LOGIC
Journal of Engineering Design and Technology
Vol. 23 No.2 July 2023 ; p. 85 - 95

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs.pnb.ac.id/index.php/LOGIC

BEHAVIOR AND PERFORMANCE OF STEEL FRAME STRUCTURES WITH X-TYPE CONCENTRIC BRACING SYSTEM DUE TO VARIATIONS IN COMPARISON OF SPAN WIDTH TO STORY HEIGHT (L/H)

I Nyoman Indra Kumara[1], I Gede Fery Surya Tapa[1], I Nengah Darma Susila[2])

1) Department of Civil Engineering, Faculty of Engineering and Informatics, Universitas Pendidikan Nasional, Denpasar, Bali
2) Mechanical Engineering Department, Politeknik Negeri Bali, Bukit jimbaran, Badung Bali
Corresponding email [1)] :
indrakumara@undiknas.ac.id

Abstract. X-type bracing is the strongest bracing. The bigger ratio of the width of the span to the high level (L/H), the slope of the angle on the bracing will be more declivous. The analysis of the structure with the L/H ratio to determine the behavior of the structure using linear analysis of response spectrum and structural performance using the static nonlinear pushover analysis (ETABS 2016) to determine the displacement target that occurred in the structure. Structural modeling is done on 3D portals with levels of 3, 5, 8 and 10 floors with different L/H variations, including L/H=1; L/H=1.25; L/H=1.5; L/H=1.75; and L/H=2. Structural modeling is planned to be in the Surabaya area with moderate soil conditions. This study obtains data such as: (1) The largest maximum drift and floor drift are at type L/H=2, (2) The largest base shear force in the nonlinear pushover analysis at each story occurs at L/H=1, (3) In the yield condition type L/H=1 has the smallest percentage of structural stiffness, but in the ultimate condition type L/H=1 has the largest percentage of structural stiffness, and (4) The highest ductility value at each story occurs in type L/H=2 . Based on these results, it shows that the greater the type of L/H in the bracing structure, the greater the displacement target produced. If the angle of bracing becomes more sloping, then the displacement and target displacement that occurs increases.

Keywords : Bracing, L/H, Response Spectrum, Pushover.

1. INTRODUCTION

The area of Indonesia is very vulnerable to earthquakes [1]. Indonesia's location is based on its geographical location in the Pacific Ring of Fire region, namely the confluence of three world tectonic plates, the Indo-Australian Plate, the Eurasian Plate, and the Pacific Plate. This makes Indonesia vulnerable to disasters such as earthquakes. Therefore, buildings in Indonesia must take into account the impact that an earthquake will have on building structures [2]. The impact of a building structure that gets an earthquake force is to experience a lateral deviation [3]. Precise calculations are needed so that the building can withstand earthquake forces. If the calculation is not correct and the structure gets too large a lateral deviation, then the structure will collapse [4]. Structural systems in buildings must be designed to resist earthquake forces (lateral forces) [5]. In terms of materials also need to be considered in designing a building. The use of steel material is most often used in the construction of high-rise buildings [6]. This is because steel has very high elasticity and strength compared to concrete [7]. So steel is the most suitable material used in bracing frame systems.

One of the systems that can withstand earthquake forces is the bracing frame system [8]. There are several parts in the bracing system, including the eccentric bracing system and the concentric bracing system [9]. Furthermore, there are two types of concentric bracing systems, namely Ordinary Concentric Bracing Systems and Special Concentric Bracing Systems. The Special Concentric Bracing System has higher stiffness when subjected to earthquake forces compared to the Ordinary Concentric Bracing System [9]. Buildings that use a bracing system will minimize the value of deformation that occurs in the building structure because bracing will increase the value of the stiffness of the structure [10]. Bracing has several types and X-type bracing is the type of bracing that has the highest structural strength value compared to other bracing types [11]. This study aims to determine the ability of a steel frame structure using concentric bracing with the X-type as a result of the variation in the ratio between span width and story height (L/H). Thus, due to the L/H ratio, different bracing angle ratios will be formed. This will cause a difference in angle, so the ability of each X-type concentric bracing of each L/H type will be known.

2. METHODS

This research will conduct research on behavior and performance in each structure. The research aims to determine the behavior of the structure using a linear response spectrum analysis. Meanwhile, to determine the performance of the structure will use a non-linear static pushover analysis using the help of the 2016 ETABS application.

The steps taken for this research began with determining the cross-sectional dimensions used in each structure. Structural data worked on in this research were typical steel structures with 3, 5, 8, and 10 stories which the dimensions for each story are 4 m. The election for those total of the stories is mostly classification that we can find at the site consisting of a special concentric bracing system model made with five different types of L/H, namely L/H=1, L/H= 1.25, L/H=1.5, L/H=1.75, and L/H=2. So that the total models to be made are 20 models, of which 1 type of L/H consists of 4 models. The modeling was carried out using the 2016 ETABS application. The structure to be modeled is assumed to be in the Surabaya area with moderate soil conditions. The function of the building that will be used in each building is an office. Here are the materials and load used in each structure:

