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COMPARATIVE STUDY OF DESIGN VARIATIONS OF SIZES AND POSITIONS OF OPENINGS IN SHEARWALLS FOR HOTEL BUILDINGS ON SOFT LAND

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ABSTRACT

The soft soil found in Banjarmasin, South Kalimantan, has a low bearing capacity and tends to magnify the effects of earthquake-induced vibrations. This condition requires the planning of building structures that are able to withstand lateral forces adequately. One structural system that is often used to increase stiffness and lateral stability is a shear wall. The purpose of this study is to evaluate the building structure in response to earthquake force, both with and without shear wall elements. Modeling is done using Tekla Structure Designer software, response parameters in the form of inter-story Deviation (drift) and base shear force (base shear). The analysis shows that the use of shear walls without openings provides more optimal results in resisting earthquake loads. Structures with this element show lower drift values, more stable shear forces, and shorter vibration periods compared to structures without shear walls.

Keywords: *Shear Wall*, *Opening*, *Tekla Structure Designer*, *Structural Response*, *Earthquake Resistance*.

1. INTRODUCTION

Rapid population growth pushes the increasing need for space,especially in urban areas. Limitations of land make development building tiered become a choice to overcome the problem (Avandi et al, 2022). In planning a building with tiered aspects, earthquake resilience becomes an important factor to note. SNI 1726:2019 stipulates that buildings must be designed to carry the seismic load throught a customized seismic frame system with bearing moments at the level of seismic risk on site development. One of the multiple systems used to make the structure stiffer and stable in the face of lateral forces, such as earthquakes or winds, is the wall shear (shear wall) (Bush, Shirkol, & Surthi, 2022).

Wall shift functioning as an element of the structural main thing helps withhold lateral load due to earhquake, so that its untilization is significant in building a tiered high-rise. Some studies show that the existence or absence of an element can have a significant impact on behavioral structure, especially in withholding response structure in the form of deviation and force shift basis (Pribadi et al., 2022). Research was conducted in the city of Banjarmasin, South Kalimantan, witch is know for its own characteristics, soft land with low power support, and high compressibility index (Wardoyo et al., 2019). This study aims to compare the response structure between building models without wall slide and using wall slide, with analysis of mark drift and base shear consequence burden, using the earthquake device, Software Tekla Structure Designer.

2. THEORETICAL BASIS

Types of Shear Walls Reviewed from its location and function

Wall slide, if reviewed from the location of placement and function structurally, is divided into three main categories (Nugroho, 2017), including:

a. *Bearing walls*: ypes of walls shift. This plays a role in supporting the burden of gravity in buildings. Generally, the wall functioned as a partition, separating adjacent spaces and becoming a vertical supporting structural element.
b. *Frame wall*: Is a type of wall designed to slide to withstand lateral loads due to earthquake or wind. Usually, the walls are placed between rows of columns in a building section.
c. *Core wall*: This is located in the core area of the building, such as around the elevator shaft or stairs, and is often used in tiered buildings.

Loading Structure

Loading structure by the provisions in SNI 1727:2020 regarding minimum load on the design structure of buildings and constructions other than:

a. Live load is categorized as a burden while those that do not remain constant, because their value depends on the activity users, as well as mobility items inside the building. This load appears to consist of the existence of humans, furniture, non-structural elements, and others that can move or change from time to time.
b. The dead load is a burden originating from heavy elements in buildings, including all structural and non-structural components that are permanent.
c. Earthquake load is the consequence of the external appearance of seismic activity or movement of the land, and usually produces a horizontal force that affects the structural elements of a building.

Interfloor Drift

By SNI 1726:2019 Article 7.12, which stipulates the provision of a planning structure for earthquake-resistant buildings for both buildings and non-building structures. Drift is obtained from the difference deflection between the center mass of the floor above and the floor below. The deflection value is counted using equality as follows:

$$\delta_M \frac{C_d \delta_{max}}{l_e}$$

Where: Cd = Multiplier factor deviation

δ_M = Deviation level

I_e = Coefficient priority seismic

Base *Shear* Force

By provisions of SNI 1726:2019 Article 7.8.1, value style shift base earthquake (V) is calculated using the formula that has been determined as follows:

$$V = C_s W$$

Where: C_s = Coefficient of seismic response

W = Seismic weight effective

Tekla Structure Designer **(TSD)**

Tekla Structure Designer is a device-based Building Information Modeling (BIM) designed to make modeling and analyzing structures easier in a three-dimensional way. This software allows calculation of element structure in an automatic way, so that it can be efficiently used for designing concrete and steel in buildings (Saputro et al., 2021).

