INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Existing Building Evaluation against SNI (Indonesian National Standards) 1726-2019 Concerning Earthquake Resistance Planning Procedures for Building and Non-Building Structures

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Abstract:
With the issuance of the 2019 SNI 1726-2019 Earthquake Regulations, it is necessary to recalculate the strength of the existing buildings designed with SNI 1726-2012. The building that becomes the case study is a hospital located in Mojokerto City, East Java, Indonesia. This study aims to determine the strength of the existing building against the provisions in SNI 1726-2019. The method of calculation is by evaluating the workload of the foundation, calculating the amount of deviation between levels and the effect of P - Δ that occurs. The building was built in 2018 and designed using the SNI 1726-2012Earthquake Regulations which are based on the 2017 Earthquake Map. The results of the recalculation are: 1. The deviation between levels in the X-direction on the 1st floor and 2nd floor is greater than the allowable deviation, while on the 3rdand 4th floor it is smaller than allowed. The Y-direction deviation on all floors is smaller than allowable; 2Workload on the foundation at all points of the column with a combination of gravity load and earthquake load is smaller than the allowable bearing capacity.

Keywords: *SNI 1726-2019 Earthquake Regulations; Allowable bearing capacity for the foundation; Deviation between levels; Effect of P – Δ.*

1. Introduction

1.1. Background

The country of Indonesia, which is an archipelago, is one of the areas that has a very high level of risk of earthquake disasters because of its geographic location between four active tectonic systems, namely the Eurasian plate, the Indo-Australian plate, the Philippine plate and the Pacific plate, which are known to be as the most active plate. In the territory of Indonesia, the incidence of strong earthquakes that damage the average is 3 times in 2 years (Siddiq, 2014).

In every earthquake, there are often many victims of life and property. However, the large number of casualties during an earthquake is often caused by the collapse of the structure of the occupied buildings, whether residential buildings, offices or other types of buildings due to not being able to withstand the dynamic loads of the earthquake. Therefore, it is important to pay attention to the planning of earthquake-resistant buildings in Indonesia in order to reduce the risk of casualties in the event of an earthquake. Suwandojo Siddiq (Siddiq, 2014) suggests that efforts can be made to prevent damage to buildings due to earthquake disasters as follows: 1) planning new earthquake-resistant buildings; 2) Performing repairing, strengthening and retrofitting of existing buildings which are considered 'weak' so that they are strong against the impending earthquake forces; 3) repairing and strengthening damaged buildings (mild to moderate) due to the previous earthquake, so that their strength and rigidity can be returned, even stronger or more rigid.

Many factors cause and level of damage to building structures caused by the earthquake, including the configuration of the structural system, uneven distribution of loads and the lack of rigidity of the building structure (vertical and horizontal). Currently, the limitation of land is the main reason for the implementation of multi-story building planning. Such vertical building planning is, in fact, prone to earthquakes (Istiono and Khoe, 2020). Meanwhile, the potential risk of an earthquake in Indonesia is high. The regulations for the design of earthquake resistant building structures in Indonesia that are used refer to SNI 1726-2012. However, due to the large number of earthquakes with a large enough magnitude in Indonesia and causing damage to building structures and casualties, SNI 1726-2012 is deemed inappropriate to be applied as a guideline for earthquake-resistant building structure planning. Therefore it is necessary to renew so that SNI 03 1726-2019 is compiled as a regulation for planning new earthquake resistant building structures (Afnan et al, 2020).

The enactment of the SNI 1726-2019 Earthquake Regulations in 2019 causes changes in earthquake parameters which result in changes in the magnitude of the seismic force. This is what motivates the need to re-evaluate buildings that have been designed with the previous SNI 1726-2012 Earthquake Regulations with the latest SNI, namely SNI 1726-2019.

1.2. The Aim of the Study

Make an evaluation of the strength of existing buildings designed with SNI 1726-2012 against the provisions for earthquake resistant buildings in SNI 1726-2019.

