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Planning Parking Building Using Flat Slab and Drop Panel as a Replacement Conventional Beam with Analyzing Bending Moment Value & Sliding Style Based On SNI 1726-2012

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Abstract

The construction of a 5-stored parking building is planned to use a flat slab (with drop panels). Flat slab (with drop panel) is a type of two-way plate without beams that directly rests on the column. the flat slab can reduce the height of the structure and construction time. However, flat slabs require plates that are thicker than usual to overcome deflection and punching shears. In this final project, a 5-story reinforced concrete structure will be reviewed with a span of 8 x 8.3 m. Analysis and design was carried out with the help of the 2016 ETABS program to find the value of intersection between floors, shear moments and forces taking into account the consequences of dead load, super dead load, life, and earthquake (dynamic)
Keyword: flat slab, drop panel, parking building, planning

1. Introduction

In developing countries like Indonesia, especially in Jakarta with very high mobility, the use of vehicles is very much needed starting from private and public vehicles. At present, the use of private vehicles is still in demand by some people on a more flexible basis because they can walk at any time without having to wait like public transportation. Then the ratio is not balanced between the increasing population of vehicles with available parking space, given that the vacant land in Jakarta is decreasing because it is used for residential and office space, which sometimes has insufficient parking space. So one solution is to build a multi-storey parking building so that it can accommodate a large number of vehicles. In this parking building there are elements consisting of columns, flat slabs with drop panels. All elements are made of reinforced concrete. Reinforced concrete is a concrete reinforced with an area and the number of reinforcement that is not less than the minimum value required with or without prestressing, and is planned based on the assumption that the two materials work together in bearing forces. Flat slabs are thick, evenly thick concrete slabs that transfer loads directly to supporting columns without the help of beams (McCormac, 2000). Drop panel is an increase in the thickness of the plate in the column area that serves to reduce the shear stress caused by the column against the plate. The use of flat slabs with this drop panel system will increase the magnitude of the moment of resistance in places where the negative moments are (More and sawant, 2015). The use of flat slab with this drop panel system will increase the strength of the plate against shear and flexural force and can withstand heavy loads and longer spans.

While the purpose of this research is:

1) Find out how many intersections between floors of the building design
2) Knowing the number of bending moments and shear forces of the building design

2. Research methods

Using analysis methods in structural modeling using the 2016 ETABS program to find the value of bending moment and shear force by referring to applicable regulations such as SNI 1726-2012, SNI 1727-2013, SNI 2847-2013. The flowchart of the study in this study is as follows:

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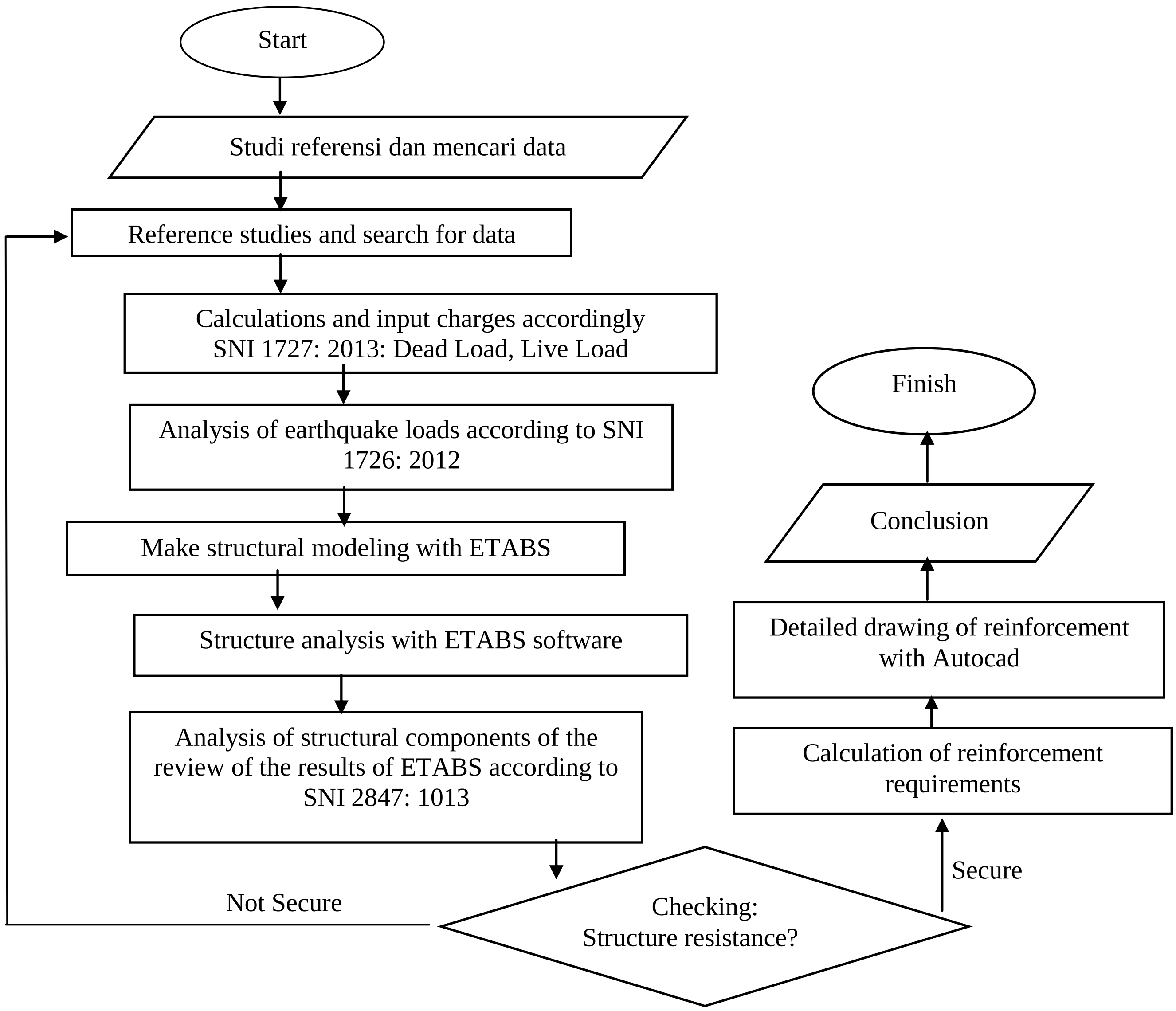

