Journal of Global Engineering Research & Science (J-GERS)
Vol. 2, No. 1, June 2023, pp. 40-50
ISSN: 2830-5906, *e*-ISSN: 2830-5418, DOI: 10.56904/j-gers.v2i1.41

Structural Design of The Building Grand Diara Cileungsi Hotel 10 Floor

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Article Info

Article history:

Received November 25, 2022
Revised Maret 17, 2023
Accepted Juni 5, 2023

Keywords:

Hotel Building;
Building Structure Design;
Upper Structure;
ETABS.

ABSTRACT

Hotel buildings are tall buildings that have a fairly complex design. This research will discuss the design of the upper structure of the Grand Diara Cileungsi hotel building including beams, columns, and floor plates. The design of this upper structure also takes into account the loads acting on the structure such as dead loads, live loads, and earthquake loads by using a moment-bearing frame system. This building is designed based on SNI 2847-2019 and SNI 1726-2019 to design earthquake-resistant buildings. The building structure design stage begins with the collection of structural design data which is then modeled in ETABS 19.0.2 software. After modeling in ETABS software, the design recommendations on concrete structures are as follows; 120 mm thick plate with a ratio of (0.79%), 100 mm thick plate for the roof with a ratio of (0.65%) Main Beam (350 x 650 mm with a ratio of 1.34%), Child Beam (300 x 500 mm with a ratio of 0.67%), Child beam (300 x 500 mm with a ratio of 0.67%). 67%) and sub-beams (250 x 350 mm with a ratio of 0.67%), (Concrete columns 600 x 600 mm with a ratio of 1.29%) and (400 x 400 mm with a ratio of 1.93%) with concrete quality (fc') = 30 Mpa and flexural reinforcement quality is (fy) = 420 Mpa.

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1. INTRODUCTION

A hotel is a building that is managed to provide a temporary accommodation that is relatively occupied for a short period of time. The need for a hotel is not only a place to stay, but also provides Meeting, Incentive, Conference, and Exhibition (MICE) facilities. While there are many different types of hotel buildings around the world to meet the demands of guests, their diverse existence can also benefit the local environment and communities through sustainable building design [1]. The construction of high-rise buildings must be designed safely and beautifully in accordance with architectural planning, to obtain optimal results in terms of cost, quality, and time [2]. The main types of structures used in a hotel building are column structures, beams, floor plates and roof structures [3]. The structure of the hotel building is made using a type of reinforced concrete which is a combination of concrete material that is strong enough to withstand compressive forces but weak against tensile forces and steel reinforcement to withstand the tensile forces caused by the building structure [4]. Concrete is a mixture of fine aggregate and coarse aggregate, with cement and water as chemical reaction auxiliaries during the curing and hardening process [5]. In designing the structure of the Grand Diara Hotel consisting of 10 floors, of course, many load factors must be considered, including the factors of live load, dead load, and earthquake factors that will greatly affect the construction of the building itself.

2. RESEARCH METHOD

The design of this building refers to SNI 1726-2019 [6] on earthquake resistance planning procedures for building and non-building structures, SNI 1727-2020 [7] on minimum design loading and related criteria for buildings and other structures, and SNI 2847-2019 [8] which discusses the minimum requirements for structural concrete for buildings. Building modeling and structural analysis were conducted using AutoCad 2014 software (for building drawing) and Etabs 19.0.2 (for building structural analysis).

2.1 Flowchart

Figure 1 below is a flowchart that shows how this research process runs.

