JOS - MRK ***Volume 6, Nomor 1, Maret 2025, Page 142-148***

JURNAL ONLINE SKRIPSI
MANAJEMEN REKAYASA KONSTRUKSI POLINEMA

Journal homepage: http://jurnal.polinema.ac.id/ **ISSN: 2722-9203 (media online/daring)**

BUIILDING PLANNING FOR THE MEDICAL BUILDING AT JENDERAL ACHMAD YANI UNIVERSITY BANDUNG USING SPECIAL MOMENT RESISTING FRAME SYSTEM

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ABSTRACT

Indonesia, as a country prone to earthquakes, motivates civil engineers to prioritize earthquake-resistant structural planning. The primary goal is to ensure that buildings not only withstand seismic forces but also exhibit ductile behavior during strong earthquakes. National standards like SNI 2847-2013 and SNI 1726-2012 provide clear guidelines for using Special Moment Resisting Frame Systems (SMRFS) in designing earthquake-resistant buildings. The implementation of these standards is crucial to be disseminated among academics, consultants, and contractors to ensure that all planning aspects meet the established safety standards.

The author conducted research to design Building Medical Building at Jenderal Achmad Yani University, Bandung, integrating SMRFS according to SNI 2847-2013 and SNI 1726-2012. The location of the building in Bandung, known for its high seismic activity, emphasizes the urgency of ensuring structural reliability, especially for high-rise buildings. The planning process involved using the ETABS application for comprehensive analysis of structural resilience against seismic moment forces.

Pushover analysis was employed as a method to evaluate the structural performance under earthquake loads. This method not only measures the capacity of the structure to withstand push forces but also predicts failure patterns and plasticity distribution in structural elements. Thus, pushover analysis aids in identifying weak points that require improvement or reinforcement to ensure the structure can withstand and exhibit ductile behavior during strong earthquakes.

Overall, this research aims to optimize structural designs to meet high earthquake resilience requirements in accordance with geographic conditions and national standards. The application of SMRFS and pushover analysis is expected to not only enhance the structural safety of laboratory buildings but also make a significant contribution to the development of safe and sustainable infrastructure in Indonesia.

Keywords : SMRFS, SNI 2847, SNI 1726, Pushover

1. INTRODUCTION

Indonesia's location in an active tectonic zone makes it highly susceptible to earthquakes, which can cause severe damage to buildings and infrastructure. To ensure safety, building designs in Indonesia must adhere to the Indonesian National Standard (SNI) 1726:2012, which provides guidelines for constructing earthquake-resistant structures. A critical component of this standard is the Special Moment Resisting Frame, designed to absorb and manage the lateral forces generated by earthquakes, reducing the risk of structural failure.

Designing these frames involves detailed analysis to predict how buildings will respond to seismic activity, aligning with international standards like those from the American Concrete Institute. Given Indonesia's high seismic risk, it is essential to create buildings that are both safe and resilient. This research focuses on the new lecture building at Universitas Jenderal Ahmad Yani (UNJANI), aiming to ensure that its reinforced concrete superstructure is effectively designed to withstand earthquakes, thereby enhancing the safety and durability of the university's facilities.

2. METHODE

The planning of the laboratory building on this campus follows a rigorous methodology focused on structural safety, space efficiency, sustainability, and user satisfaction. Given Indonesia's seismic-prone location, the building design adheres to the Indonesian National Standard (SNI) 1726:2012, which outlines technical guidelines for earthquake resistance. Key aspects of SNI 1726:2012 incorporated in the planning process include the determination of seismic response spectrum using data from Desain Spektra Indonesia (pu.go.id) to predict building responses during earthquakes, assessing earthquake risk to assign an appropriate seismic design category based on the building's geographic location and vulnerability, and selecting the Special Moment Resisting Frame System (SMRFS) for its superior earthquake resistance. The SMRFS is implemented with an emphasis on adequate stiffness, using robust materials and appropriate bracing to resist lateral loads; structural support through shear walls, special beams, and reinforced columns; and the selection of reliable, widely available construction materials to ensure structural integrity. Additionally, the system is designed with self-repair capability, allowing the building to reduce and repair damage post-earthquake, thus maintaining its functionality. This methodical approach ensures that the laboratory building meets the necessary standards for earthquake resistance while addressing critical factors such as efficiency, sustainability, and user needs.

