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Design of an 8-Story Reinforced Concrete Hotel Building Using a Moment-Resisting Frame System at Sepakat II Street in Pontianak City

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Abstract: Pontianak City has experienced a steady increase in tourist arrivals, which has resulted in a higher demand for temporary accommodation facilities. In response to this development, this study presents the structural design of an eight-story reinforced concrete hotel building located on Sepakat II Street in Pontianak City. The structure is designed using an Intermediate Moment-Resisting Frame (IMRF) system to ensure adequate performance under seismic loading conditions. The structural design process was carried out in accordance with the applicable Indonesian National Standards (SNI). Structural analysis was conducted using ETABS software to evaluate the building's behavior under gravity and earthquake loads, while technical drawings were prepared using AutoCAD and SketchUp. The building utilizes concrete with a compressive strength of $f'_c = 30$ MPa and reinforcing steel with a yield strength of $f_y = 420$ MPa. The seismic performance of the structure was evaluated through several parameters, including mass participation ratios, inter story drift limits, natural period verification, and P-Delta effects. The analysis results show that the structural system satisfies all required performance criteria, indicating that the building is capable of resisting seismic forces safely and efficiently. The slab system consists of D10 main reinforcement bars and Ø8 shrinkage reinforcement bars, with slab thicknesses of 150 mm for the roof, 130 mm for typical floors (Levels 1–8), and 160 mm for stair landings. The primary beams (B1) have cross-sectional dimensions of 300 × 600 mm and are reinforced with D19 longitudinal bars, D13 shear reinforcement, and D19 torsional reinforcement. Secondary beams (B2) measure 200 × 400 mm and use D16 longitudinal bars, D13 shear reinforcement, and D16 torsional reinforcement. Columns have a uniform cross-section of 700 × 700 mm and are reinforced with 20D22 longitudinal bars and D13 transverse reinforcement. The foundation system consists of three types of pile foundations using 200 × 200 mm precast concrete piles with reinforced pile caps designed to accommodate varying structural loads.

Keywords: *Hotel Design, Structural Analysis, Reinforced Concrete, IMRF, ETABS*

1. Introduction

Based on domestic tourist travel data from West Kalimantan Province, Pontianak City experienced a significant increase in tourist visits, reaching 1,815,000 in 2024. International arrivals also rose from 9,492 visits in 2023 to 10,480 by the end of 2024 [1]. This increase has led to a high demand for temporary accommodations, with hotel occupancy rates reaching up to 90% during annual festivals and major events [2].

Along with the rapid development of Pontianak's economy and tourism sector, the construction of multi-story hotels has become one of the city's priorities. However, such buildings are vulnerable to horizontal seismic forces, thus requiring earthquake-resistant design [3]. This is further supported by several significant earthquakes recorded in 2024, with the largest magnitude reaching 4.6 [4].

Globally, structural systems such as the Moment Resisting Frame are widely used in earthquake-prone regions—such as Japan, Turkey, and Chile—due to their proven ability to provide sufficient ductility and energy dissipation capacity under seismic loading. Among the types of the Intermediate Moment Resisting Frame offers an optimal balance between stiffness and flexibility, making it particularly suitable for mid-rise buildings like hotels in moderate seismic zones [5].

Previous studies have extensively explored the seismic performance of reinforced concrete structures using various lateral force-resisting systems. However, limited research has specifically focused on the application of the Intermediate Moment Resisting Frame system for hotel buildings in medium-risk seismic zones like Pontianak. Furthermore, the use of performance-based modeling tools, such as ETABS, integrated with the latest Indonesia National standards, remains underrepresented in the context of local hotel development. This study addresses that gap by implementing a comprehensive structural design approach for an 8-story hotel building using an Intermediate Moment Resisting Frame system configuration.

The structural system uses reinforced concrete due to its elasticity, high compressive strength, and reliable bond between concrete and steel, which are essential characteristics in seismic design [6]. This research applies response spectrum analysis in ETABS software, adhering to the Indonesian National Standards for earthquake resistance, structural concrete design, and minimum loading.

This study aims to design an eight-story hotel building in Pontianak that meets the latest standards for earthquake-resistant structures, ensuring the building's safety, functionality, and compliance with structural codes. The outcomes are expected to contribute practical design insights for engineers and planners involved in similar mid-rise hotel projects within seismic-prone urban regions

2. Literature Riview

2.1. Multi-Story Structures and Seismic Design

Buildings located in seismic regions such as West Kalimantan are subjected to both gravity and seismic loads. Consequently, structural design must account for seismic risk categories to ensure adequate ductility and energy dissipation capacity. The primary objective of seismic design is to prevent structural collapse during strong earthquake events while maintaining acceptable structural performance and ensuring occupant safety, as stipulated in SNI 1726:2019.