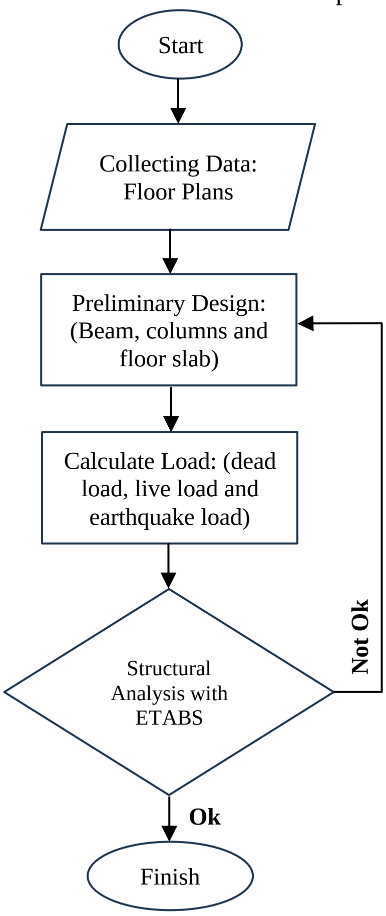

Figure 1. Flowchart

2.2 Building Design Data

As planned in the flow chart, the first step taken in this research is to Collecting project data of the hotel building to be built. The following data is used as the basis for structural calculations of the building:

- **a.** Building Function: Hotel
- **b.** Number of Floors: 10 Floors
- **c.** Location: Cileungsi, Bogor
- **d.** Soil Condition: Soft
- **e.** Building Structure: Concrete Structure
- **f.** Roof Structure: Concrete Structure
- **g.** Ground Floor Height: 2.95 meters
- **h.** Mezzanine Height: 2.9 meters
- **i.** Floor Height 1~9: 3.5 meters
- **j.** Lift Roof Height: 3.00 meters

k. Overall Building Height: 40.35 meters

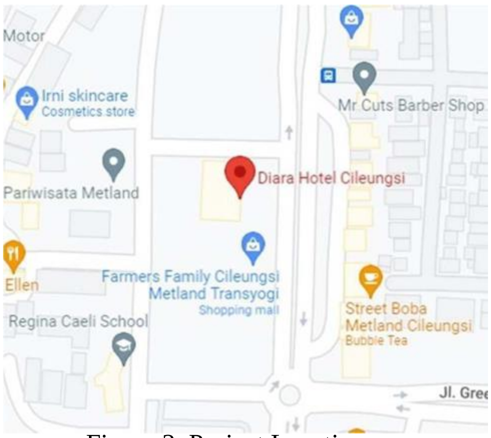

Figure 2. Project Location

2.3 Structure Analysis and Calculation

a. Preliminary Planning and 3D Modeling
   1. At this stage, initial planning is carried out as a step to obtain optimal structural dimensions and able to withstand workloads that are also adjusted to the requirements in SNI [9].
   2. The next step is to do modeling using ETABS software and then enter the loading that was planned at the beginning [10].

b. Earthquake Spectrum Response Analysis
   This earthquake response and spectrum analysis is divided into two types of load analysis, which are [11] :
   1. Equivalent static is a method of structural static analysis, where the effect of earthquakes on the structure is considered as a horizontal static load to simulate the actual earthquake effect due to ground motion.
   2. Dynamic is a dynamic analysis to obtain a building response that is close to the actual structural response during an earthquake.

c. Drawing of Planning
   At this stage, planning drawings are made using AutoCad software.

3. RESULTS AND DISCUSSION

3.1. Planning and Design Flow

a. Determine the dimensions of the length and width of the beam with SNI 2847:2019.
b. Determine the type of one-way or two-way plate and the thickness of the plate with SNI 2847:2019.
c. Determine the dimensions of the length and width of the column with SNI 2847:2019.

3.2. Planning and Design Flow

a. Dead load is adjusted to SNI 1727-2020 regulations:
   1. Reinforced Concrete : 2400 kg/m^3
   2. Ceramic : 22 kg/m^2
   3. Sand : 16 kg/m^2
   4. Spec : 66 kg/m^2
   5. Ceiling Frame + ME : 21 kg/m^2

b. The live load is adjusted to the regulations of SNI 1727-2020:
   1. Residential floor load : 200 kg/m^2
   2. Meeting floor load : 500 kg/m^2
   3. Minimarket floor load : 500 kg/m^2
   4. Office/staff floor load : 250 kg/m^2

c. Earthquake load using SNI 1726-2019 Procedures for planning earthquake resistance for building and non-building structures.

d. Beam, Column & Plate Material Data
   1. Concrete Quality : fc' 30 MPa
   2. Reinforcement Quality : fy' 420 MPa

3.3. Sire Class

The land used at the building site in Metland Transyogi Cileungsi is Soft Soil. Soft soils are categorized in the SE. site class group.