1.3. Limitation of Research Problem

The location of the building is in Mojokerto City, East Java Province, Indonesia. The building function is for a hospital with a building area of 15 x 25 m^2 and the number of floors is 4 floors. Soil conditions are soft. Main column dimensions 60x60 cm^2, transverse beam 40/70 cm^2 and 30/60 cm^2, spun pile foundation Φ 40 cm with a depth of 25 m. The height of the 1st floor is 5 m, while the floors above are typically 4 m.
Evaluation is done by calculating: 1. Foundation workload; 2. Deviation between levels; 3. Effect of P - Δ

2. Research Method

2.1. The Stages of Analysis Carried Out in This Study Are as Follows:

- Determine the building Risk Category
- Determining Priority Factor
- Determine the Earthquake Spectra Response Parameters for a short period (S_s)
- Determine the Earthquake Spectra Response Parameters for a period of 1 second (S_1)
- Determining the Classification of Land Sites (SA – SF)
- Determining the Land Sites Coefficient Factor (F_a, F_V)
- Calculate the Design SpectralAcceleration Parameterfor a short period (S_{DS})
- Calculate the Design SpectralAcceleration Parameterfor a period of 1 second(S_{D1})
- Select the System danStructure Parameters (R_1 C_d, Ω_o)
- Evaluation of structures system related toconfiguration irregularities
- Determine flexibility of diaphragm (flexible, semi-rigid, rigid)
- Determine the redundancy factor (ρ)
- Define the lateral force analysis procedure
- Calculating the lateral load

2.2. Equivalent Static Load Analysis

- Basic SeismikLoad→ $V = C_s\ W$
- EquivalentStatic Earthquake Force Distribution:

F_X = $C_{VX}\ V$

C_{VX} = $\frac{W_x\ h_x^k}{\sum_i^n W_i\ h_i^k}$

F = Earthquake Load

C_V = Coefficient ofdistribution

h_i = floor height at level i

W_i = effective weight on floor i

K forequivalent static

2.3. Analysis of Spectra Response

- Determining Time of Vibration (T)

$T_S = S_{D1}/S_{DS}$

$T_o = 0,2\ (S_{D1} / S_{DS})$

- Determining the Design Acceleration Spectrum Response (S_a)

For $T < T_o$ → $Sa = S_{DS} \times [\ 0,4 + 0,6\ \frac{T}{To}\ ]$

For $T < T_o < T_S$ → $Sa = S_{DS}$

For $T > T_S$ → $Sa = \frac{SD1}{T}$

2.4. Combination of Loading

- Combination ofUltimite Load
  - 1,4DL
  - 1,2DL + 1,6LL + 0,5(A or R)
  - 1,2DL + 1,0LL ± 1,6W + 0,5(A or R)
  - 1,2DL + 1,0LL± 1,0E
  - 0,9DL ± 1,6W
  - 0,9DL± 1,0E
- Combination of Service Load
  - 1,0DL
  - 1,0DL + 1,0LL
  - 1,0DL + 1,0(A or R)

- 1,0DL + 0,75LL + 0,75(A or R)
- 1,0DL± (0,6W or 0,7 E)
- 1,0DL± 0,75(0,6W or 0,75E) + 0,75LL + 0,75(A or R)
- 0,6DL± 0,6W
- 0,6DL± 0,7E

2.5. Controlof Strengthand Stability

- Deviation between levels
- Effect of P - Δ
- Number ofFoundations

3. Result and Discussion

3.1. Determine the Seismic Design Category (KDS)

Building Location : Mojokerto City, East Java Province, Indonesia
Soil condition : Soft
Building Function : Hospital
Risk Category : IV (table 3, SNI 1726-2019)
Priority Factor : 1,5 (table 4, SNI 1726-2019)
Application of Indonesia's 2021 Design Response Spectrum:

