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

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Abstract

The load-bearing structure is made from a special moment-bearer frame structure. The structure is planned against earthquake loads by the earthquake resistance planning standard for building structures, or Indonesian National Standard 1726:2019, has a 2,500-year return period, and is based on an earthquake strategy. The response spectrum method possesses an Earthquake Resistance Planning foundation. Procedure for Buildings is used in the earthquake load analysis and Non-Building Structures (Indonesian National Standard- 726: 2012 and Indonesian National Standard 1726: 2019). This study aims to make a comparison between the two procedures in terms of changes in seismic bottom shear forces and to examine the building structure's performance 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 were 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.

***Keywords**: Earthquake Load; Internal Force; Seismic Bottom Shear Force; Return Period*

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. Evaluation of the performance of building structure can be done by analyzing the performance of ultimate limits and regarding the operation of the service limitations according to SNI 1726: 2012, earthquake loads according to the Indonesian National Standard, 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. [1-4] The Indonesian National Standard Guidelines 1726: 2019 have used the latest earthquake history maps since 2017 so 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. The building that will be the subject of this study's research is a building that has 8 floors using a concrete structure. This study's goal is to evaluate the building's performance 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[3-6].

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2. Methods

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 Figures 1 & 2. (Farlianti S, 2019). 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 short period (SMS) acceleration response spectrum is 1.306 g, the one second (SM1) acceleration response spectrum is 0.721 g, period (Ts) = 0.552 s, Period (To) = 0.110 s, the one second (SD1) design spectral acceleration, and the short period (SDS) design spectral acceleration are all 0.480 g.

