JTS Jurnal Teknik dan Science
JTS Vol 4 No. 3 October 2025 | ISSN: 2828-7002 (Print), ISSN: 2828-6871 (online), Page 47-63

Evaluation of Reinforced Concrete Structural Design of Rukost Tawakal, West Jakarta Against Earthquake Load

Gilang Aditiya[1], Reynold Andika Pratama[2]
Teknik Sipil, Universitas Dian Nusantara

Article History
Received : 15-08-2025
Revised : 20-08-2025
Accepted : 19-10-2025
Published : 27-10-2025

Corresponding author*:
reynold.andika.pratama@dosen.undira.ac.id

Cite This Article: Gilang Aditiya, & Reynold Andika Pratama. (2025). Evaluation of Reinforced Concrete Structural Design of Rukost Tawakal, West Jakarta Against Earthquake Loads. Jurnal Teknik Dan Science, 4(3), 47–63.

DOI: https://doi.org/10.56127/jts.v4i3.2856

Abstract: The high population density in West Jakarta has led to an increased demand for housing; however, rising property prices have become a barrier for younger generations to own a place to live. The limited land availability in densely populated areas like West Jakarta encourages the development of vertical housing as a solution to the growing residential needs, such as the Rukost Tawakal IX project. This building is designed as a five-story residence with a reinforced concrete structure. Given that Indonesia is located in an earthquake-prone region, the building's structural system must be evaluated against seismic loads in accordance with national design standards. This study aims to evaluate the structural system of the Rukost Tawakal IX building using structural analysis software based on the provisions of SNI 1726:2019, SNI 1727:2020, and SNI 2847:2019. The evaluation focuses on the performance of primary structural elements such as columns, beams, and concrete slabs, as well as their compliance with the requirements of the Special Moment Resisting Frame (SMRF) system and the Strong Column Weak Beam (SCWB) principle, which are designated for high-ductility structures. The results of the evaluation are expected to provide recommendations for a safe, efficient, and earthquake-resistant structural design.

Keywords: SNI, Seismic Load, Structure, SMRF, SCWB

INTRODUCTION

Indonesia, especially West Jakarta, is an area with a high population density of around 2.5 million people (BPS, 2023). This density is influenced by natural growth and migration, thereby increasing the need for housing amidst limited land. These conditions encourage the construction of multi-storey housing. However, high property prices make the younger generation prefer rental housing such as boarding houses or rented houses, which is the background for the construction of Rukost Tawakal in West Jakarta. Geographically, West Jakarta is in an earthquake-prone area because Indonesia is located at the meeting point of four tectonic plates. Therefore, Rukost Tawakal as a multi-storey residence needs to be designed taking into account earthquake loads according to SNI standards. This final project research aims to evaluate the upper structural system of Rukost Tawakal using a structural analysis program, with the SMRF system as a reference. The evaluation focused on column, beam and concrete slab elements to assess the structure's performance against earthquake loads and its conformity with high ductility requirements based on SNI 1726:2019, SNI 1727:2020 and SNI 2847:2019, in order to produce safe, efficient and optimal structural planning.

PROBLEM FORMULATION

1. How is the performance of the upper structure of the Rukost Tawakal building in West Jakarta in accepting earthquake loads based on the provisions of SNI 1726:2019, SNI 1727:2020, and SNI 2847:2019?
2. Does the superstructure system of the Rukost Tawakal building meet the high ductility capacity requirements required in the SMRF system?
3. How are the main structural elements of the Rukost Tawakal building evaluated for earthquake resistance and structural planning efficiency?

RESEARCH OBJECTIVES

1. Evaluate the performance of the upper structure of the Rukost Tawakal building against earthquake loads based on the provisions of SNI 1726:2019, SNI 1727:2020, and SNI 2847:2019.
2. Assess whether the upper structure of the Rukost Tawakal building meets the requirements for high ductility capacity in accordance with the SMRF system criteria.
3. Analyze the main structural elements to obtain an efficient, optimal and earthquake-resistant plan, find out the results of the comparison of the size of the structural elements and the size of the reinforcement used and their quantity.

THEORETICAL BASIS

Modeling structure

Rukost Tawakal is a 5-story building with reinforced concrete and a light steel roof, the roof of which will be modified into a reinforced concrete slab for the rooftop and evaluated based on SNI 2847:2019, SNI 1726:2019, and SNI 1727:2020 to determine the high risk and need for SMRF (Special Moment Resisting Frame Structural System). Preliminary design of structures, especially beams and columns, refers to SNI 2847:2019, where beams must be weaker than columns, beam-column connections, and foundations according to article 18.7.3.2. A slab, which functions as a floor or roof, is defined as a two-way slab if the ratio of the longest to the shortest span is ≤ 2.

Load on the structure

The loads calculated include vertical loads referring to SNI 1727:2020, such as:

1. Dead Load (DL)
2. Superimposed Dead Load (SIDL)
3. Live Load (LL)
4. Rainwater Load (RL)

Horizontal loads, such as:

1. Wind Load (W) based on SNI 1727:2020
2. Earthquake Load (E) based on SNI 1726:2019

The loads combination uses the LRFD (Load and Resistance Factor Design) method or the ultimate method due to excess strength factors, which refers to SNI 1726:2019 Article 4.2.2.1.