Figure 1. Research Flowchart

3. Result and Discussion

Research Analysis Stage

1. Geometry Structure :
   - ✓ Building function : Parking building
   - ✓ Number of floors : 5 floors (split level)
   - ✓ Height per floor : 3m
   - ✓ Soil type : Medium soil (SD)
2. Material Quality :
   - ✓ Reinforced concrete, f'c 35MPa for flat slabs, drop panels, beams and f'c 45MPa for columns
   - ✓ Reinforcing steel, Ø8, Ø10, Ø12 mm plain reinforcement BJTP-24 with 240 MPa fy. D10, D13, D16, D19, D22, D25 mm BJTD-40 screw reinforcement with fy 400 MPa. And the specific gravity of the iron used is 7850 Kg/ m^3
3. Existing Dimensions :
   - ✓ For Beam B1(300x500), column K1 (1200x1200) dan K2 (900x900)
4. Loading :

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- ✓ Dead load, self weight of its structure (calculated automatically by Etabs)
- ✓ Gravitasi Gravity load is divided into two, namely dead load (instalation ME = 0,25 kN/m^2 & waterproofing with asphalt = 0,28 kN/m^2) and live load (for parking is set 2 kN/m^2)
- ✓ Gravitasi The gravity load on the slap parapet area is equal to 21,6 kN/m^2

5. Premlimenary plates :

- ✓ Flat slab :
  - Thickness of directional plates Y, L=9000mm (the longest size)
    Clean plate length = > 9000 – 600 = 8400mm
    For external panels, a minimum thickness of plates => 8400 / 33 = 254,54mm
    For panels in a minimum thickness of plates => 8400 / 36 = 233,3mm
    The thickness of the plate to be used 260mm
  - Thickness of directional plates X, L=8000mm (the longest size)
    Clean plate length = > 8000 – 600 = 7400mm
    For external panels, a minimum thickness of plates => 7400 / 33 = 224,24mm
    For panels in a minimum thickness of plates => 7400 / 36 = 205,5mm
    The thickness of the plate to be used 230mm
    From the 2 directions Y and X, the largest value is taken 260mm
  - Thickness *drop panel* => 260 / 4 = 65. Then 260mm + 65mm = 325mm
  - Determine the extension of the area of the panel drop area with the longest formula L between columns divided by 6.

6. Earthquake load (E) - elastic earthquake response :

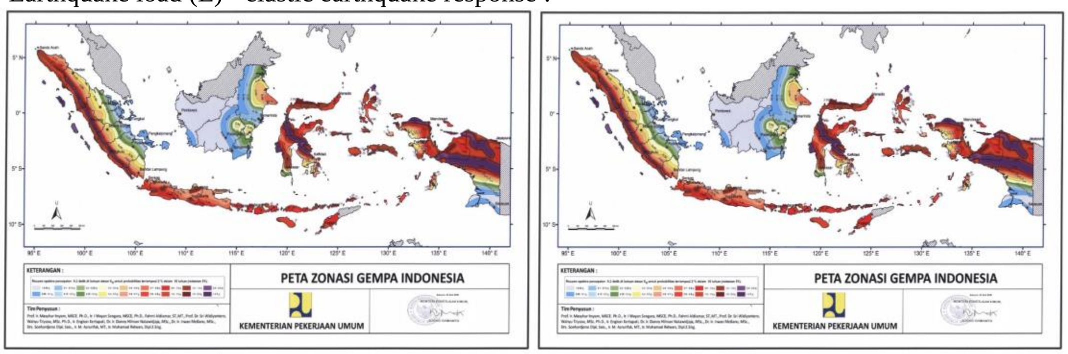

Figure 2. Indonesian Earthquake Map Zone (Ss) & (Sc)
(Source: Puskim.pu.go.id)