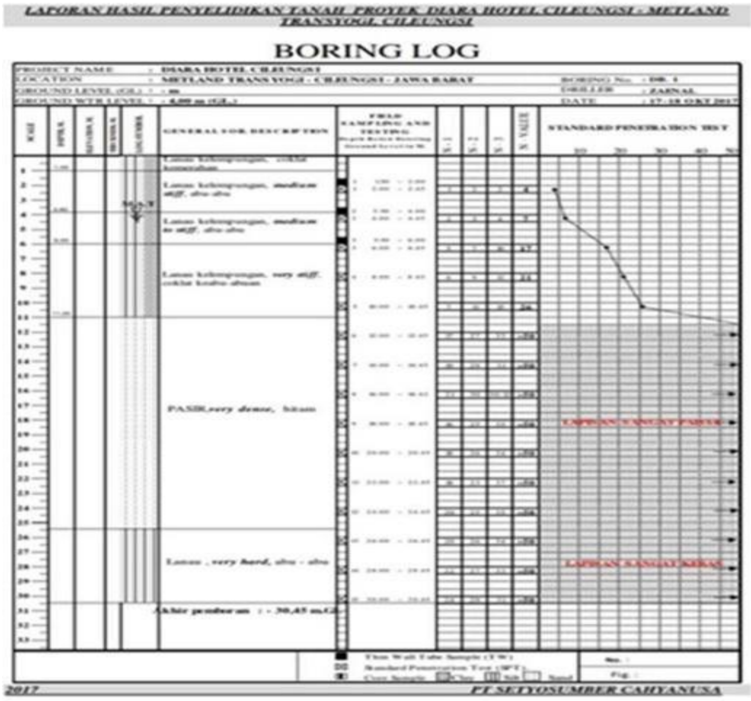

Figure 3. Boring Log

Table 1. Calculation N SPT Value

Numb	Depth	T (m)	N (SPT)	N=T/N
1	2 - 2.45	0.95	4	4.21
2	4 - 4.45	2	7	3.5
3	6 - 6.45	2	17	8.5
4	8 - 8.45	2	21	10.5
5	10 - 10.45	2	26	13
	AMOUNT	8.95		39.71
			ΣN	4.44

The earthquake response spectrum data was obtained from the results of determining the location of the building on the site (Source http://rsa.ciptakarya.pu.go.id/2021) with latitude = -6.403656622570068, longitude = 106.97606588092002.