3. RESULT and DISCUSSION

Project Description

This thesis is a design planning for a lecture building in the form of a laboratory intended for students of the Faculty of Health at the General Ahmad Yani University campus, Bandung City, West Java, Indonesia. The design planning for this building consists of 9 floors using a special moment-bearing frame system, with this it is expected that this building can withstand earthquakes and can distribute all loads that occur in the building so that its safety can be guaranteed.

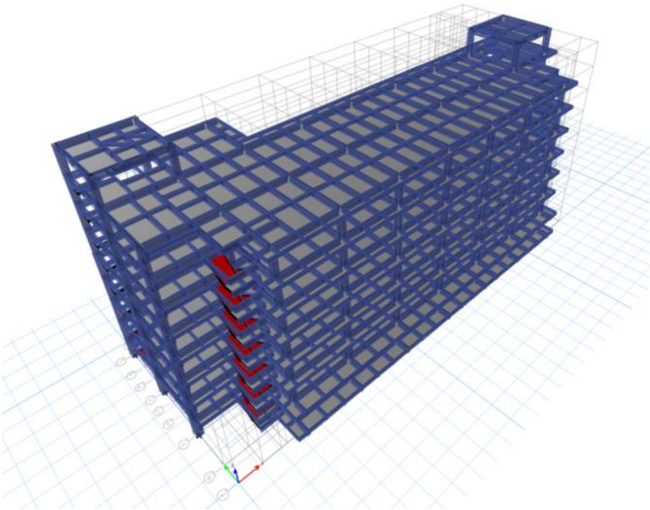

Figure 1. Modelling of The Laboratory Building

Below is the design description of the building:

1. Project name : Medical Building at Jenderal Achmad Yani University Bandung Using Special Moment Resisting Frame System
2. Project Location : Jl. Terusan Jend. Sudirman, Cimahi, Jawa Barat, Kota Cimahi, Jawa Barat 40525
3. Building Functions : Laboratorium and Lecturer Building
4. Building Type : High Rise Building
5. Structure Type : Reinforced Concrete
6. Building Height : 35,3 m
7. Number of Floors : 1 Ground Floors + 8 Lecturer Floors + 1 Lift Floors

Building Configuration

Below is information about the building configuration for this project design.

No	Floor	Height of Building (m)
1	Ground Floor	0
2	1st Floor	3,3
3	2nd Floor	7,3
4	3rd Floor	11,3
5	4th Floor	15,3
6	5th Floor	19,3
7	6th Floor	23,3
8	7th Floor	27,3
9	8th Floor	31,3
10	Lift Floor	35,3

Table 1. Height of Building

At the initial stage, structural data such as columns, beam dimensions, and material properties will be inputted into the ETABS software. Here are the details of the data being used.

Cross-Section	Type	Dimension (cm)
Column	K1	90 x 90
	K2	80 x 80
	K3	70 x 70
	K4	30 x 50
	K5	25 x 40
	Kp	15 x 15
Beam	G0	40 x 90
	G1	40 x 80
	G2	35 x 80
	G3	30 x 80
	G4	30 x 40
	B1	25 x 70
	B2	20 x 50
	B3	25 x 40
	B4	20 x 40
	B5	15 x 30
	B6	25 x 60
Floor Plate	S1	12
	S2	15
Shear wall	SW	20

Table 2 Column and Beam Dimension

Material

Part of building planning involves determining the materials to be used. Below are the data on material properties that will be used.

