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Planning Earthquake-Resistant Upper Building Structures With Moment Grabbing Frame System In The Mardhika Park Apartment Building 20 Floors Tambun – Bekasi

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ABSTRACT

Indonesia is an area with a high level of vulnerability to earthquake disasters, where this earthquake has caused a lot of losses and damage to building structures. Therefore, to reduce the risk due to the earthquake, it is necessary to plan earthquake-resistant building structures. The structural planning of building construction is needed to get the most effective and efficient dimensions and configuration of the structure. Collapsed buildings that are not strong enough to withstand lateral loads caused by the earthquake have resulted in significant loss of property and even lives. The purpose of writing this thesis is to design an earthquake-resistant Mardhika Park Apartment Building with a moment-resisting frame system (SRPM) which is planned in accordance with SNI 1726:2019 Earthquake (Earthquake Resistance Planning Procedures for Building and Non-Building Structures), SNI 2847 for Reinforced Concrete: 2019 (Requirements for structural concrete for buildings and their explanations), and the loading in accordance with SNI 1727:2020 for (Minimum Loads for Design of Buildings and Other Structures). The structural design of the Mardhika Park Apartment Building includes the design of this superstructure which includes columns, beams, and floor plates. Then the loads that are reviewed for structural element planning are dead, live, and earthquake loads. To assist in calculating the structure is also used Software "SAP2000 " to facilitate the calculation of the structure.

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1. INTRODUCTION

Population development in Indonesia is considered very fast. The growth rate in Indonesia is quite significant. This means that the need for housing for the increasing population is also increasing. Besides the need for this is increasing, on the other hand, the availability of land for housing or housing is very limited. It is the needs of the population that will demand development in big cities such as Bekasi City to meet the needs for housing for its people [1]. The continuous population growth coupled with immigrants who want to change their fate in big cities has resulted in increasingly limited land in Bekasi City to be used as a place to live.

Bekasi and surrounding areas (Jabodetabek) are earthquake-prone areas. Although this earthquake did not cause any damage, Jakarta residents who live in high-rise buildings and apartments felt a stronger shock [2].

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There have been several times Jakarta and its surroundings have been rocked by earthquakes [3]. This shows that the same disaster can be repeated in Bekasi and its surroundings because the facts prove that the history of earthquakes always repeats itself in a certain period of time. Therefore, high-rise buildings in Bekasi and its surroundings must be built with earthquake-resistant construction to prevent structural failure so that it is expected to minimize the damage that occurs and the loss of life due to the earthquake that occurs [4].

The apartment is a model of residence that only takes up a small part of the space of a building. In addition, apartments are also intended for housing or residence as a solution to the limited residential land in big cities such as Bekasi city. As one of the large densely populated cities with limited residential land. This apartment building is expected to meet the residential needs in the densely populated city of Bekasi with limited residential land.

And to reduce the risk due to the earthquake, it is necessary to plan earthquake-resistant building structures [5]. Mardhika Park Apartment Building 20 Floors, Tambun - Bekasi with a reinforced concrete structure using a structural method in the form of a Special Moment Bearing Frame System (SRPMK) which is planned not only to be adapted to SNI 1726:2019 Earthquake to design buildings that are able to withstand earthquake loads [6]. However, planning is also needed in accordance with the latest existing SNI standards. For the planning of the building using SNI Reinforced Concrete 2847:2019 Requirements for structural concrete for buildings and their explanations [7][8]. And the loading is in accordance with SNI 1727:2020 for the minimum load for the design of buildings and other structures [9][10].

2. METHOD

The data used to plan earthquake-resistant superstructure planning with moment resisting frame system in Mardhika Park Apartment Building 20 Floors, Tambun – Bekasi, namely primary data, and secondary data.

1. Primary Data

Primary data is data obtained from direct observation and research both in the development area and around the construction site, which will later be used as a source in structural design. These data include:

1. Project working drawing
2. Project location point
3. Building data

Figure 1. Project Location

2. Secondary Data

The process of collecting data needed for planning the structure of the building, namely:

A. Literature studies or reference materials used in the completion of this thesis include:

1. SNI 2847-2019, Structural Concrete Requirements for Buildings and Explanation.
2. SNI 1727-2018, Minimum Load for Design of Buildings and Other Structures.

3. SNI 1726-2019, Procedures for Planning Earthquake Resistance for Building and Non-Building
4. Journals and books related to the analysis of the calculation of the structure of high-rise buildings.

B. Selection of Design Criteria

From the data obtained, it will be designed using the Special Moment Resistant Frame System (SRPMK) method, with the earthquake area being zone 4.

- Technical Data:

1. Upper Structure
   a. Plate = K 300
   b. Beam = K 300
   c. Column = K 300
   d. Reinforcement : fy = 240 MPa (Hoop reinforcement)
      fy = 400 MPa (principal reinforcement)
   e. Quality of concrete fc' = 35 Mpa

- Non-Technical Data

Non-technical data is data that functions as support and planning, such as the condition and location of the project location.

