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THE EFFECT OF TSUNAMI LOADS ON THE PRAYOGA FOREIGN LANGUAGE COLLEGE BUILDING IN PADANG CITY, INDONESIA

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ABSTRACT: Padang, the capital city of West Sumatra, is located in coastal areas and has a high level of tsunami disaster vulnerability (High-Risk Zone). Therefore, public buildings in Padang City must have certain technical engineering to reduce the risk of structural failure. One of the public buildings that need to be considered as an educational facility and vertical evacuation in Padang City is the Prayoga Foreign Language College (STBA) building. Based on the results of an evaluation conducted by the Andalas University assessment team, the Prayoga STBA building was designed without taking into account the tsunami loads. Therefore, it is necessary to re-analyze the building by taking into account the tsunami loads. In this study, the building was analyzed using ETABS v.18.1.1 software concerning current Indonesian building standards such as SNI 2847:2019 for building structural reinforced concrete requirements, SNI 1726:2019 for earthquake resistance building design, SNI 1727:2020 for minimum design load for buildings, and international standard of FEMA P646-2019 for tsunami loads calculation. The results of the analysis show that the building is able to withstand the earthquake load, but the capacity of the building is insufficient when the tsunami loads are applied to the structure. The beams and columns on the 1st and 2nd floors do not have strong enough capacity to resist the tsunami loads, so there is a possibility of structural failure. The effect of tsunami loads on the internal forces and other structural responses of the building is also discussed in this paper.

Keywords: Tsunami loads, Building, Structural evaluation, Earthquake, Load-carrying capacity

1. INTRODUCTION

Indonesia is a country that is prone to natural disasters, especially earthquakes and tsunamis, due to the meeting or collision of two plates, namely the Indo-Australian oceanic plate and the Eurasian continental plate. The risk of death due to earthquakes and tsunamis is very high, so good risk management is needed to reduce the number of victims.

Disaster management in tsunamis can be considered through mapping of tsunami evacuation routes and shelters. Based on previous research, mapping of tsunami horizontal evacuation routes can be successfully implemented if the horizontal evacuation time is sufficient [1,2]. In several cases, the horizontal evacuation does not work mainly due to the behavior of people who tend to drive their vehicles, such as car and motorbike, after the earthquake, and street-blockage caused by building damaged by an earthquake that increase the number of human injured because evacuees walking speed is decreased [3]. To overcome this problem, vertical evacuation routes are needed by constructing shelter buildings.

Vertical evacuation must be supported by a strong building structure capable of resisting the working loads, including the earthquake and tsunami loads. Research on tsunami loads on building structures has been carried out previously by varying the percentage of wall opening and thickness [4] and evaluating a school building as an evacuation shelter with/without strengthening the building structure [5].

One of the public buildings that need to be considered as an educational facility and vertical evacuation in Padang City is the Prayoga Foreign Language College (STBA) building.

Prayoga Foreign Languages College (Prayoga STBA) building is a development of the Prayoga Foreign Language Academy (ABA) under the auspices of the Prayoga Foundation. Indonesia, especially Padang City, is an area with an earthquake-prone category [6]. Padang City has been recorded to have occurred several large earthquakes, one of which was the Padang earthquake on September 30, 2009 [7].

The Prayoga STBA building is located around 450 m from Padang Beach, which is very vulnerable, and it will have a very impact if a tsunami hits Padang City, as shown in Fig.1. Therefore, it is necessary to observe whether the Prayoga STBA building can withstand the combined earthquake and tsunami loads, as well as the impact that occurred due to the tsunami loads.

The building had been evaluated previously by the Andalas University (UNAND) assessment team, with the results showing that this building was designed without taking into account the tsunami loads. In this study, therefore, a structural evaluation of the Proyoga STBA building using the current Indonesian building standards and the international standard of

FEMA for tsunami vertical evacuation structures should be carried out by taking into account the tsunami loads in order to investigate the effect of tsunami loads on the building.

