

BAB IV METODE PERENCANAAN

A. Pembebanan

Struktur portal yang akan dirancang ditinjau terhadap beban gravitasi (beban mati dan beban hidup) dan beban gempa. Dalam hal ini beban horisontal akibat angin tidak ditinjau karena pengaruhnya sangat kecil terhadap kekuatan bangunan, semua beban yang ditinjau terangkum dalam beban tetap dan beban sementara.

Beban tetap merupakan penjumlahan dari beban mati (DL) dan beban hidup (LL). Beban mati terdiri dari semua beban yang bekerja pada semua elemen struktur yang bersifat permanen, termasuk didalamnya adalah berat sendiri struktur. Beban hidup adalah beban yang terjadi akibat penghunian dan penggunaan suatu gedung, termasuk beban-beban pada lantai yang berasal dari barang-barang yang dapat dipindah dan atau beban air pada atap, sehingga mengakibatkan perubahan dalam pebebanan pada lantai dan atap. Berdasarkan Peraturan Pembebanan Indonesia Untuk Gedung (PPIUG) tahun 1983, untuk plat lantai struktur gedung yang digunakan untuk perkantoran dipakai beban hidup 250kg/m^2 dan untuk plat atap 100 kg/m^2 .

Pembebanan pada struktur direncanakan terhadap kombinasi pembebanan seperti yang tercantum dalam SK SNI T-15-1991-03 yang memenuhi rumus (3-8), (3-11) dan (3-12).

B. Analisis Struktur

Hasil gaya-gaya batang yang terjadi pada portal yang digunakan pada elemen struktur diperoleh dengan analisis portal dengan menggunakan analisis statik ekuivalen daktilitas penuh dengan bantuan komputer yaitu program SAP 2000. Analisis struktur menggunakan tipe elemen frame dengan pembebanan statis 3 dimensi.

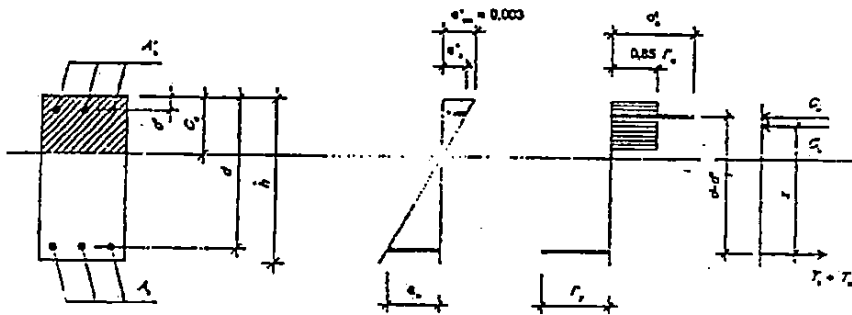
C. Perencanaan Elemen Struktur

1. Balok

Perencanaan pada struktur balok harus dijamin terbentuknya sendi-sendi plastis pada ujung-ujung balok, oleh karena itu kekuatan kolom-kolom pada suatu titik buhul dibuat lebih besar dari kekuatan balok.

Perencanaan balok portal terhadap beban lentur harus memperhitungkan beban terhadap tiga kombinasi pembebanan seperti pada persamaan (3-21), (3-22) dan persamaan (3-23), serta perencanaan terhadap beban geser harus memenuhi persamaan (3-25) dan (3-26).

a. Perhitungan Balok Bertulangan Lentur Rangkap



Gambar 4.1. Penampang, diagram tegangan dan regangan.

Tulangan Tarik

$$M_n = M_u / 0.8$$

$$R_n = M_n / (b \cdot w \cdot d^2)$$

$$\rho_{perlu} = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$

$$\rho_{min} = 1.4 / f_y$$

$$\rho_{maks} = 0.76 \cdot \rho_b$$

$$\rho_{min} < \rho_{perlu} < \rho_{maks}$$

$$A_s = \rho_{perlu} \times b \cdot w \times d$$

Tulangan tekan

Rasio antara tulangan tarik dengan tulangan tekan adalah 0,5

$$A_s = \rho_{perlu} \times b_w \times d \times 0,5$$

Menentukan kapasitas momen

Anggapan tulangan tarik dan tulangan tekan leleh

$$a = \frac{(A_s - A_s') f_y}{(0,85 f_c') b} \text{ tentukan letak garis netral,}$$

$$a = \beta_1 \cdot c, \beta_1 = 0,85 \text{ (SK SNI T-15-1991-03 Pasal 3.3.2. ayat 7)}$$

$$c = \frac{a}{\beta_1}$$

periksaan regangan tulangan baja dengan berdasarkan segi tiga sebangun, sesuai dengan gambar 4.1.

Pada tulangan tekan

$$\varepsilon_s' = \frac{c - d'}{c} (0,003)$$

Pada tulangan tarik

$$\varepsilon_s = \frac{d - c}{c} (0,003)$$

Jika ternyata anggapan awal tidak benar, maka diperlukan mencari garis netral dahulu dengan menggunakan kesetimbangan gaya horisontal ($\sum H_f = 0$)

Untuk mencari nilai c (garis netral) dapat menggunakan persamaan kuadrat sebagai berikut :

$$c = \pm \sqrt{(Q + R^2)} - R$$

$$\text{dimana, } R = \frac{600 \cdot A_s' - A_s \cdot f_y}{1,7 \cdot f_c' \cdot b \cdot \beta_1} \text{ dan } Q = \frac{600 \cdot d' \cdot A_s'}{1,7 \cdot f_c' \cdot b \cdot \beta_1}$$

dengan nilai c, maka nilai fs' dapat diketahui

$$f_s' = \frac{(c - d') \cdot 600}{c}$$

jika anggapan yang digunakan benar.

$$N_t = A_s \cdot f_y$$

$$Nd1 = Ast' \cdot fs'$$

$$Nd2 = 0,85 \cdot fc' \cdot b \cdot c \cdot 0,85$$

$$Nt = Nd1 + Nd2$$

$$Mn1 = Nd1 \cdot (d - d')$$

$$Mn2 = Nd2 \cdot (d - 1/2 \cdot a)$$

Dan untuk mencari momen nominal aktual,

$$Mn = Mn1 + Mn2$$

b. Perencanaan Balok T

Balok beton yang dicor secara monolit dengan lantai atau pelat, jika melendut maka tegangan akan timbul baik pada bagian-bagian balok persegi maupun pada daerah lebar lantai. Dengan demikian lebar lantai yang ikut menerima distribusi gaya-gaya dalam atau lebar flens, sangat perlu diketahui dalam perhitungan.

Pada SK SNI-T-15-1991-03 pasal 3.10, dicantumkan ketentuan untuk lebar efektif balok T yang harus ditetapkan sebagai berikut :

- 1). pada konstruksi balok T, pengerjaan flens dan badan dari balok harus dilaksanakan secara menyatu atau harus diusahakan agar didapat lekatan yang efektif antara keduanya,
- 2). lebar plat yang secara efektif bekerja sebagai suatu flens dari balok-T tidak boleh melebihi seperempat bentang dari balok dan lebar efektif dari flens yang membentang pada tiap sisi dari badan balok tidak boleh melebihi :
 - a) delapan kali tebal plat,
 - b) setengah dari jarak bersih dari badan balok yang bersebelahan
- 3). untuk balok yang mempunyai pelat hanya pada satu sisi, lebar efektif flens yang membentang tidak boleh lebih dari :
 - a) seperduasbelas dari bentang balok,
 - b) enam kali tebal pelat, dan
 - c) setengah jarak bersih dari lebar badan balok yang bersebelahan.
- 4). balok tunggal dimana bentuk T-nya diperlukan untuk menambah luas daerah tekan harus mempunyai flens tidak kurang dari setengah lebar

badan balok, dan lebar efektif flens tidak lebih dari empatkali lebar badan balok.

- 5). Bila tulangan lentur utama pelat yang dianggap sebagai suatu flens balok-T (kecuali konstruksi pelat rusuk) sejajar dengan balok, maka harus disediakan penulangannya sisi atas plat yang tegak lurus balok berdasarkan ketentuan berikut :

Tulangan transversal harus direncanakan untuk menahan beban terfaktor pada lebar pelat yang membentang (yang dianggap berperilaku sebagai kantilever). Untuk balok tunggal, seluruh lebar dari flens yang membentang harus diperhitungkan. Untuk seluruh lebar efektifnya saja yang perlu diperhitungkan.

Tulangan transversal harus dipasang dengan spasi tidak melebihi 5 kali tebal pelat dan atau 500 mm.

Untuk balok-T berlaku :

$$b = b_w + b_1 + b_2 < 1/4L$$

dengan b_w lebar badan balok dari penampang persegi.

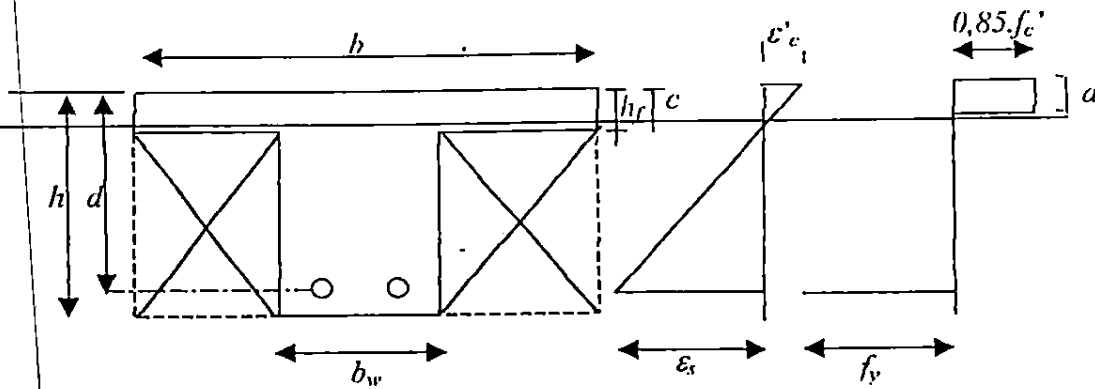
$$b_1 = 8 \times h_1 \text{ atau } \frac{1}{2} L_1$$

$$b_2 = 8 \times h_2 \text{ atau } \frac{1}{2} L_2$$

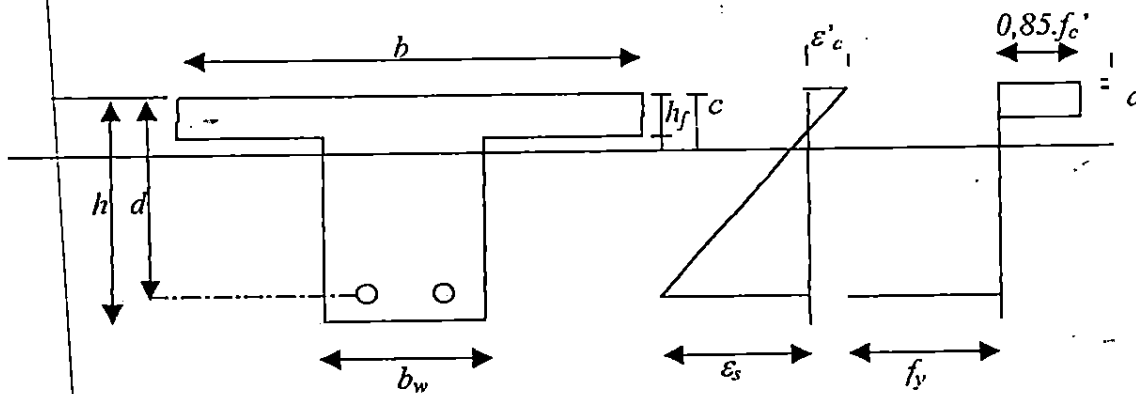
balok yang berbentuk L ditetapkan $b = b_w + b_1$, dengan b_1 adalah harga terkecil dari $b_1 = \frac{1}{2} \cdot L_1$.

Dalam perhitungan, sebuah balok dianggap sebagai balok-T maka berarti seluruh daerah tekan harus terdapat pada daerah flens ($c < hf$).

Bila $c < hf$ maka balok dianggap sebagai persegi dengan lebar b (sebagai pengganti b_w) dan tinggi efektif d . jika $a = 0,85 \cdot c$ terletak pada daerah flens berarti tidak memadai, dalam diagram tegangan regangan beton yang diestimasi, tanpa dipengaruhi tinggi dari daerah tekan ditetapkan sama dengan c .



Gambar 4.2 Penampang Balok-T dengan diagram tegangan-regangan ($c < h_f$)



Gambar 4.3 penampang balok-T dengan diagram tegangan-regangan ($c > h_f$)

Bila $c > h_f$ berarti daerah tekan tidak terbatas pada flens saja, maka perhitungan momen berdasarkan pada bentuk balok dengan ukuran $b_e \times h$.

Pada balok-T yang ditumpu menerus, letak flens terdapat disekitar tumpuan balok pada bagian tarik. Pada titik maupun balok-T dihitung sebagai balok persegi ($b_w \times h$).

c. Lendutan Balok

Kekuatan dan kemampuan kelayakan struktur terhadap lendutan diatur dalam SKSNI T-12-1991-03, dimana nilai yang diberikan harus digunakan langsung untuk komponen struktur dengan beton ($W_c = 2400 \text{ kg/m}^3$) dan

tulangan BJTD 40. Untuk kondisi lain, nilai diatas harus dimodifikasikan sebagai berikut:

- 1) untuk struktur beton ringan dengan unit masa di antara 1500 – 2000 kg/m³, nilai tadi harus dikalikan dengan (1,65 – 0,005 Wc) tidak kurang dari 1,09, dimana Wc adalah unit massa dalam kg/m³.
- 2) untuk fy lain dari M₁' a nilainya harus dikalikan dengan (0,4+fy/700).

Lendutan maksimum dalam penampang elastis dapat dinyatakan sebagai berikut:

$$\delta \text{ maks} = \beta_a.M.L/Eic$$

dengan

M = momen lentur positif maks.

L = Panjang Bentangan

E = Modulus elastisitas tg C.

β_a = koefisien yang tergantung pada derajat jepitan tumpu.

Variasi dari momen inersia sepanjang bentang dan distribusi beban.

Untuk balok sederhana, prismatis dengan beban merata,

$$\beta_a = 5/48 \text{ dan untuk kantilever dengan beta merata } \beta_a = 1/4.$$

Tabel 4.1 Tebal minimum balok non-pratekan atau pelat satu arah bila lendutan tidak dihitung.

| KOMPONEN STRUKTUR | TEBAL MINIMUM, h | | | |
|-----------------------|--|--------------------|---------------------|------------|
| | DUA TUMPUAN | SATU UJUNG MENERUS | KEDUA UJUNG MENERUS | KANTILEVER |
| | KOMPONEN TIDAK Mendukung ATAU menyatu dengan PARTISI ATAU KONSTRUKSI LAIN YANG AKAN RUSAK KARENA LENDUTAN YANG BESAR | | | |
| Pelat solid satu arah | l/20 | l/24 | l/28 | l/10 |
| Pelat jalur Satu arah | l/16 | l/18.5 | l/21 | l/8 |

(Sumber: SKSNI T-15-1991, hal 19)

Tabel 4.2. Lentutan maksimum

| TIPE KOMPONEN STRUKTUR | LENDUTAN YANG DIPERHITUNGAN | BATAS LENDUTAN |
|---|--|-----------------|
| Atap datar tidak menahan atau berhubungan dengan komponen nonstruktural yang mungkin akan rusak akibat lentutan yang besar. | Lentutan akibat beban hidup L | $\frac{1}{180}$ |
| Lantai tidak menahan atau berhubungan dengan komponen nonstruktural yang mungkin rusak akibat lentutan yang besar. | Lentutan akibat beban hidup L | $\frac{1}{380}$ |
| Konstruksi atap atau lantai yang menahan atau berhubungan dengan komponen non struktural yang mungkin rusak akibat lentutan yang besar. | Bagian dari lentutan total yang terjadi setelah pemasangan komponen non struktural (jumlah dari lentutan jangka panjang akibat semua beban yang bekerja dan lentutan seketika yang terjadi akibat penambahan sebarang beban hidup) | $\frac{1}{480}$ |
| Konstruksi atap atau lantai yang menahan atau berhubungan dengan komponen non struktural yang mungkin tidak rusak akibat lentutan yang besar. | | $\frac{1}{240}$ |

(Sumber: SK SNI T-15-1991-03,hal 19)

Nilai lentutan pada balok tidak boleh melebihi nilai yang disyaratkan SKSNI yang tertera dalam tabel.

d. Perencanaan penulangan geser.

Dasar perencanaan penulangan geser adalah usaha menyediakan sejumlah tulangan baja untuk menahan gaya tarik arah tegak lurus terhadap retak tarik diagonal sedemikian rupa sehingga mampu mencegah bukaan retak lebih lanjut. Penulangan geser dapat dilakukan dalam beberapa cara, sebagai berikut :

- 1) sengkang vertikal,
- 2) jaringan kawat baja las yang dipasang tegak lurus terhadap sumbu aksial.
- 3) sengkang miring atau diagonal,
- 4) batang tulangan miring diagonal yang dapat dilakukan dengan membengkokkan batang tulangan balok ditempat-tempat yang diperlukan, atau;
- 5) tulangan spiral.

Untuk komponen-komponen yang menahan geser dan lentur saja, persamaan 3.4-3 SK SNI-T-15-1991-03 memberikan kapasitas kemampuan beton (tanpa tulangan geser) untuk menahan geser adalah V_c , dimana

$$V_c = (1/6 \cdot (\sqrt{f_c'})) \cdot bw \cdot d$$

Atau dengan menggunakan persamaan 3.4-6 SK SNI T-15-1991-03 Pasal 3.4.3 yang lebih terinci sebagai berikut :

$$V_c = (1/7 \cdot (\sqrt{f_c'} + 120 \rho_w \cdot (V_u \cdot d / M_u))) \cdot bw \cdot d$$

Dimana M_u adalah momen terfaktor yang terjadi bersamaan dengan gaya geser terfaktor maksimum V_u pada penampang kritis. Sedangkan batas atas faktor pengali dan V_c adalah sebagai berikut,

$$(V_u \cdot d / M_u) \leq 1,0$$

$$V_c \leq (0,30 \cdot \sqrt{f_c'}) \cdot bw \cdot d$$

Dalam perencanaan tersebut satuan f_c' dalam Mpa, bw dan d dalam mm, V_c dalam kN, sedangkan untuk balok persegi bw sama dengan b . kuat geser beton dikenakan faktor reduksi kekuatan $\phi = 0,6$ sehingga menjadi kuat geser beton (SK SNI-T-15-1991-03 pasal 3.2.3). sedangkan kuat geser rencana V_u didapatkan dari hasil penerapan faktor beban.

Peraturan teoritis :

$$V_u \leq V_c$$

Akan tetapi peraturan mengharuskan untuk selalu menyediakan penulangan geser minimum pada semua bagian struktur beton yang mengalami lentur, kecuali pada :

- 1) plat dan pondasi plat,
- 2) struktur balok beton rusuk yang ditentukan dalam SK-SNI-T-15-1991-03. Pasal 3.1.11,
- 3) balok dengan tinggi total tidak melebihi 250 mm atau 2,5 kali tebal flens atau 1,5 kali lebar badan balok diambil yang terbesar,
- 4) tempat dimana nilai $V_u < \frac{1}{2} \phi \cdot V_c$.

Ketentuan penulangan geser minimum tersebut terutama untuk menjaga apabila timbul beban yang tak terduga pada komponen struktur yang mungkin akan mengakibatkan kerusakan (kegagalan) geser. Jumlah luas tulangan geser ditentukan dengan persamaan 3.4-14 SK SNI-T-15-1991-03 pasal 3.41 dinyatakan bahwa dasar perencanaan tulangan geser adalah sebagai berikut :

$$V_u \leq \phi \cdot V_n$$

$$\text{Dimana } V_n = V_c + V_s$$

$$\text{Sehingga } V_u \leq \phi \cdot V_c + \phi \cdot V_s$$

Dimana V_u , ϕ , V_c , sudah ditentukan, V_n adalah kuat geser ideal atau nominal dan V_s adalah kuat geser nominal yang disediakan oleh tulangan geser.

Untuk sengkang vertikal, V_s dapat dihitung menggunakan persamaan 3.4-17 SK SNI-T-15-1991-03 sebagai berikut :

$$V_s = (A_v \cdot f_y \cdot d) / S$$

Persamaan diatas dapat diuraikan dengan menganggap bahwa sengkang menahan komponen vertikal dari gaya tarik yang bekerja di daerah $\frac{1}{2}$ s kanan dan kiri dari sengkang yang bersangkutan. sedangkan komponen horisontal dimasukkan dalam perancangan tulangan memanjang.

2. Perencanaan Kolom.

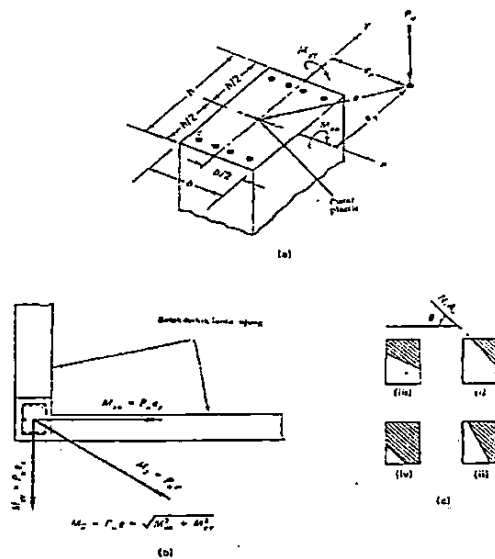
Salah satu elemen yang cukup kompleks perilakunya adalah elemen kolom (*beam column*), pada elemen tersebut terjadi interaksi antara pengaruh gaya aksial tekan dan momen lentur.

Apabila suatu kolom yang ditumpu kedua ujungnya dengan sendi dan rol, dibebani dengan gaya aksial tekan P dengan eksentrisitas e , maka secara ekuivalen kondisi tersebut dapat diwakili dengan suatu batang lurus yang dibebani secara aksial dikedua ujungnya dengan gaya tekan sentris P ditambah dengan momen sebesar $M_p = P \cdot e$ yang bekerja di kedua ujungnya.

a. Perencanaan kolom akibat gaya tekan dan momen biaksial

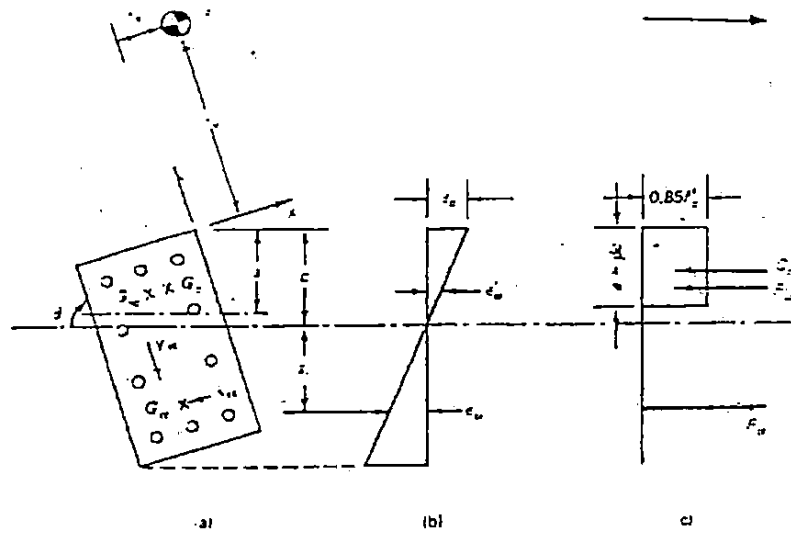
1. Analisis dengan Metode Eksak

Kolom-kolom pada bangunan gedung adalah elemen struktur yang mengalami momen lentur biaksial, yaitu momen lentur terhadap sumbu x dan momen lentur terhadap sumbu y . Kolom yang mengalami momen M_{xx} terhadap sumbu x menghasilkan eksentrisitas e_y , dan momen M_{yy} terhadap sumbu y menghasilkan eksentrisitas e_x . Dengan demikian sumbu netealnya membentuk sudut θ dengan garis horisontal.



Gambar 4.4. Penampang kolom dengan lentur biaksial

Besar sudut θ bergantung pada interaksi momen lentur terhadap kedua sumbu dan besarnya beban P_u . Daerah yang tertekan pada beton dapat mempunyai bentuk-bentuk seperti yang diperlihatkan pada gambar 4.4. Karena kolom demikian harus dirancang terhadap prinsip-prinsip awalnya, maka harus digunakan prosedur coba-coba dan penyesuaian dimana keserasian regangan harus dipertahankan pada setiap taraf tulangan.



Gambar 4.5. Keseserasian regangan dan gaya-gaya pada kolom segi empat yang mengalami lentur biaksial : (a) Penampang melintang, (b) regangan, (c) gaya-gaya.

Gambar 4.5 memperlihatkan distribusi regangan dan gaya-gaya pada penampang kolom segi empat. G_c adalah pusat berat daerah beton yang tertekan, yang koordinatnya x_c dan y_c dari sumbu netral berturut-turut dalam arah x dan y . G_{sc} adalah posisi resultan pada tulangan tekan yang koordinatnya x_{sc} dan y_{sc} dari sumbu netral berturut-turut dalam arah x dan y . G_{st} adalah posisi resultan pada tulangan tarik yang koordinatnya x_{st} dan y_{st} dari sumbu netral berturut-turut dalam arah x dan y . Persamaan keseimbangan gaya-gaya luar dan dalam menghasilkan :

$$P_n = 0,85 f_c' A_c + F_{sc} - F_{st}$$

dimana A_c = luas beton yang dicakup oleh blok tegangan ekialen.

$$F_{sc} = \text{resultan gaya tulangan tekan} = \sum A'_s s f_{sc}$$

$$F_{st} = \text{resultan gaya tulangan tarik} = \sum A_s s f_{sc}$$

Persamaan keseimbangan momen luar dan dalam menghasilkan:

$$P_n e_s = 0,85 f_c' A_c x_c + F_{sc} x_{sc} + F_{st} x_{st}$$

$$P_n e_s = 0,85 f_c' A_c y_c + F_{sc} y_{sc} + F_{st} y_{st}$$

Dalam setiap coba-coba, posisi sumbu netral harus diasumsikan terlebih dahulu, dan tegangan pada tulangan dihitung dengan menggunakan:

$$F_{si} = E_s \epsilon_{si} = E_c \epsilon_c \cdot \frac{s_i}{c} < f_y$$

2. Metode kontur beban

Pendekatan dengan metode ini adalah dengan mentransformasikan lentur biaksial menjadi momen uniaksial dan eksentrisitas uniaksial ekuivalen. Dengan demikian penampang dapat dirancang terhadap lentur uniaksial, dan penampang yang diperoleh dengan cara demikian akan mampu memikul momen lentur biaksial rencana.

Pada metode ini ditinjau permukaan runtuh (failure surface) – bukan bidang runtuh – dan metode ini biasa disebut sebagai *metode kontur Bresler-Parme*. Metode ini melibatkan potongan permukaan runtuh tiga dimensi, seperti yang diperlihatkan pada Gambar 4.6., untuk suatu gaya konstan P_n sehingga didapatkan bidang potongan yang menyatakan hubungan antara M_{nx} dan M_{ny} . Dengan perkataan lain, permukaan kontur S dapat dipandang sebagai bidang lengkung yang terdiri atas sekumpulan kurva yang disebut *kontur beban*.

Persamaan umum tak berdimensi kontur beban untuk P_n konstan dapat dinyatakan sebagai:

$$\left(\frac{M_{u-kx}}{M_{n-x}} \right)^{\alpha_1} + \left(\frac{M_{u-ky}}{M_{n-y}} \right)^{\alpha_2} = 1,0$$

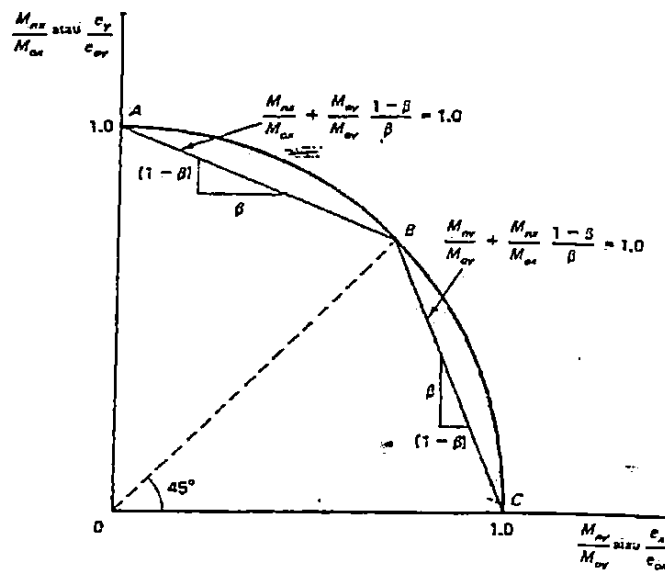
dimana $M_{nx} = P_n \cdot e_y$ dan $M_{ny} = P_n \cdot e_x$

$M_{ox} = M_{nx}$ untuk P_n tertentu apabila M_{ny} atau $e_x = 0$

$M_{oy} = M_{ny}$ untuk P_n tertentu apabila M_{nx} atau $e_y = 0$

a) Untuk AB dimana $M_{ny}/M_{oy} < M_{nx}/M_{ox}$:

$$\frac{M_{nx}}{M_{ox}} + \frac{M_{ny}}{M_{oy}} \left[\frac{1-\beta}{\beta} \right] = 1,0$$



Gambar 4.7. Plot kontur interaksi yang dimodifikasi pada P_n konstan untuk kolom yang mengalami lentur biaksial.

b) Untuk AB dimana $M_{ny}/M_{oy} > M_{nx}/M_{ox}$:

$$\frac{M_{ny}}{M_{oy}} + \frac{M_{nx}}{M_{ox}} \left[\frac{1-\beta}{\beta} \right] = 1,0$$

dalam kedua persamaan ini kekuatan momen uniaksial ekuivalen aktual M_{oxn} dan M_{oyn} yang menentukan paling sedikit harus sama dengan kekuatan momen uniaksial M_{ox} dan M_{oy} yang diperlukan.

Untuk penampang segi empat yang tulangnya didistribusikan secara merata pada semua sisi kolom, angka perbandingan M_{oy}/M_{ox} dapat didekati dengan b/h . dengan demikian persamaan di atas dapat dimodifikasi menjadi:

1) untuk $Mny/Mnx > b/h$:

$$Mny + Mnx \frac{b}{h} \frac{1-\beta}{\beta} \approx Moy$$

2) untuk $Mny/Mnx \leq b/h$:

$$Mnx + Mny \frac{b}{h} \frac{1-\beta}{\beta} \approx Moy$$

Kekuatan momen yang diperlukan adalah yang terbesar diantara Mox dan Moy yang diperoleh dari persamaan di atas.

Gambar 4.8. dapat digunakan untuk memilih β dalam analisis dan desain kolom biaksial. Dengan demikian metode kontur gaya merupakan metode untuk mencari kekuatan momen ekuivalen Mox dan Moy yang dapat dipakai untuk merencanakan kolom yang seolah-olah mengalami lentur uniaksial.

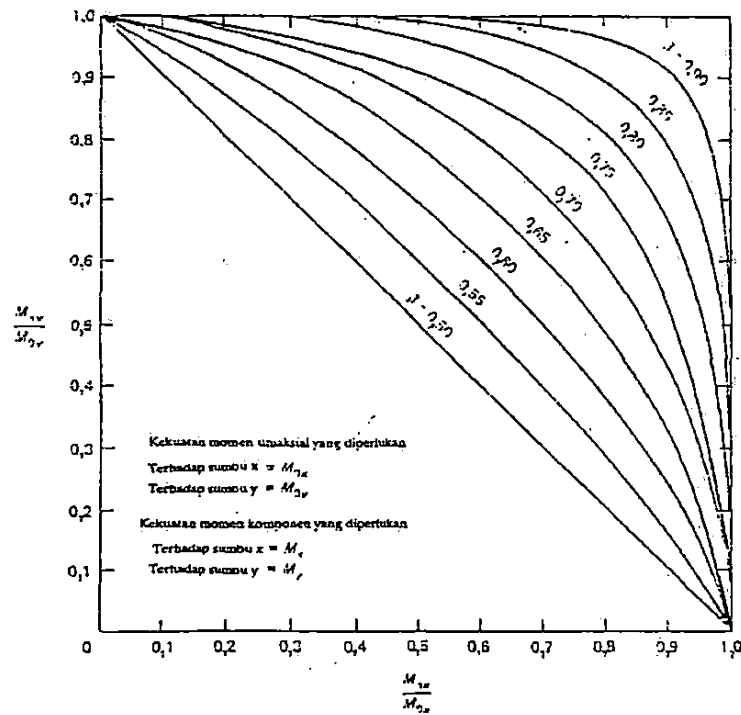
3. Prosedur operasional langkah demi langkah untuk desain kolom yang mengalami lentur biaksial.

Langkah-langkah berikut ini dapat dipakai sebagai petunjuk dalam desain kolom yang mengalami lentur pada arah x dan y . Prosedur ini beranggapan bahwa luas tulangan sama (terbagi rata) pada semua sisi.

- a) Hitung momen lentur uniaksial dengan menganggap banyaknya tulangan pada masing-masing sisi sama. Asumsikan faktor konstanta interaksi β antara 0,65 dan 0,80. Asumsikan perbandingan b/h . angka perbandingan ini dapat didekati dengan Mnx/Mny . Kemudian ditentukan momen uniaksial ekuivalen yang diperlukan Mox atau Moy . Apabila Mnx lebih besar daripada Mny gunakan Mox untuk desain, begitu juga sebaliknya.
- b) Asumsikan ukuran penampang melintang kolom dan angka penulangan $\rho = \rho'$ pada setiap dua sisi yang sejajar dengan sumbu lentur dari momen ekuivalen yang terbesar. Tentukan penulangan prarencana. Hitung kapasitas P_n penampang yang telah diasumsikan. Dalam desain akhir, jumlah tulangan memanjang pada keempat sisi harus sama.

- c) Hitung kekuatan momen nominal aktual M_{oxn} untuk lentur uniaksial ekuivalen terhadap sumbu x dan $M_{ox}=0$. Besarnya tidak boleh lebih kecil dari kekuatan momen yang diperlukan M_{ox} .
- d) Hitung kekuatan momen nominal aktual M_{oyn} untuk momen lentur uniaksial ekuivalen terhadap sumbu y untuk $M_{oy}=0$.
- e) Carilah M_{ny} dengan memasukkan M_{nx}/M_{oxn} dan harga β coba-coba pada gambar 4.8.
- f) Lakukan coba-coba dan penyesuaian berikutnya dengan memperbesar β apabila M_{nx} yang diperoleh dari diagram lebih kecil dari M_{ny} yang diperlukan.

Ulangi langkah-langkah diatas sampai harga kedua M_{nx} sama, baik dengan mengubah-ubah harga β maupun dengan mengubah-ubah penampangnya.



Gambar 4.8. diagram faktor kontur β untuk kolom segiempat yang mengalami lentur biaksial.

Cara perancangan

Menghitung momen lentur uniaksial ekuivalen dengan menganggap banyaknya tulangan pada semua sisi sama.

Anggap bahwa $\phi = 0,7$ untuk kolom bersengkang.

$$P_n = \frac{P_u}{\phi}$$

$$M_{nx} = \frac{M_{ux}}{\phi}$$

$$M_{ny} = \frac{M_{uy}}{\phi}$$

eksentrisitas ekuivalen = $\frac{M_{nx}}{M_{ny}}$ atau sebaliknya

diasumsikan nilai faktor kontur interaksi β

$$M_{ox_{ekuivalen}} = M_{nx} + M_{ny} \frac{h}{b} \frac{1 - \beta}{\beta}$$

kontrol kapasitas P_n penampang yang telah di asumsikan.

$$A_s = A_s'$$

Analisis kondisi balanced:

$$C_b = \frac{600d}{600 + f_y}$$

$$a_b = \beta_1 \cdot C_b$$

$$f_s' = 600 \left(\frac{C_b - d'}{C_b} \right)$$

Jika $f_s' > f_y$ dengan demikian digunakan $f_s' = f_y$

$$P_{nb} = 0,85 \cdot f_c' \cdot b \cdot a_b + A_s' \cdot f_s' - A_s \cdot f_y$$

Selanjutnya analisis tampang terhadap beban yang bekerja.

$$\rho = \frac{A_s}{b \cdot d}$$

$$m = \frac{f_y}{0,85 \cdot f_c'}$$

$$e = \frac{M_{oy}}{P_n}$$

$$P_n = 0,85 \cdot f_c' \cdot b \cdot d \left[\frac{h - 2e}{2d} + \sqrt{\left(\frac{h - 2e}{2d} \right)^2 + 2m\rho \left(1 - \frac{d'}{d} \right)} \right]$$

$$P_r = \theta \cdot P_n$$

$$P_r > 0,1 \cdot A_g \cdot f_c'$$

Maka tetap dipakai $\theta = 0,7$.

Cek apakah benar tegangan pada tulangan desak $f_s' \geq f_y$

$$a = \frac{P_n}{0,85 \cdot f_c' \cdot b}$$

$$C = \frac{a}{0,85}$$

$$f_s' = 600 \left(\frac{C - 50}{C} \right)$$

Kemudian dihitung momen tahanan nominal aktual $M_{o,yn}$ untuk lentur uniaksial ekuivalen terhadap sumbu y ($M_{oy} = 0$). Keruntuhan yang terjadi adalah keruntuhan tarik. Dengan menganggap bahwa pada keadaan beban P_n yang diperlukan tulangan tekan telah leleh, maka didapat :

$$a = \frac{P_n}{0,85 \cdot f_c' \cdot b}$$

$$C = \frac{a}{0,85}$$

$$f_s' > f_y < f_y = 400 \text{ asumsi benar}$$

$$M_{o,yn} = P_u \cdot e$$

$$= 0,85 \cdot f_c' \cdot b \cdot a \cdot \left(\frac{h}{2} - \frac{a}{2} \right) + A_s' \cdot f_s' \left(\frac{h}{2} - d' \right) + A_s \cdot f_y \left(d - \frac{h}{2} \right)$$

Selanjutnya menentukan momen tahanan nominal aktual $M_{o,sn}$ untuk momen lentur uniaksial ekuivalen terhadap sumbu x dimana $M_{oy} = 0$.

Dalam kondisi ini $A_s = A_s'$

Menentukan tinggi blok tegangan a atau tinggi garis netral dengan coba-coba dan penyesuaian sehingga P_n yang dihitung mendekati P_n yang diperlukan.

Kemudian digunakan a coba-coba yang sesuai untuk menghitung M_{oxn}

$$M_{oxn} = P_u \cdot e$$

$$= 0,85 \cdot f_c' \cdot b \cdot a \cdot \left(\frac{h}{2} - \frac{a}{2} \right) + A_s' \cdot f_s' \cdot \left(\frac{h}{2} - d' \right) + A_s \cdot f_y \cdot \left(d - \frac{h}{2} \right)$$

kemudian untuk mencari M_{nx} diperlukan data nilai M_{ny}/M_{oy} dan faktor β yang selanjutnya diplotkan pada diagram faktor kontur.

Dari kedua data tersebut diperoleh nilai $\frac{M_{nx}}{M_{oxn}}$ yang kemudian nilai

tersebut dikalikan dengan M_{oy} guna mencari M_{nx} . Ukuran penampang dan penulangannya dapat digunakan apabila nilai $M_{nx} >$ dari M_{nx} perlu.

b. Perencanaan kolom terhadap gaya geser

Perencanaan pada penulangan geser kolom, digunakan sebagai pembatas gaya geser rencana (V_u), sama dengan kuat geser beton (V_c) ditambah kuat geser tulangan geser (V_s).

$$V_u \leq \phi V_n$$

$$\text{Dimana } V_n = V_c + V_s \quad \text{SKSNI T-15-1991-03 pers (3.4 - 1)}$$

$$\text{Sehingga } V_u/\phi \leq V_c + V_s \quad \text{SKSNI T-15-1991-03 pers (3.4 - 2)}$$

Untuk sengkang tegak (vertikal), V_s dapat dihitung menggunakan persamaan (3.4 - 17) SKSNI T-15-1991-03:

$$V_s = \frac{A_v \cdot f_y \cdot d}{S}$$

BAB V ANALISIS STRUKTUR

A. Umum

Perencanaan beban struktur didaerah gempa, perencanaan limit *state designnya* disebut *capacity design* yang berarti bahwa ragam keruntuhan akibat beban gempa yang besar ditentukan lebih dulu dengan elemen-elemen kritisnya dipilih sedemikian rupa agar mekanisme keruntuhannya dapat memancarkan energi yang sebesar-besarnya.

Beban gempa merupakan beban yang sangat tidak dapat di perkirakan baik besarnya maupun arahnya. Besarnya gaya gempa sangat ditentukan oleh perilaku struktur tersebut. Gaya horisontal, gaya vertikal, momen torsi yang terjadi sangat tergantung pada waktu getar struktur dan eksentrisitas antara pusat kekakuan struktur dengan pusat massa struktur.

B. Perencanaan Dimensi Struktur

1. Penentuan Dimensi Balok

Balok yang digunakan dalam penentuan dimensi digunakan balok yang diperkirakan menerima beban paling besar dengan menggunakan perkiraan pembebanan kasar.

a. Pembebanan

1) Beban mati

a) Beban merata

| | | |
|-------------------|--|---|
| - Berat plat | $= 0,12 \cdot 7,2 \cdot 24 \text{ kN/m}^3$ | $= 20.736 \text{ kN/m}$ |
| - Berat tegel | $= 0,01 \cdot 7,2 \cdot 24 \text{ kN/m}^3$ | $= 1,728 \text{ kN/m}$ |
| - Berat instalasi | $= 7,2 \cdot 0,20 \text{ kN/m}^2$ | $= 1,44 \text{ kN/m}$ |
| - Berat partisi | $= 3,8 \cdot 0,5 \text{ kN/m}^2$ | $= 9,5 \text{ kN/m}$ |
| - Berat spesi | $= 0,02 \cdot 7,2 \cdot 21 \text{ kN/m}^3$ | $= 3,024 \text{ kN/m} +$ $= 36,544 \text{ kN/m}$ |

b) Beban titik

- Balok anak $= \overset{40 \text{ kN}}{(0,4 \cdot 0,4)} 7,2 \cdot 24 \text{ kN/m}^3 = 27,648 \text{ kN}$.

