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Application Of Earthquake Resistant Standards (SNI 1726: 2019) Against Building in Yogyakarta City

Full Paper

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Abstract

The load-bearing structure is made from a Special Moment Bearer Frame Structure. The structure is prepared against earthquake loads in line 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 study adopts the response spectrum approach based on the Earthquake Resistance Planning Procedure for Building and Non-Building Structures (Indonesian National Standard 1726: 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 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. The City Hall Tower building structure is still in a stable condition when the stability of the building and the P-Delta effect are checked in the subsequent control study.

Keywords: - Earthquake Resistant Standards, Yogyakarta city

1. Introduction

Use 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. 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.

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 a type of soft ground site class. The building that will be the object of research in this study is a building that has 8 floors using a concrete structure (Hardianto W, 2014). 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.

2. Methodology

The design response spectrum (*Sa*) in Indonesian National Earthquake Standard

2.1 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 Fig. 1 and Fig. 2 (Farlianti S, 2019).

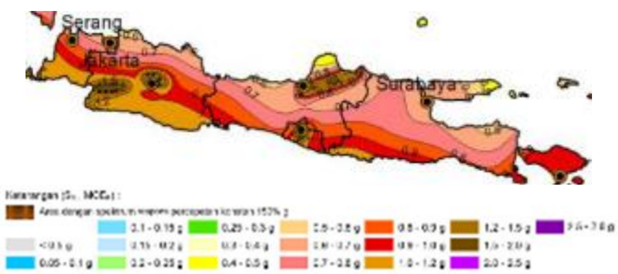

Fig. 1. SS values based on the 1726: 2019 Indonesian National Standard earthquake map

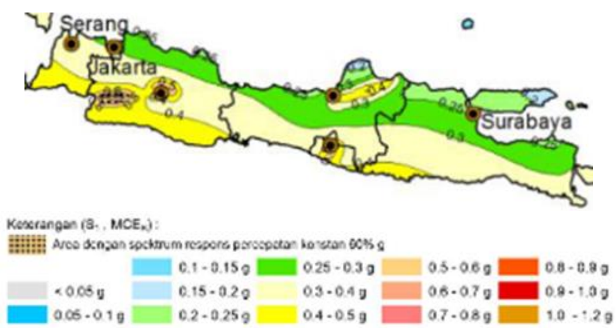

Fig. 2. S1 values based on the 1726: 2019 Indonesian National Standard earthquake map

Data of the design value of the acceleration response spectra obtained, among others: Hard soil, bedrock acceleration value 0.2 seconds (Ss) = 1.306 g, bedrock acceleration 1 second (S1) = 0.472 g, the acceleration response spectrum in the short period (SMS) = 1.306 g, the acceleration response spectrum for the 1 second period (SM1) = 0.721 g, the design spectral acceleration for the short period (SDS) = 0.871 g, the design spectral acceleration for the 1 second period (SD1) = 0.480 g, Period (Ts) = 0.552 s and Period (To) = 0.110 s.

2.2 Response Spectrum for 2019 Earthquake SNI Design

The design response spectrum (Sa) in SNI for Earthquake 2012 is taken as shown in Fig. 3 and Fig. 4.