- ✓ From the Puskim the following data are obtained :

S_s	0,669	F_a	1,265	S_{DS}	0,564g
S_1	0,295	F_y	1,811	S_{D1}	0,356g

- ✓ The design category is determined by value S_{DS} dan S_{D1} that is type D
- ✓ Vibration period , T_0 = 0,126 dt dan T_s = 0,631 dt

7. Design calculation

- ✓ The value of the fundamental period => T_a = 0,533 second & T_{maks} = 0,746 second
- ✓ Periode The period value of Etabs => T_x = 0,708 second & T_y = 0,659 second (OK)
- ✓ Seismic response coefficient values => $C_{s\text{-}x}$ = 0,0785 & $C_{s\text{-}y}$ = 0,0844
- ✓ The weight value of the building structure => 70389,82 kN
- ✓ Value of basic seismic shear forces => $V_{s\text{-}x}$ = 5525,6 kN & $V_{s\text{-}y}$ = 5940,9 kN
- ✓ Exponent value (k) => T_x = 1,104 & T_y = 1,07
- ✓ Lateral earthquake force values => F_x = 5525,6 kN & F_y = 5940,9 kN
- ✓ Selection of types => 4,9 % entered into CQC
- ✓ Basic shear force scale => E_x = 1594,897 & E_y =1678,047
- ✓ Intersection between floors due to earthquake loads X and Y

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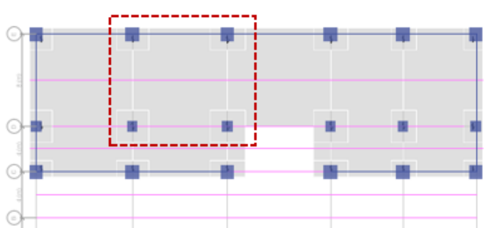
Floor	h	X-Dir	Y-Dir	Δ_{izin}= 0,015h	Check	
	(mm)	(mm)	(mm)	(mm)	X-Dir	Y-Dir
P5A	15000	0,256	0,027	22,5	OK	OK
P5	13500	0,223	0,009	22,5	OK	OK
P4A	12000	0,19	0,02	22,5	OK	OK
P4	10500	0,157	0,007	22,5	OK	OK
P3A	9000	0,124	0,014	22,5	OK	OK
P3	7500	0,093	0,004	22,5	OK	OK
P2A	6000	0,064	0,007	22,5	OK	OK
P2	4500	0,039	0,002	22,5	OK	OK
P1A	3000	0,019	0,002	22,5	OK	OK
P1	1500	0,005	0,000248	22,5	OK	OK
Base	0	0	0	0		

✓ Output shear and moment values

Lantai	V maks	V min
Base		
P1	472,05	-1109,658
P1A	476,713	-1043,016
P2	835,537	-1261,551
P2A	858,514	-1316,273
P3	789,126	-1324,012
P3A	887,051	-1384,624
P4	802,956	-1327,791
P4A	871,651	-1358,133
P5	764,171	-1332,95
P5A	853,337	-1276,898

Lantai	Arah X		Arah Y	
	M max	M min	M max	M min
Base				
P1	80,307	-489,473	79,73	-580,26
P1A	235,517	-530,764	247,289	-630,154
P2	190,708	-551,333	256,59	-659,61
P2A	319,738	-578,021	282,405	-686,357
P3	236,877	-575,467	326,877	-692,452
P3A	328,285	-588,671	328,179	-702,975
P4	50,336	-578,859	328,47	-694,669
P4A	324,552	-585,06	323,885	-695,009
P5	49,887	-564,647	324,31	-697,134
P5A	261,125	-567,894	283,987	-693,891

✓ *The reviewed flat slab area and the moment of etabs*



Arah X (memendek)			
Lajur kolom		Lajur Tengah	
Tumpuan	Lapangan	Tumpuan	Lapangan
-312,855	-15,657	13,235	12,521
Arah Y (memanjang)			
Lajur kolom		Lajur Tengah	
Tumpuan	Lapangan	Tumpuan	Lapangan
-319,506	-3,536	16,546	28,3

✓ Reinforcement calculation steps

- 1-way slide check for critical cross sections A-A (X)

Vu = 312,855 kN = 31,9 ton

$\emptyset Vc = 0{,}75 \times \sqrt{\frac{f'c}{6}} \times b \times d$

$\emptyset Vc = 0{,}75 \times \sqrt{\frac{35}{6}} \times 8 \times 0{,}233 = 137{,}84$ ton

Vu < ∅Vc (OK)