2) Beban Hidup

Beban hidup untuk bangunan kantor

$$: 2,5 \text{ kN/m}^2 \cdot 7,2 = 18 \text{ kN/m.}$$

Beban terfaktor

$$\text{Beban merata (q)} = 1,2 \cdot 36,544 + 1,6 \cdot 18 = 72,653 \text{ kN/m.}$$

$$\text{Beban titik (P)} = 1,2 \cdot 27,648 = 33,178 \text{ kN.}$$

b. Perkiraan penampang

Bentang bersih maksimal = 9,6 m

$$\begin{aligned} f_c' &= 22,5 \text{ Mpa} \\ &= 22500 \text{ kN/m}^2 \end{aligned}$$

$$\begin{aligned} E_c &= 4700 \sqrt{22,5} \\ &= 22294,0575 \text{ Mpa} \end{aligned}$$

$$E_c = 200.000 \text{ Mpa}$$

$$f_y = 400 \text{ Mpa}$$

ukuran penampang minimum didapat apabila tulangannya maksimum :

$$A_{\text{maks}} = 0,75 A_b \longrightarrow \rho_{\text{maks}} = 0,75 \rho_b$$

Pada kondisi ini $f_s = f_y$

$$\rho_{\text{maks}} = 0,75 \cdot 0,85 \cdot \beta_1 \frac{f_c'}{f_y} \cdot \frac{0,003}{0,003 + f_y / E_s}$$

$$\beta_1 = 0,85$$

$$\phi = 0,8$$

$$\rho_{\text{maks}} = 0,75 \cdot 0,85 \cdot 0,85 \cdot \frac{22,5}{400} \cdot \frac{0,003}{0,003 + 400 / E_s}$$

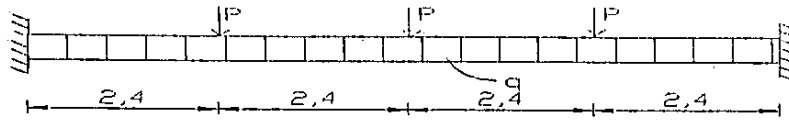
$$\rho_{\text{maks}} = 0,01907$$

$$M_u = \phi \cdot \rho_{\text{maks}} \cdot f_y \cdot b \cdot d^2 \left[1 - 0,59 \rho_{\text{maks}} \frac{f_y}{f_c'} \right]$$

$$M_u = 0,8 \cdot 0,01907 \cdot 400000 \cdot b \cdot d^2 \left[1 - 0,59 \cdot 0,01907 \frac{400000}{225000} \right]$$

$$M_u = 4882b \cdot d^2$$

$$\text{Berat sendiri balok} = b \cdot h \cdot 24$$



Gambar 5.1. Batang balok dengan beban rencana

misal : $h = d + 60$

Dimana diperkirakan jarak tepi tarik sampai pusat berat tulangan = 60 mm

$$\begin{aligned}\text{Berat sendiri} &= b(d + 0,06) \cdot 24 \\ &= 24bd + 1,44b\end{aligned}$$

$$\begin{aligned}MA &= \frac{1}{12} \cdot (72,653 + 24bd + 1,440b) \cdot 9,6^2 + \frac{2,4}{9,6} \frac{33,178 \cdot 7,2 \cdot 2,4}{9,6} + \frac{4,8}{9,6} \frac{33,178 \cdot 4,8 \cdot 4,8}{9,6} \\ &+ \frac{7,2}{9,6} \frac{33,178 \cdot 2,4 \cdot 7,2}{9,6}\end{aligned}$$

$$MA = 557,975 + 184,2bd + 11,06d + 14,93 + 39,814 + 44,79 = 4882 bd^2$$

diasumsikan $b = \frac{1}{2} d$ maka didapat

$$657,509 + 92,16d^2 + 11,06d = 2441d^3$$

$$2441d^3 - 92,1d^2 - 11,06d - 657,509 = 0$$

$$d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$$

Tabel 5.1. Trial & Error tinggi efektif penampang balok

| d (m) | Persamaan | hasil |
|----------|--|----------|
| 0,6 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | 0.053659 |
| 0,7 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | -0.06823 |
| 0,61 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | -0.05772 |
| 0,62 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | -0.04686 |
| 0,63 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | -0.03563 |

| | | |
|------|--|----------|
| 0,64 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | -0.02404 |
| 0,65 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | -0.012 |
| 0,66 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | 0.000291 |
| 0,67 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | 0.013036 |
| 0,68 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | 0.026174 |
| 0,69 | $d^3 - 0,03776d^2 - 0,0020586d - 0,2694 = 0$ | 0.039713 |

Diambil d yang hasilnya mendekati nol = 0,66 m

$$h = d + d'$$

$$h = 0,66 + 0,06 = 0,72 \text{ m}$$

digunakan tinggi balok 70 cm

$$b = \frac{1}{2} d$$

$$= \frac{1}{2} \cdot 66 = 33 \text{ cm}$$

digunakan lebar balok 40 cm

Bentang bersih maksimal = 9,6 m

$$\begin{aligned} \text{Lebar minimal} &= 9600/50 \\ &= 192 \text{ mm.} \\ &= 19,2 \text{ cm} \end{aligned}$$

$b > b$ minimal

sehingga lebar balok bisa digunakan.

2. Penentuan Dimensi Kolom

Kolom yang digunakan adalah kolom yang diperkirakan menerima beban paling besar dengan menggunakan perkiraan pembebanan kasar.

a. Pembebanan

1) Beban mati

$$\begin{aligned} - \text{Berat plat} &= 0,12 \cdot 7,2 \cdot (1,2 + 4,8) \cdot 24 \text{ kN/m}^3 = 124,416 \text{ kN} \\ - \text{Berat tegel} &= 0,01 \cdot 7,2 \cdot (1,2 + 4,8) \cdot 24 \text{ kN/m}^3 = 10,268 \text{ kN} \\ - \text{Berat instalasi} &= 7,2 \cdot (1,2 + 4,8) \cdot 0,20 \text{ kN/m}^2 = 8,64 \text{ kN} \\ - \text{Berat plafond} &= 7,2 \cdot (1,2 + 4,8) \cdot 0,20 \text{ kN/m}^2 = 8,64 \text{ kN} \end{aligned}$$

$$\begin{aligned}
 - \text{Berat Tembok} &= 3,8 \cdot (7,2 + 6 + 22,8) \cdot 2,5 \text{ kN/m}^2 = 342 \text{ kN} \\
 - \text{Berat spesi} &= 0,02 \cdot 7,2 \cdot (1,2 + 4,8) \cdot 21 \text{ kN/m}^3 = 18,144 \text{ kN} \\
 - \text{Berat balok} &= 0,7 \cdot 0,4 \cdot (7,2 + 6) \cdot 24 \text{ kN/m}^3 = 88,704 \text{ kN} \\
 - \text{Balok anak} &= 0,4 \cdot 0,4 \cdot 22,8 \cdot 24 \text{ kN/m}^3 = 87,552 \text{ kN} \\
 &= 688,364 \text{ kN}
 \end{aligned}$$

2) Beban Hidup

Beban hidup untuk bangunan kantor

$$= 3 \text{ kN/m}^2 \cdot 6 \cdot 7,2 = 129,6 \text{ kN}$$

$$\text{Beban terfaktor} = 1,2 \cdot 688,364 + 1,6 \cdot 129,6 = 1033,40 \text{ kN}$$

$$\text{Jumlah lantai + atap} = 5$$

$$\text{Sehingga } P = 1033,40 \cdot 5 = 5167 \text{ kN}$$

b. Perkiraan penampang

$$\begin{aligned}
 f_c' &= 22,5 \text{ Mpa} \\
 &= 22500 \text{ kN/m}^2
 \end{aligned}$$

perkiraan penampang dapat dihitung dengan rumus :

$$0,3-0,6 = \frac{P}{0,9 \cdot f_c' \cdot A_g}$$

$$\begin{aligned}
 A_g &= \frac{P}{0,9 \cdot f_c' \cdot 0,6} \\
 &= \frac{5167}{0,9 \cdot 22500 \cdot 0,6} = 0,4253 \text{ m}^2
 \end{aligned}$$

$$\begin{aligned}
 b &= \sqrt{0,4235} \\
 &= 0,65213 \text{ m}
 \end{aligned}$$

perkiraan tersebut belum termasuk berat kolom, sehingga bila berat kolom dimasukkan :

di ambil lebar rencana 70 cm

$$W_{\text{kolom}} = 0,7 \cdot 0,7 \cdot 3,8 \cdot 24 \cdot 5 = 223,44 \text{ kN}$$

Perkiraan penampang kolom bila berat kolom dimasukkan dengan lebar rencana 70 cm :

$$A_g = \frac{P}{0,9 \cdot f_c' \cdot 0,6}$$

$$= \frac{5390,44}{0,9.22500.0,6} = 0,44366 \text{ m}^2.$$

$$b = \sqrt{0,44366}$$

$$= 0,6661 \text{ m}$$

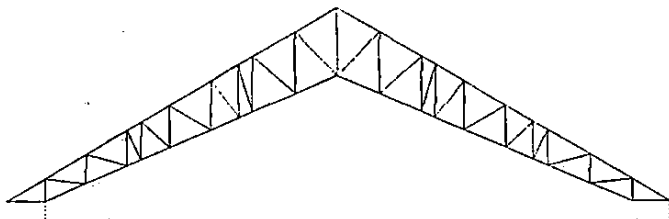
diambil lebar kolom 70 cm x 70 cm sebagai antisipasi terhadap beban yang tak terduga seperti beban angin dan beban gempa.

C. Perhitungan Pembebanan Struktur

1. Beban Mati

a. Beban Kuda-kuda

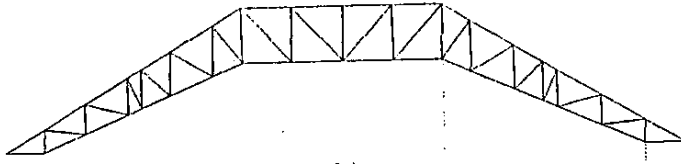
1) Kuda-kuda tipe KK1 :



Gambar 5.2. Kuda-kuda tipe KK1

| | |
|---|----------------|
| Beban mati kuda-kuda KK1 | = 666,52 kg |
| Berat langit-langit dan penggantung : 18.3,6.24,4 | = 1581,12 kg |
| Berat gording: 880.3,6.0,12.0,08.16 | = 486,6 kg |
| Berat atap : 50.3,6.29,787 | = 5361,66 kg + |
| Berat total | = 8095,9 kg |
| | = 80,959 kN |
| Berat yang dipikul oleh masing-masing tumpuan | = 40,4795 kN |

2) Kuda-kuda tipe KK2 :



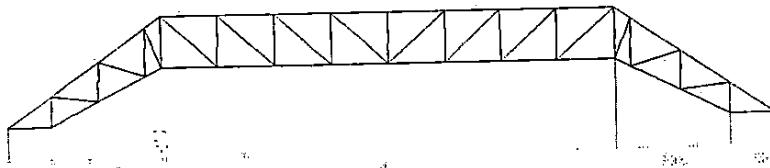
Gambar 5.3. Kuda-kuda tipe KK2

| | |
|---|----------------|
| Beban mati kuda-kuda KK2 | = 662,454 kg |
| Berat langit-langit dan penggantung : 18.3,6.24,4 | = 1581,12 kg |
| Berat gording: 880.3,6.0,12.0,08.16 | = 486,6 kg |
| Berat atap : 50.3,6.29,787 | = 5361,66 kg + |
| Berat total | = 8091,834 kg |
| | = 80,9183 kN |

Berat yang dipikul oleh masing-masing tumpuan

$$: 80,9183/2 = 40,4592 \text{ kN}$$

3) Kuda-kuda tipe KK3:



Gambar 5.4. Kuda-kuda tipe KK3

| | |
|---|--------------|
| Beban mati kuda-kuda KK3 | = 616,822 kg |
| Berat langit-langit dan penggantung : 18.3,6.24,4 | = 1581,12 kg |
| Berat gording: 880.3,6.0,12.0,08.16 | = 486,6 kg |

$$\begin{aligned} \text{Berat atap} &: 50.3,6.29,787 &= \underline{5361,66 \text{ kg}} + \\ \text{Berat total} &&= 8046,20 \text{ kg} \\ &&= 80,462 \text{ kN} \end{aligned}$$

Berat yang dipikul oleh masing-masing tumpuan :
 $: 80,462/2 = 40,231 \text{ kN}$

b. Beban Pelat Atap

$$\begin{aligned} \text{Berat sendiri plat} &: 0,12 \cdot 24 &= 2,88 \text{ kN/m}^2. \\ \text{Berat langit-langit dan penggantung} &&= 0,20 \text{ kN/m}^2. \\ \text{Berat aspal 2,5 cm} &: 2,5 \cdot 0,14 &= \underline{0,35 \text{ kN/m}^2} + \\ \text{Berat total} &&= 3,41 \text{ kN/m}^2. \end{aligned}$$

c. Beban tiap lantai

1) Beban merata tiap m^2 .

$$\begin{aligned} \text{Berat sendiri plat} &: 0,12 \cdot 24 &= 2,88 \text{ kN/m}^2. \\ \text{Berat langit-langit dan penggantung} &&= 0,20 \text{ kN/m}^2. \\ \text{Berat spesi tebal 2 cm} &: 2 \cdot 0,21 &= 0,42 \text{ kN/m}^2. \\ \text{Berat tegel} &&= 0,24 \text{ kN/m}^2. \\ \text{Berat instalasi} &&= \underline{0,20 \text{ kN/m}^2} + \\ \text{Berat total} &&= 3,94 \text{ kN/m}^2. \end{aligned}$$

2) Beban merata tiap meter

$$\begin{aligned} \text{Berat tembok} &: 3,8 \cdot 2,5 \text{ kN/m}^2 &= 9,5 \text{ kN/m} \\ \text{Berat partisi} &: 3,8 \cdot 0,5 \text{ kN/m}^2 &= 1,9 \text{ kN/m} \end{aligned}$$

3) Beban titik

Beban mati pada plat lantai yang di distribusikan oleh grid.

2. Beban hidup

a. Beban hidup kuda-kuda

Beban hidup pada kuda-kuda diperhitungkan terhadap air hujan yang dihitung dengan rumus :

$$WL = (40 - 0,8\alpha) < 20 \text{ kg/m}^2.$$

Dimana α adalah sudut kemiringan atap.

Jadi beban hidup kuda-kuda adalah :

$$WL = (40 - 0,8 \cdot 35) \\ = 12 \text{ kg/m}^2 \text{ jadi dipakai beban hidup } 20 \text{ kg/m}^2.$$

b. Beban hidup plat

1) Beban merata

Beban hidup plat lantai yang berfungsi sebagai kantor menurut Peraturan Pembebanan Indonesia untuk Gedung tahun 1983 adalah 250 kg/m^2 , sedangkan untuk plat atap diambil sebesar 100 kg/m^2 .

2) Beban titik

Berupa beban hidup pada plat lantai yang didistribusikan melalui grid.

c. Perhitungan beban gempa

1) Berat Bangunan

Beban pelat atap tiap meter persegi

| | |
|---------------------------------------|-------------------------|
| Berat sendiri plat : $0,12 \cdot 24$ | $= 2,88 \text{ kN/m}^2$ |
| Berat langit-langit dan penggantung | $= 0,20 \text{ kN/m}^2$ |
| Berat aspal 2,5 cm : $2,5 \cdot 0,14$ | $= 0,35 \text{ kN/m}^2$ |
| Berat total | $= 3,41 \text{ kN/m}^2$ |

Beban pelat lantai tiap meter persegi

| | |
|---|-------------------------|
| Berat sendiri plat : $0,12 \cdot 24$ | $= 2,88 \text{ kN/m}^2$ |
| Berat langit-langit dan penggantung | $= 0,20 \text{ kN/m}^2$ |
| Berat spesi tebal 2 cm : $2 \cdot 0,21$ | $= 0,42 \text{ kN/m}^2$ |
| Berat tegel | $= 0,24 \text{ kN/m}^2$ |
| Berat instalasi | $= 0,20 \text{ kN/m}^2$ |
| Berat total | $= 3,94 \text{ kN/m}^2$ |

Beban atap tiap meter persegi

| | |
|---|-------------------------|
| Berat sendiri rangka atap | |
| : $((2 \cdot 6,66) + (4 \cdot 6,63) + (4 \cdot 6,17)) / 466,56$ | $= 0,35 \text{ kN/m}^2$ |
| Berat langit-langit dan penggantung | $= 0,20 \text{ kN/m}^2$ |
| Berat genteng dan usuk | $= 0,50 \text{ kN/m}^2$ |
| Beban hidup | $= 0,20 \text{ kN/m}^2$ |
| Berat total | $= 1,25 \text{ kN/m}^2$ |

a) Portal As A dan F

Berat atap

| | | |
|-------|----------------------|--|
| Atap | : 12,3.21,6.1,25 | = 332,10 kN |
| Ring | : 0,3.0,5.24.21,6 | = 77,760 kN |
| Kolom | : (0,6.0,6.24).1,9.4 | = 65,664 kN |
| | | <u>W_{atap} = 475,524 kN</u> + |

(dibulatkan)

Berat Lantai 1 s/d 4 (tingkat 2 s/d 5)

| | | |
|-----------------------|------------------|--|
| Kolom | : 8,64.3,8.4 | = 131,328 kN |
| Lantai | : 2,4.21,6.3,94 | = 228,100 kN |
| Balok | : 6,72.4,8.4 | = 129,024 kN |
| Balok | : 6,72.21,6 | = 145,52 kN |
| Balok | : 1,5.4,32.21,60 | = 139,969 kN |
| Tembok | : 2,5.3,2.21,6 | = 172,800 kN |
| Beban hidup tereduksi | 0,6.2,4.21,6.3 | = 93,312 kN |
| | | <u>W_{1 s/d W₄} = 1040 kN</u> + |

b) Portal As C dan D

Berat lantai 1 s/d 4 (tingkat 2 s/d 5)

| | | |
|-------------------|------------------|--|
| Kolom | : 8,64.3,8.6 | = 197,02 kN |
| Lantai | : 6,0.21,6.3,94 | = 570,240 kN |
| Balok | : 6,72.21,60 | = 145,152 kN |
| Balok | : 6,72.6.4 | = 161,280 kN |
| Balok | : 2,5.3,20.21,60 | = 172,800 kN |
| B.Hidup tereduksi | : 0,6.6,00.21,60 | = 233,280 kN |
| | | <u>W_{1 s/d W₄} = 1687,200 kN</u> + |

c) Portal As 2 dan 5

Berat atap

| | | |
|------|-------------------|-------------|
| Atap | : 12,3.21,6.1,25 | = 332,1 kN |
| Ring | : 0,3.0,5.24.21,6 | = 77,760 kN |

$$\begin{aligned} \text{Kolom} & : (0,6.0,6.24).1,9.6 = 98,496 \text{ kN} \\ & \qquad \qquad \qquad W_{\text{atap}} = 508,356 \text{ kN} \quad + \end{aligned}$$

Berat Lantai 1 s/d 4 (tingkat 2 s/d 5)

$$\begin{aligned} \text{Kolom} & : 8,64.3,8.6 = 196,100 \text{ kN} \\ \text{Lantai} & : 3,6.21,6.3,94 = 342,144 \text{ kN} \\ \text{Lantai} & : 1,8.12,3,94 = 95,040 \text{ kN} \\ \text{Balok} & : 6,72.3,6.6 = 145,152 \text{ kN} \\ \text{Balok} & : 6,72.1,8.4 = 48,364 \text{ kN} \\ \text{Balok} & : 4,8.3,60.4 = 69,120 \text{ kN} \\ \text{Balok} & : 6,72.21,60 = 145,152 \text{ kN} \\ \text{Tembok} & : 2,5.3,2.21,6 = 172,800 \text{ kN} \end{aligned}$$

Beban hidup tereduksi

$$\begin{aligned} & : 0,6.1,80.12.2,00 = 32,400 \text{ kN} \\ & : 0,6.3,60.21,60.2,50 = 116,640 \text{ kN} \\ & \qquad \qquad \qquad W_1 \text{ s/d } W_4 = 1363 \text{ kN} \end{aligned}$$

d) Portal As 1 dan 6

Berat atap

$$\begin{aligned} \text{Atap} & : 1,9.12.3,41 = 77,748 \text{ kN} \\ \text{Ring} & : 0,3.0,5.24.12 = 31,200 \text{ kN} \\ \text{Kolom} & : (0,6.0,6.24).1,9.4 = 65,664 \text{ kN} \\ & \qquad \qquad \qquad W_{\text{atap}} = 174,612 \text{ kN} \quad + \end{aligned}$$

Berat Lantai 1 s/d 4 (tingkat 2 s/d 5)

$$\begin{aligned} \text{Kolom} & : 0,7.0,7.24.3,8.4 = 178,750 \text{ kN} \\ \text{Lantai} & : 0,8125.1,8.3,94.12 = 77,220 \text{ kN} \\ \text{Balok} & : 0,4.0,7.24.12 = 80,640 \text{ kN} \\ \text{Balok} & : 6,72.1,8.4 = 48,390 \text{ kN} \\ \text{Tembok} & : 2,5.3,2.12 = 96,000 \text{ kN} \end{aligned}$$

Beban hidup tereduksi

$$\begin{aligned} & : 0,6.1,80.12.3,00 = 38,800 \text{ kN} \\ & \qquad \qquad \qquad W_1 \text{ s/d } W_4 = 519,800 \text{ kN} \quad + \end{aligned}$$

e) Portal As 3 dan 4

Beban Gempa

Berat lantai 1 s/d 4 (tingkat 2 s/d 5)

$$\text{Kolom} : 8,64.3,8.4 = 131,330 \text{ kN}$$

$$\text{Lantai} : 6,0.21,6.3,94 = 570,240 \text{ kN}$$

$$\text{Balok} : 6,72.21,60 = 145,152 \text{ kN}$$

$$\text{Balok} : 6,72.6.4 = 161,280 \text{ kN}$$

$$\text{Balok} : 2,5.3,20.21,60 = 172,800 \text{ kN}$$

Beban hidup tereduksi

$$: 0,6.6,00.21,60 = 233,280 \text{ kN} +$$

$$\text{W1 s/d W}_4 = 1880,5 \text{ kN}$$

Waktu Getar Bangunan (T)

Waktu getar bangunan ditentukan dengan rumus :

$$T_x = T_y = 0,06.H^{3/4}$$

H = 20 m , sehingga :

$$T_x = T_y = 0,06.20^{3/4}$$

$$= 0,5674 \text{ detik.}$$

Koefisien Gempa Dasar

Koefisien gempa dasar diperoleh dari grafik Respon Percepatan struktur. Untuk $T_x = T_y = 0,5674$ detik, dengan wilayah gempa 3 dan dengan jenis tanah lunak, maka diperoleh nilai $C = 0,07$.

Faktor Keutamaan (I) dan Faktor Jenis Struktur (K)

Dari Pedoman Perencanaan Ketahanan Gempa Untuk Rumah dan Gedung diperoleh nilai I untuk bangunan kantor = 1 dan K untuk bangunan dengan perencanaan daktilitas penuh = 1.

Gaya Geser Horisontal Akibat Gempa

$$V_x = V_y = C.I.K.W_t$$

a) Portal As A & F

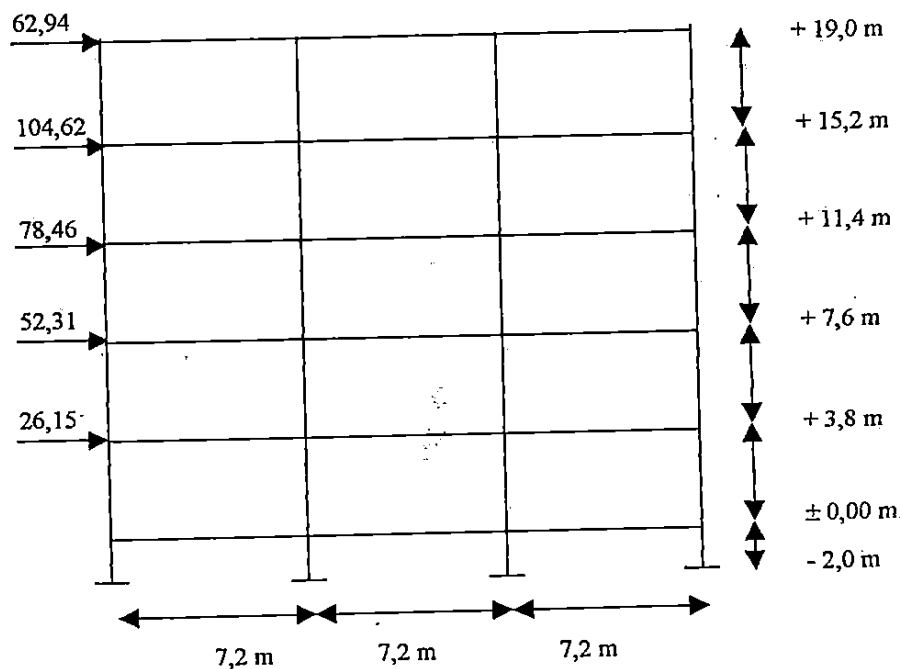
$$W_{\text{total}} = 475,524 + 4 \cdot 1040 = 4635,52 \text{ kN (dibulatkan)}$$

$$V = C.I.K. \cdot W_e = 0,07 \cdot 1 \cdot 1 \cdot 4635,52$$

$$= 324,49 \text{ kN}$$

Tabel 5.2. Distribusi Gaya Lateral Akibat Gempa Portal As – A & F

| Tingkat | W_i (kN) | h_i (m) | $W_i \cdot h_i$ (kN.m) | $f_i = \frac{W_i \cdot h_i}{\sum W_i \cdot h_i} \cdot V$ (m) |
|---------|---------------|--------------|---------------------------|---|
| Atap | 475,524 | 20 | 9510,48 | 62,94 |
| 4 | 1040 | 16,20 | 15808 | 104,62 |
| 3 | 1040 | 12,40 | 11856 | 78,46 |
| 2 | 1040 | 8,6 | 7904 | 52,31 |
| 1 | 1040 | 4,8 | 3952 | 26,15 |
| | | | 49030,48 | 324,49 |



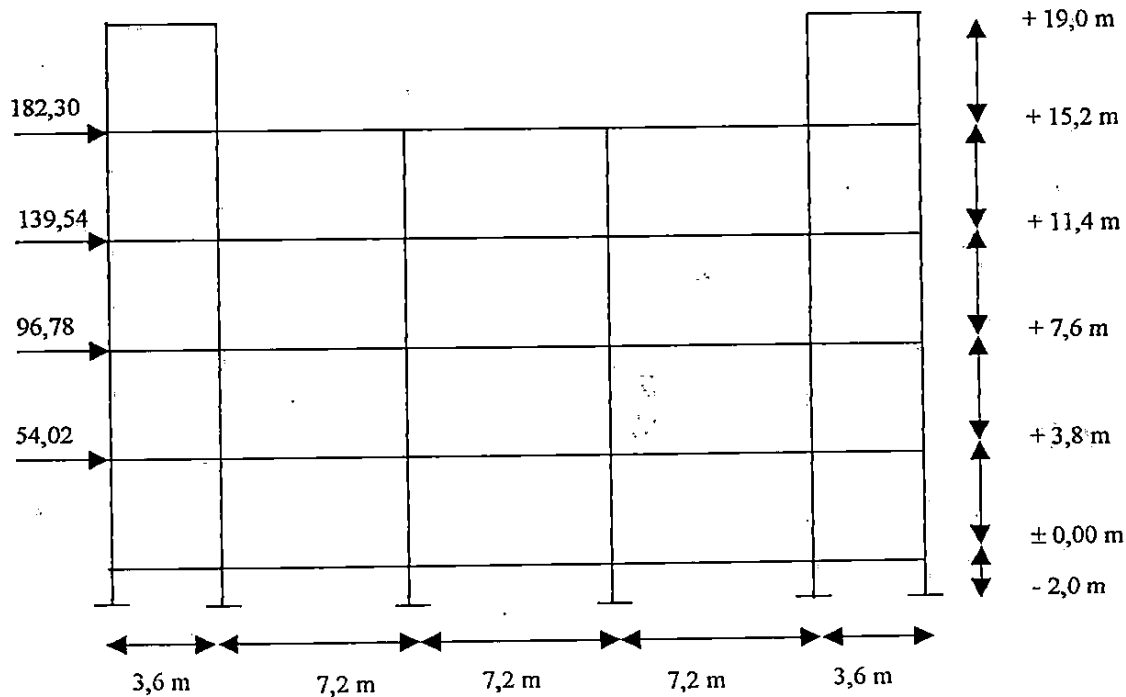
Gambar 5.5. Distribusi gaya geser horizontal akibat gempa sepanjang tinggi gedung pada Portal As – A & F

b) Portal As C & D

$$\begin{aligned} W_{tot} &= 4.1688 &= 6752 \text{ kN} \\ V &= C.I.K.W_c &= 0,07.1.1.6752 \\ &= 472,64 \text{ kN} \end{aligned}$$

Tabel 5.3. Distribusi Gaya Lateral Akibat Gempa Portal As – C & D

| Tingkat | W_i (kN) | h_i (m) | $W_i \cdot h_i$ (kN.m) | $f_i = \frac{W_i \cdot h_i}{\sum W_i \cdot h_i} \cdot V$ (m) |
|---------|---------------|--------------|---------------------------|---|
| 4 | 1688 | 16,20 | 27345,64 | 182,304 |
| 3 | 1688 | 12,40 | 20931,20 | 139,541 |
| 2 | 1688 | 8,6 | 14516,80 | 96,78 |
| 1 | 1688 | 4,8 | 8102,40 | 54,016 |
| | | | 87089,6 | 472,64 |



Gambar 5.6. Distribusi gaya geser horizontal akibat gempa sepanjang tinggi gedung pada Portal As – C & D

c) Portal As 1 & 6

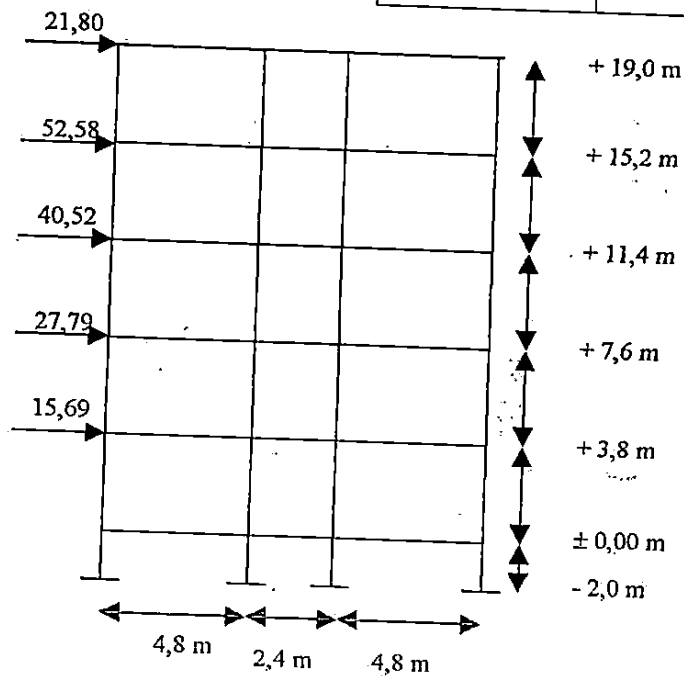
$$W_{\text{total}} = 174,612 + 4.519,8 = 2254,412 \text{ kN}$$

$$V = C.I.K.W_c = 0,07.1.1.2254,412$$

$$= 157,81 \text{ kN}$$

Tabel 5.4. Distribusi Gaya Lateral Akibat Gempa Portal As - 1 & 6

| Tingkat | W_i (kN) | h_i (m) | $W_i \cdot h_i$ (Kn.m) | $f_i = \frac{W_i \cdot h_i}{\sum W_i \cdot h_i} \cdot V$ (m) |
|---------|---------------|--------------|---------------------------|---|
| Atap | 174,612 | 20 | 3492,24 | 21,80 |
| 4 | 519,80 | 16,20 | 8420,76 | 52,58 |
| 3 | 519,80 | 12,40 | 6445,52 | 40,52 |
| 2 | 519,80 | 8,6 | 4420,28 | 27,79 |
| 1 | 519,80 | 4,8 | 2495,04 | 15,69 |
| | | | 25273,84 | 157,81 |



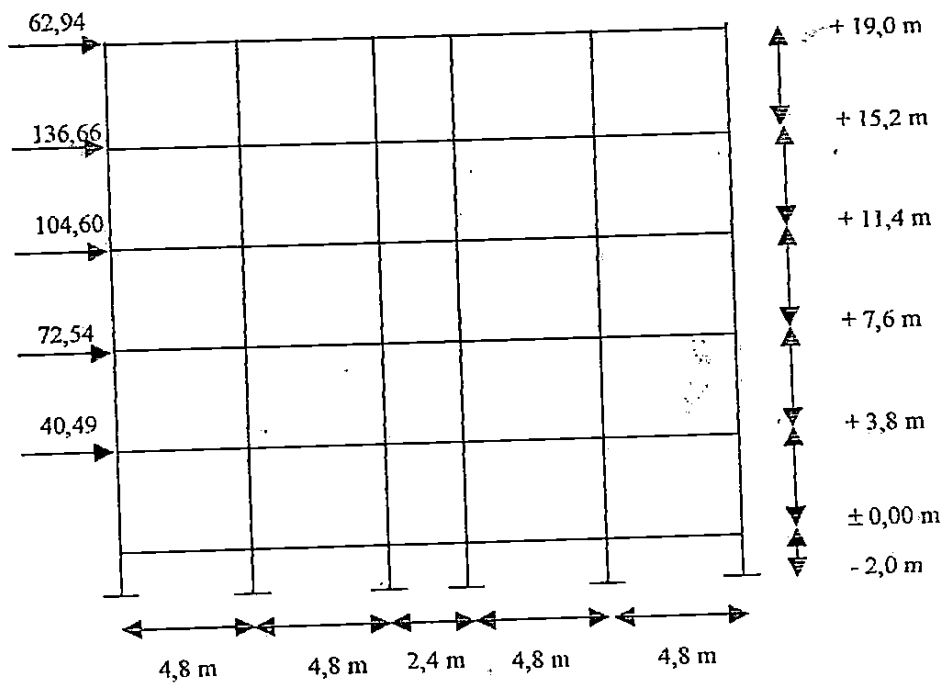
Gambar 5.7. Distribusi gaya geser horisontal akibat gempa sepanjang tinggi gedung pada Portal As - 1 & 6

d) Portal As 2 & 5

$$\begin{aligned}
 W_{\text{total}} &= 508,356 + 4.1363 = 5960,356 \text{ kN} \\
 V &= C.I.K.W_e = 0,07.1.1.5960,356 \\
 &= 417,22 \text{ kN}
 \end{aligned}$$

Tabel 5.5. Distribusi Gaya Lateral Akibat Gempa Portal As - 2 & 5

| Tingkat | W_i (kN) | h_i (m) | $W_i \cdot h_i$ (kN.m) | $f_i = \frac{W_i \cdot h_i}{\sum W_i \cdot h_i} \cdot V$ (m) |
|---------|---------------|--------------|---------------------------|---|
| Atap | 508,356 | 20 | 10167,12 | 62,93 |
| 4 | 1363 | 16,20 | 22080,6 | 136,66 |
| 3 | 1363 | 12,40 | 16901,2 | 104,60 |
| 2 | 1363 | 8,6 | 11721 | 72,54 |
| 1 | 1363 | 4,8 | 6542,4 | 40,49 |
| | | | 67412,32 | 417,22 |



Gambar 5.8. Distribusi gaya geser horisontal akibat gempa sepanjang tinggi gedung pada Portal As - 2 & 5

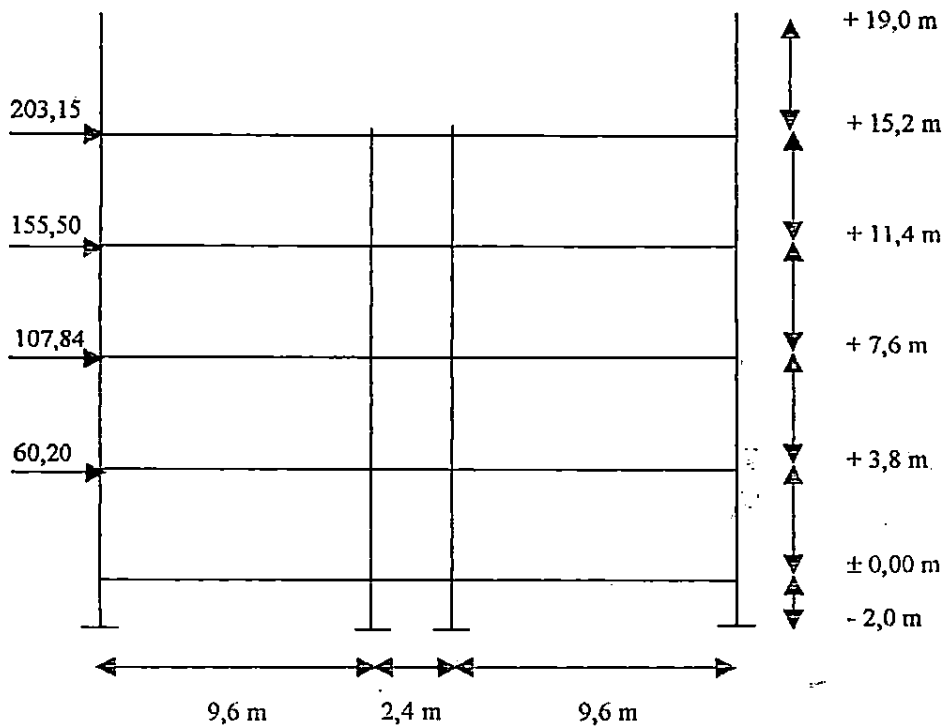
c) Portal As 3 & 4

$$W_{tot} : 4.1880,50 = 7524 \text{ kN}$$

$$V : 0,07.1.1.7524 = 526,68 \text{ Kn}$$

Tabel 5.6. Distribusi Gaya Lateral Akibat Gempa Portal As – 3 & 4

| Tingkat | W_i (kN) | h_i (m) | $W_i \cdot h_i$ (kN.m) | $f_i = \frac{W_i \cdot h_i}{\sum W_i \cdot h_i} \cdot V$ (m) |
|---------|---------------|--------------|---------------------------|---|
| 4 | 1880,50 | 16,20 | 30473 | 203,148 |
| 3 | 1880,50 | 12,40 | 23325 | 155,50 |
| 2 | 1880,50 | 8,6 | 16177 | 107,84 |
| 1 | 1880,50 | 4,8 | 9029 | 60,20 |
| | | | 79004 | 526,68 |



Gambar 5.9. Distribusi gaya geser horisontal akibat gempa sepanjang tinggi gedung pada Portal As – 3 & 4

6) Kontrol Waktu Getar dengan Cara T.Rayleigh.

Setelah melakukan analisis struktur maka dihitung besarnya simpangan bangunan (deformasi lateral akibat beban gempa).

Waktu getar struktur yang sebenarnya untuk tiap-tiap arah dihitung berdasarkan besar simpangan dengan rumus T.Rayleigh :

$$T_x = 6,3 \sqrt{\frac{\sum W_i \cdot d_{ix}^2}{g \cdot \sum F_{ix} \cdot d_{ix}}} \quad \text{untuk arah X}$$

$$T_y = 6,3 \sqrt{\frac{\sum W_i \cdot d_{iy}^2}{g \cdot \sum F_{iy} \cdot d_{iy}}} \quad \text{untuk arah Y}$$

dengan :

W_i = Berat lantai ke-i

F_i = Gaya gempa lantai ke-i

d_i = Deformasi lateral akibat F_i yang terjadi pada lantai ke-i

g = Percepatan gravitasi = $9,81 \text{ m/det}^2$.

Tabel 5.7. Waktu getar bangunan arah x (T_x) portal As-A & F

| Lantai | W_i (kN) | d_i x(m) | d_i^2 (m ²) | F_i x (kN) | $W_i \cdot d_{ix}^2$ (kNm ²) | $F_{ix} \cdot d_{ix}$ (kNm) |
|--------|------------|------------|---------------------------|--------------|---|--------------------------------|
| 5 | 475.524 | 0.00899 | 8.082E-05 | 62.94 | 0.038432 | 0.565831 |
| 4 | 1040 | 0.0077 | 0.00005929 | 104.62 | 0.061662 | 0.805574 |
| 3 | 1040 | 0.00635 | 4.0323E-05 | 78.46 | 0.041935 | 0.498221 |
| 2 | 1040 | 0.00442 | 1.9536E-05 | 52.31 | 0.020318 | 0.23121 |
| 1 | 1040 | 0.0022 | 0.00000484 | 26.15 | 0.005034 | 0.05753 |
| | | | | | 0.16738 | 2.158366 |
| | | | | $T =$ | 0.560139 > 0.4539 | |

Tabel 5.8. Waktu getar bangunan arah x (T_x) portal As-C & D

| Lantai | W_i (kN) | d_i x(m) | d_i^2 (m ²) | F_i x (kN) | $W_i \cdot d_{ix}^2$ (kNm ²) | $F_{ix} \cdot d_{ix}$ (kNm) |
|--------|------------|------------|---------------------------|--------------|---|--------------------------------|
| 4 | 1688 | 0.0077 | 0.00005929 | 182.304 | 0.100082 | 1.403741 |
| 3 | 1688 | 0.00635 | 4.0323E-05 | 139.540 | 0.068064 | 0.886079 |
| 2 | 1688 | 0.00442 | 1.9536E-05 | 96.780 | 0.032977 | 0.427768 |
| 1 | 1688 | 0.0022 | 0.00000484 | 54.016 | 0.00817 | 0.118835 |
| | | | | | 0.209293 | 2.836423 |
| | | | | $T =$ | 0.546384 > 0.4539 | |

Tabel 5.9. Waktu getar bangunan arah y (T_y) portal As-1 & 6

| Lantai | W_i (kN) | d_i x(m) | d_i^2 (m ²) | F_i x (kN) | $W_i \cdot d_i^2$ (kNm ²) | $F_i \cdot d_i$ (kNm) |
|--------|------------|------------|---------------------------|--------------|---------------------------------------|-----------------------|
| 5 | 174.612 | 0.01156 | 0.00013363 | 21.8 | 0.023334 | 0.252008 |
| 4 | 519.8 | 0.01057 | 0.00011172 | 52.58 | 0.058075 | 0.555771 |
| 3 | 519.8 | 0.0088 | 0.00007744 | 40.52 | 0.040253 | 0.356576 |
| 2 | 519.8 | 0.00617 | 3.8094E-05 | 27.79 | 0.019801 | 0.17152 |
| 1 | 519.8 | 0.00302 | 9.1325E-06 | 15.69 | 0.004747 | 0.047415 |
| | | | | | 0.14621 | 1.38329 |

$$T = 0.65394 > 0.4539$$

Tabel 5.10. Waktu getar bangunan arah y (T_y) portal As-2 & 5

| Lantai | W_i (kN) | d_i x(m) | d_i^2 (m ²) | F_i x (kN) | $W_i \cdot d_i^2$ (kNm ²) | $F_i \cdot d_i$ (kNm) |
|--------|------------|------------|---------------------------|--------------|---------------------------------------|-----------------------|
| 5 | 508.356 | 0.01164 | 0.00013549 | 62.93 | 0.068877 | 0.732505 |
| 4 | 1353 | 0.01057 | 0.00011172 | 136.66 | 0.151164 | 1.444496 |
| 3 | 1353 | 0.0088 | 0.00007744 | 104.6 | 0.104776 | 0.92048 |
| 2 | 1353 | 0.00617 | 3.8094E-05 | 72.54 | 0.051541 | 0.447717 |
| 1 | 1353 | 0.00302 | 9.1325E-06 | 40.49 | 0.012356 | 0.122361 |
| | | | | | 0.388714 | 3.667559 |

$$T = 0.654836 > 0.4539$$

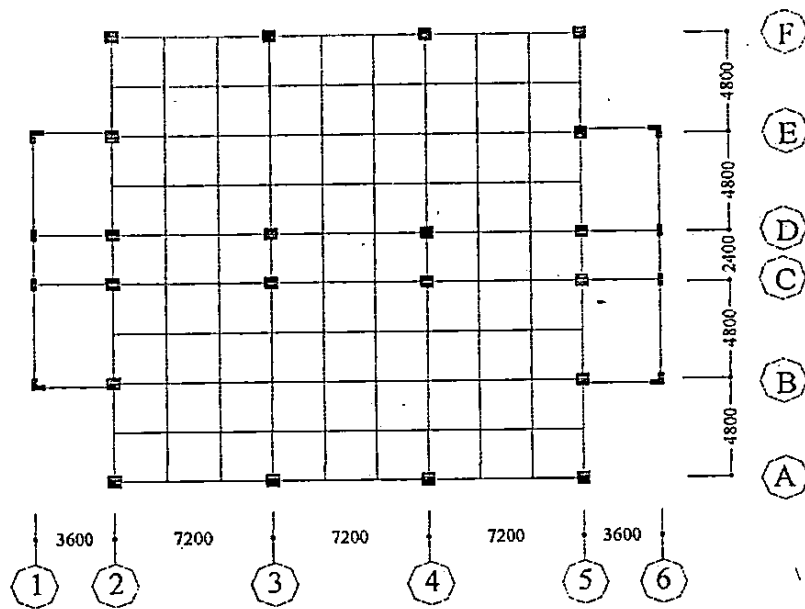
Tabel 5.11. Waktu getar bangunan arah y (T_y) portal As-3 & 4

| Lantai | W_i (kN) | d_i x(m) | d_i^2 (m ²) | F_i x (kN) | $W_i \cdot d_i^2$ (kNm ²) | $F_i \cdot d_i$ (kNm) |
|--------|------------|------------|---------------------------|--------------|---------------------------------------|-----------------------|
| 4 | 1880.5 | 0.01057 | 0.00011172 | 203.148 | 0.210099 | 2.147274 |
| 3 | 1880.5 | 0.0088 | 0.00007744 | 155.500 | 0.145626 | 1.3684 |
| 2 | 1880.5 | 0.00617 | 3.8069E-05 | 107.840 | 0.071589 | 0.665373 |
| 1 | 1880.5 | 0.00302 | 9.1325E-06 | 60.200 | 0.017174 | 0.181924 |
| | | | | | 0.444487 | 4.362972 |

$$T = 0.642014 > 0.4539$$

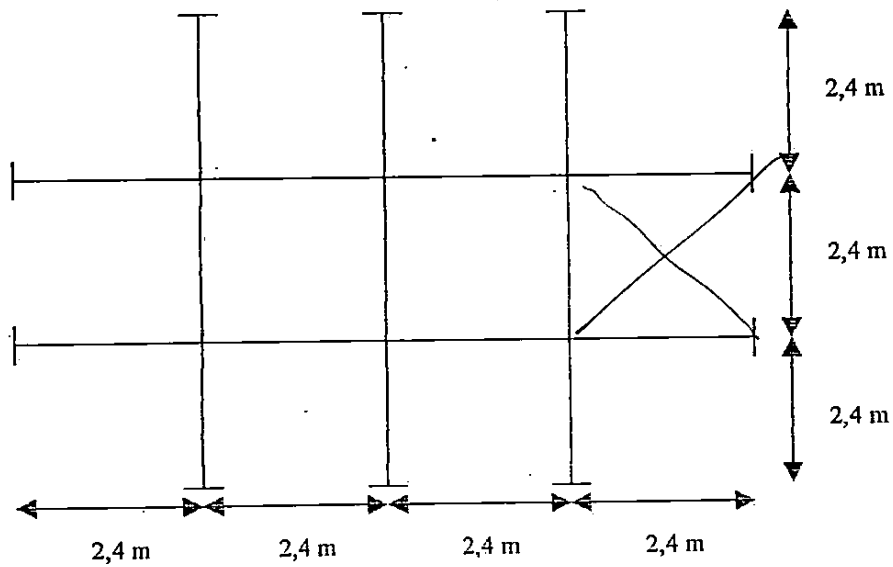
Dari kontrol waktu getar bangunan dengan cara T.Rayleigh didapat bahwa waktu getar bangunan (T) lebih besar dari 80% T awal sehingga tidak perlu desain ulang penampang. Sedangkan dari data defleksi yang ada diketahui bahwa simpangan antar lantai lebih kecil dari 2 cm, sehingga bangunan aman terhadap displacement yang terjadi.

