Evaluation of the performance of high-rise building structures with plan 'H' shaped for earthquake with height increase (Case study: Apartment Urban Sky-Bekasi)

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Evaluation of the performance of high-rise building structures with plan 'H' shaped for earthquake with height increase (Case study: Apartment Urban Sky-Bekasi)

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Abstract. Currently, Bekasi City is developing into a residence for an urban, industrial center, and built apartments. One of them is the Urban Sky-Bekasi Apartment. This researched raises by an apartment as a case study to evaluate the performance of multi-story building structures as earthquake-resistant buildings. This researched conduct by add the original building height to 8 m (a basic height equals 102 m and a new height equals 110 m) to analyze whether the planning data made could still bear the same load with different heights and could still be categorized as earthquake-resistant buildings. From the results of the SAP-2000 output. The value of the basic static and dynamic shear forces in a 110 m building is always greater than a 102 m building in both the X and Y directions, this indicates that the taller a building is, the higher the design earthquake force used will be. The displacement in a 110 m building is always bigger than a 102 m building in both the X and Y directions. The weakest strength of the structure in a 110 m building is on the 29th floor in the X directions and Y directions, while the 102 m building is on the 26th floor in the X directions and 24 directions. It shows that with the addition of high SAP-2000 output data such as displacement, drift ratio, and other data after analysis shows that a 110 m building is categorized as an earthquake-resistant building according to SNI 1726-2012.

1. Introduction

Indonesia is one of the many countries that have many historical records of earthquakes that occurred. Many sectors have suffered from the earthquake, such as damage to building structures [1]. It should serve as the basis for the need to apply regulations in earthquake-resistant development planning in Indonesia. Especially in building construction, the majority of which is the center of community activities. The destruction was more than expected because of some reasons like the construction techniques used were not good without taking into account the seismic design and provisions. The wall construction was non-engineered and not durable, and there were no good ties of walls with floor and roof [2]. The seismic design philosophy aims to ensure safety to structural components and human life. It states that the load-bearing structural elements must suffer no damage in the event of a (frequent) minor shaking, sustain repairable damage in the event of (occasional) moderate shaking and sustain severe damage without collapse under (rare) strong shaking [3]. According Mc. Cormak, the thing that needs to be considered is the strength of the building which is adequate to provide comfort for its residents, especially the upper floors. The higher the building, the greater the lateral deflection in the upper floors [4]. An earthquake-resistant structure is a resistant structure (not damaged and does not collapse) when hit by an earthquake, not a structure that has been calculated solely (in planning) with the earthquake load [5]. Performance-based earthquake-resistant planning is a process that can be used for planning new buildings or evaluating existing buildings for reinforced concrete of beam, column, plate, and beam-column joint by understanding the strength of an earthquake against safety risks (life), readiness for use (occupancy) and possible economic loss due to the upcoming earthquake [6]. With the making of this research to evaluate the performance of the structure of the Urban Sky Apartment building, whether it is classified as an earthquake-resistant building and also to analyze by adding a building height of 8 m from its original height whether it can withstand earthquake loads under the previously made plans.

2. Methods

The research uses an analysis method by SAP-2000 to evaluate the performance of high-rise building structures by comparing the original height (as planned) with the new height of the Urban Sky Apartment building. The purpose of this analysis to show Urban Sky Apartment building whether it can still be categorized as an earthquake-resistant building with the addition of the height of the building. The steps for the research method carried out are as follows: In the early stages, the data collection process for the Urban Sky-Bekasi Apartment project was carried out according to the specifications and standards used. In the next stage, the earthquake load calculation is carried out based on SNI 1726-2012 [7]. In the next stage, building modeling was carried out with the help of the SAP 2000 program with a building height of 102 m (original building height) and 110 m. Furthermore, static and dynamic analysis is carried out with the response spectrum method by taking the response-spectrum according to SNI 1726-2012 to determine how much shear force (base shear), level displacement (displacement), and the deviation between floors (drift ratio) are generated using the program SAP 2000 [8]. The next step to compare the results of shear force, level displacement, and the deviation between floors between a building with a height of 102 m and a building with a height of 110 m based on SNI 1726-2012.

3. Results and discussion

3.1. Structure model

The analysis was carried out on the Urban Sky-Bekasi Apartment building with the original building height of 102 m and the research was carried out by adding the building height to 8 m (110 m). This research was conducted on a 33 storey structural model with static and dynamic response spectrum analysis using the SAP 2000 program [9].