Fig.1 Prayoga STBA building in Padang City

2. RESEARCH SIGNIFICANCE

This study discusses the influence of tsunami loads on one of the education buildings in a region susceptible to near-source generated tsunamis, which is likely to experience strong ground shaking immediately before the tsunami in accordance with current regulations. The effect of tsunami loads aims to investigate the behavior of buildings before and after being subjected to tsunami loads. The finding of this study will be useful as a reference in the structural analysis of educational buildings that function as vertical evacuation buildings/shelters in considering the occurrence of natural disasters in strong earthquake areas with the potential for tsunamis.

3. ANALYSIS AND DISCUSSION

3.1 The Location of Prayoga STBA Building

Based on the data observed using Google Maps (Fig.1), the location of the Prayoga STBA building on Veteran Street, No. 8, West Padang, is 450.785m distance from the shoreline. The location of the building is also around urban areas, offices, and residential areas [8].

3.2 The Level of Tsunami Vulnerability

The Prayoga STBA building is located in the red zone (high-risk zone) of the tsunami [6] and the area with a tsunami inundation depth of 5m [9].

3.3 Building Data

Prayoga STBA building is a five-story building made of reinforced concrete structures with a size of 48m length and 12m width. The yield strength of steel (fy) was 240 MPa and 400 MPa for plain and deformed reinforcements, respectively, while the compressive strength of the concrete (f'c) was 24.5 MPa. The dimensions of the structural elements are:

1. Beam: B1, G1 (35 x 75cm), B2, G2 (35 x 50cm), B3 (20 x 30cm), CG1, G3, G4 and G5 (20 x 75cm)
2. Column: K1, K2, K3 (65 x 65cm) and K4 (40 x 40cm).

3.4 The Modeling of Building Structure

Structural analysis of the Prayoga STBA building was carried out using ETABS software. The columns and beams of the building structure are modeled as frame elements, the slabs as shell elements, and the structural walls as wall elements [10]. The 3D modeling of the building structure was carried out following the existing condition of the current Prayoga STBA building, as shown in Fig.2.

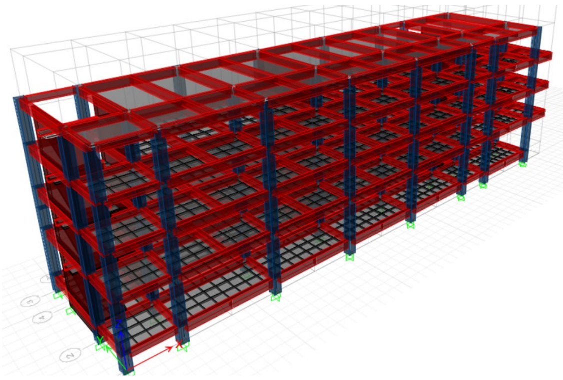

Fig.2 3D modeling of Prayoga STBA building

3.5 Loading Analysis

3.5.1 Dead load

Dead loads are obtained from the self-weight of building materials and building components [11]. The dead load on the building was calculated using the Indonesian Standards, SNI 1727:2020 [11]. The dead loads that work on the Prayoga STBA building are:

1. The self-weight of structural elements was calculated directly by the structural analysis program ETABS.
2. Superimposed dead load was calculated based on SNI 1727:2020, as shown in Table 1.

3.5.2 Live load

Based on article 4.3.1 of SNI 1727:2020, explaining the live load used for building planning must use a maximum live load [11]. Table 2 shows the live loads on the Prayoga STBA building.

Table 1 Dead loads on the Prayoga STBA building

Material type	Load value
Plaster	42 kg/m^2
Plafond	20 kg/m^2
Ceramic	48 kg/m^2
Wall	250 kg/m^2

Table 2 Live loads on the Prayoga STBA building

Room type	Load value
Classrooms	1.92 kN/m^2
1st floor corridor	4.79 kN/m^2
Corridor above the 1st floor	3.83 kN/m^2

3.5.3 Earthquake load

The spectrum response is used as an analysis of dynamic earthquake loads. The spectrum response earthquake load is calculated based on SNI 1726:2019 using the 2019 Indonesian Earthquake Hazard Map [12]. Therefore, the design spectral acceleration parameter values for medium soil, the value of spectral design S_{D1} and S_{DS} are 1.0g and 0.68g, respectively. Fig.3 shows the spectrum response of Prayoga STBA in Padang City with medium soil conditions.