2.2. Intermediate Moment Resisting Frame System

Moment-Resisting Frame (MRF) systems are widely used to resist seismic lateral loads and are classified into Ordinary, Intermediate, and Special systems based on their ductility levels. The Intermediate Moment-Resisting Frame (IMRF) system provides an optimal balance between stiffness and flexibility, making it suitable for mid-rise buildings located in moderate seismic regions such as Pontianak. Rigid beam–column connections in IMRF systems enhance lateral load resistance while maintaining structural integrity and constructability [7]

Compared to Ordinary Moment-Resisting Frames (OMRF), IMRF systems offer improved ductility and seismic performance through stricter detailing requirements. Conversely, when compared to Special Moment-Resisting Frames (SMRF), IMRF systems require less complex reinforcement detailing and lower construction costs. Therefore, IMRF systems are considered a practical and efficient structural solution for mid-rise buildings in moderate seismic regions, where adequate seismic performance is required without excessive construction complexity.

2.3. Reinforced Concrate in Seismic Applications

Reinforced concrete is one of the most commonly used materials in earthquake-resistant structures due to its high compressive strength and ductile behavior. When properly designed and detailed in accordance with Indonesian National Standards, reinforced concrete structures are capable of dissipating seismic energy effectively and minimizing structural damage under cyclic loading conditions. The bond behavior between reinforcing steel and concrete plays a critical role in achieving the required seismic performance [6].

2.4. Structural Modeling Using ETABS

ETABS provides a comprehensive platform for performing static and dynamic analyses, including response spectrum analysis, which is crucial in earthquake-resistant structural design [8]. ETABS's capability to model structural elements in detail, such as beams, columns, and joints, enables engineers to obtain highly accurate calculations of internal forces and displacements [9]. This greatly aids in ensuring that structural designs comply with standards such as SNI 1726:2019 and SNI 2847:2019, allowing buildings to be designed with optimal safety and efficiency.

2.5. Research Gap and Relevance

Previous studies have demonstrated that the application of IMRF systems can enhance the seismic performance of mid-rise buildings by increasing lateral stiffness and reducing inter-story drift without significantly increasing construction costs [10]. However, most existing studies focus on general building functions or alternative structural systems, while research specifically addressing the seismic structural design of reinforced concrete hotel buildings employing IMRF systems in moderate seismic regions such as Pontianak remains limited. In addition, previous studies often emphasize general seismic performance without providing a comprehensive evaluation of code-based seismic design parameters. Therefore, this study aims to address this gap by integrating a detailed, code-compliant seismic performance evaluation—covering mass participation ratios, inter-story drift limits, natural period verification, and P-Delta effects—into the structural design of a reinforced concrete hotel building, in accordance with Indonesian standards and tailored to local seismic conditions.

3. Methodology

3.1. Problem – Solving Method

The problem-solving stages in the design of the eight-story hotel building are shown in Figure 1. The flowchart illustrates the sequential steps taken to meet the technical and structural requirements.