a) Steel profile material
   The steel material used in all steel profiles is ASTM A992, with the following data:
   - Yield Stress (Fy) = 344,74 MPa
   - Ultimate stress (Fu) = 448,16 MPa
   - Modulus of elasticity of steel (E) = 200.000 MPa
b) Corrugated steel deck material
   - Melting stress (Fy) = 550 MPa
   - Steel deck thickness (td) = 0,70 mm
   - Steel deck weight = 7,35 kg/m^2
   - Sliding link (@90 mm) = 19 mm
c) Concrete materials
   - Compressive strength (f'c) = 25 MPa
   - Modulus of elasticity of concrete (Ec) = 23.500 MPa
   - Concrete slab thickness = 120 mm
d) Dead Load
   The dead load has been calculated by the 2016 ETABS application, the additional dead load on the floor slab is 166 kg/m^2, and the additional dead load on the roof plate is 142 kg/m^2.
e) Live Load
   The structure is assumed to be used as an office building, so the live load on the floor used according to SNI 1727:2013 [12] is 2.4 kN/m^2 and the live load used on the roof is 0,96 kN/m^2.
f) Earthquake Load
   The earthquake load used on the structure is class D in the Surabaya area. The place choices in Surabaya are because Surabaya is an industrial city also the classification of class D is the current primary situation at the site.

After the structural data is determined, then the criteria are checked for each structure with a stress ratio. Next, calculate the deviation between floors based on the classification from SNI 1726:2012. The structure studied is in risk category II (office). Then a nonlinear pushover static analysis is carried out which will produce a curve due to the base shear force and displacement which is called the capacity curve. After obtaining the capacity curve for each type of L/H, the value of the stiffness of the structure can be determined. Stiffness of the structure can be seen from the slope of the capacity curve in yielding and ultimate conditions. If the displacement values at the time of melting and ultimate conditions are known, then the value of the ductility of each structure can be known. Next determine the displacement target by determining the assumption that there is a maximum displacement that may occur as a result of the earthquake load. The displacement target in this study used the ASCE 41-13 NSP (Nonlinear Static Procedure) method which is available in the ETABS 2016 software application. Determination of the displacement target based on the nonlinear static procedure is carried out by constructing an idealization curve from the capacity curve resulting from the static nonlinear pushover analysis. With the idealization curve, it will be known the target displacement that occurs from the structural model. After knowing the target displacement of the structure, it can also be known the level of performance of each structure.

3. RESULTS AND DISCUSSION

Cross Section Dimensions

Determining the cross-sectional dimensions used in each structure is carried out by checking the criteria for each structure with a stress ratio of less than 0.95. The dimensions used in the structure are the dimensions obtained for the largest L/H type (L/H=2). Dimensions and stress ratios in the 3-floor, 5-floor, 8-floor and 10-floor models can be seen in Table 1 to Table 4.

Table 1. Dimensions and Stress Ratio on the 3 Floor Model

Structure Model for 3 Floors							
Structure Elements	Structural Element Dimensions	Stress Ratio					
		L/H= 1	L/H= 1,25	L/H=1.5	L/H= 1.75	L/H= 2	Status
BA floors 1-3	W310 × 310 × 179	0,043	0,083	0,108	0,203	0,889	OK
BI floors 1-3	W360 × 370 × 196	0,059	0,109	0,182	0,273	0,895	OK
K floors 1-3	W360 × 410 × 216	0,100	0,220	0,273	0,345	0,846	OK
BR floors 1-3	HSS177,8 × 177,8 × 9,5	0,094	0,226	0,371	0,487	0,943	OK

Table 2. Dimensions and Stress Ratio on the 5 Floor Model

Structure Model for 5 Floors							
Structure Elements	Structural Element Dimensions	Stress Ratio					
		L/H= 1	L/H= 1,25	L/H=1.5	L/H= 1.75	L/H= 2	Status
BA floors 1-5	W310 × 310 × 179	0,043	0,083	0,116	0,223	0,899	OK
BI floors 1-5	W360 × 370 × 196	0,071	0,121	0,198	0,286	0,939	OK
K floors 1-3	W360 × 410 × 314	0,223	0,270	0,327	0,377	0,901	OK
K floors 4-5	W360 × 370 × 196	0,092	0,125	0,198	0,290	0,870	OK
BR floors 1-5	HSS177,8 × 177,8 × 9,5	0,097	0,230	0,311	0,656	0,923	OK

Table 3. Dimensions and Stress Ratio on the 8 Floor Model

Structure Model for 8 Floors							
Structure Elements	Structural Element Dimensions	Stress Ratio					
		L/H= 1	L/H= 1,25	L/H=1.5	L/H= 1.75	L/H= 2	Status
BA floors 1-8	W310 × 310 ×179	0,043	0,083	0,107	0,204	0,899	OK
BI floors 1-5	W360 × 370 ×196	0,086	0,121	0,200	0,270	0,905	OK
BI floors 6-8	W310 × 310 × 202	0,089	0,129	0,198	0,296	0,936	OK
K floors 1-3	W360 × 410 × 463	0,217	0,273	0,331	0,400	0,945	OK
K floors 4-5	W360 × 410 × 287	0,115	0,219	0,290	0,318	0,939	OK
K floors 6-8	W310 × 310 × 342	0,087	0,109	0,151	0,231	0,701	OK
BR floors 1-8	HSS177,8 × 177,8 × 9,5	0,097	0,239	0,330	0,459	0,940	OK