The spectral response data are inputted into the structural modeling, then scale factor calculations are performed on ETABS using Eq. (1):

$$SF = G.I/R \quad (1)$$

Where G is the acceleration of gravity, I is the building priority factor, and R is the response modification coefficient.

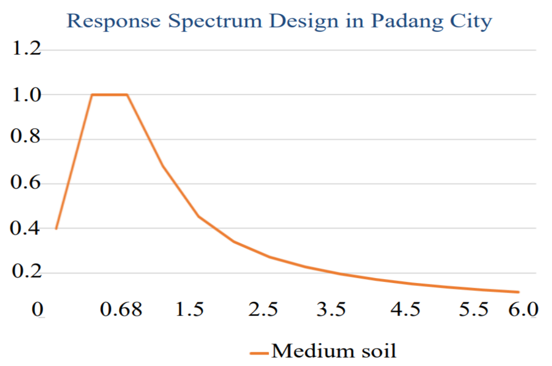

Fig.3 The response spectrum in Padang City with medium soil

3.5.4 Tsunami loads

Article 8.8 of FEMA P-646 2019 explains the calculated tsunami loads as follows:

1. Hydrostatic force

Hydrostatic force is the horizontal force caused by the water pressure against a surface. The amount of this force depends on the depth of the water [13]. Hydrostatic force can be calculated by Eq. (2).

$$Fh = 0.5\,\rho_s\,g\,b\,{h_{max}}^2 \quad (2)$$

Where ρs is tsunami volume weight, g is the acceleration of gravity, b is the width that accepts the pressure, and h_{max} is the maximum water height above the wall base.

2. Buoyant force

The buoyant forces on a structure subject to partial or total submergence will act vertically through the center of mass of the displaced volume [13]. The buoyant force on the structure can be calculated by Eq. (3).

$$Fb = \rho_s\,g\,V \quad (3)$$

Where V is the volume of water below the maximum inundation.

3. Hydrodynamic force

Hydrodynamic force is a combination of horizontal forces caused by the compressive force of moving water and the friction caused by the flow around the structure [13]. Hydrodynamic force can be calculated by Eq. (4).

$$Fh_d = 0.5\,\rho_s\,cd\,b\,(hu^2)_{max} \quad (4)$$

Where cd is the drag coefficient, h is the depth of flow, and u is the flow velocity.

4. Impulsive force

Impulsive forces are caused by the leading edge of a surge of water impinging on a structure and by the water wave that comes suddenly. The impulsive force of the building is 1.5 times the hydrodynamic force [13].

5. Debris load

Debris impact is caused by a buildup of debris that is assumed by additional hydrodynamic force and depends on the thickness of the layer of debris [14]. To calculate the debris force, use Eq. (5).

$$F_{dm} = 0.5\,\rho_s\,cd\,Bd\,(hu^2)_{max} \quad (5)$$

6. Impact load

Impact loads result from debris such as driftwood, small boats, portions of a house, or any object transported by floodwaters, striking against buildings and structures [13]. This value is calculated by the following Eq. (6).

$$Fi = 1.3\,u_{max}\sqrt{k + md\,(1 + c)} \quad (6)$$

Where u_{max} is the maximum flow with the volume of water below the maximum inundation.

7. Additional gravity load

Due to the high depreciation rate of water being rapid, likely, there will be plenty of water suspended in the floor, causing the addition of a significant gravitational force on the floor [13]. The potential additional load of gravity per unit area can be calculated by Eq. (7).

$$F_i = \rho_s \, g \, h_r \quad (7)$$

Where hr is hmax - 1st floor height.

8. Uplift forces on elevated floors

Uplift hydrodynamic force is given on the top floor of the tsunami inundation affected [13]. The uplift load can be calculated by Eq. (8).

$$F_u = 0.5 \, C_u \, \rho_s \, A_f \, U_v^{\,2} \quad (8)$$

Where C_u is the uplift coefficient, A_F is the tsunami inundation area, and U_V is the hydrodynamic uplift force. The calculation results of tsunami loads are given in Table 3.