3. METHOD

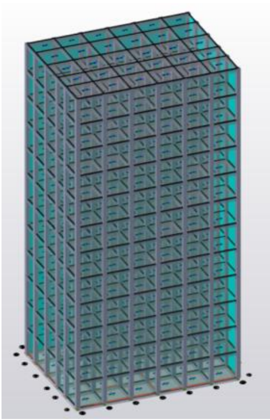
Planning Data

No	Building Description	Description
1	Main Function of Building	Hotel
2	Structural Development Area	Banjarmasin
3	Classification of Soil Types	Soft Soil
4	Number of Floors	12 Floors
5	Net Height Every Floor	4 m
6	Height Overall Building	48 m

No	Building Description	Description
7	Total Building Length	24 m
8	Total Building Width	20 m
9	Concrete Quality (fc')	K-350
10	Yield Strength of Reinforcing Steel Flexible (fy)	420 MPa
11	Yield Strength of Shear Reinforcement Steel (fy)	280 MPa

Modeling Building Structure

Models performed analysis among others , namely :



Non-Shear Wall Model

Non-Opening Shear Wall Model

Figure 1. Building Model

Analysis Method

Analysis structure done with help device soft Tekla Structure Designer for get response structure consequence burden work, such as dead load, live load, earthquakes, and wind. Analysis results cover style in structure, namely, style axial, shear, and moment flexibility, and deformation, such as the Deviation between the floor and the shift base structure.

4. RESULTS AND DISCUSSION

Comparison of Base *Shear* Forces

Base shear value results analysis using TSD for each structural model presented in Table 1.

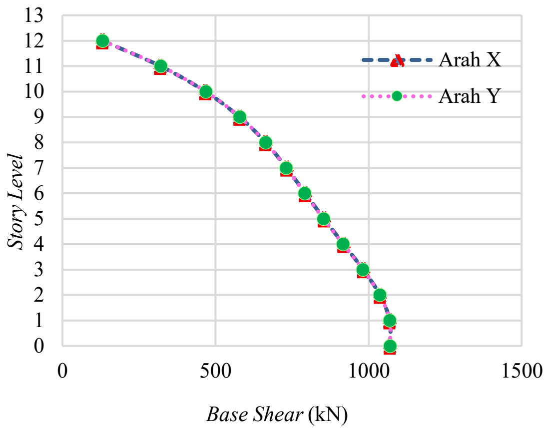


Figure 2. *Base Shear* NSW

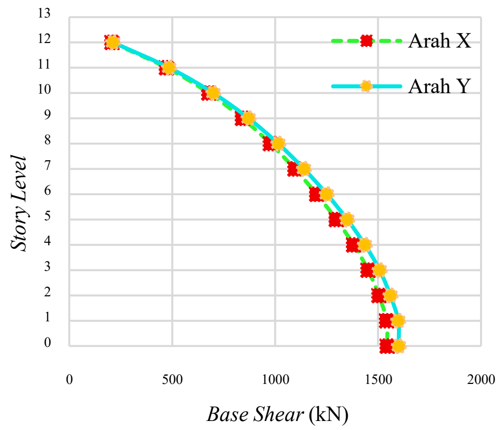


Figure 3. *Base Shear* SWNO

Table 1 Comparison *Base Shear*

Building Model	***Base Shear* (kN)**	
	X	**Y**
Non-Shear Wall (NSW)	1070.2	1070.2
Shear Wall Non-Opening (SWNO)	1544.3	1600.3

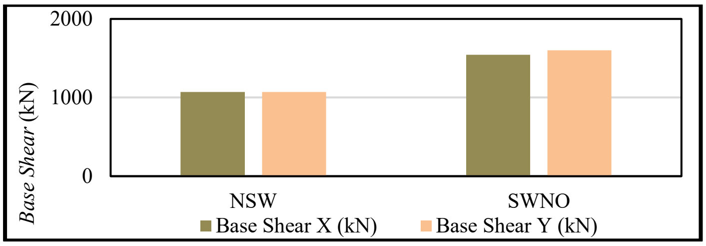


Figure 4. Comparison *Base Shear*

Table 2 Comparison *Base Shear*

Model	**Comparison (%)**			
	X direction		**Y direction**	
	NSW	**SWNO**	**NSW**	**SWNO**
NSW	0.0	30.7	0.0	33.1
SWNO	-44.3	0.0	-49.5	0.0