- 1-way slide check for critical cross sections B-B (Y)
  Vu = 319,506 kN = 32,58 ton
  $\emptyset Vc = 0,75 \text{ x } \sqrt{\frac{f'c}{6}} \text{ x b x d}$
  $\emptyset Vc = 0,75 \text{ x } \sqrt{\frac{35}{6}} \text{ x } 8,3 \text{ x } 0,233 = 143,01 \text{ ton}$
  Vu < ∅Vc (OK)
- Check 2-way slide
  Vu = 319,506 kN = 32,58 ton
  Bc = 900/900 = 1
  as = 40
  b_o = 2 x (1016,75 + 1016,75) = 4067mm = 4,067m
  $V_{c(a)} = \frac{1}{6} \text{ x } (1 + \frac{2}{Bc}) \text{ x } \sqrt{f'c} \text{ x } b_o \text{ x d}$
  $= \frac{1}{6} \text{ x } (1 + \frac{2}{1}) \text{ x } \sqrt{35} \text{ x } 4,067 \text{ x } 0,233 = 2,8 = 280 \text{ ton}$
  $V_{c(b)} = (\frac{as \ x \ d}{12bo} + \frac{1}{6}) \text{ x } \sqrt{f'c} \text{ x } b_o \text{ x d}$
  $= (\frac{40 \ x \ 0,233}{12 \ x \ 4,067} + \frac{1}{6}) \text{ x } \sqrt{35} \text{ x } 4,067 \text{ x } 0,233 = 2,0049 = 200 \text{ ton}$
  $V_{c(c)} = \frac{1}{3} \text{ x } \sqrt{f'c} \text{ x } b_o \text{ x d} = \frac{1}{3} \text{ x } \sqrt{35} \text{ x } 4,067 \text{ x } 0,233 = 1,86 = 186 \text{ ton}$
  Take the smallest Vc value, such that
  $\emptyset Vc$ = 0,75 x 186 = 139,5 ton
  Then , Vu = 32,58 ton < $\emptyset Vc$ = 139,5 ton , the plate shear capacity is sufficient to carry two-way shear
- Calculate the effective height of a floor plate (d)
  Concrete blanket for floor plates 20mm (t_s)
  Principal reinforcement used D13mm
  d = h – t_s – 0,5 x D
  = 260 – 20 – 0,5 x 13 = 233,5mm (long direction)
  d = h – t_s – D - 0,5 x D
  = 260 – 20 – 13 - 0,5 x 13 = 220,5mm (short direction)
- Calculate the value β_1
  For f'c ≤ 30 MPa, β_1 = 0,85
  For f'c 30 < f'c < 55 MPa, β_1 = 0,85 – 0,008 (f'c – 30)
  For f'c > 55 Mpa, β_1 = 0,65
  Then,
  f'c 35 MPa, β_1 = 0,85 – 0,008 (35 – 30) = 0,81
  $$\rho_b = \frac{0.85 x \beta x f'c}{fy}\left(\frac{600}{600+fy}\right) = \frac{0,85x0,81x35}{400}\left(\frac{600}{600+400}\right) = 0,0361$$
- *Calculate the amount of the minimum and maximum reinforcement ratio*
  ρ_g = 0,0018 (bersumber SNI 2847:2013 pasal 7.12.2.1)
  $\rho_{maks} = 0,75 \ x \ p_b = 0,75 \ x \ 0,0361 = 0,027$
- Calculating the reinforcement of the column shortening direction (pedestal)
  Calculation of the principal reinforcement in the column lane area uses reinforcement D 13 mm.
  M_o = 312,855 kNm
  $$M_n = \left(\frac{M_o}{\varphi}\right) = \left(\frac{312,855}{0.9}\right) = 347,62 \text{ kNm}$$
  $$R_n = \left(\frac{M_n}{bxd^2}\right) = \left(\frac{347610000}{1000x\,220,5^2}\right) = 7,15$$
  $$m = \left(\frac{fy}{0,85xf'c}\right) = \left(\frac{400}{0,85x35}\right) = 13,45$$
  Reinforcement ratio

$$\rho = \frac{1}{m}\left[1 - \sqrt{1 - \frac{2(m)(R_n)}{fy}}\right]$$

$$\rho = \frac{1}{13{,}45}\left[1 - \sqrt{1 - \frac{2(13{,}45)(7{,}15)}{400}}\right] = 0{,}0208$$

Area reinforcement needed

As min $= \rho_g$ x b x t = 0,0018 x 1000 x 260 = 468 mm^2

As $= \rho$ x b x d = 0,0208 x 1000 x 220,5 = 4581,067 mm^2

Then used As = 4581,067 mm^2

Distance between reinforcement

$$S = \left(\frac{0.25 x \pi x \varphi^2 x b}{As}\right) = \left(\frac{0{,}25x3{,}14x13^2x1000}{4581{,}067}\right) = 28{,}95 \text{ mm} \sim \mathbf{30\ mm}$$

$$S = \left(\frac{0.25 x \pi x \varphi^2 x b}{S}\right) = \left(\frac{0.25x3.14x13^2x1000}{30}\right) = 4422{,}16 > \mathbf{30\ mm (OK)}$$

Then the reinforcement of column lane shortening **(Footing)** is used**= D13 - 30 mm**