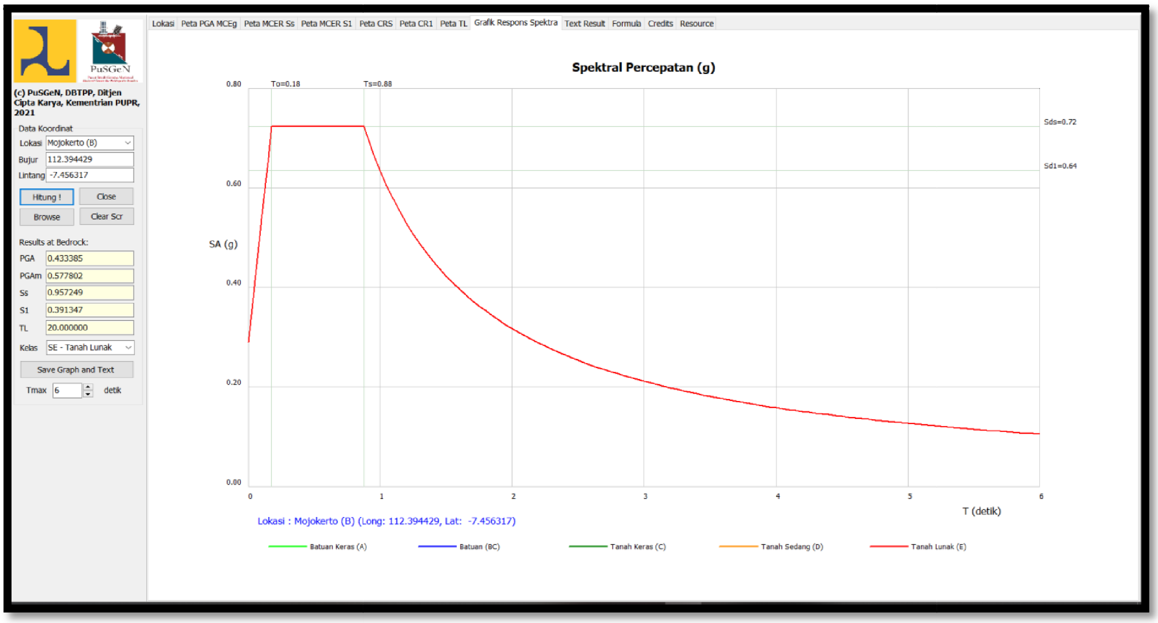

Figure 1

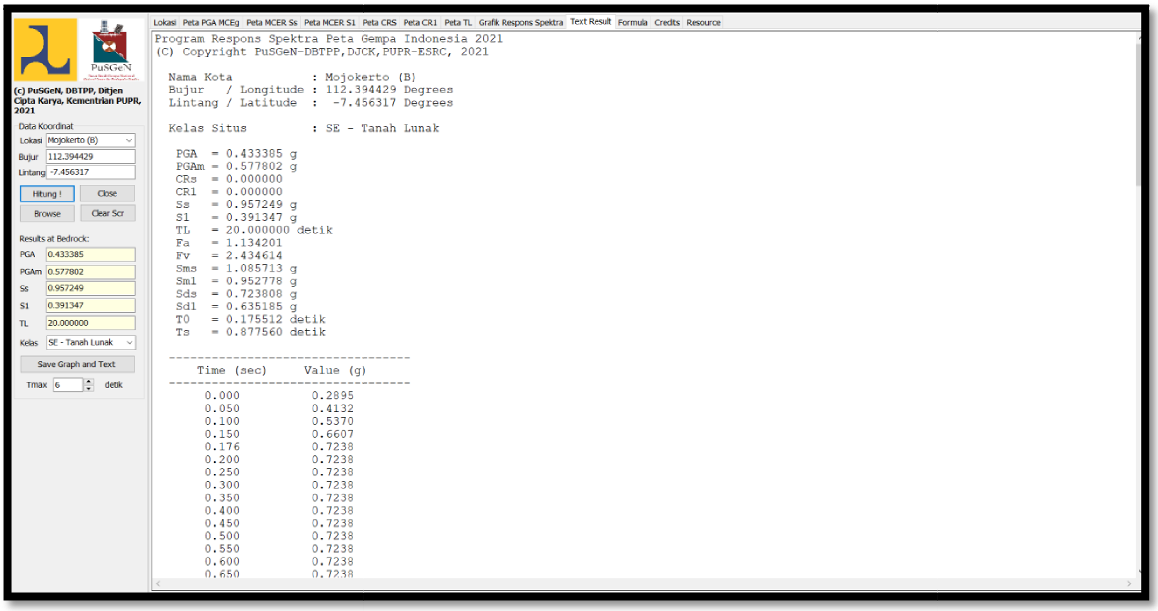

Figure 2

Mojokerto Location : S_s = 0,957 g
S_1 = 0,391 g
F_a = 1,134
F_v = 2,434
S_{DS} = 0,723 g
S_{D1} = 0,635 g

3.2.Determine the Natural Vibration TimeT
For Mojokerto S_{D1} = 0,635 → C_U = 1,4
$T_a = C_t\ h^x{}_n$
T_a = 0,0466 x $17^{0,9}$ = 0,597 sec,
T_a max allowable = C_U T_a = 1,4 x 0,597 = 0,836 sec
Crack Condition
T_c mode 1 = 0,952
T_c mode 2 = 0,906

