STRUCTURE DESIGN OF PARKING BUILDING SUNTER PARK VIEW APARTMENT WITH THE EQUIVALENT STATIC ANALYSIS METHOD

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Abstract: *Parking building (Tower C), Project Sunter Park View Apartment is a public facility that serves as a parking garage. This building consists of 4 floors including the roof plate with a typical floor plan for each level. Floor to floor elevation is 3 meters height, so the total height of the building reach 9 meters height (less than 40 meters height). Review Design Parking building structure (Tower C) Project Title: "Structure Design Of Parking Building Sunter Park View Apartment With The Equivalent Static Analysis Method" , wherein the influence of earthquakes on structures analyzed by Equivalent Static method based on the Standard Provisions Design for Earthquake Resistance of Building Structures (SNI 03-1726-2002). Structural components of buildings designed by Special Moment Frame System Bearers (SRPMK) based on Procedure for Calculation of Concrete Structure for Buildings (SNI 03-2847-2002).*

Key words*: Design, Parking Building Sunter Park View Apartment, Equivalent Static Analysis Method, Special Moment* Frame *Structure bearers (SRPMK)*

INTRODUCTION

To avoid human victims caused by the collapse of the building due to the strong earthquake, it required construction of earthquake resistant buildings. Standard Design for Earthquake Resistance of Building Structures (SNI 03-1726-2002) define a concept of Capacity Design, where in the structure of the building is planned to have sufficient ductility level with the formation of plastic joints in the structure of the building, so that the structure remains to standing despite of being in a state on the verge of collapse. It located on the Yos Sudarso Street Kav 30A, Sunter Jaya – North Jakarta.

Aim and Purpose

Able to designing the building structure with the equivalent static analysis methods, with Special Moment Frame Systems bearer design based on SNI 03-1726-2002 and SNI 03-2847-2002.

Problem Restriction

Problem restriction of Project :

1. The building structure is designed by Frame System bearers of reinforced concrete moment.
2. Buildings located in North Jakarta area (Earthquake Regional 3).
3. Regular building structures category.
4. Structural analysis using Equivalent Static Analysis Method by SAP2000 programme.
5. Ductility level full planned with the Special Moment Frame System bearers (SRPMK).
6. Guidelines used:
   - Standard Design for Earthquake Resistance of Building Structures, SNI 03-1726-2002.
   - Procedure for Calculation of Concrete Structure for Buildings, SNI 03-2847-2002.
   - Loading Design Guidelines for Home and Building, SNI-1727-1989-F.
7. Design structures viewed:
   - Secondary Structure Design, including: roof plate, floor plate, secondary beam and Stairs.
   - Primary Structure Design, including: Beams Design, Columns, and

Foundations.
8. Not discuss the Budget Plan (RAB) Structure.
9. Not discuss the method of implementation in field.

Earthquake

Earthquakes can cause vibration. Mechanical energy due to damage of the rocks structure in the earthquake event then will be turned into energy waves that vibrate the surrounding rocks. Rocks vibration due to the earthquake will subsequently forwarded by the media to the soil surface. Ground shaking caused by the earthquake will lead to the building on the ground get shaking too. The buildings damage may occur due to that vibration.

Earthquake Area and Response Spectrum

Regulation of the Indonesian Earthquake SNI 03-1726-2002, divides Indonesia into 6 Regional Earthquake (WG). It based on the acceleration of peak bedrock due to the influence of the Earthquake Plan with 500 years return period,which is average value for each Region Earthquake (WG) as shown in Figure 1.