D. Pembebanan Portal



Gambar 5.10. Denah struktur portal

1. Pembebanan grid



Gambar 5.11. Denah struktur grid

a. Beban mati

1) Beban trapesium

$$\text{Beban lantai } (q_1) : 3,94 \cdot 1,2 = 4,728 \text{ kN/m.}$$

2) Beban merata

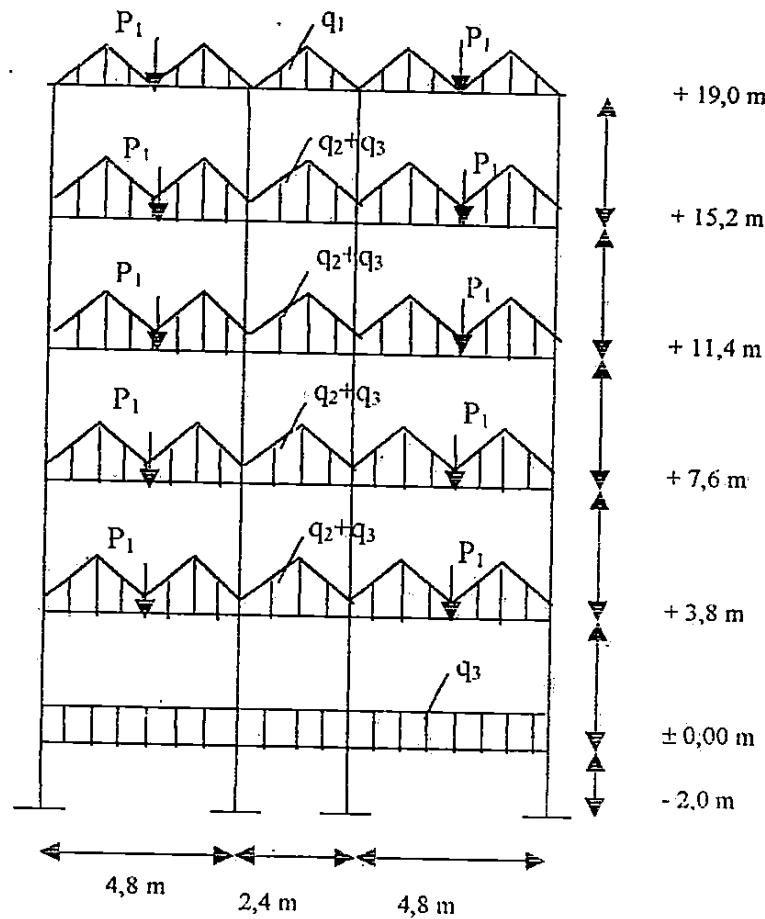
$$\text{Beban partisi } (q_2) : 0,5 \cdot 3,8 = 1,9 \text{ kN/m.}$$

b. Beban hidup

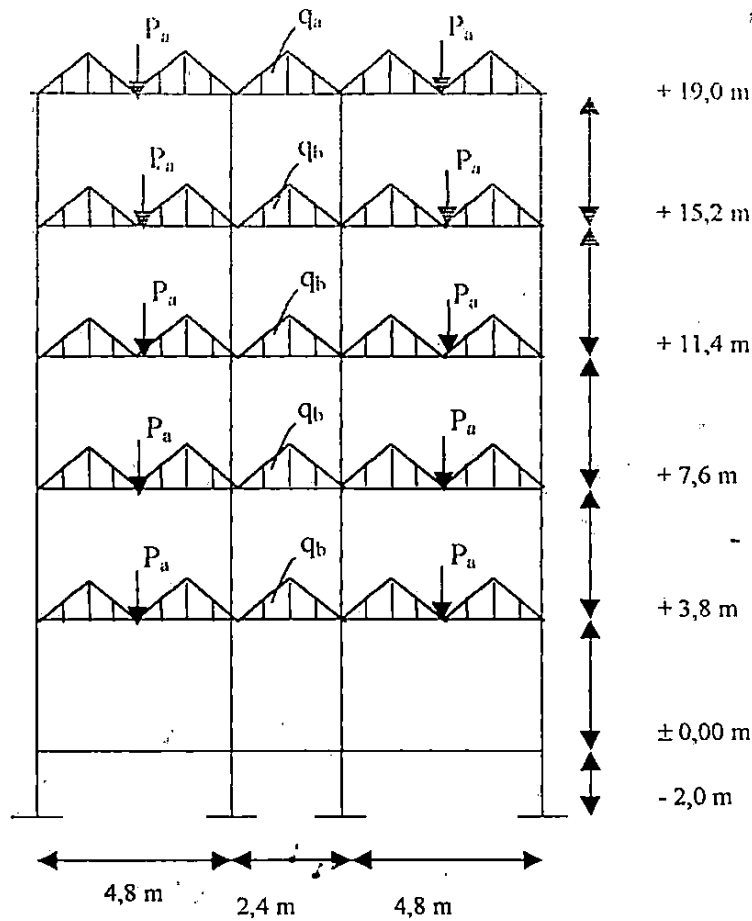
$$\text{Beban trapesium } (q_a) : 2,5 \cdot 1,2 = 3,0 \text{ kN/m.}$$

2. Pembebanan portal

a. Portal As 1 & 6



Gambar 5.12. Beban mati pada struktur portal As 1 & 6



Gambar 5.13. Beban hidup pada struktur portal As 1 & 6

1) Beban mati

a) Beban trapesium

$$\text{Beban atap (bentang 2,4 m) } (q_1) : 3,41 \cdot 1,2 = 4,092 \text{ kN/m}$$

$$\text{Beban lantai (bentang 2,4 m) } (q_2) : 3,94 \cdot 1,2 = 4,728 \text{ kN/m}$$

b) Beban merata

$$\text{Beban tembok } (q_1) : 2,5 \cdot 3,8 = 9,5 \text{ kN/m.}$$

c) Beban titik

Beban dari reaksi grid.

Dari hasil analisis struktur SAP 2000 didapat reaksi akibat beban mati (P_1) = 24,28 kN

2) Beban hidup

a) Beban trapesium

$$\text{Beban atap (bentang 2,4 m) } (q_a) : 1 \cdot 1,2 = 1,2 \text{ kN/m}$$

Beban lantai (bentang 2,4 m) (q_b) : $2,5 \cdot 1,2 = 3,0 \text{ kN/m}$

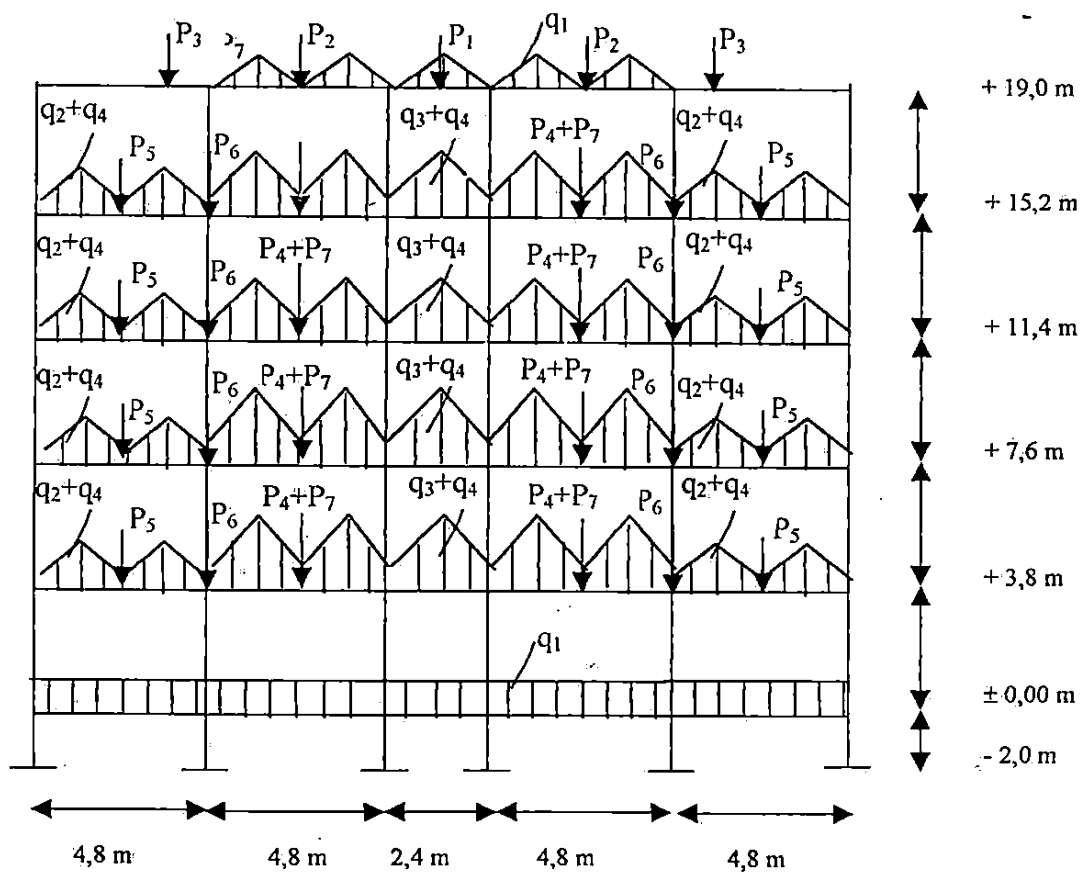
b) Beban titik

Beban dari reaksi grid.

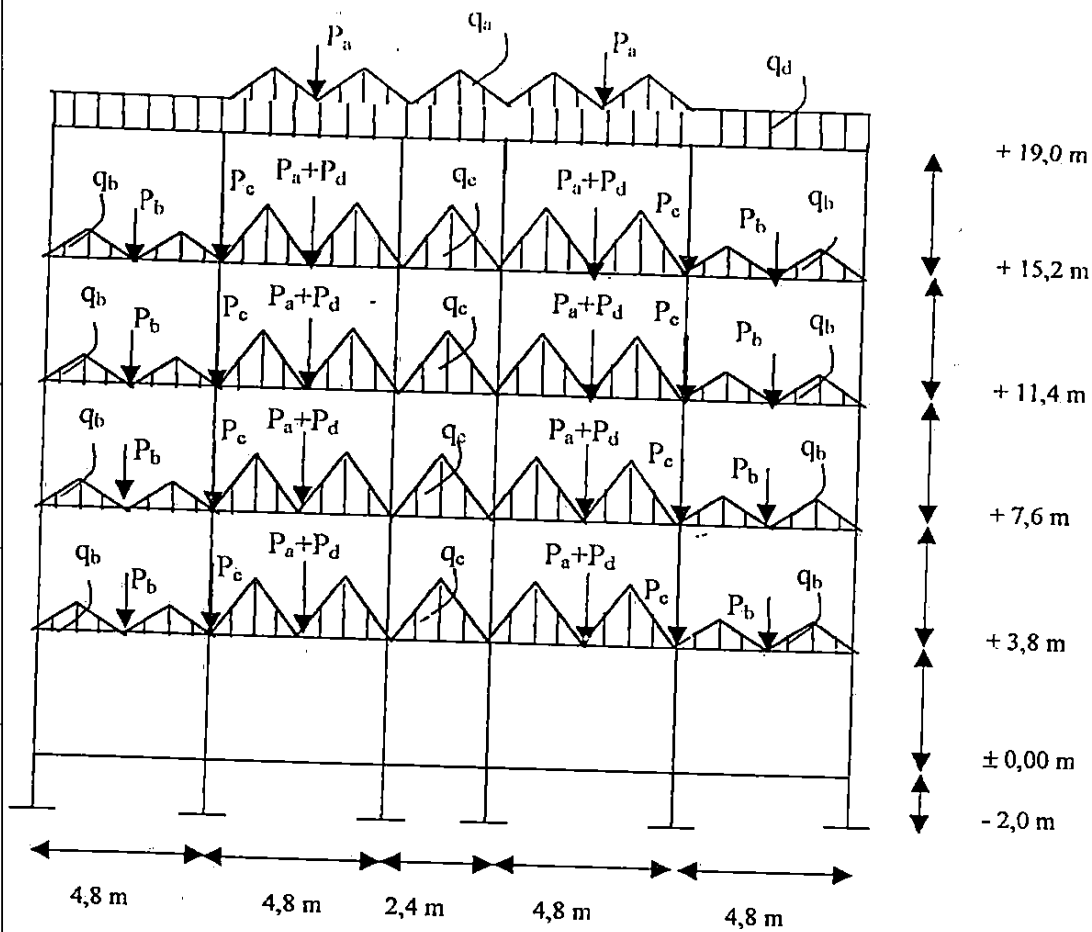
Dari hasil analisis struktur SAP 2000 didapat reaksi akibat beban

hidup (P_a) = 8,10 kN

b. Portal As 2 & 5



Gambar 5.14. Beban mati pada struktur portal As 2 & 5



Gambar 5.15. Beban hidup pada struktur portal As 2 & 5

1) Beban mati

a) Beban trapesium

$$\text{Beban atap (bentang 2,4 m)} (q_1) : 3,41 \cdot 1,2 = 4,092 \text{ kN/m}$$

$$\text{Beban lantai (bentang 2,4 m)} (q_2) : 3,94 \cdot 1,2 = 4,728 \text{ kN/m}$$

$$\text{Beban lantai (bentang 2,4 m)} (q_3) : 3,94 \cdot 1,2 \cdot 2 = 9,456 \text{ kN/m}$$

b) Beban merata

$$\text{Beban tembok } (q_4) : 2,5 \cdot 3,8 = 9,5 \text{ kN/m.}$$

c) Beban titik

Beban dari reaksi atap.

Berat yang dipikul oleh tumpuan (KK1) (P_1) = 40,4795 kN

Berat yang dipikul oleh tumpuan (KK2) (P_2) = 40,4592 kN

Berat yang dipikul oleh tumpuan (KK3) (P_3) = 40,231 kN

Beban dari reaksi grid.

Dari hasil analisis struktur SAP 2000 didapat reaksi akibat beban mati :

$$\text{Grid sebelah kanan (P}_4) = 24,28 \text{ kN}$$

$$\text{Grid sebelah kiri} = (P_5) = 25,84 \text{ kN}$$

$$(P_6) = 36,76 \text{ kN}$$

$$(P_7) = 25,84 \text{ kN}$$

2) **Beban hidup**a) **Beban trapesium**

$$\text{Beban atap (bentang 2,4 m) (q}_a) : 1 \cdot 1,2 = 1,2 \text{ kN/m}$$

$$\text{Beban lantai (bentang 2,4 m) (q}_b) : 2,5 \cdot 1,2 = 3,0 \text{ kN/m}$$

$$\text{Beban lantai (bentang 2,4 m) (q}_c) : 2,5 \cdot 1,2 \cdot 2 = 6,0 \text{ kN/m}$$

b) **Beban merata**

$$\text{Beban atap (q}_d) : 0,2 \cdot 12,3 = 2,46 \text{ kN/m.}$$

c) **Beban titik***Beban dari reaksi grid.*

Dari hasil analisis struktur SAP 2000 didapat reaksi akibat beban

hidup =

$$\text{Grid sebelah kanan (P}_a) = 8,10 \text{ kN}$$

$$\text{Grid sebelah kiri} = (P_b) = 11,70 \text{ kN}$$

$$(P_c) = 16,64 \text{ kN}$$

$$(P_d) = 11,70 \text{ kN}$$

c. **Portal As 3 & 4**1) **Beban mati**a) **Beban trapesium**

$$\text{Beban lantai (bentang 2,4 m) (q}_1) : 3,94 \cdot 1,2 \cdot 2 = 9,456 \text{ kN/m}$$

b) **Beban merata**

$$\text{Beban partisi (q}_2) : 0,5 \cdot 3,8 = 1,9 \text{ kN/m.}$$

c) Beban titik

Beban dari reaksi grid.

Dari hasil analisis struktur SAP 2000 didapat reaksi akibat beban mati =

Grid sebelah kanan + Grid sebelah kiri

$$-(P_1) = 25,84 \text{ kN} + 25,84 \text{ kN} = 51,68 \text{ kN}$$

$$-(P_2) = 36,76 \text{ kN} + 36,76 \text{ kN} = 73,52 \text{ kN}$$

$$-(P_3) = 25,84 \text{ kN} + 25,84 \text{ kN} = 51,68 \text{ kN}$$

2) Beban hidup

a) Beban trapesium

$$\text{Beban lantai (bentang 2,4 m) } (q_a) : 2,5 \cdot 1,2 \cdot 2 = 6,0 \text{ kN/m}$$

b) Beban titik

Beban dari reaksi grid.

Dari hasil analisis struktur SAP 2000 didapat reaksi akibat beban hidup =

Grid sebelah kanan + Grid sebelah kiri

$$-(P_a) = 11,70 \text{ kN} + 11,70 \text{ kN} = 23,40 \text{ kN}$$

$$-(P_b) = 16,64 \text{ kN} + 16,64 \text{ kN} = 33,28 \text{ kN}$$

$$-(P_c) = 11,70 \text{ kN} + 11,70 \text{ kN} = 23,40 \text{ kN}$$

d. Portal As A & F

1) Beban mati

a) Beban trapesium

$$\text{Beban lantai (bentang 2,4 m) } (q_1) : 3,94 \cdot 1,2 = 4,728 \text{ kN/m}$$

b) Beban merata

$$\text{Beban tembok } (q_2) : 2,5 \cdot 3,8 = 9,5 \text{ kN/m.}$$

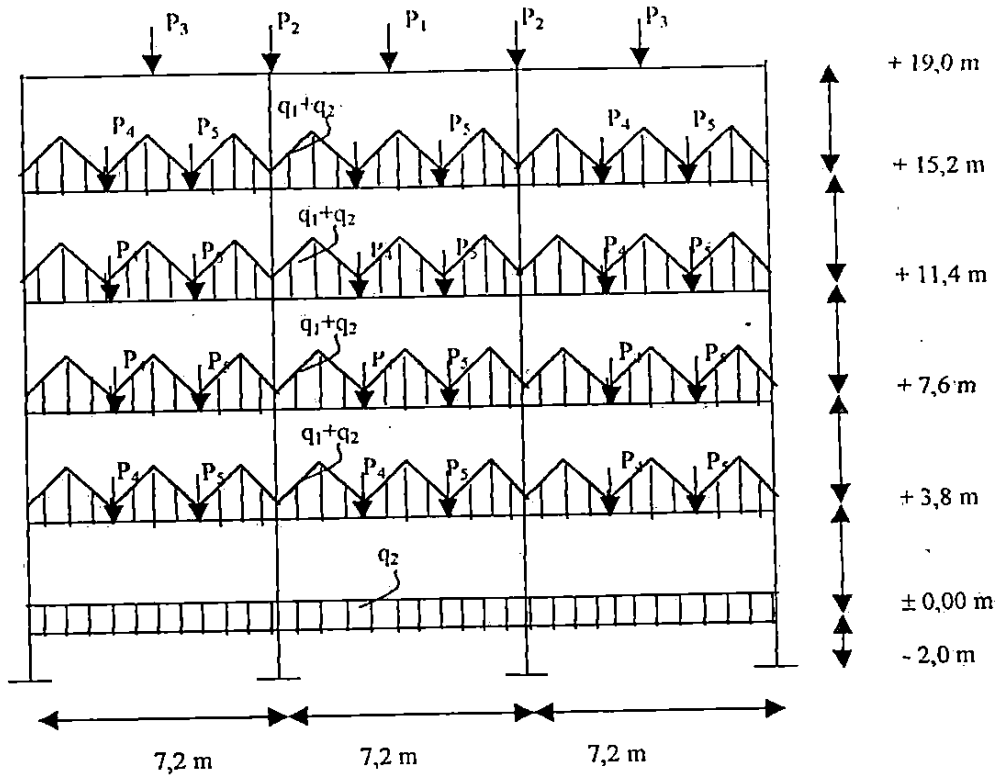
c) Beban titik

Beban dari reaksi atap.

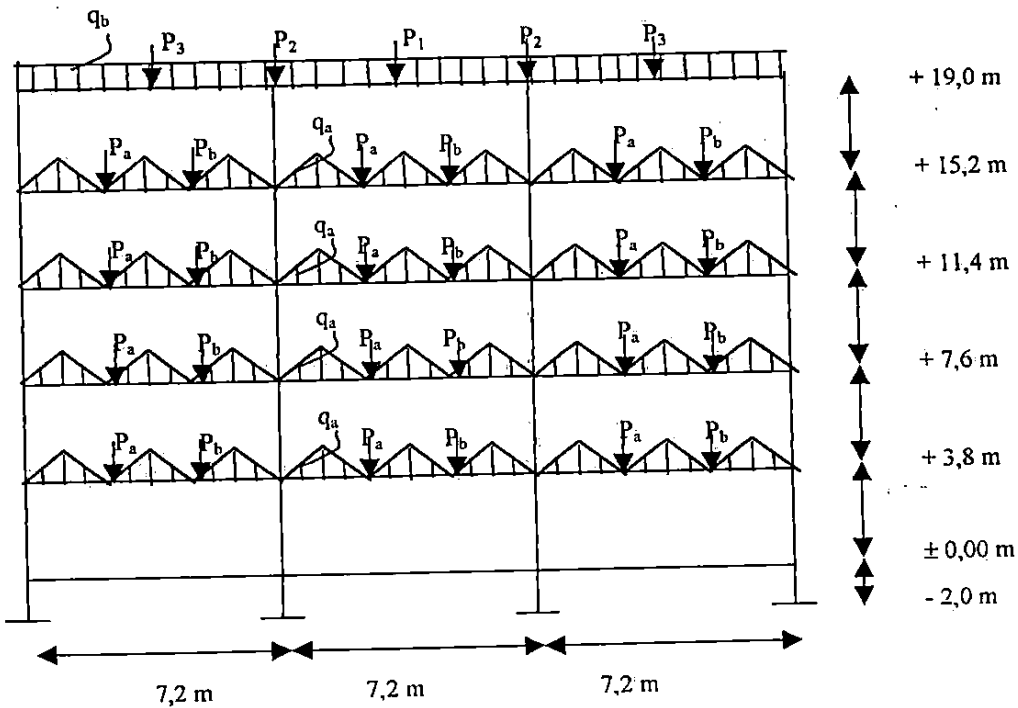
Berat yang dipikul oleh tumpuan (KK1) $(P_1) = 40,4795 \text{ kN}$

Berat yang dipikul oleh tumpuan (KK2) $(P_2) = 40,4592 \text{ kN}$

Berat yang dipikul oleh tumpuan (KK3) $(P_3) = 40,231 \text{ kN}$



Gambar 5.18. Beban mati pada struktur portal As A & F



Gambar 5.19. Beban hidup pada struktur portal As A & F

2) Beban mati

a) Beban trapesium

$$\text{Beban lantai (bentang 2,4 m) } (q_1) : 3,94 \cdot 1,2 = 4,728 \text{ kN/m}$$

b) Beban merata

$$\text{Beban tembok } (q_2) : 2,5 \cdot 3,8 = 9,5 \text{ kN/m.}$$

c) Beban titik

Beban dari reaksi atap.

Berat yang dipikul oleh tumpuan (KK1) (P_1) = 40,4795 kN

Berat yang dipikul oleh tumpuan (KK2) (P_2) = 40,4592 kN

Berat yang dipikul oleh tumpuan (KK3) (P_3) = 40,231 kN

Beban dari reaksi grid.

Dari hasil analisis struktur SAP 2000 didapat reaksi akibat beban mati =

Grid sebelah kanan

$$- (P_4) = 23,38 \text{ kN}$$

$$- (P_5) = 23,38 \text{ kN}$$

3) Beban hidup

a) Beban trapesium

$$\text{Beban lantai (bentang 2,4 m) } (q_a) : 2,5 \cdot 1,2 = 3,0 \text{ kN/m}$$

b) Beban merata

$$\text{Beban atap } (q_b) : 0,2 \cdot 12,3 = 2,46 \text{ kN/m.}$$

c) Beban titik

Beban dari reaksi grid.

Dari hasil analisis struktur SAP 2000 didapat reaksi akibat beban hidup =

Grid sebelah kanan

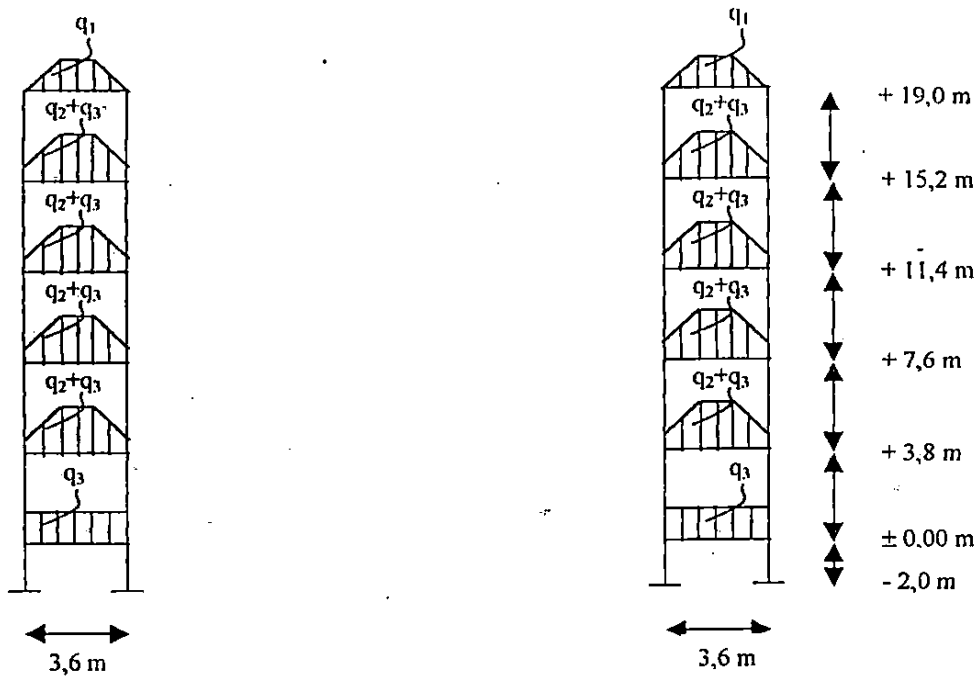
$$- (P_a) = 10,58 \text{ kN}$$

$$- (P_b) = 10,58 \text{ kN}$$

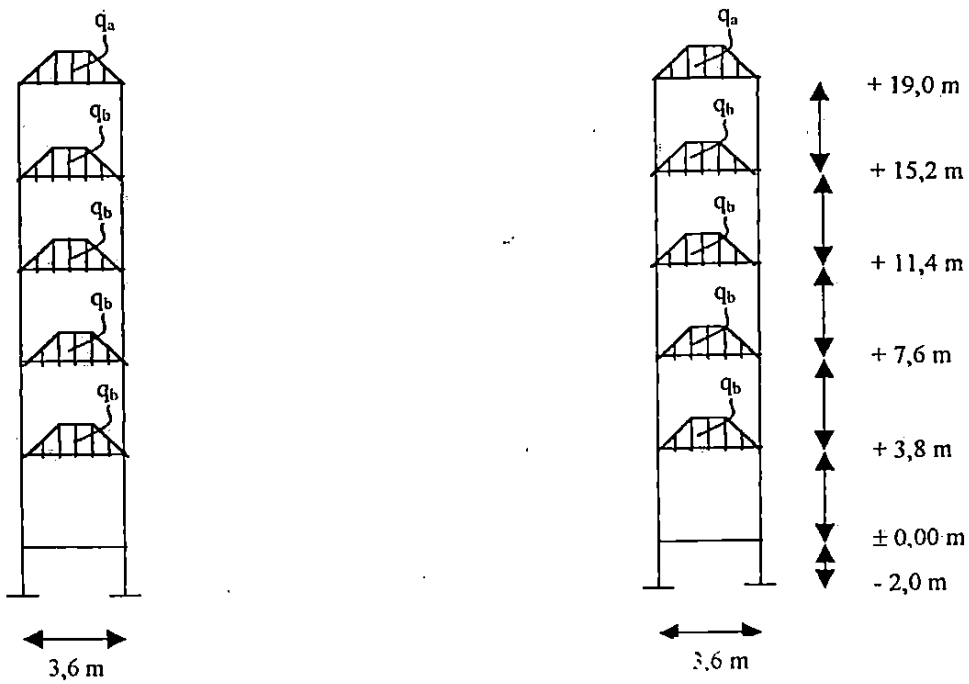
e. Portal As B & E

1) Beban mati

a) Beban trapesium



Gambar 5.20. Beban mati pada struktur portal As B & E



Gambar 5.21. Beban hidup pada struktur portal As B & E

$$\text{Beban atap (bentang 3,6 m)} (q_1) : 3,41 \cdot 1,8 = 6,14 \text{ kN/m}$$

$$\text{Beban lantai (bentang 3,6 m)} (q_2) : 3,94 \cdot 1,8 = 7,092 \text{ kN/m}$$

b) **Beban merata**

$$\text{Beban tembok } (q_3) : 2,5 \cdot 3,8 = 9,5 \text{ kN/m.}$$

2) **Beban hidup**

Beban trapesium

$$\text{Beban atap (bentang 3,6 m)} (q_a) : 1 \cdot 1,8 = 1,8 \text{ kN/m}$$

$$\text{Beban lantai (bentang 3,6 m)} (q_b) : 2,5 \cdot 1,8 = 4,5 \text{ kN/m}$$

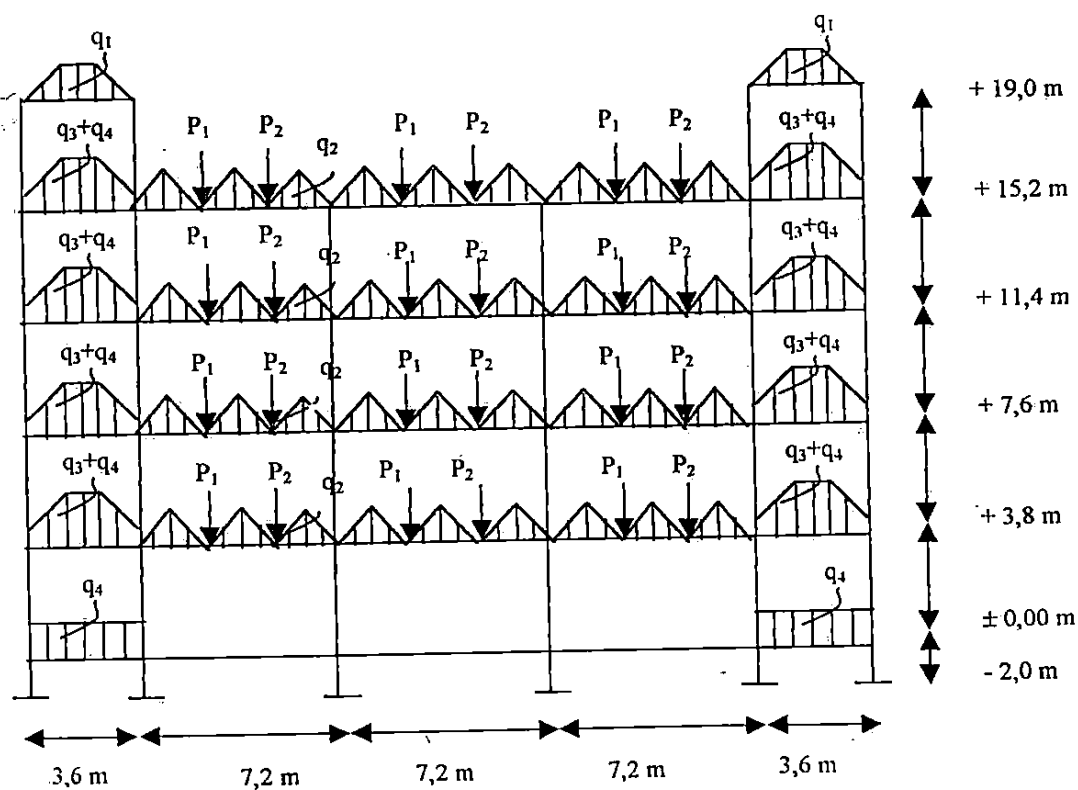
f. **Portal As C & D**

1) **Beban mati**

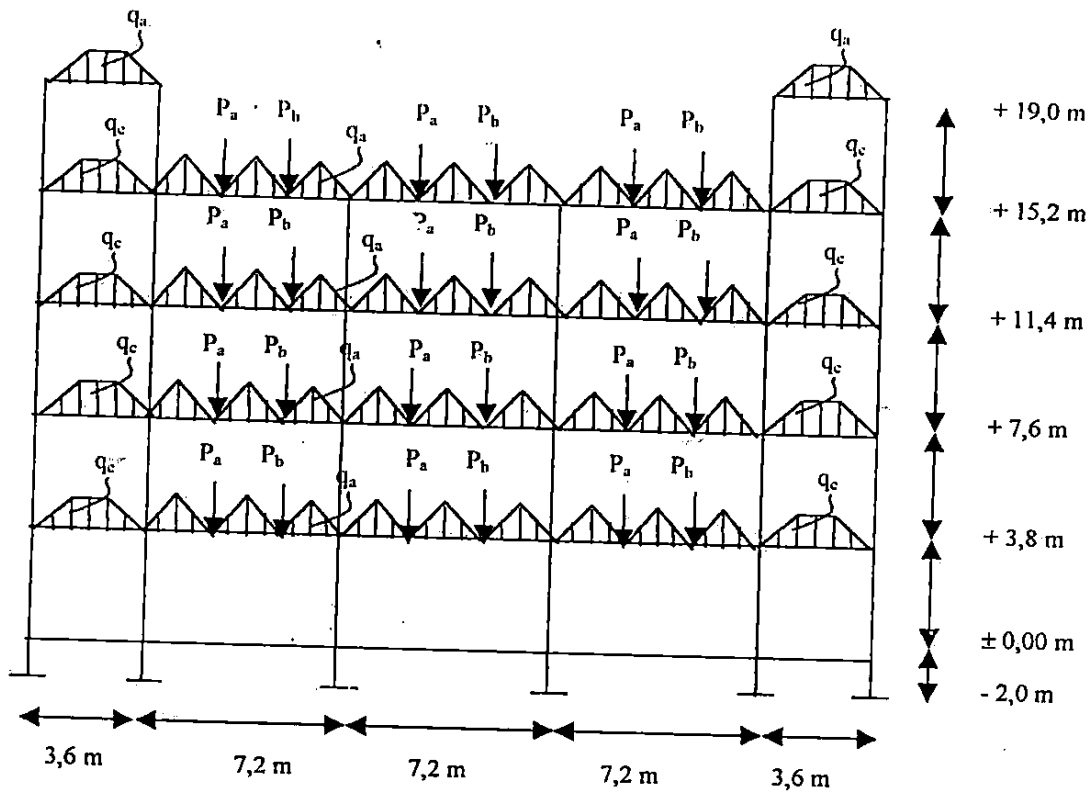
a) **Beban trapesium**

$$\text{Beban atap (bentang 3,6 m)} (q_1) : 3,41 \cdot 1,2 \cdot 2 = 6,14 \text{ kN/m}$$

$$\text{Beban lantai (bentang 2,4 m)} (q_2) : 3,94 \cdot 1,2 \cdot 2 = 4,728 \text{ kN/m}$$



Gambar 5.22. Beban mati pada struktur portal As C & D



Gambar 5.23. Beban hidup pada struktur portal As C & D

Beban lantai (bentang 3,6 m) (q_3) : $3,94 \cdot 1,8 \cdot 2 = 7,092 \text{ kN/m}$

b) Beban merata

Beban tembok (q_4) : $2,5 \cdot 3,8 = 9,5 \text{ kN/m}$.

Beban partisi (q_5) : $0,5 \cdot 3,8 = 1,9 \text{ kN/m}$.

3. Beban titik

Beban dari reaksi grid.

Dari hasil analisis struktur SAP 2000 didapat reaksi akibat beban mati =

Grid sebelah kanan + Grid sebelah kiri

- (P_1) = $23,38 \text{ kN} + 12,48 \text{ kN} = 45,86 \text{ kN}$

- (P_2) = $23,38 \text{ kN} + 12,48 \text{ kN} = 45,86 \text{ kN}$

1) Beban hidup

a) Beban trapesium

$$\text{Beban atap (bentang 3,6 m) } (q_a) : 1 \cdot 1,8 \cdot 2 = 3,6 \text{ kN/m}$$

$$\text{Beban lantai (bentang 2,4 m) } (q_b) : 2,5 \cdot 1,2 \cdot 2 = 6,0 \text{ kN/m}$$

$$\text{Beban lantai (bentang 3,6 m) } (q_c) : 2,5 \cdot 1,8 \cdot 2 = 9,0 \text{ kN/m}$$

b) Beban titik

Beban dari reaksi grid.

Dari hasil analisis struktur SAP 2000 didapat reaksi akibat beban hidup =

Grid sebelah kanan + Grid sebelah kiri

$$- (P_a) = 10,58 \text{ kN} + 8,12 \text{ kN} = 18,70 \text{ kN}$$

$$- (P_b) = 10,58 \text{ kN} + 8,12 \text{ kN} = 18,70 \text{ kN}$$

E. Analisis Struktur

Data pembebanan yang diperoleh kemudian dianalisis untuk mencari gaya dalam portal guna merancang struktur baik balok maupun kolom. Dalam analisis struktur portal ini penulis menggunakan bantuan program SAP2000 dengan model portal 3 dimensi. Data-data hasil analisis struktur antara lain momen, gaya geser, gaya aksial dan displacement terlampir.

BAB VI

PERHITUNGAN PENULANGAN BALOK, KOLOM DAN JOIN PERTEMUAN BALOK DAN KOLOM

A. Umum

Perancangan dimensi tulangan (luas tulangan) pada balok, kolom dan join pertemuan balok dan kolom dimaksudkan untuk mendapatkan hasil perancangan yang memenuhi syarat dan peraturan yang berlaku. Perancangan dimensi tulangan juga dimaksudkan untuk memperoleh kekuatan struktur yang dapat memberikan keamanan pada struktur tersebut.

Prinsip perhitungan tulangan yang diterapkan adalah perancangan dimensi yang ekonomis tetapi tetap cukup memberikan kekuatan untuk keamanannya yang memenuhi persyaratan.

Bab ini Perhitungan Penulangan Balok, Kolom dan Join akan memperhitungkan luas tulangan yang diperlukan baik pada balok, kolom dan panel pertemuan balok dan kolom. Momen diperoleh dari bab IV Analisis Struktur portal. Dan hasil selanjutnya akan dibahas pada pembahasan.

B. Perhitungan Penulangan Balok

1. Perhitungan Penulangan Balok terhadap Lentur

a. Momen rencana balok. Momen rencana balok adalah momen yang digunakan untuk perhitungan luas tulangan pada balok. Momen rencana ini dihitung akibat kombinasi pembebanan struktur oleh beban mati, hidup dan beban gempa.

Momen rencana balok dengan perencanaan daktilitas penuh dihitung berdasarkan 3 kombinasi pembebanan menurut SK SNI Pasal 3.2.2 sebagai berikut:

Kombinasi pembebanan 1 $M_u = 1,2 M_D + 1,6 M_L$.

Kombinasi pembebanan 2 $M_u = 0,9 M_D \pm M_E$.

Kombinasi pembebanan 3 $M_u = 1,05 (M_D + M_L \pm M_E)$.