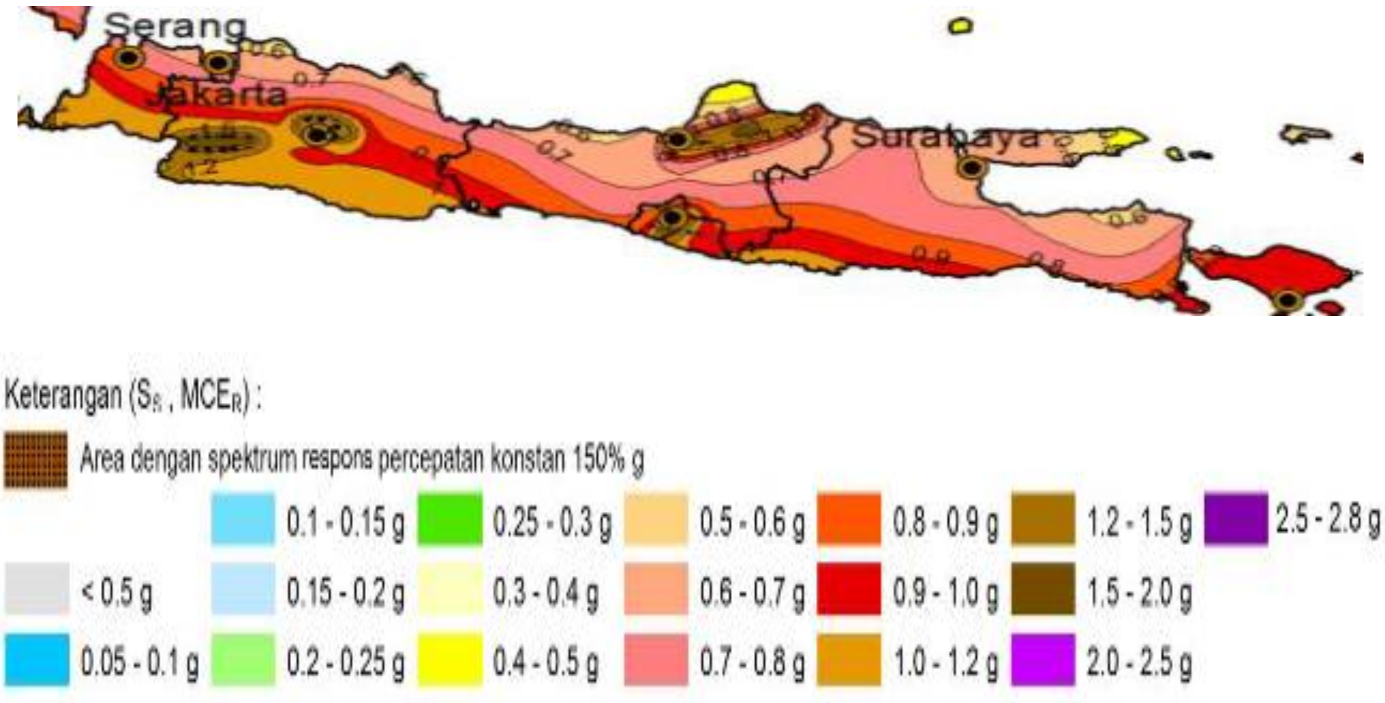
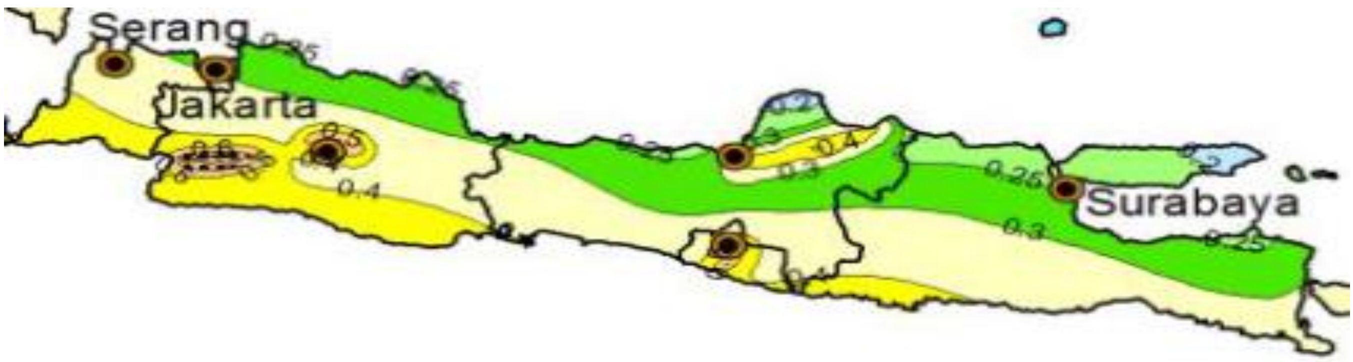


Figure 1 **SS values are taken from the Indonesian National Standard seismic map 1726: 2019**



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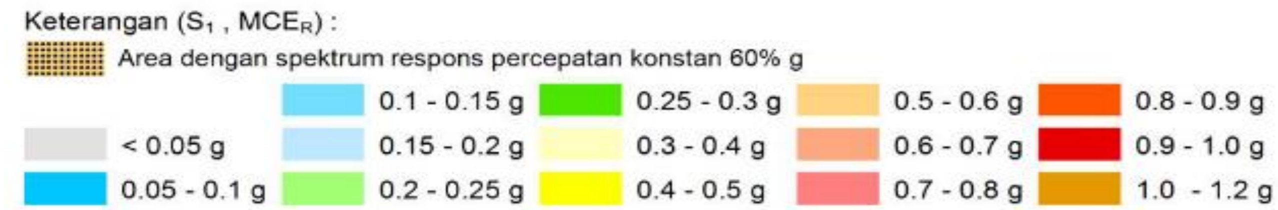

Figure 2 S1 values derived from the Indonesian National Standard seismic map 1726: 2019