Un Crack Condition
T_c mode 1 = 0,690
T_c mode 2 = 0,665
Tmax = 0,836
Used T_x = 0,836; T_y = 0,836

3.3. Analysis of Equivalent Static
The Basic Seismik Load→ $V = C_S\ W$
S_{D1} = 0,635
S_{Ds} = 0,723
T_X = 0,836 sec,
T_Y = 0,836 sec
R_X = 8
R_Y = 8
I_e = 1,5

	$C_{s\ min}$	C_S	$C_{S\ max}$	C_S
	0,044 S_{DS} I_E	S_{DS} / (R/I_E)	S_{DS} / [T (R/I_E)]	Value Selected
X-direction	0,048	0,135	0,162	**0,135**
Y-direction	0,048	0,135	0,162	**0,135**

Table 1

Distribution ofEquivalent Static Earthquake Force:
$F_X = C_{VX}\ V$
$C_{VX} = \frac{Wx\ hx^k}{\sum_i^n Wi\ hi^k}$
F = Earthquake Load
C_V = Coefficientof Distribution
h_i = Floor height at level i
W_i = Effective weight at level i
K for the equivalent static calculation:

T (sec)	**K**
T $\leq$ 0,5	1
0,5 < T < 2,5	Interpolation
T $\geq$ 2,5	2

Table 2

T_X = 0,836→ k = 1,168
T_Y = 0,836→ k = 1,168
Earthquake Scale Factor = (g x I) / R :
R_x = 8 I_e = 1,5
R_x = 8 I_e = 1,5
g (gravitation) = 9,81 m/sec^2

3.4. Analysisof Design Spectra Response
Using Spectra Responsefrom Puskim in 2021
Earthquake ScaleFactor= (g x I) / R :

$R_X = 8$ $I_e = 1{,}5$
$R_Y = 8$ $I_e = 1{,}5$
g (gravitation) = 9,81 m/sec^2

3.5. Deflectionat Level X

$\delta_X = \frac{Cd\ \delta xe}{Ie}$

C_d = deflection enlargement factor, x direction = 5,5, y direction = 5,5
δ_{Xe} =deflection determined byelasticanalysis
I_e = the virtue factor (1,5)
Deviation :

Floor	h (m)	Lateral Load, X direction			Lateral Load, Y direction			$\Delta a/\rho$
		δ_{Xe}	δx	Δx	δy_e	δy	Δy	
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Roof	17	34,50	126,50	**17,60**	28,07	102,92	**13,82**	30,77
4	13	29,70	108,90	**29,33**	24,30	89,10	**23,36**	30,77
3	9	21,70	79,57	**38,10**	17,93	65,74	**30,69**	30,77
2	5	11,31	41,47	**41,47**	9,56	35,05	**35,05**	38,46

Table 3

3.6. Determination of P – Δ Effect

Coefficient ofstability (θ) can be calculated based on the following equation:

$\theta = \frac{Px\ \Delta\ Ie}{Vx\ hsx\ Cd}$ $\theta_{mak} = 0{,}5/(1 \times C_d)$

Calculation of θ due to the influence of P – Δ

X direction

Floor	h (m)	P (kN)	Δx (mm)	Vx (kN)	Θ	θ max
4th floor	4	4283	17,60	883	0,0039	0,091
3rd floor	4	9969	29,33	1574	0,0084	0,091
2nd floor	4	15656	38,10	2079	0,0130	0,091
1st floor	5	21473	41,47	2367	0,0137	0,091

Table 4

Y direction

Floor	h (m)	P (kN)	Δy (mm)	Vy (kN)	Θ	θ max
4th floor	4	4283	13,82	886	0,0030	0,091
3rd floor	4	9969	23,36	1588	0,0067	0,091
2nd floor	4	15656	30,69	2104	0,0104	0,091
1st floor	5	21473	35,05	2404	0,0114	0,091