Table 3 The tsunami loads of the Prayoga STBA building

Load type	Load value
Hydrostatic forces	329.946 kN
Buoyant forces	17.266 kN/m^2
Hydrodynamic forces	84.077 kN
Impulsive forces	126.116 kN
Floating debris impact forces	447.815 kN
Debris load	517.398 kN
Additional gravity load	15.107 kN/m^2
Uplift forces on elevated floors	8.41x10^{-6} kN/m^2

3.6 Load Combination

The load combination refers to SNI 1726-2019 for the combination of loading due to the earthquake and FEMA P646-2019 for the combination of loading due to the tsunami loads [12,13]. The load combination for this analysis is as follows:

1. 1.4 DL
2. 1.2 DL + 1.6 LL+ 0.5 R
3. 1.2 DL + 1.0 LL ± 1.0 EQx ± 0.3 EQy
4. 1.2 DL + 1.0 LL ± 0.3 EQx ± 1.0 EQy
5. 0.9 DL ± 1.0 EQx ± 0.3 EQy
6. 0.9 DL ± 0.3 EQx ± 1.0 EQy
7. 1.2 DL + 0.25 LL + 1 (FB+FU) + 1 Lref
8. 1.2 DL + 0.25 LL + 1 (FH+FHD) + 1 Lref
9. 1.2 DL + 0.25 LL + 1 (FI+FHD) + 1 Lref
10. 0.9 DL + 1 (FB+FU)
11. 0.9 DL + 1 (FH+FHD)
12. 0.9 DL + 1 (FI+FHD)

Where DL is dead load, LL is live load, EQX is X-directional earthquake load, EQY is Y-direction earthquake load, Lref is life refuge load, FB is buoyant load, FU is uplift load, FHD is hydrodynamic load, and FI is impact load.

3.7 Inter-story Drift

Based on SNI 1726:2019, the inter-story drift (Δ) must be calculated using the following Eq. (9) [12].

$$\delta = \frac{C_d \, \delta_x}{I_e} \leq 0.010 \, h_{sx} \quad (9)$$

From Eq. (9), the inter-story drift can be obtained. Tables 4 and 5 show the inter-story results in X and Y directions with and without tsunami loads.

Table 4 Inter-story drift in X-direction

Story	Displacement - X: With tsunami loads (mm)	Displacement - X: Without tsunami loads (mm)	Limit (mm)	Increased ratio (%)	Check $\Delta_{limit}>\Delta x$
5	4.671	4.697	35	0.55	OK
4	7.715	7.803	35	1.14	OK
3	10.362	10.828	35	4.49	OK
2	13.416	14.777	35	10.14	OK
1	1.793	1.984	42	10.63	OK

Table 5 Inter-story drift in Y-direction

Story	Displacement - Y: With tsunami loads (mm)	Displacement - Y: Without tsunami loads (mm)	Limit (mm)	Increased ratio (%)	Check $\Delta_{limit}>\Delta x$
5	2.574	2.585	35	0.43	OK
4	4.411	4.429	35	0.42	OK
3	4.217	4.231	35	0.35	OK
2	3.843	3.920	35	2.00	OK
1	0.532	0.554	42	4.14	OK

4. INTERNAL FORCES IN COLUMNS AND BEAMS

The analysis was carried out to obtain the force in the Prayoga STBA Padang building in the form of the results of internal forces such as the axial force, the shear force, and the bending moment.

4.1 Internal Forces in Columns

Tables 6 and 7 show the results of internal forces in columns with and without tsunami loads. From these tables, the internal forces in the column have increased due to being given a tsunami load. The maximum increase of internal force on the 2nd floor is 67% for axial force, 279% for shear force, and 469% for bending moment.

4.2 Internal Forces in Beams

The internal forces in the beams with tsunami loads calculated based on FEMA P-646 were higher than those calculated without tsunami loads, as shown in Tables 8 and 9. From these tables, the internal forces in the beam have increased due to being given a tsunami load. The internal forces increased with a maximum increase of 170% for the shear force and 184% for the bending moments on the 2nd floor.