1. Project Data
   a. Project Name : Mardhika Apartment Structure Planning Park Tambun - Bekasi
   b. Building Function : Residential
   c. Number of Floors : 20 Floors
   d. Elevation height of each floor:
      - Elevation height of each floor:
        - 1st floor : 3.80 m
        - 2nd floor : 3.60 m
        - Floors 3 to 13 : 3.10 m
        - Stairs Roof Dak : 2.75 m
        - Lift Roof Dak : 4.10 m
      - Building area per floor:
        - 1st floor : 794.45 m2
        - 2nd to 20th floor : 787.17 m2
        - Stairs Roof Dak : 24.50 m2
        - Lift Roof Dak : 19.44 m2

      Total Area : 15,794.62 m2
   e. Location : Jl. Kebon Kelapa No.25, Tambun, Kec.Tambun Sel., Bekasi Regency, West Java
   f. Building Structure : Reinforced Concrete Frame Construction
   g. Roof Structure : Concrete Construction (Dak)
   h. Building Material : Concrete Structure

Plans and Sections Apartment

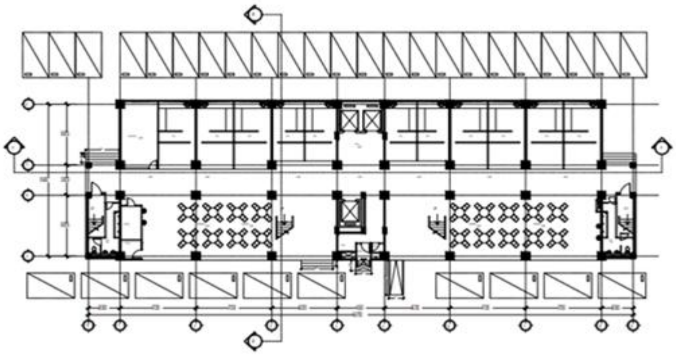


Figure 2. 1st Floor Plan

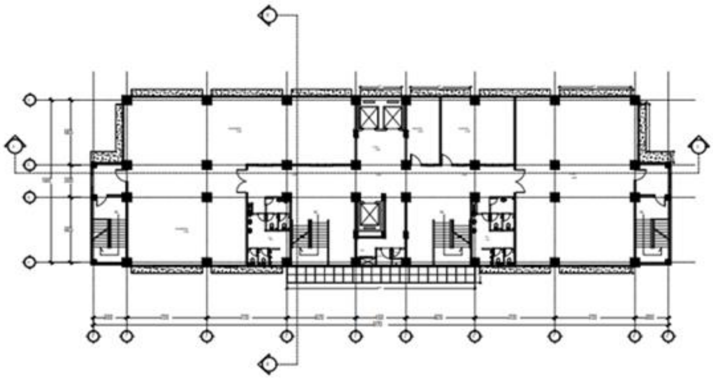


Figure 4. 3rd to 11th Floor Plan

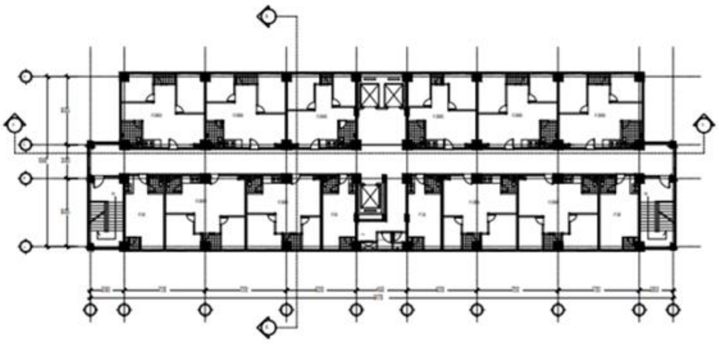


Figure 5. 12th to 20th Floor Plan

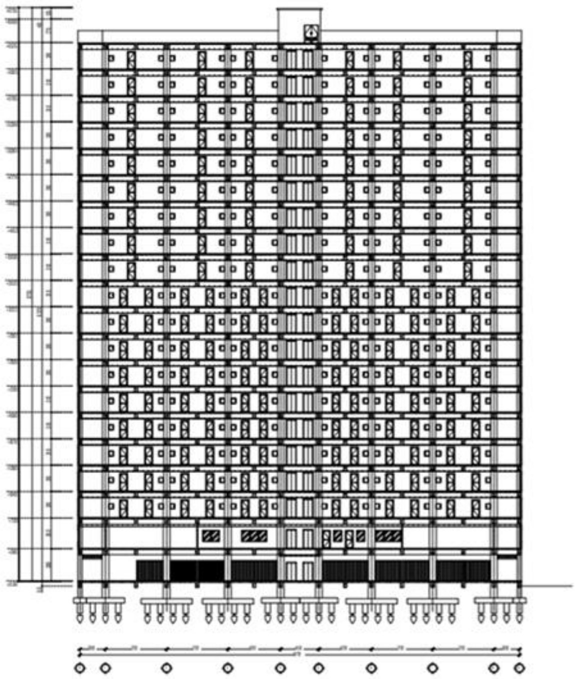


Figure 6. Apartment Section

3. RESULTS AND DISCUSSION

3.1. Preliminary Design

a. Beam Dimension Planning

Table 1. Beam Dimension Planning

Kode	Lb Cm	h min Cm	h cm	b cm	h pakai cm	b pakai cm	Dimensi cm2
BI 1	720	45	43,714	29.142	90	45	45/90