Table 4. Dimensions and Stress Ratio on the 10 Floor Model

Structure Model for 10 Floors							
Structure Elements	Structural Element Dimensions	Stress Ratio					
		L/H= 1	L/H= 1,25	L/H=1.5	L/H= 1.75	L/H= 2	Status
BA floors 1-8	W310 × 310 × 179	0,043	0,083	0,107	0,204	0,899	OK
BA Lt 9-10	W310 × 310 × 179	0,043	0,083	0,107	0,223	0,899	OK
BI floors 1-5	W360 × 370 × 196	0,087	0,127	0,184	0,261	0,819	OK
BI floors 6-8	W310 × 310 × 202	0,092	0,137	0,200	0,282	0,890	OK
BI floors 9-10	W310 × 310 × 202	0,083	0,127	0,188	0,273	0,878	OK
K floors 1-3	W360 × 410 × 592	0,100	0,235	0,281	0,355	0,913	OK
K floors 4-5	W360 × 410 × 463	0,092	0,120	0,243	0,306	0,801	OK
K floors 6-8	W310 × 310 × 314	0,110	0,142	0,269	0,336	0,870	OK
K floors 9-10	W310 × 310 × 216	0,095	0,134	0,182	0,265	0,892	OK
BR floors 1-8	HSS203,2 × 203,2 × 4,8	0,216	0,284	0,356	0,437	0,847	OK

Deviation between floor levels

Determination of the deviation between floors based on the classification of SNI 1726: 2012 [13] the structure studied is in risk category II (office). So that the requirements of the deviation between floors of the design level should not be more than 0,020 hsx. The level height of each structure is 4000 mm, then the allowable deviation of each structural model is 80 mm. The results of the deviations between storey levels on floors 3, 5, 8 and 10 along with the X and Y directions can be seen in Figure 1−4.

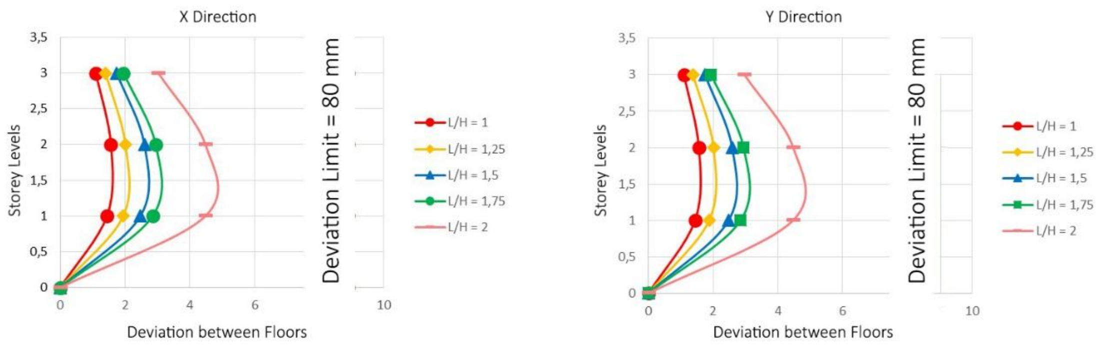

Figure 1. Deviation between Floors at Level 3 Floor X and Y Direction.