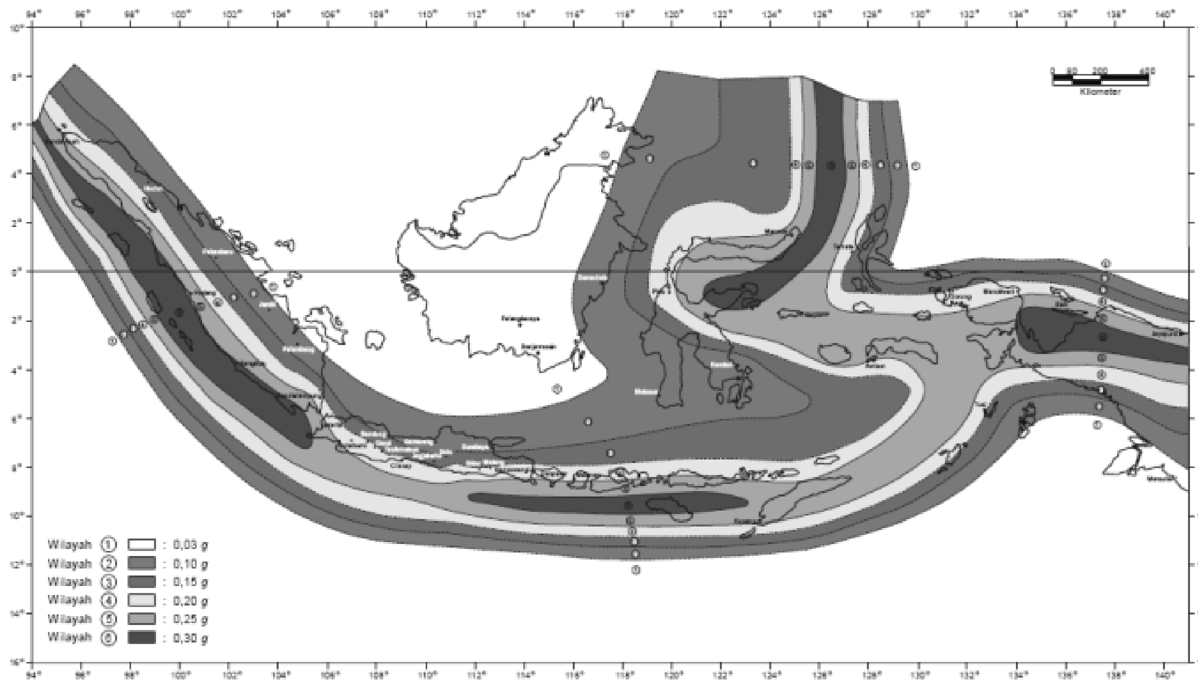


Figure 1. Indonesia Earthquake Regional

Response Spectrum for earthquake regional 3, as shown as Figure 2.

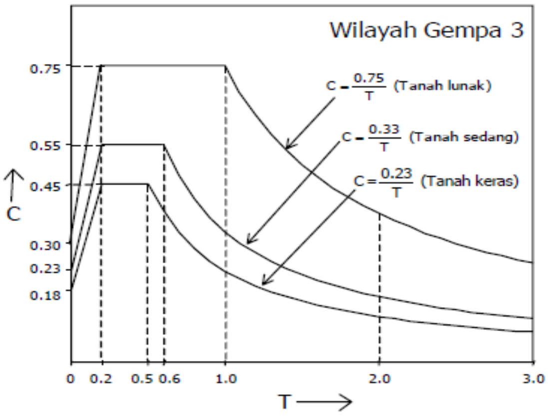


Figure 2. Response Spectrum For Earthquake Regional Plan 3

The Plan Of Earthquake and Primacy Buildings Factor

Effect of the plan of earthquake must be multiplied by a primacy buildings factor to adjust the probability occurrence of collapse of the building structure during the ages of the building and the expected ages of the building. The primacy factor I determined by the equation :

$I = I_1 I_2$................................(Table-1)

The primacy factors I_1 and I_2 defined in the Table-1 Standard Design for Earthquake Resistance of Building Structure SNI 03-1726-2002.

Structure Ductility and Earthquake Reduction Factor

Building structural ductility factor value μ, earthquake reduction factor, R, when design the building structure can be selected according to the needs, but shouldn't be taken more greater than the value of the maximum ductility factor μm which can be deploys by each of system or subsystem building structures contained in table of 2.3. (Table 3 SNI 03-1726-2002)

Structure System for Earthquake Load

Based on SNI 03-1726-2002 Frame System moment bearers is a system structure that basically has framework of a complete gravity load bearing. Lateral load borne by the bearers moments frame, especially through flexible mechanisms.

Building Structure Category

For regular building structures, the influence of the Plan of Earthquake can be viewed as the equivalent static earthquake load effects, so according to SNI 03-1726-2002 standard analysis can be performed based on equivalent static analysis

Regular Building Structure Design

Based on SNI 03-1726-2002 Clause 6.1.2 states that if the building has a Primacy Factor I according to Table 1 (SNI 03-1726-2002) and its structure to direction main axis structure plan and direction of loading plan of earthquake had a reduction earthquake factor R and fundamental natural vibration period T1, then the load base shear nominal equivalent static V which is happening at the ground level can be calculated according to the equation:

$$V = \frac{C_1 I}{R} W_t$$

Wherein :

C1 = Earthquake response factor values obtained from the response spectrum of the plan of earthquake according to Figure 2 (SNI 03-1726-2002) for the fundamental natural vibration period T1,

I = Primacy Buildings Factor , Table 1 (SNI 03-1726-2002).