Material			Unit
Volume Weight of Reinforced Concrete		2400	kg/m^3
Concrete Quality	K300	*f'c* = 25	Mpa
	K400	*f'c* = 33,2	Mpa
Modulus Elasticity of Concrete	K300	23500	Mpa
	K400	27081,137	Mpa
Main Reinforcing Steel		400	Mpa
Shear Reinforcing Steel		240	Mpa
Poisson Ratio Number		0,2	-

Table 3 Material Properties

Seismic Factor

Because the building uses a special moment-resisting frame system and is designed as a laboratory.The priority factor is 1.5 and a seismic reduction factor is 8. These values are based on SNI 1726-2012. The soil at the site where the building structure is to be erected is assumed to fall into the soft soil category.

Design Response Spectrum

Value SS and S1 can obtained by access through the website https://rsa.kreatkarya.pu.go.id /2021.

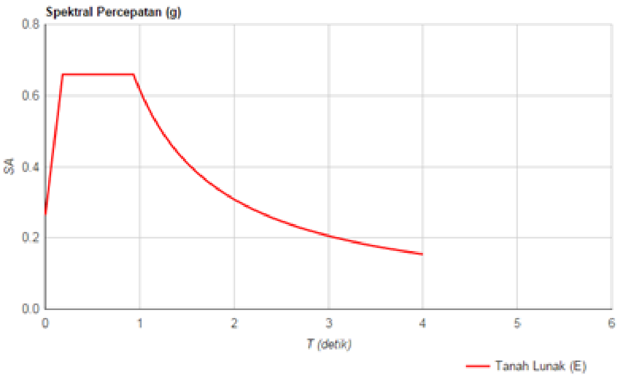

Figure 1. Puskim Spectra Response Graph

The response spectrum design according to SNI 1726-2012. With the base rock acceleration data located in the City of Bandung with values of Ss (1.098g) and S1 (0.364g). These values is to find SDS and SD1 value to input on ETabs.

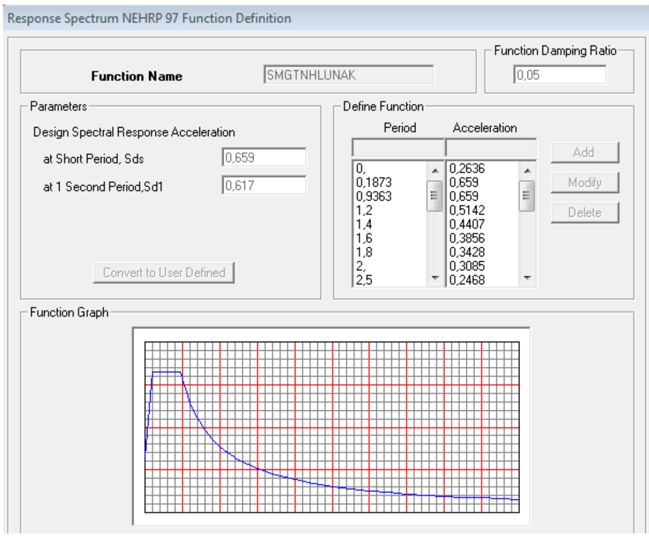

Figure 2 Input Response Spectra SNI 1726-2012

Load

The load planning for this building follows the Indonesian National Standard (SNI), ensuring that each structural element meets the required strength and stability. The load includes essential components such as floor slabs, roof slabs, and stair slabs, all calculated meticulously to support daily and additional loads. Furthermore, the load planning also considers brickwork and partitions as integral parts of the building's structure, ensuring alignment between structural strength and intended space functionality. With load planning adhering to SNI, this building is expected to operate safely and optimally throughout its lifespan.

Load Combination

This building use load combination that obtained from SNI :

1) 1,4 DL
2) 1,2 DL + 1,6 LL
3) 1,2DL + 1LL + 1 (ρQ_E+0,2S_{DS} . DL)
4) 1,2DL + 1LL + 1(ρQ_E- 0,2S_{DS}DL)
5) 0,9DL + 0,3(ρQ_E+ 0,2S_{DS}DL)
6) 0,9DL + 1(ρQ_E-0,2S_{DS}DL)

Where:

DL = Dead Load
LL = Live Load
Q_E = Effect of horizontal seismic force from V.
P = Redundancy factor for seismic design.
S_{DS} = Design spectral response acceleration parameter at short periods.