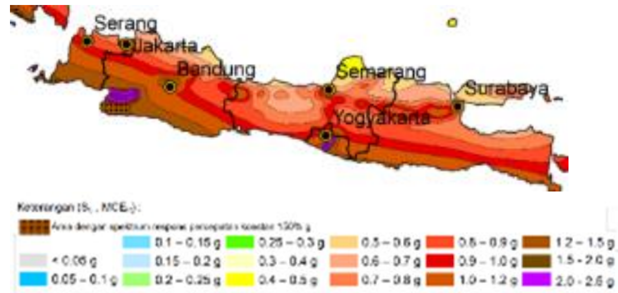

Fig. 3. S1 and SS values based on the SNI 1726: 2019 earthquake map

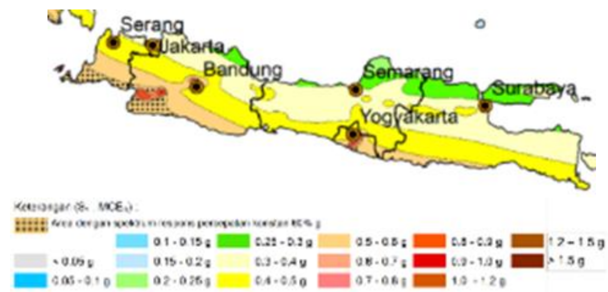

Fig. 4. S1 and SS values based on the SNI 1726: 2019 earthquake map

3. Result and Discussion

3.1 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.

3.2 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. Spectral parameters

PARAMETER	SNI 2019	SNI 2012
Ss	1.209	1.306
S1	0.530	0.472
Fa	1.200	1.000
Fv	1.470	1.529
Sms	1.451	1.304
Sm1	0.779	0.720
Sds	0.967	0.871

Sd1	0.520	0.480
T0	0.107	0.110
Ts	0.537	0.552
TL	8	8

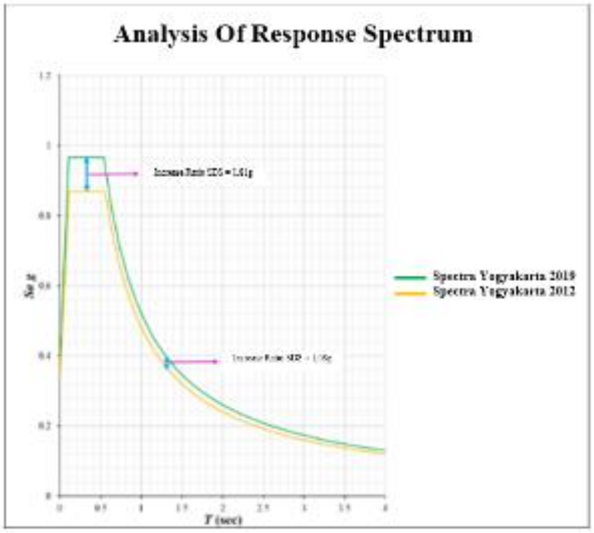

Fig. 5. Comparison of Yogyakarta regional design spectrum curves

Increase in the value of the spectral acceleration (SA) of 1.81g. Data retrieval of SNI 1726:2012 and SNI 1726:2019 coordinate points at Yogyakarta City Hall Yogyakarta city buildings built on hard, soft soil (SC) referring to SNI 1726:2019 will be safer against earthquakes compared to buildings referring to SNI 1726:2012 due to the relatively large difference in SA.

3.3 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. According to SNI 1726:2012, to determine the scale factor of an earthquake using the formula (G x I)/R, for the x direction and the y direction, the earthquake scale factor is 30% of the x direction.

3.3.1 Sliding Force

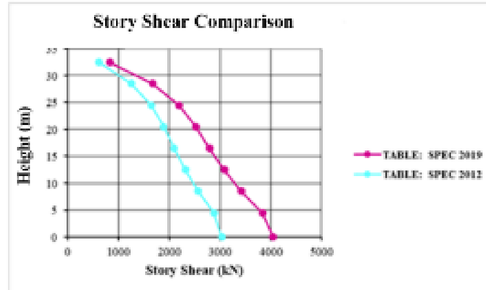

Fig. 6. Story Shear graphics on hard and medium soils

a) 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 Fig. 7.