Wt = total weight of the building including suitable live load.

R = earthquake reduction factor

Based on SNI 03-1726-2002 Clause 6.1.3 states that the nominal base shear load V according to Clause 6.1.2 should be distributed along the height of the building structure into equivalent static nominal earthquake loads Fi that captures the center of mass of the i-th floor level according to the equation:

$$F_i = \frac{W_i Z_i}{\sum_{i=1}^{n} W_i Z_i} V \quad (2.5)$$

Wherein :

Wi = weight of the i-th floor level, including suitable live load

zi = the height of the i-th floor level measured from lateral clamping level according to Section 5.1.2 and Section 5.1.3 (SNI 03-1726-2002).

V = the load base shear nominal static equivalent

n = number of top level floor.

METHODOLOGY

Compiling of The Final Project Flowchart

This compiling of the Final Project methodology are shown in Figure 3

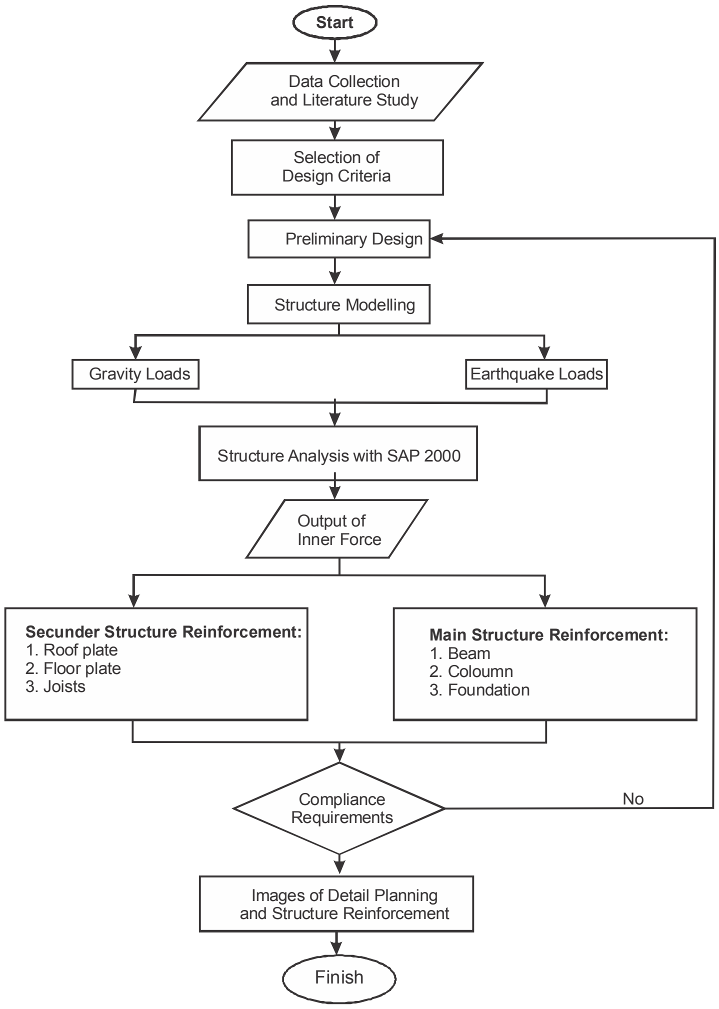


Figure 3. Compiling of The Final Project Flowchart

STRUCTURE CALCULATION

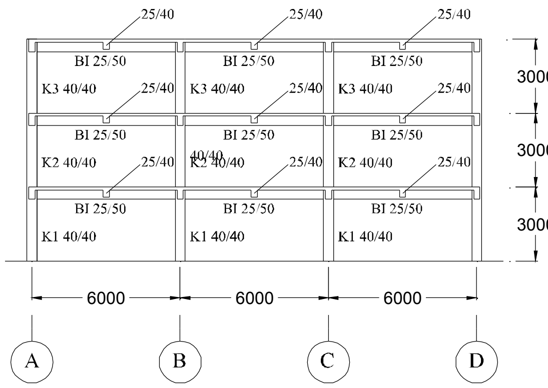
Overview

Guidelines used in the analysis and design of structural components refer to: Standard Design for Earthquake Resistance of Building Structures (SNI 03-1726-2002) and Procedure for Calculation of Concrete Structure for Buildings (SNI 03-2847-2002.)