- Calculate the reinforcement of the column shortening direction (field)
  Calculation of the principal reinforcement in the column lane area uses reinforcement D 13 mm.
  M_o = 15,657 kNm

$$M_n = \left(\frac{M_o}{\varphi}\right) = \left(\frac{15{,}657}{0.9}\right) = 17{,}4 \text{ kNm}$$

$$R_n = \left(\frac{M_n}{bxd^2}\right) = \left(\frac{17400000}{1000x\,220{,}5^2}\right) = 0{,}36$$

$$m = \left(\frac{fy}{0{,}85xf'c}\right) = \left(\frac{400}{0{,}85x35}\right) = 13{,}45$$

Reinforcement ratio

$$\rho = \frac{1}{m}\left[1 - \sqrt{1 - \frac{2(m)(R_n)}{fy}}\right]$$

$$\rho = \frac{1}{13{,}45}\left[1 - \sqrt{1 - \frac{2(13{,}45)(0{,}36)}{400}}\right] = 0{,}0009$$

Area reinforcement needed

As min $= \rho_g$ x b x t = 0,0018 x 1000 x 260 = 468 mm^2

As $= \rho$ x b x d = 0,0009 x 1000 x 220,5 = 198,442 mm^2

Because As min > As, then used As min = 468 mm^2

Distance between reinforcement

$$S = \left(\frac{0.25 x \pi x \varphi^2 x b}{As}\right) = \left(\frac{0{,}25x3{,}14x13^2x1000}{468}\right) = 283{,}47 \text{ mm} \sim \mathbf{290\ mm}$$

$$S = \left(\frac{0.25 x \pi x \varphi^2 x b}{S}\right) = \left(\frac{0.25x3.14x13^2x1000}{290}\right) = 457{,}46 > \mathbf{290\ mm\ (OK)}$$

Then used the direction of the column shortening direction column (Field) **= D13 - 290 mm**

- Calculate the reinforcement of the shortened center lane (pedestal)
  Calculation of the principal reinforcement in the column lane area uses reinforcement D 13 mm.
  M_o = 13,235 kNm

$$M_n = \left(\frac{M_o}{\varphi}\right) = \left(\frac{13{,}235}{0.9}\right) = 14{,}71 \text{ kNm}$$

$$R_n = \left(\frac{M_n}{bxd^2}\right) = \left(\frac{14710000}{1000x\,220{,}5^2}\right) = 0{,}30$$

$$m = \left(\frac{fy}{0{,}85xf'c}\right) = \left(\frac{400}{0{,}85x35}\right) = 13{,}45$$

Reinforcement ratio

$\rho = \frac{1}{m}\left[1 - \sqrt{1 - \frac{2(m)(R_n)}{fy}}\right]$

$\rho = \frac{1}{13{,}45}\left[1 - \sqrt{1 - \frac{2(13{,}45)(0{,}3)}{400}}\right]$ = 0,0008

Area reinforcement needed

As min = ρ_g x b x t = 0,0018 x 1000 x 260 = 468 mm^2

As = ρ x b x d = 0,0008 x 1000 x 220,5 = 167,586 mm^2

Because As min > As, then used As min = 468 mm^2

Distance between reinforcement

$S = \left(\frac{0.25 x \pi x \varphi^2 x b}{A_S}\right) = \left(\frac{0{,}25x3{,}14x13^2x1000}{468}\right)$ = 283,47 mm ~ **290 mm**

$S = \left(\frac{0.25 x \pi x \varphi^2 x b}{S}\right) = \left(\frac{0.25x3.14x13^2x1000}{290}\right)$ = 457,46 > **290 mm (OK)**

Maka digunakan tulangan arah memendek lajur tengah (**Tumpuan**) **= D13 - 290 mm**

- Calculate the shortened center lane reinforcement (field)

Calculation of the main reinforcement in the column path are D 13 mm.

M_o = 12,521 kNm

$M_n = \left(\frac{M_o}{\varphi}\right) = \left(\frac{12{,}521}{0.9}\right)$ = 13,91 kNm

$R_n = \left(\frac{M_n}{bxd^2}\right) = \left(\frac{14710000}{1000x\,220{,}5^2}\right)$ = 0,29

$m = \left(\frac{fy}{0{,}85xf'c}\right) = \left(\frac{400}{0{,}85x35}\right)$ = 13,45

Reinforcement ratio

$\rho = \frac{1}{m}\left[1 - \sqrt{1 - \frac{2(m)(R_n)}{fy}}\right]$

$\rho = \frac{1}{13{,}45}\left[1 - \sqrt{1 - \frac{2(13{,}45)(0{,}29)}{400}}\right]$ = 0,0007

Area reinforcement needed

As min = ρ_g x b x t = 0,0018 x 1000 x 260 = 468 mm^2

As = ρ x b x d = 0,0007 x 1000 x 220,5 = 158,501 mm^2

Becuase As min > As, then used As min = 468 mm^2

Distance between reinforcement

$S = \left(\frac{0.25 x \pi x \varphi^2 x b}{A_S}\right) = \left(\frac{0{,}25x3{,}14x13^2x1000}{468}\right)$ = 283,47 mm ~ **290 mm**