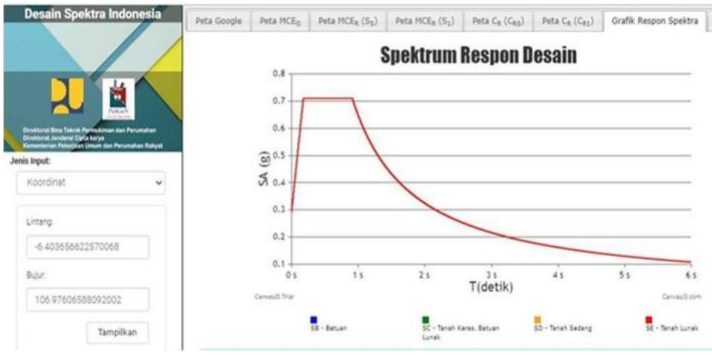

Figure 4. Spectrum Response Graph

3.4. Structural Analysis

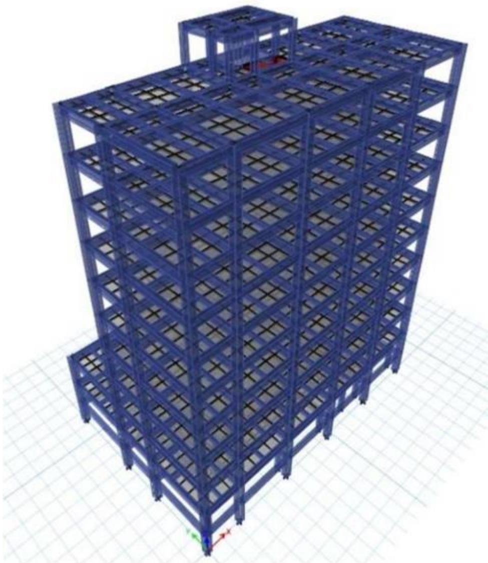

Figure 5. 3D modeling using ETABS Software

3.5. Moments and Forces on Beams

Table 2. Moments and Forces on Beams 350 x 650

Floor	*Location*	*V2 (Kn.m)*	*M3 (Kn.m)*	*Description*
Floor 4Th Beams (350x650)	0		161.1359	Left Focus (+)
	4650	179.8273	162.1895	Field (+)
	7225		214.3596	Right Focus (+)
	0		-344.025	Left Focus (-)
	2325		-107.1798	Field (-)
	7225	218.3876	-428.7192	Right Focus (-)

Beam Reinforcement Table

Type	Dimension	End		Mid		End		Stirrup	
Beam	(mm)	Top Rebar	Bottom Rebar	Top Rebar	Bottom Rebar	Top Rebar	Bottom Rebar	End	Mid
B1	350 x 650	6 D22	4 D22	4 D22	4 D22	6 D22	4 D22	4D 13-150	4D 13-200

Table 3. Moments and Forces on Beams 250 x 350

Floor	Location	V2 (Kn.m)	M3 (Kn.m)	Description
Floor.MEZZ. Beams (250x350)	1955		21.3561	Left Focus (+)
	4895		24.3663	Field (+)
	7850		14.2878	Right Focus (+)
	0	36.2572	-34.5872	Left Focus (-)
	2932.5	12.2246	-8.6461	Field (-)
	7850		-28.5757	Right Focus (-)

Beam Reinforcement Table

Type	Dimension	End		Mid		End		Stirrup	
Beam	(mm)	Top Rebar	Bottom Rebar	Top Rebar	Bottom Rebar	Top Rebar	Bottom Rebar	End	Mid
B3	250 x 350	3 D22	3 D22	3 D22	3 D22	3 D22	3 D22	3D 13-150	3D 13-150

Table 4. Moments and Forces on Beams 500 x 500

Floor	Location	V2 (Kn.m)	M3 (Kn.m)	Description
Floor LIFT Beams (300x500mm)	0	73.2854	35.6646	Left Focus (+)
	2680		18.0161	Field (+)
	4020		24.9364	Right Focus (+)
	0		-55.6163	Left Focus (-)
	2680	59.1508	-17.8323	Field (-)
	3573.3		-17.8323	Right Focus (-)

Beam Reinforcement Table

Type	Dimension	End		Mid		End		Stirrup	
Beam	(mm)	Top Rebar	Bottom Rebar	Top Rebar	Bottom Rebar	Top Rebar	Bottom Rebar	End	Mid
B2	300 x 500	3 D22	3 D22	3 D22	3 D22	3 D22	3 D22	3D 13-150	3D 13-200

3.6. Column reinforcement design

This column reinforcement design aims to determine the amount of reinforcement needed which is based on several criteria that already exist in SNI 2847 – 2019 [1]. In this column planning, the Mnc value will be sought with the help of spcolumn software. The Mnc value is obtained from the axial value based on the installed reinforcement ratio. Article 18.7.4.1 states that the reinforcement ratio shall not be less than 1% and shall not exceed 6%. This ratio value will be taken from the minimum limit of 1%. From the ratio value, the required reinforcement area will be calculated as follows:

Planning Data:

Bw = 600 mm

H = 600 mm

fc' = 30 MPa

fy = 420 MPa

Diameter of longitudinal reinforcement = 22 mm Transverse reinforcement diameter = 13 mm