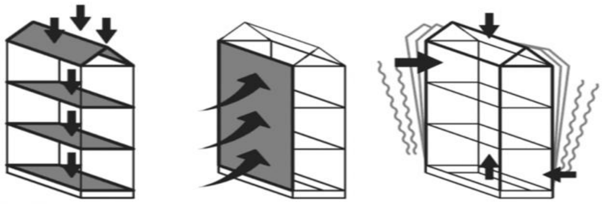


Figure 1. Types of loads on structures
(Source: sisipil.com, 2024)

Structural analysis

1. The structural analysis carried out includes regularity analysis, evaluation of element dimensions, analysis of reinforcement requirements, evaluation of earthquake resistant structural systems, and analysis of story drift.
2. The design of beam, column, and slab reinforcement must meet the dimensional requirements, minimum reinforcement area (A_s), and reinforcement ratio, as well as ensuring reduced nominal moment capacity (ϕM_n) is greater than the ultimate moment (M_u).
3. The earthquake resistant structural system used is SMRF (Special Moment Resisting Frame Structural System) which must fulfill the Strong Column-Weak Beam (SCWB) principle in beam-column connections.
4. Interstory drift analysis (Δ) is obtained from the lateral displacement which is enlarged by the factors C_d and I_e and must be smaller than the permitted drift (Δ_{max}) according to the Risk Category.

RESEARCH METHODS

This research uses descriptive quantitative methods with this type of research evaluative. This method was chosen because it is focused on evaluation or assessment activities redesign of the reinforced concrete structure of the Rukost Tawakal building. This research was conducted at the Rukost construction project location on Jl. Tawakal IX RT.7/RW.9, Tomang, Grogol Petamburan, West Jakarta, Jakarta 11440 with point latitude coordinates -6.168638° longitude 106.79632°. The regulations that serve as guidelines for evaluating the structure of Rukost Tawakal are as follows:

1. SNI 2847:2019 "Structural Concrete Requirements for Buildings"
2. SNI 1726:2019 "Earthquake Resistance Planning for Buildings and Non-Buildings"
3. SNI 1727:2020 "Minimum Loads for Design Buildings and Other Structures"

On evaluating the structure of Rukost Tawakal, the structural analysis support program used is ETABS and spColumn. The following is some secondary data collected as a basis for evaluation is as follows:

Project Name : Rukost Tawakal IX
Planner : Gafa House
Floors : 5 Floors
Construction : Reinforced Concrete
Concrete : f_c' 30 MPa
Reinforcement : f_y 420 MPa
f_y 280 MPa
Building area : 9 × 18 m = 72 m 2
Column Size : K1 = 650 × 500 mm
K2 = 550 × 400 mm

K3 = 400 ⨉ 300 mm
Beam Size : B1 = 750 ⨉ 350 mm
B2 = 700 ⨉ 300 mm
B3 = 550 ⨉ 250 mm
Slab thickness : S1 = 150 mm
The flow diagram or visual representation that describes this research process is as follows:

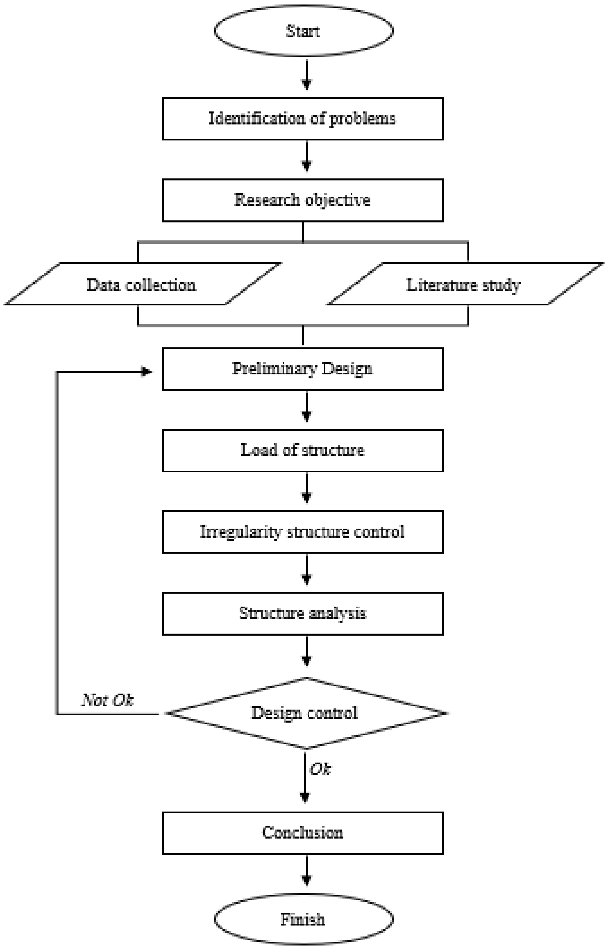


Figure 2. Research flow chart
(Source: Personal data)

RESULT AND DISCUSSION

Preliminary design

Table 1. Preliminary column dimensions

Code	Column Dimensions (mm)		Ratio (%)	Limit ratio (%)	Dimensions minimum (mm)	Cek
	c_1	c_2	c_2 / c_1			
K1	450	400	0,89	0,40	300	Oke
K2	300	300	1,00	0,40	300	Oke

(Source: Personal data)

Table 2. Preliminary beam dimensions

Code	Beam dimensions (mm)			Beam height min. (mm)	Beam width requirements (mm)			Cek
				h_{min}	b_{min}	b_{max}		
	h	b	*l*	*l*/16	0,3h ≤ 250	c_2	$0{,}75c_1$	
Main beam								
B1	500	300	3650	228,1	150	400	337,5	Oke
	500	300	4200	262,5	150	400	337,5	Oke
	500	300	3150	196,9	150	400	337,5	Oke
	500	300	2100	131,3	150	400	337,5	Oke
B2	350	300	1550	96,9	105	400	337,5	Oke
Support beam								
B3	350	200	1550	96,9	105	300	225,0	Oke
	350	200	5200	325,0	105	300	225,0	Oke
	350	200	2700	168,8	105	300	225,0	Oke
	350	200	2100	131,3	105	300	225,0	Oke
	350	200	3150	196,9	105	300	225,0	Oke
	350	200	4200	262,5	105	300	225,0	Oke