Comparison of Shear Forces Between Floors

This is table that show comparison of shear forces between floors that we get from ETABS.

Level	Static Equivalent	Dynamic
m	ton	ton
35,3	29,73	34,47
31,3	225,2	206,7
27,3	405,5	357,3
23,3	560,5	483,4
19,3	690,9	588,9
15,3	798,7	678,5
11,3	878,3	746,2
7,3	932,4	790,9
3,3	957	806

Table 4 Comparison of Shear Force Between Floors

Analysis of Variety Response Spectrum

In SNI Earthquake 1726-2012 Article 7.9.3, it is mentioned that the values for each reviewed parameter, computed for various types, should be combined using the Square Root of the Sum of Squares (SRSS) method or the Complete Quadratic Combination (CQC) method, in accordance with SNI 1726-2012. The CQC method must be used for each value when the closely spaced types have significant cross-correlation between translational and torsional responses. The value obtained from ETabs then calculate the difference in vibration period/time or ΔT (%) which is calculated using the method ΔT (%) = $\frac{(\mathrm{T1} - \mathrm{T2})}{\mathrm{T1} \times 100\ \%}$.

Mode	Period	ΔT %
1	1,065376	0,683
2	1,058101	9,811
3	0,954293	61,992
4	0,362709	1,254
5	0,35816	7,969
6	0,329617	37,264
7	0,206787	2,075
8	0,202496	5,266
9	0,191832	25,222
10	0,143449	0,544
11	0,142668	4,117
12	0,136794	13,600

Table 5 Calculation of Period Differences for Each Mode

Nominal Base Shear Force

In SNI 1726-2012 Section 7.9.4.1, the shear force results from the basic spectrum response method must exceed 85% of the equivalent static analysis.

Earthquake Load Type		Fx (Kn)	Fy(Kn)	85% static x	85% static y
Static	Eqx	-9384,89	-	-7977,1565	-
	Eqy	-	-9445,38	-	-8028,573
Dynamic	RSP x	5430,37	5208,41		
	RSP y	5095,75	5488,9		

Table 6 Base Shear Results from ETABS Output

The conclusion drawn from the above is that the dynamic seismic shear style requirements have not been met (Vdynamic > 85% Vstatic) thus the dynamic V value must be multiplied by a scaling factor $\frac{0{,}85\ statik}{V\ Dinamik}$ Dynamic Earthquake Scale Response Spectrum Factors. The corrected scale factor values are inputted into ETABS. After multiplying $V_{dynamic}$ with the scale factor, the dynamic seismic shear force is satisfied ($V_{dynamic}$ > 85% V_{static}).

Mass Partiipation Control

In SNI Earthquake 1726-2012 Article 7.9.1, it is stated that analysis must be conducted to determine the natural vibration modes for the structure. The analysis must include an adequate number of modes to obtain mass participation, combined to at least 90% of the actual mass in each horizontal direction of the response reviewed by the model that can be obtained on ETabs.

Structural Analysis and Reinforcement Design for Moment Resisting Frame Buildings

The planning of a new laboratory building at UNJANI, Bandung, focuses on safety, functionality, and compliance with relevant standards. The building uses a Special Moment Frame (SMF) structural design based on SNI 1726:2012, which outlines guidelines for earthquake-resistant structures in Indonesia. This ensures the building's resistance to seismic activity, protecting its occupants.

For structural analysis and design, ETABS software was used to accurately model the building, analyze load conditions, and ensure compliance with structural requirements. In addition, detailed calculations were performed using Excel, following SNI 2847:2013 for concrete structures. This combined approach with ETABS and Excel ensures a thorough and optimal design process, meeting all required standards. Below is an attachment of the excel calculation results for the reinforcement of this building structure.