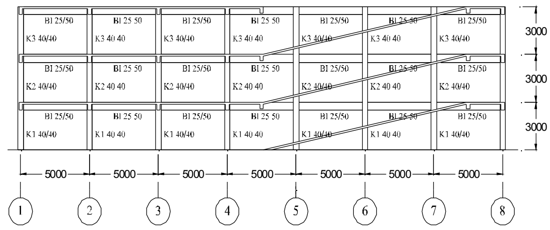
Description of Building Plan

Building site plan and section are shown in Figure 4 and 5.

With reference from the provisions of Clause 4.2 SNI 03-1726-2002, parking building has a regular structure. For regular building structures, the influence of Plan of Earthquake can be viewed as the equivalent static earthquake load effect, so the analysis can be performed based on equivalent static analysis.



(a) Section A-A



(b) Section B-B

Figure 5. Site plan Section X-direction (a) and Y direction (b)

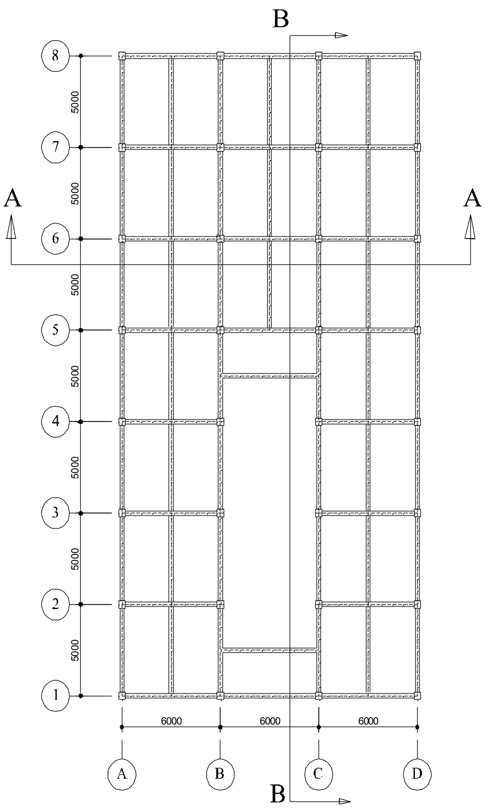


Figure 4. Building siteplan

Structure Analysis

Effect of earthquakes on structures made with Equivalent Static analysis methods with the aid of SAP2000 software.

1. Modeling structure in SAP2000

   The structure is modeled as an open framework structure (Open Frame). Columns and beams are modeled as frame elements. Pedestal at the base of the structure is modeled as a clips footstool. Specification of structural components used in the modeling of the structure shown in Table 1.

Tabel 1. Components Structure Data

COMPONENTS	DIMENSION	QUALITY
SECONDARY BEAM	25 X 40 cm	f'c = 30 Mpa
MAIN BEAM	25 X 50 cm	f'c = 30 MPa
COLUMN	40 X 40 cm	f'c = 40 MPa

Figure 6 shows the result of modeling the structure from the SAP2000 software.

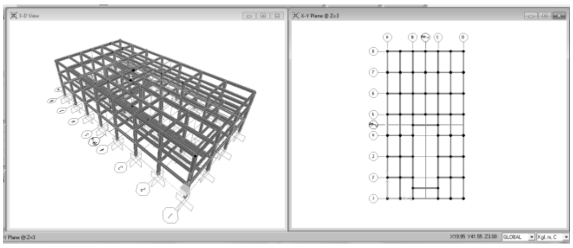


Figure 6. Modeling structure in SAP2000

2. Structure Loading

   Load combinations that were reviewed in the analysis determined by a strong need, SNI 03-2847-2002 Clause 11.2 as follows:

   - COMB 1 = 1,4 D
   - COMB 2 = 1,2 D + 1,6 L + 0,5R
   - COMB 3 = 1,2 D + L + 1,6 W + 0,5 R
   - COMB 4 = 0,9 D + 1,6 W
   - COMB 5 = 1,2 D + 1 L + Ex + 0,3 Ey
   - COMB 6 = 1,2 D + 1 L + Ey + 0,3 Ex
   - COMB 7= 0,9 D + Ex + 0,3 Ey
   - COMB 8= 0,9 D + Ey + 0,3 Ex

   Wherein : D = Dead Load
   L = Live Load
   W = Wind Load
   R = Rain Load
   Ex and Ey = Earthquake load in X-direction and Y-direction

3. The Nominal Equivalent Static Earthquake Load

   Time vibrating structures obtained by 3 Dimensional free vibration analysis get T1 = 0.5322 dt, using the response spectrum of the plan of earthquake, Earthquake Regional 3 – Soft soil, obtained;