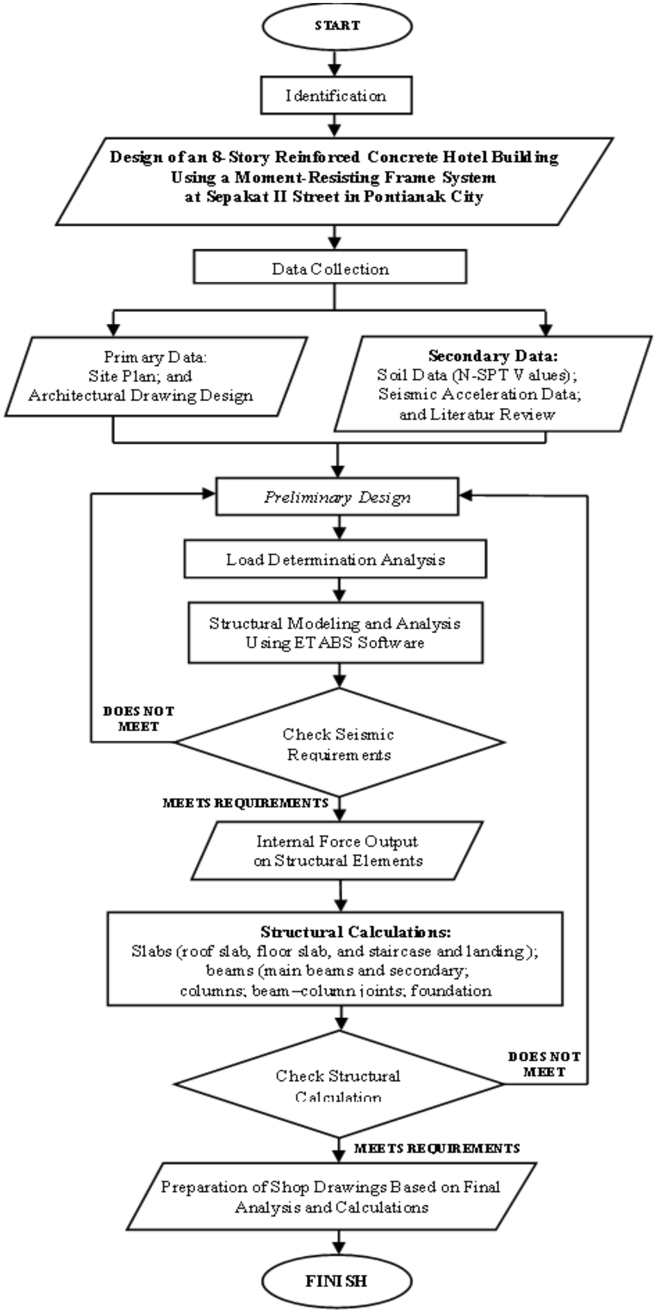


Figure 1. *Flowchart of the Problem-Solving Stages.*

If the square-shaped pixel size in our images was 8 × 8 screen-pixels, this amounted to about 21 pixels per face quantization (an equivalent of about 10.5 cycles/face). With this level of image detail, all three basic varieties of configural information (hange of spatial quantization between 11 pixels/face and 6 pixels/face levels altogether indicate that this ERP- component is especially sensitive to the first-order configural cues. Some other works have supported both of these ideas.

3.2. Data Collection Methodology

This study employs a quantitative numerical approach, with data collected using two methods: primary and secondary data collection.

3.2.1 Design Data

The planned construction site is located on Sepakat II Street, Pontianak City, West Kalimantan Province. The design data to be used in the structural analysis process is presented in Table 1.

Table 1. *Technical Planning Data*

Parameter	Speciffication
Number of floors	8 floors
Floor height	38 m
Building area	1,955 m^2
Foundation structure	Pile foundation
Seismic analysis	Response spectrum
Seismic zone	Pontianak
Concrete strength (f'_c)	30 MPa
Steel strength (f_y)	420 MPa
Site Classification	E

3.2.2 Standards and Codes

The structural design of this eight-story hotel building is based on the applicable standards and codes, as shown in Table 2.

Table 2. *Standards Codes Applied*

Standards/Regulation Code	Title
SNI 2847-2019	Structural Concrete Requirements for Building Construction
SNI 1726-2019	Procedures for Earthquake Resistance Design of Building and Non-Building Structures
SNI 1727-2020	Minimum Loads for the Design of Buildings and Other Structures
SNI 2052-2017	Reinforcing Steel
PPPURG 1987	Guidelines for Load Planning for Houses and Buildings
SNI 2847-2019	Structural Concrete Requirements for Building Construction
SNI 1726-2019	Procedures for Earthquake Resistance Design of Building and Non-Building Structures
SNI 1727-2020	Minimum Loads for the Design of Buildings and Other Structures
SNI 2052-2017	Reinforcing Steel

3.3. Preliminary Design

The preliminary design calculations of the structural elements are based on the Indonesian National Standards, and then adjusted through a trial-and-error process using ETABS software.

3.3.1 Preliminary Beam Design

The initial beam dimensions were determined based on the span length using empirical span-to-depth ratios.

$$h_{min} = \frac{L}{18.5} \tag{1}$$

$$b_{min} = \frac{1}{2}\, x\, h \tag{2}$$

In Equation (1), where $h_{\min}$ is the minimum beam depth and L is the beam span, and Equation (2) b_{min} is the minimum beam width and h is the designed beam depth.

The proposed initial beam dimensions are presented in Table 3.

