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Planning Of Beam Structure in the Diamond Hospital Building In Gebang Cirebon West Java

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ABSTRACT

Hospital buildings are critical infrastructure that require structural designs ensuring safety, strength, and compliance with national standards. However, many structural failures in public facilities arise from inadequate design considerations and failure to meet updated seismic and load-bearing codes, creating a significant safety risk. This research addresses the problem by analyzing and designing the beam structure of a hospital building located in Gebang, Cirebon Regency, West Java. The building consists of four levels with dimensions of 16 m in height, 60 m in length, and 40 m in width. The objective of this study is to evaluate whether the beam structure complies with the latest Indonesian National Standards, including SNI 1726:2019 for seismic resistance, SNI 1727:2020 for loading design, and SNI 2847:2019 for concrete structural requirements. The analysis was carried out using the ETABS 19 application through a series of modeling and loading simulations. The results show that the designed beam structure successfully withstands critical loading components while maintaining structural stability. These findings confirm that the hospital's beam design meets the required safety criteria, providing practical implications for ensuring resilience, durability, and compliance in health facility construction.

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INTRODUCTION

Indonesia is known as an earthquake-prone country, so planning for earthquake-resistant building structures is very important (Nugroho et al., 2022). This research focuses on the planning stage of the hospital building in Gebang, Cirebon, West Java, which is located in an earthquake-prone area of zone 4 with a medium risk level. To ensure the safety of the building, planning must refer to the SNI 1726:2019 regulations regarding the procedures for planning earthquake resistance for building structures (Al Jauhari et al., 2021; Darmawan et al., 2023). Therefore, thorough planning is needed to ensure the safety and security of the building (Imran et al., 2024; Hakam et al., 2024; Syarif, Astika, & Viddy, 2023; Lestari et al., 2022).

This research focuses on the planning stage of the Berlian Hospital building in Gebang, Cirebon, West Java, which is located in seismic zone 4 with a medium risk level. Buildings in this zone must be designed with strict adherence to safety codes to reduce the risk of structural failure. To ensure the safety of the building, planning must refer to the SNI 1726:2019 regulations regarding earthquake-resistant building structures, as well as SNI 1727:2020 on loads for building planning and SNI 2847:2019 on concrete structures. These regulations provide a comprehensive framework that ensures building performance under

seismic loads while maintaining efficiency in material use (Hakam et al., 2024; Fauzan et al., 2025; Sutjipto & Sumeru, 2023; Manik, 2024; Nugroho, 2022; Amalia et al., 2022).

Previous studies on earthquake-resistant building design in Indonesia highlight both achievements and shortcomings (Brata, 2023; Putranesia et al., 2023; Shahjalal et al., 2024). For instance, Bhatti (2021) analyzed reinforced concrete structures in hospital buildings using pushover analysis and found that many existing designs did not fully comply with the latest seismic codes, which posed a risk to structural resilience during medium to strong earthquakes. Similarly, Poudel & Shrestha (2024) emphasized that although the application of SNI 1726:2019 improved safety margins, there was still a lack of integration with practical design tools such as ETABS in modeling beam and column elements under multi-directional seismic loads. Both studies contribute significantly but leave a gap in addressing how hospital structures—critical facilities in disaster response—can be systematically designed to fully comply with SNI 1726:2019, SNI 1727:2020, and SNI 2847:2019, while ensuring stability and serviceability in high-risk seismic zones.

The purpose of this research is to design the structure of the 4-story Berlian Hospital building in Gebang, Cirebon Regency, West Java. This structure is designed to meet safety standards in medium earthquake zones by referring to the regulations SNI 1726:2019, SNI 1727:2020, and SNI 2847:2019 to ensure the safety and comfort of the building. Thus, the planning of this hospital building is expected to be well-designed and meet all applicable safety requirements and specifications. The findings are expected to not only ensure the structural safety and comfort of the building but also provide practical implications for improving the resilience of health facilities in earthquake-prone regions.