   C = 0,75 / T
   = 0,75 / 0,5322
   = 1,4092

   From the calculations result obtained the data analysis:

   - Primacy Structure Factor, I= 1
   - Earthquake Reducion Factor, R = 8,5
   - Spectrum Response, C = 1,4092
   - Building Total Weight, Wt = 1396 ton (Structure Total Weight + load)

   So the base shear load, V for each direction of loading obtained :

   V_x and V_y = C.I.Wt / R
   = 1,4092x1x1396/8,5
   = 231,44 ton

   The value of equivalent static load (Fi) at the i-th level is obtained :

Table 2. Calculation of equivalent static loads at each level

FLOOR	WEIGHT (ton)	HEIGHT (m)	W_i x z_i	$V_x = V_y$ (ton)	F_i (ton)
4th Floor	465,4	9	4188,46	231,44	115,72
3rd Floor	465,4	6	2792,30	231,44	77,147
2nd Floor	465,4	3	1396,15	231,44	38,573
		TOTAL	8376,91		

For each joint in the direction of loading (X-Direction and Y), Fi must be divided by the number of portals on each direction of loading.

Table 3. Calculation of equivalent static loads at each Joint

FLOOR	F_i (ton)	Loading X-Direction Fi / (8 Portal) (ton)	Loading Y-Direction (Fi / 4 Portal) (ton)
4th Floor	115,72	14.46	28,93
3rd Floor	77,14	9.64	19.28
2nd Floor	38,57	4.82	9.64

For each portal in the direction of loading (X-Direction and Y), can be showed:

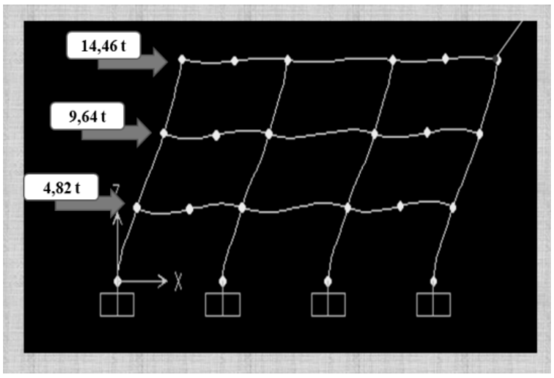


Figure 7. equivalent static load, X-Direction

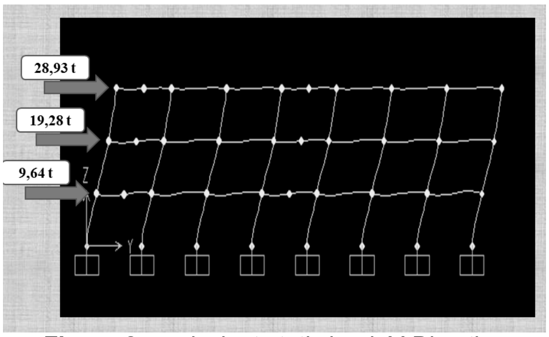


Figure 8. equivalent static load, Y-Direction

ENDING

Special Moment Frame systems bearers (SRPMK) as planned in the Parking Building (Tower C) Sunter Park View Apartment, guarantee it structure to ductile behave with plastic hinge formation during a strong earthquake.

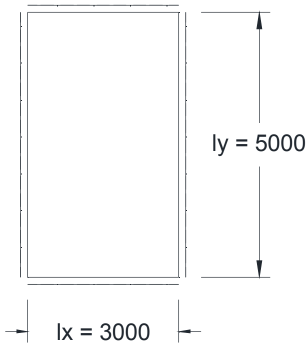
Guidelines used in the analysis and design of structural components refer to: Standard Design for Earthquake Resistance of Building Structures (SNI 03-1726-2002) and Procedure for Calculation of Concrete Structure for Buildings (SNI 03-2847-2002.)