Table 3. *Preliminary Beam Dimension Design*

Beam Type	Dimension
Main Beam (B1)	300 x 600 mm
Secondary Beam (BA)	400 x 200 mm
Stair-Landing Beams (BT/BB)	400 x 200 mm

3.3.2 Preliminary Slabs Design

The initial slab thickness was determined based on the effective stiffness ratio between beams and slabs, as well as the slab span lengths.

$$h_{min} = \frac{L_n\left(0.8 + \frac{fy}{1400}\right)}{36 + 9\beta} \tag{3}$$

In Equation (3), where L_n is the clear span length in the longitudinal direction of the two-way slab, f_y is the yield strength of the reinforcing steel, and β is the ratio of the clear span in the long direction to that in the short direction.

The proposed initial thicknesses for the roof slab, floor slab, and stair slab are shown in Table 4.

Table 4. *Preliminary Slab Dimension Design*

Slab Type	Adopted Thickness
Roof Slab	150 mm
Floor Slab	130 mm
Stair Slab	160 mm

3.3.3 Preliminary Columns Design

The preliminary dimensions of the column were determined by calculating the dead and live loads acting on each floor, including the self-weight of slabs, beams, walls, and mechanical/electrical equipment. These loads were then combined in accordance with structural design standards to obtain the total ultimate load.

$$\sqrt{A_g} = \frac{\rho_0}{[0.85 \,.\, f'_c + \rho_g \,.\, (f_y - 0.85 \,.\, f'_c)]} \tag{4}$$

In Equation (4), where A_g is the gross cross-sectional area of the column, ρ_0 is the column eccentricity, f'_c is the compressive strength of concrete, ρ_g is the gross reinforcement ratio, and f_y is the yield strength of the reinforcing steel

Based on this, an initial column cross-section of 700 × 700 mm was adopted.

3.3.4 Structural Loading

The structural loading in the design of the 8-storey hotel building consists of the following loads.

a) $1.4\, D$
b) $1.2\, D + 1.6\, L + 0.5\, L_r$ *(or R)*
c) $1.2\, D + 1.6\, L_r$ *(or R)* $+ 1.0\, L$ *(or* $0.5\, W$*)*
d) $1.2\, D + 1.0\, W + L + 0.5\, L_r$ *(or R)*
e) $0.9\, D + 1.0\, W$
f) $1.2\, D + 1.0\, E_v + 1.0\, E_h + L$
g) $0.9\, D - 1.0\, E_v + 1.0\, E_h$

Where ϕ is the strength reduction factor, M_n, V_n, P_n are the nominal flexural moment, shear force, and axial force capacities, M_u, V_u, P_u are the factored flexural moment, shear force, and axial force obtained from ETABS analysis

These load combinations are used to ensure the strength, stability, and safety of the structure under the most critical loading conditions.

3.4. Modeling Using ETABS

Structural modeling was conducted using ETABS v20. Beam and column elements were modeled as frame elements, while slabs were modeled as shell elements, with concrete compressive strength f'_c = 30 MPa and steel yield strength f_y = 420 MPa. The floor system was assumed to act as a rigid diaphragm, and supports were modeled as fixed bases.

Gravity and lateral loads were applied in accordance with Indonesian National Standard 1727:2020 and Indonesian National Standard 1726:2019, including response spectrum analysis. Evaluations included internal forces, structural irregularities, inter-story drift, and natural vibration periods.

The obtained internal forces must satisfy the applicable requirements, with structural strength criteria referring to the LRFD (Load and Resistance Factor Design) approach according to Indonesian National Standard.