METHOD

The research method used in this study is a descriptive qualitative method with a case study and engineering design approach. This method was chosen because the research focuses on earthquake-resistant building planning by outlining systematic stages that must be followed to ensure the planning process runs effectively and complies with standards. The study is applied research, as it not only provides conceptual analysis but also produces practical outputs in the form of technical building designs in accordance with SNI 1726:2019. The research location is set on Jalan Raya Pantura Kalipasung, Gebang Village, Gebang District, Cirebon Regency, West Java, so the study is carried out in the real conditions of the field. By applying this method, the research integrates theoretical aspects and technical regulations to produce applicable earthquake-resistant building designs while also contributing to the development of knowledge in the field of structural building planning in Indonesia. To ensure the smoothness and effectiveness of the final project preparation, this research methodology is designed with several systematic stages. The following are some stages of the research methodology:

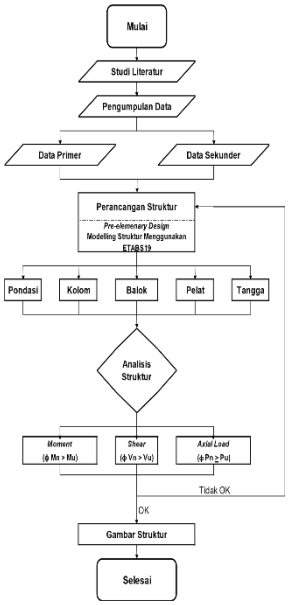

Figure 1. stages of the research methodology

This planning is located on Jalan Raya Pantura Kalipasung, Gebang Village, Gebang District, Cirebon Regency, West Java.

RESULTS AND DISCUSSION

Plate Loading

Dead Load

Floor Plate

Table 1. Floor Plate

Component	Result (kN/m²)
Weight of the floor itself 13 cm	3,12
Weight of the concrete screed 2 cm	0,40
Weight of the ceiling and frame	0,18
Weight of the ME installation	0,25
Total dead load	**4,21**

Roof Plate

Table 2. Roof Plate

Component	Result (kN/m²)
Self weight of 10 cm roof slab	2,40
Weight of the ceiling and frame	0,18
Weight of the ME installation	0,25
Total dead load	**2,83**

Live Load

Table 3. Live Load

Space	Result (kN/m²)
Public Space	3,83
Private Space	1,92
Lab and Operating Room	2,87
Roof	0,96

Wall Load

Dead load of the wall is calculated by multiplying the length of the wall by the weight of lightweight bricks of 1.0 kN/m².

Earthquake Load

The analysis of the earthquake load on this building is conducted based on SNI 1726:2019 using the response spectrum method

Building Location = Cirebon Regency

Building Function = Hospital

Soil Type = SE (Soft Soil)

The following are the parameters for calculating the earthquake load:

a. Risk Category and Earthquake Importance Factor

Risk Category = IV

I_e = 1,50

b. Earthquake Acceleration

S1 = 0,3415

Ss = 0,7636

c. Site Classification

Soft Soil = "SE"

d. Response Spectrum Acceleration

Fa = 1,2891

Fv = 2,6340

SDS = 0,6026

SD1 = 0,5997

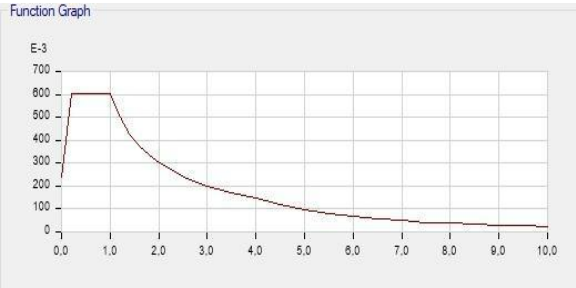

Figure 2. Earthquake Spectrum Response in Cirebon Regency

Wind Load

Based on weather data from Weather Spark Kec. Gebang Regency, Cirebon, it has an average wind speed per hour of 11.5 km/h

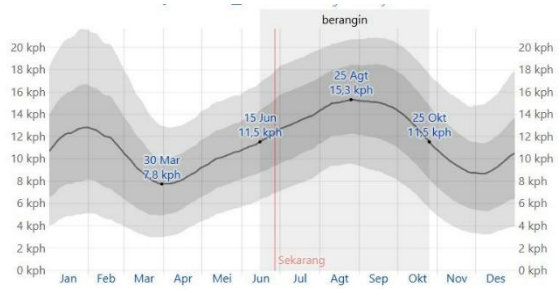

Figure 3. Average wind speed in Cirebon

Load Combination
To analyze the inner force, a load combination that complies with SNI 1726:2019 is required in the ETAB modeling.
1. U = 1.4D
2. U = 1.2D + 1.6L + 0.5 (Lr or S or R)
3. U = 1.2D + 1.6 (Lr or S or R) + (L or 0.5W)
4. U = 1.2D + 1.0W + 1.0L + 0.5 (Lr or S or R)
5. U = 1.2D + 1.0E + 1.0L
6. U = 0.9D + 1.0W
7. U = 0.9D + 1.0E