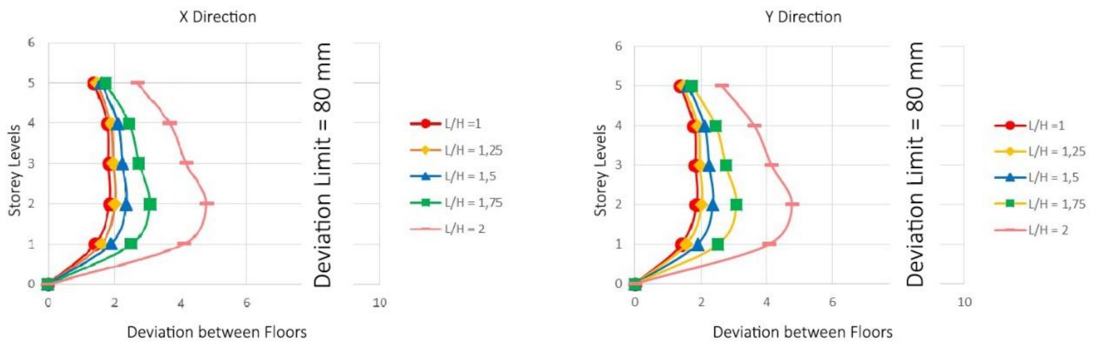

Figure 2. Deviation between Floors at Level 5 Floor Y Direction

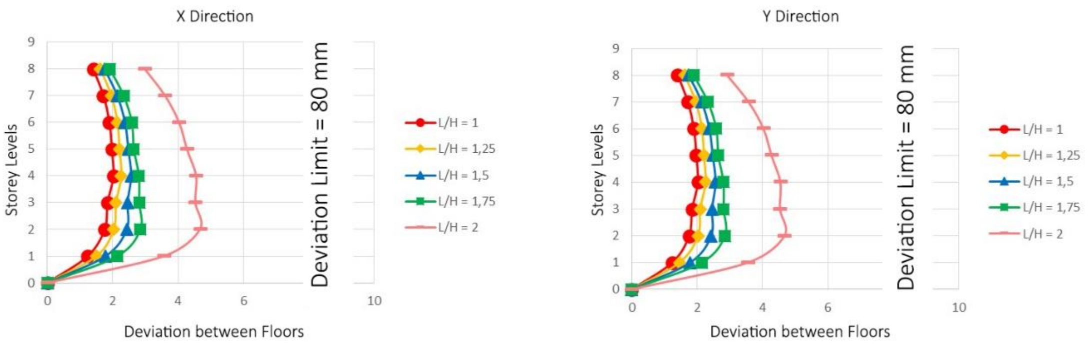

Figure 3. Deviation between Floors at Level 8 Floor Y Direction

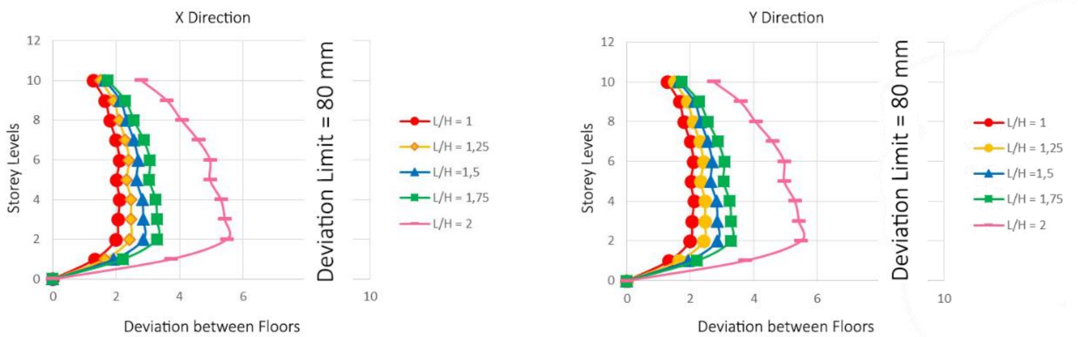

Figure 4. Deviation between Floors at Level 10 Floor Y Direction

Based on the results from Figure 1−4, the deviation between storey floors at each level in the X direction and Y direction occurs at type L/H=2. This is due to the smaller the resulting bracing angle, the less resistance of the bracing in resisting the deformation received by the structure.

Pushover Nonlinear Static Analysis

In this pushover analysis it will produce a curve due to the base shear force and displacement which is called the capacity curve. With the existence of a capacity curve it will also be known the capacity of the structure including the stiffness of the structure and the ductility of the structure. The results of the day's pushover analysis can be seen in Figure 5−8.

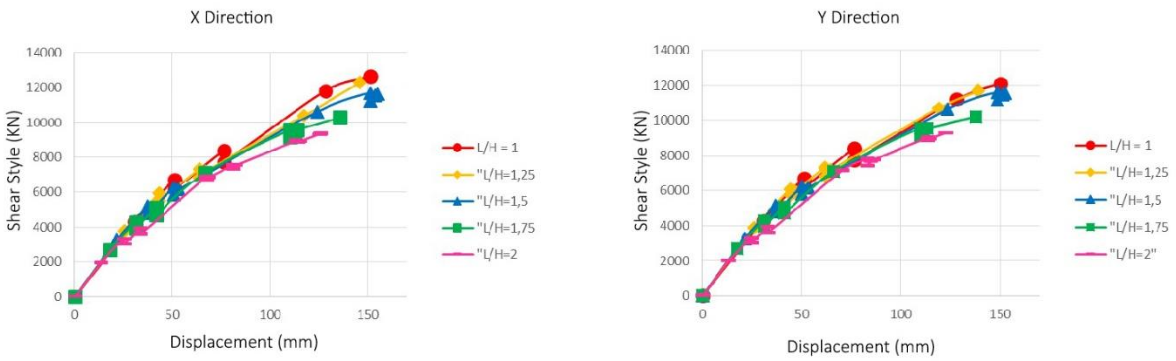

Figure 5. Comparison of Capacity Curves in X and Y Directional 3 Storey Structures.

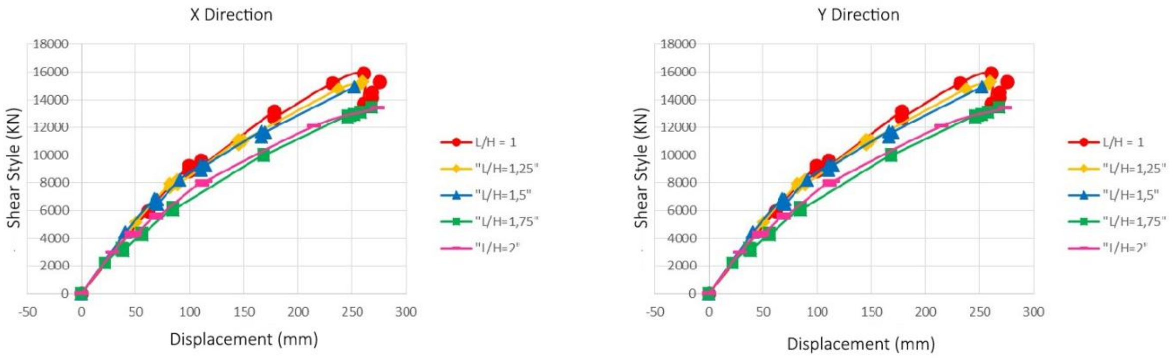

Figure 6. Comparison of Capacity Curves in X and Y Directional 5 Storey Structures.