Conclusion

From calculations that have been done based on the configuration of the structure and specification of design, structural reinforcement obtained results as follows:

Floor Plate Reinforcement

For plates which clip on all four sides moments per meter width is obtained as follows



- X-Direction Field Moment :
  M_{lx} = 5540500 Nmm
- Y-Direction Field Moment :
  M_{ly} = 1696000 Nmm
- X-Direction Pedestal Moment :
  M_{tx} = - 8819600 Nmm
- Y-Direction Pedestal Moment :
  M_{ty} = - 6105900 Nmm

Dimension	: X-direction = 3 m
	: Y-direction = 5 m
Thickness	: 12 cm
Concrete Quality	: f'_c = 30 MPa
Reinforcement Quality	: f_y = 400 MPa
X-Direction Pedestal Reinforcement	: D10-200
Y-Direction Pedestal Reinforcement	: D10-250
X-Direction Field Reinforcement	: D10-200
Y-Direction Field Reinforcement	: D10-250

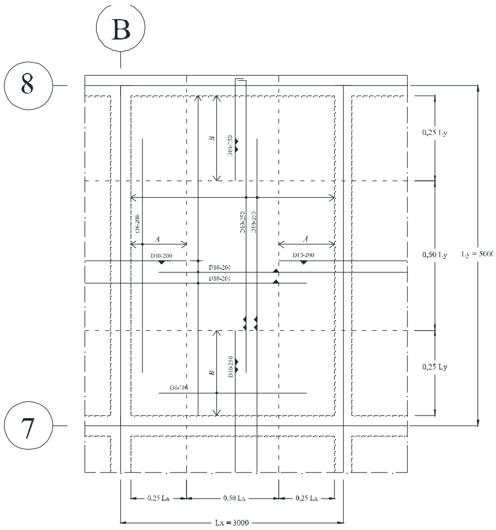


Figure 9. Floor Plate Reinforcement

Stairs Plate Reinforcement

Moments at stairs plate;

- X-direction pedestal moment;
  = 4883940 Nmm
- X-direction field moment;
  = 2521310 Nmm
- Y-direction pedestal moment;
  = 9578120 Nmm
- Y-direction field moment;
  = 5083000 Nmm

Dimension : X-direction = 5 m
: Y-direction = 3 m
Thickness : 14 cm
Concrete Quality : f'_c = 30 MPa
Reinforcement Quality : f_y = 400 Mpa
X-direction pedestal reinforcement : D13-200
Y-direction pedestal reinforcement : D13-250
X-direction field reinforcement : D13-200
Y-direction field reinforcement : D13-250

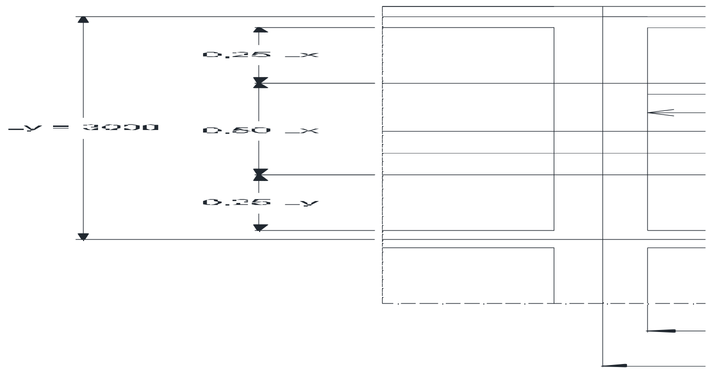


Figure 10. Stairs Plate Reinforcement

Secondary beam Reinforcement (BA)

Force Factor analysis results displayed on Table 4.

Secondary beam design data:

Dimension : 250 x 400 mm
Length : 5 m
Concrete Quality : f'_c = 30 MPa
Reinforcement Quality : f_y = 400 MPa

Table 4. secondary beam reinforcement (BA) Inner Forces

TABLE: Element Forces - Frames (BALOK ANAK)							
OutputCase	**StepType**	**P**	**V2**	**V3**	**T**	**M2**	**M3**
Text	Text	N	N	N	N-mm	N-mm	N-mm
ENVELOPE	max	4.265E-11	78792.5	2.224E-12	327956.16	2.23E-08	55942188.64
ENVELOPE	min	-3.568E-11	-79262.21	-4.46E-12	-231767.76	-8.919E-09	-74874070