$S = \left(\frac{0.25 x \pi x \varphi^2 x b}{S}\right) = \left(\frac{0.25x3.14x13^2x1000}{290}\right)$ = 457,46 > **290 mm (OK)**

Then used the direction bar shortening the middle lane (Field) **= D13 - 290 mm**

✓ Recap the flat slab reinforcement is shortened (X)

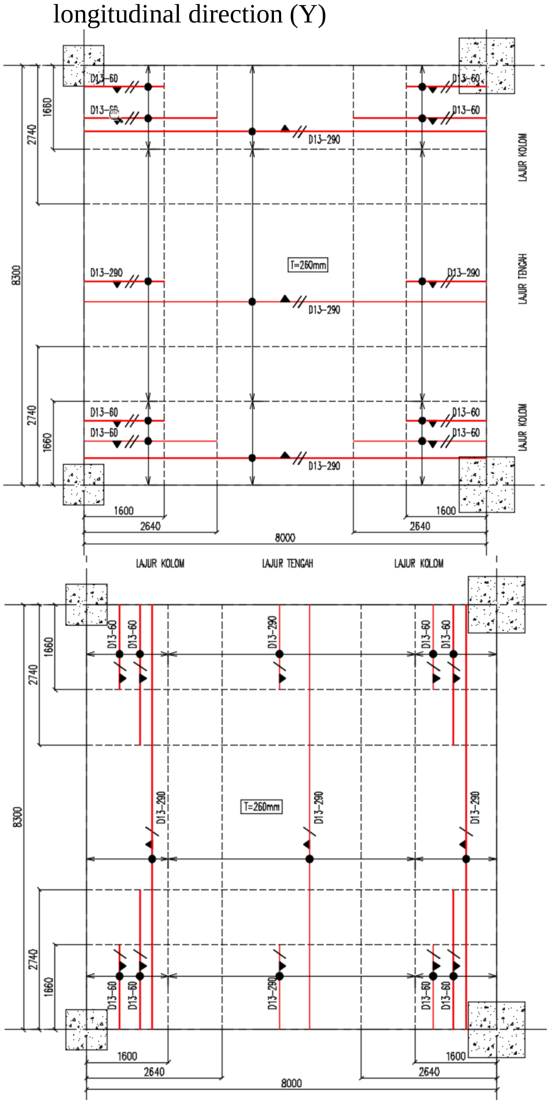
Momen yang di tinjau	Diameter	Jarak
Tumpuan (lajur kolom)	D 13	30
Lapangan (lajur kolom)	D 13	290
Tumpuan (lajur tengah)	D 13	290
Lapangan (lajur tengah)	D 13	290

✓ Using the Mo value according to the output etabs and the same calculation steps with the reinforcement of the flat slab in the shortening direction, it is obtained the Recap of the flat slab reinforcement in the longitudinal direction (Y)

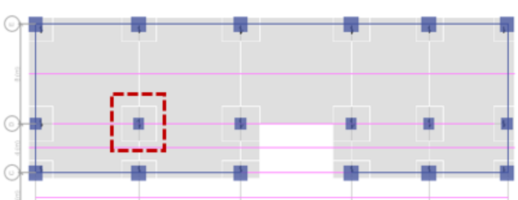
Momen yang di tinjau	Diameter	Jarak
Tumpuan (lajur kolom)	D 13	30
Lapangan (lajur kolom)	D 13	290
Tumpuan (lajur tengah)	D 13	290
Lapangan (lajur tengah)	D 13	290

Arah X (memendek)			
Lajur kolom		Lajur Tengah	
Tumpuan	Lapangan	Tumpuan	Lapangan
232,261	55,93	79,84	5,12
Arah Y (memanjang)			
Lajur kolom		Lajur Tengah	
Tumpuan	Lapangan	Tumpuan	Lapangan
182,826	68,12	78,85	9,29

✓ Flat slab reinforcement image shortening (X) and longitudinal direction (Y)