1	2		3		4		5		6	
Position	Dimension		Rft Left supp		Rebar		Rft Right Supp		Shear Reinforcement	
	b (mm)	h (mm)	Top	Bottom	Top	Bottom	Top	Bottom	Support	Field
As 3 (c-d) 2nd	400	800	14 D 22	7 D 22	3 D 22	5 D 22	14 D 22	7 D 22	2D10-100	D10-150
As 3 (c-d) 3rd	400	800	14 D 22	7 D 22	3 D 22	5 D 22	14 D 22	7 D 22	2D10-100	D10-150
As 3 (c-d) 4th	400	800	14 D 22	7 D 22	3 D 22	5 D 22	14 D 22	7 D 22	2D10-100	D10-150
As 3 (c-d) 5th	400	800	14 D 22	7 D 22	3 D 22	5 D 22	14 D 22	7 D 22	2D10-100	D10-150
As 3 (c-d) 6th	400	800	13 D 22	7 D 22	3 D 22	5 D 22	13 D 22	7 D 22	2D10-100	D10-150
As 3 (c-d) 7th	400	800	12 D 22	6 D 22	3 D 22	5 D 22	12 D 22	6 D 22	2D10-100	D10-150
As 3 (c-d) 8th	400	800	11 D 22	6 D 22	3 D 22	5 D 22	11 D 22	6 D 22	2D10-100	D10-150
As 3 (c-d) Roof	400	800	8 D 22	5 D 22	3 D 22	4 D 22	9 D 22	5 D 22	2D10-100	D10-150

Table 7 Reinforcement of Moment Resisting Frame Beam

As 3 "C-D"	DIMENSION		Moment Resisting Frame			Moment Resisting Frame		
	b	h	Left Supp (D22)	Field Rft (D22)	Right supp (D22)	Left Supp (%)	Field Rft (%)	Right Supp (%)
Floor	mm	mm						
2	400	800	14	5	14	1.66	0.59	1.66
3	400	800	14	5	14	1.66	0.59	1.66
4	400	800	14	5	14	1.66	0.59	1.66
5	400	800	14	5	14	1.66	0.59	1.66
6	400	800	13	5	13	1.54	0.59	1.54
7	400	800	12	5	12	1.42	0.59	1.42
8	400	800	11	5	11	1.31	0.59	1.31
Roof	400	800	8	4	9	0.95	0.47	1.07

Table 8 Reinforcement Ratio of Moment Resisting Frame Beam

SECTION	COLUMN	DESIGN CAPACITY	SHEAR REINFORCEMENT
AS 3.E 1st	K 90 X 90	52D22	6 D12-100
AS 3.E 2nd	K 90 X 90	52D22	6 D12-100
AS 3.E 3rd	K 80 X 80	52D22	4 D12-100
AS 3.E 4th	K 80 X 80	48D22	4 D12-100
AS 3.E 5th	K 80 X 80	48D22	4 D12-100
AS 3.E 6th	K 70 X 70	44D22	4 D12-100
AS 3.E 7th	K 70 X 70	36D22	4 D12-100
AS 3.E 8th (Roof)	K 70 X 70	36D22	4 D12-100

Table 9 Results of Column Reinforcement and Moment Resisting Frame Shear Reinforcement

As 3- C	Column	Special Moment Resisting Frame System	Special Moment Resisting Frame System

Floor			
	mm	Reinforcement D22	Ratio (%)
1	900x900	52	2.44
2	900x900	52	2.44
3	800x800	52	3.09
4	800x800	48	2.85
5	800x800	48	2.85
6	700x700	44	3.41
7	700x700	36	2.79
8	700x700	36	2.79

Table 10 Reinforcement Ratio Column Moment Resisting Frame

Pushover Analysis Special Moment Resisting Frame

From the iteration process, a capacity curve was obtained, representing the relationship between the reference point displacement on the roof (D) and the base shear force. By entering the values of Ca = 0.23 and Cv = 0.225, obtained from SNI 1726-2012, the performance point values for each direction of the laboratory building at the Faculty of Medicine, UNJANI Bandung, will appear.