Floor Plate Load

Table 4. Floor Plate Load

Load Type	Result (kN/m²)
Dead Load	4,21
Load Live	3,83
Factored Design Load	11,18

Plate Moment Due To Factored Load

Table 5. Plate Moment Due to Factored Load

Moment	Result (kNm/m)
X Direction Field Moment (Mulx)	2,11
Y Direction Field Moment (Muly)	3,74
X Direction Support Moment (Mulx)	5,23
Y Direction Support Moment (Muly)	9,30

Floor Plate Repeating

Table 6. Floor Plate Repeating

Data	Result (mm)
Slab width is measured at 1 m	1000
Slab thickness (h)	130
Concrete cover (dc)	20
Reinforcement diameter (Ø)	10
Floor Slab thickness x (dx)	104
Floor Slab thickness y (dy)	92

To: Fc' $\leq$ 30 Mpa,

$$\beta\beta_1 = \frac{0{,}85 - 0{,}05 * (fc' - 30)}{7} = 0{,}85$$

$\beta\beta_1$ = 0,85 (Concrete Tension Dissipation)

Table 7. Roof Plate Reinforcement Calculation

Thickness (mm)	Frame	Mu (kNm)	ϕMn (kNm)	As Need (mm²)	As Use (mm²)	Reinforcement
130	X Direction					
	Field Lower	2,35	0,2171	520	452	Ø12 – 250
	Focus On	58,136	0,538	520	452,389	Ø12 – 250
	Field On	4,174	0,4931	460	452,38	Ø12 – 250
	Y Direction					
	Focus Lower	10,335	1,221	460	452,39	Ø12 – 250

Roof Plate Load

Table 8. Roof Plate Load

Load	Hasil (kNm/m²)
Dead Load	2,83
Load Live	0,96
Factored Design Load	4,932

Plate Moment Due To Factored Load

Table 9. Plate Moment Due to Factored Load

Moment	Result (kNm/m)
X Direction Field Moment (Mulx)	2,446
Y Direction Field Moment (Muly)	1,499
X Direction Support Moment (Mulx)	5,445
Y Direction Support Moment (Muly)	4,498

Roof Plate Repeating

Table 10. Roof Plate Repeating

Data	Result (mm)
Slab width is measured at 1 m	1000
Slab thickness (h)	100
Concrete cover (dc)	20
Reinforcement diameter (Ø)	12
Floor Slab thickness x (dx)	74
Floor Slab thickness y (dy)	62

To fc' > 30 Mpa,

$$\beta\beta_1 = \frac{0{,}85 - 0{,}05 * (fc' - 30)}{7} = 0{,}85$$

β $\beta_1 = 0{,}85$ (Concrete Tension Dissipation)

Table 11. Roof Plate Reinforcement (100 mm thick)

Thick (mm)	Frame	Mu (kNm)	ϕMn (kNm)	As Need (mm²)	As Use (mm²)	Reinforcement
100	X Direction					
	Field	2,78	0,4964	370	565,487	Ø12 – 200
	Focus On	6,05	1,105	370	565,487	Ø12 – 200
	Field On	1,666	0,4334	310	565,487	Ø12 – 200
	Y Direction					
	Focus Lower	4,99	1,300	310	565,49	Ø12 – 200

Child Beam

Child Beam Data

Table 12. Child Beam Data

Structural materials	Result (MPa)
Concrete compression strength	30
Steel yield stress (deformed)	420
Steel yield stress (plain)	280
Beam dimensions	**Result (mm)**
Beam width	250
Beam length	450
Reinforcement diameter (deformed)	13
Stirrup diameter (plain)	10
Net Concrete cover thickness	30
Design shear moments and forces	**Result (kNm)**
Positive Design moment due to factored load	20,247
Negative Design moment due to factored load	40,495
Design shear force due to factored load	60,235

Calculation of Child Beam Repeats

To fc' > 30 Mpa,

$$\beta_1 = \frac{0{,}85 - 0{,}05 * (fc' - 30)}{7} = 0{,}85$$

β_1 = 0,85 (Concrete Tension Dissipation)

Table 13. Child Beam Reinforcement Calculation

Thick (mm)	Frame	Mu (kNm)	ØMn (kNm)	As Need (mm²)	As Use (mm²)	Reinforcement
30	Support Reinforcement	50,619	0,733	315,2	530,9	4 D 13
30	Field Reinforcement	25,310	0,6538	321	398	3 D 13