(Source: Personal data)

Table 2. Preliminary slab dimensions

Slab dimensions (mm)			Ratio *lx/ly*	Slab type	Thickness min. (mm)	Cek
Thickness	*lx*	*ly*	*lx/ly* ≤ 2		*l*/36	
120	3650	2100	1,74	Two way	101,4	Oke
120	3650	3150	1,16	Two way	101,4	Oke
120	2700	2100	1,29	Two way	75,0	Oke
120	1550	3150	0,49	Two way	87,5	Oke
120	1550	2100	0,74	Two way	58,3	Oke
120	4250	4200	1,01	Two way	118,1	Oke
120	2700	3150	0,86	Two way	87,5	Oke

(Source: Personal data)

Modeling structure

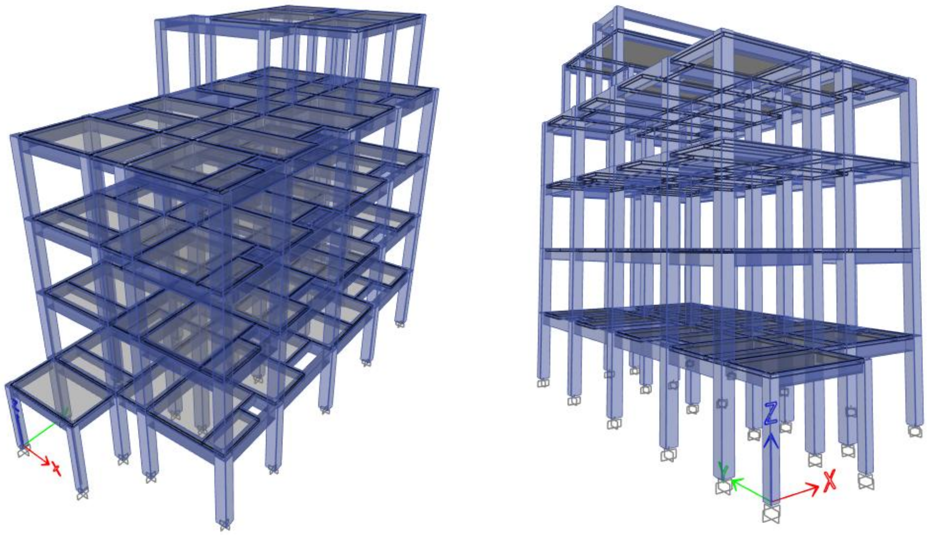


Figure 3. Rukost Tawakal structural modeling
(Source: Personal data)

Vertical load

Dead load (DL)

- Specific gravity of concrete : 23,536 kN/m^3

Superimposed Dead Load (SIDL)

- Load of wall (1/2 clay bricks) : 4,8 kN/m
- Floor and ceiling finishing : 1,53 kN/m^2
- Rooftop : 1,10 kN/m^2

Live Load (LL)

- Partitioned : 1,92 kN/m^2
- Nonpartitioned : 3,83 kN/m^2
- Live roof : 0,96 kN/m^2

Rainwater Load (RL)

- Puddles of rainwater 3 cm: 0,03 m × 9,81 kN/m3 = 0,294 kN/m^2

Horizontal load

Wind Load (W)

Parameters

- Exposure category : B
- Surface roughness : B
- VR : 40 m/s
- Ke : 1 → for all cases
- Kzt : 1 → not cliff or hill
- G : 0,85 → for buildings
- Kd : 0,85 → MWFRS (Main Wind Force Resisting System)
- zg : 365,76 m → exposure B
- α : 7 → exposure B

Determine K_z (for height $4,6 \leq z \leq z_g \rightarrow K_z = 2,01\,(z/z_g)^{2/\alpha}$)

- Story 5 (z = 16 m) : $2,01(16/365,76)^{2/7}$ = 0,82
- Story 4 (z = 12,8 m) : $2,01(12,8/365,76)^{2/7}$ = 0,77
- Story 3 (z = 9,6 m) : $2,01(9,6/365,76)^{2/7}$ = 0,71
- Story 2 (z = 6,4 m) : $2,01(6,4/365,76)^{2/7}$ = 0,63

Determine K_z (for height $z \leq 4,6 \rightarrow K_z = 2,01\ (15/z_g)^{2/\alpha}$)

- Story 1 (z = 3,2 m) : $2,01(15/365,76)^{2/7}$ = 0,81

Determine q_z ($q_z = 0,613.K_z.K_{zt}.K_d.K_e.V_R^2$)

- Story 5 : $0,613 \times 0,82 \times 1 \times 0,85 \times 1 \times 40^2 = 0,69$ kN/m^2
- Story 4 : $0,613 \times 0,77 \times 1 \times 0,85 \times 1 \times 40^2 = 0,64$ kN/m^2
- Story 3 : $0,613 \times 0,71 \times 1 \times 0,85 \times 1 \times 40^2 = 0,59$ kN/m^2
- Story 2 : $0,613 \times 0,63 \times 1 \times 0,85 \times 1 \times 40^2 = 0,53$ kN/m^2
- Story 1 : $0,613 \times 0,81 \times 1 \times 0,85 \times 1 \times 40^2 = 0,67$ kN/m^2

Determine C_p

- L/B direction X : 9/18 = 0,5
- L/B direction Y : 18/9 = 2,0

Table 3. Coefficient wind pressure

Surface	**X (0,5)**	**Y (2,0)**
Windward (C_{pW})	0,8	0,8
Leeward (C_{pL})	-0,5	-0,3
Side wall	-0,7	-0,7

(Source: Personal data)

Determine p ($p = q_z\ (G.C_{pW}) - q_h\ (G.C_{pL})$)