2.1.1 Response Spectrum for 2019 Earthquake SNI Design

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

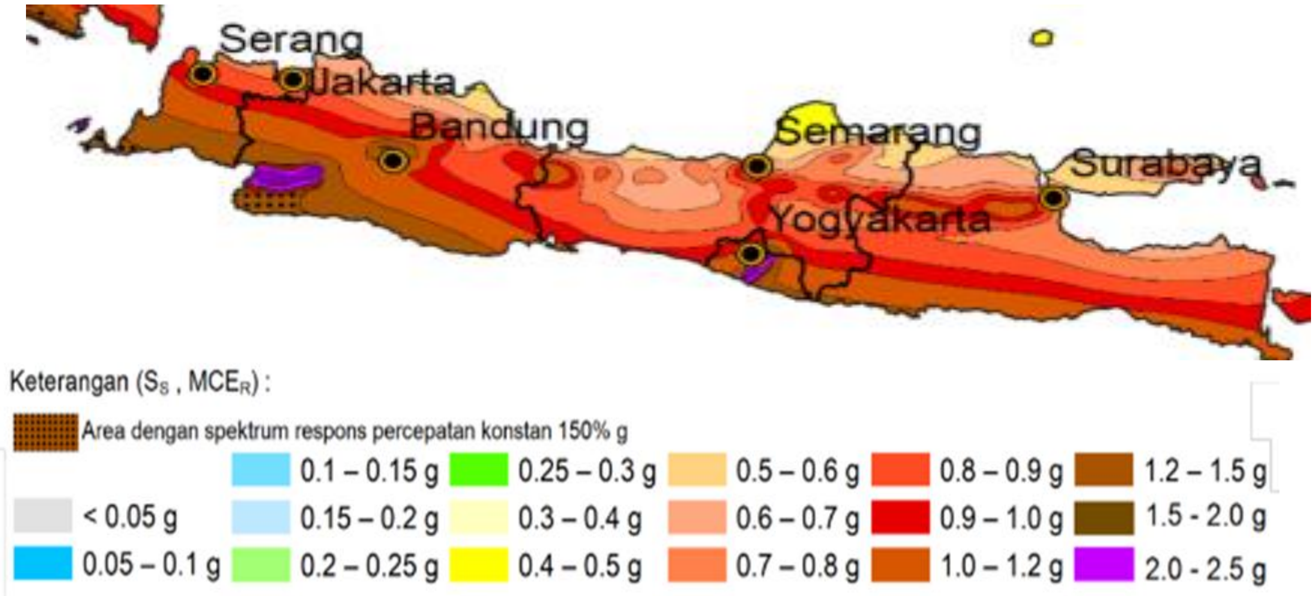

Figure 3 S1 and SS values based on the SNI 1726: 2019 earthquake map

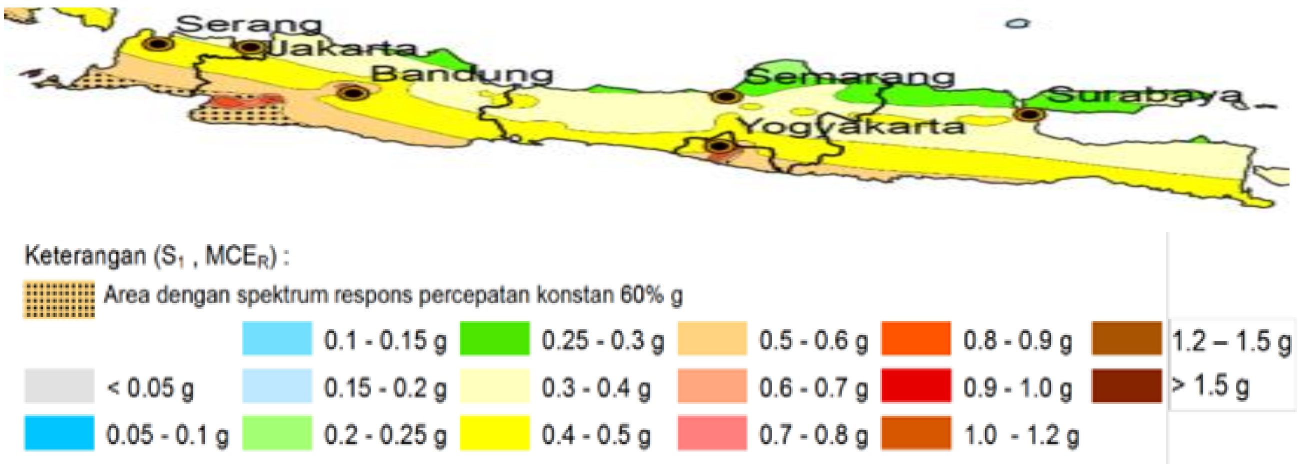

Figure 4 S1 and SS values based on the SNI 1726: 2019 earthquake map

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3. Results 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.[5-9]

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 shown in Table 1. An increase in the spectral acceleration value (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. [8-12] Comparison of Yogyakarta Regional Design Spectrum Curves Shown in Figure 5.

Table 1 Soil Spectral Parameters of Yogyakarta City

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

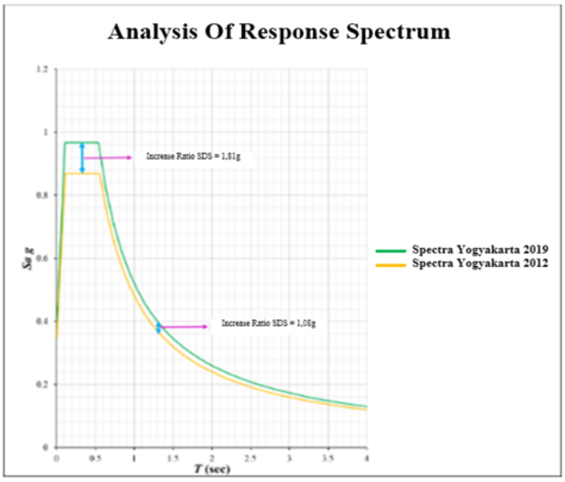

Figure 5 Comparison of Yogyakarta Regional Design Spectrum Curves

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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.