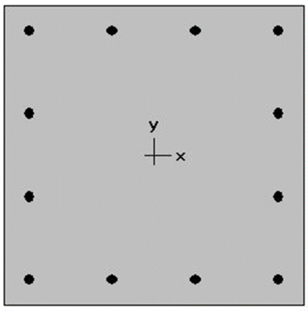

Figure 5. Sp Column. column reinforcement cross-section

3.7. Column reinforcement design K 400 x 400

The design of this column reinforcement aims to determine the amount of reinforcement needed based on several criteria that are already by SNI 2847 – 2019 [1]. To get the Mnc value, it will be assisted by the spcolumn software. The Mnc value is obtained from the axial value based on the ratio of the installed reinforcement. Article 18.7.4.1 states that the reinforcement ratio cannot be less than 1% and cannot exceed 6%. The value of this ratio will be taken from the minimum limit of 1%. From the ratio value, the required area of reinforcement will be calculated as follows:

Planning Data:

Bw = 400 mm

H = 400 mm

fc' = 30 MPa

fy = 420 MPa

Diameter of longitudinal reinforcement = 22 mm Transverse reinforcement diameter = 13 mm

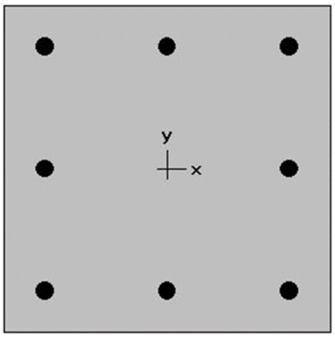

Figure 6. Column Reinforcement Cross-Section

3.8. Floor Plate Reinforcement Design

a. Types of Residential Floor Plates

1. Structure Material Data
   - Concrete compressive strength fc = 30 MPa
   - Yield stress of steel for flexural reinforcement fy = 420 MPa
2. Residential Plate Type
   - Span X = 4.578 m
   - Span Y = 3.25 m
3. Burden
   - Dead Load = 288 kg/m^2

- Live Load = 200 kg/m²
- Structural Design Load = 125 kg/m²

4. Reinforcement diameter (Ø)
   - X direction = 10 mm
   - Y direction = 10 mm
5. Plate Thickness = 120 mm

Table 5. Residential Floor Plate Reinforcement Design

Moment	(m)	(m)	Ly/Lx	Koef x	Ultimit (kg.m)	R_n	p_{min}	p	p_{maks}	mm²	Continuous Tul	-	S	mm²	Cek
X Direction															
Mtx = 0,001.Qu.lx².x	4.578	3.25	1.41	72.26	622	0.8622	0.0018	0.0021	0.0220	198.54	10	-	150	523.33	ok
Mlx = 0,001.Qu.lx².x	4.578	3.25	1.41	42.30	364	0.5047	0.0018	0.0012	0.0220	171.00	10	-	150	523.33	ok
Y Direction															
Mty = 0,001.Qu.lx².x	4.578	3.25	1.41	54.96	473	0.8191	0.0018	0.0020	0.0220	168.62	10	-	150	523.33	ok
Mly = 0,001.Qu.lx².x	4.578	3.25	1.41	17.87	154	0.2664	0.0018	0.0006	0.0220	153.00	10	-	150	523.33	ok

b. Office Floor Plate Type

4. Structure Material Data
   - Concrete compressive strength fc = 30 MPa
   - Yield stress of steel for flexural reinforcement fy = 420 Mpa
5. Office Plate Type
   - Span X = 3.875
   - Span Y = 2.233 m
6. Burden
   - DL Load = 288 kg/m²
   - Live Load = 250 kg/m²
   - SDL Load = 125 kg/m²
7. Reinforcement diameter (Ø)
   - X direction = 10 mm
   - Y direction = 10 mm
8. Plate Thickness 120 mm