X direction (0º)

- Story 5 : $0,69 \times (0,85 \times 0,8) – 0,69 \times (0,85 \times (-0,5)) = 0,76$ kN/m^2
- Story 4 : $0,64 \times (0,85 \times 0,8) – 0,64 \times (0,85 \times (-0,5)) = 0,71$ kN/m^2
- Story 3 : $0,59 \times (0,85 \times 0,8) – 0,59 \times (0,85 \times (-0,5)) = 0,65$ kN/m^2
- Story 2 : $0,53 \times (0,85 \times 0,8) – 0,53 \times (0,85 \times (-0,5)) = 0,58$ kN/m^2
- Story 1 : $0,67 \times (0,85 \times 0,8) – 0,67 \times (0,85 \times (-0,5)) = 0,74$ kN/m^2

Y direction (90º)

- Story 5 : $0,69 \times (0,85 \times 0,8) – 0,69 \times (0,85 \times (-0,3)) = 0,64$ kN/m^2
- Story 4 : $0,64 \times (0,85 \times 0,8) – 0,64 \times (0,85 \times (-0,3)) = 0,60$ kN/m^2
- Story 3 : $0,59 \times (0,85 \times 0,8) – 0,59 \times (0,85 \times (-0,3)) = 0,55$ kN/m^2
- Story 2 : $0,53 \times (0,85 \times 0,8) – 0,53 \times (0,85 \times (-0,3)) = 0,49$ kN/m^2
- Story 1 : $0,67 \times (0,85 \times 0,8) – 0,67 \times (0,85 \times (-0,3)) = 0,63$ kN/m^2

Distribution of lateral wind force at each story ($F_x = (h_1/2.B.p_1)+(h_2/2.B.p_2)$)

X (0º) h_i = 3,2 m

- Story 5 (B = 6,30 m) : $((3,2/2) \times 6,3 \times 0,76) + 0 = 7,63$ kN

- Story 4 (B = 15,75 m) : ((3,2/2) × 15,75 × 0,71) + ((3,2/2) × 15,75 × 0,76) = 36,99 kN
- Story 3 (B = 15,75 m) : ((3,2/2) × 15,75 × 0,65) + ((3,2/2) × 15,75 × 0,71) = 34,40 kN
- Story 2 (B = 15,75 m) : ((3,2/2) × 17,85 × 0,58) + ((3,2/2) × 15,75 × 0,65) = 33,14 kN
- Story 1 (B = 17,85 m) : ((3,2/2) × 17,85 × 0,74) + ((3,2/2) × 15,75 × 0,58) = 35,92 kN

Y (90°) h_i = 3,2 m

- Story 5 (B = 6,95 m) : ((3,2/2) × 6,95 × 0,64) + 0 = 7,13 kN
- Story 4 (B = 8,85 m) : ((3,2/2) × 8,85 × 0,60) + ((3,2/2) × 8,85 × 0,64) = 17,59 kN
- Story 3 (B = 8,85 m) : ((3,2/2) × 8,85 × 0,55) + ((3,2/2) × 8,85 × 0,60) = 16,35 kN
- Story 2 (B = 8,85 m) : ((3,2/2) × 8,85 × 0,49) + ((3,2/2) × 8,85 × 0,55) = 14,82 kN
- Story 1 (B = 7,30 m) : ((3,2/2) × 7,30 × 0,63) + ((3,2/2) × 8,85 × 0,49) = 14,33 kN

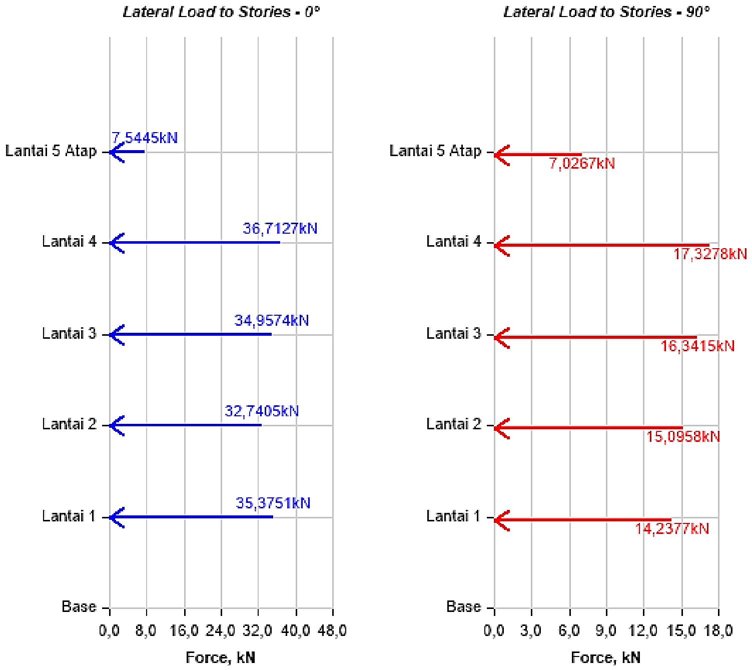


Figure 4. Lateral wind force distribution results from ETABS
(Source: Personal data)

Earthquake Load (E)

Site class from boring log

S_u is obtained from interpolation linear, for example:

If, N 5 – 10 = 8

So, S_u 25 – 50 kPa = 25 + (8-5/10-5) × (50 – 25) = 40 kPa

Table 3. Value $\bar{N}$ dan $\bar{S}_u$

Depth		d (m)	N – SPT	d/N	S_u (kPa)	d/S_u
0,0	1,5	1,5	8	0,19	40	0,04
1,5	3,0	1,5	6	0,25	30	0,05
3,0	4,5	1,5	9	0,17	45	0,03
4,5	6,0	1,5	13	0,12	65	0,02
6,0	7,5	1,5	15	0,10	75	0,02
7,5	9,0	1,5	29	0,05	145	0,01
9,0	10,5	1,5	60	0,03	300	0,01
10,5	12,0	1,5	60	0,03	300	0,01
12,0	13,5	1,5	59	0,03	295	0,01
13,5	15,0	1,5	49	0,03	245	0,01
15,0	16,5	1,5	51	0,03	255	0,01
16,5	18,0	1,5	54	0,03	270	0,01
18,0	19,5	1,5	11	0,14	55	0,03
19,5	21,0	1,5	13	0,12	65	0,02
21,0	22,5	1,5	15	0,10	75	0,02
22,5	24,0	1,5	10	0,15	50	0,03
24,0	25,5	1,5	12	0,13	60	0,03
25,5	27,0	1,5	39	0,04	195	0,01
27,0	28,5	1,5	41	0,04	205	0,01
28,5	30,0	1,5	42	0,04	210	0,01
Depth total (Σd)		30	$\Sigma \frac{d}{N}$	1,77	$\Sigma \frac{d}{S_u}$	0,35
			$\bar{N} = \frac{\Sigma d}{\Sigma \frac{d}{N}}$	16,93	$\bar{S}_u = \frac{\Sigma d}{\Sigma \frac{d}{S_u}}$	84,6

(Source: Personal data)

- $15 < \bar{N} = 16{,}93 < 50$ → SD (medium soil)
- $50 < \bar{S}_u = 84{,}6 < 100$ kPa → SD (medium soil)

TL	20
Ss	0.784
S1	0.385
Fa	1.186
Fv	1.915
SMS	0.930
SM1	0.737
SDS	0.620
SD1	0.491
T0	0.158
Ts	0.792

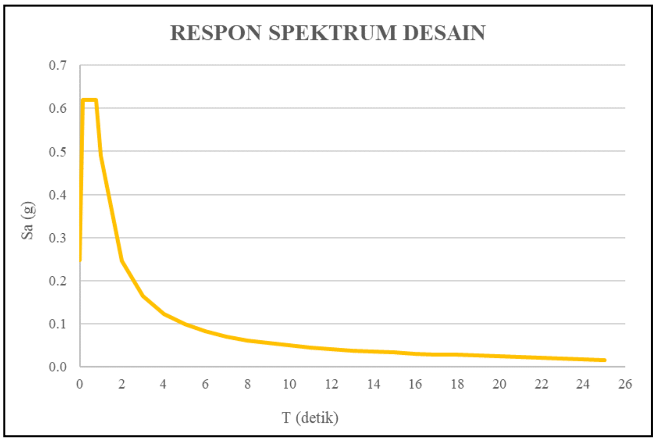


Figure 5. Design spectrum response graph
(Source: Personal data)

Seismic design category
- Risk category : II
- I_e : 1
- $0,50 \leq SDS = 0,620$ g : D
- $0,20 \leq SD1 = 0,491$ g : D

So, the seismic design category is D ($\rho = 1,3$)
And, the factors that bear seismic forces are:
- R : 8
- Ω_0 : 3
- C_d : 5,5

Period structure
- C_u : 1,4 $\rightarrow S_{D1} = 0,491 \geq 0,4$ g
- Ct : 0,0466 → Moment-resisting concrete frame
- x : 0,9 → Moment-resisting concrete frame
- h_s : 16 m
- T_a : $Ct \cdot h_s^x = 0,0466 \times 16^{0,9} = 0,565$ s
- T_{max} : $C_u \cdot T_a = 1,4 \times 0,565 = 0,791$ s

ETABS modeling of the structure period obtained is as follows:
- Period X (T_x) : 0,685 s
- Period Y (T_y) : 0,677 s

Because $T_a \leq T_{ETABS} \leq T_{max}$, the period structure of ETABS is used

Seismic basic shear forces (Static equivalent)
C_s : $S_{DS}/(R/I_e) = 0,6201/(8/1) = 0,0775$

Table 4. Effective seismic weight

Story	***Mass Summary by Story***	
	kg	**kN**
Story 5	29265,24	286,99
Story 4	133914,03	1313,25
Story 3	180977,15	1774,78
Story 2	180977,15	1774,78
Story 1	185886,44	1822,92
TOTAL	711020,01	**6972,72**

(Source: Personal data)

W_e : 6972,72 kN
V : $C_s.W_e$ = 0,0775 × 6972,72 = 540,52 kN
Vx_{ETABS} : 395,62 kN < 540,52 kN
Vy_{ETABS} : 453,85 kN < 540,52 kN
Initial force scale factor : Gravity / (R/I_e)
: 9,81 / (8/1) = 1,22583 m/s^2 → 1225,83 mm/s^2
Scale factor X : 1225,83 × V/V_x = 1225,83 × 540,52/395,62 = 1674,80 mm/s^2
Scale factor Y : 1225,83 × V/V_y = 1225,83 × 540,52/453,85 = 1459,93 mm/s^2

Distribution of lateral earthquake forces at each Story (F_x)
The k value is obtained by the following linear interpolation:
If, T_x 0,5 – 2,5 = 0,685 s → k 1 – 2 = 1 + (0,685−0,5)/(2,5−0,5) × (2 – 1) = 1,093
If, T_y 0,5 – 2,5 = 0,677 s → k 1 – 2 = 1 + (0,677−0,5)/(2,5−0,5) × (2 – 1) = 1,089