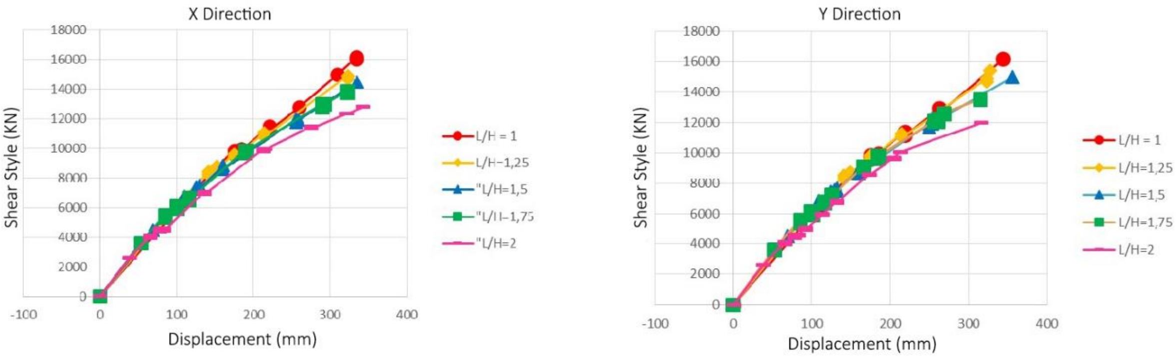

Figure 7. Comparison of Capacity Curves in X and Y Directional 8 Storey Structures.

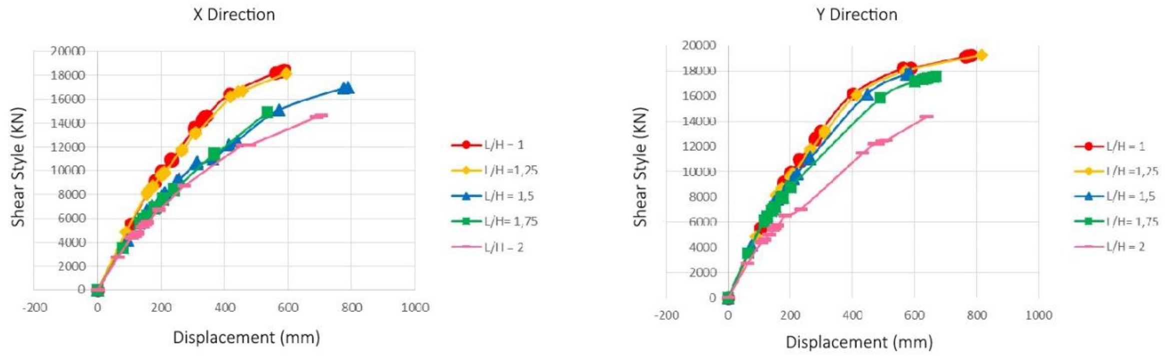

Figure 8. Comparison of Capacity Curves in X and Y Directional 10 Storey Structures.

Based on the results obtained, for a 3-storey building the largest base shear force occurs in the L/H=1 type in the X direction of 12,263 KN with a displacement of 151 mm, while the Y direction is 12,124 KN with a displacement of 150 mm. Furthermore, in a 5-storey building the largest base shear force occurs in type L/H=1 in the X direction of 15,316 KN with a displacement of 275 mm, while in the Y direction of 15,937 KN with a displacement of 262 mm. Then, in the 8-storey building the largest base shear force occurs in the L/H=1 type in the X direction of 16,173 KN with a displacement of 334 mm, while the Y direction is 16,168 KN with a displacement of 343 mm. In the 10-storey building the largest base shear force occurs in the L/H=1 type in the X direction of 18,221 KN with a displacement of 561 mm, while the Y direction is 18,236 KN with a displacement of 563 mm.

Structure Stiffness

After obtaining the capacity curve for each type of L/H, the value of the stiffness of the structure can be determined. The magnitude of the structural stiffness value is the result of the comparison between the base shear force (V) to the displacement (δ), both in yield (y) and ultimate (u) conditions. The results of structural stiffness can be seen from the slope of the capacity curve in yielding and ultimate conditions. Based on the data in Table 5 to Table 12, it can be seen that in the melting condition, the L/H=1 type is the L/H type which has the smallest percentage of stiffness at each level. Meanwhile, in the ultimate condition the greatest structural stiffness at each level occurs in the L/H=1 type. So that it can be said that in the ultimate condition, the greater the L/H type, the smaller the stiffness value of the structure. The relation between the structural stiffness and the shear force is the bigger of the structure stiffness in the building, it will resist with the bigger shear force.