Performance of the Urban Sky-Bekasi Apartment are:

- Category of building structure : I
- The main factor of the earthquake : 1.0
- Earthquake acceleration parameters : Ss = 0.677g; S1 = 0.295g
- Site class : Soft Soil (SE)
- Site coefficient : Fa = 1.2; Fv = 2.8
- Response spectrum parameters : SMS = 0.812; SM1 = 0.826
- Spectral acceleration design parameters : SDS = 0.54; SD1 = 0.55
- Seismic design category : D
- System structure and system parameters :
  - Special modification coefficient (R) : 8
  - System overpower factor (Ω) : 3
  - Deflection amplification coefficient (Cd) : 5.5

3.2. Base shear force

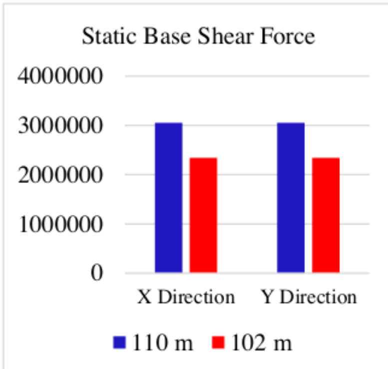

Figure 1. Static base shear force.

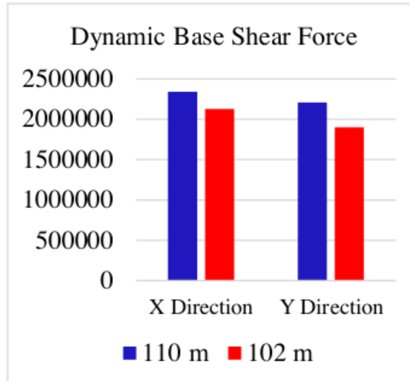

Figure 2. Dynamic base shear force.

In figure 1 and figure 2 shows that the static and dynamic basic shear forces in buildings with a height of 110 m are greater than the static and dynamic basic shear forces in buildings with a height of 102 m both in the X direction and in the Y direction, this study shows that the taller a building, the greater the static and dynamic shear forces or the planned earthquake load will be higher which will be used for the evaluation of a building structure. The difference in basic shear forces is of course caused by the structural stiffness. The increase in the shear force absorbed towards Y is greater than the shear force absorbed towards X because the difference in stiffness and the number of columns in the Y direction portal is more than the column in the X direction portal [10].

3.3. Displacement

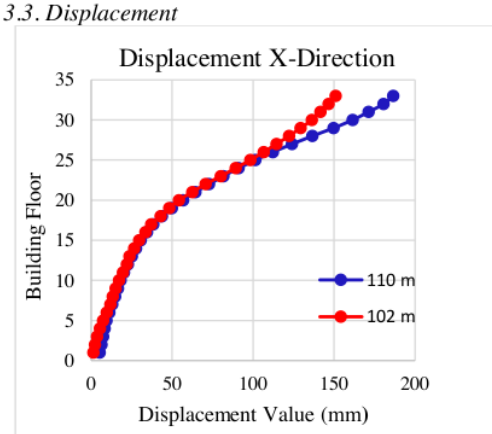

Figure 3. Displacement at X-direction.

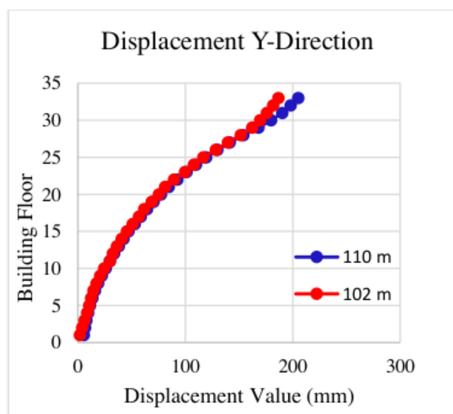

Figure 4. Displacement at Y-direction.

Figure 3 and figure 4 showed the output of SAP 2000 for displacement value of the Urban Sky-Bekasi Apartment building with a height of 110 m has a greater displacement value than the building with a height of 102 m (original building height) both in the X and Y direction. This shows that the taller a building is, the higher its displacement value will be. From the two graphs of the displacement values in the X and Y directions above, it can also be seen that the displacement value in the Y direction is always greater than the displacement value in the X direction for both building 110 m and building 102. This occurs because there is a change in the lateral force resistance system in the Y direction, causing the structural stiffness in the X direction is greater than the structural stiffness in the Y direction. Based on the graph, when a force (Base Force) is applied to a building, there is a displacement (Displacement). The greater the force applied, the greater the displacement that occurs in the building [11].