$$\phi M_n \geq M_u,\ \phi V_n \geq V_u,\ \phi P_n \geq P_u \tag{5}$$

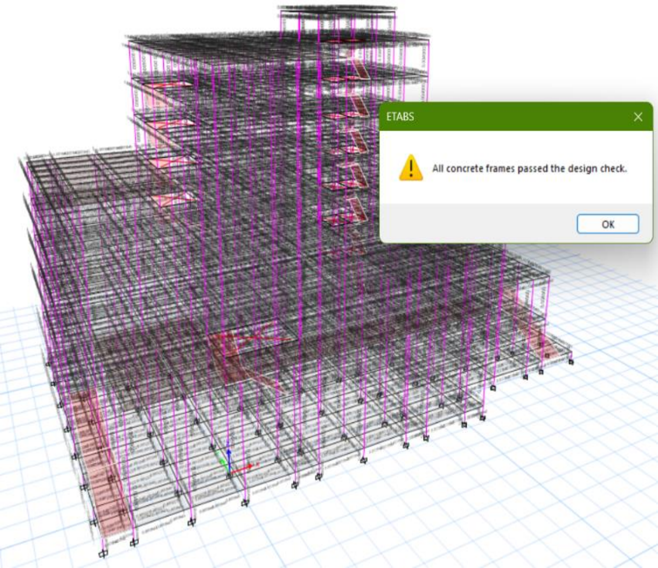
In Equation (5), where ϕ is the strength reduction factor, M_n, V_n, P_n are the nominal flexural moment, shear force, and axial force capacities, M_u, V_u, P_u are the factored flexural moment, shear force, and axial force obtained from ETABS analysis.

4. Result and Discussion

The results of the design for the 8-story hotel structure were obtained based on the Indonesian National Standards and analyzed using ETABS software.

4.1. Frame Design Verification

Frame Design checking in ETABS functions to ensure that structural elements such as beams and columns are designed according to loads and standards, verify dimensions and reinforcement, and identify strengthening requirements to ensure the structure is safe and efficient under applied loads. The results of the frame design check are shown in Figure 2.



All concrete frames passed the design check.

Figure 2. Structural frame design check.

Based on the frame design verification results of the 8-story hotel building structure, all reinforced concrete frames have successfully met the design criteria.

4.2. Seismic Force Verification

4.2.1 Irregularity Check

The irregularities in the design of the 8-storey hotel building include horizontal torsional irregularities types 1a and 1b, as well as story drift irregularities. Based on the torsional irregularity coefficients obtained from the structural analysis, these irregularities meet the building's safety requirements. The verification results of structural irregularities indicate that the building complies with the safety criteria as specified in Indonesian National Standard 1726:2019. This outcome demonstrates that the structural design possesses adequate deformation capacity and lateral stability, despite the presence of non-ideal geometric conditions.

4.2.2 Verification of the Structure's Natural Period

This check is carried out to ensure that the ETABS modeling is efficient and capable of accurately representing the structural behavior. This validates the feasibility of the earthquake-resistant design. The results of the natural vibration period analysis of the structure are shown in Table 5.

***Table 5.** Natural Period of Vibration of the Buiding Structure*

Parameter	**Value**
Analysis period (T) [a]	1.380 s
Fundamental period (T_a) [b]	1.231 s
Maximum allowable period [c]	1.969 s
Status [d]	**Safe**

[a] T Analysis period obtained from the simulation using ETABS software.

[b] T_a fundamental period calculated using the formula $T_a = C_t \times h^n$, with $C_t = 0.0466$ and $h = 38^{0,9}$ m

[c] C_u is the maximum allowable period factor, taken as 1.6 according to design standards.

[d] The structure is considered safe since $T < C_u \times T_a$ (1.380 s < 1.969 s).

4.2.3 Verification of Mass Participation Ratio

This check is conducted to ensure that the structural model created using ETABS can accurately represent the dynamic response of the building. The results of the check are presented in Table 6.

***Table 6.** Natural Period of Vibration of the Buiding Structur*

Case	**Item**	**Static (%)**	**Dynamic (%)**	**Status**
Modal	UX	100	99.97	**Safe**
Modal	UY	100	99.83	**Safe**

Table 6 shows that the building meets the minimum total mass participation requirement of 90% in both the U_X and U_Y directions.

4.2.4 Interstory Drift Check

Based on the interstory drift check, the eight-story hotel building structure is considered safe against inelastic drift in both the X and Y directions, as it does not exceed the allowable drift limit. The results of the interstory drift calculation are shown in Figure 3.

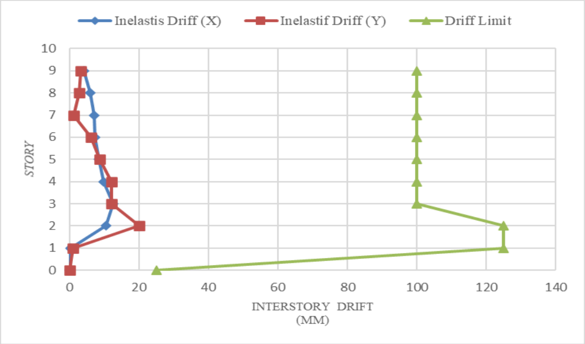


***Figure 3**. Graph of Interstory Drift Influence.*

4.2.5 P-Delta Verification

The P-Delta effect on the stability coefficient in both the X and Y directions meets safety requirements, as it does not exceed the P-Delta effect limit or the structural stability limit. The results of the P-Delta check are shown in Figure 4.