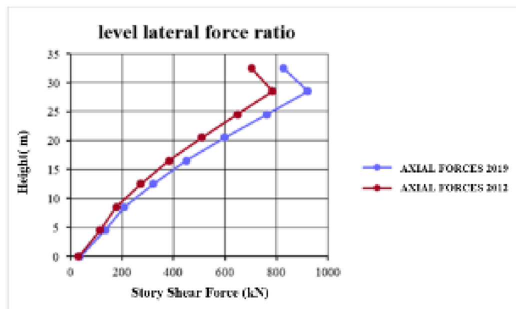

Fig. 7. Lateral force

3.3.2 Image Lateral Force

a) Service Limit Performance Analysis

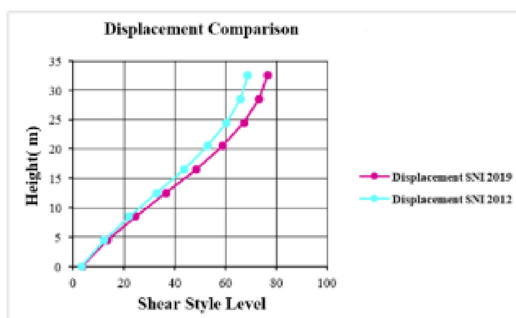

Fig. 8. Displacement

3.4 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.

3.4.1 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 Fig. 9.

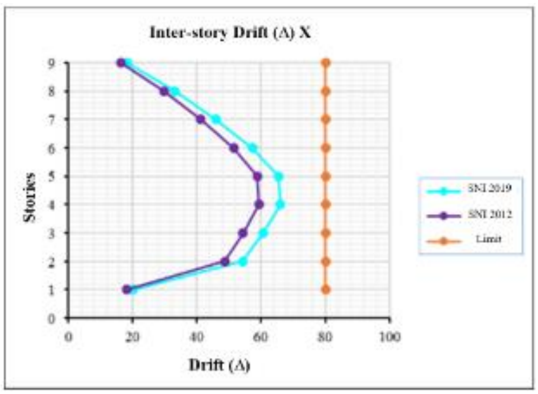

Fig. 9. Allowable deviation between levels

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.

$$Ve\,\frac{M_{pr1}+M_{pr3}}{l_n} \pm \frac{Wu \; x \; ln}{2} \tag{1}$$

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) and *Ln* = length of clear span (m).

Based on the calculation results, the main reinforcement for the upper reinforcement in the right pedestal area is 4D19, and for the lower reinforcement, it is 2D19. In the left support area, the top reinforcement uses 4D19, while the lower reinforcement uses 2D19. In the middle span area, the top reinforcement utilizes 2D19, while the lower reinforcement uses 4D19. For the supports, Sengkang D10-100 mm is employed, and for the fields on beam dimensions of 250 mm x 450 mm, D10-150 is utilized. For details on reinforcement can be seen in Fig. 10 and Fig. 11.

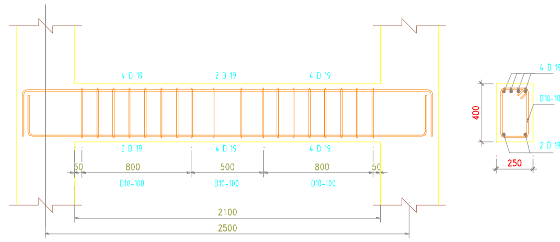

Fig. 10. Main beam reinforcement details

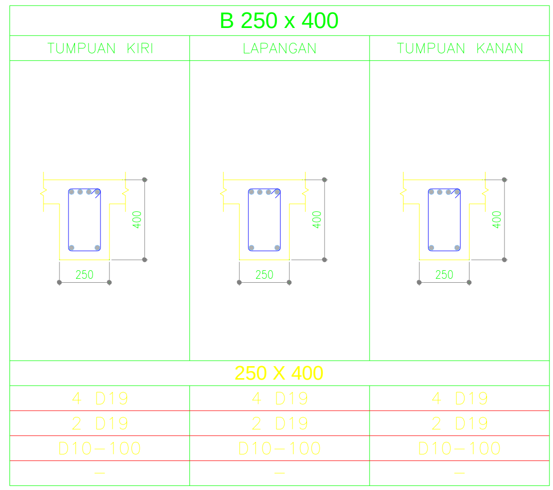

Fig. 11. Main beam reinforcement details

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 (BSN, 2013). 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.

$$\sum M_c \geq 1{,}2 \sum M_g \tag{2}$$

Where $\sum M_c$= column nominal moment and $\sum M_g$= 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

Fig. 12.