Based on results, shear wall model analysis non-opening (SWNO) is capable of increasing stiffness and capacity of the structure in a withhold style consequence of an earthquake. Conditions: This is seen from the size and style shift based on a structure that uses wall shift compared to a model that does not use it (NSW). In the X direction, the base shear in the SWNO model is more than 44.3% larger than NSW. Meanwhile, in the Y direction, the increase reached 49.5%.

Comparison *Displacement*

Displacement obtained from TSD analysis on each X and Y direction model is presented in Table 3, and comparison of displacement on the 12th floor is shown in Table 4.

Table 3*Displacement*

Floor	Elevation (m)	***Displacement* (mm)**		***Displacement* in Y Direction (mm)**	
		NSW	**SWNO**	**NSW**	**SWNO**
0	0	0	0	0	0
1	4	2.1	0.3	0.8	0.4
2	8	5.3	0.9	5.7	1
3	12	8.7	1.7	9.6	2
4	16	12	2.6	13.3	3
5	20	15	3.7	16.8	4.2
6	24	17.9	4.7	19.3	5.3
7	28	20.4	5.8	23.1	6.8
8	32	22.6	6.9	25.8	8.2
9	36	24.4	8	28	9.5
10	40	25.8	9	29.8	10.7
11	44	26.8	9.9	31.1	11.9
12	48	27.3	10.9	32	13.1

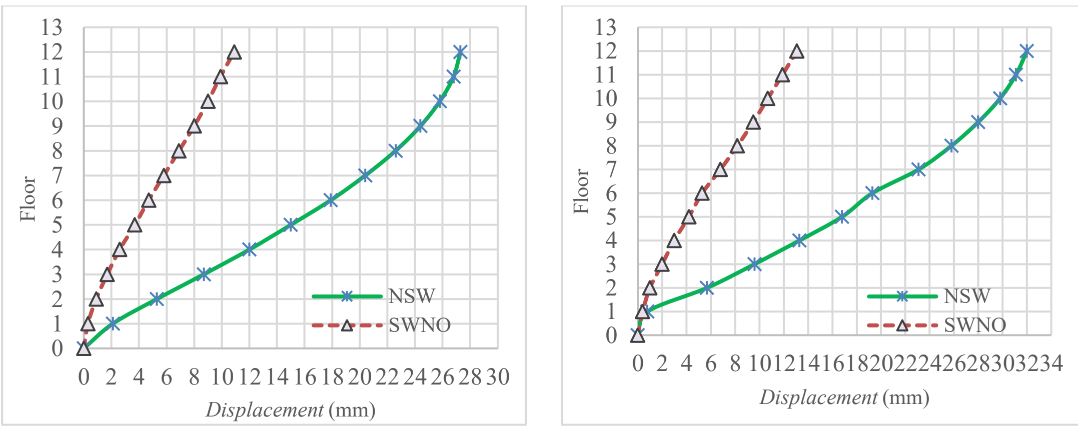


Figure 5. Comparison *Displacement* in X and Y Directions

Table 4Comparison 12th Floor *Displacement*

Model	Comparison (%)			
	X direction		Y direction	
	NSW	SWNO	NSW	SWNO
NSW	0.0	-150.5	0.0	-144.3
SWNO	60.1	0.0	59.1	0.0

Analysis of the top floor shows that the existence of a wall shift without aperture (SWNO) can significantly reduce the horizontal displacement of the structure compared to a structure without wall shear (NSW). In the X direction, the displacement of the NSW model is 27.3 mm, while the SWNO is only 10.9 mm. It is interpreted that SWNO has a Deviation of about 150.5% smaller. In the Y direction, NSW experienced displacement of 32.0 mm, while SWNO is only 13.1 mm, indicating that SWNO has a Deviation of 144.3% which is smaller.

Comparison Interfloor Drift

From the results analysis, the calculation drift obtained comparison mark drift presented in Table 5, and the comparison mark maximum is presented in Table 6.