Table 5

$\Theta < \Theta_{mak}$, then the effect of P - Δ was ignored

3.7. Foundation Workload

3.7.1. Due to Load 1DL+1LL

Joint Text	**OutputCase** Text	**P** ton	**Mx** ton-m	**My** ton-m	**Jumlah** Pile (n)	Xmax	Ymax	∑ X²	∑ Y²	P/n	(Mx.Xmax) / ∑ X²	(My.Ymax) / ∑ Y²	P terjadi (ton/pile)	P Ijin 65 ton x Eff	Eff
126	1DL+1LL	125,12	2,27	5,63	**4,00**	0,50	0,50	0,75	0,50	31,28	1,51	5,63	**38,42**	**51,35**	0,790
128	1DL+1LL	143,38	2,08	5,86	**5,00**	0,75	0,75	2,25	2,25	28,68	0,69	1,95	**31,32**	**45,11**	0,694
130	1DL+1LL	126,14	4,21	4,41	**4,00**	0,50	0,50	0,75	0,50	31,53	2,80	4,41	**38,75**	**50,70**	0,780
132	1DL+1LL	261,37	1,05	0,94	**7,00**	0,75	0,75	2,25	2,25	37,34	0,35	0,31	**38,00**	**45,11**	0,694
134	1DL+1LL	220,83	3,96	4,12	**7,00**	0,75	0,75	2,25	2,25	31,55	1,32	1,37	**34,24**	**45,11**	0,694
136	1DL+1LL	185,33	0,17	2,73	**5,00**	0,75	0,75	2,25	2,25	37,07	0,06	0,91	**38,03**	**45,11**	0,694
138	1DL+1LL	318,43	0,11	1,24	**8,00**	0,75	0,75	3,38	2,25	39,80	0,03	0,41	**40,24**	**44,01**	0,677
139	1DL+1LL	205,45	0,58	2,19	**7,00**	0,75	0,75	2,25	2,25	29,35	0,19	0,73	**30,27**	**45,11**	0,694
141	1DL+1LL	117,17	4,41	4,07	**4,00**	0,50	0,50	0,75	0,50	29,29	2,94	4,07	**36,31**	**50,70**	0,780
143	1DL+1LL	210,32	2,05	0,45	**6,00**	0,75	0,75	2,25	2,25	35,05	0,68	0,15	**35,89**	**45,11**	0,694
145	1DL+1LL	145,06	3,50	3,82	**5,00**	0,75	0,75	1,69	1,13	29,01	1,55	2,55	**33,11**	**45,11**	0,694
147	1DL+1LL	41,12	1,07	5,49	**2,00**	0,50		0,50		20,56	1,07	1,37	**23,01**	**58,31**	0,897
149	1DL+1LL	85,35	0,85	1,04	**3,00**	0,60	0,60	0,72	0,72	28,45	0,00	0,87	**29,32**	**49,01**	0,754
200	1DL+1LL	62,40	0,64	6,35	**2,00**	0,50		0,50		31,20		1,59	**32,79**	**58,31**	0,897

Table 6

3.7.2. Due to Load1DL+0,75LL+0,525RSPX+0,157RSPY

Joint	OutputCase	P	Mx	My	Jumlah	Xmax	Ymax	∑ X²	∑ Y²	P/n	(Mx.Xmax)	(My.Ymax)	P terjadi	P Ijin	Eff
Text	Text	ton	ton-m	ton-m	Pile (n)						∑ X²	∑ Y²	(ton/pile)	65x1,3 ton x Eff	
126	1DL+0,75LL+0,525RSPX+	125,22	8,96	23,62	**4,00**	0,50	0,50	0,75	0,50	31,30	5,97	23,62	**60,90**	**66,76**	0,790
128	1DL+0,75LL+0,525RSPX+	158,00	11,65	33,67	**5,00**	0,75	0,75	2,25	2,25	31,60	3,88	11,22	**46,71**	**58,64**	0,694
130	1DL+0,75LL+0,525RSPX+	135,98	12,81	19,88	**4,00**	0,50	0,50	0,75	0,50	33,99	8,54	19,88	**62,42**	**65,91**	0,780
132	1DL+0,75LL+0,525RSPX+	253,16	8,83	27,32	**7,00**	0,75	0,75	2,25	2,25	36,17	2,94	9,11	**48,22**	**58,64**	0,694
134	1DL+0,75LL+0,525RSPX+	230,08	14,63	30,36	**7,00**	0,75	0,75	2,25	2,25	32,87	4,88	10,12	**47,87**	**58,64**	0,694
136	1DL+0,75LL+0,525RSPX+	191,63	8,73	20,88	**5,00**	0,75	0,75	2,25	2,25	38,33	2,91	6,96	**48,20**	**58,64**	0,694
138	1DL+0,75LL+0,525RSPX+	309,27	8,10	26,23	**8,00**	0,75	0,75	3,38	2,25	38,66	1,80	8,74	**49,20**	**57,21**	0,677
139	1DL+0,75LL+0,525RSPX+	214,82	11,66	27,76	**7,00**	0,75	0,75	2,25	2,25	30,69	3,89	9,25	**43,83**	**58,64**	0,694
141	1DL+0,75LL+0,525RSPX+	127,45	3,90	22,55	**4,00**	0,50	0,50	0,75	0,50	31,86	2,60	22,55	**57,01**	**65,91**	0,780
143	1DL+0,75LL+0,525RSPX+	209,62	5,41	30,35	**6,00**	0,75	0,75	2,25	2,25	34,94	1,80	10,12	**46,86**	**58,64**	0,694
145	1DL+0,75LL+0,525RSPX+	160,85	6,97	32,60	**5,00**	0,75	0,75	1,69	1,13	32,17	3,10	21,74	**57,01**	**58,64**	0,694
147	1DL+0,75LL+0,525RSPX+	53,93	2,87	8,85	**2,00**	0,50		0,50		26,97	2,87	2,21	**32,05**	**75,80**	0,897
149	1DL+0,75LL+0,525RSPX+	93,67	2,73	16,22	**3,00**	0,60	0,60	0,72	0,72	31,22	0,00	13,52	**44,74**	**63,71**	0,754
200	1DL+0,75LL+0,525RSPX+	78,44	4,37	22,06	**2,00**	0,50		0,50		39,22		5,51	**44,73**	**75,80**	0,897