Table 6 Internal forces in columns with and without tsunami loads

Story	Code	Without tsunami loads			With tsunami loads		
		Axial	Shear	Moment	Axial	Shear	Moment
1	K1	3632.1	404.2	393.6	5051.8	690.9	703.0
	K2	2879.5	338.3	381.9	3960.6	517.1	661.9
	K3	1680.1	265.1	362.7	2261.5	460.8	648.2
	K4	1203.5	64.05	59.90	1203.5	100.7	99.93
2	K1	2902.9	238.9	480.5	4253.6	430.5	545.3
	K2	2332.9	174.8	340.3	3335.9	407.1	505.3
	K3	1395.6	164.2	324.8	1938.9	398.8	493.9
	K4	523.0	64.7	44.1	875.0	245.6	250.9
3	K1	2110.6	277.9	479.7	2465.1	283.7	484.3
	K2	1705.2	216.7	307.4	1705.2	221.5	314.3
	K3	1057.3	147.6	255.7	1281.2	151.3	255.7
	K4	523.0	27.9	44.1	100.7	13.2	45.9

Table 7 Increased ratio of internal forces in columns

Story	Code	Increased ratio		
		Axial	Shear	Moment
1	K1	39%	70%	78%
	K2	37%	52%	73%
	K3	34%	73%	78%
	K4	0%	57%	66%
2	K1	46%	80%	13%
	K2	43%	132%	48%
	K3	38%	142%	52%
	K4	67%	279%	469%
3	K1	16%	2%	1%
	K2	0%	2%	2%
	K3	21%	2%	0%
	K4	0%	52%	116%

5. CROSS-SECTIONAL CAPACITY OF THE STRUCTURE

5.1 Column Capacities

The capacity of the column to withstand the working loads can be seen from the column P-M interaction diagram and shear capacity. The calculation of the P-M interaction diagram and shear capacity of the building was carried out based on the Indonesia building standard, SNI 2847:2019 [15].

5.1.1 First floor column P-M interaction diagram

Figs.4 and 5 show the P-M interaction diagram obtained from structural analysis results with and without tsunami loads. From these figures, it can be seen that the increase in internal force marked in blue is quite significant, and the bending capacity of the columns can withstand the working loads, including tsunami loads.

5.1.2 Shear capacity of columns

The shear capacity of the columns is shown in Table 10. The table reveals that the shear capacity of the building without tsunami load can withstand the working loads, while the shear capacity of the building with tsunami loads shows that the 1st and 3rd floor columns are not able to withstand the shear force.

Table 8 Internal forces in beams with and without tsunami loads

Story	Code	Without tsunami loads		With tsunami loads	
		Shear	Moment	Shear	Moment
1	B3	16.26	12.81	16.20	27.32
	G1	184.27	222.51	206.25	250.90
	G2	149.18	124.98	149.18	175.29
	G3	194.93	140.51	194.94	184.07
	G4	233.87	196.37	233.50	278.13
	G5	138.04	103.29	137.77	182.63
2	B1	53.65	153.53	145.01	434.90
	B2	53.65	153.53	115.02	153.53
	B3	20.76	18.45	24.51	18.38
	CG1	6.90	32.65	6.90	72.61
	G1	195.13	169.02	441.75	417.01
	G2	151.14	125.27	178.11	125.27
	G4	237.71	199.00	381.99	411.13
	G4	294.41	345.92	489.92	760.21
	G5	180.51	229.69	240.35	229.69
3	B1	53.95	152.82	63.78	179.50
	B2	54.14	152.82	54.14	152.82
	B3	18.64	18.39	18.64	18.39
	CG1	8.03	28.70	8.03	28.70
	G1	197.88	164.90	219.71	181.58
	G2	113.66	92.17	113.66	92.17
	G3	228.11	192.46	228.11	209.58
	G4	265.51	316.28	348.13	343.32
	G5	169.47	176.06	169.47	176.06

Table 9 Increased ratio of internal forces in beams

Story	Code	Increased Ratio	
		Shear	Bending Moment
1	B3	0%	113%
	G1	12%	13%
	G2	0%	40%
	G3	0%	31%
	G4	0%	42%
	G5	0%	77%
2	B1	170%	183%
	B2	114%	0%
	B3	18%	0%
	CG1	0%	122%
	G1	126%	147%
	G2	18%	0%
	G4	61%	107%
	G4	66%	120%
	G5	33%	0%
3	B1	18%	17%
	B2	0%	0%
	B3	0%	0%
	CG1	0%	0%
	G1	11%	10%
	G2	0%	0%
	G3	0%	9%
	G4	31%	9%
	G5	0%	0%