Pedestal Reinforcement:
Above = 4D16
Below = 2D16
Cross bar = 2D10-150

Field Reinforcement :
Above = 2D16
Below = 3D16
Cross bar = 2D10-200

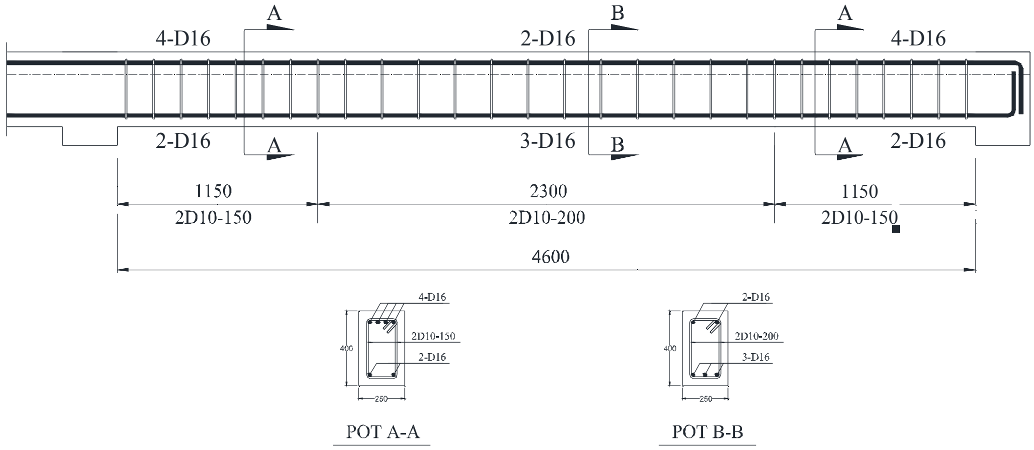


Figure 11. Secondary beam Reinforcement (BA)

Main Beam Reinforcement (BI)

Results of the structural analysis of the beam inner forces displayed on Table 5

Tabel 5. Main Beam Inner Forces

TABLE: Element Forces - Frames (BALOK INDUK)							
OutputCase	**StepType**	**P**	**V2**	**V3**	**T**	**M2**	**M3**
Text	Text	N	N	N	N-mm	N-mm	N-mm
ENVELOPE	Max	2.283E-10	151079.09	2.373E-12	16739036.52	0.000000036	169172366.7
ENVELOPE	Min	-4.567E-10	-144749.7	-1.8E-11	-16851635.1	-3.576E-08	-255231639

Dimension : 250 x 500 mm
Length : 5 dan 6 m
Concrete Quality : f'c = 30 MPa
Reinforcement Quality : fy = 400 MPa
Pedestal Reinforcement :
Above = 6D22
Below = 4D22
Cross bar = 4D10-100
Field Reinforcement :
Above = 2D22 + 1D16
Below = 4D22
Cross bar = 3D10-150

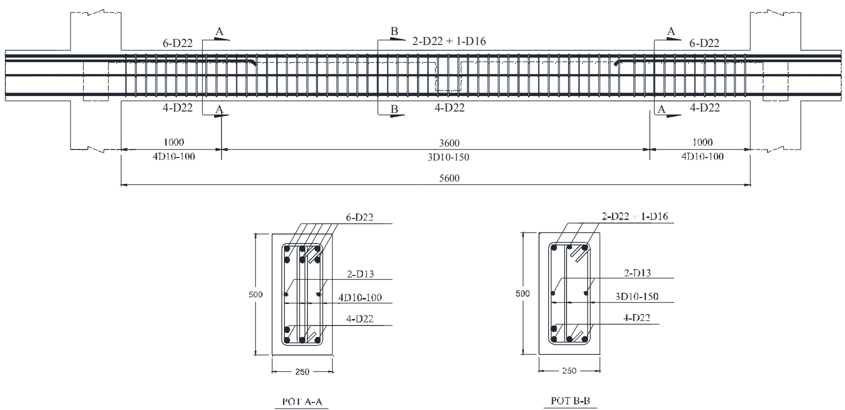


Figure 12. Main Beam Reinforcement

Dimension : 400 x 400 mm

Concrete Quality : f'c= 40 Mpa

Reinforcement Quality : fy 400 MPa

Pedestal Reinforcement: 12D25

: Cross bar = 5D12 - 100

Field Reinforcement : 12D25

: Cross bar = 5D12– 150

Length of connection : 1000 mm

Column Reinforcement

Table 6. Factored Forces on Column (Frame No.26)