Table 7

3.7.3. Due to Load1DL+0, 75LL+0,525RSPY+0,157RSPX

Joint	OutputCase	P	Mx	My	Jumlah	Xmax	Ymax	∑ X²	∑ Y²	P/n	(Mx.Xmax)	(My.Ymax)	P terjadi	P Ijin	Eff
Text	Text	ton	ton-m	ton-m	Pile (n)						∑ X²	∑ Y²	(ton/pile)	65x1,3 ton x Eff	
126	1SW+1DL+0,75LL+0,5	132,17	23,93	11,08	**4,00**	0,50	0,50	0,75	0,50	33,04	15,96	11,08	**60,08**	**66,76**	0,790
128	1SW+1DL+0,75LL+0,5	154,11	28,63	21,89	**5,00**	0,75	0,75	2,25	2,25	30,82	9,54	7,30	**47,66**	**58,64**	0,694
130	1SW+1DL+0,75LL+0,5	129,72	27,14	6,22	**4,00**	0,50	0,50	0,75	0,50	32,43	18,09	6,22	**56,74**	**65,91**	0,780
132	1SW+1DL+0,75LL+0,5	252,23	26,12	11,63	**7,00**	0,75	0,75	2,25	2,25	36,03	8,71	3,88	**48,62**	**58,64**	0,694
134	1SW+1DL+0,75LL+0,5	220,10	34,11	15,75	**7,00**	0,75	0,75	2,25	2,25	31,44	11,37	5,25	**48,06**	**58,64**	0,694
136	1SW+1DL+0,75LL+0,5	183,44	23,85	5,37	**5,00**	0,75	0,75	2,25	2,25	36,69	7,95	1,79	**46,43**	**58,64**	0,694
138	1SW+1DL+0,75LL+0,5	306,89	26,30	8,30	**8,00**	0,75	0,75	3,38	2,25	38,36	5,84	2,77	**46,97**	**57,21**	0,677
139	1SW+1DL+0,75LL+0,5	204,40	31,87	11,31	**7,00**	0,75	0,75	2,25	2,25	29,20	10,62	3,77	**43,59**	**58,64**	0,694
141	1SW+1DL+0,75LL+0,5	122,10	18,43	9,74	**4,00**	0,50	0,50	0,75	0,50	30,52	12,28	9,74	**52,55**	**65,91**	0,780
143	1SW+1DL+0,75LL+0,5	210,95	22,87	15,34	**6,00**	0,75	0,75	2,25	2,25	35,16	7,62	5,11	**47,90**	**58,64**	0,694
145	1SW+1DL+0,75LL+0,5	157,70	26,47	18,98	**5,00**	0,75	0,75	1,69	1,13	31,54	11,76	12,65	**55,96**	**58,64**	0,694
147	1SW+1DL+0,75LL+0,5	60,67	9,54	2,72	**2,00**	0,50		0,50		30,34	9,54	0,68	**40,56**	**75,80**	0,897
149	1SW+1DL+0,75LL+0,5	106,11	10,91	8,95	**3,00**	0,60	0,60	0,72	0,72	35,37	0,00	7,46	**42,83**	**63,71**	0,754
200	1SW+1DL+0,75LL+0,5	85,13	13,53	15,23	**2,00**	0,50		0,50		42,56		3,81	**46,37**	**75,80**	0,897