Figure 6 Story Shear graphics on hard and medium soils

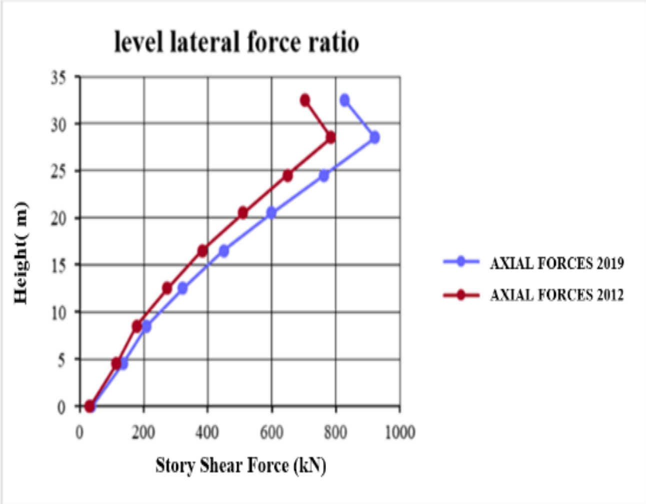

Figure 7 Lateral Force

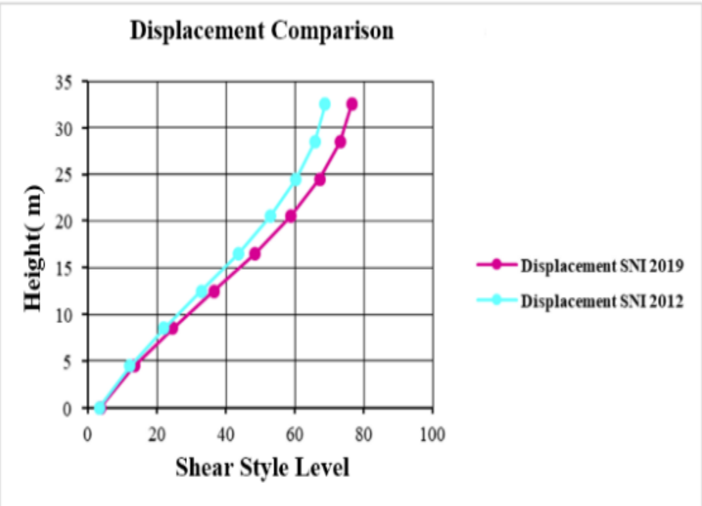

Figure 8 Displacement

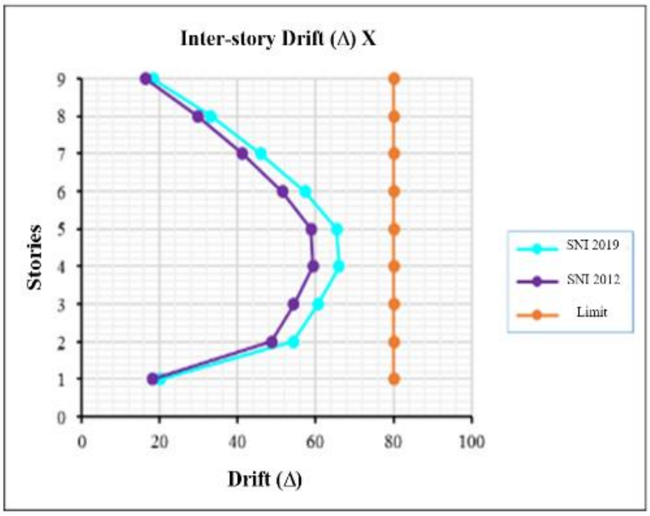

Figure 9 Allowable deviation between levels

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3.3.1 Sliding Force

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 the respective values can be seen in Figures 6 & 7.

3.3.2 Image Lateral Force

Service Limit Performance Analysis is shown in Figures 7 and 8.

3.4 Design Control

Structural design control is carried out by 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. Considering the analysis's conclusions of Etabs v.19.0.0 software, the displacement, and deviation between floors in the x direction are obtained as shown in Figure 9. The shear design of the beam is planned based on the highest flexural strength of the beam (Mpr) that takes place in the plastic area of the beam, namely at the critical section [10-14] 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.

$$Ve \frac{M_{pr1}+M_{pr3}}{ln} \pm \frac{W_u+l_n}{2} \quad (1)$$

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).
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 the following Figures 10 & 11.

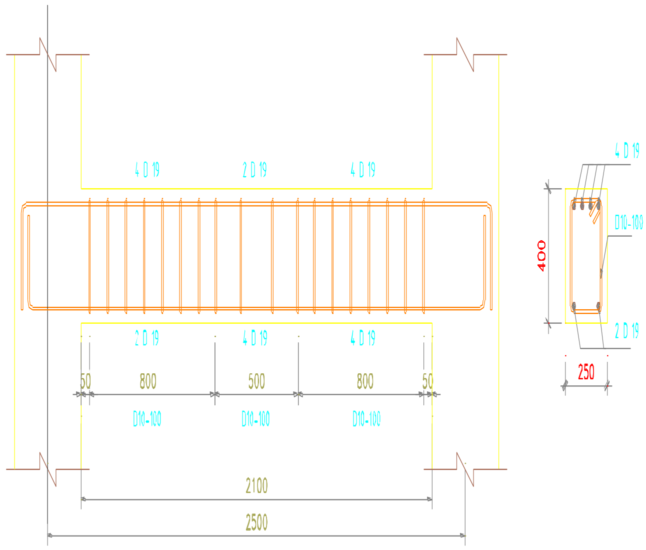

Figure 10 Main beam reinforcement details

SNI 2847-2013 article 23.4 explains that for structural components in the calculation of the unique moment-bearing frame structure (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

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of the shortest side is not less than 300 mm (BSN, 2013).