Table 5. Structural Stiffness with 3 Storey Levels in Melting Conditions

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Vy (kN)	4.293	4.294	3.770	3.879	3.286	3.289	2.706	2.709	1.957	1.976
δy (m)	0,03	0,03	0,025	0,026	0,022	0,022	0,018	0,028	0,013	0,013
K (kN/m)	143.100	138.516	150.800	149.192	149.364	149.500	150.333	150.500	150.538	152.000
%	100	100	105	108	104	108	106	109	105	110

Table 6. Structural Stiffness with 3 Floor Levels in Ultimate Condition

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Vy (kN)	12.676	12.124	12.277	11.704	11.645	11.596	10.295	10.228	9.343	9.315
δy (m)	0,151	0,15	0,147	0,145	0,154	0,153	0,135	0,138	0,125	0,123
K (kN/m)	83.616	80.827	83.517	80.717	75.617	75.791	76.259	74.116	74.744	75.732
%	100	100	99	99	91	94	91	92	89	93

Table 7. Structural Stiffness with 5 Storey Levels in Melting Conditions

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Vy (kN)	5.968	5.970	5.145	5.280	4.427	4.432	2.211	2.215	2.943	2.962
δy (m)	0,061	0,061	0,05	0,051	0,041	0,041	0,022	0,022	0,028	0,026
K (kN/m)	97,836	97.869	102.900	103.529	107.976	108.098	100.500	100.682	105.107	113.923
%	100	100	105	106	110	111	103	103	107	116

Table 8. Structural Stiffness with 5 Floor Levels in Ultimate Condition

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Vy (kN)	15.912	15937	15.804	15.453	14.946	15.828	13.432	13.784	13.401	13.269
δy (m)	0,26	0,262	0,26	0,258	0,253	0,294	0,268	0,262	0,273	0,264
K (kN/m)	61.200	60.828	60.785	59.895	59.075	53.837	50.119	52.611	49.088	50.261
%	100	100	99,3	98,5	96,5	88,5	81,9	86,5	80,2	82,6

Table 9. Structural Stiffness with 8 Storey Levels in Melting Conditions

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Vy (kN)	6.484	6.489	5.521	5.533	4.460	4.470	3.614	3.616	2.590	2.539
δy (m)	0,111	0,111	0,089	0,089	0,069	0,069	0,053	0,053	0,039	0,038
K (kN/m)	58.414	58.459	62.034	62.169	64.638	64.783	68.189	68.226	66.410	66.816
%	100	100	106	106	111	111	117	117	114	114

Table 10. Structural Stiffness with 8 Floor Levels in Ultimate Condition

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Vy (kN)	16.172	16.180	14.910	15.414	14.486	15.055	13.886	13.533	12.788	11.975
δy (m)	0,333	0,343	0,322	0,327	0,334	0,355	0,322	0,314	0,342	0,316
K (kN/m)	48.565	47.172	46.304	47.138	43.371	42.268	43.124	43.099	37.392	37.896
%	100	100	95	99	89	90	88	91	77	80

Table 11. Structural Stiffness with 10 Storey Levels in Melting Conditions

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Vy (kN)	5.522	5.525	4.834	4.837	4.175	4.280	3.532	3.533	2.708	2.710
δy (m)	0,128	0,129	0,110	0,110	0,094	0,094	0,079	0,079	0,062	0,062
K (kN/m)	43.141	42.829	43.945	43.973	44.415	45.532	44.709	44.722	43.677	43.710
%	100	100	102	103	103	106	104	104	101	102

Table 12. Structural Stiffness with 10 Floor Levels in Ultimate Condition

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Vy (kN)	18.468	18.221	18.161	17.999	15.125	17.817	15.962	17.548	14.488	14.323
δy (m)	0,586	0,567	0,594	0,572	0,572	0,575	0,608	0,670	0,687	0,637
K (kN/m)	31.515	32.136	30.574	31.467	26.442	30.986	26.253	26.191	21.089	22.485
%	100	100	97	98	84	96	83	82	67	70

Structural Ductility

After knowing the value of the displacement during the melting condition and the ultimate condition, it can be known the value of the ductility of each structure. The ductility value of the structure is the result of a comparison between the displacements in the melting state (δy) and the ultimate condition (δu). Based on data from Tables 13 to 16, the type L/=1 is used as a comparison for the structural ductility of each type of L/H. The greatest structural ductility at the 3 story level in the X direction and Y direction occurs in the L/H=2 type with a value of 9.3. The greatest structural ductility at the 5 storey level in the X and Y directions occurs in type L/H=2 with values of 9.7 and 9.4 respectively. The greatest structural ductility at the 8 storey level in the X direction and Y direction occurs in the L/H=2 type with values of 8.9 and 8.2 respectively. The greatest structural ductility at the 10 story level in the X and Y directions occurs in type L/H=2 with values of 11 and 10.6 respectively. So at each level, the greatest ductility occurs at type L/H=2.

Table 13. Structure Ductility with Level 3 Floors

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
δu (m)	0,151	0,15	0,146	0,145	0,155	0,152	0,136	0,138	0,125	0,123
δy (m)	0,031	0,031	0,025	0,026	0,022	0,021	0,018	0,018	0,013	0,013
Daktailitas	4,9	4,9	5,7	5,6	7,1	7,1	7,6	7,8	9,3	9,3
%	100	100	116	114	145	145	153	159	188	191

Table 14. Structure Ductility with Level 5 Floors

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
δu (m)	0,275	0,262	0,260	0,259	0,252	0,253	0,268	0,263	0,273	0,265
δy (m)	0,061	0,061	0,050	0,051	0,041	0,040	0,037	0,037	0,028	0,028
Daktailitas	4,5	4,3	5,2	5,1	6,2	6,3	7,3	7,2	9,7	9,4
%	100	100	116	118	138	146	162	167	215	219