BI 2	450	28,125	27,321	18,214	80	40	40/80
BI 3	605	37.812	36.732	24.488	75	35	35/75
BI 4	605	28.809	27.985	18.656	70	35	35/70
BI 5	605	28.809	27.985	18.656	50	25	25/50

b. Floor Plate Thickness Planning

For plate dimensions from floor 1 to 20, the thickness of the plate for the floor and roof is 150 mm, and for the 21st floor or the roof of stairs and lifts using a 100 mm plate.

c. Column Dimension Planning

In SNI 2847:2019 article 18.7.2.1 that the smallest cross-sectional size should not be less than 300 mm and the ratio between the smallest cross-sectional size to the size in the perpendicular direction should not be less than 0.4.

- Kolom K1 : (900 x 900)
  900/900 : 1 > 0.4 (OK)
- Kolom K2 : (800 x 800)
  800/800 : 1 > 0.4 (OK)
- Kolom K3 : (750 x 750)
  750/750 : 1 > 0.4 (OK)
- Kolom K4 : (650 x 650)
  650/650 : 1 > 0.4 (OK)

3.2. Structure Modeling

Input material data based on the planned quality, namely fc' = 40 Mpa and for the quality of the main reinforcing steel it is planned to be fy = 400 Mpa, and for the quality of the stirrup reinforcing steel it is planned to be fy = 240 MPa

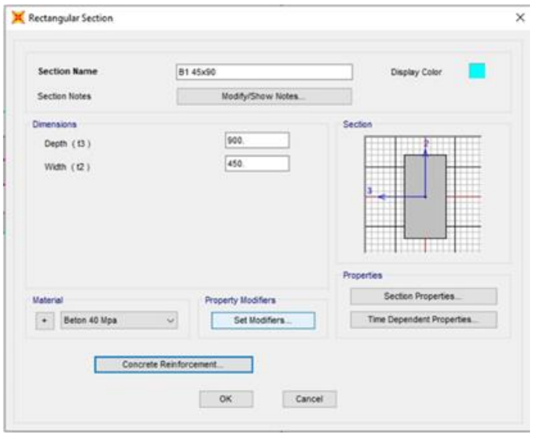
(a)

(b)

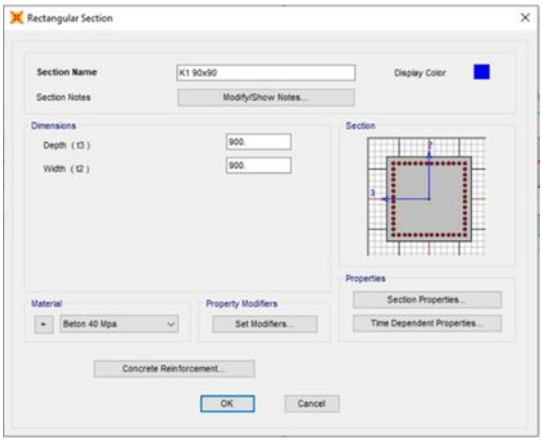
(c)

Figure 7. Input concrete quality data (a) Fc 40 MPa, (b) fy = 400 Mpa, (c) fy = 240 Mpa

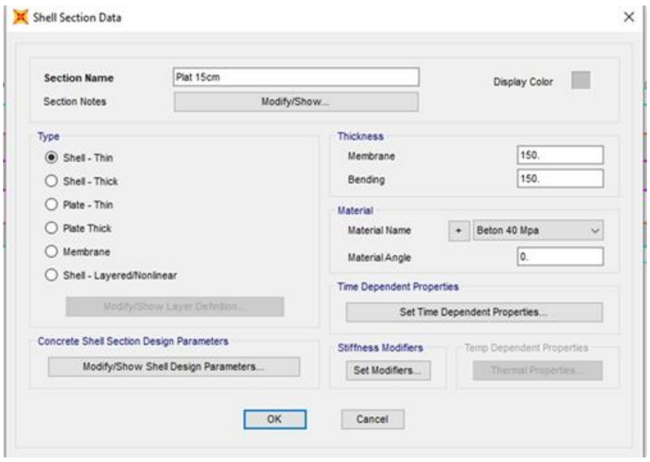
Enter the dimensions of the beam, column and floor slab based on the preliminary design that has been done.