3.4. Drift ratio

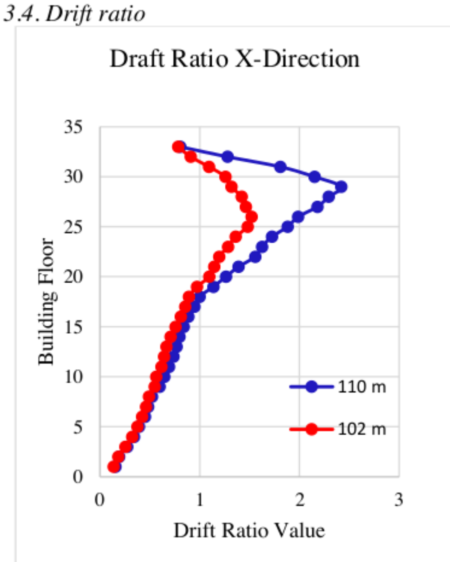

Figure 5. Drift ratio at X-direction.

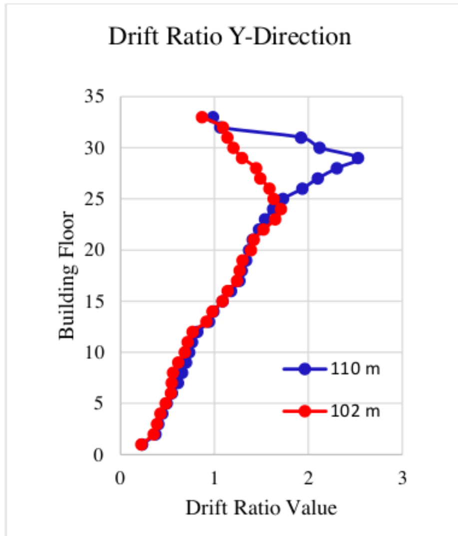

Figure 6. Drift ratio at Y-direction.

Figure 5 showed the drift ratio that occurs in buildings 110 m and 102 m in the X direction floors 1, 2, 3, 4, 5, 6, 7, and 8 have almost the same drift ratio values, but for the next floors start there is a difference in the value of the drift ratio which is getting bigger, this is due to the addition of the height of the building will increase the value of the drift ratio. Figure 6 above shows that the drift ratio value in the two buildings has almost the same drift ratio value from the 1st floor to the 24th floor, but for the next floor the difference in the drift ratio value between the two is getting bigger due to the addition of height which makes the drift ratio value increase too. The figure also shows that there are several points where the drift ratio value of a building 102 m on floors 20, 21, 22, 23 and 24 is greater than that of a 110 m building, this is due to differences in the area of the building in the X and Y directions, so there is a difference in stiffness between floors in the X directions and the Y directions. Based on the diagrams and spectra displacements peak have been calculated as well, revealing significant differences in the demand displacement curves of the buildings. As a result, damage estimates and predicted building performance will deviate from site-specific performance to a greater degree. Using site-specific spectra and field data will be important for future earthquake-resistant design. One of the conclusions of the study is that the Code spectra do not offer a sufficient or comprehensive enough set of seismic demands and would lead to an underestimation of seismic hazard in the region of study [12].

4. Conclusion

According to the analyzed SAP-2000 for the Apartment Urban Sky with the addition of building height from 102 m to 110 m, can be concluded: Value of the basic static and dynamic shear forces in a 110 m building is always greater than a 102 m building in the X and Y directions, this indicates that the taller a building is, the higher the design earthquake force used will be. So it can be concluded that a 110 m building is classified as an earthquake-resistant building. The displacement in a 110 m building is always bigger than a 102 m building in the X and Y directions and the displacement in the Y direction is always greater than the X direction because of the difference in the area of the load-bearing area in the Y direction. The largest Drift Ratio value in the 110 m building in the X and Y directions is on the 29th floor, respectively, the value is 2,419 and 2,531. Whereas in the 102 m building, the largest drift ratio in the X and Y directions is on the 26th and 24th floors, respectively, with a value of 1.521 and 1.71. This shows that the weakest strength of the structure in a 110 m building is on the 29th floor in the X directions and Y directions, while the 102 m building is on the 26th floor in the X directions and 24 directions.

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