✓ *Drop The reviewed panel drop area and the moment output from etabs*



- 1-way slide check for critical cross sections A-A (X)
  Vu = 232,261 kN = 23,684 ton
  $\emptyset Vc$ = 0,75 x $\sqrt{\frac{f'c}{6}}$ x b x d
  $\emptyset Vc$ = 0,75 x $\sqrt{\frac{35}{6}}$ x 2,8 x 0,289 = 59,84 ton
  $Vu < \emptyset Vc$ *(OK)*
- 1-way slide check for critical cross sections B-B (Y)
  Vu = 182,826 kN = 18,64 ton
  $\emptyset Vc$ = 0,75 x $\sqrt{\frac{f'c}{6}}$ x b x d
  $\emptyset Vc$ = 0,75 x $\sqrt{\frac{35}{6}}$ x 2,8 x 0,289 = 59,84 ton
  $Vu < \emptyset Vc$ *(OK)*
- Check 2-way slide
  Vu = 232,261 kN = 23,684 ton
  Bc = 900/900 = 1
  as = 40
  b_o = 2 x (1044,5 + 1044,5) = 4,178mm = 4,2mm
  $V_{c(a)}$ = $\frac{1}{6}$ x (1 + $\frac{2}{Bc}$) x $\sqrt{f'c}$ x b_o x d
  = $\frac{1}{6}$ x (1 + $\frac{2}{1}$) x $\sqrt{35}$ x 4,2 x 0,289 = 3,590 = 359 ton
  $V_{c(b)}$ = ($\frac{as \ x \ d}{12bo}$ + $\frac{1}{6}$) x $\sqrt{f'c}$ x b_o x d
  = ($\frac{40 \ x \ 0{,}289}{12 \ x \ 4{,}2}$ + $\frac{1}{6}$) x $\sqrt{35}$ x 4,2 x 0,289 = 2,84 = 284,34 ton
  $V_{c(c)}$ = $\frac{1}{3}$ x $\sqrt{f'c}$ x b_o x d = $\frac{1}{3}$ x $\sqrt{35}$ x 4,2 x 0,289 = 2,39 = 239,4 ton
  Take the smallest Vc value, such that
  $\emptyset Vc$ = 0,75 x 239,4 = 179,55 ton
  Then , Vu = 23,684 ton < $\emptyset Vc$ = 179,55 ton , the plate shear capacity is sufficient to carry two-way shear
- Calculate the effective height of the floor plate (d)Selimut beton untuk pelat lantai 20mm (t_s). Main reinforcement used D16mm
  d = h – t_s – D
  = 325 – 20 – 16 = 289 mm (lajur kolom)
  d = h – t_s – D
  = 260 – 20 – 16 = 224 mm (lajur tengah)
- Calculate the value $\boldsymbol{\beta_1}$
  For f'c ≤ 30 MPa, β_1 = 0,85
  For f'c 30 < f'c < 55 MPa, β_1 = 0,85 – 0,008 (f'c – 30)
  For f'c > 55 Mpa, β_1 = 0,65
  Then,
  f'c 35 MPa, β_1 = 0,85 – 0,008 (35 – 30) = 0,81

  $$\rho_b = \frac{0.85 x \beta x f'c}{fy}\left(\frac{600}{600+fy}\right) = \frac{0{,}85 x 0{,}81 x 35}{400}\left(\frac{600}{600+400}\right) = 0{,}0361$$
- Calculate the amount of the minimum and maximum reinforcement ratio ρ_g = 0,0018 (based on SNI 2847:2013 pasal 7.12.2.1)
  $\rho_{maks} = 0{,}75 \ x \ p_b = 0{,}75 \ x \ 0{,}0361 = 0{,}027$
- Calculating the reinforcement of the column shortening direction (pedestal)
  Calculation of the principal reinforcement in the column lane area uses reinforcement D 16 mm.
  M_o = 232,261 kNm

$M_n = \left(\frac{M_o}{\varphi}\right) = \left(\frac{232{,}261}{0.9}\right)$ = 258,067 kNm

$R_n = \left(\frac{M_n}{bxd^2}\right) = \left(\frac{258067000}{1000x\,289^2}\right)$ = 3,09

$m = \left(\frac{fy}{0{,}85xf'c}\right) = \left(\frac{400}{0{,}85x35}\right)$= 13,45

Reinforcement ratio

$$\rho = \frac{1}{m}\left[1 - \sqrt{1 - \frac{2(m)(R_n)}{fy}}\right]$$

$$\rho = \frac{1}{13{,}45}\left[1 - \sqrt{1 - \frac{2(13{,}45)(3{,}09)}{400}}\right] = 0{,}0082$$

Area reinforcement needed

As min = ρ_g x b x t = 0,0018 x 1000 x 325 = 585 mm^2

As = ρ x b x d = 0,0082 x 1000 x 289 = 2369,8 mm^2

Then used As = 2369,8 mm^2

Distance between reinforcement

$S = \left(\frac{0.25x\pi x\varphi^2 xb}{As}\right) = \left(\frac{0{,}25x3{,}14x16^2x1000}{2369{,}8}\right)$ = 84,8 mm ~ **90 mm**

$As = \left(\frac{0.25x\pi x\varphi^2 xb}{S}\right) = \left(\frac{0.25x3.14x16^2x1000}{90}\right)$ = 2232,8 > **90 mm(OK)**

Then the reinforcement of column lane shortening (Footing) is used = D16 - 90 mm

Then use the same steps as the calculation in the slab

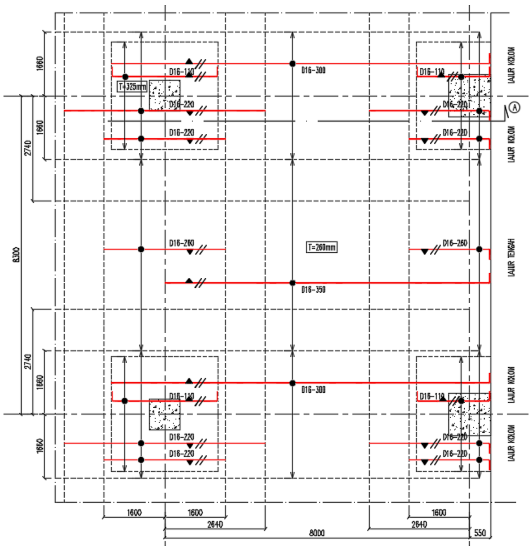
- ✓ Recap the shortening direction drop bar reinforcement (X)