Hasil perhitungan momen akibat tiga kombinasi pembebanan di atas adalah:

Tabel 6.1: Momen rencana balok As- A & F

| ELEMEN | SECTION | MD (kNm) | ML (kNm) | ME,x (kNm) | 1,2 MD + 1,6 ML (kNm) | 1,05(MD+M L+ MEx) (kNm) | 1,05(MD+ ML- MEx) (kNm) | 0,9MD+ (ME,x) (kNm) | 0,9MD- (ME,x) (kNm) | keterangan |
|--------|---------|-------------|-------------|---------------|-----------------------------|-------------------------------|-------------------------------|---------------------------|---------------------------|------------|
| 29 | 0 | -64,08247 | -0,79276 | 32,93757 | -78,167374 | -47,906484 | -102,7034 | -28,03041 | -87,31804 | S60X40 |
| 29 | 3,6 | 33,44838 | -0,09822 | 0,1745375 | 39,9809083 | 35,200935 | 34,83441 | 30,26063 | 29,946458 | S60X40 |
| 29 | 7,2 | -65,42179 | 0,59632 | -32,58849 | -77,552034 | -146,12094 | -33,84883 | -88,20925 | -29,54997 | S60X40 |
| 30 | 0 | -65,46044 | -0,00325 | 32,4349 | -78,557724 | -49,543181 | -102,7935 | -29,72299 | -88,10581 | S60X40 |
| 30 | 3,6 | 32,74191 | -0,00325 | -7,34E-06 | 39,285096 | 34,375588 | 34,3756 | 29,46771 | 29,467726 | S60X40 |
| 30 | 7,2 | -65,45676 | -0,00325 | -32,43491 | -78,553308 | -146,84238 | -34,67635 | -88,1025 | -29,71967 | S60X40 |
| 31 | 0 | -65,42731 | 0,59632 | 32,59109 | -77,558658 | -48,359848 | -102,2932 | -29,5526 | -88,21656 | S60X40 |
| 31 | 3,6 | 33,44883 | -0,09822 | -0,173893 | 39,9814483 | 49,76508 | 35,20073 | 29,94744 | 30,26045 | S60X40 |
| 31 | 7,2 | -64,07605 | -0,79276 | -32,93888 | -78,15967 | -146,71153 | -33,52642 | -87,31344 | -28,02345 | S60X40 |
| 68 | 0 | -64,08247 | -0,79276 | 32,93757 | -78,167374 | -47,906484 | -102,7034 | -28,03041 | -87,31804 | S60X40 |
| 68 | 3,6 | 33,44838 | -0,09822 | 0,1745375 | 39,9809083 | 35,200935 | 34,83441 | 30,26063 | 29,946458 | S60X40 |
| 68 | 7,2 | -65,42179 | 0,59632 | -32,58849 | -77,552034 | -146,12094 | -33,84883 | -88,20925 | -29,54997 | S60X40 |
| 69 | 0 | -65,46044 | -0,00325 | 32,4349 | -78,557724 | -49,543181 | -102,7935 | -29,72299 | -88,10581 | S60X40 |
| 69 | 3,6 | 32,74191 | -0,00325 | -7,34E-06 | 39,285096 | 34,375588 | 34,3756 | 29,46771 | 29,467726 | S60X40 |
| 69 | 7,2 | -65,45676 | -0,00325 | -32,43491 | -78,553308 | -146,84238 | -34,67635 | -88,1025 | -29,71967 | S60X40 |
| 70 | 0 | -65,42731 | 0,59632 | 32,59109 | -77,558658 | -48,359848 | -102,2932 | -29,5526 | -88,21656 | S60X40 |
| 70 | 3,6 | 33,44883 | -0,09822 | -0,173893 | 39,9814483 | 49,76508 | 35,20073 | 29,94744 | 30,26045 | S60X40 |
| 70 | 7,2 | -64,07605 | -0,79276 | -32,93888 | -78,15967 | -146,71153 | -33,52642 | -87,31344 | -28,02345 | S60X40 |
| 99 | 0 | -120,911 | -23,2563 | 120,1125 | -182,3064 | -36,085125 | -277,4958 | -0,71865 | -216,9212 | B70X40 |
| 99 | 3,6 | 67,48922 | 12,8286 | 3,951965 | 101,51284 | 126,40469 | 80,18416 | 64,29707 | 57,18353 | B70X40 |
| 99 | 7,2 | -122,1562 | -22,0285 | -112,2086 | -181,83307 | -384,58998 | -33,57493 | -210,9283 | -8,95284 | B70X40 |
| 100 | 0 | -125,7091 | -23,4931 | 106,2177 | -188,43994 | -64,47681 | -268,1909 | -17,54226 | -208,7341 | B70X40 |
| 100 | 3,6 | 63,2719 | 11,9789 | 0,0009926 | 95,092456 | 112,87763 | 79,01226 | 56,9456 | 56,943817 | B70X40 |
| 100 | 7,2 | -125,7928 | -23,4931 | -106,2157 | -188,54038 | -383,25246 | -45,22375 | -208,8077 | -17,61939 | B70X40 |
| 101 | 0 | -122,0742 | -22,0285 | 112,25 | -181,73467 | -47,77908 | -269,1704 | -8,84178 | -210,8918 | B70X40 |
| 101 | 3,6 | 67,4855 | 12,8286 | -3,958275 | 101,508376 | 114,53375 | 88,486 | 57,1745 | 64,299398 | B70X40 |
| 101 | 7,2 | -121,0005 | -23,2583 | -120,1665 | -182,4138 | -396,63788 | -25,29686 | -217,0503 | -0,7506 | B70X40 |
| 138 | 0 | -120,911 | -23,2583 | 120,1125 | -182,3064 | -36,085125 | -277,4958 | -0,71865 | -216,9212 | B70X40 |
| 138 | 3,6 | 67,48922 | 12,8286 | 3,951965 | 101,51284 | 126,40469 | 80,18416 | 64,29707 | 57,18353 | B70X40 |
| 138 | 7,2 | -122,1562 | -22,0285 | -112,2086 | -181,83307 | -384,58998 | -33,57493 | -210,9283 | -8,95284 | B70X40 |
| 139 | 0 | -125,7091 | -23,4931 | 106,2177 | -188,43994 | -64,47681 | -268,1909 | -17,54226 | -208,7341 | B70X40 |
| 139 | 3,6 | 63,2719 | 11,9789 | 0,0009926 | 95,092456 | 112,87763 | 79,01226 | 56,9456 | 56,943817 | B70X40 |
| 139 | 7,2 | -125,7928 | -23,4931 | -106,2157 | -188,54038 | -383,25246 | -45,22375 | -208,8077 | -17,61939 | B70X40 |
| 140 | 0 | -122,0742 | -22,0285 | 112,25 | -181,73467 | -47,77908 | -269,1704 | -8,84178 | -210,8918 | B70X40 |
| 140 | 3,6 | 67,4855 | 12,8286 | -3,958275 | 101,508376 | 114,53375 | 88,486 | 57,1745 | 64,299398 | B70X40 |
| 140 | 7,2 | -121,0005 | -23,2583 | -120,1665 | -182,4138 | -396,63788 | -25,29686 | -217,0503 | -0,7506 | B70X40 |
| 169 | 0 | -129,039 | -25,9353 | 111,5446 | -196,34328 | -65,14455 | -279,8448 | -15,74496 | -216,5252 | B70X40 |
| 169 | 3,6 | 66,92329 | 12,5786 | 3,174245 | 100,433644 | 124,01414 | 80,14399 | 63,08778 | 57,374141 | B70X40 |
| 169 | 7,2 | -115,1602 | -19,8516 | -105,1961 | -169,95477 | -360,31182 | -31,30646 | -198,3207 | -8,96769 | B70X40 |
| 170 | 0 | -125,1537 | -23,3373 | 101,4878 | -187,52406 | -70,50474 | -262,4777 | -21,29931 | -203,9774 | B70X40 |
| 170 | 3,6 | 63,83129 | 12,1347 | 0,0039464 | 96,013132 | 113,95496 | 79,76019 | 57,45171 | 57,444609 | B70X40 |
| 170 | 7,2 | -125,2294 | -23,3373 | -101,4799 | -187,6149 | -375,06984 | -49,4411 | -204,0384 | -21,37455 | B70X40 |
| 171 | 0 | -115,0939 | -19,8516 | 105,1803 | -169,87521 | -44,64777 | -252,1321 | -8,92224 | -198,2468 | B70X40 |
| 171 | 3,6 | 66,92099 | 12,5786 | -3,145017 | 100,430884 | 114,5318 | 86,7768 | 57,39838 | 63,059406 | B70X40 |
| 171 | 7,2 | -129,1098 | -25,9353 | -111,4703 | -196,42824 | -399,7731 | -45,75354 | -216,5221 | -15,87555 | B70X40 |
| 208 | 0 | -129,039 | -25,9353 | 111,5446 | -196,34328 | -65,14455 | -279,8448 | -15,74496 | -216,5252 | B70X40 |
| 208 | 3,6 | 66,92329 | 12,5786 | 3,174245 | 100,433644 | 124,01414 | 80,14399 | 63,08778 | 57,374141 | B70X40 |
| 208 | 7,2 | -115,1602 | -19,8516 | -105,1961 | -169,95477 | -360,31182 | -31,30646 | -198,3207 | -8,96769 | B70X40 |
| 209 | 0 | -125,1537 | -23,3373 | 101,4878 | -187,52406 | -70,50474 | -262,4777 | -21,29931 | -203,9774 | B70X40 |
| 209 | 3,6 | 63,83129 | 12,1347 | 0,0039464 | 96,013132 | 113,95496 | 79,76019 | 57,45171 | 57,444609 | B70X40 |
| 209 | 7,2 | -125,2294 | -23,3373 | -101,4799 | -187,6149 | -375,06984 | -49,4411 | -204,0384 | -21,37455 | B70X40 |
| 210 | 0 | -115,0939 | -19,8516 | 105,1803 | -169,87521 | -44,64777 | -252,1321 | -8,92224 | -198,2468 | B70X40 |

| | | | | | | | | | | |
|-----|-----|-----------|----------|-----------|------------|------------|-----------|-----------|-----------|--------|
| 210 | 3,6 | 66,92099 | 12,5786 | -3,145017 | 100,430884 | 114,5318 | 86,7768 | 57,39838 | 63,059406 | B70X40 |
| 210 | 7,2 | -129,1098 | -25,9353 | -111,4703 | -196,42824 | -399,7731 | -45,75354 | -216,5221 | -15,87555 | B70X40 |
| 239 | 0 | -133,7049 | -27,0993 | 83,78646 | -203,80471 | -115,52657 | -256,8202 | -44,9266 | -195,7422 | B70X40 |
| 239 | 3,6 | 66,92686 | 12,6138 | 2,291156 | 100,49428 | 122,74769 | 81,11196 | 62,29621 | 58,172134 | B70X40 |
| 239 | 7,2 | -110,4871 | -18,6172 | -79,20415 | -162,37198 | -312,46262 | -52,39512 | -170,7221 | -28,15466 | B70X40 |
| 240 | 0 | -124,9708 | -23,2918 | 77,67281 | -187,23189 | -105,88473 | -237,2322 | -42,56819 | -182,3792 | B70X40 |
| 240 | 3,6 | 64,01571 | 12,1802 | -0,023258 | 96,307124 | 114,25893 | 80,03009 | 57,59321 | 57,635071 | B70X40 |
| 240 | 7,2 | -125,0435 | -23,2918 | -77,71933 | -187,31913 | -339,08199 | -74,1468 | -182,4865 | -42,59175 | B70X40 |
| 241 | 0 | -110,4273 | -18,6172 | 79,68919 | -162,30022 | -74,032905 | -219,1703 | -27,6643 | -171,1048 | B70X40 |
| 241 | 3,6 | 66,92465 | 12,6138 | -2,425397 | 100,491628 | 115,66955 | 86,06202 | 58,04933 | 62,415042 | B70X40 |
| 241 | 7,2 | -133,7691 | -27,0993 | -84,53999 | -203,88175 | -368,11254 | -80,1448 | -196,4782 | -44,3062 | B70X40 |
| 278 | 0 | -133,7049 | -27,0993 | 83,78646 | -203,80471 | -115,52657 | -256,8202 | -44,9266 | -195,7422 | B70X40 |
| 278 | 3,6 | 66,92686 | 12,6138 | 2,291156 | 100,49428 | 122,74769 | 81,11196 | 62,29621 | 58,172134 | B70X40 |
| 278 | 7,2 | -110,4871 | -18,6172 | -79,20415 | -162,37198 | -312,46262 | -52,39512 | -170,7221 | -28,15466 | B70X40 |
| 279 | 0 | -124,9708 | -23,2918 | 77,67281 | -187,23189 | -105,88473 | -237,2322 | -42,56819 | -182,3792 | B70X40 |
| 279 | 3,6 | 64,01571 | 12,1802 | -0,023258 | 96,307124 | 114,25893 | 80,03009 | 57,59321 | 57,635071 | B70X40 |
| 279 | 7,2 | -125,0435 | -23,2918 | -77,71933 | -187,31913 | -339,08199 | -74,1468 | -182,4865 | -42,59175 | B70X40 |
| 280 | 0 | -110,4273 | -18,6172 | 79,68919 | -162,30022 | -74,032905 | -219,1703 | -27,6643 | -171,1048 | B70X40 |
| 280 | 3,6 | 66,92465 | 12,6138 | -2,425397 | 100,491628 | 115,66955 | 86,06202 | 58,04933 | 62,415042 | B70X40 |
| 280 | 7,2 | -133,7691 | -27,0993 | -84,53999 | -203,88175 | -368,11254 | -80,1448 | -196,4782 | -44,3062 | B70X40 |
| 309 | 0 | -132,7206 | -27,0246 | 62,24752 | -202,50402 | -146,24646 | -233,0923 | -63,42577 | -175,4713 | B70X40 |
| 309 | 3,6 | 67,52926 | 12,7064 | 2,342693 | 101,365416 | 123,86759 | 81,78766 | 62,88476 | 58,66791 | B70X40 |
| 309 | 7,2 | -110,2666 | -18,5066 | -57,56214 | -161,93042 | -279,50295 | -74,77157 | -151,0459 | -47,43401 | B70X40 |
| 310 | 0 | -124,4397 | -23,1421 | 55,67844 | -186,35495 | -137,855 | -213,4232 | -61,88513 | -162,1063 | B70X40 |
| 310 | 3,6 | 64,55087 | 12,3299 | 0,2102018 | 97,188932 | 115,6365 | 80,50413 | 58,28496 | 57,906601 | B70X40 |
| 310 | 7,2 | -124,5043 | -23,1421 | -55,25804 | -186,43247 | -304,35662 | -97,00775 | -161,7861 | -62,32163 | B70X40 |
| 311 | 0 | -110,2143 | -18,5066 | 55,27922 | -161,86766 | -110,16246 | -193,2001 | -49,44157 | -148,9442 | B70X40 |
| 311 | 3,6 | 67,52594 | 12,7064 | -1,727968 | 101,361432 | 117,75662 | 86,05837 | 59,21817 | 62,328517 | B70X40 |
| 311 | 7,2 | -132,7795 | -27,0246 | -58,73516 | -202,5747 | -327,80883 | -106,1223 | -172,3632 | -66,63991 | B70X40 |
| 348 | 0 | -132,7206 | -27,0246 | 62,24752 | -202,50402 | -146,24646 | -233,0923 | -63,42577 | -175,4713 | B70X40 |
| 348 | 3,6 | 67,52926 | 12,7064 | 2,342693 | 101,365416 | 123,86759 | 81,78766 | 62,88476 | 58,66791 | B70X40 |
| 348 | 7,2 | -110,2666 | -18,5066 | -57,56214 | -161,93042 | -279,50295 | -74,77157 | -151,0459 | -47,43401 | B70X40 |
| 349 | 0 | -124,4397 | -23,1421 | 55,67844 | -186,35495 | -137,855 | -213,4232 | -61,88513 | -162,1063 | B70X40 |
| 349 | 3,6 | 64,55087 | 12,3299 | 0,2102018 | 97,188932 | 115,6365 | 80,50413 | 58,28496 | 57,906601 | B70X40 |
| 349 | 7,2 | -124,5043 | -23,1421 | -55,25804 | -186,43247 | -304,35662 | -97,00775 | -161,7861 | -62,32163 | B70X40 |
| 350 | 0 | -110,2143 | -18,5066 | 55,27922 | -161,86766 | -110,16246 | -193,2001 | -49,44157 | -148,9442 | B70X40 |
| 350 | 3,6 | 67,52594 | 12,7064 | -1,727968 | 101,361432 | 117,75662 | 86,05837 | 59,21817 | 62,328517 | B70X40 |
| 350 | 7,2 | -132,7795 | -27,0246 | -58,73516 | -202,5747 | -327,80883 | -106,1223 | -172,3632 | -66,63991 | B70X40 |
| 375 | 0 | -54,07798 | -11,5171 | 17,24253 | -83,321 | -72,528885 | -86,97953 | -33,15191 | -64,18846 | R50X30 |
| 375 | 3,6 | 44,91571 | 5,50214 | 0,4586099 | 62,7022792 | 76,314693 | 52,4572 | 40,83689 | 40,01139 | R50X30 |
| 375 | 7,2 | -47,54723 | -9,36018 | -16,32531 | -72,032956 | -109,84907 | -42,6112 | -57,48529 | -28,09973 | R50X30 |
| 376 | 0 | -51,41798 | -10,5651 | 15,80596 | -78,6058 | -69,26574 | -81,67853 | -32,05082 | -60,50155 | R50X30 |
| 376 | 3,6 | 44,31823 | 5,37566 | 0,1619661 | 61,7829256 | 74,783778 | 52,00852 | 40,03218 | 39,740638 | R50X30 |
| 376 | 7,2 | -51,40221 | -10,5651 | -15,48203 | -78,586876 | -116,17407 | -48,80959 | -60,19582 | -32,32816 | R50X30 |
| 377 | 0 | -47,5685 | -9,36018 | 14,63407 | -72,05848 | -63,441908 | -75,14088 | -29,64099 | -55,98231 | R50X30 |
| 377 | 3,6 | 44,91636 | 5,50214 | -0,068459 | 62,7030592 | 75,525064 | 53,01131 | 40,36311 | 40,486337 | R50X30 |
| 377 | 7,2 | -54,05541 | -11,5171 | -14,77099 | -83,293916 | -120,51531 | -53,34164 | -61,94376 | -35,35598 | R50X30 |
| 402 | 0 | -54,07798 | -11,5171 | 17,24253 | -83,321 | -72,528885 | -86,97953 | -33,15191 | -64,18846 | R50X30 |
| 402 | 3,6 | 44,91571 | 5,50214 | 0,4586099 | 62,7022792 | 76,314693 | 52,4572 | 40,83689 | 40,01139 | R50X30 |
| 402 | 7,2 | -47,54723 | -9,36018 | -16,32531 | -72,032956 | -109,84907 | -42,6112 | -57,48529 | -28,09973 | R50X30 |
| 403 | 0 | -51,41798 | -10,5651 | 15,80596 | -78,6058 | -69,26574 | -81,67853 | -32,05082 | -60,50155 | R50X30 |
| 403 | 3,6 | 44,31823 | 5,37566 | 0,1619661 | 61,7829256 | 74,783778 | 52,00852 | 40,03218 | 39,740638 | R50X30 |
| 403 | 7,2 | -51,40221 | -10,5651 | -15,48203 | -78,586876 | -116,17407 | -48,80959 | -60,19582 | -32,32816 | R50X30 |
| 404 | 0 | -47,5685 | -9,36018 | 14,63407 | -72,05848 | -63,441908 | -75,14088 | -29,64099 | -55,98231 | R50X30 |
| 404 | 3,6 | 44,91636 | 5,50214 | -0,068459 | 62,7030592 | 75,525064 | 53,01131 | 40,36311 | 40,486337 | R50X30 |
| 404 | 7,2 | -54,05541 | -11,5171 | -14,77099 | -83,293916 | -120,51531 | -53,34164 | -61,94376 | -35,35598 | R50X30 |

Tabel 6.2. Momen rencana balok As- B & E

| ELEMEN | SECTION | MD (kNm) | ML (kNm) | ME,x (kNm) | 1,2 MD + 1,6 ML (kNm) | 1,05(MD+M L+ ME,x) (kNm) | 1,05(MD+ ML-ME,x) (kNm) | 0,9MD+ ME,x (kNm) | 0,9MD - ME,x (kNm) | keterangan |
|--------|---------|-------------|-------------|---------------|-----------------------------|--------------------------------|-------------------------------|-------------------------|--------------------------|------------|
| 34 | 0 | -18,21099 | -0,82214 | 57,25891 | -23,168607 | 40,137072 | -80,10664 | 34,4032 | -67,92291 | S70X20 |
| 34 | 1,8 | 8,993022 | -0,02734 | 0,0087128 | 10,7478752 | 9,4231098 | 9,404813 | 8,076951 | 8,0858783 | S70X20 |
| 34 | 3,6 | -12,90322 | 0,76745 | -57,24148 | -14,255947 | -72,846115 | 47,36099 | -62,43953 | 39,904434 | S70X20 |
| 37 | 0 | -18,19331 | -0,82214 | -57,25857 | -23,147391 | -80,087718 | 40,15528 | -68,64662 | 35,158734 | S70X20 |
| 37 | 1,8 | 8,993112 | -0,02734 | -0,00883 | 10,7479832 | 9,4047839 | 9,423328 | 8,061243 | 8,1017482 | S70X20 |
| 37 | 3,6 | -12,92072 | 0,76745 | 57,24091 | -14,276947 | 47,34202 | -72,86389 | 40,57887 | -63,14547 | S70X20 |
| 62 | 0 | -18,21099 | -0,82214 | 57,25891 | -23,168607 | 40,137072 | -80,10664 | 34,4032 | -67,92291 | S70X20 |
| 62 | 1,8 | 8,993022 | -0,02734 | 0,0087128 | 10,7478752 | 9,4231098 | 9,404813 | 8,076951 | 8,0858783 | S70X20 |
| 62 | 3,6 | -12,90322 | 0,76745 | -57,24148 | -14,255947 | -72,846115 | 47,36099 | -62,43953 | 39,904434 | S70X20 |
| 65 | 0 | -18,19331 | -0,82214 | -57,25857 | -23,147391 | -80,087718 | 40,15528 | -68,64662 | 35,158734 | S70X20 |
| 65 | 1,8 | 8,993112 | -0,02734 | -0,00883 | 10,7479832 | 9,4047839 | 9,423328 | 8,061243 | 8,1017482 | S70X20 |
| 65 | 3,6 | -12,92072 | 0,76745 | 57,24091 | -14,276947 | 47,34202 | -72,86389 | 40,57887 | -63,14547 | S70X20 |
| 104 | 0 | -35,66894 | -6,88803 | 180,3188 | -53,823571 | 144,64992 | -234,0196 | 123,9856 | -194,389 | B70X20 |
| 104 | 1,8 | 15,32322 | 2,17741 | -0,286698 | 21,8717136 | 18,074624 | 18,67669 | 15,49253 | 14,048926 | B70X20 |
| 104 | 3,6 | -7,263726 | 1,52284 | -180,8922 | -6,2799304 | -195,96474 | 183,9089 | -167,9698 | 156,26563 | B70X20 |
| 107 | 0 | -35,57747 | -6,88803 | -180,3181 | -53,713807 | -233,92278 | 144,7452 | -200,5052 | 130,26657 | B70X20 |
| 107 | 1,8 | 15,32251 | 2,17741 | 0,2878889 | 21,8708616 | 18,677195 | 18,07263 | 16,00902 | 13,531159 | B70X20 |
| 107 | 3,6 | -7,356625 | 1,52284 | 180,8939 | -6,3914092 | 183,81312 | -196,0641 | 157,5541 | -169,4255 | B70X20 |
| 132 | 0 | -35,66894 | -6,88803 | 180,3188 | -53,823571 | 144,64992 | -234,0196 | 123,9856 | -194,389 | B70X20 |
| 132 | 1,8 | 15,32322 | 2,17741 | -0,286698 | 21,8717136 | 18,074624 | 18,67669 | 15,49253 | 14,048926 | B70X20 |
| 132 | 3,6 | -7,263726 | 1,52284 | -180,8922 | -6,2799304 | -195,96474 | 183,9089 | -167,9698 | 156,26563 | B70X20 |
| 135 | 0 | -35,57747 | -6,88803 | -180,3181 | -53,713807 | -233,92278 | 144,7452 | -200,5052 | 130,26657 | B70X20 |
| 135 | 1,8 | 15,32251 | 2,17741 | 0,2878889 | 21,8708616 | 18,677195 | 18,07263 | 16,00902 | 13,531159 | B70X20 |
| 135 | 3,6 | -7,356625 | 1,52284 | 180,8939 | -6,3914092 | 183,81312 | -196,0641 | 157,5541 | -169,4255 | B70X20 |
| 174 | 0 | -45,12434 | -9,77128 | 157,746 | -69,783258 | 107,9929 | -223,2737 | 92,56534 | -182,5833 | B70X20 |
| 174 | 1,8 | 15,16689 | 2,11713 | -0,145551 | 21,5876808 | 17,995395 | 18,30105 | 15,42462 | 13,781197 | B70X20 |
| 174 | 3,6 | 1,879009 | 4,28555 | -158,0371 | 9,111686 | -159,46617 | 172,4117 | -136,6853 | 143,9245 | B70X20 |
| 177 | 0 | -45,00406 | -9,77128 | -157,741 | -69,638922 | -223,14216 | 108,1139 | -191,2647 | 101,46325 | B70X20 |
| 177 | 1,8 | 15,16651 | 2,11713 | 0,1408396 | 21,5872248 | 18,295707 | 17,99994 | 15,68203 | 13,523103 | B70X20 |
| 177 | 3,6 | 1,757974 | 4,28555 | 158,0226 | 8,966444 | 172,26943 | -159,578 | 147,6595 | -140,6382 | B70X20 |
| 202 | 0 | -45,12434 | -9,77128 | 157,746 | -69,783258 | 107,9929 | -223,2737 | 92,56534 | -182,5833 | B70X20 |
| 202 | 1,8 | 15,16689 | 2,11713 | -0,145551 | 21,5876808 | 17,995395 | 18,30105 | 15,42462 | 13,781197 | B70X20 |
| 202 | 3,6 | 1,879009 | 4,28555 | -158,0371 | 9,111686 | -159,46617 | 172,4117 | -136,6853 | 143,9245 | B70X20 |
| 205 | 0 | -45,00406 | -9,77128 | -157,741 | -69,638922 | -223,14216 | 108,1139 | -191,2647 | 101,46325 | B70X20 |
| 205 | 1,8 | 15,16651 | 2,11713 | 0,1408396 | 21,5872248 | 18,295707 | 17,99994 | 15,68203 | 13,523103 | B70X20 |
| 205 | 3,6 | 1,757974 | 4,28555 | 158,0226 | 8,966444 | 172,26943 | -159,578 | 147,6595 | -140,6382 | B70X20 |
| 244 | 0 | -51,23069 | -11,518 | 109,3045 | -79,90558 | 48,883632 | -180,6558 | 41,90026 | -144,4817 | B70X20 |
| 244 | 1,8 | 15,18379 | 2,1375 | -0,054331 | 21,6405496 | 18,130308 | 18,2444 | 15,54026 | 13,714309 | B70X20 |
| 244 | 3,6 | 8,01917 | 6,07297 | -109,4132 | 19,3397544 | -100,08711 | 129,6806 | -85,78895 | 105,68913 | B70X20 |
| 247 | 0 | -51,11058 | -11,518 | -109,3157 | -79,761448 | -180,54146 | 49,02151 | -154,7498 | 52,384608 | B70X20 |
| 247 | 1,8 | 15,18345 | 2,1375 | 0,0696804 | 21,6401416 | 18,260163 | 18,11383 | 15,65157 | 13,602393 | B70X20 |
| 247 | 3,6 | 7,898381 | 6,07297 | 109,4551 | 19,1948076 | 129,59777 | -100,2579 | 111,0838 | -91,40105 | B70X20 |
| 272 | 0 | -51,23069 | -11,518 | 109,3045 | -79,90558 | 48,883632 | -180,6558 | 41,90026 | -144,4817 | B70X20 |
| 272 | 1,8 | 15,18379 | 2,1375 | -0,054331 | 21,6405496 | 18,130308 | 18,2444 | 15,54026 | 13,714309 | B70X20 |
| 272 | 3,6 | 8,01917 | 6,07297 | -109,4132 | 19,3397544 | -100,08711 | 129,6806 | -85,78895 | 105,68913 | B70X20 |
| 275 | 0 | -51,11058 | -11,518 | -109,3157 | -79,761448 | -180,54146 | 49,02151 | -154,7498 | 52,384608 | B70X20 |
| 275 | 1,8 | 15,18345 | 2,1375 | 0,0696804 | 21,6401416 | 18,260163 | 18,11383 | 15,65157 | 13,602393 | B70X20 |
| 275 | 3,6 | 7,898381 | 6,07297 | 109,4551 | 19,1948076 | 129,59777 | -100,2579 | 111,0838 | -91,40105 | B70X20 |
| 314 | 0 | -53,03249 | -11,9944 | 49,14891 | -82,82998 | -16,671848 | -119,8846 | -14,29016 | -91,96326 | B70X20 |
| 314 | 1,8 | 15,2709 | 2,09752 | -0,054313 | 21,6811152 | 18,179815 | 18,29387 | 15,5827 | 13,792692 | B70X20 |
| 314 | 3,6 | 9,99518 | 6,46941 | -49,25754 | 22,3452768 | -34,432594 | 69,00824 | -29,51365 | 53,327448 | B70X20 |

| | | | | | | | | | | |
|-----|-----|-----------|----------|-----------|------------|------------|-----------|-----------|-----------|--------|
| 317 | 0 | 9,90861 | 6,46941 | 49,14519 | 22,2413928 | 68,799374 | -34,40553 | 58,97089 | -35,31292 | B70X20 |
| 317 | 1,8 | 15,27028 | 2,09752 | 0,0181483 | 21,6803712 | 18,255248 | 18,21714 | 15,64736 | 13,726919 | B70X20 |
| 317 | 3,6 | -52,94715 | -11,9944 | -49,10889 | -82,727572 | -119,75293 | -16,62426 | -102,6454 | -3,454434 | B70X20 |
| 342 | 0 | -53,03249 | -11,9944 | 49,14891 | -82,82998 | -16,671848 | -119,8846 | -14,29016 | -91,96326 | B70X20 |
| 342 | 1,8 | 15,2709 | 2,09752 | -0,054313 | 21,6811152 | 18,179815 | 18,29387 | 15,5827 | 13,792692 | B70X20 |
| 342 | 3,6 | 9,99518 | 6,46941 | -49,25754 | 22,3452768 | -34,432594 | 69,00824 | -29,51365 | 53,327448 | B70X20 |
| 345 | 0 | 9,90861 | 6,46941 | 49,14519 | 22,2413928 | 68,799374 | -34,40553 | 58,97089 | -35,31292 | B70X20 |
| 345 | 1,8 | 15,27028 | 2,09752 | 0,0181483 | 21,6803712 | 18,255248 | 18,21714 | 15,64736 | 13,726919 | B70X20 |
| 345 | 3,6 | -52,94715 | -11,9944 | -49,10889 | -82,727572 | -119,75293 | -16,62426 | -102,6454 | -3,454434 | B70X20 |
| 380 | 0 | -17,62544 | -4,05788 | 5,419436 | -27,643142 | -17,077082 | -28,4579 | -14,6375 | -20,74039 | R70X20 |
| 380 | 1,8 | 4,778204 | 0,80279 | -0,032679 | 7,01830704 | 5,82573 | 5,894355 | 4,993483 | 4,3297943 | R70X20 |
| 380 | 3,6 | 2,469291 | 1,77546 | -5,484793 | 5,8038884 | -1,302042 | 10,21602 | -1,116036 | 7,1586756 | R70X20 |
| 381 | 0 | 2,454475 | 1,77546 | 5,451773 | 5,7861092 | 10,165796 | -1,282928 | 8,713539 | -2,697568 | R70X20 |
| 381 | 1,8 | 4,778259 | 0,80279 | 0,0237233 | 7,01837304 | 5,8850097 | 5,835191 | 5,044294 | 4,2790821 | R70X20 |
| 381 | 3,6 | -17,61052 | -4,05788 | -5,404326 | -27,625238 | -28,426367 | -17,07728 | -24,36546 | -10,98557 | R70X20 |
| 398 | 0 | -17,62544 | -4,05788 | 5,419436 | -27,643142 | -17,077082 | -28,4579 | -14,6375 | -20,74039 | R70X20 |
| 398 | 1,8 | 4,778204 | 0,80279 | -0,032679 | 7,01830704 | 5,82573 | 5,894355 | 4,993483 | 4,3297943 | R70X20 |
| 398 | 3,6 | 2,469291 | 1,77546 | -5,484793 | 5,8038884 | -1,302042 | 10,21602 | -1,116036 | 7,1586756 | R70X20 |
| 399 | 0 | 2,454475 | 1,77546 | 5,451773 | 5,7861092 | 10,165796 | -1,282928 | 8,713539 | -2,697568 | R70X20 |
| 399 | 1,8 | 4,778259 | 0,80279 | 0,0237233 | 7,01837304 | 5,8850097 | 5,835191 | 5,044294 | 4,2790821 | R70X20 |
| 399 | 3,6 | -17,61052 | -4,05788 | -5,404326 | -27,625238 | -28,426367 | -17,07728 | -24,36546 | -10,98557 | R70X20 |

Tabel 6.3. Momen rencana balok As- C & D

| ELEMEN | SECTION | MD (kNm) | ML (kNm) | ME,x (kNm) | 1,2 MD + 1,6 ML (kNm) | 1,05(MD+M L+ ME,x) (kNm) | 1,05(MD+ ML-ME,x) (kNm) | 0,9MD - ME,x (kNm) | 0,9MD+ ME,x (kNm) | keterangan |
|--------|---------|-------------|-------------|---------------|-----------------------------|--------------------------------|-------------------------------|--------------------------|-------------------------|------------|
| 42 | 0 | -11,26261 | -0,88949 | 49,37178 | -14,93832 | 39,080661 | -64,60008 | 34,29825 | -54,57095 | S60X40 |
| 42 | 1,8 | 9,088233 | 0,16032 | -1,164952 | 11,162395 | 8,4877833 | 10,93418 | 7,130953 | 9,2278665 | S60X40 |
| 42 | 3,6 | -19,66118 | 1,21014 | -51,70169 | -21,657197 | -73,66037 | 34,91318 | -64,22658 | 28,836459 | S60X40 |
| 43 | 0 | -33,09612 | -0,74629 | 31,58125 | -40,909404 | -2,3742151 | -68,69484 | -1,363383 | -58,20963 | S60X40 |
| 43 | 3,6 | 16,31868 | -0,09716 | -0,244086 | 19,4269595 | 16,776305 | 17,28889 | 14,46713 | 14,906489 | S60X40 |
| 43 | 7,2 | -32,17154 | 0,55197 | -32,06942 | -37,722702 | -66,873443 | 0,472339 | -57,81686 | -0,091908 | S60X40 |
| 44 | 0 | -32,62594 | 7,2E-05 | 32,33254 | -39,151013 | -0,3079946 | -68,20633 | -0,26406 | -58,46263 | S60X40 |
| 44 | 3,6 | 16,32847 | 7,2E-05 | 2,616E-06 | 19,5942789 | 17,144972 | 17,14497 | 14,69563 | 14,695621 | S60X40 |
| 44 | 7,2 | -32,62215 | 7,2E-05 | -32,33253 | -39,146465 | -68,202339 | -0,304026 | -58,45921 | -0,260658 | S60X40 |
| 45 | 0 | -32,17789 | 0,55197 | 32,06944 | -37,730322 | 0,4656923 | -66,88013 | -0,097605 | -57,8226 | S60X40 |
| 45 | 3,6 | 16,31936 | -0,09716 | 0,2440852 | 19,4277755 | 17,289599 | 16,77702 | 14,9071 | 14,467747 | S60X40 |
| 45 | 7,2 | -33,08843 | -0,74629 | -31,58127 | -40,900176 | -68,686787 | -2,36612 | -58,20273 | -1,356444 | S60X40 |
| 46 | 0 | -11,25198 | -0,88949 | -49,37183 | -14,925564 | -64,588968 | 39,09188 | -54,56143 | 34,307865 | S60X40 |
| 46 | 1,8 | 9,089084 | 0,16032 | 1,164948 | 11,1634162 | 10,935072 | 8,488681 | 9,228629 | 7,1317224 | S60X40 |
| 46 | 3,6 | -19,67011 | 1,21014 | 51,70173 | -21,667913 | 34,903845 | -73,66979 | 28,82846 | -64,23466 | S60X40 |
| 53 | 0 | -11,26261 | -0,88949 | 49,37178 | -14,93832 | 39,080661 | -64,60008 | 34,29825 | -54,57095 | S60X40 |
| 53 | 1,8 | 9,088233 | 0,16032 | -1,164952 | 11,162395 | 8,4877833 | 10,93418 | 7,130953 | 9,2278665 | S60X40 |
| 53 | 3,6 | -19,66118 | 1,21014 | -51,70169 | -21,657197 | -73,66037 | 34,91318 | -64,22658 | 28,836459 | S60X40 |
| 54 | 0 | -33,09612 | -0,74629 | 31,58125 | -40,909404 | -2,3742151 | -68,69484 | -1,363383 | -58,20963 | S60X40 |
| 54 | 3,6 | 16,31868 | -0,09716 | -0,244086 | 19,4269595 | 16,776305 | 17,28889 | 14,46713 | 14,906489 | S60X40 |
| 54 | 7,2 | -32,17154 | 0,55197 | -32,06942 | -37,722702 | -66,873443 | 0,472339 | -57,81686 | -0,091908 | S60X40 |
| 55 | 0 | -32,62594 | 7,2E-05 | 32,33254 | -39,151013 | -0,3079946 | -68,20633 | -0,26406 | -58,46263 | S60X40 |
| 55 | 3,6 | 16,32847 | 7,2E-05 | 2,616E-06 | 19,5942789 | 17,144972 | 17,14497 | 14,69563 | 14,695621 | S60X40 |
| 55 | 7,2 | -32,62215 | 7,2E-05 | -32,33253 | -39,146465 | -68,202339 | -0,304026 | -58,45921 | -0,260658 | S60X40 |
| 56 | 0 | -32,17789 | 0,55197 | 32,06944 | -37,730322 | 0,4656923 | -66,88013 | -0,097605 | -57,8226 | S60X40 |
| 56 | 3,6 | 16,31936 | -0,09716 | 0,2440852 | 19,4277755 | 17,289599 | 16,77702 | 14,9071 | 14,467747 | S60X40 |
| 56 | 7,2 | -33,08843 | -0,74629 | -31,58127 | -40,900176 | -68,686787 | -2,36612 | -58,20273 | -1,356444 | S60X40 |
| 57 | 0 | -11,25198 | -0,88949 | -49,37183 | -14,925564 | -64,588968 | 39,09188 | -54,56143 | 34,307865 | S60X40 |
| 57 | 1,8 | 9,089084 | 0,16032 | 1,164948 | 11,1634162 | 10,935072 | 8,488681 | 9,228629 | 7,1317224 | S60X40 |
| 57 | 3,6 | -19,67011 | 1,21014 | 51,70173 | -21,667913 | 34,903845 | -73,66979 | 28,82846 | -64,23466 | S60X40 |
| 112 | 0 | -6,417798 | -3,17374 | 122,8734 | -12,779337 | 118,94596 | -139,0882 | 104,81 | -116,3621 | B70X40 |
| 112 | 1,8 | 11,86332 | 1,91194 | -7,360326 | 17,2950944 | 6,7356849 | 22,19237 | 4,052695 | 17,301281 | B70X40 |
| 112 | 3,6 | -58,75339 | -12,4424 | -137,594 | -90,411876 | -219,22926 | 69,71814 | -176,7127 | 70,956549 | B70X40 |
| 113 | 0 | -118,7712 | -41,7704 | 104,8313 | -209,35813 | -58,495847 | -278,6416 | -12,54591 | -201,2423 | B70X40 |
| 113 | 3,6 | 64,49279 | 22,9918 | -1,065317 | 114,178244 | 90,740247 | 92,97741 | 57,08473 | 59,002296 | B70X40 |
| 113 | 7,2 | -123,4691 | -42,3259 | -106,9619 | -215,88442 | -286,39479 | -61,7748 | -207,3879 | -14,85648 | B70X40 |
| 114 | 0 | -123,5435 | -43,1919 | 107,3101 | -217,35918 | -62,396523 | -287,7477 | -14,61006 | -207,7682 | B70X40 |
| 114 | 3,6 | 62,02773 | 21,8481 | -2,39E-05 | 109,3903 | 88,069638 | 88,06969 | 55,82494 | 55,824979 | B70X40 |
| 114 | 7,2 | -123,6269 | -43,1919 | -107,3101 | -217,45926 | -287,8353 | -62,48409 | -207,8433 | -14,68512 | B70X40 |
| 115 | 0 | -123,3837 | -42,3259 | 106,9623 | -215,78194 | -61,684707 | -286,3055 | -14,77926 | -207,3114 | B70X40 |
| 115 | 3,6 | 64,48581 | 22,9918 | 1,065341 | 114,169868 | 92,970109 | 90,73289 | 58,99604 | 57,078422 | B70X40 |
| 115 | 7,2 | -118,8706 | -41,7704 | -104,8316 | -209,47741 | -278,74626 | -58,5999 | -201,332 | -12,6351 | B70X40 |
| 116 | 0 | -6,361326 | -3,17374 | -122,8736 | -12,71157 | -139,0291 | 119,0055 | -116,3114 | 104,86105 | B70X40 |
| 116 | 1,8 | 11,84909 | 1,91194 | 7,360391 | 17,2780184 | 22,177496 | 6,720675 | 17,28853 | 4,0398291 | B70X40 |
| 116 | 3,6 | -58,83833 | -12,4424 | 137,5943 | -90,513804 | 69,62927 | -219,3188 | 70,88037 | -176,7894 | B70X40 |
| 123 | 0 | -6,417798 | -3,17374 | 122,8734 | -12,779337 | 118,94596 | -139,0882 | 104,81 | -116,3621 | B70X40 |
| 123 | 1,8 | 11,86332 | 1,91194 | -7,360326 | 17,2950944 | 6,7356849 | 22,19237 | 4,052695 | 17,301281 | B70X40 |
| 123 | 3,6 | -58,75339 | -12,4424 | -137,594 | -90,411876 | -219,22926 | 69,71814 | -176,7127 | 70,956549 | B70X40 |
| 124 | 0 | -118,7712 | -41,7704 | 104,8313 | -209,35813 | -58,495847 | -278,6416 | -12,54591 | -201,2423 | B70X40 |
| 124 | 3,6 | 64,49279 | 22,9918 | -1,065317 | 114,178244 | 90,740247 | 92,97741 | 57,08473 | 59,002296 | B70X40 |
| 124 | 7,2 | -123,4691 | -42,3259 | -106,9619 | -215,88442 | -286,39479 | -61,7748 | -207,3879 | -14,85648 | B70X40 |
| 125 | 0 | -123,5435 | -43,1919 | 107,3101 | -217,35918 | -62,396523 | -287,7477 | -14,61006 | -207,7682 | B70X40 |