Table 15. Structure Ductility with Level 8 Floors

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
δu (m)	0,334	0,344	0,323	0,328	0,335	0,355	0,322	0,315	0,342	0,316
δy (m)	0,111	0,111	0,089	0,089	0,069	0,069	0,053	0,053	0,039	0,038
Daktailitas	3,0	3,1	3,6	3,7	4,9	5,2	6,1	6,0	8,9	8,2
%	100	100	120	119	162	168	202	194	295	266

Table 16. Structure Ductility with Level 10 Floors

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
δu (m)	0,588	0,587	0,594	0,573	0,573	0,573	0,608	0,661	0,688	0,657
δy (m)	0,128	0,129	0,111	0,111	0,095	0,085	0,079	0,071	0,063	0,062
Daktailitas	4,6	4,5	5,4	5,2	6,0	6,7	7,7	9,3	11,0	10,6
%	100	100	117	114	131	149	167	205	239	234

Displacement Target

Then determine the displacement target, namely the assumption that there is a maximum displacement that may occur as a result of the earthquake load. The displacement target in this study used the ASCE 41-13 NSP (Nonlinear Static Procedure) method which is available in the ETABS 2016 software application. Determination of the displacement target based on this nonlinear static procedure is carried out by making an idealization curve of the capacity curve resulting from a static nonlinear pushover analysis. So, with the idealization curve, it will be known the displacement target that occurs from the structural model [14]. Based on data from Table 17 to Table 20, it is known that the largest displacement target for each type occurs at type L/H=2. So that the greater the type L/H in the bracing structure, the greater the displacement target produced.

Table 17. Target Displacement and Basic Shear Force of 3 Floor Structure Model

Type	Displacement Target (mm)		Basic Shear Force (KN)	
	X	Y	X	Y
L/H = 1.00	0,052	0,052	6.270	6.271
L/H = 1,25	0,070	0,070	7.434	7.505
L/H = 1,50	0,098	0,098	8.982	8.993
L/H = 1,75	0,129	0,129	10.297	10.326
L/H = 2.00	0,195	0,194	9.343	9.315

Table 18. Target Displacement and Basic Shear Force of 5 Floor Structure Model

Type	Displacement Target (mm)		Basic Shear Force (KN)	
	X	Y	X	Y
L/H = 1.00	0,114	0,114	9.425	9.431
L/H = 1,25	0,137	0,137	10.602	10.737
L/H = 1,50	0,152	0,152	11.069	11.082
L/H = 1,75	0,192	0,190	10.809	10.842
L/H = 2.00	0,264	0,262	13.533	13.494

Table 19. Target Displacement and Basic Shear Force of 8 Floor Structure Model

Type	Displacement Target (mm)		Basic Shear Force (KN)	
	X	Y	X	Y
L/H = 1.00	0,192	0,193	10.244	10.258
L/H = 1,25	0,211	0,211	10.912	10.987
L/H = 1,50	0,233	0,233	11.169	11.164
L/H = 1,75	0,259	0,258	12.050	12.006
L/H = 2.00	0,408	0,401	12.788	12.788

Table 20. Target Displacement and Basic Shear Force of 10 Floor Structure Model

Type	Displacement Target (mm)		Basic Shear Force (KN)	
	X	Y	X	Y
L/H = 1.00	0,246	0,246	9.696	9.699
L/H = 1,25	0,278	0,278	10.262	10.251
L/H = 1,50	0,315	0,314	10.630	10.626
L/H = 1,75	0,356	0,357	11.185	10.891
L/H = 2.00	0,565	0,571	13.128	13.388

Structure Performance Level

After knowing the target displacement of the structure, it can be known the level of performance of each structure. Based on FEMA 273, the determination of the performance level of the structure is based on the calculation between the target displacement and the total height of the building. The structure performance level grouping is divided into 3, namely: Immediate Occupancy (IO), Life Safety (LS), and Collapse Prevention (CP) [15]. The performance level of each structure can be seen in table 21 to table 24.

Tabel 21. Structural Performance Level In 3 Floor Model

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Displacement Target (m)	0,052	0,052	0,07	0,07	0,098	0,098	0,129	0,129	0,195	0,194
Height (m)	12	12	12	12	12	12	12	12	12	12
Drift Ratio (%)	0,43	0,43	0,58	0,58	0,82	0,82	1,08	1,08	1,63	1,62
Performance Levels	IO	IO	LS	LS	LS	LS	LS	LS	CP	CP

Tabel 22. Structural Performance Level In 5 Floor Model

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Displacement Target (m)	0,114	0,114	0,137	0,137	0,152	0,152	0,19	0,19	0,264	0,262
Height (m)	12	12	12	12	12	12	12	12	12	12
Drift Ratio (%)	0,57	0,57	0,69	0,69	0,76	0,76	0,95	0,95	1,32	1,31
Performance Levels	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS

Tabel 23. Structural Performance Level In 8 Floor Model

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Displacement Target (m)	0,192	0,192	0,211	0,211	0,233	0,233	0,259	0,258	0,408	0,401
Height (m)	12	12	12	12	12	12	12	12	12	12
Drift Ratio (%)	0,6	0,6	0,66	0,66	0,73	0,73	0,81	0,81	1,28	1,25
Performance Levels	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS

Tabel 24. Structural Performance Level In 10 Floor Model

Parameter	L/H=1		L/H=1.25		L/H=1.5		L/H=1.75		L/H=2	
	X	Y	X	Y	X	Y	X	Y	X	Y
Displacement Target (m)	0,246	0,246	0,278	0,278	0,315	0,314	0,356	0,357	0,565	0,571
Height (m)	12	12	12	12	12	12	12	12	12	12
Drift Ratio (%)	0,62	0,62	0,7	0,7	0,79	0,79	0,89	0,89	1,41	1,43
Performance Levels	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS

So, based on data from Tables 21 to Table 24, it shows that the highest level of performance is in the 3-story structure model in the X direction and Y direction with type L/H=2, which is at the Collapse Prevention (CP). The level of Collapse Prevention (CP) occurs when 0% -0.5% = IO ; 0.5%-1.5% = LS ; > 1.5% = CP level which if 0%-0,5% = IO ; 0,5%-1,5% = LS ; > 1,5% = CP.

4. CONCLUSION

The conclusions that can be drawn from this research are: (1) The greater the increase in the type of L/H, the greater the deviation generated by the structural model, (2) After performing a nonlinear pushover analysis, the largest shear and displacement forces on each story occur in the type L/H=1, (3) In the melting condition, type L/H=1 is the type L/H which has the smallest percentage of stiffness at each level. However, in the ultimate condition, the greatest structural stiffness at each story occurs in the L/H=1 type. So that it can be said that in the ultimate condition, the greater the L/H type, the smaller the stiffness value of the structure, (4) The greatest value of structural ductility at each story occurs in the L/H=2 type in both the X and Y directions, (5) Based on ASCE 41-13 NSP model displacement targets L/H=2, all level models experience the largest displacement targets in the X and Y directions when compared to the other 4 types of L/H, (6) The highest level of structural performance occurs in the 3-floor structure model with type L/H=2, namely at the Collapse Prevention (CP) level, while for other structural models all are at the Life Safety (LS) level.

5. REFERENCES

[1] Amirsardari, A., Sofi, M., Lumantarna, E., Imran, I., & Duffield, C. (2019). Impact of earthquakes on the transportation infrastructure of indonesia: A preliminary study. Civil Engineering Dimension. 21(1), 19-28.
[2] Rajindra, R., Suardi, I., Sabara, Z., Pushpalal, D., Samad, M. A., Yani, A., & Umam, R. (2019). Diversity, resilience, and tragedy: Three disasters in Palu of Indonesia. International Journal of Innovation, Creativity and Change. 5(2), 1592-1607
[3] Doğangün, A., Yön, B., Onat, O., Emin Öncü, M., & Sağıroğlu, S. (2021). Seismicity of East Anatolian of Turkey and failures of infill walls induced by major earthquakes. Journal of Earthquake and Tsunami. 15(04), 2150017.
[4] Eren, N., Brunesi, E., & Nascimbene, R. (2019). Influence of masonry infills on the progressive collapse resistance of reinforced concrete framed buildings. Engineering Structures. 178, 375-394.
[5] Terán-Gilmore, A., Roeslin, S., Tapia-Hernández, E., & Cuadros-Hipólito, E. (2021). Displacement-based design of tall earthquake-resistant diagrid systems. Journal of Building Engineering. 35, 102022.
[6] Liew, J. Y. R., Chua, Y. S., & Dai, Z. (2019). Steel Concrete Composite Systems for Modular Construction of High-Rise Buildings. In Structures Elsevier. 21, 135-149.
[7] Shi, X., Park, P., Rew, Y., Huang, K., & Sim, C. (2020). Constitutive Behaviors of Steel Fiber Reinforced Concrete Under Uniaxial Compression and Tension. Construction and Building Materials. 233, 117316.
[8] Hashemi, A., Clifton, G. C., Bagheri, H., Zarnani, P., & Quenneville, P. (2020). Proposed Design Procedure for Steel Self-Centring Tension-Only Braces with Resilient Connections. In Structures Elsevier. 25, 147-156.
[9] Hemmati, A., Kheyroddin, A., & Farzad, M. (2020). Experimental Study of Reinforced Concrete Frame Rehabilitated by Concentric and Eccentric Bracing. Journal of Rehabilitation in Civil Engineering. 8(1), 97-108.
[10] Zhang, G., Xu, L. H., & Li, Z. X. (2021). Development and Seismic Retrofit of An Innovative Modular Steel Structure Connection Using Symmetrical Self-Centering Haunch Braces. Engineering Structures. 229, 111671.
[11] Seker, O. (2022). Seismic Response of Dual Concentrically Braced Steel Frames with Various Bracing Configurations. Journal of Constructional Steel Research. 188, 107057.
[12] National Standardization Agency. (2013). Minimum Load for the Design of Buildings and Other Structures: SNI 1727-2013.
[13] National Standardization Agency. (2012). Earthquake Resistance Planning Procedures for Building and Non-Building Structures: SNI 1726-2012.
[14] Speicher, M. S., & Harris III, J. L. (2018). Collapse Prevention Seismic Performance Assessment of New Buckling-Restrained Braced Frames Using ASCE 41. Engineering Structures. 164, 274-289.
[15] Chopra, A. K., & Goel, R. K. (2002). A Modal Pushover Analysis Procedure for Estimating Seismic Demands for Buildings. Earthquake Engineering & Structural Dynamics. 31(3), 561-582.