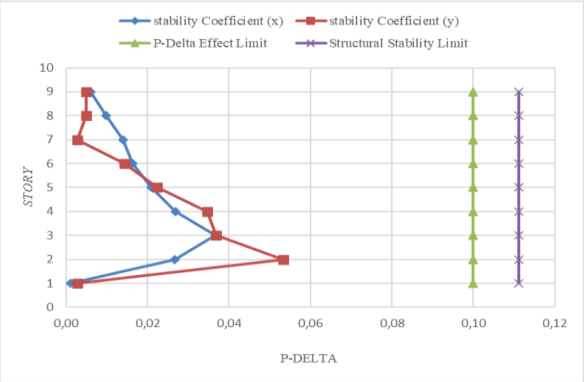


Figure 4. *Graph of Interstory Drift Influence.*

4.3. Slab Desig

In the design of the 8-story hotel structure, three slabs with varying thicknesses are used: the roof slab at 150 mm, floor slabs from levels 1 to 8 at 130 mm, and the staircase slab at 160 mm. All slabs are reinforced with 10 mm diameter bars.

The planned reinforcement details of the slabs are presented in Figures 5, 6, and 7.

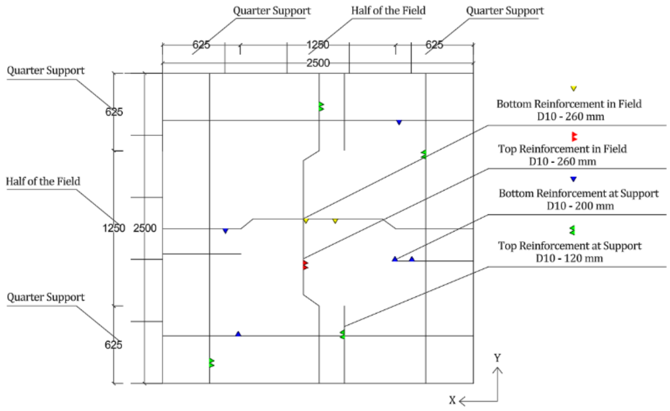


Figure 5*. Floor Slabs Reinforcement.*

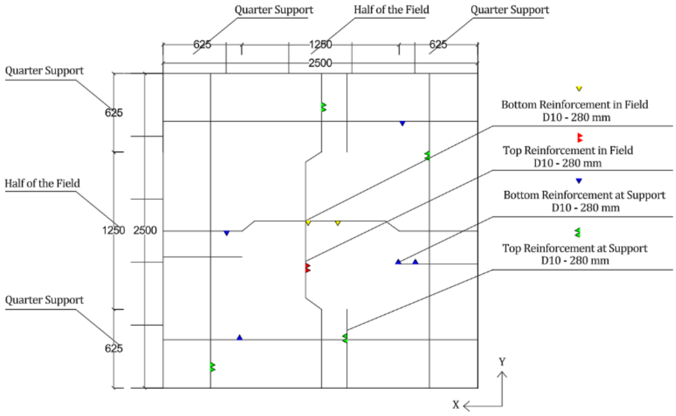


Figure 6*. Roof Slabs Reinforcement.*

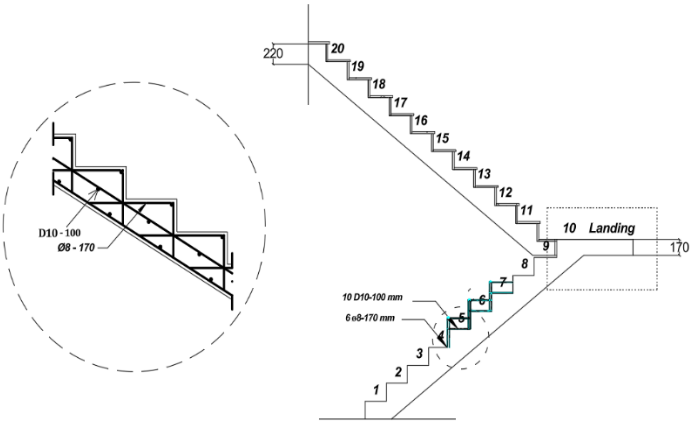
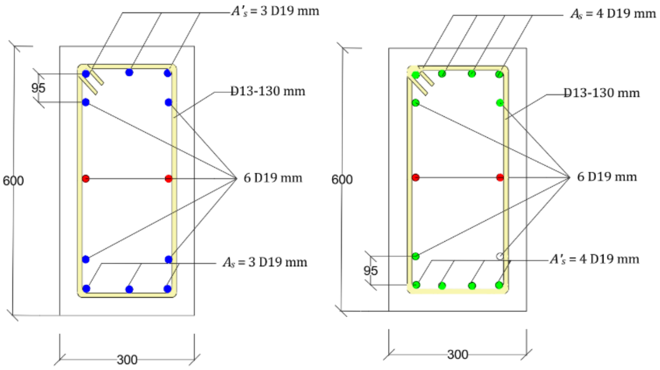