(a)



(b)



(c)

Figure 8. dimensions of the beam (a) 450x900, column (b) 900x900 and floor slab (c) 150m

After defining the dimensions of the columns, beams, floor slabs, then a drawing is carried out based on the grids that have been made.

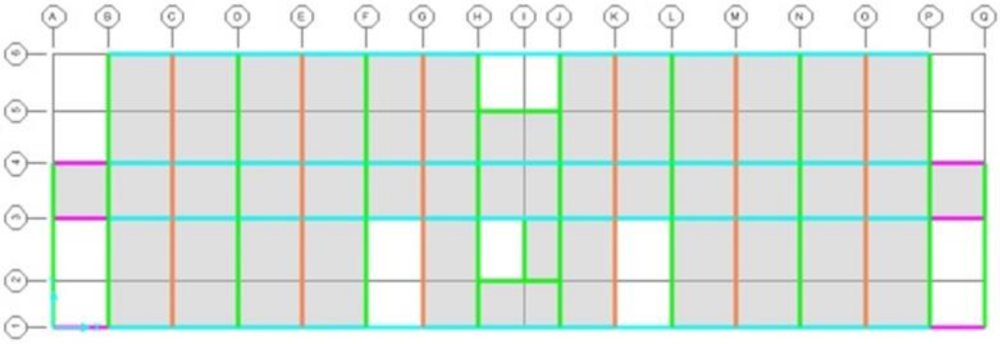


Figure 9. View X-Y Axis Building Structure Modeling

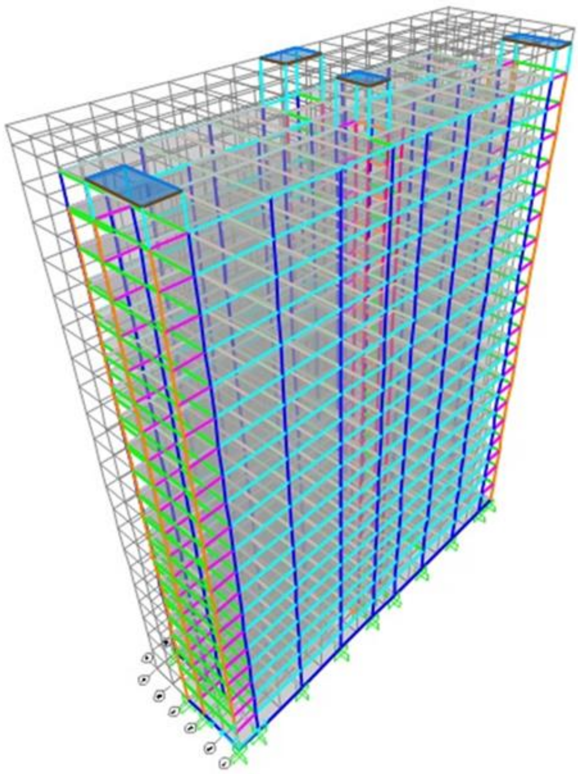


Figure 10. View 3D Building Structure Modeling

3.3. Burden

Types of loads acting on buildings include:

a. **Self-dead load of structural elements (Dead Load)**

The self-weight of the structural elements (self-weight) consisting of columns, beams and plates has been calculated automatically in SAP2000 by providing a self-weight multiplier equal to 1.

b. **Additional element dead load (Super Dead Load)**

1. **Additional dead load on Floor Slab**

Dead loads acting on floor slabs include:

- Weight of sand 1cm thick = 0.01 x 16 = 0.16 kN/m2
- Specific weight 3cm thick = 0.03 x 22 = 0.66 kN/m2
- Weight of 1 cm thick ceramic = 0.01 x 22 = 0.22 kN/m2
- Ceiling and hanging weight = 0.2 kN/m2
- ME Installation Weight = 0.25 kN/m2

Total dead load on floor slab = 1.49 kN/m2

2. **Additional dead load on roof slab**

Dead loads acting on the roof slab include:

- Weight of waterproofing with a thickness of 2cm = 0.02 x 14 = 0.28kN/m2
- Ceiling and hanging weight = 02 kN/m2
- ME Installation Weight = 0.25 kN/m2

Total dead load on the roof slab = 0.73 kN/m2

3. **Additional dead load on beam**

Dead loads acting on beams include:

- 1st floor wall load (3.8m -0.8) x 2.5 = 7.50 kN/m2
- Floor load 2 (3.6m -0.8) x 2.5 = 7.00kN/m2
- Floor load 3-20 (3.1m -0.8) x 2.5 = 5.75 kN/m2
- Top wall load (2.75m -0.5) x 2.5 = 5.625 kN/m2
- Top wall load (4.1 m -0.5) x 2.5 = 9.00 kN/m2

c. **Live Load (Live Load)**

The amount of live load on the floor of the building is determined based on the reference to SNI 1727 – 2020.