| | | | | | | | | | | |
|-----|-----|-----------|----------|-----------|------------|------------|-----------|-----------|-----------|--------|
| 125 | 3,6 | 62,02773 | 21,8481 | -2,39E-05 | 109,3903 | 88,069638 | 88,06969 | 55,82494 | 55,824979 | B70X40 |
| 125 | 7,2 | -123,6269 | -43,1919 | -107,3101 | -217,45926 | -287,8353 | -62,48409 | -207,8433 | -14,68512 | B70X40 |
| 126 | 0 | -123,3837 | -42,3259 | 106,9623 | -215,78194 | -61,684707 | -286,3055 | -14,77926 | -207,3114 | B70X40 |
| 126 | 3,6 | 64,48581 | 22,9918 | 1,065341 | 114,169868 | 92,970109 | 90,73289 | 58,99604 | 57,078422 | B70X40 |
| 126 | 7,2 | -118,8706 | -41,7704 | -104,8316 | -209,47741 | -278,74626 | -58,5999 | -201,332 | -12,6351 | B70X40 |
| 127 | 0 | -6,361326 | -3,17374 | -122,8736 | -12,71157 | -139,0291 | 119,0055 | -116,3114 | 104,86105 | B70X40 |
| 127 | 1,8 | 11,84909 | 1,91194 | 7,360391 | 17,2780184 | 22,177496 | 6,720675 | 17,28853 | 4,0398291 | B70X40 |
| 127 | 3,6 | -58,83833 | -12,4424 | 137,5943 | -90,513804 | 69,62927 | -219,3188 | 70,88037 | -176,7894 | B70X40 |
| 182 | 0 | -4,271658 | -4,85976 | 108,6702 | -12,901607 | 104,51572 | -123,6917 | 93,95869 | -101,6477 | B70X40 |
| 182 | 1,8 | 12,33415 | 2,34928 | -5,165385 | 18,5598264 | 9,9939462 | 20,84125 | 6,451889 | 15,749582 | B70X40 |
| 182 | 3,6 | -59,95786 | -9,88168 | -119,001 | -87,760122 | -198,28257 | 51,61953 | -161,063 | 53,138826 | B70X40 |
| 183 | 0 | -122,5283 | -44,022 | 101,865 | -217,46916 | -67,919565 | -281,8361 | -18,59697 | -201,954 | B70X40 |
| 183 | 3,6 | 63,97046 | 22,8045 | -0,489382 | 113,251768 | 90,599868 | 91,62757 | 57,13297 | 58,013857 | B70X40 |
| 183 | 7,2 | -120,7566 | -40,449 | -102,8438 | -209,62627 | -277,25184 | -61,27986 | -201,2404 | -16,12152 | B70X40 |
| 184 | 0 | -123,3031 | -43,045 | 101,3509 | -216,83564 | -68,247008 | -281,0839 | -19,75698 | -202,1886 | B70X40 |
| 184 | 3,6 | 62,27203 | 21,995 | 0,0002553 | 109,9185 | 88,480692 | 88,48016 | 56,04506 | 56,044597 | B70X40 |
| 184 | 7,2 | -123,3787 | -43,045 | -101,3504 | -216,92636 | -281,16275 | -68,32691 | -202,2562 | -19,82547 | B70X40 |
| 185 | 0 | -120,6892 | -40,449 | 102,8431 | -209,54539 | -61,209824 | -277,1803 | -16,06149 | -201,1791 | B70X40 |
| 185 | 3,6 | 63,96535 | 22,8045 | 0,4891934 | 113,245636 | 91,622006 | 90,5947 | 58,00909 | 57,128541 | B70X40 |
| 185 | 7,2 | -122,6059 | -44,022 | -101,8648 | -217,56228 | -281,91734 | -68,00126 | -202,0236 | -18,66699 | B70X40 |
| 186 | 0 | -4,205462 | -4,85976 | -108,6708 | -12,822172 | -123,62282 | 104,5859 | -101,5886 | 94,018804 | B70X40 |
| 186 | 1,8 | 12,3232 | 2,34928 | 5,16524 | 18,5466864 | 20,829605 | 9,982601 | 15,7396 | 6,442164 | B70X40 |
| 186 | 3,6 | -60,04596 | -9,88168 | 119,0012 | -87,865842 | 51,527237 | -198,3753 | 53,05972 | -161,1424 | B70X40 |
| 193 | 0 | -4,271658 | -4,85976 | 108,6702 | -12,901607 | 104,51572 | -123,6917 | 93,95869 | -101,6477 | B70X40 |
| 193 | 1,8 | 12,33415 | 2,34928 | -5,165385 | 18,5598264 | 9,9939462 | 20,84125 | 6,451889 | 15,749582 | B70X40 |
| 193 | 3,6 | -59,95786 | -9,88168 | -119,001 | -87,760122 | -198,28257 | 51,61953 | -161,063 | 53,138826 | B70X40 |
| 194 | 0 | -122,5283 | -44,022 | 101,865 | -217,46916 | -67,919565 | -281,8361 | -18,59697 | -201,954 | B70X40 |
| 194 | 3,6 | 63,97046 | 22,8045 | -0,489382 | 113,251768 | 90,599868 | 91,62757 | 57,13297 | 58,013857 | B70X40 |
| 194 | 7,2 | -120,7566 | -40,449 | -102,8438 | -209,62627 | -277,25184 | -61,27986 | -201,2404 | -16,12152 | B70X40 |
| 195 | 0 | -123,3031 | -43,045 | 101,3509 | -216,83564 | -68,247008 | -281,0839 | -19,75698 | -202,1886 | B70X40 |
| 195 | 3,6 | 62,27203 | 21,995 | 0,0002553 | 109,9185 | 88,480692 | 88,48016 | 56,04506 | 56,044597 | B70X40 |
| 195 | 7,2 | -123,3787 | -43,045 | -101,3504 | -216,92636 | -281,16275 | -68,32691 | -202,2562 | -19,82547 | B70X40 |
| 196 | 0 | -120,6892 | -40,449 | 102,8431 | -209,54539 | -61,209824 | -277,1803 | -16,06149 | -201,1791 | B70X40 |
| 196 | 3,6 | 63,96535 | 22,8045 | 0,4891934 | 113,245636 | 91,622006 | 90,5947 | 58,00909 | 57,128541 | B70X40 |
| 196 | 7,2 | -122,6059 | -44,022 | -101,8648 | -217,56228 | -281,91734 | -68,00126 | -202,0236 | -18,66699 | B70X40 |
| 197 | 0 | -4,205462 | -4,85976 | -108,6708 | -12,822172 | -123,62282 | 104,5859 | -101,5886 | 94,018804 | B70X40 |
| 197 | 1,8 | 12,3232 | 2,34928 | 5,16524 | 18,5466864 | 20,829605 | 9,982601 | 15,7396 | 6,442164 | B70X40 |
| 197 | 3,6 | -60,04596 | -9,88168 | 119,0012 | -87,865842 | 51,527237 | -198,3753 | 53,05972 | -161,1424 | B70X40 |
| 252 | 0 | -2,178768 | -5,42091 | 72,78448 | -11,287976 | 68,444043 | -84,40336 | 63,54514 | -67,46692 | B70X40 |
| 252 | 1,8 | 12,33255 | 2,42368 | -2,810632 | 18,6769448 | 12,542876 | 18,4452 | 8,569726 | 13,628864 | B70X40 |
| 252 | 3,6 | -62,05396 | -9,17173 | -78,40575 | -89,139526 | -157,11302 | 7,539059 | -126,4137 | 14,716611 | B70X40 |
| 253 | 0 | -124,0161 | -45,1135 | 81,70853 | -221,00092 | -91,792124 | -263,38 | -38,07681 | -185,1522 | B70X40 |
| 253 | 3,6 | 63,83801 | 22,8302 | -0,076374 | 113,1339 | 90,921407 | 91,08179 | 57,38547 | 57,522946 | B70X40 |
| 253 | 7,2 | -119,5337 | -39,3061 | -81,86128 | -206,33025 | -252,73617 | -80,82748 | -181,2555 | -33,90518 | B70X40 |
| 254 | 0 | -123,2535 | -43,0262 | 79,28883 | -216,74614 | -91,340424 | -257,847 | -39,5682 | -182,2881 | B70X40 |
| 254 | 3,6 | 62,32168 | 22,0138 | -0,001071 | 110,00808 | 88,551119 | 88,55337 | 56,08855 | 56,090475 | B70X40 |
| 254 | 7,2 | -123,3289 | -43,0262 | -79,29097 | -216,83662 | -257,92838 | -91,41735 | -182,3579 | -39,63414 | B70X40 |
| 255 | 0 | -119,4731 | -39,3061 | 81,86625 | -206,25753 | -80,758629 | -252,6778 | -33,84617 | -181,2054 | B70X40 |
| 255 | 3,6 | 63,83414 | 22,8302 | 0,0773941 | 113,129256 | 91,0788 | 90,91627 | 57,52038 | 57,381071 | B70X40 |
| 255 | 7,2 | -124,0844 | -45,1135 | -81,71146 | -221,08288 | -263,45483 | -91,86076 | -185,2163 | -38,13565 | B70X40 |
| 256 | 0 | -2,119151 | -5,42091 | -72,7847 | -11,216436 | -84,340998 | 68,50687 | -67,41347 | 63,598994 | B70X40 |
| 256 | 1,8 | 12,32235 | 2,42368 | 2,810987 | 18,6647048 | 18,434866 | 12,53179 | 13,62 | 8,5602267 | B70X40 |
| 256 | 3,6 | -62,13397 | -9,17173 | 78,40667 | -89,235538 | 7,4560143 | -157,198 | 14,64543 | -126,4866 | B70X40 |
| 263 | 0 | -2,178768 | -5,42091 | 72,78448 | -11,287976 | 68,444043 | -84,40336 | 63,54514 | -67,46692 | B70X40 |
| 263 | 1,8 | 12,33255 | 2,42368 | -2,810632 | 18,6769448 | 12,542876 | 18,4452 | 8,569726 | 13,628864 | B70X40 |
| 263 | 3,6 | -62,05396 | -9,17173 | -78,40575 | -89,139526 | -157,11302 | 7,539059 | -126,4137 | 14,716611 | B70X40 |
| 264 | 0 | -124,0161 | -45,1135 | 81,70853 | -221,00092 | -91,792124 | -263,38 | -38,07681 | -185,1522 | B70X40 |
| 264 | 3,6 | 63,83801 | 22,8302 | -0,076374 | 113,1339 | 90,921407 | 91,08179 | 57,38547 | 57,522946 | B70X40 |

| | | | | | | | | | | |
|-----|-----|-----------|----------|-----------|------------|------------|-----------|-----------|-----------|--------|
| 264 | 7,2 | -119,5337 | -39,3061 | -81,86128 | -206,33025 | -252,73617 | -80,82748 | -181,2555 | -33,90518 | B70X40 |
| 265 | 0 | -123,2535 | -43,0262 | 79,28883 | -216,74614 | -91,340424 | -257,847 | -39,5682 | -182,2881 | B70X40 |
| 265 | 3,6 | 62,32168 | 22,0138 | -0,001071 | 110,00808 | 88,551119 | 88,55337 | 56,08855 | 56,090475 | B70X40 |
| 265 | 7,2 | -123,3289 | -43,0262 | -79,29097 | -216,83662 | -257,92838 | -91,41735 | -182,3579 | -39,63414 | B70X40 |
| 266 | 0 | -119,4731 | -39,3061 | 81,86625 | -206,25753 | -80,758629 | -252,6778 | -33,84617 | -181,2054 | B70X40 |
| 266 | 3,6 | 63,83414 | 22,8302 | 0,0773941 | 113,129256 | 91,0788 | 90,91627 | 57,52038 | 57,381071 | B70X40 |
| 266 | 7,2 | -124,0844 | -45,1135 | -81,71146 | -221,08288 | -263,45483 | -91,86076 | -185,2163 | -38,13565 | B70X40 |
| 267 | 0 | -2,119151 | -5,42091 | -72,7847 | -11,216436 | -84,340998 | 68,50687 | -67,41347 | 63,598994 | B70X40 |
| 267 | 1,8 | 12,32235 | 2,42368 | 2,810987 | 18,6647048 | 18,434866 | 12,53179 | 13,62 | 8,5602267 | B70X40 |
| 267 | 3,6 | -62,13397 | -9,17173 | 78,40667 | -89,235538 | 7,4560143 | -157,198 | 14,64543 | -126,4866 | B70X40 |
| 322 | 0 | -1,013363 | -5,26906 | 29,96788 | -9,64653 | 24,869731 | -38,06282 | 26,05907 | -27,88312 | B70X40 |
| 322 | 1,8 | 9,787374 | 1,55477 | 0,6042967 | 14,2324776 | 12,543761 | 11,27474 | 9,352504 | 8,2647696 | B70X40 |
| 322 | 3,6 | -68,30972 | -11,0614 | -28,75929 | -99,66992 | -113,53694 | -53,14243 | -87,36211 | -35,59539 | B70X40 |
| 323 | 0 | -120,7866 | -44,0691 | 50,43808 | -215,45451 | -120,13852 | -226,0585 | -63,31367 | -154,1022 | B70X40 |
| 323 | 3,6 | 64,58683 | 23,0511 | 1,276429 | 114,386004 | 93,360108 | 90,67961 | 59,27693 | 56,979361 | B70X40 |
| 323 | 7,2 | -121,2656 | -39,9086 | -47,88523 | -209,37251 | -219,51242 | -118,9534 | -152,2357 | -66,04233 | B70X40 |
| 324 | 0 | -123,2195 | -42,7764 | 42,66349 | -216,30569 | -129,49906 | -219,0924 | -72,50041 | -149,2947 | B70X40 |
| 324 | 3,6 | 62,36747 | 22,2636 | 0,004382 | 110,462676 | 88,867193 | 88,85799 | 56,13467 | 56,126779 | B70X40 |
| 324 | 7,2 | -123,2714 | -42,7764 | -42,65473 | -216,36797 | -219,13769 | -129,5628 | -149,3335 | -72,555 | B70X40 |
| 325 | 0 | -121,219 | -39,9086 | 47,8687 | -209,31659 | -118,92187 | -219,4461 | -66,01527 | -152,1789 | B70X40 |
| 325 | 3,6 | 64,5769 | 23,0511 | -1,280714 | 114,374088 | 90,664682 | 93,35418 | 56,96657 | 59,271853 | B70X40 |
| 325 | 7,2 | -120,8531 | -44,0691 | -50,43013 | -215,53431 | -226,11997 | -120,2167 | -154,1549 | -63,38067 | B70X40 |
| 326 | 0 | -68,36017 | -11,0614 | 28,75982 | -99,73046 | -53,194848 | -113,5905 | -35,64032 | -87,40799 | B70X40 |
| 326 | 1,8 | 9,77864 | 1,55477 | -0,604596 | 14,2219968 | 11,265253 | 12,5349 | 8,25664 | 9,3449124 | B70X40 |
| 326 | 3,6 | -0,980375 | -5,26906 | -29,96901 | -9,6069443 | -38,029366 | 24,90555 | -27,85445 | 26,089772 | B70X40 |
| 333 | 0 | -1,013363 | -5,26906 | 29,96788 | -9,64653 | 24,869731 | -38,06282 | 26,05907 | -27,88312 | B70X40 |
| 333 | 1,8 | 9,787374 | 1,55477 | 0,6042967 | 14,2324776 | 12,543761 | 11,27474 | 9,352504 | 8,2647696 | B70X40 |
| 333 | 3,6 | -68,30972 | -11,0614 | -28,75929 | -99,66992 | -113,53694 | -53,14243 | -87,36211 | -35,59539 | B70X40 |
| 334 | 0 | -120,7866 | -44,0691 | 50,43808 | -215,45451 | -120,13852 | -226,0585 | -63,31367 | -154,1022 | B70X40 |
| 334 | 3,6 | 64,58683 | 23,0511 | 1,276429 | 114,386004 | 93,360108 | 90,67961 | 59,27693 | 56,979361 | B70X40 |
| 334 | 7,2 | -121,2656 | -39,9086 | -47,88523 | -209,37251 | -219,51242 | -118,9534 | -152,2357 | -66,04233 | B70X40 |
| 335 | 0 | -123,2195 | -42,7764 | 42,66349 | -216,30569 | -129,49906 | -219,0924 | -72,50041 | -149,2947 | B70X40 |
| 335 | 3,6 | 62,36747 | 22,2636 | 0,004382 | 110,462676 | 88,867193 | 88,85799 | 56,13467 | 56,126779 | B70X40 |
| 335 | 7,2 | -123,2714 | -42,7764 | -42,65473 | -216,36797 | -219,13769 | -129,5628 | -149,3335 | -72,555 | B70X40 |
| 336 | 0 | -121,219 | -39,9086 | 47,8687 | -209,31659 | -118,92187 | -219,4461 | -66,01527 | -152,1789 | B70X40 |
| 336 | 3,6 | 64,5769 | 23,0511 | -1,280714 | 114,374088 | 90,664682 | 93,35418 | 56,96657 | 59,271853 | B70X40 |
| 336 | 7,2 | -120,8531 | -44,0691 | -50,43013 | -215,53431 | -226,11997 | -120,2167 | -154,1549 | -63,38067 | B70X40 |
| 337 | 0 | -68,36017 | -11,0614 | 28,75982 | -99,73046 | -53,194848 | -113,5905 | -35,64032 | -87,40799 | B70X40 |
| 337 | 1,8 | 9,77864 | 1,55477 | -0,604596 | 14,2219968 | 11,265253 | 12,5349 | 8,25664 | 9,3449124 | B70X40 |
| 337 | 3,6 | -0,980375 | -5,26906 | -29,96901 | -9,6069443 | -38,029366 | 24,90555 | -27,85445 | 26,089772 | B70X40 |
| 386 | 0 | -6,125962 | -3,4038 | 3,725534 | -12,79723 | -6,0944363 | -13,91806 | -2,160385 | -8,866346 | R50X30 |
| 386 | 1,8 | 8,829042 | 2,09306 | -0,326005 | 13,9437496 | 11,125904 | 11,81051 | 7,652733 | 8,2395424 | R50X30 |
| 386 | 3,6 | -14,19091 | -0,18608 | -4,377544 | -17,326817 | -19,692259 | -10,49942 | -16,71161 | -8,832029 | R50X30 |
| 387 | 0 | -14,19109 | -0,18608 | 4,377466 | -17,327033 | -10,499688 | -19,69237 | -8,832262 | -16,7117 | R50X30 |
| 387 | 1,8 | 8,829747 | 2,09306 | 0,3259321 | 13,9445956 | 11,811178 | 11,12672 | 8,240111 | 7,6534334 | R50X30 |
| 387 | 3,6 | -6,124375 | -3,4038 | -3,725601 | -12,795325 | -13,916462 | -6,0927 | -8,864978 | -2,158897 | R50X30 |
| 392 | 0 | -6,125962 | -3,4038 | 3,725534 | -12,79723 | -6,0944363 | -13,91806 | -2,160385 | -8,866346 | R50X30 |
| 392 | 1,8 | 8,829042 | 2,09306 | -0,326005 | 13,9437496 | 11,125904 | 11,81051 | 7,652733 | 8,2395424 | R50X30 |
| 392 | 3,6 | -14,19091 | -0,18608 | -4,377544 | -17,326817 | -19,692259 | -10,49942 | -16,71161 | -8,832029 | R50X30 |
| 393 | 0 | -14,19109 | -0,18608 | 4,377466 | -17,327033 | -10,499688 | -19,69237 | -8,832262 | -16,7117 | R50X30 |
| 393 | 1,8 | 8,829747 | 2,09306 | 0,3259321 | 13,9445956 | 11,811178 | 11,12672 | 8,240111 | 7,6534334 | R50X30 |
| 393 | 3,6 | -6,124375 | -3,4038 | -3,725601 | -12,795325 | -13,916462 | -6,0927 | -8,864978 | -2,158897 | R50X30 |

Tabel 6.4. Momen rencana balok As- 1 & 6

| ELEMEN | SECTION | MD (kNm) | ML (kNm) | ME,y (kNm) | 1,2 MD + 1,6 ML (kNm) | 1,05(MD+M L+ ME,y) (kNm) | 1,05(MD+ ML-ME,y) (kNm) | 0,9 MD+ ME,y (kNm) | 0,9MD- ME,y (kNm) | keterangan |
|--------|---------|-------------|-------------|---------------|-----------------------------|--------------------------------|-------------------------------|--------------------------|-------------------------|------------|
| 38 | 0 | -33,41561 | -0,49019 | 46,75406 | -40,883029 | 13,490678 | -84,69285 | 12,00461 | -72,1527 | S70X20 |
| 38 | 2,4 | 16,78993 | -0,10865 | 10,26524 | 19,9740752 | 28,293845 | 6,736841 | 24,34965 | 5,872221 | S70X20 |
| 38 | 4,8 | -20,29387 | 0,27288 | -26,22358 | -23,916029 | -48,556794 | 6,512724 | -41,86571 | 5,336739 | S70X20 |
| 41 | 0 | -33,41515 | -0,49019 | 46,75406 | -40,882477 | 13,491161 | -84,69237 | 12,00502 | -72,15229 | S70X20 |
| 41 | 2,4 | 16,78998 | -0,10865 | 10,26524 | 19,9741352 | 28,293898 | 6,736894 | 24,3497 | 5,872266 | S70X20 |
| 41 | 4,8 | -20,29423 | 0,27288 | -26,22358 | -23,916461 | -48,557172 | 6,512346 | -41,86603 | 5,336415 | S70X20 |
| 47 | 0 | -14,19299 | 0,20894 | 17,78483 | -16,697283 | 3,9908198 | -33,35732 | 3,232656 | -28,78004 | S70X20 |
| 47 | 1,2 | -3,281822 | 0,20894 | -5,01E-05 | -3,6038811 | -3,2265779 | -3,226473 | -2,953685 | -2,953595 | S70X20 |
| 47 | 2,4 | -14,19299 | 0,20894 | -17,78493 | -16,697283 | -33,357428 | 3,990925 | -28,78013 | 3,232746 | S70X20 |
| 52 | 0 | -14,19315 | 0,20894 | 17,78483 | -16,697475 | 3,9906518 | -33,35749 | 3,232512 | -28,78018 | S70X20 |
| 52 | 1,2 | -3,281984 | 0,20894 | -5,01E-05 | -3,6040755 | -3,226748 | -3,226643 | -2,953831 | -2,95374 | S70X20 |
| 52 | 2,4 | -14,19315 | 0,20894 | -17,78493 | -16,697475 | -33,357596 | 3,990757 | -28,78027 | 3,232602 | S70X20 |
| 58 | 0 | -20,29387 | 0,27288 | 26,22331 | -23,916029 | 6,5124407 | -48,55651 | 5,336496 | -41,86546 | S70X20 |
| 58 | 2,4 | 16,78993 | -0,10865 | -10,26523 | 19,9740752 | 6,736852 | 28,29383 | 5,87223 | 24,349644 | S70X20 |
| 58 | 4,8 | -33,41561 | -0,49019 | -46,75376 | -40,883029 | -84,692533 | 13,49036 | -72,15243 | 12,004335 | S70X20 |
| 61 | 0 | -20,29423 | 0,27288 | 26,22331 | -23,916461 | 6,5120627 | -48,55689 | 5,336172 | -41,86579 | S70X20 |
| 61 | 2,4 | 16,78998 | -0,10865 | -10,26523 | 19,9741352 | 6,7369045 | 28,29389 | 5,872275 | 24,349689 | S70X20 |
| 61 | 4,8 | -33,41515 | -0,49019 | -46,75376 | -40,882477 | -84,69205 | 13,49085 | -72,15202 | 12,004749 | S70X20 |
| 108 | 0 | -68,86348 | -9,91582 | 164,2657 | -98,50149 | 89,760719 | -255,1973 | 85,862 | -209,8163 | B70X20 |
| 108 | 2,4 | 40,67775 | 7,33831 | 49,40118 | 60,554288 | 102,28783 | -1,454644 | 81,07081 | -7,851312 | B70X20 |
| 108 | 4,8 | -25,24417 | -3,53557 | -65,46331 | -35,949913 | -98,9552 | 38,51775 | -81,63673 | 36,197226 | B70X20 |
| 111 | 0 | -68,86035 | -9,91582 | 164,2657 | -98,497734 | 89,764005 | -255,194 | 85,86482 | -209,8134 | B70X20 |
| 111 | 2,4 | 40,67776 | 7,33831 | 49,40118 | 60,5546 | 102,28811 | -1,454371 | 81,07105 | -7,851078 | B70X20 |
| 111 | 4,8 | -25,24679 | -3,53557 | -65,46331 | -35,953057 | -98,957951 | 38,515 | -81,63909 | 36,194868 | B70X20 |
| 117 | 0 | -22,1802 | -3,19669 | 4,900966 | -31,730949 | -21,499723 | -31,79175 | -15,55131 | -24,37305 | B70X20 |
| 117 | 1,2 | -6,964006 | -1,75669 | -0,000849 | -11,167516 | -9,1576257 | -9,155842 | -6,26837 | -6,266841 | B70X20 |
| 117 | 2,4 | -22,1802 | -3,19669 | -4,902664 | -31,730949 | -31,793535 | -21,49794 | -24,37458 | -15,54978 | B70X20 |
| 122 | 0 | -22,18189 | -3,19669 | 4,900966 | -31,732977 | -21,501498 | -31,79353 | -15,55283 | -24,37457 | B70X20 |
| 122 | 1,2 | -6,965698 | -1,75669 | -0,000849 | -11,169546 | -9,1594023 | -9,157619 | -6,269893 | -6,268364 | B70X20 |
| 122 | 2,4 | -22,18189 | -3,19669 | -4,902664 | -31,732977 | -31,795309 | -21,49971 | -24,3761 | -15,5513 | B70X20 |
| 128 | 0 | -25,24417 | -3,53557 | 65,46152 | -35,949913 | 38,515871 | -98,95332 | 36,19562 | -81,63512 | B70X20 |
| 128 | 2,4 | 40,67775 | 7,33831 | -49,40076 | 60,554288 | -1,4542028 | 102,2874 | -7,850934 | 81,070434 | B70X20 |
| 128 | 4,8 | -68,86348 | -9,91582 | -164,263 | -98,50149 | -255,19442 | 89,75788 | -209,8138 | 85,859568 | B70X20 |
| 131 | 0 | -25,24679 | -3,53557 | 65,46152 | -35,953057 | 38,51312 | -98,95607 | 36,19326 | -81,63748 | B70X20 |
| 131 | 2,4 | 40,67776 | 7,33831 | -49,40076 | 60,5546 | -1,4539298 | 102,2877 | -7,8507 | 81,070668 | B70X20 |
| 131 | 4,8 | -68,86035 | -9,91582 | -164,263 | -98,497734 | -255,19113 | 89,76117 | -209,811 | 85,862385 | B70X20 |
| 178 | 0 | -79,37574 | -11,7414 | 145,3701 | -114,03711 | 56,965619 | -248,3116 | 59,39492 | -202,2713 | B70X20 |
| 178 | 2,4 | 39,24808 | 7,01115 | 45,03531 | 58,3155328 | 95,859265 | 1,285114 | 75,85505 | -5,208507 | B70X20 |
| 178 | 4,8 | -17,59076 | -2,36431 | -55,29953 | -24,891813 | -79,017333 | 37,11168 | -65,60126 | 33,937893 | B70X20 |
| 181 | 0 | -79,37106 | -11,7414 | 145,3701 | -114,0315 | 56,970533 | -248,3067 | 59,39914 | -202,267 | B70X20 |
| 181 | 2,4 | 39,24847 | 7,01115 | 45,03531 | 58,3160008 | 95,859674 | 1,285523 | 75,8554 | -5,208156 | B70X20 |
| 181 | 4,8 | -17,59464 | -2,36431 | -55,29953 | -24,896469 | -79,021407 | 37,10761 | -65,60475 | 33,934401 | B70X20 |
| 187 | 0 | -16,25769 | -2,15352 | 13,48883 | -22,95486 | -5,168499 | -33,49504 | -2,491974 | -26,77187 | B70X20 |
| 187 | 1,2 | -1,041495 | -0,71352 | -0,001174 | -2,3914266 | -1,8439994 | -1,841533 | -0,938403 | -0,936288 | B70X20 |
| 187 | 2,4 | -16,25769 | -2,15352 | -13,49118 | -22,95486 | -33,49751 | -5,166032 | -26,77398 | -2,489859 | B70X20 |
| 192 | 0 | -16,26018 | -2,15352 | 13,48883 | -22,957848 | -5,1711135 | -33,49766 | -2,494215 | -26,77411 | B70X20 |
| 192 | 1,2 | -1,043992 | -0,71352 | -0,001174 | -2,394423 | -1,8466212 | -1,844155 | -0,94065 | -0,938536 | B70X20 |
| 192 | 2,4 | -16,26018 | -2,15352 | -13,49118 | -22,957848 | -33,500124 | -5,168646 | -26,77622 | -2,4921 | B70X20 |
| 198 | 0 | -17,59076 | -2,36431 | 55,29664 | -24,891813 | 37,108645 | -79,0143 | 33,93529 | -65,59866 | B70X20 |
| 198 | 2,4 | 39,24808 | 7,01115 | -45,03517 | 58,3155328 | 1,2852609 | 95,85912 | -5,208381 | 75,854925 | B70X20 |
| 198 | 4,8 | -79,37574 | -11,7414 | -145,367 | -114,03711 | -248,30834 | 56,96236 | -202,2685 | 59,392134 | B70X20 |
| 201 | 0 | -17,59464 | -2,36431 | 55,29664 | -24,896469 | 37,104571 | -79,01837 | 33,9318 | -65,60215 | B70X20 |

| | | | | | | | | | | |
|-----|-----|-----------|----------|-----------|------------|------------|-----------|-----------|-----------|--------|
| 201 | 2,4 | 39,24847 | 7,01115 | -45,03517 | 58,3160008 | 1,2856704 | 95,85953 | -5,20803 | 75,855276 | B70X20 |
| 201 | 4,8 | -79,37106 | -11,7414 | -145,367 | -114,0315 | -248,30342 | 56,96728 | -202,2643 | 59,396346 | B70X20 |
| 248 | 0 | -85,57386 | -12,6271 | 106,9273 | -122,89196 | 9,162678 | -215,3847 | 19,2181 | -173,251 | B70X20 |
| 248 | 2,4 | 38,67231 | 6,95531 | 34,45389 | 57,5352648 | 84,085583 | 11,73241 | 65,81358 | 3,796578 | B70X20 |
| 248 | 4,8 | -12,54416 | -1,59031 | -38,01952 | -17,597485 | -54,761687 | 25,0793 | -45,50731 | 22,927824 | B70X20 |
| 251 | 0 | -85,56852 | -12,6271 | 106,9273 | -122,88555 | 9,168285 | -215,379 | 19,2229 | -173,2462 | B70X20 |
| 251 | 2,4 | 38,67277 | 6,95531 | 34,45389 | 57,5358168 | 84,086066 | 11,7329 | 65,81399 | 3,796992 | B70X20 |
| 251 | 4,8 | -12,54859 | -1,59031 | -38,01952 | -17,602801 | -54,766339 | 25,07465 | -45,5113 | 22,923837 | B70X20 |
| 257 | 0 | -12,59504 | -1,59552 | 14,88277 | -17,666885 | 0,7268174 | -30,527 | 2,058957 | -24,73003 | B70X20 |
| 257 | 1,2 | 2,621148 | -0,15552 | -0,002428 | 2,89654128 | 2,5863568 | 2,591456 | 2,356848 | 2,3612187 | B70X20 |
| 257 | 2,4 | -12,59504 | -1,59552 | -14,88763 | -17,666885 | -30,532103 | 0,73192 | -24,7344 | 2,063331 | B70X20 |
| 262 | 0 | -12,59787 | -1,59552 | 14,88277 | -17,670281 | 0,7238459 | -30,52997 | 2,05641 | -24,73258 | B70X20 |
| 262 | 1,2 | 2,618318 | -0,15552 | -0,002428 | 2,89314528 | 2,5833853 | 2,588485 | 2,354301 | 2,3586717 | B70X20 |
| 262 | 2,4 | -12,59787 | -1,59552 | -14,88763 | -17,670281 | -30,535074 | 0,728949 | -24,73695 | 2,060784 | B70X20 |
| 268 | 0 | -12,54416 | -1,59031 | 38,01507 | -17,597485 | 25,074632 | -54,75701 | 22,92382 | -45,50331 | B70X20 |
| 268 | 2,4 | 38,67231 | 6,95531 | -34,4521 | 57,5352648 | 11,734294 | 84,0837 | 3,798189 | 65,811969 | B70X20 |
| 268 | 4,8 | -85,57386 | -12,6271 | -106,9193 | -122,89196 | -215,37625 | 9,154278 | -173,2438 | 19,210896 | B70X20 |
| 271 | 0 | -12,54859 | -1,59031 | 38,01507 | -17,602801 | 25,069981 | -54,76167 | 22,91983 | -45,50729 | B70X20 |
| 271 | 2,4 | 38,67277 | 6,95531 | -34,4521 | 57,5358168 | 11,734777 | 84,08419 | 3,798603 | 65,812383 | B70X20 |
| 271 | 4,8 | -85,56852 | -12,6271 | -106,9193 | -122,88555 | -215,37065 | 9,159885 | -173,239 | 19,215702 | B70X20 |
| 318 | 0 | -88,24835 | -13,3665 | 58,23143 | -127,28447 | -45,552623 | -167,8386 | -27,01523 | -131,8318 | B70X20 |
| 318 | 2,4 | 38,53491 | 6,80924 | 20,41352 | 57,1366792 | 69,045556 | 26,17716 | 53,05359 | 16,309251 | B70X20 |
| 318 | 4,8 | -10,14449 | -1,14298 | -17,40438 | -14,002161 | -30,126446 | 6,422752 | -24,79398 | 6,533901 | B70X20 |
| 321 | 0 | -88,2431 | -13,3665 | 58,23143 | -127,27817 | -45,54711 | -167,8331 | -27,0105 | -131,8271 | B70X20 |
| 321 | 2,4 | 38,53531 | 6,80924 | 20,41352 | 57,1371592 | 69,045976 | 26,17758 | 53,05395 | 16,309611 | B70X20 |
| 321 | 4,8 | -10,14894 | -1,14298 | -17,40438 | -14,007501 | -30,131118 | 6,41808 | -24,79799 | 6,529896 | B70X20 |
| 327 | 0 | -10,33607 | -1,08111 | 15,78905 | -14,133054 | 4,5904677 | -28,56654 | 4,907682 | -23,51261 | B70X20 |
| 327 | 1,2 | 4,880119 | 0,35889 | -0,001448 | 6,4303724 | 5,4994424 | 5,502484 | 4,390804 | 4,3934106 | B70X20 |
| 327 | 2,4 | -10,33607 | -1,08111 | -15,79195 | -14,133054 | -28,569582 | 4,593513 | -23,51522 | 4,910292 | B70X20 |
| 332 | 0 | -10,33883 | -1,08111 | 15,78905 | -14,136366 | 4,5875697 | -28,56944 | 4,905198 | -23,51509 | B70X20 |
| 332 | 1,2 | 4,877362 | 0,35889 | -0,001448 | 6,427064 | 5,4965475 | 5,499589 | 4,388322 | 4,3909293 | B70X20 |
| 332 | 2,4 | -10,33883 | -1,08111 | -15,79195 | -14,136366 | -28,57248 | 4,590615 | -23,5177 | 4,907808 | B70X20 |
| 338 | 0 | -10,14449 | -1,14298 | 17,40047 | -14,002161 | 6,4186469 | -30,12234 | 6,530382 | -24,79046 | B70X20 |
| 338 | 2,4 | 38,53491 | 6,80924 | -20,41437 | 57,1366792 | 26,176271 | 69,04645 | 16,30849 | 53,054352 | B70X20 |
| 338 | 4,8 | -88,24835 | -13,3665 | -58,22921 | -127,28447 | -167,83629 | -45,55495 | -131,8298 | -27,01723 | B70X20 |
| 341 | 0 | -10,14894 | -1,14298 | 17,40047 | -14,007501 | 6,4139744 | -30,12701 | 6,526377 | -24,79447 | B70X20 |
| 341 | 2,4 | 38,53531 | 6,80924 | -20,41437 | 57,1371592 | 26,176691 | 69,04687 | 16,30885 | 53,054712 | B70X20 |
| 341 | 4,8 | -88,2431 | -13,3665 | -58,22921 | -127,27817 | -167,83078 | -45,54944 | -131,8251 | -27,0125 | B70X20 |
| 382 | 0 | -37,34385 | -8,04005 | 9,76245 | -57,676697 | -37,40252 | -57,90367 | -24,82326 | -42,39567 | R70X20 |
| 382 | 2,4 | 21,60508 | 6,00228 | 3,189841 | 35,5297488 | 32,337064 | 25,6384 | 22,31543 | 16,573715 | R70X20 |
| 382 | 4,8 | -9,858795 | -2,89939 | -3,382767 | -16,469572 | -16,947995 | -9,844185 | -11,91741 | -5,828425 | R70X20 |
| 385 | 0 | -37,34249 | -8,04005 | 9,76245 | -57,675065 | -37,401092 | -57,90224 | -24,82204 | -42,39445 | R70X20 |
| 385 | 2,4 | 21,60522 | 6,00228 | 3,189841 | 35,5299168 | 32,337211 | 25,63855 | 22,31555 | 16,573841 | R70X20 |
| 385 | 4,8 | -9,859871 | -2,89939 | -3,382767 | -16,470863 | -16,949125 | -9,845315 | -11,91837 | -5,829394 | R70X20 |
| 388 | 0 | -7,663887 | -2,07491 | 6,524886 | -12,516527 | -3,3746108 | -17,07687 | -1,025101 | -12,7699 | R70X20 |
| 388 | 1,2 | -3,155247 | -1,49891 | -0,000365 | -6,1845588 | -4,8872521 | -4,886486 | -2,840051 | -2,839394 | R70X20 |
| 388 | 2,4 | -7,663887 | -2,07491 | -6,525616 | -12,516527 | -17,077638 | -3,373844 | -12,77055 | -1,024444 | R70X20 |
| 391 | 0 | -7,664506 | -2,07491 | 6,524886 | -12,51727 | -3,3752607 | -17,07752 | -1,025658 | -12,77045 | R70X20 |
| 391 | 1,2 | -3,155866 | -1,49891 | -0,000365 | -6,1853016 | -4,887902 | -4,887136 | -2,840608 | -2,839951 | R70X20 |
| 391 | 2,4 | -7,664506 | -2,07491 | -6,525616 | -12,51727 | -17,078288 | -3,374494 | -12,77111 | -1,025001 | R70X20 |
| 394 | 0 | -9,858795 | -2,89939 | 3,381443 | -16,469572 | -9,8455749 | -16,94661 | -5,829617 | -11,91621 | R70X20 |
| 394 | 2,4 | 21,60508 | 6,00228 | -3,189794 | 35,5297488 | 25,638447 | 32,33701 | 16,57376 | 22,315387 | R70X20 |
| 394 | 4,8 | -37,34385 | -8,04005 | -9,761032 | -57,676697 | -57,902177 | -37,40401 | -42,39439 | -24,82454 | R70X20 |
| 397 | 0 | -9,859871 | -2,89939 | 3,381443 | -16,470863 | -9,8467047 | -16,94774 | -5,830585 | -11,91718 | R70X20 |
| 397 | 2,4 | 21,60522 | 6,00228 | -3,189794 | 35,5299168 | 25,638594 | 32,33716 | 16,57388 | 22,315513 | R70X20 |
| 397 | 4,8 | -37,34249 | -8,04005 | -9,761032 | -57,675065 | -57,900749 | -37,40258 | -42,39317 | -24,82331 | R70X20 |

Tabel 6.5. Momen rencana balok As- 2 & 5

| ELEMEN | SECTION | MD (kNm) | ML (kNm) | ME,y (kNm) | 1,2 MD + 1,6 ML (kNm) | 1,05(MD+M L+ME,y) (kNm) | 1,05(MD+ ML-ME,y) (kNm) | 0,9MD- ME,y (kNm) | 0,9MD+ ME,y (kNm) | keterangan |
|--------|---------|-------------|-------------|---------------|-----------------------------|-------------------------------|-------------------------------|-------------------------|-------------------------|------------|
| 32 | 0 | -28,31327 | -0,59615 | 65,28934 | -34,929759 | 38,198919 | -98,90869 | 33,27846 | -84,24235 | S60X40 |
| 32 | 2,4 | 15,08271 | -0,03327 | 0,6841977 | 18,0460141 | 16,520316 | 15,0835 | 14,19022 | 12,958661 | S60X40 |
| 32 | 4,8 | -28,81064 | 0,5296 | -63,92094 | -33,725408 | -96,812079 | 37,42189 | -83,45842 | 31,59927 | S60X40 |
| 33 | 0 | -28,31215 | -0,59615 | 65,28934 | -34,928415 | 38,200095 | -98,90752 | 33,27947 | -84,24134 | S60X40 |
| 33 | 2,4 | 15,08274 | -0,03327 | 0,6841977 | 18,0460501 | 16,520347 | 15,08353 | 14,19024 | 12,958688 | S60X40 |
| 33 | 4,8 | -28,81172 | 0,5296 | -63,92094 | -33,726704 | -96,813213 | 37,42076 | -83,45939 | 31,598298 | S60X40 |
| 39 | 0 | -30,59817 | -0,25021 | 63,33232 | -37,118144 | 34,108134 | -98,88974 | 29,46074 | -84,53744 | S60X40 |
| 39 | 2,4 | 14,74893 | -0,09439 | 0,7041222 | 17,5476945 | 16,126597 | 14,64794 | 13,90775 | 12,640327 | S60X40 |
| 39 | 4,8 | -27,19332 | 0,06144 | -61,92408 | -32,533687 | -93,508762 | 36,53181 | -80,20566 | 31,257684 | S60X40 |
| 40 | 0 | -30,59977 | -0,25021 | 63,33232 | -37,120064 | 34,106454 | -98,89142 | 29,4593 | -84,53888 | S60X40 |
| 40 | 2,4 | 14,74893 | -0,09439 | 0,7041222 | 17,5476945 | 16,126597 | 14,64794 | 13,90775 | 12,640327 | S60X40 |
| 40 | 4,8 | -27,19171 | 0,06144 | -61,92408 | -32,531755 | -93,507072 | 36,5335 | -80,20421 | 31,259133 | S60X40 |
| 48 | 0 | -8,378322 | 0,22834 | 98,04818 | -9,6886368 | 94,393112 | -111,5081 | 80,70287 | -95,78385 | S60X40 |
| 48 | 1,2 | 2,532847 | 0,22834 | 4,859E-05 | 3,404766 | 2,899301 | 2,899199 | 2,279606 | 2,2795186 | S60X40 |
| 48 | 2,4 | -8,378322 | 0,22834 | -98,04809 | -9,6886368 | -111,50797 | 94,39302 | -95,78377 | 80,702791 | S60X40 |
| 51 | 0 | -8,378343 | 0,22834 | 98,04818 | -9,688662 | 94,39309 | -111,5081 | 80,70285 | -95,78387 | S60X40 |
| 51 | 1,2 | 2,532825 | 0,22834 | 4,859E-05 | 3,4047396 | 2,8992779 | 2,899176 | 2,279586 | 2,2794988 | S60X40 |
| 51 | 2,4 | -8,378343 | 0,22834 | -98,04809 | -9,688662 | -111,50799 | 94,393 | -95,78379 | 80,702772 | S60X40 |
| 59 | 0 | -27,19332 | 0,06144 | 61,922 | -32,533687 | 36,529622 | -93,50658 | 31,25581 | -80,20379 | S60X40 |
| 59 | 2,4 | 14,74893 | -0,09439 | -0,704225 | 17,5476945 | 14,647832 | 16,1267 | 12,64023 | 13,90784 | S60X40 |
| 59 | 4,8 | -30,59817 | -0,25021 | -63,33045 | -37,118144 | -98,887774 | 34,10617 | -84,53576 | 29,459052 | S60X40 |
| 60 | 0 | -27,19171 | 0,06144 | 61,922 | -32,531755 | 36,531312 | -93,50489 | 31,25726 | -80,20234 | S60X40 |
| 60 | 2,4 | 14,74893 | -0,09439 | -0,704225 | 17,5476945 | 14,647832 | 16,1267 | 12,64023 | 13,90784 | S60X40 |
| 60 | 4,8 | -30,59977 | -0,25021 | -63,33045 | -37,120064 | -98,889454 | 34,10449 | -84,5372 | 29,457612 | S60X40 |
| 66 | 0 | -28,81064 | 0,5296 | 63,92574 | -33,725408 | 37,426935 | -96,81712 | 31,60359 | -83,46274 | S60X40 |
| 66 | 2,4 | 15,08271 | -0,03327 | -0,683807 | 18,0460141 | 15,08391 | 16,51991 | 12,95901 | 14,189866 | S60X40 |
| 66 | 4,8 | -28,31327 | -0,59615 | -65,29336 | -34,929759 | -98,912916 | 38,20314 | -84,24597 | 33,282081 | S60X40 |
| 67 | 0 | -28,81172 | 0,5296 | 63,92574 | -33,726704 | 37,425801 | -96,81825 | 31,60262 | -83,46371 | S60X40 |
| 67 | 2,4 | 15,08274 | -0,03327 | -0,683807 | 18,0460501 | 15,083942 | 16,51994 | 12,95904 | 14,189893 | S60X40 |
| 67 | 4,8 | -28,31215 | -0,59615 | -65,29336 | -34,928415 | -98,91174 | 38,20432 | -84,24496 | 33,283089 | S60X40 |
| 102 | 0 | -48,44024 | -8,84583 | 219,2458 | -72,281608 | 170,05772 | -290,3585 | 153,725 | -240,9174 | B70X40 |
| 102 | 2,4 | 36,34833 | 8,44714 | 9,974157 | 57,1334152 | 57,508105 | 36,56238 | 41,69024 | 23,736756 | B70X40 |
| 102 | 4,8 | -58,06975 | -10,9799 | -199,2975 | -87,25154 | -281,76451 | 136,7602 | -231,6305 | 127,10498 | B70X40 |
| 103 | 0 | -48,43184 | -8,84583 | 219,2458 | -72,271528 | 170,06654 | -290,3496 | 153,7326 | -240,9099 | B70X40 |
| 103 | 2,4 | 36,34769 | 8,44714 | 9,974157 | 57,1326472 | 57,507433 | 36,5617 | 41,68966 | 23,73618 | B70X40 |
| 103 | 4,8 | -58,07944 | -10,9799 | -199,2975 | -87,263168 | -281,77468 | 136,7501 | -231,6392 | 127,09625 | B70X40 |
| 109 | 0 | -79,59154 | -19,2512 | 191,4321 | -126,31174 | 97,218849 | -304,7886 | 100,6565 | -243,9213 | B70X40 |
| 109 | 2,4 | 55,24143 | 15,6369 | 3,188297 | 91,308772 | 77,769969 | 71,07455 | 52,58675 | 46,84782 | B70X40 |
| 109 | 4,8 | -61,02089 | -14,323 | -185,0555 | -96,141868 | -273,41936 | 115,1972 | -221,4688 | 111,63115 | B70X40 |
| 110 | 0 | -79,60461 | -19,2512 | 191,4321 | -126,32742 | 97,205126 | -304,8023 | 100,6447 | -243,933 | B70X40 |
| 110 | 2,4 | 55,24108 | 15,6369 | 3,188297 | 91,308352 | 77,769601 | 71,07418 | 52,58644 | 46,847505 | B70X40 |
| 110 | 4,8 | -61,00852 | -14,323 | -185,0555 | -96,127024 | -273,40637 | 115,2102 | -221,4576 | 111,64228 | B70X40 |
| 118 | 0 | -21,64943 | -4,62455 | 235,7815 | -33,378599 | 219,98289 | -275,1583 | 192,7189 | -231,6878 | B70X40 |
| 118 | 1,2 | -4,163795 | -1,74455 | -0,001875 | -7,7878372 | -6,2057327 | -6,201796 | -3,749103 | -3,745728 | B70X40 |
| 118 | 2,4 | -21,64943 | -4,62455 | -235,7853 | -33,378599 | -275,16225 | 219,9869 | -231,6913 | 192,72228 | B70X40 |
| 121 | 0 | -21,64731 | -4,62455 | 235,7815 | -33,376055 | 219,98512 | -275,156 | 192,7208 | -231,6859 | B70X40 |
| 121 | 1,2 | -4,161676 | -1,74455 | -0,001875 | -7,7852944 | -6,2035077 | -6,199571 | -3,747196 | -3,743821 | B70X40 |
| 121 | 2,4 | -21,64731 | -4,62455 | -235,7853 | -33,376055 | -275,16002 | 219,9891 | -231,6893 | 192,72419 | B70X40 |
| 129 | 0 | -61,02089 | -14,323 | 185,0361 | -96,141868 | 115,17682 | -273,399 | 111,6137 | -221,4513 | B70X40 |
| 129 | 2,4 | 55,24143 | 15,6369 | -3,185505 | 91,308772 | 71,077477 | 77,76704 | 46,85033 | 52,584242 | B70X40 |
| 129 | 4,8 | -79,59154 | -19,2512 | -191,4071 | -126,31174 | -304,76231 | 97,1926 | -243,8988 | 100,634 | B70X40 |
| 130 | 0 | -61,00852 | -14,323 | 185,0361 | -96,127024 | 115,18981 | -273,386 | 111,6248 | -221,4402 | B70X40 |