Master Beam

Master Beam Data

Table 14. Master Beam Data

Structural materials	Result (MPa)
Concrete compression strength	30
Steel yield stress (deformed)	420
Steel yield stress (plain)	280
Beam dimensions	**Result (mm)**
Column width	300

Column length	600
Reinforcement diameter (deformed)	22
Stirrup diameter (plain)	12
Net Concrete cover thickness	30
Design shear moments and forces	**Result (kNm)**
Axial force due to factored load	25,380
Ultimate moment due to factored load	50,760
Design shear force due to factored load	63,714

Master Beam Repeating Calculation

To fc' > 30 Mpa,

$$\beta_1 = \frac{0{,}85 - 0{,}05 * (fc' - 30)}{7} = 0{,}85$$

β_1 = 0,85 (ConcreteTension Dissipation)

Table 15. Master Beam Reinforcement Calculation

Thick (mm)	Frame	Mu (kNm)	ØMn (kNm)	As Need (mm²)	As Use (mm²)	Reinforcement
40	Support Reinforcement	63,451	0,733	285	1521	4 D 22
40	Field Reinforcement	31,725	0,3667	525	1521	4 D 22

Column

Column Data

Table 16. Column Data

Structural materials	Result (MPa)
Concrete compression strength	30
Steel yield stress (deformed)	420
Steel yield stress (plain)	280
Beam dimensions	**Result (mm)**
Column width	550
Column length	550
Reinforcement diameter (deformed)	22
Stirrup diameter (plain)	12
Net Concrete cover thickness	40
Design shear moments and forces	**Result (kNm)**
Axial force due to factored load	245,952
Ultimate moment due to factored load	78,065
Design shear force due to factored load	232,031

Column Recurrence Calculation

Column Reinforcement

Concrete outer side reinforcement distancae. ds = 63mm

Column height, d = 487mm

Minimum amount of eccentricity, e_0 = 32

Emin = 32 mm

Agr = 302500 (0,3025)

Pu = 907,5

Determining the reduction factor,

Pu < 0,1 * fc'* Agr
245,952 < 907,5
Because Pu > 0,1 x fc' x Agr, then it is used ϕ = 0,65

On the repetition of the 4 sides of the column obtained:
r = 0,01; β = 1
ρ = β x r
= 1 x 0,01 = 0,01
Ast = ρ x Agr
= 0,0100 x 302500
= 3025
Maximum nominal axial force,
φPn = 0,8 *φ*(0,85 *fc* (Ag – As) + (fy*As))
= 0,8 x 0,65 x (0,85 x 30) x (302500-
3040) + (420 x 3040))
= 4634,677
According to SNI 2847:2019, the requirements:
ϕPn ≥ Pu
4634,77 ≥ 245,952 → SAFE (OK)

Inner Force

The purpose of this analysis is to determine the effects of the combination of loads on the structure, including axial forces, shear, torque, and the resulting moment.

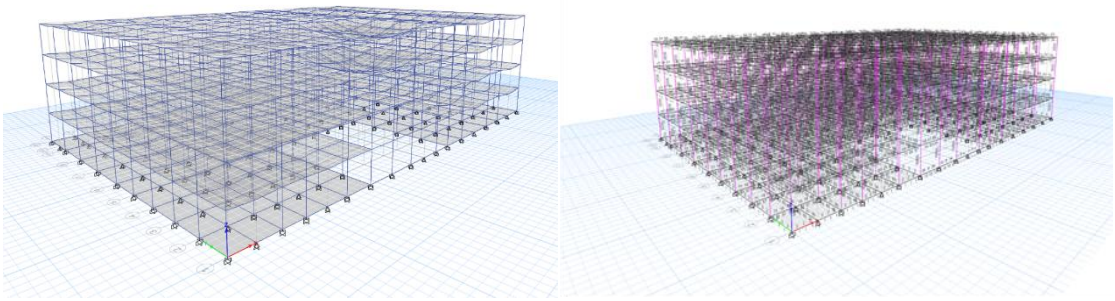

Figure 4. Moment due to load combination

CONCLUSION

The planning of this hospital building employs the MACC method with a building category value of I=1.50. The site's soft soil type (SE) influences the Ss and S1 values of the spectral response, impacting structural design considerations. The slab structure includes a floor slab thickness of 130mm and a roof slab thickness of 100mm. The beam structure is composed of parent beams sized 600mm x 300mm and smaller child beams. Columns are designed in two-dimension types: 1m x 1m and 55cm x 55cm. Future research could explore the long-term performance and settlement effects of the soft soil on the structure's integrity and optimize beam and column dimensions for enhanced seismic resilience.

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