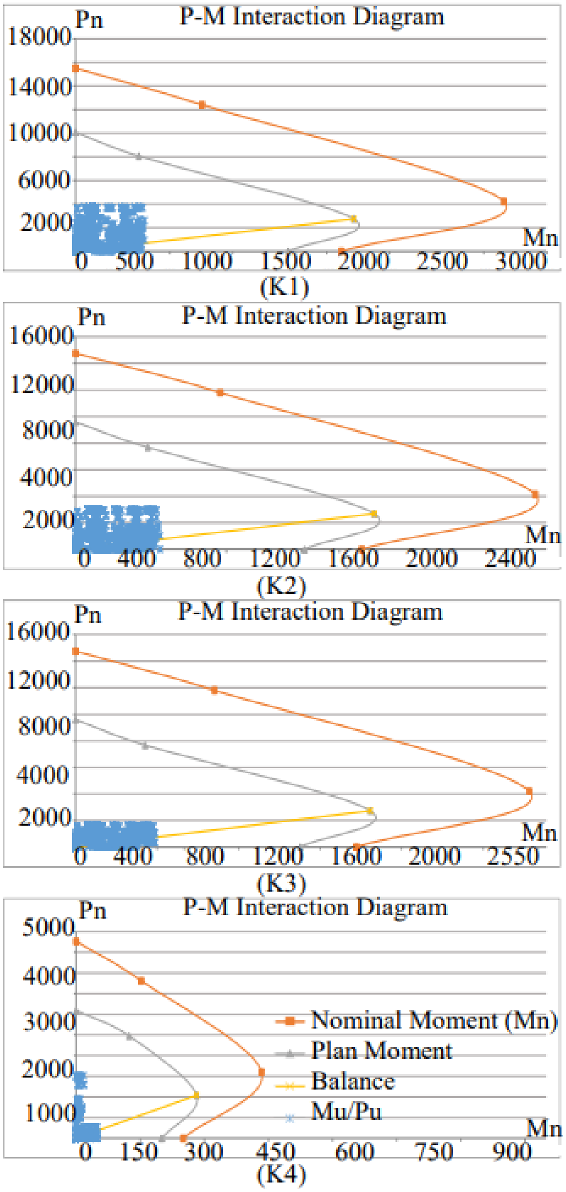

Fig.4 P-M interaction diagram of the column without tsunami loads on the 1st floor