Table 6. Office Floor Plate Reinforcement Design

Moment	Ly (m)	Lx (m)	*Ly/Lx*	*Koef x*	Momen Ultimit (kg.m)	*Rn*	*p min*	*p*	*pmaks*	*As Need (mm)*	*Reinforcement Continuous*			*Us Tide (mm)*	Check
X Direction															
Mtx = 0,001.Qu.lx².x	3.875	2.233	1.74	80.03	357	0.4950	0.0018	0.0012	0.0220	171	10	-	150	523.33	ok
Mlx = 0,001.Qu.lx².x	3.875	2.233	1.74	51.71	231	0.3198	0.0018	0.0008	0.0220	171	10	-	150	523.33	ok
Y Direction															
Mty = 0,001.Qu.lx².x	3.875	2.233	1.74	54.00	241	0.4172	0.0018	0.0010	0.0220	153	10	-	150	523.33	ok
Mly = 0,001.Qu.lx².x	3.875	2.233	1.74	15.00	67	0.1159	0.0018	0.0003	0.0220	153	10	-	150	523.33	ok

c. Minimarket Floor Plate Type

1. Structure Material Data
   - Concrete compressive strength fc = 30 MPa
   - Yield stress of steel for flexural reinforcement fy = 420 Mpa

2. Mini Market Plate Type
   - Span X = 3.925 m
   - Span Y = 2.233 m

3. Burden
   - DL Load = 288 kg/m²
   - Live Load = 500 kg/m²
   - SDL Load = 125 kg/m²

4. Reinforcement diameter (Ø)
- X Direction = 10 mm
- Y direction = 10 mm

5. Plate Thickness = 120 mm

Table 7. Minimarket Floor Plate Reinforcement Design

Moment	*Ly* (m)	*Lx* (m)	*Ly/Lx*	*Koef x*	Momen Ultimit (kg.m)	*Rn*	*p min*	*p*	*pmaks*	*As Need* (mm)	*Reinforcement Continuous*			*Us Tide* (mm)	Check
X Direction															
Mtx = 0,001.Qu.lx^2.x	3.925	2.233	1.76	80.37	519	0.7191	0.0018	0.0017	0.0220	171.00	10	-	150	523.33	ok
Mlx = 0,001.Qu.lx^2.x	3.925	2.233	1.76	52.15	337	0.4667	0.0018	0.0011	0.0220	171.00	10	-	150	523.33	ok
Y Direction															
Mty = 0,001.Qu.lx^2.x	3.925	2.233	1.76	54.00	349	0.6036	0.0018	0.0015	0.0220	153.00	10	-	150	523.33	ok
Mly = 0,001.Qu.lx^2.x	3.925	2.233	1.76	15.00	97	0.1677	0.0018	0.0004	0.0220	153.00	10	-	150	523.33	ok

d. Meeting Floor Plate Type

1. Structure Material Data
   - Concrete compressive strength fc = 30 MPa
   - Yield stress of steel for flexural reinforcement fy = 420 Mpa
2. Meeting Plate Type
   - Span X = 3.925 m
   - Span Y = 3.25 m
3. Burden
   - DL Load = 288 kg/m^2
   - Live Load = 500 kg/m^2
   - SDL Load = 125 kg/m^2
4. Reinforcement diameter (Ø)
   - X direction = 10 mm
   - Y direction = 10 mm
5. Plate Thickness 120 mm

Table 8. Meeting Floor Plate Reinforcement Design

Moment	*Ly* (m)	*Lx* (m)	*Ly/Lx*	*Koef x*	Momen Ultimit (kg.m)	*Rn*	*p min*	*p*	*pmaks*	*As Need* (mm)	*Reinforcement Continuous*			*Us Tide* (mm)	Check
X Direction															
Mtx = 0,001.Qu.lx^2.x	3.925	3.25	1.21	63.35	867	1.2007	0.0018	0.0029	0.0220	278.52	10	-	150	523.33	ok
Mlx = 0,001.Qu.lx^2.x	3.925	3.25	1.21	34.80	476	0.6597	0.0018	0.0016	0.0220	171.00	10	-	150	523.33	ok
Y Direction															
Mty = 0,001.Qu.lx^2.x	3.925	3.25	1.21	54.04	740	1.2794	0.0018	0.0031	0.0220	266.01	10	-	150	523.33	ok
Mly = 0,001.Qu.lx^2.x	3.925	3.25	1.21	21.85	299	0.5172	0.0018	0.0012	0.0220	153.00	10	-	150	523.33	ok

e. Roof Floor Plate Type

1. Structure Material Data
   - Concrete compressive strength fc = 30 MPa
   - Yield stress of steel for flexural reinforcement fy = 420 Mpa
2. Roof Plate Type
   - Span X = 3.875 m
   - Span Y = 2.233 m
3. Burden
   - DL Load = 288 kg/m^2