Table 8

4. Conclusion

From the results of the evaluation, the following conclusions can be drawn

4.1. The Deviation between Levels

Floor	Δx (mm)	Δy (mm)	Δa/ρ (mm)
4th	17,60	13,82	30,77
3rd	29,33	23,26	30,77
2nd	38,10	30,69	30,77
1st	41,47	35,05	38,46

Table 9

4.2. The Effect ofP – Δbetween Levels

Floor	θx	θy	θmax
4th	0,0039	0,0030	0,091
3rd	0,0084	0,0067	0,091
2nd	0,0130	0,0104	0,091
1st	0,0137	0,0114	0,091

Table 10

4.3. Foundation Workload

4.3.1. Due to Load 1DL+1LL

Joint	Workload (Ton)	Allowable Carrying Capacity (Ton)
126	38,42	51,35
128	31,32	45,11
130	38,75	50,70
132	38,00	45,11
134	34,24	45,11
136	38,03	45,11
138	40,24	44,01
139	30,27	45,11
141	36,31	50,70
143	35,89	45,11
145	33,11	45,11
147	23,01	58,31
149	29,32	49,01
200	32,79	58,31

Table 11

4.3.2. Due to Load 1DL+0, 75LL+0,525RSPX+0,157RSPY

Joint	Workload (Ton)	Allowable Carrying Capacity (Ton)
126	60,90	66,76
128	46,71	58,64
130	62,42	65,91
132	48,22	58,64
134	47,87	58,64
136	48,20	58,64
138	49,20	57,21
139	43,83	58,64
141	57,01	65,91
143	46,86	58,64
145	57,01	58,64
147	32,05	76,80
149	44,47	63,71
200	44,73	75,80

Table 12

4.3.3. Due to load 1DL+0, 75LL+0,525RSPY+0,157RSPX

Joint	Workload (ton)	Allowable Carrying Capacity (ton)
126	60,08	66,76
128	47,66	58,64
130	56,74	65,91
132	48,62	58,64
134	48,06	58,64
136	46,43	58,64
138	46,97	57,21
139	43,59	58,64
141	52,55	65,91
143	47,90	58,64
145	55,96	58,64
147	40,56	75,80
149	42,83	63,71
200	46,37	75,80

Table 13

4.3.4. From the Calculation Results It Can Be Concluded as Follows

- The deviation between levels in the X direction on the 1st floor and the 2nd floor is greater than the allowable deviation, while on the 3rd and 4th floors it is smaller than allowed. The deviation between the levels in the Y direction of all floors is less than the allowable.
- The effect of P - Δ on all floors is less than the allowable.
- Work load on the foundation at all points of the column with a combination of gravity load and earthquake load is less than the allowable bearing capacity.

5. References

i. Afnan, Yucha Al Kautsar; M. AfifShulhan, M. Afif; and Iskandar Yasin, Iskandar (2020). *Perbandingan Respons Spektrum Gempa Antara SNI 1726-2012 Dan SNI 1726-2019 Di Indonesia*. JurnalUniversitas SarjanawiyataTamansiswa. jurnal.ustjogja.ac.id.
ii. Istiono, Heri; Khoe, Letisia (2020). *Analisis Perhitungan Struktur Bangunan Tahan Gempadengan KolamRenang Berdasarkan SNI 1726:2019*. JurnalTeknikSipil, Vol 1, No 2, November 2020. ISSN (*Online*) 2747-0733. 146-151.
iii. Siddiq, Suwandojo (2014). *BangunanTahan Gempa Berbasis Standar Nasional Indonesia*. Jurnal Standardisasi. ISSN: 1411-0822. E-ISSN: 2337-5833. https://js.bsn.go.id/index.php/standardisasi/article/view/664/351
iv. Tata caraperencanaanketahanangempauntukstrukturbangunanged ungdan non gedungSNI 1726-2012.
v. Tata caraperencanaanketahanangempauntukstrukturbangunangedungdan non gedungSNI 1726-2019.
vi. AplikasiSpektrumResponsDesain Indonesia 2021.
vii. Dokumen Perencanaan Gedung Rumah Sakit Basuni Mojokerto
viii. Soil Test