Table 5. Distribution of lateral earthquake forces at each Story X direction

Story	h_i (m)	h_i^K (m)	W_e (kN)	$W_e.h_i^K$ (kN)	C_{vx}	V (kN)	F_x (kN)
					$\frac{W_e.h_i^k}{\Sigma W_e.h_i^k}$		$C_{vx}.V$
Story 5	16	20,7	287,0	5934,4	0,0870	540,52	47,03
Story 4	12,8	16,2	1313,2	21280,1	0,3120	540,52	168,66
Story 3	9,6	11,8	1774,8	21002,7	0,3080	540,52	166,46
Story 2	6,4	7,6	1774,8	13486,4	0,1977	540,52	106,89
Story 1	3,2	3,6	1822,9	6496,0	0,0952	540,52	51,48
$\Sigma W_e.h_i^k$				68199,6	1,00		

(Source: Personal data)

Table 6. Distribution of lateral earthquake forces at each Story Y direction

Story	h_i (m)	h_i^K (m)	W_e (kN)	$W_e.h_i^K$ (kN)	C_{vx}	V (kN)	F_x (kN)
					$\frac{W_e.h_i^k}{\Sigma W_e.h_i^k}$		$C_{vx}.V$
Story 5	16	20,4	287,0	5868,9	0,0868	540,52	46,93
Story 4	12,8	16,0	1313,2	21064,2	0,3116	540,52	168,43
Story 3	9,6	11,7	1774,8	20813,6	0,3079	540,52	166,42
Story 2	6,4	7,5	1774,8	13386,6	0,1980	540,52	107,04
Story 1	3,2	3,5	1822,9	6465,8	0,0956	540,52	51,70
$\Sigma W_e.h_i^k$				68199,6	1,00		

(Source: Personal data)

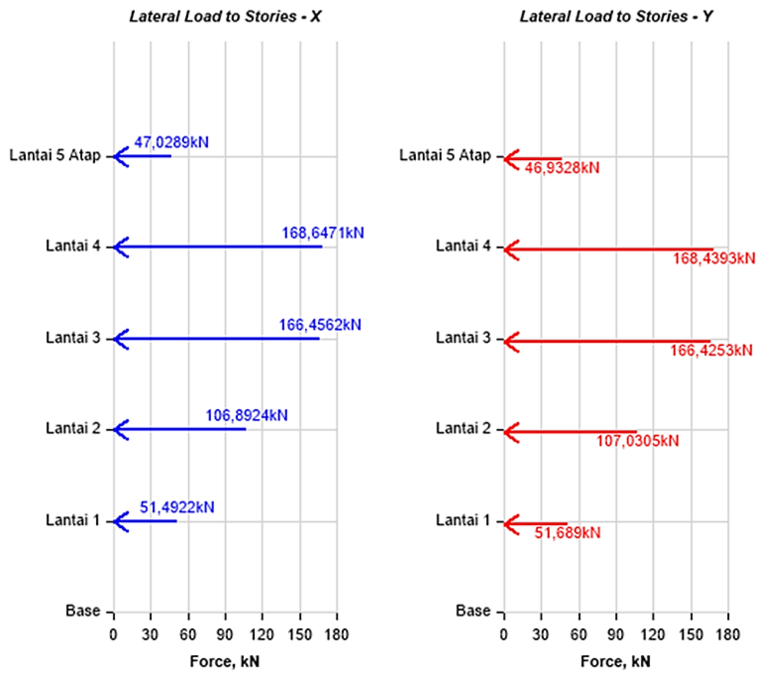


Figure 6. Lateral earthquake force distribution results from ETABS
(Source: Personal data)

Load combination

Stronger factors are used as a consequence of structural irregularities. For a combination of stronger factors using the LRFD method, it is as follows:

1. $1{,}4DL + 1{,}4SIDL$
2. $1{,}2DL + 1{,}2SIDL + 1{,}6LL + 0{,}5\ (LL_r$ atau $RL)$
3. $1{,}2DL + 1{,}2SIDL + 1{,}6\ (LL_r$ atau $RL) + (LL$ atau $0{,}5W)$
4. $1{,}2DL + 1{,}2SIDL + 1{,}0W + LL + 0{,}5\ (LL_r$ atau $R)$
5. $0{,}9DL + 0{,}9SIDL + 1{,}0W$
6. $1{,}2DL + 1{,}2SIDL + E_v + E_{mh} + LL$
7. $0{,}9DL + 0{,}9SIDL - E_v + E_{mh}$

For E_v and E_{mh} can be determined as follows:

- $E_v = 0{,}2S_{DS}.DL \rightarrow 0{,}2 \times 0{,}620 = 0{,}124DL$
- $E_{mh} = \Omega_0.Q_E \rightarrow 3 \times 100\ \% = 3$
- $E_{mh} = \Omega_0.Q_E \rightarrow 3 \times 30\ \% = 0{,}9$

Structural analysis

Column reinforcement analysis

Based on the results of the maximum force analysis, column reinforcement using the ETABS and spColumn programs in accordance with the provisions of SNI 2847:2019, a recapitulation of column reinforcement is obtained as follows:

Table 7. Column reinforcement

Code	Column dimensions (mm)		Longitudinal (mm)	Transversal (mm)			
				End-i/j		Middle	
	c1	c2		Strong axis	Weak axis	Strong axis	Weak axis

K1	450	400	14D25	4D13-100	4D13-100	2D13-150	2D13-150
K2	300	300	12D19	2D13-100	2D13-100	2D13-100	2D13-100

(Source: Personal data)

Beam reinforcement analysis

Based on the results of the maximum force analysis, beam reinforcement using the ETABS programs in accordance with the provisions of SNI 2847:2019, a recapitulation of beam reinforcement is obtained as follows:

Table 8. Beam reinforcement

Code	**Beam dimensions (mm)**			**Condition**	**Longitudinal (mm)**		**Transversal (mm)**	**Torque (mm)**
	h	**b**	***l***		**Top**	**Bottom**		
Main beam								
B1a	500	300	3650	End-i/j	5D19	5D19	3D13-100	2D10
				Middle	2D19	3D19	2D13-150	2D10
B1b	500	300	4200	End-i/j	5D19	3D19	2D13-100	2D10
				Middle	2D19	2D19	2D13-150	2D10
B1b	500	300	3150	End-i/j	5D19	3D19	2D13-100	2D10
				Middle	2D19	2D19	2D13-150	2D10
B1c	500	300	2100	End-i/j	2D19	2D19	2D13-100	2D10
				Middle	2D19	2D19	2D13-150	2D10
B2	350	300	1550	End-i/j	5D19	4D19	2D13-100	2D10
				Middle	2D19	2D19	2D13-100	–
Support beam								
B3	350	200	Semua bentang	End-i/j	3D16	2D16	2D10-100	–
				Middle	2D16	2D16	2D10-100	–

(Source: Personal data)

Slab reinforcement analysis

Based on the results of the maximum force analysis, slab reinforcement using the ETABS programs in accordance with the provisions of SNI 2847:2019, a recapitulation of slab reinforcement is obtained as follows:

Table 9. Slab reinforcement

Slab dimensions (mm)			**Longitudinal (mm)**			
			X direction (M11)		**Y direction (M22)**	
Thickness	***lx***	***ly***	**Top**	**Bottom**	**Top**	**Bottom**
120	3650	2100	D10-150	D10-150	D10-150	D10-150
120	3650	3150	D10-150	D10-150	D10-150	D10-150
120	2700	2100	D10-150	D10-150	D10-150	D10-150
120	1550	3150	D10-150	D10-150	D10-150	D10-150
120	1550	2100	D10-150	D10-150	D10-150	D10-150
120	4250	4200	D10-150	D10-150	D10-150	D10-150
120	2700	3150	D10-150	D10-150	D10-150	D10-150

(Source: Personal data)

Earthquake resistant structure
Moment nominal column, M_{nc} = 409,89 kNm
Moment nominal beam, M_{nb} = 237,32 kNm
Earthquake resistant structure requirements $= \Sigma M_{nc} \geq (1,2)\Sigma M_{nb}$
$= 409,89 \geq (1,2)237,32$
$= 409,89 \geq 284,78 \rightarrow$ OK

From these two controls, it can be concluded that the SMRF system's earthquake resistance to SCWB has been fulfilled.

Story drift

Δ_{max} $= \Delta/\rho \rightarrow$ Consequences of structural irregularities
$= 0,020.hi / 1,3$
$= 0,0154.hi$
$= 0,0154 \times 3200 = 49,23$ mm

Table 10. Story drift control

Lantai	h_i (mm)	δ ETABS		$\Delta = \frac{(\delta_x - \delta_{x-1}).C_d}{I_e}$		Cek $\Delta \leq \Delta_{max}$
		δ_X (mm)	δ_Y (mm)	Δ_X (mm)	Δ_Y (mm)	
Lantai 5	3200	24,2	15,0	10,1	6,1	Oke
Lantai 4	3200	22,3	13,8	21,0	11,7	Oke
Lantai 3	3200	18,5	11,7	33,8	20,6	Oke
Lantai 2	3200	12,4	8,0	40,5	25,6	Oke
Lantai 1	3200	5,0	3,3	27,6	18,2	Oke

(Source: Personal data)

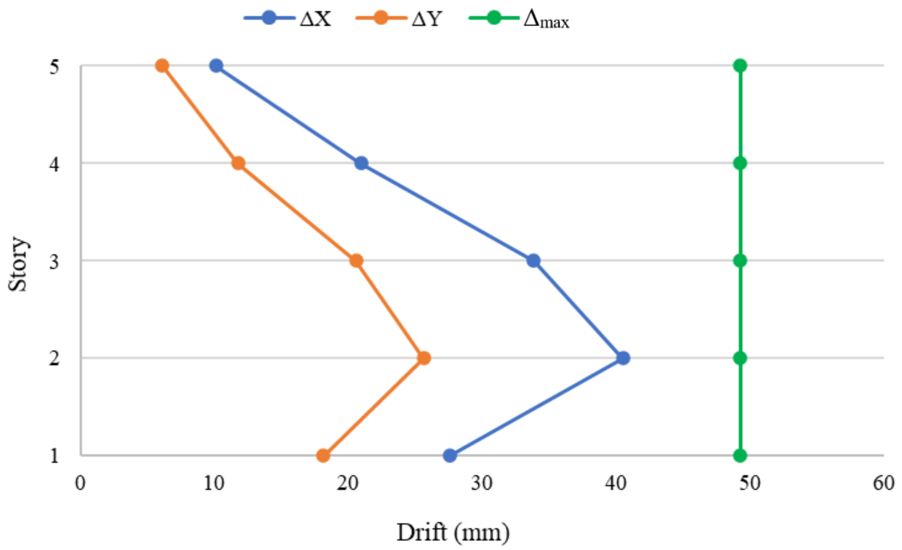
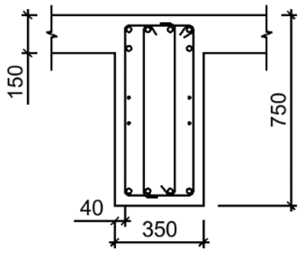
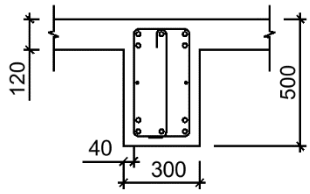
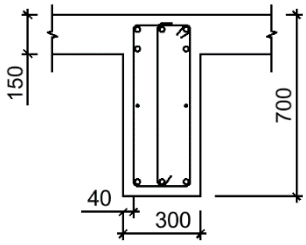
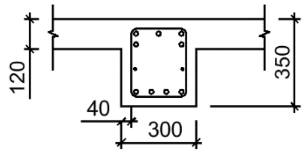
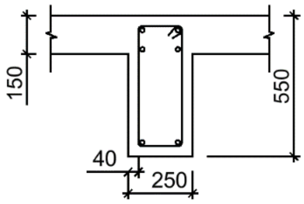
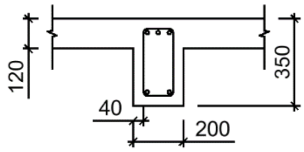
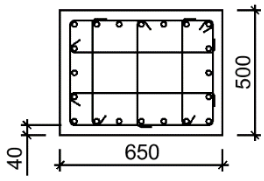
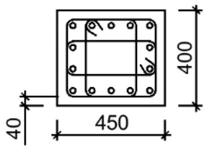
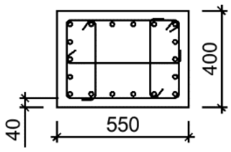
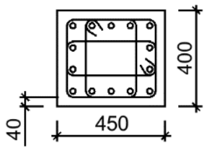
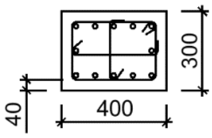
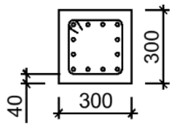
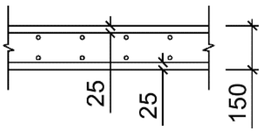
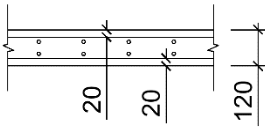