| | | | | | | | | | | |
|-----|-----|-----------|----------|-----------|------------|------------|-----------|-----------|-----------|--------|
| 130 | 2,4 | 55,24108 | 15,6369 | -3,185505 | 91,308352 | 71,077109 | 77,76667 | 46,85002 | 52,583927 | B70X40 |
| 130 | 4,8 | -79,60461 | -19,2512 | -191,4071 | -126,32742 | -304,77603 | 97,17888 | -243,9105 | 100,62224 | B70X40 |
| 136 | 0 | -58,06975 | -10,9799 | 199,3403 | -87,25154 | 136,80518 | -281,8094 | 127,1435 | -231,669 | B70X40 |
| 136 | 2,4 | 36,34833 | 8,44714 | -9,977877 | 57,1334152 | 36,55847 | 57,51201 | 23,73341 | 41,693586 | B70X40 |
| 136 | 4,8 | -48,44024 | -8,84583 | -219,2961 | -72,281608 | -290,41127 | 170,1105 | -240,9627 | 153,77027 | B70X40 |
| 137 | 0 | -58,07944 | -10,9799 | 199,3403 | -87,263168 | 136,79501 | -281,8196 | 127,1348 | -231,6778 | B70X40 |
| 137 | 2,4 | 36,34769 | 8,44714 | -9,977877 | 57,1326472 | 36,557798 | 57,51134 | 23,73283 | 41,69301 | B70X40 |
| 137 | 4,8 | -48,43184 | -8,84583 | -219,2961 | -72,271528 | -290,40245 | 170,1194 | -240,9551 | 153,77783 | B70X40 |
| 172 | 0 | -53,30356 | -10,5545 | 198,9743 | -80,851504 | 141,87203 | -275,974 | 131,1037 | -227,0501 | B70X40 |
| 172 | 2,4 | 36,09523 | 8,33045 | 8,320862 | 56,6429896 | 55,383865 | 37,91005 | 39,97448 | 24,996931 | B70X40 |
| 172 | 4,8 | -53,71262 | -9,50459 | -182,3325 | -79,662491 | -257,8272 | 125,0711 | -212,4406 | 115,75789 | B70X40 |
| 173 | 0 | -53,29047 | -10,5545 | 198,9743 | -80,835796 | 141,88578 | -275,9603 | 131,1154 | -227,0383 | B70X40 |
| 173 | 2,4 | 36,09431 | 8,33045 | 8,320862 | 56,6418856 | 55,382899 | 37,90909 | 39,97365 | 24,996103 | B70X40 |
| 173 | 4,8 | -53,72756 | -9,50459 | -182,3325 | -79,680419 | -257,84288 | 125,0554 | -212,4541 | 115,74445 | B70X40 |
| 179 | 0 | -82,08181 | -20,0699 | 186,1626 | -130,61001 | 88,211435 | -302,73 | 93,67271 | -241,42 | B70X40 |
| 179 | 2,4 | 54,83849 | 15,4579 | 2,157007 | 90,538764 | 76,076025 | 71,54631 | 51,29595 | 47,413335 | B70X40 |
| 179 | 4,8 | -59,33651 | -13,8624 | -181,8486 | -93,383636 | -267,79988 | 114,0822 | -217,0666 | 110,26088 | B70X40 |
| 180 | 0 | -82,10211 | -20,0699 | 186,1626 | -130,63437 | 88,19012 | -302,7513 | 93,65444 | -241,4382 | B70X40 |
| 180 | 2,4 | 54,83797 | 15,4579 | 2,157007 | 90,53814 | 76,075479 | 71,54576 | 51,29548 | 47,412867 | B70X40 |
| 180 | 4,8 | -59,31724 | -13,8624 | -181,8486 | -93,360512 | -267,77964 | 114,1024 | -217,0493 | 110,27822 | B70X40 |
| 188 | 0 | -19,69304 | -3,88607 | 206,4324 | -29,849363 | 191,99595 | -241,5121 | 168,0654 | -203,5129 | B70X40 |
| 188 | 1,2 | -2,207403 | -1,00607 | -0,001577 | -4,2585988 | -3,3758049 | -3,372493 | -1,988082 | -1,985243 | B70X40 |
| 188 | 2,4 | -19,69304 | -3,88607 | -206,4356 | -29,849363 | -241,51545 | 191,9993 | -203,5158 | 168,0683 | B70X40 |
| 191 | 0 | -19,68993 | -3,88607 | 206,4324 | -29,845631 | 191,99922 | -241,5088 | 168,0682 | -203,5101 | B70X40 |
| 191 | 1,2 | -2,204295 | -1,00607 | -0,001577 | -4,2548692 | -3,3725415 | -3,369229 | -1,985285 | -1,982446 | B70X40 |
| 191 | 2,4 | -19,68993 | -3,88607 | -206,4356 | -29,845631 | -241,51218 | 192,0026 | -203,513 | 168,0711 | B70X40 |
| 199 | 0 | -59,33651 | -13,8624 | 181,8197 | -93,383636 | 114,05184 | -267,7695 | 110,2349 | -217,0406 | B70X40 |
| 199 | 2,4 | 54,83849 | 15,4579 | -2,158674 | 90,538764 | 71,54456 | 76,07778 | 47,41183 | 51,297448 | B70X40 |
| 199 | 4,8 | -82,08181 | -20,0699 | -186,1371 | -130,61001 | -302,70325 | 88,18466 | -241,397 | 93,649761 | B70X40 |
| 200 | 0 | -59,31724 | -13,8624 | 181,8197 | -93,360512 | 114,07207 | -267,7493 | 110,2522 | -217,0232 | B70X40 |
| 200 | 2,4 | 54,83797 | 15,4579 | -2,158674 | 90,53814 | 71,544014 | 76,07723 | 47,41137 | 51,29698 | B70X40 |
| 200 | 4,8 | -82,10211 | -20,0699 | -186,1371 | -130,63437 | -302,72457 | 88,16334 | -241,4153 | 93,631491 | B70X40 |
| 206 | 0 | -53,71262 | -9,50459 | 182,3845 | -79,662491 | 125,12565 | -257,8818 | 115,8047 | -212,4874 | B70X40 |
| 206 | 2,4 | 36,09523 | 8,33045 | -8,295122 | 56,6429896 | 37,937082 | 55,35684 | 25,0201 | 39,951317 | B70X40 |
| 206 | 4,8 | -53,30356 | -10,5545 | -198,9747 | -80,851504 | -275,97442 | 141,8725 | -227,0504 | 131,10403 | B70X40 |
| 207 | 0 | -53,72756 | -9,50459 | 182,3845 | -79,680419 | 125,10997 | -257,8975 | 115,7912 | -212,5009 | B70X40 |
| 207 | 2,4 | 36,09431 | 8,33045 | -8,295122 | 56,6418856 | 37,936116 | 55,35587 | 25,01927 | 39,950489 | B70X40 |
| 207 | 4,8 | -53,29047 | -10,5545 | -198,9747 | -80,835796 | -275,96067 | 141,8862 | -227,0387 | 131,11581 | B70X40 |
| 242 | 0 | -56,20459 | -11,2527 | 145,773 | -85,44978 | 82,231527 | -223,8918 | 80,61157 | -181,7798 | B70X40 |
| 242 | 2,4 | 35,84821 | 8,27605 | 6,411941 | 56,2595352 | 53,063013 | 39,59794 | 38,03414 | 26,492642 | B70X40 |
| 242 | 4,8 | -51,30564 | -8,91522 | -132,9492 | -75,831122 | -202,82856 | 76,36476 | -165,8294 | 73,479204 | B70X40 |
| 243 | 0 | -56,18849 | -11,2527 | 145,773 | -85,43046 | 82,248432 | -223,8749 | 80,62606 | -181,7653 | B70X40 |
| 243 | 2,4 | 35,84713 | 8,27605 | 6,411941 | 56,2582392 | 53,061879 | 39,5968 | 38,03316 | 26,49167 | B70X40 |
| 243 | 4,8 | -51,32391 | -8,91522 | -132,9492 | -75,853046 | -202,84775 | 76,34557 | -165,8458 | 73,462761 | B70X40 |
| 249 | 0 | -83,62868 | -20,585 | 144,8967 | -133,29048 | 42,717129 | -261,5659 | 55,14122 | -205,6728 | B70X40 |
| 249 | 2,4 | 54,93042 | 15,4859 | 0,9966576 | 90,693388 | 74,983584 | 72,8906 | 50,33437 | 48,540386 | B70X40 |
| 249 | 4,8 | -57,60576 | -13,2913 | -142,9034 | -90,392912 | -224,49043 | 75,60671 | -180,4582 | 76,767876 | B70X40 |
| 250 | 0 | -83,65352 | -20,585 | 144,8967 | -133,32029 | 42,691047 | -261,592 | 55,11886 | -205,6952 | B70X40 |
| 250 | 2,4 | 54,9298 | 15,4859 | 0,9966576 | 90,693136 | 74,982933 | 72,88995 | 50,33381 | 48,539828 | B70X40 |
| 250 | 4,8 | -57,58218 | -13,2913 | -142,9034 | -90,364616 | -224,46567 | 75,63147 | -180,437 | 76,789098 | B70X40 |
| 258 | 0 | -19,2459 | -3,7645 | 135,8343 | -29,118274 | 118,4651 | -166,7869 | 104,9296 | -139,5722 | B70X40 |
| 258 | 1,2 | -1,760272 | -0,8845 | -0,00748 | -3,5275203 | -2,7848603 | -2,769153 | -1,590977 | -1,577513 | B70X40 |
| 258 | 2,4 | -19,2459 | -3,7645 | -135,8493 | -29,118274 | -166,80268 | 118,4808 | -139,5857 | 104,94306 | B70X40 |
| 261 | 0 | -19,24216 | -3,7645 | 135,8343 | -29,113786 | 118,46903 | -166,783 | 104,9329 | -139,5688 | B70X40 |
| 261 | 1,2 | -1,756531 | -0,8845 | -0,00748 | -3,5230311 | -2,7809323 | -2,765225 | -1,58761 | -1,574146 | B70X40 |
| 261 | 2,4 | -19,24216 | -3,7645 | -135,8493 | -29,113786 | -166,79875 | 118,4848 | -139,5823 | 104,94643 | B70X40 |
| 269 | 0 | -57,60576 | -13,2913 | 142,8312 | -90,392912 | 75,5309 | -224,4146 | 76,7029 | -180,3933 | B70X40 |
| 269 | 2,4 | 54,93042 | 15,4859 | -0,97544 | 90,69388 | 72,912882 | 74,98131 | 48,55948 | 50,315274 | B70X40 |

| | | | | | | | | | | |
|-----|-----|-----------|----------|-----------|------------|------------|-----------|-----------|-----------|--------|
| 269 | 4,8 | -83,62868 | -20,585 | -144,7821 | -133,29048 | -261,44561 | 42,5968 | -205,5697 | 55,038078 | B70X40 |
| 270 | 0 | -57,58218 | -13,2913 | 142,8312 | -90,364616 | 75,555659 | -224,3899 | 76,72412 | -180,372 | B70X40 |
| 270 | 2,4 | 54,9298 | 15,4859 | -0,97544 | 90,693136 | 72,912231 | 74,96066 | 48,55892 | 50,314716 | B70X40 |
| 270 | 4,8 | -83,65352 | -20,585 | -144,7821 | -133,32029 | -261,47169 | 42,57072 | -205,5921 | 55,015722 | B70X40 |
| 276 | 0 | -51,30564 | -8,91522 | 133,1901 | -75,831122 | 76,617701 | -203,0815 | 73,69601 | -166,0462 | B70X40 |
| 276 | 2,4 | 35,84821 | 8,27605 | -6,529497 | 56,2595352 | 39,474503 | 53,18645 | 26,38684 | 38,139936 | B70X40 |
| 276 | 4,8 | -56,20459 | -11,2527 | -146,2491 | -85,44978 | -224,39168 | 82,73143 | -182,2083 | 81,040059 | B70X40 |
| 277 | 0 | -51,32391 | -8,91522 | 133,1901 | -75,853046 | 76,598517 | -203,1007 | 73,67957 | -166,0626 | B70X40 |
| 277 | 2,4 | 35,84713 | 8,27605 | -6,529497 | 56,2582392 | 39,473369 | 53,18531 | 26,38587 | 38,138964 | B70X40 |
| 277 | 4,8 | -56,18849 | -11,2527 | -146,2491 | -85,43046 | -224,37477 | 82,74834 | -182,1938 | 81,054549 | B70X40 |
| 312 | 0 | -53,96309 | -10,6654 | 81,72005 | -81,820268 | 17,946191 | -153,6659 | 24,98126 | -122,1148 | B70X40 |
| 312 | 2,4 | 36,49072 | 8,38677 | 4,722081 | 57,207688 | 52,079544 | 42,16317 | 37,09152 | 28,591775 | B70X40 |
| 312 | 4,8 | -52,26212 | -9,28112 | -72,27589 | -77,564338 | -140,51009 | 11,26928 | -112,0842 | 18,012393 | B70X40 |
| 313 | 0 | -53,94625 | -10,6654 | 81,72005 | -81,80006 | 17,963873 | -153,6482 | 24,99642 | -122,0997 | B70X40 |
| 313 | 2,4 | 36,48931 | 8,38677 | 4,722081 | 57,205996 | 52,078064 | 42,16169 | 37,09025 | 28,590506 | B70X40 |
| 313 | 4,8 | -52,28179 | -9,28112 | -72,27589 | -77,587942 | -140,53074 | 11,24863 | -112,1019 | 17,99469 | B70X40 |
| 319 | 0 | -84,13612 | -20,7857 | 90,42344 | -134,22043 | -15,223278 | -205,1125 | 5,658588 | -157,1036 | B70X40 |
| 319 | 2,4 | 55,51371 | 15,6846 | -0,604657 | 91,71178 | 74,123314 | 75,39309 | 49,41815 | 50,506531 | B70X40 |
| 319 | 4,8 | -55,93174 | -12,6932 | -91,63275 | -87,427144 | -168,27053 | 24,15824 | -132,808 | 32,130909 | B70X40 |
| 320 | 0 | -84,16267 | -20,7857 | 90,42344 | -134,25229 | -15,251156 | -205,1404 | 5,634693 | -157,1275 | B70X40 |
| 320 | 2,4 | 55,51297 | 15,6846 | -0,604657 | 91,710892 | 74,122537 | 75,39232 | 49,41748 | 50,505865 | B70X40 |
| 320 | 4,8 | -55,90667 | -12,6932 | -91,63275 | -87,39706 | -168,24421 | 24,18457 | -132,7855 | 32,153472 | B70X40 |
| 328 | 0 | -20,31812 | -4,16783 | 55,01419 | -31,050274 | 32,054651 | -83,47515 | 31,22646 | -67,79908 | B70X40 |
| 328 | 1,2 | -2,832484 | -1,28783 | -0,000684 | -5,4595104 | -4,3270494 | -4,325612 | -2,549852 | -2,54862 | B70X40 |
| 328 | 2,4 | -20,31812 | -4,16783 | -55,01556 | -31,050274 | -83,476587 | 32,05609 | -67,80031 | 31,227696 | B70X40 |
| 331 | 0 | -20,31365 | -4,16783 | 55,01419 | -31,04491 | 32,059344 | -83,47045 | 31,23049 | -67,79506 | B70X40 |
| 331 | 1,2 | -2,828016 | -1,28783 | -0,000684 | -5,4541488 | -4,322358 | -4,320921 | -2,54583 | -2,544598 | B70X40 |
| 331 | 2,4 | -20,31365 | -4,16783 | -55,01556 | -31,04491 | -83,471893 | 32,06078 | -67,79629 | 31,231719 | B70X40 |
| 339 | 0 | -55,93174 | -12,6932 | 91,61963 | -87,427144 | 24,144467 | -168,2568 | 32,1191 | -132,7962 | B70X40 |
| 339 | 2,4 | 55,51371 | 15,6846 | 0,5692449 | 91,71178 | 75,355912 | 74,1605 | 50,47466 | 49,450019 | B70X40 |
| 339 | 4,8 | -84,13612 | -20,7857 | -90,48114 | -134,22043 | -205,17309 | -15,16269 | -157,1555 | 5,710518 | B70X40 |
| 340 | 0 | -55,90667 | -12,6932 | 91,61963 | -87,39706 | 24,17079 | -168,2304 | 32,14166 | -132,7737 | B70X40 |
| 340 | 2,4 | 55,51297 | 15,6846 | 0,5692449 | 91,710892 | 75,355135 | 74,15972 | 50,47399 | 49,449353 | B70X40 |
| 340 | 4,8 | -84,16267 | -20,7857 | -90,48114 | -134,25229 | -205,20096 | -15,19057 | -157,1794 | 5,686623 | B70X40 |
| 346 | 0 | -52,26212 | -9,28112 | 71,55389 | -77,564338 | 10,511181 | -139,752 | 17,36259 | -111,4344 | B70X40 |
| 346 | 2,4 | 36,49072 | 8,38677 | -4,119666 | 57,207688 | 42,79571 | 51,44701 | 29,13395 | 36,549347 | B70X40 |
| 346 | 4,8 | -53,96309 | -10,6654 | -79,79322 | -81,820268 | -151,64274 | 15,92302 | -120,3807 | 23,247117 | B70X40 |
| 347 | 0 | -52,28179 | -9,28112 | 71,55389 | -77,587942 | 10,490528 | -139,7726 | 17,34489 | -111,4521 | B70X40 |
| 347 | 2,4 | 36,48931 | 8,38677 | -4,119666 | 57,205996 | 42,794229 | 51,44553 | 29,13268 | 36,548078 | B70X40 |
| 347 | 4,8 | -53,94625 | -10,6654 | -79,79322 | -81,80006 | -151,62506 | 15,9407 | -120,3655 | 23,262273 | B70X40 |
| 378 | 0 | -18,6102 | -5,23526 | 15,75298 | -30,708651 | -8,4971009 | -41,57836 | -2,571498 | -30,92686 | R50X30 |
| 378 | 2,4 | 9,74419 | 2,47157 | 0,5799368 | 15,6475384 | 13,435481 | 12,21761 | 9,291714 | 8,2478279 | R50X30 |
| 378 | 4,8 | -30,53446 | -3,99121 | -14,59311 | -43,02728 | -51,574714 | -20,92918 | -40,61481 | -14,34722 | R50X30 |
| 379 | 0 | -18,60586 | -5,23526 | 15,75298 | -30,703443 | -8,4925439 | -41,5738 | -2,567592 | -30,92296 | R50X30 |
| 379 | 2,4 | 9,744102 | 2,47157 | 0,5799368 | 15,6474328 | 13,435388 | 12,21752 | 9,291635 | 8,2477487 | R50X30 |
| 379 | 4,8 | -30,53898 | -3,99121 | -14,59311 | -43,032704 | -51,57946 | -20,93393 | -40,61888 | -14,35128 | R50X30 |
| 383 | 0 | -38,59553 | -6,91687 | 19,45558 | -57,381622 | -27,359657 | -68,21637 | -17,22596 | -52,246 | R50X30 |
| 383 | 2,4 | 29,73697 | 2,9414 | -0,0224 | 40,3905976 | 34,288765 | 34,3358 | 26,74311 | 26,783433 | R50X30 |
| 383 | 4,8 | -31,17294 | -4,82594 | -19,50038 | -45,129037 | -58,274226 | -17,32343 | -45,60599 | -10,5053 | R50X30 |
| 384 | 0 | -38,60212 | -6,91687 | 19,45558 | -57,38953 | -27,366576 | -68,22329 | -17,23189 | -52,25193 | R50X30 |
| 384 | 2,4 | 29,73691 | 2,9414 | -0,0224 | 40,3905256 | 34,288702 | 34,33574 | 26,74306 | 26,783379 | R50X30 |
| 384 | 4,8 | -31,16646 | -4,82594 | -19,50038 | -45,121261 | -58,267422 | -17,31662 | -45,60016 | -10,49947 | R50X30 |
| 389 | 0 | -16,18949 | -1,72929 | 10,35796 | -22,194244 | -7,9388558 | -29,69057 | -5,248377 | -23,89271 | R50X30 |
| 389 | 1,2 | 12,60715 | 0,61791 | 0,0004764 | 16,1172432 | 13,886818 | 13,88582 | 11,34686 | 11,346006 | R50X30 |
| 389 | 2,4 | -16,18949 | -1,72929 | -10,357 | -22,194244 | -29,689564 | -7,939864 | -23,89184 | -5,249241 | R50X30 |
| 390 | 0 | -16,18916 | -1,72929 | 10,35796 | -22,193848 | -7,9385093 | -29,69023 | -5,24808 | -23,89241 | R50X30 |
| 390 | 1,2 | 12,60748 | 0,61791 | 0,0004764 | 16,1176392 | 13,887164 | 13,88616 | 11,34716 | 11,346303 | R50X30 |
| 390 | 2,4 | -16,18916 | -1,72929 | -10,357 | -22,193848 | -29,689217 | -7,939517 | -23,89154 | -5,248944 | R50X30 |

| | | | | | | | | | | |
|-----|-----|-----------|----------|-----------|------------|------------|-----------|-----------|-----------|--------|
| 395 | 0 | -31,17294 | -4,82594 | 19,50765 | -45,129037 | -17,315795 | -58,28186 | -10,49876 | -45,61253 | R50X30 |
| 395 | 2,4 | 29,73697 | 2,9414 | 0,0068301 | 40,3905976 | 34,319456 | 34,30511 | 26,76942 | 26,757126 | R50X30 |
| 395 | 4,8 | -38,59553 | -6,91687 | -19,49399 | -57,381622 | -68,256705 | -27,31933 | -52,28057 | -17,19139 | R50X30 |
| 396 | 0 | -31,16646 | -4,82594 | 19,50765 | -45,121261 | -17,308991 | -58,27506 | -10,49293 | -45,6067 | R50X30 |
| 396 | 2,4 | 29,73691 | 2,9414 | 0,0068301 | 40,3905256 | 34,319393 | 34,30505 | 26,76937 | 26,757072 | R50X30 |
| 396 | 4,8 | -38,60212 | -6,91687 | -19,49399 | -57,38953 | -68,263625 | -27,32625 | -52,2865 | -17,19732 | R50X30 |
| 400 | 0 | -30,53446 | -3,99121 | 13,97157 | -43,02728 | -21,5818 | -50,9221 | -14,9066 | -40,05543 | R50X30 |
| 400 | 2,4 | 9,74419 | 2,47157 | -0,183703 | 15,6475384 | 12,633658 | 13,01944 | 8,604438 | 8,935104 | R50X30 |
| 400 | 4,8 | -18,6102 | -5,23526 | -14,33897 | -30,708651 | -40,093648 | -9,981811 | -29,65425 | -3,844107 | R50X30 |
| 401 | 0 | -30,53898 | -3,99121 | 13,97157 | -43,032704 | -21,586546 | -50,92684 | -14,91067 | -40,0595 | R50X30 |
| 401 | 2,4 | 9,744102 | 2,47157 | -0,183703 | 15,6474328 | 12,633566 | 13,01934 | 8,604359 | 8,9350248 | R50X30 |
| 401 | 4,8 | -18,60586 | -5,23526 | -14,33897 | -30,703443 | -40,089091 | -9,977254 | -29,65035 | -3,840201 | R50X30 |

Tabel 6.6. Momen rencana balok As- 3 & 4

| ELEMEN | SECTION | MD (kNm) | ML (kNm) | ME,y (kNm) | 1,2 MD + 1,6 ML (kNm) | 1,05(MD+M L+ MEy) (kNm) | 1,05(MD+ ML- MEy) (kNm) | 0,9MD+ ME,y (kNm) | 0,9MD- ME,y (kNm) | keterangan |
|--------|---------|-------------|-------------|---------------|-----------------------------|-------------------------------|-------------------------------|-------------------------|-------------------------|------------|
| 35 | 0 | -58,59886 | -1,14466 | 34,84081 | -72,15009 | -37,354067 | -99,31355 | -21,38225 | -84,0957 | S60X40 |
| 35 | 4,8 | 28,95603 | -0,54694 | 0,6027729 | 33,8721349 | 43,517797 | 29,19663 | 26,60292 | 25,517931 | S60X40 |
| 36 | 9,6 | -57,54246 | 0,05078 | -33,63527 | -68,969697 | -136,69042 | -25,04923 | -82,05996 | -21,51647 | S60X40 |
| 36 | 0 | -58,59885 | -1,14466 | 34,84081 | -72,150078 | -37,354052 | -99,31354 | -21,38224 | -84,09569 | S60X40 |
| 36 | 4,8 | 28,95603 | -0,54694 | 0,6027729 | 33,8721349 | 43,517797 | 29,19663 | 26,60292 | 25,517931 | S60X40 |
| 49 | 9,6 | -57,54247 | 0,05078 | -33,63527 | -68,969709 | -136,69043 | -25,04924 | -82,05997 | -21,51648 | S60X40 |
| 49 | 0 | -4,322224 | 1,51918 | 97,79696 | -2,7559792 | 142,49088 | -105,63 | 84,12726 | -91,90727 | S60X40 |
| 49 | 1,2 | 1,116944 | 1,51918 | -1,26E-05 | 3,7710224 | 3,9541687 | 2,767944 | 1,005238 | 1,0052609 | S60X40 |
| 49 | 2,4 | -4,322224 | 1,51918 | -97,79698 | -2,7559792 | -150,90003 | 99,74363 | -91,90728 | 84,12728 | S60X40 |
| 50 | 0 | -4,322226 | 1,51918 | 97,79696 | -2,7559816 | 142,49087 | -105,63 | 84,12726 | -91,90727 | S60X40 |
| 50 | 1,2 | 1,116942 | 1,51918 | -1,26E-05 | 3,77102 | 3,9541657 | 2,767942 | 1,005236 | 1,0052591 | S60X40 |
| 50 | 2,4 | -4,322226 | 1,51918 | -97,79698 | -2,7559816 | -150,90004 | 99,74363 | -91,90729 | 84,127279 | S60X40 |
| 63 | 0 | -57,54246 | 0,05078 | 33,63525 | -68,969697 | -35,784638 | -95,68327 | -21,51649 | -82,05994 | S60X40 |
| 63 | 4,8 | 28,95603 | -0,54694 | -0,602728 | 33,8721349 | 41,709546 | 30,46241 | 25,51797 | 26,602882 | S60X40 |
| 63 | 9,6 | -58,59886 | -1,14466 | -34,8407 | -72,15009 | -141,87633 | -26,14796 | -84,0956 | -21,38234 | S60X40 |
| 64 | 0 | -57,54247 | 0,05078 | 33,63525 | -68,969709 | -35,784653 | -95,68328 | -21,5165 | -82,05995 | S60X40 |
| 64 | 4,8 | 28,95603 | -0,54694 | -0,602728 | 33,8721349 | 41,709546 | 30,46241 | 25,51797 | 26,602882 | S60X40 |
| 64 | 9,6 | -58,59885 | -1,14466 | -34,8407 | -72,150078 | -141,87632 | -26,14795 | -84,0956 | -21,38234 | S60X40 |
| 105 | 0 | -276,2701 | -98,5137 | 133,1272 | -489,14607 | -362,48493 | -533,3066 | -128,8286 | -368,4576 | S60X40 |
| 105 | 4,8 | 192,1005 | 70,8636 | 6,987997 | 343,902376 | 404,92816 | 268,7749 | 179,1796 | 166,60125 | S60X40 |
| 105 | 9,6 | -288,6141 | -100,943 | -119,1512 | -507,84588 | -763,0626 | -283,9263 | -366,9888 | -152,5166 | S60X40 |
| 106 | 0 | -276,2701 | -98,5137 | 133,1272 | -489,14607 | -362,48493 | -533,3066 | -128,8286 | -368,4576 | S60X40 |
| 106 | 4,8 | 192,1005 | 70,8636 | 6,987997 | 343,902376 | 404,92816 | 268,7749 | 179,1796 | 166,60125 | B70X40 |
| 106 | 9,6 | -288,6141 | -100,943 | -119,1512 | -507,84588 | -763,0626 | -283,9263 | -366,9888 | -152,5166 | B70X40 |
| 119 | 0 | -62,50144 | -21,7907 | 240,4465 | -109,86682 | 234,23157 | -340,9756 | 160,1506 | -272,6531 | B70X40 |
| 119 | 1,2 | -50,48781 | -18,9107 | 0,0002102 | -90,84246 | -104,09742 | -72,86864 | -45,43884 | -45,43922 | B70X40 |
| 119 | 2,4 | -62,50144 | -21,7907 | -240,446 | -109,86682 | 487,10718 | 163,9616 | -272,6527 | 160,1501 | B70X40 |
| 120 | 0 | -62,50143 | -21,7907 | 240,4465 | -109,8668 | 234,23159 | -340,9755 | 160,1506 | -272,6531 | B70X40 |
| 120 | 1,2 | -50,48779 | -18,9107 | 0,0002102 | -90,842436 | -104,09739 | -72,86861 | -45,43882 | -45,4392 | B70X40 |
| 120 | 2,4 | -62,50143 | -21,7907 | -240,446 | -109,8668 | 487,10717 | 163,9616 | -272,6527 | 160,15011 | B70X40 |
| 133 | 0 | -288,6141 | -100,943 | 119,1522 | -507,84588 | -405,6075 | -534,1449 | -152,5157 | -366,9897 | B70X40 |
| 133 | 4,8 | 192,1005 | 70,8636 | -6,988405 | 343,902376 | 383,96356 | 283,4501 | 166,6009 | 179,18001 | B70X40 |
| 133 | 9,6 | -276,2701 | -98,5137 | -133,129 | -489,14607 | -761,86923 | -253,7376 | -368,4592 | -128,827 | B70X40 |
| 134 | 0 | -288,6141 | -100,943 | 119,1522 | -507,84588 | -405,6075 | -534,1449 | -152,5157 | -366,9897 | B70X40 |
| 134 | 4,8 | 192,1005 | 70,8636 | -6,988405 | 343,902376 | 383,96356 | 283,4501 | 166,6009 | 179,18001 | B70X40 |
| 134 | 9,6 | -276,2701 | -98,5137 | -133,129 | -489,14607 | -761,86923 | -253,7376 | -368,4592 | -128,827 | B70X40 |
| 175 | 0 | -279,8109 | -101,057 | 123,9436 | -497,46396 | -385,38615 | -530,0519 | -140,2806 | -363,3791 | B70X40 |
| 175 | 4,8 | 189,5272 | 69,657 | 4,652427 | 338,883792 | 395,7549 | 267,2583 | 174,7617 | 166,3873 | B70X40 |
| 175 | 9,6 | -290,2198 | -100,813 | -114,6387 | -509,56504 | -758,5077 | -290,2141 | -364,3727 | -158,023 | B70X40 |
| 176 | 0 | -279,8109 | -101,057 | 123,9436 | -497,46396 | -385,38615 | -530,0519 | -140,2806 | -363,3791 | B70X40 |
| 176 | 4,8 | 189,5272 | 69,657 | 4,652427 | 338,883792 | 395,7549 | 267,2583 | 174,7617 | 166,3873 | B70X40 |
| 176 | 9,6 | -290,2198 | -100,813 | -114,6387 | -509,56504 | -758,5077 | -290,2141 | -364,3727 | -158,023 | B70X40 |
| 189 | 0 | -54,59882 | -18,0575 | 196,8596 | -94,410568 | 186,30494 | -282,9917 | 128,0347 | -226,3126 | B70X40 |
| 189 | 1,2 | -42,58519 | -15,1775 | -0,000748 | -75,386212 | -86,645141 | -60,65003 | -38,32734 | -38,326 | B70X40 |
| 189 | 2,4 | -54,59882 | -18,0575 | -196,8611 | -94,410568 | -404,27612 | 130,415 | -226,3139 | 128,03605 | B70X40 |
| 190 | 0 | -54,5988 | -18,0575 | 196,8596 | -94,410544 | 186,30497 | -282,9917 | 128,0347 | -226,3126 | B70X40 |
| 190 | 1,2 | -42,58517 | -15,1775 | -0,000748 | -75,386188 | -86,645111 | -60,65001 | -38,32733 | -38,32598 | B70X40 |
| 190 | 2,4 | -54,5988 | -18,0575 | -196,8611 | -94,410544 | -404,27609 | 130,4151 | -226,3139 | 128,03607 | B70X40 |
| 203 | 0 | -290,2198 | -100,813 | 114,6371 | -509,56504 | -414,594 | -530,9537 | -158,0244 | -364,3712 | B70X40 |
| 203 | 4,8 | 189,5272 | 69,657 | -4,650599 | 338,883792 | 381,80036 | 277,0265 | 166,3889 | 174,76002 | B70X40 |
| 203 | 9,6 | -279,8109 | -101,057 | -123,9383 | -497,46396 | -757,209 | -269,7759 | -363,3743 | -140,2853 | B70X40 |
| 204 | 0 | -290,2198 | -100,813 | 114,6371 | -509,56504 | -414,594 | -530,9537 | -158,0244 | -364,3712 | B70X40 |

| | | | | | | | | | | |
|-----|-----|-----------|----------|-----------|------------|------------|-----------|-----------|-----------|--------|
| 204 | 4,8 | 189,5272 | 69,657 | -4,650599 | 338,883792 | 381,80036 | 277,0265 | 166,3889 | 174,76002 | B70X40 |
| 204 | 9,6 | -279,8109 | -101,057 | -123,9383 | -497,46396 | -757,209 | -269,7759 | -363,3743 | -140,2853 | B70X40 |
| 245 | 0 | -284,2905 | -103,133 | 96,04487 | -506,1606 | -437,0672 | -507,6413 | -169,4211 | -342,3018 | B70X40 |
| 245 | 4,8 | 186,8123 | 68,7464 | 2,782642 | 334,16892 | 387,51194 | 265,4148 | 170,6354 | 165,62669 | B70X40 |
| 245 | 9,6 | -291,1701 | -100,559 | -90,47958 | -510,2982 | -723,31272 | -316,3118 | -343,4847 | -180,6215 | B70X40 |
| 246 | 0 | -284,2904 | -103,133 | 96,04487 | -506,16048 | -437,06705 | -507,6412 | -169,421 | -342,3017 | B70X40 |
| 246 | 4,8 | 186,8123 | 68,7464 | 2,782642 | 334,16892 | 387,51194 | 265,4148 | 170,6354 | 165,62669 | B70X40 |
| 246 | 9,6 | -291,1703 | -100,559 | -90,47958 | -510,29844 | -723,31302 | -316,312 | -343,4849 | -180,6216 | B70X40 |
| 259 | 0 | -47,29504 | -15,566 | 113,8707 | -81,659712 | 76,51443 | -185,5684 | 59,91809 | -145,0492 | B70X40 |
| 259 | 1,2 | -35,2814 | -12,686 | 0,0028152 | -62,635344 | -71,946937 | -50,36877 | -31,75073 | -31,75579 | B70X40 |
| 259 | 2,4 | -47,29504 | -15,566 | -113,8651 | -81,659712 | -265,08927 | 53,55422 | -145,0441 | 59,913054 | B70X40 |
| 260 | 0 | -47,29502 | -15,566 | 113,8707 | -81,659688 | 76,51446 | -185,5683 | 59,91811 | -145,0491 | B70X40 |
| 260 | 1,2 | -35,28139 | -12,686 | 0,0028152 | -62,635332 | -71,946922 | -50,36876 | -31,75072 | -31,75578 | B70X40 |
| 260 | 2,4 | -47,29502 | -15,566 | -113,8651 | -81,659688 | -265,08924 | 53,55424 | -145,0441 | 59,913072 | B70X40 |
| 273 | 0 | -291,1701 | -100,559 | 90,49091 | -510,2982 | -451,85699 | -506,3308 | -180,6113 | -343,4949 | B70X40 |
| 273 | 4,8 | 186,8123 | 68,7464 | -2,790014 | 334,16892 | 379,15295 | 271,2661 | 165,6201 | 170,64208 | B70X40 |
| 273 | 9,6 | -284,2905 | -103,133 | -96,07093 | -506,1606 | -725,2409 | -305,9197 | -342,3253 | -169,3976 | B70X40 |
| 274 | 0 | -291,1703 | -100,559 | 90,49091 | -510,29844 | -451,85729 | -506,331 | -180,6115 | -343,4951 | B70X40 |
| 274 | 4,8 | 186,8123 | 68,7464 | -2,790014 | 334,16892 | 379,15295 | 271,2661 | 165,6201 | 170,64208 | B70X40 |
| 274 | 9,6 | -284,2904 | -103,133 | -96,07093 | -506,16048 | -725,24075 | -305,9196 | -342,3252 | -169,3975 | B70X40 |
| 315 | 0 | -255,2856 | -92,8689 | 61,29132 | -454,93288 | -430,2947 | -429,9181 | -174,5949 | -284,9192 | B70X40 |
| 315 | 4,8 | 203,3373 | 74,6402 | 0,6277364 | 363,429144 | 417,90791 | 291,2173 | 183,5685 | 182,43861 | B70X40 |
| 315 | 9,6 | -287,1249 | -99,0347 | -60,03585 | -503,00534 | -669,29312 | -342,4299 | -312,4447 | -204,3801 | B70X40 |
| 316 | 0 | -255,2855 | -92,8689 | 61,29132 | -454,93276 | -430,29455 | -429,918 | -174,5948 | -284,9191 | B70X40 |
| 316 | 4,8 | 203,3373 | 74,6402 | 0,6277364 | 363,429144 | 417,90791 | 291,2173 | 183,5685 | 182,43861 | B70X40 |
| 316 | 9,6 | -287,1251 | -99,0347 | -60,03585 | -503,00558 | -669,29342 | -342,4301 | -312,4449 | -204,3803 | B70X40 |
| 329 | 0 | -97,75214 | -33,0834 | 26,95606 | -170,23602 | -155,81924 | -165,6812 | -63,71647 | -112,2374 | B70X40 |
| 329 | 1,2 | -85,73851 | -30,2034 | -0,008686 | -151,21167 | -173,92591 | -121,7299 | -77,17248 | -77,15684 | B70X40 |
| 329 | 2,4 | -97,75214 | -33,0834 | -26,97343 | -170,23602 | -236,71347 | -109,0552 | -112,253 | -63,70084 | B70X40 |
| 330 | 0 | -97,75211 | -33,0834 | 26,95606 | -170,23599 | -155,81919 | -165,6812 | -63,71645 | -112,2374 | B70X40 |
| 330 | 1,2 | -85,73847 | -30,2034 | -0,008686 | -151,21162 | -173,92585 | -121,7299 | -77,17244 | -77,15681 | B70X40 |
| 330 | 2,4 | -97,75211 | -33,0834 | -26,97343 | -170,23599 | -236,71343 | -109,0552 | -112,253 | -63,70081 | B70X40 |
| 343 | 0 | -287,1249 | -99,0347 | 59,99231 | -503,00534 | -489,25088 | -468,4595 | -204,4193 | -312,4055 | B70X40 |
| 343 | 4,8 | 203,3373 | 74,6402 | -0,598195 | 363,429144 | 416,06902 | 292,5045 | 182,4652 | 183,54195 | B70X40 |
| 343 | 9,6 | -255,2856 | -92,8689 | -61,18871 | -454,93288 | -614,01474 | -301,314 | -284,8269 | -174,6872 | B70X40 |
| 344 | 0 | -287,1251 | -99,0347 | 59,99231 | -503,00558 | -489,25118 | -468,4597 | -204,4195 | -312,4057 | B70X40 |
| 344 | 4,8 | 203,3373 | 74,6402 | -0,598195 | 363,429144 | 416,06902 | 292,5045 | 182,4652 | 183,54195 | B70X40 |
| 344 | 9,6 | -255,2855 | -92,8689 | -61,18871 | -454,93276 | -614,01459 | -301,3139 | -284,8268 | -174,6871 | B70X40 |

b. Data Penampang balok

Lebar balok bagian bawah , $b_w = 400$ mm

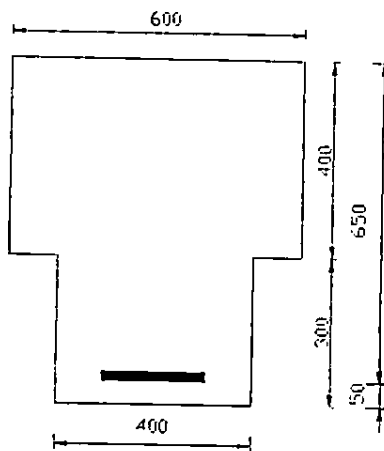
Lebar balok bagian atas , $b_w = 600$ mm

Tinggi balok, $h = 700$ mm

Jarak pusat tulangan ke tepi balok, $d' = 50$ mm

Tinggi efektif, $d = 650$ mm

Digunakan balok T dengan bentuk sebagai berikut:



Gambar 6.1 Balok T yang digunakan

$F_y = 400$ Mpa untuk tulangan dengan diameter > 12 mm.

$$\begin{aligned} \rho_{\min} &= \frac{1,4}{f_y} \\ &= \frac{1,4}{400} \\ &= 0,0035. \end{aligned}$$

c. Penulangan Balok

1) *Perancangan tulangan lentur tumpuan balok.*

Data :

Diketahui momen rencana $M_u = 406,31$ kNm

$$M_n = \frac{Mu}{0,8} = \frac{406,31}{0,8}$$

$$= 507,89 \text{ kNm.}$$

$$m = \frac{fy}{0,85 \cdot fc'}$$

$$= \frac{400}{0,85 \cdot 22,5}$$

$$= 20,915$$

$$R_n = \frac{M_n}{bw \cdot d^2}$$

$$= \frac{507,89 \cdot 10^6}{600 \cdot 650^2}$$

$$= 2,004 \text{ N/mm}^2.$$

$$\rho_{perlu} = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{fy}} \right)$$

$$\rho_{perlu} = \frac{1}{20,915} \left(1 - \sqrt{1 - \frac{2 \cdot 20,915 \cdot 2,004}{400}} \right)$$

$$= 0,0053$$

$$\rho_{maks} = 0,75 \cdot 0,85 \cdot fc' \cdot \frac{\beta_1 \left(\frac{600}{600 + fy} \right)}{fy}$$

$$\rho_{maks} = 0,75 \cdot 0,85 \cdot 22,5 \cdot \frac{0,85 \left(\frac{600}{600 + 400} \right)}{400}$$

$$= 0,0183$$

sehingga digunakan $\rho_{perlu} = 0,0053$

kebutuhan tulangan:

$$A_s = \rho \cdot b \cdot d$$

$$= 0,0053 \cdot 600 \cdot 650$$

$$= 2068 \text{ mm}^2.$$

$$n = \frac{A_{s_{perlu}}}{A_{tul}}$$

digunakan tulangan D25 dengan luas $A_{tul} = 490$

$$= \frac{2068}{490}$$

$$= 4,22 \text{ buah} \sim 5 \text{ buah (5 D25)}$$

$$A_s = 5.490 = 2450 \text{ mm}^2.$$

$$\rho'/\rho = 0,5$$

digunakan tulangan tekan 3 D 25.

$$A_s' = 3.490 = 1470 \text{ mm}^2.$$

Analisis penampang

Asumsi tulangan tarik dan tekan belum leleh $c > d'$

$$0,85 \cdot f_c' \cdot \beta \cdot c \cdot b + A_s' \cdot 600 \cdot \left(\frac{c - d'}{c} \right) = A_s \cdot f_y$$

$$0,85 \cdot 22,5 \cdot 400 \cdot 0,85 \cdot c = 2450 \cdot 400 - 1470 \cdot 600 \left(\frac{c - 50}{c} \right)$$

$$6502,5 c^2 = 980000c - 882000c + 44100000$$

$$c^2 - 15,071 c - 6782,01 = 0$$

$$c = 90,23 \text{ mm}$$

$$a = 0,85 \cdot 90,23$$

$$a = 76,70 \text{ mm} > d' \text{ asumsi benar.}$$

Cek kelelehan tulangan

$$\epsilon_s' = 0,003 \cdot \frac{(90,23 - 50)}{90,23}$$

$$\epsilon_s' = 0,00134 < \epsilon_y = 0,0020 \text{ asumsi benar.}$$

$$f_s' = 600 \cdot \frac{(90,23 - 50)}{90,23}$$

$$f_s' = 267,51 \text{ Mpa}$$

$$\epsilon_s = 0,003 \cdot \frac{(650 - 90,23)}{90,23}$$

Kapasitas balok terhadap momen

$$M1 = 0,85 \cdot 22,5 \cdot 400 \cdot 76,7 \cdot (650 - 76,7/2) \\ = 358888695 \text{ Nmm.}$$

$$M2 = 1470 \cdot 267,51 \cdot (650 - 50) \\ = 235943820 \text{ Nmm.}$$

$$M_{nak} = M1 + M2 \\ = 358888695 + 235943820 \\ = 594832515 \text{ Nmm} \\ = 594,83 \text{ kNm} > 507,89 \text{ kNm}$$

$$M_{kap} = \phi_o \cdot M_{nak} \\ = 1,25 \cdot 594,83 \\ = 743,54 \text{ kNm.}$$

sehingga balok tumpuan aman terhadap lenturan.