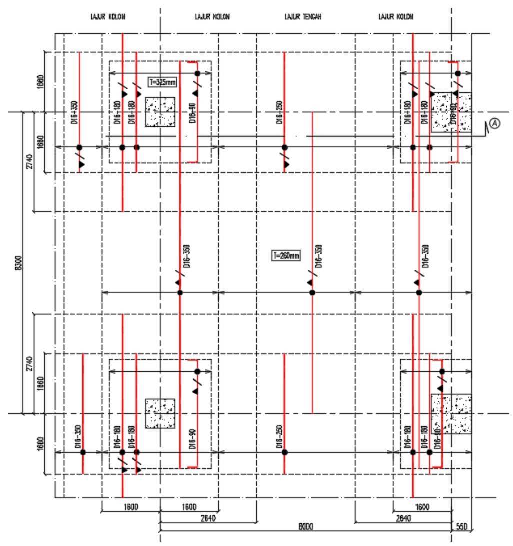
Momen yang di tinjau	Diameter	Jarak
Tumpuan (lajur kolom)	D 16	90
Lapangan (lajur kolom)	D 16	350
Tumpuan (lajur tengah)	D 16	250
Lapangan (lajur tengah)	D 16	350

- ✓ Using the Mo value according to the output etabs and the same calculation steps as the reinforcement of the shortening direction panel then the longitudinal direction of the drop panel reinforcement is obtained (Y)

Momen yang di tinjau	Diameter	Jarak
Tumpuan (lajur kolom)	D 16	110
Lapangan (lajur kolom)	D 16	300
Tumpuan (lajur tengah)	D 16	260
Lapangan (lajur tengah)	D 16	350

- ✓ Image of reinforcement drop panel shortening (X) and longitudinal direction (Y)





4. Conclussion

a. Conclusion

From the results and analysis of flat slab and drop panel calculations can be concluded:

1. This parking building with flat slab and Drop panel 5 floors is feasible to use because the intersection between floors is 0.10mm for X direction and 0.008mm for Y direction taken on average from 5 floors. This value is below the permit value limit of 22.5cm.
2. Thick flat slab 260mm and Drop panel 325mm using reinforcement D13-30, D13-290, D16-90, D16-110, D16-250, D16-260, D16-300 and D16-350
3. The smallest panel drop size from 1650x1950mm to 2800x3000mm (floor plan attached)
4. For the biggest moment value on the P3A floor with:
   - ✓ M max direction X = 32,285
   - ✓ M min direction X = -588,671
   - ✓ M max direction Y = 328,179
   - ✓ M min direction Y = -702,975
5. For flat slabs, slide one-way cross section critical A-A (X), Vu <ØVc (OK) => 31.9 tons <137.84 tons. For one-way sliding critical cross sections B-B (Y), Vu <ØVc (OK) => 32.58 tons <143.01 tons. For the two-way cross section critical A-A (X), Vu <ØVc (OK) => 32.58 tons <139.5 tons
6. For drop panels, slide one-way critical cross sections A-A (X), Vu <ØVc (OK) => 23,684 tons <59.84 tons. For one-way sliding critical cross section B-B (Y), Vu <ØVc (OK) => 18.64 tons <59.84 tons. For the two-way sliding cross section critical A-A (X), Vu <ØVc (OK) => 23,684 tons <179.55 tons

b. Suggestion

For further research development regarding flat slabs and drop panels, it is recommended to:

1. In this Final Project do not try various assumptions about the thickness of the flat slab and drop panel due to time constraints. Maybe this can be a material for further researchers to conduct more detailed research in order to obtain an efficient thickness
2. Taking into account the use of shear reinforcement, such as shear stud or structural shearhead on flat plates and flat slabs (drop panels).
3. Calculating the reinforcement ratio

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Biographies

Agyanata Tua Munthe was born in March 21, 1981. After graduation his highschool education at BPK Penabur senior high school in Bandar Lampung, continued his civil engineering education at Atmajaya University, Special Region of Yogyakarta in 2004. He obtained his Master's degree in civil engineering in 2006 at University of Gadjah Mada, Special Region of Yogyakarta. Currentlt active as lecturer at Mercu Buana University, Jakarta as a lecturer with a concentration in structure and currently active as a project manager handling several construction project.

Guntur Jatmiko was born in Special Region of Yogyakarta on January 31, 1996. After graduation a vocational high school education in building engineering department continued his undergraduate civil engineering education at Mercu Buana University Jakarta in 2016 to 2020 by compiling the final project is Planning parking building using flat slab and drop panel as a replacement conventional beam with analyzing bending moment value and sliding style based on SNI 1726-2012. Aalso active as a staff in building construction projects.