Figure 7. Story drift graph
(Source: Personal data)

Comparison of Existing Structure Design with Evaluation Results

Table 11. Result comparison

Code	Existing design secondary data	Evaluation results	Percentage comparison of cross-sectional areas
B1			42,9 %
B2			50,0 %
B3			49,1 %
K1			44,6 %
K2			18,2 %
K3			25,0 %
S1			20,0 %

Average efficiency	35.7 %

(Source: Personal data)

CONCLUSION

1. Based on the evaluation results, the structural elements that have been analyzed are more efficient than the existing structural element designs from secondary data. Although the use of concrete slabs on the roof increases the structural load, the structural elements from the evaluation results are considered more efficient than the existing structure with a lightweight steel roof frame. So the existing structure of Rukost Tawakal is considered overdesigned and needs to be redesigned, so that it can save costs based on the difference in cross-sectional area percentage.
2. The evaluation results show that the structure of Rukost Tawakal meets the requirements for an earthquake resistant structural system, by implementing the SMRF system. A column design that is stronger than a beam shows that the SCWB principle has been fulfilled and the condition of the connection or joint is able to withstand shear forces due to the earthquake that occurred.
3. Based on the results of the evaluation of Rukost Tawakal's structural elements, it resulted in changes (redesign) to the condition of the beams, columns and plates as follows:
   a. Initially, B1 beams were only used on the 1st and 2nd floors. However, the evaluation results showed that B1 beams needed to be used from the 1st to the 4th floor.
   b. Meanwhile, beam B2, which was originally only applied to floors 3 and 4, after evaluation, beam B2 was designed to be used on a span of 1550 mm from floor 1 to floor 4, this is because beam B2 was designed to meet the clean span requirements of the SMRF structural system, namely $l_n \geq 4d$.
   c. On the 5th floor, B3 beams are still used which also function as joists on each floor.
   d. Initially column K1 was only used on floors 1 and 2. However, evaluation results showed that column K1 was used from floors 1 to 4.
   e. Meanwhile, column K2 is not used.
   f. For columns on the 5th floor, K3 columns are still used.
   g. Apart from that, the condition of the slab remains as before, with only changes to the roof which is modeled as a concrete slab in order to evaluate the structure against greater loads.

SUGGESTIONS

1. From the results of the evaluation of the main structural elements, it is recommended that the planner (Gafa House) carry out a review of the dimensions and reinforcement of columns and beams that are more efficient. Adjustments to the stiffness and strength ratio need to be made to achieve the specified mechanism according to national standards.
2. Re-evaluation of load-carrying configurations and systems can also help improve design efficiency.

REFERENCE

Computers & Structures, I. (2016) *Manual Lateral Loads*. ISO ETA122. United States of America.

Moehle, J.P. dan Hooper, J.D. (2016) "Seismic Design of Reinforced Concrete Special Moment Frames: A Guide for Practicing Engineers, Second Edition," *NEHRP Seismic Design Technical Brief No. 1*, (2), hal. 27. Tersedia pada: http://nehrp.gov/pdf/nistgcr8-917-1.pdf%0Ahttps://nvlpubs.nist.gov/nistpubs/gcr/2016/NIST.GCR.16-917-40.pdf.

PuSGeN, DBTPP, Ditjen Cipta Karya, K.P. (2021) *Desain Spektra Indonesia*, *rsa.ciptakarya.pu.go.id*. Tersedia pada: https://rsa.ciptakarya.pu.go.id/2021/ (Diakses: 2 Oktober 2025).

sisipil.com (2024) *Jenis-Jenis Beban Pada Struktur Bangunan*, *sisipil.com*. Tersedia pada: https://www.sisipil.com/jenis-jenis-beban-pada-struktur-bangunan/ (Diakses: 2 Oktober 2025).

SNI 1726 (2019) *Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan nongedung*, *Badan Standarisasi Nasional*. Indonesia.

SNI 1727 (2020) *Beban desain minimum dan Kriteria terkait untuk bangunan gedung dan struktur lain*, *Badan Standarisasi Nasional*. Indonesia.

SNI 2847 (2019) *Persyaratan Beton Struktural untuk Bangunan Gedung*, *Badan Standarisasi Nasional*. Indonesia.