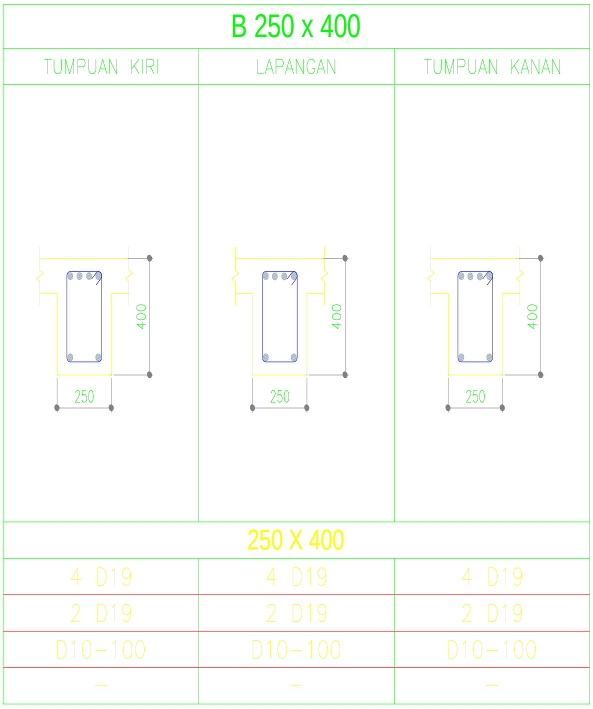

Figure 11 **Main beam reinforcement details**

Third, the ratio of the dimensions of the shortest section to the perpendicular side is not less than 0.40. The intended design of the column is to outweigh the beam (strong column weak beam). Columns are viewed against the wobbling or non-swaying portals, as well as for wandering. [12-17] Based on the strong column weak beam capacity design, the column's flexural strength is computed, which is as follows.

$$\sum M_c \geq 1{,}2 \sum M_g \quad (4)$$

Where:

- M_c = Column nominal moment.
- 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, by dividing the Mpr of the lower column by the net height of the column and adding it to the Mpr of the higher column, the shear force is calculated. It is not necessary to assume that the shear force is higher than the beam-column's design shear force connection strength based on the Mpr of the beam, and cannot be less than the structural analysis's calculated shear force. The column plan shear force diagram can be seen in the following Figure 12.

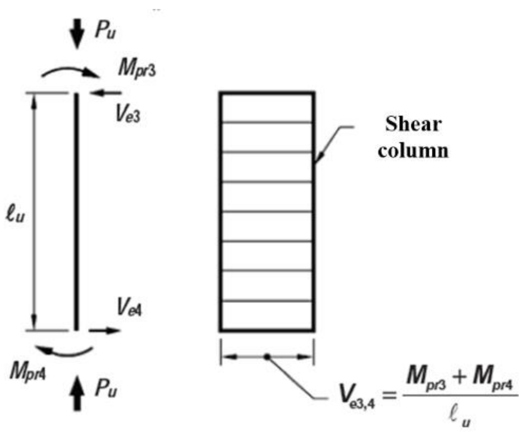

Figure 12 **Column Shift Style Diagram**

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 the following Figure 13.

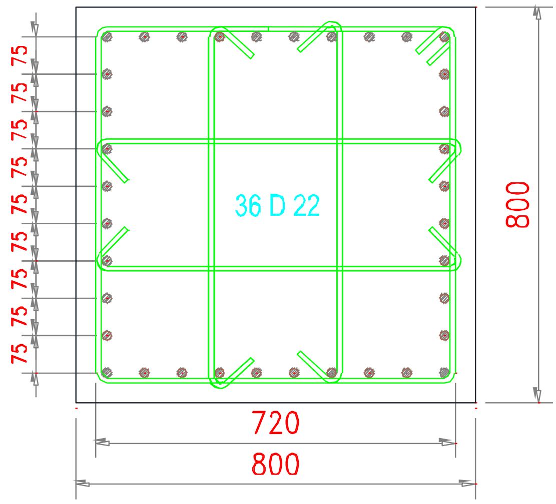

Figure 13 **Column Reinforcement Details**

3.5 Beam-Column Relationships

When planning high-rise building structures with the Special Moment Bearer Frame System (SRPMK), the beam-column union or connection is crucial [16-20]. 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

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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 free-body diagram of the style in the following Figure 14.