Figure 7*. Staircase and Landing Reinforcement.*

The reinforcement details shown in Figures 5, 6, and 7 are considered safe, as the reduced flexural capacity (ϕM_n) exceeds the ultimate moment demand (M_u) in the floor slab, roof slabs, and stair–landing slab.

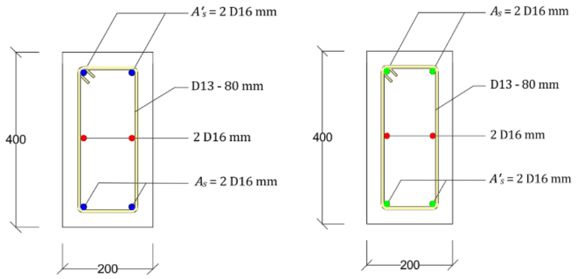
4.4. Beam Design

The 8-story hotel structure uses two beam types: main beams (B1) of 300 × 600 mm and secondary beams (B2) of 200 × 400 mm, installed from the first floor to the roof. B1 uses 19 mm bars for main and torsional reinforcement and 13 mm for shear, while B2 uses 16 mm and 13 mm bars, respectively. Reinforcement is provided at span and support regions to ensure structural performance under flexural, shear, and torsional loads. Figure 8 and 9 shows the reinforcement details.



(a) (b)

Figure 8*. (a) Reinforcement of the Main Beam at the Span Region, (b) Reinforcement of the Main Beam at the Support Region.*



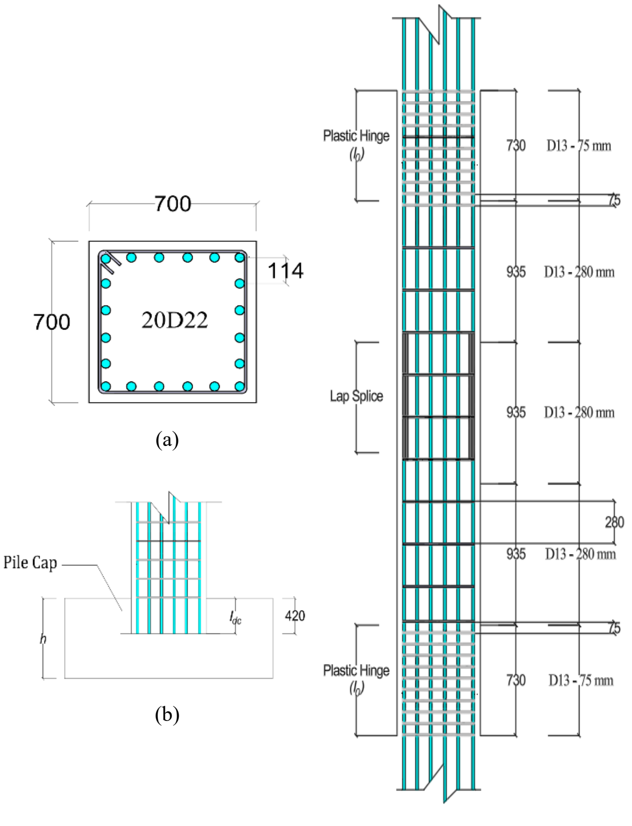
(a) (b)

Figure 9*. (a) Reinforcement of the Secondary Beam at the Span Region, (b) Reinforcement of the Secondary Beam at the Support Region.*

The beam reinforcement details shown in Figure 8 and 9 are considered safe, as the reduced flexural capacity (ϕM_n) exceeds the ultimate moment demand (M_u) in both the span and support regions of the main and secondary beams.