- Lt.1 live load (Restaurant Area) = 4.75 kN/m2
- Living expenses 2nd floor (Education + Clinic) = 3.84 kN/m2
  (1.92kN/m2 + 1.92 kN/m2)
- Living load Lt.3 - 20 (Bedroom) = 1.92 kN/m2
- Live load on top floor (flat roof) = 0.96 kN/m2
- Live load Lt. not roof stairs & elevator = 0.96 kN/m2

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Table 2. Overall load per floor

BERAT STRUKTUR GEDUNG APARTEMENT								
Lantai	Berat Sendiri	Beban Mati Tambahan (Plat)	Beban Mati Tambahan (Balok)	Beban Hidup	Beban Hidup Tereduksi (30%)	Beban Total	Volume	
							Luas Plat Lantai	Panjang Dinding
	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	m2	m2
Lantai 1	8379.66	1022.60	1488.4785	3287.41	986.22	11876.96	686.31	198.4638
Lantai 2	8596.12	1085.61	138.92466	2797.81	839.34	10659.99	728.60	198.4638
Lantai 3	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 4	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 5	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 6	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 7	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 8	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 9	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 10	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 11	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 12	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 13	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 14	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 15	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 16	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 17	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 18	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 19	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai 20	8309.92	1085.61	1407.62415	1398.90	419.67	11222.82	728.60	244.8042
Lantai Dak Atas	6400.35	1085.61	208.564875	699.45	209.84	7904.36	728.60	37.0782
Lantai Dak Atap Tangga dan Lift	332.47	86.69	229.3326	55.86	16.76	665.26	58.18	25.4814
Beban Total	173287.19	50223.97		9606.24		233117.40		

d. **Response Spectrum**

In determining KDS, what we need to know is the value of the acceleration of the short response spectrum (Ss) and the speed of acceleration of the response spectrum of 1 second (S1). The values of Ss and S1 can be seen on the response map of the SNI 1726:2019 spectra. However, to get more accurate Ss and S1 values, the author uses an auxiliary program, namely the Indonesia Earthquake Map Spectra Response Program 2019.

And the results obtained are:

- City Name : Tambun (C)
- Longitude : 107.0616 Degrees
- Latitude / Latitude : -6.2641 Degrees
- Site Class : Elementary School - Medium Ground
- PGA : 0.376025 g

- PGAm : 0.460245 g
- CRs : 0.000000
- CR1 : 0.000000
- Ss : 0.797222 g
- S1 : 0.378157 g
- TL : 20000000 seconds
- Fa : 1.181111
- Fv : 1.921843
- SMS : 0.941607 g
- Sm1 : 0.726758 g
- SD : 0.627738 g
- SD1 : 0.484505 g
- T0 : 0.154365 seconds
- Ts : 0.771827 seconds

The results of the Bekasi City Earthquake Design Response Spectrum can be seen in the graph below:

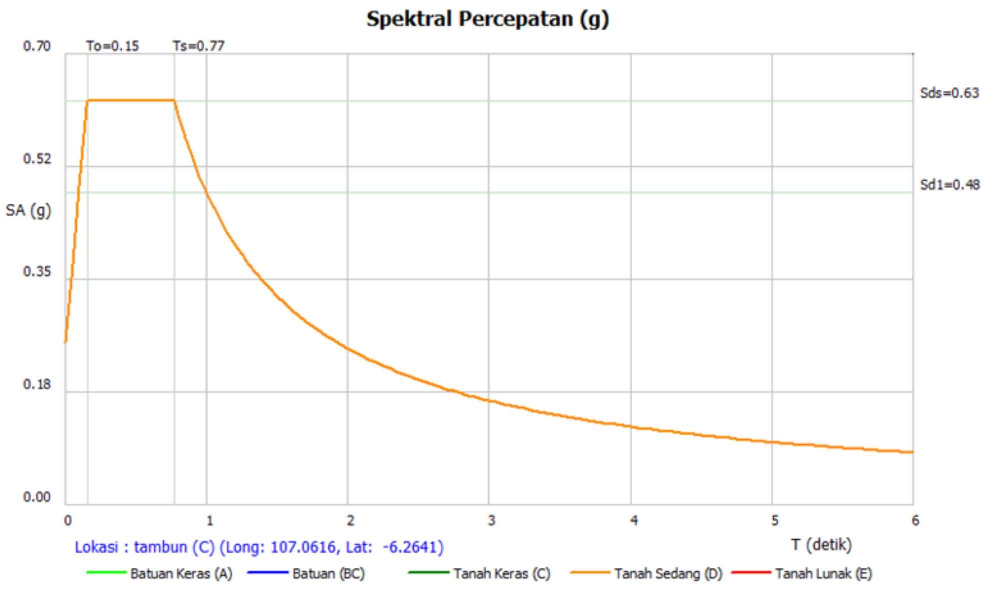
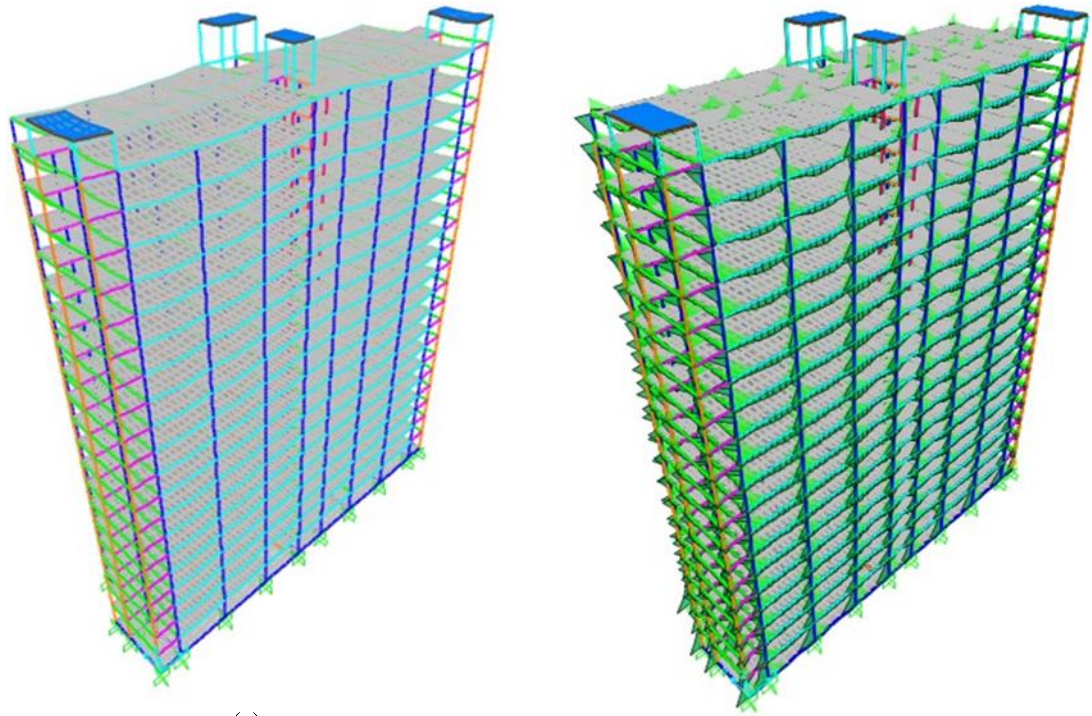


Figure 11. Graph of Medium Soil Spectrum Response

3.4. Structural Analysis

Structural analysis was carried out after entering all dead loads, live loads and earthquake loads into the SAP2000 modeling and loading combinations based on SNI 1726:2019. Then the results of the Structural Analysis are obtained as follows:



(a) (b)

Figure 12. Modeling after Run in SAP2000 (a), Moment structure after Run in SAP2000 (b)

3.4.1. Moments and Forces on Beams

The moments and forces acting on each beam are positive design moments due to factored loads (Mu+), negative design moments due to factored loads (Mu-), and design shear forces due to factored loads (Vu).

1. Beam B1 450 x 900

Element Force – Frames Balok B1 450 x 900			
Frame	Step Type	V2	M3
Text	Text	kN	kN/m
11	Max	366.612	376.310
656	Min	-217.122	-581.667

Plan B1 Shear Moment and Force
Moment (Mu +) = 376.31 KN/m
Moment (Mu -) = -581.67 KN/m

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2. Shear Force (Vu) = 366.61 KN

Element Force – Frames Balok B2 400 x 800			
Frame	Step Type	V2	M3
Text	Text	kN	kN/m
276	Max	319.532	325.127
453	Min	-232.334	-345.72

Plan B2 Shear Moments and Forces
Moment (Mu +) = 325.127 KN/m
Moment (Mu -) = -345.72 KN/m
Shear Force (Vu) = 319.53 KN

3. Beam B2 400x 800

Element Force – Frames Balok B3 350 x 750			
Frame	Step Type	V2	M3
Text	Text	kN	kN/m
606	Max	260.741	367.423
606	Min	-284.03	-401.409

B3 Planned Shear Moment and Force
Moment (Mu +) = 367,423 KN/m
Moment (Mu -) = -401.409 KN/m
Shear Force (Vu) = 260,741 KN

4. Beam B4 300x 700

Element Force – Frames Balok B4 350 x 700			
Frame	Step Type	V2	M3
Text	Text	kN	kN/m
544	Max	163.465	231.824
633	Min	-180.414	-274.167

Momen dan Gaya Geser Rencana B4
Momen (Mu +) = 231.824 KN/m
Momen (Mu -) = -274.167 KN/m
Gaya Geser (Vu) = 163.465 KN

5. Beam B5 250 x 500

Element Force – Frames Balok B5 250 x 500			
Frame	Step Type	V2	M3
Text	Text	kN	kN/m
1891	Max	2.004	22.405
1894	Min	9.356	-46.661

B4 Planned Shear Moment and Force
Moment (Mu +) = 231,824 KN/m
Moment (Mu -) = -274.167 KN/m
Shear Force (Vu = 163.465 KN

3.4.2. Moments and Forces on Columns

The moments and forces acting on each column are positive design moments due to factored loads (Mu+), and negative design moments due to factored loads (Mu-).