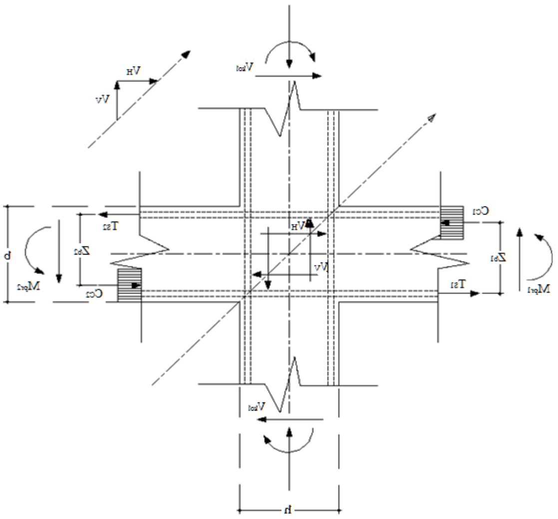

Figure 14 Column Reinforcement Details

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

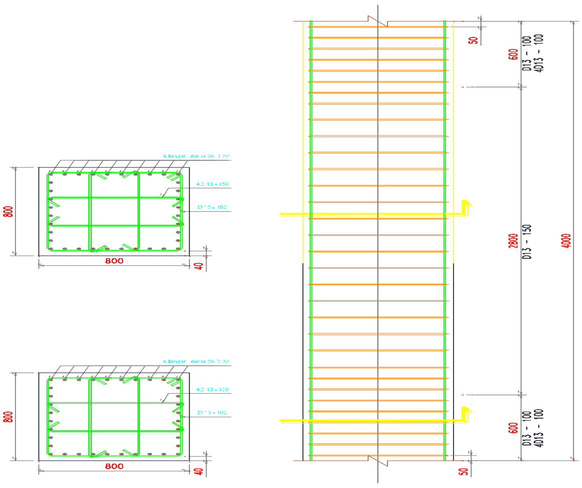

Figure 15 Details of Beam-Column Relationships

Conclusion

The following conclusions can be made from the findings of the examination of the City Hall Tower building structure about the impact of modifications to the design seismic loads (from SNI 1726: 2012 to SNI 1726: 2019): In the x and y directions, the seismic bottom shear force has grown from 3,572,917 kN (SNI 2012) to 4,050.72 kN (SNI 2019), or a 113,373% increase, statistically similar. The seismic base shear force for both the x and y directions is 3,036.98 kN based on the dynamic analysis findings with the 2012 SNI response spectrum analysis method, whereas the seismic base shear force for both the x and y directions is 4,050,720 kN based on the SNI 2019 data. The basic dynamic shear force increased by 133.38% in both the x and y dimensions. 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 the Stability of the building / P-Delta effect, the structure of the City Hall Tower building is still in stable condition. The 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. In 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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References

[1]. Brackley, P. (1995). Through other eyes. In D. H. Owen & B. F. Frey (Eds.). Ergonomics tomorrow: Adapting the future: Proceedings of the Sixth Conference of the New Zealand Ergonomics Society, Lincoln, 16-17 February 1995(pp. 50-52). Palmerston North, New Zealand: New Zealand Ergonomics Society.

[2]. Jongmans, D., & Garambois, S. (2007). Geophysical investigation of landslides: a

review. Bulletin de La Société Géologique de France, 178(2), 101–112. https://doi.org/10.2113/GSSGFBULL.178.2.101.

[3]. Kaufman, C., Perlman, R., & Speciner, M. (1995). Network security: Private communication in a public world. Englewood Cliffs, NJ: Prentice Hall.