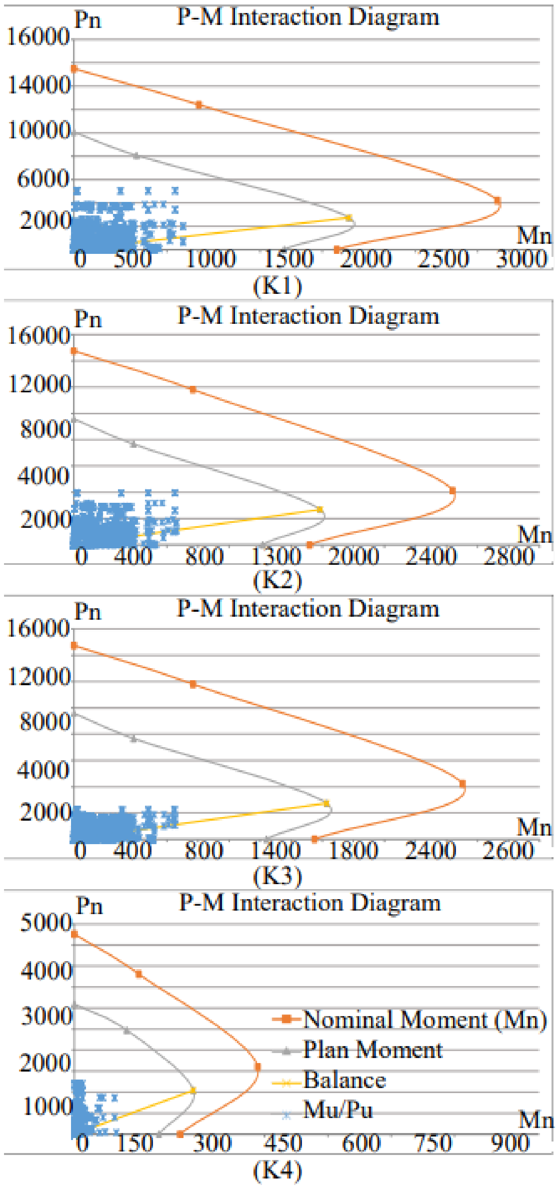

Fig.5 P-M interaction diagram of the column with tsunami loads on the 1st floor

Table 10 Shear capacity columns with and without tsunami loads

Story	Col. type	ΦVn (kN)	Without tsunami loads		With tsunami loads		Inc. Ratio
			Vu (kN)	Note	Vu (kN)	Note	(%)
1	K1	475.29	404.24	OK	690.94	Not OK	71
	K2	475.29	363.14	OK	517.06	Not OK	42
	K3	493.68	275.13	OK	460.75	OK	68
	K4	168.61	60.45	OK	123.54	OK	104
2	K1	475.29	282.48	OK	430.54	OK	52
	K2	475.29	196.31	OK	407.14	OK	107
	K3	493.68	176.24	OK	398.85	OK	126
	K4	168.61	64.65	OK	245.64	Not OK	279
3	K1	475.29	357.82	OK	362.53	OK	1
	K2	475.29	216.65	OK	221.49	OK	2
	K3	493.68	171.19	OK	171.19	OK	0
	K4	168.61	27.93	OK	42.51	OK	52

The increase in shear force due to tsunami loads is quite significant, especially for the 1st and 2nd floors, with a maximum increase on the 2nd floor of 279.9%.

5.2 Beam Capacities

5.2.1 Flexural capacity of beams

The calculation and comparison of the flexural capacity of beams that were analyzed with and without tsunami loads are shown in Table 11 [15]. From the table, it is seen that several beams have no enough capacity to resist the additional tsunami loads.

The table also shows that the flexure in the beams increases significantly on the 2nd floor beam. The highest increase in beam flexure was observed on the B2 beam on the 2nd floor, which is 230.54%.

Table 11 Beam flexural capacity at 1st floor and 2nd floor with and without tsunami loads

Story	Beam type	Location	ØMn (kNm)	Without tsunami load		With tsunami load		Inc. Ratio (%)
				Mu (kNm)	Note	Mu (kNm)	Note	
1	B3	At support	40.24	16.86	OK	27.78	OK	65
		At field	40.24	7.27	OK	13.39	OK	84
	G1	At support	276.22	263.80	OK	288.51	Not OK	9
		At field	276.22	111.55	OK	111.16	OK	0
	G2	At support	196.35	138.28	OK	146.37	OK	6
		At field	196.35	102.26	OK	144.47	OK	41
	G3	At support	371.97	314.58	OK	385.95	Not OK	23
		At field	371.97	125.33	OK	182.83	OK	46
	G4	At support	441.73	396.54	OK	469.11	Not OK	18
		At field	576.62	210.53	OK	286.77	OK	36
	G5	At support	267.76	253.33	OK	347.05	Not OK	37
		At field	267.76	108.41	OK	168.73	OK	55
2	B1	At support	150.42	39.21	OK	58.08	OK	48
		At field	198.79	2.54	OK	2.67	OK	5
	B2	At support	78.94	37.79	OK	81.19	Not OK	114
		At field	78.94	12.21	OK	40.35	OK	230
	B3	At support	67.76	24.56	OK	24.28	Oke	0
		At field	67.76	9.85	OK	10.57	Oke	7
	CG1	At support	509.95	478.08	OK	973.87	Not OK	104
		At field	371.97	289.05	OK	572.62	Not OK	98
	G1	At support	340.86	248.84	OK	538.81	Not OK	117
		At field	209.81	189.35	OK	209.97	Not OK	11
	G2	At support	165.84	142.04	OK	139.77	OK	0
		At field	196.35	57.20	OK	56.33	OK	0
	G3	At support	509.95	489.28	OK	507.43	OK	3
		At field	300.66	231.65	OK	228.99	OK	0
	G4	At support	641.75	578.07	OK	743.51	Not OK	29
		At field	371.97	246.39	OK	243.67	OK	0
	G5	At support	441.73	415.96	OK	405.45	OK	0
		At field	300.66	221.34	OK	212.58	OK	0