2) *Perancangan tulangan lentur lapangan balok.*

Data :

Diketahui momen rencana $M_u = 363,08 \text{ kNm}$

$$M_n = \frac{M_u}{0,8} = \frac{363,08}{0,8} \\ = 453,85 \text{ kNm.}$$

$$m = \frac{f_y}{0,85 \cdot f_c'} \\ = \frac{400}{0,85 \cdot 22,5} \\ = 20,915$$

$$R_n = \frac{M_n}{b \cdot w \cdot d^2} \\ = \frac{453,85 \cdot 10^6}{400 \cdot 650^2} \\ = 2,69$$

$$\rho_{perlu} = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$

$$\rho_{perlu} = \frac{1}{20,915} \left(1 - \sqrt{1 - \frac{2 \cdot 20,915 \cdot 2,69}{400}} \right)$$

$$= 0,00728$$

$$\rho_{maks} = 0,75 \cdot 0,85 \cdot f_c' \cdot \frac{\beta_1}{f_y} \left(\frac{600}{600 + f_y} \right)$$

$$\rho_{maks} = 0,75 \cdot 0,85 \cdot 22,5 \cdot \frac{0,85}{400} \left(\frac{600}{600 + 400} \right)$$

$$= 0,0183$$

sehingga digunakan $\rho_{perlu} = 0,00728$

kebutuhan tulangan:

$$A_s = \rho \cdot b \cdot d$$

$$= 0,00728 \cdot 400 \cdot 650$$

$$= 1892 \text{ mm}^2$$

$$n = \frac{A_{s_{perlu}}}{A_{tul}}$$

digunakan tulangan D25 dengan luas $A_{tul} = 490$

$$= \frac{1892}{490}$$

$$= 3,86 \text{ buah} \sim 5 \text{ buah (5 D25)}$$

$$A_s = 5 \cdot 490 = 2450 \text{ mm}^2$$

$$\rho' / \rho = 0,5$$

digunakan tulangan tekan 3 D 25.

$$A_s' = 3 \cdot 490 = 1470 \text{ mm}^2$$

Analisis penampang

Asumsi tulangan tarik dan tekan belum leleh $c > d'$

$$0,85 \cdot f_c' \cdot \beta_1 \cdot c \cdot b + A_s' \cdot 600 \cdot \left(\frac{c - d'}{c} \right) = A_s \cdot f_y$$

$$0,85 \cdot 22,5 \cdot 400 \cdot 0,85 \cdot c = 2450 \cdot 400 - 1470 \cdot 600 \left(\frac{c - 50}{c} \right)$$

$$6502,5 c^2 = 980000c - 882000c + 44100000$$

$$c^2 - 10,047 c - 4521,52 = 0$$

$$c = 72,469 \text{ mm}$$

$$a = 0,85 \cdot 72,469$$

$$a = 61,60 \text{ mm} > d^2 \text{ asumsi benar.}$$

Cek kelelahan tulangan

$$\varepsilon' = 0,003 \cdot \frac{(72,469 - 50)}{72,469}$$

$$\varepsilon' = 0,000930 < \varepsilon_y = 0,0020 \text{ asumsi benar.}$$

$$f_s' = 600 \cdot \frac{(72,469 - 50)}{72,469}$$

$$f_s' = 186,03 \text{ Mpa}$$

$$\varepsilon_s = 0,003 \cdot \frac{(650 - 72,469)}{72,469}$$

$$\varepsilon_s = 0,0239 > \varepsilon_s = 0,0020 \text{ asumsi benar.}$$

Kapasitas balok terhadap momen

$$M_1 = 0,85 \cdot 22,5 \cdot 600 \cdot 61,60 \cdot (650 - 61,60/2)$$

$$= 437687712 \text{ Nmm.}$$

$$M_2 = 1470 \cdot 186,03 \cdot (650 - 50)$$

$$= 164078460 \text{ Nmm.}$$

$$M_{nak} = M_1 + M_2$$

$$= 437687712 + 164078460$$

$$= 601766172 \text{ Nmm}$$

$$= 601,77 \text{ kNm} > 453,85 \text{ kNm}$$

$$M_{kap} = \phi_o \cdot M_{nak}$$

$$= 1,25 \cdot 601,77$$

$$= 752,21 \text{ kNm.}$$

sehingga balok tumpuan aman terhadap lenturan.

Hasil perhitungan penulangan lentur balok selanjutnya dapat dilihat pada tabel 6.7 S/D 6.18.

Tabel.6.8. Perhitungan penulangan lentur tumpuan balok Portal As B & E

| Lantai | BTG | MU (kNm) | Mn (kNm) | bf (mm) | bw (mm) | d (mm) | fc' (Mpa) | fy (Mpa) | Pergeseran | D tul (mm) | n | n aktual | n' aktual | fs | ket | fs' | keterangan | M1 (Nmm) | M2 (Nmm) | M nak (Nmm) | ket |
|--------|-----|----------|----------|---------|---------|--------|-----------|----------|------------|------------|------|----------|-----------|--------|-------|--------|-------------|-------------|-------------|-------------|------|
| Dasar | 34 | 72,85 | 91,06 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 19 | 1,60 | 4 | 3 | 400,00 | leleh | 226,47 | belum leleh | 189195217,1 | 115624286,3 | 304819503,3 | Aman |
| | 37 | 80,09 | 100,11 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 19 | 1,60 | 4 | 3 | 400,00 | leleh | 226,47 | belum leleh | 189195217,1 | 115624286,3 | 304819503,3 | Aman |
| | 62 | 72,85 | 91,06 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 19 | 1,60 | 4 | 3 | 400,00 | leleh | 226,47 | belum leleh | 189195217,1 | 115624286,3 | 304819503,3 | Aman |
| | 65 | 80,09 | 100,11 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 19 | 1,60 | 4 | 3 | 400,00 | leleh | 226,47 | belum leleh | 189195217,1 | 115624286,3 | 304819503,3 | Aman |
| 1 | 104 | 195,96 | 244,96 | 200 | 200 | 650 | 22,5 | 400 | 0,0079 | 22 | 2,70 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 107 | 233,92 | 292,40 | 200 | 200 | 650 | 22,5 | 400 | 0,0096 | 22 | 3,29 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 132 | 195,96 | 244,96 | 200 | 200 | 650 | 22,5 | 400 | 0,0079 | 22 | 2,70 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 135 | 233,92 | 292,40 | 200 | 200 | 650 | 22,5 | 400 | 0,0096 | 22 | 3,29 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| 2 | 174 | 159,47 | 199,33 | 200 | 200 | 650 | 22,5 | 400 | 0,0063 | 22 | 2,16 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 177 | 223,14 | 278,93 | 200 | 200 | 650 | 22,5 | 400 | 0,0091 | 22 | 3,12 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 202 | 159,47 | 199,33 | 200 | 200 | 650 | 22,5 | 400 | 0,0063 | 22 | 2,16 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 205 | 223,14 | 278,93 | 200 | 200 | 650 | 22,5 | 400 | 0,0091 | 22 | 3,12 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| 3 | 244 | 100,09 | 125,11 | 200 | 200 | 650 | 22,5 | 400 | 0,0039 | 22 | 1,32 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 247 | 180,54 | 225,68 | 200 | 200 | 650 | 22,5 | 400 | 0,0072 | 22 | 2,47 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 272 | 100,09 | 125,11 | 200 | 200 | 650 | 22,5 | 400 | 0,0039 | 22 | 1,32 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 275 | 180,54 | 225,68 | 200 | 200 | 650 | 22,5 | 400 | 0,0072 | 22 | 2,47 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| 4 | 314 | 34,43 | 43,04 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 317 | 119,75 | 149,69 | 200 | 200 | 650 | 22,5 | 400 | 0,0047 | 22 | 1,59 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 342 | 34,43 | 43,04 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 345 | 119,75 | 149,69 | 200 | 200 | 650 | 22,5 | 400 | 0,0047 | 22 | 1,59 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| Ring | 380 | 17,08 | 21,35 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 381 | 28,43 | 35,53 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 398 | 17,08 | 21,35 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 399 | 28,43 | 35,53 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |

| | | | | | | | | | | | | | | | | | | | | | |
|------|-----|--------|--------|-----|-----|-----|------|-----|--------|----|------|---|---|--------|-------|--------|-------------|-------------|-------------|-------------|------|
| | 267 | 84,34 | 105,43 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| | 322 | 113,54 | 141,92 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| | 323 | 219,51 | 274,39 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| | 324 | 219,14 | 273,92 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| | 325 | 226,12 | 282,65 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| | 326 | 53,19 | 66,49 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| 4 | 333 | 113,54 | 141,92 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| | 334 | 219,51 | 274,39 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| | 335 | 219,14 | 273,92 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| | 336 | 226,12 | 282,65 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| | 337 | 53,19 | 66,49 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 5 | 3 | 400,00 | leleh | 267,92 | belum leleh | 422681793,6 | 236823651,8 | 659505445,4 | Aman |
| | 386 | 19,69 | 24,62 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| Ring | 387 | 13,92 | 17,40 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 392 | 19,69 | 24,62 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 393 | 13,92 | 17,40 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |

| | | | | | | | | | | | | | | | | | | | | | |
|------|-----|--------|--------|-----|-----|-----|------|-----|--------|----|------|---|---|--------|-------|--------|-------------|-------------|-------------|-------------|------|
| | 276 | 224,39 | 280,49 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| | 277 | 224,37 | 280,47 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| 4 | 312 | 140,51 | 175,64 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| | 313 | 140,53 | 175,66 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| | 319 | 168,27 | 210,34 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| | 320 | 168,24 | 210,31 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| | 328 | 83,48 | 104,35 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| | 331 | 83,47 | 104,34 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| | 339 | 205,17 | 256,47 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| | 340 | 205,20 | 256,50 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| | 346 | 151,64 | 189,55 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| | 347 | 151,63 | 189,53 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 4 | 3 | 400,00 | leleh | 201,26 | belum leleh | 355707725,8 | 177895080,4 | 533602806,2 | Aman |
| Ring | 378 | 51,57 | 64,47 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 19 | 1,67 | 4 | 3 | 400,00 | leleh | 150,68 | belum leleh | 161513806,4 | 51285786,62 | 212799593 | Aman |
| | 379 | 51,58 | 64,47 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 19 | 1,67 | 4 | 3 | 400,00 | leleh | 150,68 | belum leleh | 161513806,4 | 51285786,62 | 212799593 | Aman |
| | 383 | 58,27 | 72,84 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 19 | 1,67 | 4 | 3 | 400,00 | leleh | 150,68 | belum leleh | 161513806,4 | 51285786,62 | 212799593 | Aman |
| | 384 | 58,27 | 72,83 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 19 | 1,67 | 4 | 3 | 400,00 | leleh | 150,68 | belum leleh | 161513806,4 | 51285786,62 | 212799593 | Aman |
| | 389 | 29,69 | 37,11 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 19 | 1,67 | 4 | 3 | 400,00 | leleh | 150,68 | belum leleh | 161513806,4 | 51285786,62 | 212799593 | Aman |
| | 390 | 29,69 | 37,11 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 19 | 1,67 | 4 | 3 | 400,00 | leleh | 150,68 | belum leleh | 161513806,4 | 51285786,62 | 212799593 | Aman |
| | 395 | 68,26 | 85,32 | 300 | 300 | 450 | 22,5 | 400 | 0,0037 | 19 | 1,74 | 4 | 3 | 400,00 | leleh | 150,68 | belum leleh | 161513806,4 | 51285786,62 | 212799593 | Aman |
| | 396 | 68,26 | 85,33 | 300 | 300 | 450 | 22,5 | 400 | 0,0037 | 19 | 1,74 | 4 | 3 | 400,00 | leleh | 150,68 | belum leleh | 161513806,4 | 51285786,62 | 212799593 | Aman |
| | 400 | 40,09 | 50,12 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 19 | 1,67 | 4 | 3 | 400,00 | leleh | 150,68 | belum leleh | 161513806,4 | 51285786,62 | 212799593 | Aman |
| | 401 | 40,09 | 50,11 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 19 | 1,67 | 4 | 3 | 400,00 | leleh | 150,68 | belum leleh | 161513806,4 | 51285786,62 | 212799593 | Aman |

Tabel 6.12. Perhitungan penulangan lentur tumpuan balok Portal As. 3 & 4

| Lantai | BTG | MU (kNm) | Mn (kNm) | bf (mm) | bw (mm) | d (mm) | fe' (Mpa) | fy (Mpa) | Pdipergunakan | D tul (mm) | n | n aktual | n' aktual | fs | ket | fs' | keterangan | M1 (Nmm) | M2 (Nmm) | M nak (Nmm) | ket |
|--------|--------|----------|----------|---------|---------|--------|-----------|----------|---------------|------------|------|----------|-----------|--------|--------|--------|-------------|-------------|-------------|-------------|------|
| Dasar | 35 | 136,69 | 170,86 | 400 | 400 | 550 | 22,5 | 400 | 0,0035 | 19 | 2,71 | 4 | 3 | 400,00 | leleh | 86,71 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| | 36 | 136,69 | 170,86 | 400 | 400 | 550 | 22,5 | 400 | 0,0038 | 19 | 2,97 | 4 | 3 | 400,00 | leleh | 86,71 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| | 49 | 150,90 | 188,63 | 400 | 400 | 550 | 22,5 | 400 | 0,0038 | 19 | 2,97 | 4 | 3 | 400,00 | leleh | 86,71 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| | 50 | 150,90 | 188,63 | 400 | 400 | 550 | 22,5 | 400 | 0,0035 | 19 | 2,71 | 4 | 3 | 400,00 | leleh | 86,71 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| | 63 | 141,88 | 177,35 | 400 | 400 | 550 | 22,5 | 400 | 0,0035 | 19 | 2,71 | 4 | 3 | 400,00 | leleh | 86,71 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| | 64 | 141,88 | 177,35 | 400 | 400 | 550 | 22,5 | 400 | 0,0047 | 19 | 3,73 | 4 | 3 | 400,00 | leleh | 86,71 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| 1 | 105 | 763,06 | 953,83 | 600 | 400 | 650 | 22,5 | 400 | 0,0047 | 25 | 3,73 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 106 | 763,06 | 953,83 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 119 | 487,11 | 608,88 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 120 | 487,11 | 608,88 | 600 | 400 | 650 | 22,5 | 400 | 0,0053 | 25 | 4,20 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 133 | 761,87 | 952,34 | 600 | 400 | 650 | 22,5 | 400 | 0,0053 | 25 | 4,20 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| 134 | 761,87 | 952,34 | 600 | 400 | 650 | 22,5 | 400 | 0,0050 | 25 | 3,98 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman | |
| 2 | 175 | 758,51 | 948,13 | 600 | 400 | 650 | 22,5 | 400 | 0,0050 | 25 | 3,98 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 176 | 758,51 | 948,13 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 189 | 404,28 | 505,35 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 190 | 404,28 | 505,35 | 600 | 400 | 650 | 22,5 | 400 | 0,0054 | 25 | 4,30 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 203 | 757,21 | 946,51 | 600 | 400 | 650 | 22,5 | 400 | 0,0054 | 25 | 4,30 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| 204 | 757,21 | 946,51 | 600 | 400 | 650 | 22,5 | 400 | 0,0057 | 25 | 4,55 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman | |
| 3 | 245 | 723,31 | 904,14 | 600 | 400 | 650 | 22,5 | 400 | 0,0057 | 25 | 4,55 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 246 | 723,31 | 904,14 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 259 | 265,09 | 331,36 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 260 | 265,09 | 331,36 | 600 | 400 | 650 | 22,5 | 400 | 0,0059 | 25 | 4,72 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 273 | 725,24 | 906,55 | 600 | 400 | 650 | 22,5 | 400 | 0,0059 | 25 | 4,72 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 274 | 725,24 | 906,55 | 600 | 400 | 650 | 22,5 | 400 | 0,0056 | 25 | 4,48 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| 4 | 315 | 669,29 | 836,62 | 600 | 400 | 650 | 22,5 | 400 | 0,0056 | 25 | 4,48 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 316 | 669,29 | 836,62 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 329 | 236,71 | 295,89 | 600 | 400 | 650 | 22,5 | 400 | 0,0035 | 25 | 2,78 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 330 | 236,71 | 295,89 | 600 | 400 | 650 | 22,5 | 400 | 0,0065 | 25 | 5,14 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 343 | 614,01 | 767,52 | 600 | 400 | 650 | 22,5 | 400 | 0,0065 | 25 | 5,14 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |
| | 344 | 489,25 | 611,56 | 600 | 400 | 650 | 22,5 | 400 | 0,0083 | 25 | 6,58 | 10 | 5 | 400,00 | leleh | 400,00 | leleh | 676878594,6 | 589285714,3 | 1266164309 | Aman |

Tabel 6.14. Perhitungan penulangan lentur lapangan balok Portal As B & E

| Lantai | BTG | MU (kNm) | Mn (kNm) | bf (mm) | bw (mm) | d (mm) | fc' (Mpa) | fy (Mpa) | Pergeseran | D.tul (mm) | n | n aktual | n' aktual | fs | ket | fs' | keterangan | M1 (Nmm) | M2 (Nmm) | M nak (Nmm) | ket |
|--------|-----|-------------|-------------|------------|------------|-----------|--------------|-------------|------------|---------------|------|-------------|--------------|--------|-------|--------|-------------|-------------|-------------|----------------|------|
| Dasar | 34 | 31,22 | 39,03 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 19 | 1,60 | 4 | 3 | 400,00 | leleh | 226,47 | belum leleh | 189195217,1 | 115624286,3 | 304819503,3 | Aman |
| | 37 | 34,82 | 43,52 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 19 | 1,60 | 4 | 3 | 400,00 | leleh | 226,47 | belum leleh | 189195217,1 | 115624286,3 | 304819503,3 | Aman |
| | 62 | 31,22 | 39,03 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 19 | 1,60 | 4 | 3 | 400,00 | leleh | 226,47 | belum leleh | 189195217,1 | 115624286,3 | 304819503,3 | Aman |
| | 65 | 34,82 | 43,52 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 19 | 1,60 | 4 | 3 | 400,00 | leleh | 226,47 | belum leleh | 189195217,1 | 115624286,3 | 304819503,3 | Aman |
| 1 | 104 | 91,47 | 114,34 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 107 | 111,36 | 139,20 | 200 | 200 | 650 | 22,5 | 400 | 0,0043 | 22 | 1,47 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 132 | 91,47 | 114,34 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 135 | 111,36 | 139,20 | 200 | 200 | 650 | 22,5 | 400 | 0,0043 | 22 | 1,47 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| 2 | 174 | 73,11 | 91,38 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 177 | 105,39 | 131,74 | 200 | 200 | 650 | 22,5 | 400 | 0,0041 | 22 | 1,39 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 202 | 73,11 | 91,38 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 205 | 105,39 | 131,74 | 200 | 200 | 650 | 22,5 | 400 | 0,0041 | 22 | 1,39 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| 3 | 244 | 43,62 | 54,52 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 247 | 84,04 | 105,05 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 272 | 43,62 | 54,52 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 275 | 84,04 | 105,05 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| 4 | 314 | 18,18 | 22,72 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 317 | 53,64 | 67,05 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 342 | 18,18 | 22,72 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 345 | 53,64 | 67,05 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| Ring | 380 | 5,45 | 6,82 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 381 | 11,22 | 14,02 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 398 | 5,45 | 6,82 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |
| | 399 | 11,22 | 14,02 | 200 | 200 | 650 | 22,5 | 400 | 0,0035 | 22 | 1,20 | 4 | 2 | 400,00 | leleh | 328,19 | belum leleh | 254607715,7 | 149767336,1 | 404375051,8 | Aman |

| | | | | | | | | | | | | | | | | | | | | | |
|------|-----|--------|--------|-----|-----|-----|------|-----|--------|----|------|---|---|--------|-------|--------|-------------|-------------|-------------|-------------|------|
| | 267 | 20,18 | 25,23 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| | 322 | 27,62 | 34,52 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| | 323 | 114,39 | 142,98 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| | 324 | 110,46 | 138,08 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| 4 | 325 | 114,37 | 142,97 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| | 326 | 27,65 | 34,57 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| | 333 | 27,62 | 34,52 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| | 334 | 114,39 | 142,98 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| | 335 | 110,46 | 138,08 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| | 336 | 114,37 | 142,97 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| | 337 | 27,65 | 34,57 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 5 | 3 | 400,00 | leleh | 186,42 | belum leleh | 515375654,9 | 164780578 | 680156232,9 | Aman |
| Ring | 386 | 13,94 | 17,43 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 387 | 13,94 | 17,43 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 392 | 13,94 | 17,43 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 393 | 13,94 | 17,43 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |

| | | | | | | | | | | | | | | | | | | | | | |
|------|-------|-------|-------|-----|-----|------|------|--------|--------|------|------|---|--------|--------|--------|-------------|-------------|-------------|-------------|-------------|------|
| | 277 | 75,52 | 94,41 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| 4 | 312 | 52,50 | 65,63 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| | 313 | 52,08 | 65,10 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| | 319 | 74,12 | 92,65 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| | 320 | 74,12 | 92,65 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| | 328 | 39,04 | 48,80 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| | 331 | 39,04 | 48,80 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| | 339 | 75,36 | 94,19 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| | 339 | 43,52 | 54,41 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| | 340 | 75,36 | 94,19 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| | 346 | 44,14 | 55,18 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman |
| 347 | 44,13 | 55,16 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 3 | 400,00 | leleh | 119,75 | belum leleh | 446900311,7 | 105852006,6 | 552752318,3 | Aman | |
| Ring | 378 | 13,44 | 16,79 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 379 | 13,44 | 16,79 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 383 | 34,29 | 42,86 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 384 | 34,29 | 42,86 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 389 | 13,89 | 17,36 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 390 | 13,89 | 17,36 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 395 | 34,32 | 42,90 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 395 | 34,32 | 42,90 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 400 | 25,40 | 31,75 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |
| | 401 | 25,40 | 31,75 | 300 | 300 | 450 | 22,5 | 400 | 0,0035 | 22 | 1,24 | 3 | 2 | 400,00 | leleh | 161,41 | belum leleh | 165193190 | 49104700,88 | 214297890,9 | Aman |

Tabel 6.18. Perhitungan penulangan lentur lapangan balok Portal As 3 & 4

| Lantai | BTG | MU (kNm) | Mn (kNm) | bf (mm) | bw (mm) | d (mm) | fc' (Mpa) | fy (Mpa) | Pdigunakan | D-tul (mm) | n | n aktual | n' aktual | fs | ket | fs' | keterangan | M1 (Nmm) | M2 (Nmm) | M nak (Nmm) | ket |
|--------|-----|-------------|-------------|------------|------------|-----------|--------------|-------------|------------|---------------|------|-------------|--------------|--------|-------|--------|-------------|-------------|-------------|----------------|------|
| Dasar | 35 | 33,87 | 42,34 | 400 | 400 | 550 | 22,5 | 400 | 0,0035 | 19 | 2,71 | 4 | 3 | 400,00 | leleh | 86,708 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| | 36 | 33,87 | 42,34 | 400 | 400 | 550 | 22,5 | 400 | 0,0035 | 19 | 2,71 | 4 | 3 | 400,00 | leleh | 86,708 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| | 49 | 3,77 | 4,71 | 400 | 400 | 550 | 22,5 | 400 | 0,0035 | 19 | 2,71 | 4 | 3 | 400,00 | leleh | 86,708 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| | 50 | 3,77 | 4,71 | 400 | 400 | 550 | 22,5 | 400 | 0,0035 | 19 | 2,71 | 4 | 3 | 400,00 | leleh | 86,708 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| | 63 | 33,87 | 42,34 | 400 | 400 | 550 | 22,5 | 400 | 0,0035 | 19 | 2,71 | 4 | 3 | 400,00 | leleh | 86,708 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| | 64 | 33,87 | 42,34 | 400 | 400 | 550 | 22,5 | 400 | 0,0035 | 19 | 2,71 | 4 | 3 | 400,00 | leleh | 86,708 | belum leleh | 234806340,7 | 36891002,73 | 271697343,4 | Aman |
| 1 | 105 | 343,90 | 429,88 | 400 | 600 | 650 | 22,5 | 400 | 0,0068 | 25 | 3,63 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 106 | 343,90 | 429,88 | 400 | 600 | 650 | 22,5 | 400 | 0,0068 | 25 | 3,63 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 119 | 96,23 | 120,28 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 6 | 400,00 | leleh | 400 | leleh | 411675354,2 | 707142857,1 | 1118818211 | Aman |
| | 120 | 96,23 | 120,28 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 6 | 400,00 | leleh | 400 | leleh | 411675354,2 | 707142857,1 | 1118818211 | Aman |
| | 133 | 343,90 | 429,88 | 400 | 600 | 650 | 22,5 | 400 | 0,0068 | 25 | 3,63 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 134 | 343,90 | 429,88 | 400 | 600 | 650 | 22,5 | 400 | 0,0068 | 25 | 3,63 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| 2 | 175 | 338,88 | 423,60 | 400 | 600 | 650 | 22,5 | 400 | 0,0067 | 25 | 3,57 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 176 | 338,88 | 423,60 | 400 | 600 | 650 | 22,5 | 400 | 0,0067 | 25 | 3,57 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 189 | 80,77 | 100,96 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 6 | 400,00 | leleh | 400 | leleh | 411675354,2 | 707142857,1 | 1118818211 | Aman |
| | 190 | 80,77 | 100,96 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 6 | 400,00 | leleh | 400 | leleh | 411675354,2 | 707142857,1 | 1118818211 | Aman |
| | 203 | 338,88 | 423,60 | 400 | 600 | 650 | 22,5 | 400 | 0,0067 | 25 | 3,57 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 204 | 338,88 | 423,60 | 400 | 600 | 650 | 22,5 | 400 | 0,0067 | 25 | 3,57 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| 3 | 245 | 334,17 | 417,71 | 400 | 600 | 650 | 22,5 | 400 | 0,0066 | 25 | 3,52 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 246 | 334,17 | 417,71 | 400 | 600 | 650 | 22,5 | 400 | 0,0066 | 25 | 3,52 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 259 | 68,02 | 85,02 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 6 | 400,00 | leleh | 400 | leleh | 411675354,2 | 707142857,1 | 1118818211 | Aman |
| | 260 | 68,02 | 85,02 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 6 | 400,00 | leleh | 400 | leleh | 411675354,2 | 707142857,1 | 1118818211 | Aman |
| | 273 | 334,17 | 417,71 | 400 | 600 | 650 | 22,5 | 400 | 0,0066 | 25 | 3,52 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 274 | 334,17 | 417,71 | 400 | 600 | 650 | 22,5 | 400 | 0,0066 | 25 | 3,52 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| 4 | 315 | 363,43 | 454,29 | 400 | 600 | 650 | 22,5 | 400 | 0,0073 | 25 | 3,85 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 316 | 363,43 | 454,29 | 400 | 600 | 650 | 22,5 | 400 | 0,0073 | 25 | 3,85 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 329 | 156,60 | 195,75 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 6 | 400,00 | leleh | 400 | leleh | 411675354,2 | 707142857,1 | 1118818211 | Aman |
| | 330 | 156,60 | 195,75 | 400 | 600 | 650 | 22,5 | 400 | 0,0035 | 25 | 1,85 | 4 | 6 | 400,00 | leleh | 400 | leleh | 411675354,2 | 707142857,1 | 1118818211 | Aman |
| | 343 | 363,43 | 454,29 | 400 | 600 | 650 | 22,5 | 400 | 0,0073 | 25 | 3,85 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |
| | 344 | 363,43 | 454,29 | 400 | 600 | 650 | 22,5 | 400 | 0,0073 | 25 | 3,85 | 8 | 4 | 400,00 | leleh | 301,29 | belum leleh | 699914247,7 | 355096663,8 | 1055010911 | Aman |

d. Kontrol balok terhadap lendutan yang terjadi

Dalam kontrol lendutan ini diambil pada balok dengan bentang terpanjang. Lendutan yang terjadi pada balok dicari dengan menggunakan program Sap 2000. Dari analisis didapatkan lendutan yang terjadi pada balok sebesar 0,006 m, sedangkan lendutan maksimum yang diijinkan adalah $1/240 = 0,04$ m, sehingga balok dengan beban terbesar aman terhadap lendutan.

2. Perhitungan Penulangan Balok terhadap Geser

a. Gaya geser rencana

Sesuai dengan konsep desain kapasitas, kuat geser balok portal yang dibebani oleh beban gravitasi sepanjang bentangnya harus dihitung dalam kondisi terjadi sendi-sendi plastis pada ujung balok portal tersebut, dengan tanda yang berlawanan (positif dan negatif) menurut persamaan berikut :

$$V_{u,b} = 0,7 \frac{M_{kap} + M_{kap'}}{L_n} + 1,05V_g$$

Tetapi tidak perlu lebih besar dari

$$V_{u,b} = 1,05 \left(V_{D,b} + V_{L,b} + \frac{4}{K} V_{E,b} \right)$$

Perhitungan gaya geser rencana:

$$M_{kap} = 743,54 \text{ kNm}$$

$$M_{kap'} = 743,54 \text{ kNm}$$

$$L_n = 7200 - 700 = 6500 \text{ mm}$$

$$V_g = V_D + 0,42 \cdot V_L$$

$$= 91,021 + 0,42 \cdot 29,58$$

$$= 103,445 \text{ kN}$$

$$V_{u,b} = 0,7 \frac{743,54 + 743,54}{6,5} + 1,05 \cdot 103,445$$

$$= 263,59 \text{ kN}$$

dan tidak perlu lebih besar dari

$$V_D = 91,021 \text{ kN}$$

$$V_L = 29,58 \text{ kN}$$

$$V_{E,x} = 29,42 \text{ kN}$$

$$V_{E,y} = 0,25 \text{ kN (diabaikan)}$$

$$K = 1$$

$$V_{u,b} = 1,05 \left(91,02 \dot{1} + 29,58 + \frac{4}{1} 29,42 \right)$$

$$= 250,2 \text{ kN}$$

sehingga digunakan $V_{u,b} = 250,2 \text{ kN}$.

Hasil perhitungan gaya geser rencana balok selanjutnya dapat dilihat pada tabel 6.19 s/d 6.24

| | | | | | | | | | | | | | |
|-----|--------|---------|--------|---------|-------|-------|------|-------------|---------|-------|-----------|-----------|---------|
| 375 | 32,045 | 8,5564 | 4,6622 | -0,2999 | | 214,3 | 6500 | 64,61905633 | 40,6553 | 105,3 | 62,2131 | 62,2131 | 55,9918 |
| 376 | -32,95 | -8,856 | 4,3456 | -2E-15 | 214,3 | | 6500 | 64,61905633 | 41,8554 | 106,5 | 62,152442 | 62,152442 | 55,9372 |
| 376 | 32,95 | 8,856 | 4,3456 | -2E-15 | | 214,3 | 6500 | 64,61905633 | 41,8508 | 106,5 | 62,147843 | 62,147843 | 55,9331 |
| 377 | -32,05 | -8,5564 | 4,084 | 0,2999 | 214,3 | | 6500 | 64,61905633 | 40,6617 | 105,3 | 59,791205 | 59,791205 | 53,8121 |
| 377 | 33,853 | 9,1556 | 4,084 | 0,2999 | | 214,3 | 6500 | 64,61905633 | 43,0444 | 107,7 | 62,312337 | 62,312337 | 56,0811 |
| 402 | -33,86 | -9,1556 | 4,6622 | 0,2971 | 214,3 | | 6500 | 64,61905633 | 43,0508 | 107,7 | 64,74702 | 64,74702 | 58,2723 |
| 402 | 32,045 | 8,5564 | 4,6622 | 0,2971 | | 214,3 | 6500 | 64,61905633 | 40,6553 | 105,3 | 62,2131 | 62,2131 | 55,9918 |
| 403 | -32,95 | -8,856 | 4,3456 | 1E-15 | 214,3 | | 6500 | 64,61905633 | 41,8554 | 106,5 | 62,152442 | 62,152442 | 55,9372 |
| 403 | 32,95 | 8,856 | 4,3456 | 1E-15 | | 214,3 | 6500 | 64,61905633 | 41,8508 | 106,5 | 62,147843 | 62,147843 | 55,9331 |
| 404 | -32,05 | -8,5564 | 4,084 | -0,2971 | 214,3 | | 6500 | 64,61905633 | 40,6617 | 105,3 | 59,791205 | 59,791205 | 53,8121 |
| 404 | 33,853 | 9,1556 | 4,084 | -0,2971 | | 214,3 | 6500 | 64,61905633 | 43,0444 | 107,7 | 62,312337 | 62,312337 | 56,0811 |

bel 6.20. Gaya geser rencana balok portal As - B & E

| emen | VD (kN) | VL (kN) | VE,x (kN) | VE,y (kN) | Mnak (kNm) | Mnak' (kNm) | Ln (mm) | $0,7 \cdot \phi_s \cdot \frac{Mnak+MnakR}{Ln}$ | 1,05.Vg | Vu,b1 (kN) | Vu,b.max (kN) | Vu,b digunakan (kN) | Vu,b terpakai (kN) |
|------|------------|---------|--------------|--------------|---------------|----------------|------------|--|---------|---------------|------------------|---------------------------|--------------------------|
| | -28,75 | -0,4416 | 31,806 | -0,4541 | 307,77 | | 2900 | 208,0124964 | 30,5515 | 238,6 | 164,23732 | 164,23732 | 127,426 |
| | 25,804 | -0,4416 | 31,806 | -0,4541 | | 307,8 | 2900 | 208,0124964 | 27,4553 | 235,5 | 161,14112 | 161,14112 | 125,023 |
| | -28,74 | -0,4416 | -31,81 | -0,4541 | 307,77 | | 2900 | 208,0124964 | 30,5413 | 238,6 | 164,22601 | 164,22601 | 127,417 |
| | 25,813 | -0,4416 | -31,81 | -0,4541 | | 307,8 | 2900 | 208,0124964 | 27,4656 | 235,5 | 161,15033 | 161,15033 | 125,03 |
| | -28,75 | -0,4416 | 31,806 | 0,4522 | 307,77 | | 2900 | 208,0124964 | 30,5515 | 238,6 | 164,23732 | 164,23732 | 127,426 |
| | 25,804 | -0,4416 | 31,806 | 0,4522 | | 307,8 | 2900 | 208,0124964 | 27,4553 | 235,5 | 161,14112 | 161,14112 | 125,023 |
| | -28,74 | -0,4416 | -31,81 | 0,4522 | 307,77 | | 2900 | 208,0124964 | 30,5413 | 238,6 | 164,22601 | 164,22601 | 127,417 |
| | 25,813 | -0,4416 | -31,81 | 0,4522 | | 307,8 | 2900 | 208,0124964 | 27,4656 | 235,5 | 161,15033 | 161,15033 | 125,03 |
| | -46,64 | -6,3864 | 100,34 | -2,5978 | 404,38 | | 2900 | 240,4828011 | 54,2024 | 294,7 | 477,09057 | 294,68524 | 228,635 |
| | 30,859 | 1,7136 | 100,34 | -2,5978 | | 307,3 | 2900 | 240,4828011 | 33,8058 | 274,3 | 455,61452 | 274,28859 | 212,81 |
| | -46,59 | -6,3864 | -100,3 | -2,5978 | 307,26 | | 2900 | 207,663843 | 54,1487 | 261,8 | 477,03805 | 261,81251 | 203,13 |
| | 30,911 | 1,7136 | -100,3 | -2,5978 | | 307,3 | 2900 | 207,663843 | 33,8596 | 241,5 | 455,66956 | 241,52341 | 187,389 |
| | -46,64 | -6,3864 | 100,34 | 2,5863 | 307,26 | | 2900 | 207,663843 | 54,2024 | 261,9 | 477,09057 | 261,86629 | 203,172 |
| | 30,859 | 1,7136 | 100,34 | 2,5863 | | 307,3 | 2900 | 207,663843 | 33,8058 | 241,5 | 455,61452 | 241,46963 | 187,347 |
| | -46,59 | -6,3864 | -100,3 | 2,5863 | 307,26 | | 2900 | 207,663843 | 54,1487 | 261,8 | 477,03805 | 261,81251 | 203,13 |
| | 30,911 | 1,7136 | -100,3 | 2,5863 | | 307,3 | 2900 | 207,663843 | 33,8596 | 241,5 | 455,66956 | 241,52341 | 187,389 |
| | -51,81 | -7,9547 | 87,718 | -3,7436 | 307,26 | | 2900 | 207,663843 | 60,9114 | 268,6 | 431,16256 | 268,5752 | 208,377 |
| | 25,693 | 0,1453 | 87,718 | -3,7436 | | 307,3 | 2900 | 207,663843 | 27,0969 | 234,8 | 395,54411 | 234,76071 | 182,142 |
| | -51,74 | -7,9547 | -87,71 | -3,7436 | 307,26 | | 2900 | 207,663843 | 60,841 | 268,5 | 431,06933 | 268,50482 | 208,323 |
| | 25,76 | 0,1453 | -87,71 | -3,7436 | | 307,3 | 2900 | 207,663843 | 27,1673 | 234,8 | 395,59165 | 234,83111 | 182,197 |
| | -51,81 | -7,9547 | 87,718 | 3,7217 | 307,26 | | 2900 | 207,663843 | 60,9114 | 268,6 | 431,16256 | 268,5752 | 208,377 |
| | 25,693 | 0,1453 | 87,718 | 3,7217 | | 307,3 | 2900 | 207,663843 | 27,0969 | 234,8 | 395,54411 | 234,76071 | 182,142 |
| | -51,74 | -7,9547 | -87,71 | 3,7217 | 307,26 | | 2900 | 207,663843 | 60,841 | 268,5 | 431,06933 | 268,50482 | 208,323 |
| | 25,76 | 0,1453 | -87,71 | 3,7217 | | 307,3 | 2900 | 207,663843 | 27,1673 | 234,8 | 395,59165 | 234,83111 | 182,197 |
| | -55,21 | -8,9364 | 60,755 | -4,1476 | 307,26 | | 2900 | 207,663843 | 65,2873 | 273 | 322,52223 | 272,95111 | 211,772 |
| | 22,291 | -0,8364 | 60,755 | -4,1476 | | 307,3 | 2900 | 207,663843 | 24,0909 | 231,8 | 279,4548 | 231,75478 | 179,81 |
| | -55,14 | -8,9364 | -60,77 | -4,1476 | 307,26 | | 2900 | 207,663843 | 65,217 | 272,9 | 322,51387 | 272,88084 | 211,718 |
| | 22,358 | -0,8364 | -60,77 | -4,1476 | | 307,3 | 2900 | 207,663843 | 24,1612 | 231,8 | 279,58698 | 231,82505 | 179,864 |
| | -55,21 | -8,9364 | 60,755 | 4,1138 | 307,26 | | 2900 | 207,663843 | 65,2873 | 273 | 322,52223 | 272,95111 | 211,772 |
| | 22,291 | -0,8364 | 60,755 | 4,1138 | | 307,3 | 2900 | 207,663843 | 24,0909 | 231,8 | 279,4548 | 231,75478 | 179,81 |
| | -55,14 | -8,9364 | -60,77 | 4,1138 | 307,26 | | 2900 | 207,663843 | 65,217 | 272,9 | 322,51387 | 272,88084 | 211,718 |
| | 22,358 | -0,8364 | -60,77 | 4,1138 | | 307,3 | 2900 | 207,663843 | 24,1612 | 231,8 | 279,58698 | 231,82505 | 179,864 |
| | -56,26 | -9,1788 | 27,335 | -4,0254 | 307,26 | | 2900 | 207,663843 | 66,5877 | 274,3 | 183,51551 | 183,51551 | 142,383 |
| | 21,242 | -1,0788 | 27,335 | -4,0254 | | 307,3 | 2900 | 207,663843 | 23,1876 | 230,9 | 138,24436 | 138,24436 | 107,259 |
| | -21,29 | 1,0788 | 27,293 | 4,0254 | 307,26 | | 2900 | 207,663843 | 23,2378 | 230,9 | 138,11677 | 138,11677 | 107,16 |
| | 56,21 | 9,1788 | 27,293 | 4,0254 | | 307,3 | 2900 | 207,663843 | 66,5376 | 274,2 | 183,28762 | 183,28762 | 142,206 |
| | -56,26 | -9,1788 | 27,335 | 3,9784 | 307,26 | | 2900 | 207,663843 | 66,5877 | 274,3 | 183,51551 | 183,51551 | 142,383 |
| | 21,242 | -1,0788 | 27,335 | 3,9784 | | 307,3 | 2900 | 207,663843 | 23,1876 | 230,9 | 138,24436 | 138,24436 | 107,259 |
| | -21,29 | 1,0788 | 27,293 | -3,9784 | 307,26 | | 2900 | 207,663843 | 23,2378 | 230,9 | 138,11677 | 138,11677 | 107,16 |
| | 56,21 | 9,1788 | 27,293 | -3,9784 | | 307,3 | 2900 | 207,663843 | 66,5376 | 274,2 | 183,28762 | 183,28762 | 142,206 |
| | -17,47 | -3,2404 | 3,029 | -1,1696 | 307,26 | | 2900 | 207,663843 | 20,9964 | 228,7 | 34,466519 | 34,466519 | 26,7413 |
| | 6,3053 | -0,0004 | 3,029 | -1,1696 | | 307,3 | 2900 | 207,663843 | 6,6209 | 214,3 | 19,342592 | 19,342592 | 15,0072 |
| | -6,314 | 0,0004 | 3,0156 | 1,1696 | 307,26 | | 2900 | 207,663843 | 6,62958 | 214,3 | 19,295112 | 19,295112 | 14,9703 |
| | 17,461 | 3,2404 | 3,0156 | 1,1696 | | 307,3 | 2900 | 207,663843 | 20,9877 | 228,7 | 34,401692 | 34,401692 | 26,691 |
| | -17,47 | -3,2404 | 3,029 | 1,1533 | 307,26 | | 2900 | 207,663843 | 20,9964 | 228,7 | 34,466519 | 34,466519 | 26,7413 |
| | 6,3053 | -0,0004 | 3,029 | 1,1533 | | 307,3 | 2900 | 207,663843 | 6,6209 | 214,3 | 19,342592 | 19,342592 | 15,0072 |
| | -6,314 | 0,0004 | 3,0156 | -1,1533 | 307,26 | | 2900 | 207,663843 | 6,62958 | 214,3 | 19,295112 | 19,295112 | 14,9703 |
| | 17,461 | 3,2404 | 3,0156 | -1,1533 | | 307,3 | 2900 | 207,663843 | 20,9877 | 228,7 | 34,401692 | 34,401692 | 26,691 |