[4]. Lu, N., Godt, J. W., & Wu, D. T. (2010). A closed-form equation for effective stress in unsaturated soil. Water Resources Research, 46(5), 5515. https://doi.org/10.1029/2009WR008646.

[5]. Persley, D. M.& Hill, M. (Ed.). (1992). Diseases of fruit crops (2nd ed.). Brisbane, Queensland, Australia: Department of Primary Industries.

[6]. Quarrie, K. L., Cantu, R. C., & Chalmers, D. J. (2002). Rugby union injuries to the cervical spine and spinal cord. Sports Medicine,32(10), 633-653. Doi: 10.1371/journal.pbio.0050289.

[7]. Rezaei, S., Shooshpasha, I., & Rezaei, H. (2018). Reconstruction of landslide model from ERT, geotechnical, and field data, Nargeschal landslide, Iran. Bulletin of Engineering Geology and the Environment 2018 78:5, 78(5), 3223–3237. https://doi.org/10.1007/S10064-018-1352-0.

[8]. Ridwan, A. S. S., Homma, R., & Liu, H. (2022). Estimation of Disaster Evacuation Shelter Capacity of Hitoyoshi City, Japan. Applied Research on Civil Engineering and Environment (ARCEE), 3(03), 113–126. https://doi.org/10.32722/arcee.v3i03.4600.

[9]. Statistics New Zealand. (1998). Samoan People in New Zealand. Wellington, New Zealand: Pub press.

[10]. Yang, K.L. et al. (2009). The real customers. Englewood Cliffs, NJ: Prentice Hall.

[11]. Kaufman, C., Perlman, R., & Speciner, M. (1995). Network security: Private communication in a public world. Englewood Cliffs, NJ: Prentice Hall.

[12]. Yang, K.L. et al. (2009). The real customers. Englewood Cliffs, NJ: Prentice Hall.

[13]. Persley, D. M.& Hill, M. (Ed.). (1992). Diseases of fruit crops (2nd ed.). Brisbane, Queensland, Australia: Department of Primary Industries.

[14]. Statistics New Zealand. (1998). Samoan People in New Zealand. Wellington, New Zealand: Pub press.

[15]. Brackley, P. (1995). Through other eyes. In D. H. Owen & B. F. Frey (Eds.). Ergonomics tomorrow: Adapting the future: Proceedings of the Sixth Conference of the New Zealand Ergonomics Society, Lincoln, 16-17 February 1995(pp. 50-52). Palmerston North, New Zealand: New Zealand Ergonomics Society.

[16]. Quarrie, K. L., Cantu, R. C., & Chalmers, D. J. (2002). Rugby union injuries to the cervical spine and spinal cord. Sports Medicine,32(10), 633-653. Doi: 10.1371/journal.pbio.0050289.

[17]. Ridwan, A. S. S., Homma, R., & Liu, H. (2022). Estimation of Disaster Evacuation Shelter Capacity of Hitoyoshi City, Japan. Applied Research on Civil Engineering and Environment (ARCEE), 3(03), 113–126. https://doi.org/10.32722/arcee.v3i03.4600.

[18]. Jongmans, D., & Garambois, S. (2007). Geophysical investigation of landslides: a review. Bulletin de La Société Géologique de France, 178(2), 101–112. https://doi.org/10.2113/GSSGFBULL.178.2.101.

[19]. Lu, N., Godt, J. W., & Wu, D. T. (2010). A closed-form equation for effective stress in unsaturated soil. Water Resources Research, 46(5), 5515. https://doi.org/10.1029/2009WR008646.

[20]. Rezaei, S., Shooshpasha, I., & Rezaei, H. (2018). Reconstruction of landslide model from ERT, geotechnical, and field data, Nargeschal landslide, Iran. Bulletin of Engineering Geology and the Environment 2018 78:5, 78(5), 3223–3237. https://doi.org/10.1007/S10064-018-1352-0.