TABLE: Element Forces - Frames								
Frame	**Station**	**OutputCase**	**P**	**V2**	**V3**	**T**	**M2**	**M3**
Text	m	Text	Tonf	Tonf	Tonf	Tonf-m	Tonf-m	Tonf-m
26	0	COMB1	-76.49	-0.14	-0.08	0.00	-0.16	-0.29
26	1.5	COMB1	-77.30	-0.14	-0.08	0.00	-0.04	-0.08
26	3	COMB1	-78.10	-0.14	-0.08	0.00	0.07	0.14
26	0	COMB2	-129.80	-0.24	-0.13	0.00	-0.26	-0.49
26	1.5	COMB2	-130.49	-0.24	-0.13	0.00	-0.07	-0.13
26	3	COMB2	-131.18	-0.24	-0.13	0.00	0.12	0.23
26	0	COMB3	-106.01	-1.18	0.67	0.00	0.74	-1.53
26	1.5	COMB3	-106.70	-1.18	0.67	0.00	-0.26	0.23
26	3	COMB3	-107.39	-1.18	0.67	0.00	-1.26	2.00
26	0	COMB4	-49.16	-1.07	0.72	0.00	0.85	-1.32
26	1.5	COMB4	-49.67	-1.07	0.72	0.00	-0.23	0.29
26	3	COMB4	-50.19	-1.07	0.72	0.00	-1.32	1.90
26	0	COMB5	-105.82	-8.50	2.18	0.02	2.54	-9.68
26	1.5	COMB5	-106.51	-8.50	2.18	0.02	-0.72	3.07
26	3	COMB5	-107.20	-8.50	2.18	0.02	-3.99	15.82
26	0	COMB6	-104.05	-2.69	7.64	0.00	9.11	-3.18
26	1.5	COMB6	-104.75	-2.69	7.64	0.00	-2.35	0.85
26	3	COMB6	-105.44	-2.69	7.64	0.00	-13.81	4.88
26	0	COMB7	-49.80	-8.40	2.23	0.02	2.65	-9.47
26	1.5	COMB7	-50.32	-8.40	2.23	0.02	-0.70	3.12
26	3	COMB7	-50.84	-8.40	2.23	0.02	-4.05	15.72
26	0	COMB8	-48.04	-2.58	7.69	0.00	9.22	-2.97
26	1.5	COMB8	-48.56	-2.58	7.69	0.00	-2.32	0.90
26	3	COMB8	-49.07	-2.58	7.69	0.00	-13.86	4.78

Reinforcement Design

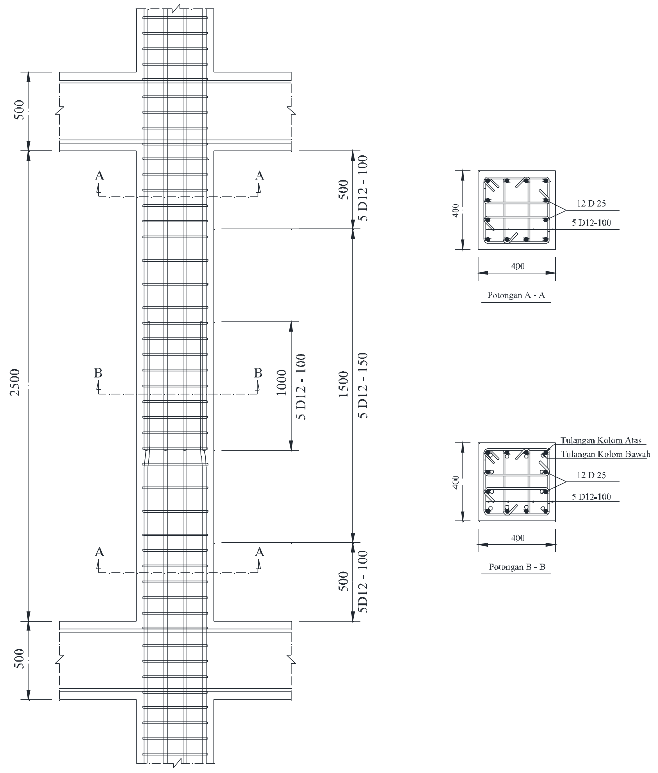


Figure 13. Column Reinforcement Details

Foundation

Foundation is planned to used a pile , because hard soil is located on the 18m depth from the soil surface. Number of piles used 3 pieces. Foundations including the type of "float" because the soil under the foundation as a whole is a soft clay.

Pile cap reinforcement design as shown in Figure 14 below:

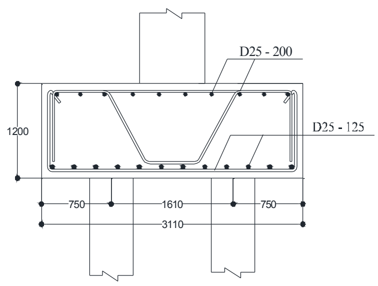


Figure 14. Pile Cap Reinforcement

Tie beam reinforcement design as shown in Figure 15 below:

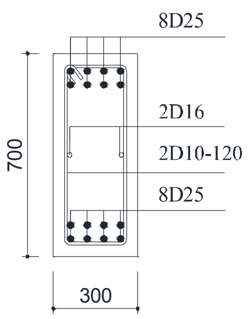


Figure 15. Tie beam reinforcement

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