- Live Load = 100 kg/m^2
- SDL Load = 141 kg/m^2

4. Reinforcement diameter (Ø)
   - X direction = 10 mm
   - Y direction = 10 mm
5. Plate Thickness 120 mm

Table 9. Roof Floor Plate Reinforcement Design

Moment	Ly (m)	Lx (m)	*Ly/Lx*	*Koef x*	Momen Ultimit (kg.m)	*Rn*	*p min*	*p*	*pmaks*	*As Need (mm)*	*Reinforcement Continuous*			*Us Tide (mm)*	Check
X Direction															
Mtx = 0,001.Qu.lx^2.x	3.875	2.233	1.74	80.03	246	0.5473	0.0018	0.0013	0.0220	135.00	10	-	200	392.50	ok
Mlx = 0,001.Qu.lx^2.x	3.875	2.233	1.74	51.71	159	0.3536	0.0018	0.0008	0.0220	135.00	10	-	200	392.50	ok
Y Direction															
Mty = 0,001.Qu.lx^2.x	3.875	2.233	1.74	54.00	166	0.4917	0.0018	0.0012	0.0220	117.00	10	-	200	392.50	ok
Mly = 0,001.Qu.lx^2.x	3.875	2.233	1.74	15.00	46	0.1366	0.0018	0.0003	0.0220	117.00	10	-	200	392.50	ok

4. CONCLUSION

After calculating Beams, Columns, & Floor slabs, structural analysis, and design for the structure of the Grand Diara Hotel Cileungsi located in Bekasi, it can be concluded:

1. Floor slabs are designed using two-way slabs.

Table 10. Floor Slabs Design Recapitulation

Plate Type	Plate Thickness (mm)	Lx (mm)	Ly (mm)	End	Mid
Roof	100	2.233	3.875	D10-200	D10-200
Occupancy	120	3.25	4.578	D10-150	D10-150
Office	120	2.233	3.875	D10-150	D10-150
Mini Market	120	2.233	3.925	D10-150	D10-150
Meeting	120	3.25	3.925	D10-150	D10-150

2. Beam structure dimensions.

Table 11. Beam Design Recapitulation

Type	Dimension		End			Mid		End		Stirrup
Beam	(mm)	Top Rebar		Bottom Rebar	Top Rebar	Bottom Rebar	Top Rebar	Bottom Rebar	End	Mid
B1	350 x 650	5 D22		4 D22	2 D22	3 D22	6 D22	4 D22	4D 13-150	2D 13-200
B2	300 x 500	3 D22		3 D22	2 D22	2 D22	3 D22	3 D22	3D 13-150	2D 13-200
B3	250 x 350	3 D22		3 D22	2 D22	2 D22	3 D22	3 D22	3D 13-150	2D 13-150

3. Column structure dimensions.

Table 12. Coloumn Design Recapitulation

Type	Dimension		End	Mid			End	Stirrup	
Column	(mm)	Top Rebar	Bottom Rebar	Top Rebar	Bottom Rebar	Top Rebar	Bottom Rebar	End	Mid
K1	600 x 600	12 D22	12 D22	12 D22	8 D22	12 D22	12 D22	3D 13-150	3D 13-150
K2	400 x 400	8 D22	8 D22	12 D22	8 D22	2 D22	2 D22	3D 13-200	3D 13-200

5. ACKNOWLEDGEMENTS

I want to say thank you to my family and thank you also to the leadership of the company who has given me enthusiasm and motivation to complete this thesis, Advisors 1 and 2, and friends, in the company. and Global University Jakarta for their support me in completing this final project.

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