5.2.2 Shear capacity of beams

The results of the calculation and comparison of the shear capacity of beams with and without tsunami loads are shown in Table 12. From the table, it is seen that two beams (CG1 and G1) are not able to resist the shear force when tsunami loads are applied to the building. The increase in the shear force of the beams was not as large as the increase in the columns, but the increase was still quite significant, in which the increase did not exceed 100%.

The calculation results of mass participation, P-delta effects, and structural irregularities in the Prayoga STBA Padang building have all met the requirements in SNI 1726-2019 and FEMA P646 [13].

Table 12 Beam shear capacity with and without tsunami loads

Story	Beam type	Location	ØVn (kN)	Without tsunami load		With tsunami load		Inc. ratio (%)
				Vu (kN)	Note	Vu (kN)	Note	
1	B3	At support	75.79	11.49	OK	19.23	OK	67
		At field	66.74	16.26	OK	16.26	OK	0
	G1	At support	474.32	194.24	OK	215.85	OK	11
		At field	329.56	184.27	OK	206.25	OK	11
	G2	At support	525.15	109.09	OK	171.12	OK	56
		At field	525.15	149.18	OK	149.18	OK	0
	G3	At support	661.23	187.81	OK	196.64	OK	4
		At field	661.23	194.93	OK	194.94	OK	0
	G4	At support	661.23	232.41	OK	325.21	OK	39
		At field	516.71	233.87	OK	233.87	OK	0
	G5	At support	661.23	137.64	OK	171.64	OK	24
		At field	516.71	138.04	OK	138.04	OK	0
2	B1	At support	442.15	54.13	OK	122.21	OK	125
		At field	313.47	53.65	OK	145.01	OK	170
	B2	At support	176.81	54.13	OK	82.54	OK	52
		At field	166.85	53.65	OK	115.02	OK	114
	B3	At support	87.85	15.04	OK	15.28	OK	1
		At field	78.20	20.76	OK	24.51	OK	18
	CG1	At support	366.42	222.03	OK	465.37	Not OK	109
		At field	366.42	6.90	OK	6.90	OK	0
	G1	At support	586.91	208.42	OK	492.07	OK	136
		At field	385.85	195.13	OK	441.75	Not OK	126
	G2	At support	403.50	131.03	OK	131.13	OK	0
		At field	403.50	151.14	OK	178.11	OK	17
	G3	At support	661.23	230.66	OK	364.03	OK	57
		At field	516.71	237.71	OK	381.99	OK	60
	G4	At support	661.23	290.35	OK	477.64	OK	64
		At field	661.23	294.41	OK	489.92	OK	66
	G5	At support	661.23	164.49	OK	225.88	OK	37
		At field	516.71	180.51	OK	240.35	OK	33

Based on the structural response results, the Prayoga STBA Padang building is strong enough to withstand the earthquake load, but not strong enough to resist the applied tsunami loads. The influence of the tsunami loads on the Prayoga STBA Padang building is significant enough so that the columns and beams of the 1st and 2nd floors of the building have the possibility of damage or collapse [16].

6. CONCLUSION

Based on the results of the analysis, the following conclusions can be drawn :

1. The addition of the tsunami load on the Prayoga STBA Padang building increases the inter-story drift value by 0.55% - 10.63% in the X direction and 0.43% - 4.14% in the Y direction.
2. For the internal force that occurs in the column, the maximum increase occurred in the 1st and 2nd floor columns, which is 67% for the axial force, 279% for the shear force, and 469% for the bending moment, while there is no significant increase for the 3rd floor column and above. Furthermore, the internal forces of the beams increased with a maximum increase of 170% and 184% for shear force and bending moment.

3. The Prayoga STBA building is strong in withstanding earthquake loads. However, when tsunami loads happen, the shear capacity of the column on the 1st floor and the bending moment and shear capacity of the beams on the 1st and 2nd floors are not strong enough to withstand the working loads.

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