.1 as well as the stability due to the P-Delta effect regulated in Indonesian article 7.8.7.

4.4.1 Deviation Between Floors of SNI 1726: 2019

Based on article 7.12.1 table 16 Deviation between floors of SNI 1726: 2012 permit for types of structures that fall into all other types of structures and are in risk category II, the deviation limit between the permit floors is 0.020 hsx. Meanwhile, SNI 1726: 2019 did not change the deviation limit between levels from the previous SNI 2012. Based on the results of the analysis of Etabs v.19.0.0 software, the displacement and deviation between floors in the x direction are obtained as shown in the table below.

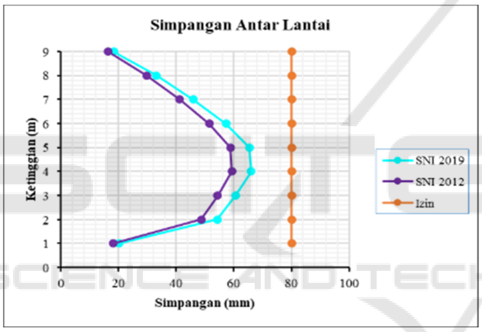

Figure 7: Allowable deviation between levels.

The shear design of the beam is planned based on the maximum flexural strength of the beam (Mpr) that occurs in the plastic area of the beam, namely at the critical section with a distance of 2h from the edge of the beam. The factor shear force on the face of the load is calculated as follows.

$$Ve\frac{M_{pr1}+M_{pr3}}{l_n} \pm \frac{Wu\ x\ ln}{2} \tag{3}$$

Where :

Ve = Shear force due to the plastic hinge at the ends of the beam (kN).

Mpr = the possible bending strength of a structural component (kNm).

Wu = Factored shear force

(kN). Ln = Length of clear span (m).

From the calculation results, the main reinforcement is 4D19 for the upper reinforcement and 2D19 for the lower reinforcement in the right pedestal area, meanwhile in the left support area 4D19 is used for the top reinforcement and 2D19 for the lower reinforcement, the middle span area uses the 2D19 for the top and 4D19 for the lower reinforcement. . Sengkang D10-100 mm for supports and D10-150 for fields on beam dimensions 250 mm x 450 mm. For details on reinforcement can be seen in the following image.

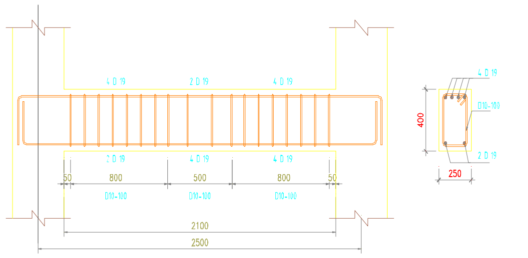

Figure 8: Main beam reinforcement details.

SNI 2847-2013 article 23.4 explains that for structural components in the calculation of the special moment-bearing frame system (SRPMK), which bears the force due to earthquake loads and receives a factored axial load greater than 0.1., the components of the structural elements must meet the following requirements: first, the structural components bear a factored axial compressive force of not less than 0.1.Ag.fc '. Second, the dimension of the shortest side is not less than 300 mm. And third, the ratio of the dimensions of the shortest section to the perpendicular side is not less than 0.40. The column is planned to be stronger than the beam (strong column weak beam). Columns are viewed against the wobbling or non-swaying portals, as well as for wandering. The flexural strength of the column is calculated based on the design of the strong column weak beam capacity, which is as follows.

$$\Sigma M_c \geq 1{,}2\ \Sigma M_g \tag{4}$$

Where:

ΣM_c = Column nominal moment.

ΣM_g = Nominal moment of block.

SRPMK column shear strength occurs plastic hinge joints at the ends of the beams that meet the column. In column planning, the shear force is obtained by adding the Mpr of the upper column with the Mpr of the lower column divided by the net height of the column. The shear force does not need to be taken to be greater than the design shear force of the beam-column connection strength based on the Mpr of the beam, and cannot be less than the factored shear force from the structural analysis. The column plan shear force diagram can be seen in the following Figure:

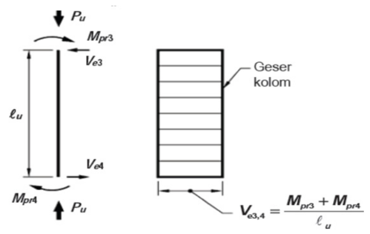

Figure 9: Column Shift Style Diagram.

From the calculations, we get the main reinforcement 36D22 and stirrup 4D10-100 for the support area and 4D10-150 for the field area. Details of column reinforcement can be seen in the following Image.

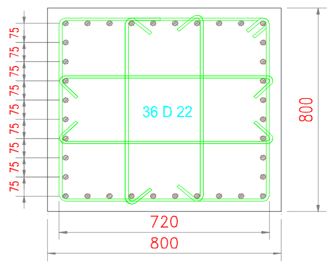

Figure 10: Column Reinforcement Details.