Displacement Limits

The displacement limits for buildings classified under risk category IV, as outlined in SNI 1726-2012, are calculated using the formula: 0.015 x H. For this particular building, with a height (H) of 35.3 meters, the allowable displacement is 0.529 meters. Since the calculated displacement (Dt) of the building is less than this limit, it indicates that the building's displacement performance is within acceptable parameters, confirming that it is structurally sound and performs well under the specified criteria.

Building Performance According to ATC-40

ATC-40 provides guidelines for evaluating the seismic performance of buildings, focusing on how much they can drift during an earthquake without significant damage. The performance of a building is categorized into levels like Operational (O), Immediate Occupancy (IO), Life Safety (LS), and Collapse Prevention (CP), depending on the extent of damage and the building's safety post-earthquake. The maximum drift, calculated as the ratio of the building's maximum lateral displacement (dt) to its height (h), helps determine which category the building falls into. To assess how much of this drift is inelastic (beyond the elastic limit), you subtract the elastic displacement (d1) from the total displacement and divide it by the building's height. The structure's ductility, or its ability to undergo large deformations without collapsing, is then calculated by comparing the inelastic drift to the elastic drift. This ductility is crucial in understanding the building's ability to absorb and dissipate energy during seismic events.

Plastic Joint Distribution Scheme

In the plastic hinge distribution scheme, the focus is on identifying the locations within a structure where plastic hinges, or points of maximum stress and rotation, are likely to form during an earthquake. For the As-5 portal, which includes the main column a critical element in maintaining the structural integrity,this distribution is particularly important. The main column, being a primary load-bearing element, plays a significant role in resisting seismic forces. During a seismic event, plastic hinges typically form at the ends of beams and columns where moments are highest. In the As-5 portal, careful analysis is required to predict these hinge locations, as the formation of plastic hinges in the main column could lead to a significant reduction in the structure's capacity to bear loads, potentially initiating a total collapse. By understanding the plastic hinge distribution, engineers can design reinforcement strategies to prevent the catastrophic failure of critical elements, ensuring that the building's performance during an earthquake remains within acceptable safety limit.

Control of The Performance Limits of Building Structures

To meet the serviceability limit state performance requirements of the structure, in all aspects, the inter-story drift calculated from the building structure displacement must not exceed 0.03/R times the respective story height.

The magnitude of the deviation in the X direction and Y direction that occurs can be known on ETABS by Display - Show Story Response. The service limit performance due to deviations in the X and Y directions can be evaluated by calculating the change in displacement between the upper and lower floors. This is done by subtracting the lower floor displacement from the upper floor displacement. To determine whether the displacement is within acceptable limits, it is compared to the permissible displacement, which is calculated as (0.03/R X H), where R is the response modification factor and H is the height of the relevant floor. For example, in the X-direction for the roof floor, the displacement difference Δs is calculated 11.35mm - 3.7 mm = 7.65 mm. This value is then compared to the permissible displacement, $\frac{0{,}03}{8}$ x 4000 mm = 15 mm. Since 7.65 mm is less than 15 mm, the displacement is within the allowable limit, indicating that the structure meets the service limit performance requirements.

Ultimate Limit Performance Control of Building Structure

To meet the ultimate limit state performance requirements of a building, the inter-story drift must not exceed 0.015 times the height of the respective story. For example, in the X-direction for the roof floor, the displacement (δ_x) is calculated using the formula $\frac{Cd.\S\,xe}{I}$, Where Cd is the deflection amplification factor, I is the seismic importance factor, and §xe is the difference in displacement between the second and first floors. In this case, with Cd=5.5, I=1.5I = 1.5I=1.5, and §xe =7.65 mm (calculated as 11.35 mm − 3.7 mm), the resulting displacement is 28,05 mm. This value is then compared to the allowable limit of 0.015×H, where H is the height of the story, resulting in 60 mm. Since 28.05 mm is less than 60 mm, the displacement satisfies the ultimate limit state performance requirement. The performance limits for the ultimate state in both the X and Y directions are detailed in the accompanying table.