1. Column K1 900 x 900

Aksial - Lentur			
Kondisi	**P (kN)**	**M2 (kN-m)**	**M3 (kN-m)**
P max	355.522	61.143	125.534
P min	-11518.083	-708.114	-558.724
M2 Max	-2059.127	712.805	615.885
M2 Min	-8904.410	-713.209	-546.056
M3 Max	-1664.438	650.189	624.499
M3 Min	-7942.474	-660.098	-627.786

Geser	
Tumpuan	
V2 (kN)	290.479
V3 (kN)	244.062
Lapangan	
V2 (kN)	290.479
V3 (kN)	244.062

Gaya Tekan Terkecil	
Nu (kN)	0.01

2. Column K2 800 x 800

Aksial - Lentur			
Kondisi	**P (kN)**	**M2 (kN-m)**	**M3 (kN-m)**
P max	145.997	15.887	26.277
P min	-6600.574	-389.012	-353.353
M2 Max	-275.339	468.132	353.111
M2 Min	-6593.107	-457.213	-344.101
M3 Max	105.139	441.757	357.153
M3 Min	-6425.323	-368.349	-356.666

Geser	
Tumpuan	
V2 (kN)	117.035
V3 (kN)	177.288
Lapangan	
V2 (kN)	117.035
V3 (kN)	177.288

Gaya Tekan Terkecil	
Nu (kN)	0.01

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3. Column K3 700 x 700

Aksial - Lentur			
Kondisi	P (kN)	M2 (kN-m)	M3 (kN-m)
P max	4.323	44.376	54.721
P min	-5299.452	-355.674	-268.227
M2 Max	-1093.042	372.718	141.572
M2 Min	-5248.219	-360.192	-278.244
M3 Max	-1694.672	216.975	409.002
M3 Min	-4208.798	-214.204	-409.766

Geser	
Tumpuan	
V2 (kN)	198.143
V3 (kN)	216.298
Lapangan	
V2 (kN)	198.143
V3 (kN)	216.298

Gaya Tekan Terkecil	
Nu (kN)	0.01

4. Column K4 650 x 650

Aksial - Lentur			
Kondisi	P (kN)	M2 (kN-m)	M3 (kN-m)
P max	3.489	13.483	5.199
P min	-98.833	7.150	13.112
M2 Max	-25.939	36.825	98.550
M2 Min	-61.109	-49.986	-37.126
M3 Max	-25.939	36.825	98.550
M3 Min	-65.175	10.750	-97.743

Geser	
Tumpuan	
V2 (kN)	38.898
V3 (kN)	24.607
Lapangan	
V2 (kN)	38.898
V3 (kN)	24.607

Gaya Tekan Terkecil	
Nu (kN)	0.01

3.4.3. Calculation of Floor Plate Reinforcement

1. Strength Need

Longest span	Iy	=	6050	mm
Shortest span	Ix	=	3600	mm
Full clamped plate condition,	Iy/Ix	=	1.7	
From the plate table (PBI 1971) obtained:	Clx	=	37	
	Cly	=	16	
	Ctx	=	79	
	Cty	=	5	

2. Momen perlu :

- Field Direction x	Mu lx	=	0,001.Clx.qu. Lx^2	=	4031804.16 N.mm
- Field Direction y	Mu ly	=	0,001.Cly.qu. Lx^2	=	1743482.88 N.mm
- Direction x	Mu tx	=	0,001.Ctx.qu. Lx^2	=	8608446.72 N.mm
- Direction y	Mu ty	=	0,001.Cty.qu. Lx^2	=	6211157.76 N.mm

3. Design Power

Is known :

- Concrete Quality	Fc'	=	40 MPa
- Steel Quality	fy	=	400 MPa
- Blanket Thickness	sn	=	20 mm
- Plate Thickness		=	150 mm
- Plate Width	b	=	1000 mm

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4. Shortest Span [Lx]

Ultimate Moment	Mu lx	=	4031804.16 N.mm
Diameter of reinforcement used	D	=	10 mm
The distance between the x-direction of the main reinforcement to the tensile fiber	ds	=	25 mm
Effective height of plate	d	=	125 mm
Strength reduction factor	Φ	=	0.9

5. Longest Spread [Ly]

Ultimate Moment	Mu lx	=	1743483 N.mm
Diameter of reinforcement used	D	=	10 mm
The distance between the x-direction of the main reinforcement to the tensile fiber	ds	=	35 mm
Effective height of plate	d	=	115 mm
Strength reduction factor	Φ	=	0.9

	Short Spans [LX]	**Long Span [Ly]**
Field	D10 - 250	D10 - 250
Pedestal	D10 - 250	D10 - 250