4.5 Beam-Column Relationships

The beam-column connection or beam-column joint has a very important role in the planning of high-rise building structures with the Special Moment Bearer Frame System (SRPMK). This is because the joints that connect the beam to the column will very often receive the force generated by the beam and column simultaneously. This can cause the joint that connects the beam and column to become weak and collapse quickly. Therefore, restraint reinforcement is needed to be able to accept and distribute the forces generated by beams and columns, so that the SRPMK concept is fulfilled. We can see the freebody diagram of the style in the following picture.

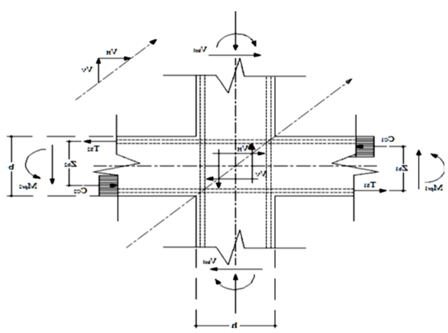

Figure 11: Forces Acting on the Beam-Column Relationship.

From the calculation results, the D10-150 count was designed. Details of beam-column reinforcement can be seen in Image 11 below.

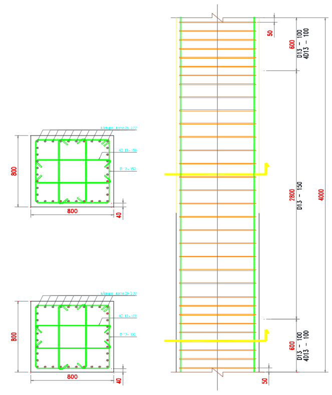

Figure 12: Details of Beam-Column Relationships.

5 CONCLUSION

From the results of the review of the City Hall Tower building structure, in terms of the effect of changes in design earthquake loads (changes from SNI 1726: 2012 to SNI 1726: 2019), several conclusions can be drawn as follows: Statically equivalent, the seismic bottom shear force has increased quite significantly, namely 3,572,917 kN (SNI 2012) for the x and y directions, to 4,050.72 kN (SNI 2019), or an increase of 113,373% in the x and y. From the results of dynamic analysis with the analysis method of the 2012 SNI response spectrum, the seismic base shear force is 3,036.98 kN for both x and y directions, while the results of SNI 2019 obtained a seismic base shear force of 4,050,720 kN for the x and y. There was an increase in the basic dynamic shear force of 133.38% in the x and y directions. The results of the examination of the deviation between floors, both according to SNI 2012 and SNI 2019 regulations, the structure of the Yogyakarta City Hall Tower building still shows a safe level of performance. In the next control analysis, namely checking Stability of the building / P-Delta effect, the structure of the City Hall Tower building is still in stable condition. Acceleration of rocks in the short period in Yogyakarta City has an acceleration decrease of 0.93g. While the acceleration of the rock in a period of 1 second, there was an increase in the acceleration of 1.12g. The design response spectrum between SNI 2012 and the 2017 Earthquake Map in the city of Yogyakarta, there was an acceleration increase ratio of 1.20g. While the acceleration in the period of 1 second, there is also an increase of 1.30g. This shows that the earthquake load of SNI 1726: 2019 is more influential than SNI 1726: 2012.

ACKNOWLEDGEMENTS

Alhamdulillah, all praises be to Allah that has given all the pleasures. With the gifts and conveniences that Allah gave, so researchers can be completed this research. Thanks to master in Civil Engineering, Faculty of Engineering Sultan Agung Islamic University Semarang and all parties for the participation and support.

REFERENCES

Chock, G. Y. (2016). Design for tsunami loads and effects in the ASCE 7-16 standard. *Journal of Structural Engineering*, *142*(11), 04016093.

Nasional, B. S. (2012). Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan non gedung. *Sni*, *1726*, 2012.

Nurjaman, H. N. Beban desain minimum dan kriteria terkait untuk bangunan gedung dan struktur lain. BSN.

Indonesia, S. N. (2013). Persyaratan beton struktural untuk bangunan gedung. *SNI*, *2847*, 2013.

Siswanto, A. B. (2018). Kriteria dasar perencanaan struktur bangunan tahan gempa. *Jurnal Teknik Sipil*, *11*, 59-72.

Hastono, B., & Syamsudin, R. (2018). Perbandingan Ketahanan Gempa SNI 03-1726-2002 & SNI 03-1726-2012 Pada Perencanaan Bangunan Gedung Di Kota Aceh. Ge-STRAM: Jurnal Perencanaan dan Rekayasa Sipil, 1(1), 1-7.

Hardianto, W., Hanintyo, A. B., Indarto, H., & Nurhuda, I. (2014). Perencanaan Struktur Gedung Kuliah di Yogyakart. *J. Karya Tek. Sipil*, *3*(1), 1056-1068.

Farlianti, S., & Sapta, S. (2020). Perhitungan Respon Spektra Percepatan Gempa Kota Palembang Berdasarkan SNI 1726; 2019 Sebagai Revisi Terhadap SNI 1726; 2012. *TEKNIKA: Jurnal Teknik*, *6*(2), 167-177.