4. CONCLUSION

Based on the ETABS analysis conducted on the medical building at Jenderal Achmad Yani University in Bandung using a special moment resisting frame system, the following conclusions can be drawn:

1. The roof displacement in the x-direction is 61.41 mm and in the y-direction is 67.36 mm. The building's displacement performance, based on its design with the ideal structural concept, can be considered good because the resulting displacement is less than the specified displacement limit (control), which is 1.5%H = 1.5% x 35300 mm = 529.5 mm.
2. The maximum drift in the x-direction is 0.0032 and in the y-direction is 0.00142. The maximum inelastic drift in the x-direction is 0.00341 and in the y-direction is 0.001. According to the criteria required by ATC-40, when considering the earthquake in the x and y directions, the medical building at Jenderal Achmad Yani University in Bandung has an immediate occupancy performance level. Therefore, the medical building at Jenderal Achmad Yani University in Bandung meets the criteria for an immediate occupancy performance level it means the building is safe.
3. The maximum ultimate limit performance control value in the x-direction is on the 3rd floor with a value of 36.850, while the maximum ultimate limit performance control value in the y-direction is on the 3rd floor with a value of 40.920. These values are still within the allowable limit of 60 mm. So, the building is still within the maximum ultimate limit performance control value.

BIBLIOGRAPHY

ACI.318S-19. (n.d.).

American Society of Civil Engineers. (n.d.). *Minimum design loads and associated criteria for buildings and other structures : provisions.*

Chopra, A. K. (2007). *Dynamics of Structures*.

Koespiadi, K., Santosa, F. R. E., & Hendika Putra, D. (2022). Building Structure Design Of Simple Rent House (Rusunawa) Tower A In Surabaya With Srpmk And Shearwall. *ADRI International Journal of Civil Engineering*, *6*(1), 89–97. https://doi.org/10.29138/aijce.v6i1.17

Manalip, S. H., Windah, R. S., & Dapas, S. O. (2014). ANALISIS PUSHOVER PADA STRUKTUR GEDUNG BERTINGKAT TIPE PODIUM. *Jurnal Sipil Statik*, *2*(4), 201–213.

Paulay, T., & Priestly, M. J. N. (1992). Frontmatter. In *Seismic Design of Reinforced Concrete and Masonry Buildings*. Wiley. https://doi.org/10.1002/9780470172841.fmatter

PPIUG. (1983). *Peraturan Pembebanan Indonesia Untuk Gedung 1983*.

Risa. (2021). *EVALUASI KINERJA STRUKTUR GEDUNG BERTINGKAT MENGGUNAKAN NON-LINEAR STATIC PUSHOVER ANALYSIS DENGAN CAPACITY SPECTRUM METHOD (CSM) (Studi Kasus: Gedung B Rumah Sakit Umum Muhammadyah Metro)*.

SNI 1726. (2012). *Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan non gedung*. www.bsn.go.id

SNI 2847. (2013). *Persyaratan beton struktural untuk bangunan gedung Badan Standardisasi Nasional*. www.bsn.go.id

SNI-03-1729. (2002). TATA CARA PERENCANAAN STRUKTUR BAJA UNTUK BANGUNAN GEDUNG. *SNI-03-1729*.

SNI-03-2847. (2002). *Tata Cara Perhitungan Struktur Beton Untuk Bangunan Gedung*.

Zachari, M. Y., & Turuallo, G. (2020). Analisis Struktur Baja Tahan Gempa dengan Sistem SRPMK (Struktur Rangka Pemikul Momen Khusus) Berdasarkan SNI 1729:2015 dan SNI 1726:2012. *REKONSTRUKSI TADULAKO: Civil Engineering Journal on Research and Development*, *September* 9–16. https://doi.org/10.22487/renstra.v1i2.24