4. CONCLUSION

Based on the results of the planning of the Mardhika Park Apartment Building Structure 20 Floors, Tambun – Bekasi. by using the Special Moment Bearing Frame System (SRPMK) based on SNI 1726:2019, SNI 1727:2018, and SNI 2847:2019 using the SAP2000 program and structural components designed on beams and columns, the following conclusions can be drawn:

1. The structure is planned as a Special Moment Bearing Frame System (SRPMK), with the following values:
   - R (response modification coefficient) : 8
   - 0 (strong factor over system) : 3
   - Cd (strong factor over system) : 5.5

2. On a beam with dimensions of 45/90 obtained:
   - Left Support Reinforcement : Pull – 22D25, Push – 20D25
   - Field Reinforcement : Tensile – 20D25, Push – 18D25
   - Right Support Reinforcement : Pull – 22D25, Push – 20D25
   - Shear Reinforcement :

   - Left Joint
   - Plastic Joint Area : 13 – 50 mm
   - Plastic Joint Outer Area : 13 – 85 mm

   - Right Joint
   - Plastic Joint Area : 13 – 50 mm
   - Plastic Joint Outer Area : 13 – 85 mm
3. On a beam with dimensions of 40/80 obtained:
   - Left Support Reinforcement : Pull – 18D25, Push – 16D25
   - Field Reinforcement : Tensile – 16D25, Push – 16D25
   - Right Support Reinforcement : Pull – 18D25, Push – 16D25
   - Shear Reinforcement :

   - Left Joint
   - Plastic Joint Area : 13 – 50 mm

- Plastic Joint Outer Area : 13 – 85 mm
- Right Joint
- Plastic Joint Area : 13 – 50 mm
- Plastic Joint Outer Area : 13 – 85 mm

4. On a beam with dimensions of 35/75 obtained:
   - Left Support Reinforcement : Pull – 15D25, Push – 14D25
   - Field Reinforcement : Tensile – 14D25, Push – 14D25
   - Right Support Reinforcement : Pull – 15D25, Push – 14D25
   - Shear Reinforcement :
   - Left Joint
   - Plastic Joint Area : 13 – 50 mm
   - Plastic Joint Outer Area : 13 – 85 mm
   - Right Joint
   - Plastic Joint Area : 13 – 50 mm
   - Plastic Joint Outer Area : 13 – 85 mm
5. On a beam with dimensions of 35/70 obtained:
   - Left Support Reinforcement : Pull – 14D25, Push – 13D25
   - Field Reinforcement : Tensile – 13D25, Push – 13D25
   - Right Support Reinforcement : Pull – 14D25, Push – 13D25
   - Shear Reinforcement :
   - Left Joint
   - Plastic Joint Area : 13 – 50 mm
   - Plastic Joint Outer Area : 13 – 85 mm
   - Right Joint
   - Plastic Joint Area : 13 – 50 mm
   - Plastic Joint Outer Area : 13 – 85 mm
6. On a beam with dimensions of 25/50 obtained:
   - Left Support Reinforcement : Pull – 13D25, Push – 12D25
   - Field Reinforcement : Tensile – 12D25, Push – 12D25
   - Right Support Reinforcement : Pull – 13D25, Push – 12D25
   - Shear Reinforcement :
   - Left Joint
   - Plastic Joint Area : 13 – 50 mm
   - Plastic Joint Outer Area : 13 – 85 mm
   - Right Joint
   - Plastic Joint Area : 13 – 50 mm
   - Plastic Joint Outer Area : 13 – 85 mm
7. In a column with dimensions of 900/900 and the amount of reinforcement 16D25, the shear reinforcement is obtained:
   - Plastic Joint Area : 13 – 100 mm
   - Joint Area : 13 – 90 mm
   - Plastic Joint Outer Area : 13 – 150 mm
8. In a column with dimensions of 800/800 and the amount of reinforcement 13D25, the shear reinforcement is obtained:
   - Plastic Joint Area : 13 – 100 mm
   - Joint Area : 13 – 90 mm
   - Plastic Joint Outer Area : 13 – 150 mm
9. In a column with dimensions of 700/700 and the amount of reinforcement 13D25, the shear reinforcement is obtained:
   - Plastic Joint Area : 13 – 100 mm

• Joint Area : 13 – 90 mm
• Plastic Joint Outer Area : 13 – 150 mm

10. In a column with dimensions of 650/650 and the amount of reinforcement 13D25, the shear reinforcement is obtained:
    • Plastic Joint Area : 13 – 100 mm
    • Joint Area : 13 – 90 mm
    • Plastic Joint Outer Area : 13 – 150 mm
11. In the capacity design planning, the column has met the concept of "Strong Column Weak Beam". At joints as follows:
    1,373,307,000.00 Nmm > 10,251,066.67 Nmm.
12. In the beam-column connection, horizontal restraints are installed 12 and for vertical restraints use column longitudinal reinforcement

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