4.5. Columns Design

A column with a cross-section of 700 × 700 mm is designed using 20 longitudinal reinforcement bars with a diameter of 22 mm, resulting in a total reinforcement area of 7,602.65 mm² and a reinforcement ratio of 1.55%, which falls within the safe range of 1% to 6%. The column reinforcement details are shown in Figure 10.



(a)

(b)

(c)

Figure 10. *(a) Column Reinforcement (b) Development Length of Column Reinforcement to the Foundation (c) Reinforcement Detailing at the Plastic Hinge Region and Splices.*

4.6. Columns Design

The results of the beam–column connection verification are shown in Table 7.

Table 7. *Beam-Column Joint Design Result*

Parameter	**Value**	**Reason for Safety According to SNI**
Effective Joint Width (b_j, h_j)	400 mm	Width ≥ column side, safe for force distribution
Beam Reinforcement Area (A_s)	1134.10 mm²	Meets minimum reinforcement requirements
Probable Reinforcement Stress (f_{pr})	525 MPa	Complies with standard probability factor
Total Shear Force at Joint (V_u)	1071.19 N	Shear force less than nominal capacity
Design Shear Strength (ϕV_n)	1266.33 N	Design shear strength ≥ actual shear force
Shear Safety Factor (SF)	1.182	$SF \geq 1$, safe
Development Length (l_{dh})	269.80 mm	Development length > minimum

4.7. Design of Foundation

A total of 116 foundation points are planned, consisting of three foundation types using 20 × 20 cm precast concrete piles, each 6 m long and installed to a 30 m depth. Type P1 uses 6 piles per point, Type P2 uses 4 piles, and Type P3 uses 2 piles, all with a 600 mm pile spacing and 350 mm edge distance. The pile caps vary according to type: P1 measures 1900 × 1300 × 550 mm with Ø19 mm bars (11 in X and 7 in Y) spaced at 150 mm; P2 measures 1300 × 1300 × 450 mm with Ø19 mm bars (6 in each direction) spaced at 200 mm; and for the P3 measures 1300 × 700 × 450 mm with Ø19 mm bars (6 in X and 5 in Y) spaced at 200 mm.

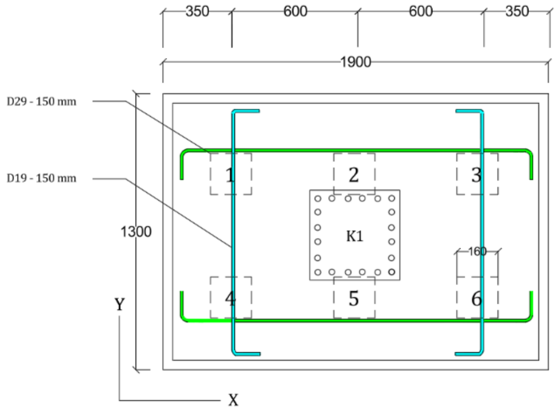


Figure 11. *Plan View of Foundation Type P1*

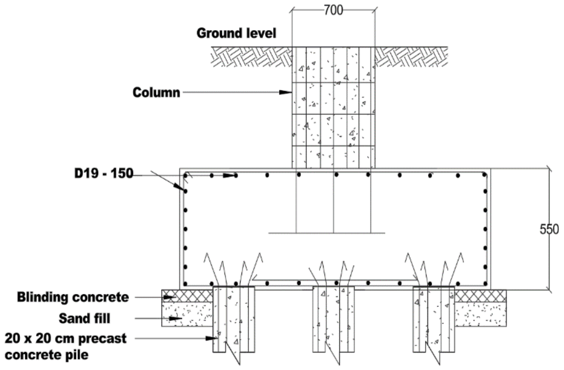


Figure 12. *Side Elevation of Foundation Type P1*

5. Conclusion

The structural design of the 8-storey hotel building, based on a Moderate Moment-Resisting Frame system, has been successfully completed using concrete grade $f'_c = 30$ MPa and steel grade $f_y = 420$ MPa as fundamental material parameters. Crucially, seismic analysis confirmed that the structure meets all safety requirements, successfully mitigating horizontal irregularities, and satisfying the P-Delta criteria. All structural elements (slabs, beams, columns, and the three-type pile foundation system) were subsequently proportioned and detailed according to code specifications, validating the safety and serviceability of the final structural configuration.

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