Table 5Inter - Floor Drift

Floor	Elevation (m)	ΔX direction (mm)		ΔY direction (mm)		Clearance (mm)	Information
		NSW	SWNO	NSW	SWNO		
0	0	0	0	0	0	80	OKAY
1	4	2.1	0.3	0.8	0.4	80	OKAY
2	8	3.2	0.6	4.9	0.6	80	OKAY
3	12	3.4	0.8	3.9	1	80	OKAY
4	16	3.3	0.9	3.7	1	80	OKAY
5	20	3	1.1	3.5	1.2	80	OKAY
6	24	2.9	1	2.5	1.1	80	OKAY
7	28	2.5	1.1	3.8	1.5	80	OKAY
8	32	2.2	1.1	2.7	1.4	80	OKAY
9	36	1.8	1.1	2.2	1.3	80	OKAY
10	40	1.4	1	1.8	1.2	80	OKAY
11	44	1	0.9	1.3	1.2	80	OKAY
12	48	0.5	1	0.9	1.2	80	OKAY

Table 6Comparison Interfloor Drift

Model	Comparison (%)			
	X direction		Y direction	
	NSW	SWNO	NSW	SWNO
NSW	0.0	-209.1	0.0	-226.7
SWNO	67.6	0.0	69.4	0.0

Analysis results show that the existence of wall shift without opening (SWNO) is significantly capable of lowering the drift compared to a structure without wall slide (NSW) in each height building. In the X direction, the Deviation at NSW is 67.7% more than SWNO, while SWNO shows a decline of up to 209.1%. In the Y direction, the Deviation at NSW is 69.4% bigger compared to SWNO, while SWNO shows a decrease of 226.7%. Overall deviations in the SWNO model were also recorded well below the clearance limit of 80 mm, indicating excellent seismic performance.

Comparison Vibration Period (*Displacement*)

Period vibration of the structure obtained from TSD analysis on each structural model in the X direction and Y direction is presented in Table 7, and the comparison of the marked periods of vibration can be seen in Table 8.

Table 7Vibration Period of Structure

Building Model	Period (seconds)
Non-Shear Wall	2.7
Non-Opening Shear Wall	1.3

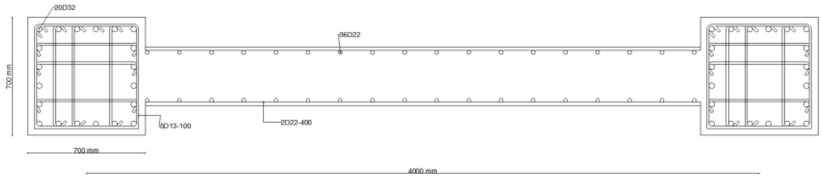
Table 8Comparison Period Structure

Model	Comparison (%)	
	NSW	***SWNO***
NSW	0.0	-107.7
SWNO	51.9	0.0

Analysis shows that NSW has a period vibration of 2.7 seconds, while the SWNO model is only 1.3 seconds. This means that the period NSW shakes about 51.9% more tall or SWNO lower low 107.7% more low than NSW. So, an additional wall shift can increase stiffness and shorten the vibration period of the structure.

Capacity Structure Non - *Opening Shear Wall*

After calculating the capacity element structure in the non-opening shear wall model based on the style in the results analysis with the device TSD software, the reinforcement details are shown in Figure 6.



Reinforcement Details Shear Wall

5. CONCLUSION

1. Use of the wall shift without aperture shows improvement in stiffness as well as resilience structure to withstand earthquakes, if compared to the model without the element wall slide. This is indicated by the increase in the base shear, namely up to 44.3% in the X direction and 49.5% in the Y direction. Drift experienced a significant decrease, with a mark as low as 209.1% in the X direction and 226.7% in the Y direction. All mark drift is still there, below the permit limit. Period vibration structure is shorter, resulting in a lower 107.7% compared to a structure without wall shift.
2. Need reinforcement wall shift with 350 mm thick is 36D22 for longitudinal reinforcement and 2D22-400 for reinforcement stirrups. 450 mm x 500 mm diameter beams are reinforced with 4D19 and 2D10-100 reinforcement. Column 700 mm x 700 mm reinforced with reinforcement longitude 20D32 and 5D13-100 on the 1st floor, while the 2nd floor to the 12th floor columns are strengthened with 16D29 and 5D13-100 reinforcement.

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