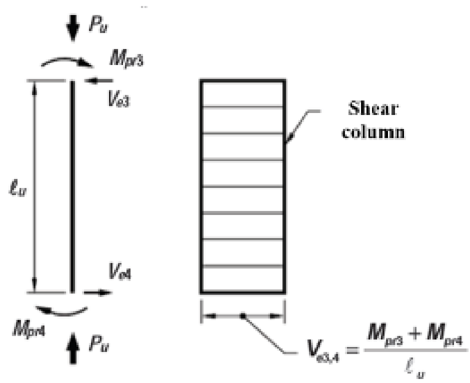

Fig. 12. Column shift style diagram

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 Fig. 13.

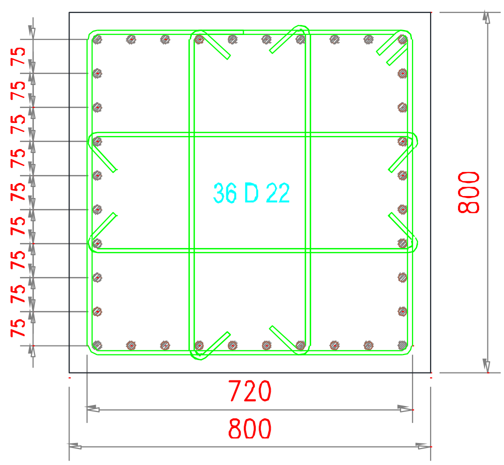

Fig. 13. Column reinforcement details

3.5 Design Control

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 Fig. 14.

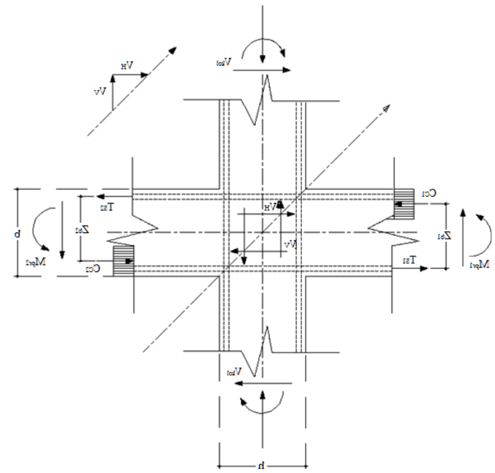

Fig. 14. Forces acting on the beam-column relationship

From the calculation results, the D10-150 count was designed. Details of beam-column reinforcement can be seen in Fig. 15.

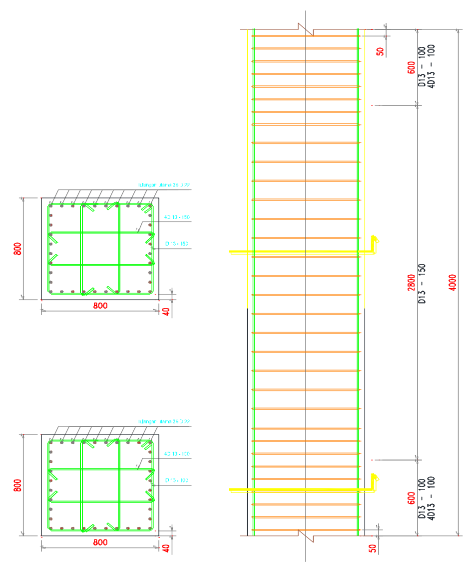

Fig. 15. Forces acting on the beam-column relationship

4. 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.

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