| | | | | | | | | | | | | |
|--------|---------|--------|---------|--------|-------|------|-------------|---------|-------|-----------|-----------|---------|
| 61,764 | 9,1419 | 41,997 | 10,839 | | 533,6 | 2900 | 360,6418966 | 72,3399 | 433 | 250,84031 | 250,84031 | 194,617 |
| -91,02 | -30,307 | 22,718 | 0,5898 | 533,6 | | 6500 | 160,9017693 | 120,389 | 281,3 | 222,80561 | 222,80561 | 200,525 |
| 89,912 | 28,693 | 22,718 | 0,5898 | | 533,6 | 6500 | 160,9017693 | 117,908 | 278,8 | 219,95142 | 219,95142 | 197,956 |
| -90,38 | -29,5 | 22,025 | -3E-15 | 659,51 | | 6500 | 198,8662574 | 119,064 | 317,9 | 218,38317 | 218,38317 | 196,545 |
| 90,545 | 29,5 | 22,025 | -3E-15 | | 659,5 | 6500 | 198,8662574 | 119,233 | 318,1 | 218,55216 | 218,55216 | 196,697 |
| -89,75 | -28,693 | 22,719 | -0,5898 | 659,51 | | 6500 | 198,8662574 | 117,742 | 316,6 | 219,79024 | 219,79024 | 197,811 |
| 91,175 | 30,307 | 22,719 | -0,5898 | | 659,5 | 6500 | 198,8662574 | 120,555 | 319,4 | 222,97604 | 222,97604 | 200,678 |
| -28,46 | -7,0581 | -42 | 10,839 | 659,51 | | 2900 | 445,7347148 | 35,6654 | 481,4 | 213,68572 | 213,68572 | 165,791 |
| 61,803 | 9,1419 | -42 | 10,839 | | 659,5 | 2900 | 445,7347148 | 72,3806 | 518,1 | 250,88233 | 250,88233 | 194,65 |
| -28,5 | -7,0581 | 41,997 | -10,84 | 533,6 | | 2900 | 360,6418966 | 35,7061 | 396,3 | 213,72513 | 213,72513 | 165,821 |
| 61,764 | 9,1419 | 41,997 | -10,84 | | 533,6 | 2900 | 360,6418966 | 72,3399 | 433 | 250,84031 | 250,84031 | 194,617 |
| -91,02 | -30,307 | 22,718 | -0,5896 | 533,6 | | 6500 | 160,9017693 | 120,389 | 281,3 | 222,80561 | 222,80561 | 200,525 |
| 89,912 | 28,693 | 22,718 | -0,5896 | | 533,6 | 6500 | 160,9017693 | 117,908 | 278,8 | 219,95142 | 219,95142 | 197,956 |
| -90,38 | -29,5 | 22,025 | 2E-15 | 659,51 | | 6500 | 198,8662574 | 119,064 | 317,9 | 218,38317 | 218,38317 | 196,545 |
| 90,545 | 29,5 | 22,025 | 2E-15 | | 659,5 | 6500 | 198,8662574 | 119,233 | 318,1 | 218,55216 | 218,55216 | 196,697 |
| -89,75 | -28,693 | 22,719 | 0,5896 | 659,51 | | 6500 | 198,8662574 | 117,742 | 316,6 | 219,79024 | 219,79024 | 197,811 |
| 91,175 | 30,307 | 22,719 | 0,5896 | | 659,5 | 6500 | 198,8662574 | 120,555 | 319,4 | 222,97604 | 222,97604 | 200,678 |
| -28,46 | -7,0581 | -42 | -10,84 | 659,51 | | 2900 | 445,7347148 | 35,6654 | 481,4 | 213,68572 | 213,68572 | 165,791 |
| 61,803 | 9,1419 | -42 | -10,84 | | 659,5 | 2900 | 445,7347148 | 72,3806 | 518,1 | 250,88233 | 250,88233 | 194,65 |
| -26,44 | -6,491 | 16,313 | 9,951 | 533,6 | | 2900 | 360,6418966 | 33,0771 | 393,7 | 103,09159 | 103,09159 | 79,9849 |
| 63,826 | 9,709 | 16,313 | 9,951 | | 533,6 | 2900 | 360,6418966 | 74,9689 | 435,6 | 145,72666 | 145,72666 | 113,064 |
| -90,33 | -30,078 | 13,656 | 0,5587 | 533,6 | | 6500 | 160,9017693 | 119,478 | 280,4 | 183,78145 | 183,78145 | 165,403 |
| 90,601 | 28,922 | 13,656 | 0,5587 | | 533,6 | 6500 | 160,9017693 | 118,818 | 279,7 | 182,8547 | 182,8547 | 164,569 |
| -90,39 | -29,5 | 11,85 | -2E-15 | 659,51 | | 6500 | 198,8662574 | 119,067 | 317,9 | 175,65068 | 175,65068 | 158,086 |
| 90,542 | 29,5 | 11,85 | -2E-15 | | 659,5 | 6500 | 198,8662574 | 119,229 | 318,1 | 175,8128 | 175,8128 | 158,232 |
| -90,45 | -28,922 | 13,653 | -0,5587 | 659,51 | | 6500 | 198,8662574 | 118,655 | 317,5 | 182,67692 | 182,67692 | 164,409 |
| 90,484 | 30,078 | 13,653 | -0,5587 | | 659,5 | 6500 | 198,8662574 | 119,642 | 318,5 | 183,93066 | 183,93066 | 165,538 |
| -63,85 | -9,709 | 16,314 | -9,951 | 659,51 | | 2900 | 445,7347148 | 74,9932 | 520,7 | 145,75293 | 145,75293 | 113,084 |
| 26,416 | 6,491 | 16,314 | -9,951 | | 659,5 | 2900 | 445,7347148 | 33,0528 | 478,8 | 103,06918 | 103,06918 | 79,9675 |
| -26,44 | -6,491 | 16,313 | -9,9508 | 533,6 | | 2900 | 360,6418966 | 33,0771 | 393,7 | 103,09159 | 103,09159 | 79,9849 |
| 63,826 | 9,709 | 16,313 | -9,9508 | | 533,6 | 2900 | 360,6418966 | 74,9689 | 435,6 | 145,72666 | 145,72666 | 113,064 |
| -90,33 | -30,078 | 13,656 | -0,5586 | 533,6 | | 6500 | 160,9017693 | 119,478 | 280,4 | 183,78145 | 183,78145 | 165,403 |
| 90,601 | 28,922 | 13,656 | -0,5586 | | 533,6 | 6500 | 160,9017693 | 118,818 | 279,7 | 182,8547 | 182,8547 | 164,569 |
| -90,39 | -29,5 | 11,85 | 2E-15 | 659,51 | | 6500 | 198,8662574 | 119,067 | 317,9 | 175,65068 | 175,65068 | 158,086 |
| 90,542 | 29,5 | 11,85 | 2E-15 | | 659,5 | 6500 | 198,8662574 | 119,229 | 318,1 | 175,8128 | 175,8128 | 158,232 |
| -90,45 | -28,922 | 13,653 | 0,5586 | 659,51 | | 6500 | 198,8662574 | 118,655 | 317,5 | 182,67692 | 182,67692 | 164,409 |
| 90,484 | 30,078 | 13,653 | 0,5586 | | 659,5 | 6500 | 198,8662574 | 119,642 | 318,5 | 183,93066 | 183,93066 | 165,538 |
| -63,85 | -9,709 | 16,314 | 9,9508 | 533,6 | | 2900 | 360,6418966 | 74,9932 | 435,6 | 145,75293 | 145,75293 | 113,084 |
| 26,416 | 6,491 | 16,314 | 9,9508 | | 533,6 | 2900 | 360,6418966 | 33,0528 | 393,7 | 103,06918 | 103,06918 | 79,9675 |
| -15,17 | -4,1338 | 2,2509 | 2,9808 | 214,3 | | 2900 | 144,8358159 | 19,3172 | 164,2 | 29,72568 | 29,72568 | 23,063 |
| 19,653 | 2,3462 | 2,2509 | 2,9808 | | 214,3 | 2900 | 144,8358159 | 22,5577 | 167,4 | 32,553222 | 32,553222 | 25,2568 |
| -19,65 | -2,3462 | 2,2509 | -2,9808 | 214,3 | | 2900 | 144,8358159 | 22,5582 | 167,4 | 32,553724 | 32,553724 | 25,2572 |
| 15,172 | 4,1338 | 2,2509 | -2,9808 | | 214,3 | 2900 | 144,8358159 | 19,3167 | 164,2 | 29,725152 | 29,725152 | 23,0626 |
| -15,17 | -4,1338 | 2,2509 | -2,9808 | 214,3 | | 2900 | 144,8358159 | 19,3172 | 164,2 | 29,72568 | 29,72568 | 23,063 |
| 19,653 | 2,3462 | 2,2509 | -2,9808 | | 214,3 | 2900 | 144,8358159 | 22,5577 | 167,4 | 32,553222 | 32,553222 | 25,2568 |
| -19,65 | -2,3462 | 2,2509 | 2,9808 | 214,3 | | 2900 | 144,8358159 | 22,5582 | 167,4 | 32,553724 | 32,553724 | 25,2572 |
| 15,172 | 4,1338 | 2,2509 | 2,9808 | | 214,3 | 2900 | 144,8358159 | 19,3167 | 164,2 | 29,725152 | 29,725152 | 23,0626 |

| | | | | | | | | | | |
|--------|--------|--------|-------|------|-------------|---------|-------|-----------|-----------|---------|
| 0,8624 | 2,7386 | | 307,3 | 4100 | 146,8841816 | 24,4236 | 171,3 | 36,948793 | 36,948793 | 31,0911 |
| -0,863 | 2,7386 | 307,26 | | 4100 | 146,8841816 | 38,2021 | 185,1 | 51,222012 | 51,222012 | 43,1014 |
| -0,863 | 2,7386 | | 307,3 | 4100 | 146,8841816 | 24,4241 | 171,3 | 36,949318 | 36,949318 | 31,0915 |
| -1E-14 | 5,4377 | 307,26 | | 1700 | 354,2500851 | 7,62048 | 361,9 | 30,625178 | 30,625178 | 18,9156 |
| -1E-14 | 5,4377 | | 307,3 | 1700 | 354,2500851 | 7,62048 | 361,9 | 30,625178 | 30,625178 | 18,9156 |
| 7E-15 | 5,4377 | 307,26 | | 1700 | 354,2500851 | 7,62048 | 361,9 | 30,625178 | 30,625178 | 18,9156 |
| 7E-15 | 5,4377 | | 307,3 | 1700 | 354,2500851 | 7,62048 | 361,9 | 30,625178 | 30,625178 | 18,9156 |
| -0,862 | 2,738 | 307,26 | | 4100 | 146,8841816 | 24,4236 | 171,3 | 36,946395 | 36,946395 | 31,089 |
| -0,862 | 2,738 | | 307,3 | 4100 | 146,8841816 | 38,2026 | 185,1 | 51,220139 | 51,220139 | 43,0999 |
| 0,8628 | 2,738 | 307,26 | | 4100 | 146,8841816 | 24,4241 | 171,3 | 36,94692 | 36,94692 | 31,0895 |
| 0,8628 | 2,738 | | 307,3 | 4100 | 146,8841816 | 38,2021 | 185,1 | 51,219614 | 51,219614 | 43,0994 |

b. Penulangan geser balok

$$\begin{aligned} V_{u,b} \text{ terpakai} &= \frac{Ln-d}{Ln} \cdot V_{u,b} \\ &= \frac{6,5-0,65}{6,5} \cdot 250,20 \\ &= 225,18 \text{ kN.} \end{aligned}$$

1) *Daerah sendi plastis*

$$V_c = 0$$

$$V_s = V_{u,b} / \phi \quad \text{dengan } \phi = 0,6$$

$$\begin{aligned} V_s &= 225,18 / 0,6 \\ &= 375,3 \text{ kN.} \end{aligned}$$

Pada lokasi yang berpotensi terjadi sendi plastis, spasi maksimum tidak boleh melebihi nilai berikut:

| | | |
|--|---------|-------------|
| - d/4 | = 650/4 | = 162,5 mm |
| - 8.d1 | = 8.25 | = 200 mm |
| - 24. ϕ sengkang | = 24.10 | = 240 mm |
| - $1600 \cdot f_y \cdot A_s / (A_s \cdot l \cdot f_y)$ | | |
| = $1600 \cdot 240 \cdot 78,5 / (490 \cdot 400)$ | | = 153,80 mm |

$$S = \frac{A_v \cdot f_y \cdot d}{V_s}$$

Digunakan sengkang 2 ϕ 10 mm dengan mutu baja $f_y = 240$ Mpa

$$A_v = 4 \cdot 78,5 = 314 \text{ mm}^2$$

$$S = \frac{314 \cdot 240 \cdot 650}{375,3 \cdot 10^3}$$

$$= 113,5 \text{ mm} < 153,80 \text{ mm.}$$

Digunakan sengkang 2 ϕ 10 - 100 mm < 153,8 mm, sehingga aman terhadap penggeseran.

2) *Di luar daerah sendi plastis*

$$V_{u,b} = \frac{Ln-2h}{Ln} \cdot V_{u,b}$$

$$= \frac{6,5 - 2,0,7}{6,5} \cdot 250,20$$

$$= 196,31 \text{ kN.}$$

$$V_c = (\sqrt{f_c'} / 6) b w \cdot d$$

$$= (\sqrt{22,5} / 6) 400 \cdot 650$$

$$= 205548,05 \text{ N}$$

$$= 205,55 \text{ kN}$$

$$V_s = V_{ub} / \phi - V_c \quad \text{dengan } \phi = 0,6$$

$$V_s = 196,31 / 0,6 - 205,55$$

$$= 121,63 \text{ kN.}$$

Pada lokasi di luar daerah sendi plastis, spasi maksimum tidak boleh melebihi nilai berikut:

$$- d/2 = 650/2 = 325 \text{ mm}$$

$$- 600 \text{ mm}$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s}$$

Digunakan sengkang $2 \phi 10$ mm dengan mutu baja $f_y = 240 \text{ Mpa}$

$$A_v = 2 \cdot 78,5 = 157 \text{ mm}^2.$$

$$S = \frac{157 \cdot 240 \cdot 650}{121,63 \cdot 10^3}$$

$$= 201,35 \text{ mm} < 325 \text{ mm}$$

digunakan sengkang $\phi 10 - 150 \text{ mm} > 325 \text{ mm}$, sehingga aman terhadap penggeseran.

Uraian lebih lanjut...

Tabel 6.25. Penulangan geser balok portal As - A & F

| Lantai | Elemen | diameter tulangan (mm) | Daerah sendi plastis | | | | | | | | Daerah di luar sendi plastis | | | | | | | | |
|--------|--------|------------------------|----------------------|--------|--------------------|---------|--------------------|---------|-----------------|-------------------|------------------------------|---------|---------|-------------|-------------|-----------------------|------------|-----------------|-------------------|
| | | | n | tul | Vu,b terpakai (kN) | Vc (kN) | Vs = Vu,b/0,6 (kN) | S (mm) | S terpakai (mm) | Vs terpasang (kN) | cek Vu,b/0,6 < Vc+Vs | n | tul | Vu,bt (kN) | Vc (kN) | Vs = Vu,b/0,6 Vc (kN) | S (mm) | S terpakai (mm) | Vs Terpasang (kN) |
| Sloof | 29 | 10 | 1 | 88,90 | 0 | 148,17 | 114,54 | 100 | 339,428571 | OK | 1 | 80,8199 | 106,727 | 27,9729537 | 606,708 | 200 | 84,8571429 | 191,584 | OK |
| | 30 | 10 | 1 | 88,54 | 0 | 147,564 | 115,011 | 100 | 339,428571 | OK | 1 | 80,4894 | 106,727 | 27,42210547 | 618,896 | 200 | 84,8571429 | 191,584 | OK |
| | 31 | 10 | 1 | 89,27 | 0 | 148,782 | 114,069 | 100 | 339,428571 | OK | 1 | 81,1538 | 106,727 | 28,52953339 | 594,872 | 200 | 84,8571429 | 191,584 | OK |
| | 68 | 10 | 1 | 89,27 | 0 | 148,776 | 114,074 | 100 | 339,428571 | OK | 1 | 81,1504 | 106,727 | 28,52385908 | 594,991 | 200 | 84,8571429 | 191,584 | OK |
| | 69 | 10 | 1 | 88,54 | 0 | 147,566 | 115,009 | 100 | 339,428571 | OK | 1 | 80,4903 | 106,727 | 27,42361585 | 618,862 | 200 | 84,8571429 | 191,584 | OK |
| | 70 | 10 | 1 | 88,90 | 0 | 148,171 | 114,54 | 100 | 339,428571 | OK | 1 | 80,8203 | 106,727 | 27,97371185 | 606,692 | 200 | 84,8571429 | 191,584 | OK |
| | 1 | 99 | 10 | 2 | 228,51 | 0 | 380,85 | 128,735 | 100 | 490,285714 | OK | 1 | 199,214 | 205,548 | 126,4746942 | 193,828 | 150 | 163,428571 | 368,9766 |
| 100 | | 10 | 2 | 218,21 | 0 | 363,69 | 134,809 | 100 | 490,285714 | OK | 1 | 190,238 | 205,548 | 111,5151722 | 219,829 | 150 | 163,428571 | 368,9766 | OK |
| 101 | | 10 | 2 | 228,54 | 0 | 380,902 | 128,717 | 100 | 490,285714 | OK | 1 | 199,241 | 205,548 | 126,5206786 | 193,757 | 150 | 163,428571 | 368,9766 | OK |
| 138 | | 10 | 2 | 228,65 | 0 | 381,077 | 128,658 | 100 | 490,285714 | OK | 1 | 199,333 | 205,548 | 126,6728567 | 193,524 | 150 | 163,428571 | 368,9766 | OK |
| 139 | | 10 | 2 | 218,06 | 0 | 363,433 | 134,904 | 100 | 490,285714 | OK | 1 | 190,103 | 205,548 | 111,2910037 | 220,272 | 150 | 163,428571 | 368,9766 | OK |
| 140 | | 10 | 2 | 228,71 | 0 | 381,191 | 128,619 | 100 | 490,285714 | OK | 1 | 199,392 | 205,548 | 126,7724185 | 193,372 | 150 | 163,428571 | 368,9766 | OK |
| 2 | | 169 | 10 | 2 | 222,95 | 0 | 371,587 | 131,944 | 100 | 490,285714 | OK | 1 | 194,369 | 205,548 | 118,3995877 | 207,047 | 150 | 163,428571 | 368,9766 |
| | 170 | 10 | 2 | 213,09 | 0 | 355,152 | 138,049 | 100 | 490,285714 | OK | 1 | 185,772 | 205,548 | 104,0719007 | 235,551 | 150 | 163,428571 | 368,9766 | OK |
| | 171 | 10 | 2 | 223,06 | 0 | 371,769 | 131,883 | 100 | 490,285714 | OK | 1 | 194,458 | 205,548 | 118,5492805 | 206,786 | 150 | 163,428571 | 368,9766 | OK |
| | 208 | 10 | 2 | 222,95 | 0 | 371,587 | 131,944 | 100 | 490,285714 | OK | 1 | 194,369 | 205,548 | 118,3995877 | 207,047 | 150 | 163,428571 | 368,9766 | OK |
| | 209 | 10 | 2 | 213,24 | 0 | 355,406 | 137,951 | 100 | 490,285714 | OK | 1 | 185,905 | 205,548 | 104,293021 | 235,052 | 150 | 163,428571 | 368,9766 | OK |
| | 210 | 10 | 2 | 217,65 | 0 | 362,745 | 135,16 | 100 | 490,285714 | OK | 1 | 189,743 | 205,548 | 110,690818 | 221,466 | 150 | 163,428571 | 368,9766 | OK |
| | 3 | 239 | 10 | 2 | 188,08 | 0 | 313,475 | 156,403 | 100 | 490,285714 | OK | 1 | 163,972 | 205,548 | 67,73780005 | 361,9 | 150 | 163,428571 | 368,9766 |
| 240 | | 10 | 2 | 188,11 | 0 | 313,524 | 156,379 | 100 | 490,285714 | OK | 1 | 163,997 | 205,548 | 67,73808482 | 361,67 | 150 | 163,428571 | 368,9766 | OK |
| 241 | | 10 | 2 | 197,07 | 0 | 328,455 | 149,27 | 100 | 490,285714 | OK | 1 | 171,807 | 205,548 | 80,79699736 | 303,406 | 150 | 163,428571 | 368,9766 | OK |
| 278 | | 10 | 2 | 195,27 | 0 | 327,123 | 149,878 | 100 | 490,285714 | OK | 1 | 171,111 | 205,548 | 79,63625305 | 307,828 | 150 | 163,428571 | 368,9766 | OK |
| 279 | | 10 | 2 | 188,27 | 0 | 313,777 | 156,253 | 100 | 490,285714 | OK | 1 | 164,129 | 205,548 | 68,00074428 | 360,5 | 150 | 163,428571 | 368,9766 | OK |
| 280 | | 10 | 2 | 188,59 | 0 | 314,311 | 155,987 | 100 | 490,285714 | OK | 1 | 164,409 | 205,548 | 68,46678032 | 358,046 | 150 | 163,428571 | 368,9766 | OK |
| 4 | | 309 | 10 | 2 | 165,51 | 0 | 275,851 | 177,736 | 100 | 490,285714 | OK | 1 | 144,291 | 205,548 | 34,93734032 | 701,664 | 150 | 163,428571 | 368,9766 |
| | 310 | 10 | 2 | 164,78 | 0 | 274,627 | 178,528 | 100 | 490,285714 | OK | 1 | 143,651 | 205,548 | 33,87069297 | 723,761 | 150 | 163,428571 | 368,9766 | OK |
| | 311 | 10 | 2 | 170,61 | 0 | 284,355 | 172,421 | 100 | 490,285714 | OK | 1 | 148,739 | 205,548 | 42,35080232 | 578,839 | 150 | 163,428571 | 368,9766 | OK |
| | 348 | 10 | 2 | 173,51 | 0 | 289,181 | 169,543 | 100 | 490,285714 | OK | 1 | 151,264 | 205,548 | 46,55815717 | 526,53 | 150 | 163,428571 | 368,9766 | OK |
| | 349 | 10 | 2 | 164,93 | 0 | 274,876 | 178,366 | 100 | 490,285714 | OK | 1 | 143,781 | 205,548 | 34,08755674 | 719,156 | 150 | 163,428571 | 368,9766 | OK |
| | 350 | 10 | 2 | 162,32 | 0 | 270,535 | 181,228 | 100 | 490,285714 | OK | 1 | 141,511 | 205,548 | 30,30313705 | 808,969 | 150 | 163,428571 | 368,9766 | OK |
| | Ring | 375 | 10 | 1 | 57,91 | 0 | 96,5101 | 175,851 | 100 | 339,428571 | OK | 1 | 52,6419 | 106,727 | -18,9904486 | -893,682 | 200 | 84,8571429 | 191,584 |
| 376 | | 10 | 1 | 57,85 | 0 | 96,416 | 176,023 | 100 | 339,428571 | OK | 1 | 52,5905 | 106,727 | -19,0759911 | -889,675 | 200 | 84,8571429 | 191,584 | OK |
| 377 | | 10 | 1 | 58,00 | 0 | 96,664 | 175,571 | 100 | 339,428571 | OK | 1 | 52,7258 | 106,727 | -18,8504981 | -900,317 | 200 | 84,8571429 | 191,584 | OK |
| 402 | | 10 | 1 | 60,26 | 0 | 100,441 | 168,969 | 100 | 339,428571 | OK | 1 | 54,7859 | 106,727 | -15,4169704 | -1100,83 | 200 | 84,8571429 | 191,584 | OK |

| | | | | | | | | | | | | | | | | | | |
|-----|----|---|-------|---|---------|---------|-----|-----------|----|---|---------|---------|-------------|----------|-----|-----------|---------|----|
| 403 | 10 | 1 | 57,85 | 0 | 96,4088 | 176,036 | 100 | 339,42857 | OK | 1 | 52,5866 | 106,727 | -19,0824769 | -889,372 | 200 | 84,857143 | 191,584 | OK |
| 404 | 10 | 1 | 55,85 | 0 | 92,753 | 182,974 | 100 | 339,42857 | OK | 1 | 50,5926 | 106,727 | -22,4059405 | -757,452 | 200 | 84,857143 | 191,584 | OK |

Tabel 6.26. Penulangan geser balok portal As - B & E

| Lantai | Elemen | diameter tulangan (mm) | Daerah sendi plastis | | | | | | | Daerah di luar sendi plastis | | | | | | | | | |
|--------|--------|------------------------|----------------------|--------------------|---------|--------------------|---------|-----------------|-------------------|------------------------------|-------|------------|---------|----------------------|----------|-----------------|-------------------|----------------|----------------------|
| | | | n tul | Vu,b terpakai (kN) | Vc (kN) | Vs = Vu,b/0,6 (kN) | S (mm) | S terpakai (mm) | Vs terpasang (kN) | cek Vu,b/0,6 < Vc+Vs | n tul | Vu,bt (kN) | Vc (kN) | Vs = Vub/0,6 Vc (kN) | S (mm) | S terpakai (mm) | Vs Terpasang (kN) | Vs t + Vc (kN) | cek Vu,b/0,6 < Vs+Vc |
| Sloof | 34 | 10 | 1 | 127,43 | 0 | 212,376 | 115,429 | 100 | 490,285714 | OK | 1 | 84,9503 | 102,774 | 38,80986903 | 631,651 | 200 | 122,571429 | 225,3455 | OK |
| | 37 | 10 | 1 | 125,03 | 0 | 208,384 | 117,64 | 100 | 490,285714 | OK | 1 | 83,3536 | 102,774 | 36,14867119 | 678,152 | 200 | 122,571429 | 225,3455 | OK |
| | 62 | 10 | 1 | 127,43 | 0 | 212,376 | 115,429 | 100 | 490,285714 | OK | 1 | 84,9503 | 102,774 | 38,80986903 | 631,651 | 200 | 122,571429 | 225,3455 | OK |
| | 65 | 10 | 1 | 125,03 | 0 | 208,384 | 117,64 | 100 | 490,285714 | OK | 1 | 83,3536 | 102,774 | 36,14867119 | 678,152 | 200 | 122,571429 | 225,3455 | OK |
| 1 | 104 | 10 | 2 | 228,64 | 0 | 381,059 | 64,3321 | 100 | 490,285714 | OK | 1 | 152,423 | 102,774 | 151,2649798 | 162,082 | 200 | 122,571429 | 225,3455 | OK |
| | 107 | 10 | 2 | 187,39 | 0 | 312,315 | 78,4922 | 100 | 490,285714 | OK | 1 | 124,926 | 102,774 | 105,4358111 | 232,504 | 200 | 122,571429 | 225,3455 | OK |
| | 132 | 10 | 2 | 203,17 | 0 | 338,62 | 72,3946 | 100 | 490,285714 | OK | 1 | 135,448 | 102,774 | 122,9727746 | 199,347 | 200 | 122,571429 | 225,3455 | OK |
| | 135 | 10 | 2 | 187,39 | 0 | 312,315 | 78,4922 | 100 | 490,285714 | OK | 1 | 124,926 | 102,774 | 105,4358111 | 232,504 | 200 | 122,571429 | 225,3455 | OK |
| 2 | 174 | 10 | 2 | 208,38 | 0 | 347,296 | 70,5862 | 100 | 490,285714 | OK | 1 | 138,918 | 102,774 | 128,7563212 | 190,393 | 200 | 122,571429 | 225,3455 | OK |
| | 177 | 10 | 2 | 182,20 | 0 | 303,661 | 80,7291 | 100 | 490,285714 | OK | 1 | 121,464 | 102,774 | 99,6665846 | 245,963 | 200 | 122,571429 | 225,3455 | OK |
| | 202 | 10 | 2 | 208,38 | 0 | 347,296 | 70,5862 | 100 | 490,285714 | OK | 1 | 138,918 | 102,774 | 128,7563212 | 190,393 | 200 | 122,571429 | 225,3455 | OK |
| | 205 | 10 | 2 | 182,20 | 0 | 303,661 | 80,7291 | 100 | 490,285714 | OK | 1 | 121,464 | 102,774 | 99,6665846 | 245,963 | 200 | 122,571429 | 225,3455 | OK |
| 3 | 244 | 10 | 2 | 211,77 | 0 | 352,954 | 69,4546 | 100 | 490,285714 | OK | 1 | 141,182 | 102,774 | 132,528657 | 184,973 | 200 | 122,571429 | 225,3455 | OK |
| | 247 | 10 | 2 | 179,86 | 0 | 299,774 | 81,776 | 100 | 490,285714 | OK | 1 | 119,91 | 102,774 | 97,07515343 | 252,529 | 200 | 122,571429 | 225,3455 | OK |
| | 272 | 10 | 2 | 211,77 | 0 | 352,954 | 69,4546 | 100 | 490,285714 | OK | 1 | 141,182 | 102,774 | 132,528657 | 184,973 | 200 | 122,571429 | 225,3455 | OK |
| | 275 | 10 | 2 | 179,86 | 0 | 299,774 | 81,776 | 100 | 490,285714 | OK | 1 | 119,91 | 102,774 | 97,07515343 | 252,529 | 200 | 122,571429 | 225,3455 | OK |
| 4 | 314 | 10 | 2 | 142,38 | 0 | 237,305 | 103,303 | 100 | 490,285714 | OK | 1 | 94,9218 | 102,774 | 55,42900354 | 442,265 | 200 | 122,571429 | 225,3455 | OK |
| | 317 | 10 | 2 | 142,21 | 0 | 237,01 | 103,432 | 100 | 490,285714 | OK | 1 | 94,8039 | 102,774 | 55,23254492 | 443,838 | 200 | 122,571429 | 225,3455 | OK |
| | 342 | 10 | 2 | 142,38 | 0 | 237,305 | 103,303 | 100 | 490,285714 | OK | 1 | 94,9218 | 102,774 | 55,42900354 | 442,265 | 200 | 122,571429 | 225,3455 | OK |
| | 345 | 10 | 2 | 142,21 | 0 | 237,01 | 103,432 | 100 | 490,285714 | OK | 1 | 94,8039 | 102,774 | 55,23254492 | 443,838 | 200 | 122,571429 | 225,3455 | OK |
| Ring | 380 | 10 | 1 | 26,74 | 0 | 44,5688 | 550,033 | 100 | 490,285714 | OK | 1 | 17,8275 | 102,774 | -73,0615077 | -335,529 | 200 | 122,571429 | 225,3455 | OK |
| | 381 | 10 | 1 | 26,69 | 0 | 44,4849 | 551,069 | 100 | 490,285714 | OK | 1 | 17,794 | 102,774 | -73,1173931 | -335,273 | 200 | 122,571429 | 225,3455 | OK |
| | 398 | 10 | 1 | 26,74 | 0 | 44,5688 | 550,033 | 100 | 490,285714 | OK | 1 | 17,8275 | 102,774 | -73,0615077 | -335,529 | 200 | 122,571429 | 225,3455 | OK |
| | 399 | 10 | 1 | 26,69 | 0 | 44,4849 | 551,069 | 100 | 490,285714 | OK | 1 | 17,794 | 102,774 | -73,1173931 | -335,273 | 200 | 122,571429 | 225,3455 | OK |

Tabel 6.27. Penulangan geser balok portal As - C & D

| Lantai | Elemen | diameter tulangan (mm) | Daerah sendi plastis | | | | | | | Daerah di luar sendi plastis | | | | | | | | | |
|--------|--------|------------------------|----------------------|--------------------|---------|--------------------|---------|-----------------|-------------------|------------------------------|---------|------------|-------------|----------------------|----------|-----------------|-------------------|----------------|----------------------|
| | | | n tul | Vu,b terpakai (kN) | Vc (kN) | Vs = Vu,b/0,6 (kN) | S (mm) | S terpakai (mm) | Vs terpasang (kN) | cek Vu,b/0,6 < Vc+Vs | n tul | Vu,bt (kN) | Vc (kN) | Vs = Vub/0,6 Vc (kN) | S (mm) | S terpakai (mm) | Vs Terpasang (kN) | Vs t + Vc (kN) | cek Vu,b/0,6 < Vs+Vc |
| Sloof | 42 | 10 | 1 | 122,27 | 0 | 203,778 | 83,2841 | 100 | 339,428571 | OK | 1 | 94,8189 | 106,727 | 51,30470388 | 330,797 | 200 | 84,8571429 | 191,584 | OK |
| | 43 | 10 | 1 | 61,19 | 0 | 101,981 | 166,418 | 100 | 339,428571 | OK | 1 | 55,6259 | 106,727 | -14,0170749 | -1210,77 | 200 | 84,8571429 | 191,584 | OK |
| | 44 | 10 | 1 | 61,69 | 0 | 102,815 | 165,068 | 100 | 339,428571 | OK | 1 | 58,0809 | 106,727 | -13,2586293 | -1280,03 | 200 | 84,8571429 | 191,584 | OK |
| | 45 | 10 | 1 | 61,44 | 0 | 102,396 | 165,743 | 100 | 339,428571 | OK | 1 | 55,8524 | 106,727 | -13,6396209 | -1244,27 | 200 | 84,8571429 | 191,584 | OK |
| | 46 | 10 | 1 | 122,26 | 0 | 203,77 | 83,2873 | 100 | 339,428571 | OK | 1 | 94,8153 | 106,727 | 51,29861569 | 330,836 | 200 | 84,8571429 | 191,584 | OK |
| | 53 | 10 | 1 | 126,41 | 0 | 210,676 | 80,5571 | 100 | 339,428571 | OK | 1 | 98,0287 | 106,727 | 56,65437664 | 299,561 | 200 | 84,8571429 | 191,584 | OK |
| | 54 | 10 | 1 | 61,44 | 0 | 102,399 | 165,738 | 100 | 339,428571 | OK | 1 | 55,8541 | 106,727 | -13,6367689 | -1244,53 | 200 | 84,8571429 | 191,584 | OK |
| | 55 | 10 | 1 | 61,69 | 0 | 102,813 | 165,07 | 100 | 339,428571 | OK | 1 | 58,08 | 106,727 | -13,2601989 | -1279,88 | 200 | 84,8571429 | 191,584 | OK |
| | 56 | 10 | 1 | 61,19 | 0 | 101,984 | 166,413 | 100 | 339,428571 | OK | 1 | 55,6276 | 106,727 | -14,014137 | -1211,02 | 200 | 84,8571429 | 191,584 | OK |
| 57 | 10 | 1 | 126,41 | 0 | 210,684 | 80,5539 | 100 | 339,428571 | OK | 1 | 98,0326 | 106,727 | 56,66074 | 299,527 | 200 | 84,8571429 | 191,584 | OK | |
| 1 | 112 | 10 | 2 | 265,19 | 0 | 441,989 | 110,927 | 100 | 490,285714 | OK | 1 | 176,796 | 205,548 | 89,11131407 | 275,097 | 150 | 163,428571 | 368,9766 | OK |
| | 113 | 10 | 2 | 225,31 | 0 | 375,523 | 130,561 | 100 | 490,285714 | OK | 1 | 196,427 | 205,548 | 121,8306597 | 201,216 | 150 | 163,428571 | 368,9766 | OK |
| | 114 | 10 | 2 | 225,97 | 0 | 376,608 | 130,185 | 100 | 490,285714 | OK | 1 | 196,995 | 205,548 | 122,7771766 | 199,665 | 150 | 163,428571 | 368,9766 | OK |
| | 115 | 10 | 2 | 223,96 | 0 | 373,265 | 131,35 | 100 | 490,285714 | OK | 1 | 195,246 | 205,548 | 119,8627659 | 204,52 | 150 | 163,428571 | 368,9766 | OK |
| | 116 | 10 | 2 | 265,16 | 0 | 441,936 | 110,94 | 100 | 490,285714 | OK | 1 | 176,775 | 205,548 | 89,0762658 | 275,206 | 150 | 163,428571 | 368,9766 | OK |
| | 123 | 10 | 2 | 293,07 | 0 | 488,458 | 100,374 | 100 | 490,285714 | OK | 1 | 195,383 | 205,548 | 120,0904435 | 204,132 | 150 | 163,428571 | 368,9766 | OK |
| | 124 | 10 | 2 | 223,80 | 0 | 373,004 | 131,443 | 100 | 490,285714 | OK | 1 | 195,11 | 205,548 | 119,6347527 | 204,909 | 150 | 163,428571 | 368,9766 | OK |
| | 125 | 10 | 2 | 226,12 | 0 | 376,865 | 130,096 | 100 | 490,285714 | OK | 1 | 197,13 | 205,548 | 123,0012353 | 199,301 | 150 | 163,428571 | 368,9766 | OK |
| | 126 | 10 | 2 | 225,16 | 0 | 375,262 | 130,651 | 100 | 490,285714 | OK | 1 | 196,291 | 205,548 | 121,6037451 | 201,592 | 150 | 163,428571 | 368,9766 | OK |
| 127 | 10 | 2 | 293,11 | 0 | 488,512 | 100,363 | 100 | 490,285714 | OK | 1 | 195,405 | 205,548 | 120,1265055 | 204,071 | 150 | 163,428571 | 368,9766 | OK | |
| 2 | 182 | 10 | 2 | 235,71 | 0 | 392,85 | 124,802 | 100 | 490,285714 | OK | 1 | 157,14 | 205,548 | 56,35188795 | 435,022 | 150 | 163,428571 | 368,9766 | OK |
| | 183 | 10 | 2 | 220,20 | 0 | 367,005 | 133,591 | 100 | 490,285714 | OK | 1 | 191,972 | 205,548 | 114,4054442 | 214,276 | 150 | 163,428571 | 368,9766 | OK |
| | 184 | 10 | 2 | 219,71 | 0 | 366,181 | 133,892 | 100 | 490,285714 | OK | 1 | 191,541 | 205,548 | 113,6867071 | 215,63 | 150 | 163,428571 | 368,9766 | OK |
| | 185 | 10 | 2 | 221,62 | 0 | 369,375 | 132,734 | 100 | 490,285714 | OK | 1 | 193,211 | 205,548 | 116,4709226 | 210,476 | 150 | 163,428571 | 368,9766 | OK |
| | 186 | 10 | 2 | 235,68 | 0 | 392,793 | 124,82 | 100 | 490,285714 | OK | 1 | 157,117 | 205,548 | 56,31392502 | 435,315 | 150 | 163,428571 | 368,9766 | OK |
| | 193 | 10 | 2 | 263,19 | 0 | 438,643 | 111,773 | 100 | 490,285714 | OK | 1 | 175,457 | 205,548 | 86,88039899 | 282,161 | 150 | 163,428571 | 368,9766 | OK |
| | 194 | 10 | 2 | 221,47 | 0 | 369,123 | 132,824 | 100 | 490,285714 | OK | 1 | 193,08 | 205,548 | 116,2517521 | 210,872 | 150 | 163,428571 | 368,9766 | OK |
| | 195 | 10 | 2 | 219,86 | 0 | 366,435 | 133,799 | 100 | 490,285714 | OK | 1 | 191,673 | 205,548 | 113,9077587 | 215,212 | 150 | 163,428571 | 368,9766 | OK |
| | 196 | 10 | 2 | 220,05 | 0 | 366,752 | 133,683 | 100 | 490,285714 | OK | 1 | 191,84 | 205,548 | 114,1848457 | 214,689 | 150 | 163,428571 | 368,9766 | OK |
| 197 | 10 | 2 | 263,22 | 0 | 438,702 | 111,758 | 100 | 490,285714 | OK | 1 | 175,481 | 205,548 | 86,92002743 | 282,033 | 150 | 163,428571 | 368,9766 | OK | |
| 252 | 10 | 2 | 165,82 | 0 | 276,369 | 177,403 | 100 | 490,285714 | OK | 1 | 110,547 | 205,548 | -21,3022442 | -1150,78 | 150 | 163,428571 | 368,9766 | OK | |
| 253 | 10 | 2 | 197,96 | 0 | 329,927 | 148,604 | 100 | 490,285714 | OK | 1 | 172,577 | 205,548 | 82,08072817 | 298,661 | 150 | 163,428571 | 368,9766 | OK | |
| 254 | 10 | 2 | 196,54 | 0 | 327,575 | 149,671 | 100 | 490,285714 | OK | 1 | 171,347 | 205,548 | 80,02994167 | 306,314 | 150 | 163,428571 | 368,9766 | OK | |

| | | | | | | | | | | | | | | | | | | | |
|------|-----|----|---|--------|---|---------|---------|-----|-----------|----|---|---------|---------|-------------|----------|-----|-----------|----------|----|
| 3 | 255 | 10 | 2 | 200,68 | 0 | 334,464 | 146,588 | 100 | 490,28571 | OK | 1 | 174,95 | 205,548 | 86,03599982 | 284,931 | 150 | 163,42857 | 368,9766 | OK |
| | 256 | 10 | 2 | 165,79 | 0 | 276,318 | 177,435 | 100 | 490,28571 | OK | 1 | 110,527 | 205,548 | -21,3362244 | -1148,95 | 150 | 163,42857 | 368,9766 | OK |
| | 263 | 10 | 2 | 194,62 | 0 | 324,362 | 151,154 | 100 | 490,28571 | OK | 1 | 129,745 | 205,548 | 10,69360015 | 2292,43 | 150 | 163,42857 | 368,9766 | OK |
| | 264 | 10 | 2 | 200,53 | 0 | 334,208 | 146,701 | 100 | 490,28571 | OK | 1 | 174,817 | 205,548 | 85,8131357 | 285,671 | 150 | 163,42857 | 368,9766 | OK |
| | 265 | 10 | 2 | 196,70 | 0 | 327,828 | 149,556 | 100 | 490,28571 | OK | 1 | 171,479 | 205,548 | 80,25092467 | 305,47 | 150 | 163,42857 | 368,9766 | OK |
| | 266 | 10 | 2 | 197,81 | 0 | 329,685 | 148,713 | 100 | 490,28571 | OK | 1 | 172,451 | 205,548 | 81,86996086 | 299,43 | 150 | 163,42857 | 368,9766 | OK |
| | 267 | 10 | 2 | 194,65 | 0 | 324,417 | 151,128 | 100 | 490,28571 | OK | 1 | 129,767 | 205,548 | 10,72982515 | 2284,69 | 150 | 163,42857 | 368,9766 | OK |
| 4 | 322 | 10 | 2 | 79,98 | 0 | 133,308 | 367,784 | 100 | 490,28571 | OK | 1 | 53,3232 | 205,548 | -116,675989 | -210,106 | 150 | 163,42857 | 368,9766 | OK |
| | 323 | 10 | 2 | 164,57 | 0 | 274,282 | 178,752 | 100 | 490,28571 | OK | 1 | 143,471 | 205,548 | 33,56963213 | 730,252 | 150 | 163,42857 | 368,9766 | OK |
| | 324 | 10 | 2 | 158,09 | 0 | 263,476 | 186,084 | 100 | 490,28571 | OK | 1 | 137,818 | 205,548 | 24,14899255 | 1015,13 | 150 | 163,42857 | 368,9766 | OK |
| | 325 | 10 | 2 | 165,54 | 0 | 275,896 | 177,707 | 100 | 490,28571 | OK | 1 | 144,315 | 205,548 | 34,97666524 | 700,875 | 150 | 163,42857 | 368,9766 | OK |
| | 326 | 10 | 2 | 113,08 | 0 | 188,474 | 260,135 | 100 | 490,28571 | OK | 1 | 75,3894 | 205,548 | -79,8989697 | -306,816 | 150 | 163,42857 | 368,9766 | OK |
| | 333 | 10 | 2 | 113,06 | 0 | 188,44 | 260,182 | 100 | 490,28571 | OK | 1 | 75,3759 | 205,548 | -79,9216171 | -306,729 | 150 | 163,42857 | 368,9766 | OK |
| | 334 | 10 | 2 | 165,40 | 0 | 275,672 | 177,851 | 100 | 490,28571 | OK | 1 | 144,198 | 205,548 | 34,78153728 | 704,807 | 150 | 163,42857 | 368,9766 | OK |
| | 335 | 10 | 2 | 158,23 | 0 | 263,719 | 185,912 | 100 | 490,28571 | OK | 1 | 137,945 | 205,548 | 24,36099563 | 1006,29 | 150 | 163,42857 | 368,9766 | OK |
| | 336 | 10 | 2 | 164,41 | 0 | 274,015 | 178,926 | 100 | 490,28571 | OK | 1 | 143,331 | 205,548 | 33,33715647 | 735,344 | 150 | 163,42857 | 368,9766 | OK |
| | 337 | 10 | 2 | 79,97 | 0 | 133,279 | 367,864 | 100 | 490,28571 | OK | 1 | 53,3116 | 205,548 | -116,695305 | -210,071 | 200 | 122,57143 | 328,1195 | OK |
| Ring | 386 | 10 | 1 | 25,11 | 0 | 41,8551 | 405,48 | 100 | 339,42857 | OK | 1 | 19,4754 | 106,727 | -74,2677957 | -228,517 | 200 | 84,857143 | 191,584 | OK |
| | 387 | 10 | 1 | 25,11 | 0 | 41,8544 | 405,488 | 100 | 339,42857 | OK | 1 | 19,4751 | 106,727 | -74,2683712 | -228,515 | 200 | 84,857143 | 191,584 | OK |
| | 392 | 10 | 1 | 25,11 | 0 | 41,8551 | 405,48 | 100 | 339,42857 | OK | 1 | 19,4754 | 106,727 | -74,2677957 | -228,517 | 200 | 84,857143 | 191,584 | OK |
| | 393 | 10 | 1 | 25,11 | 0 | 41,8544 | 405,488 | 100 | 339,42857 | OK | 1 | 19,4751 | 106,727 | -74,2683712 | -228,515 | 200 | 84,857143 | 191,584 | OK |

Tabel 6.28. Penulangan geser balok portal As - 1 & 6

| Lantai | Elemen | diameter tulangan (mm) | Daerah sendi plastis | | | | | | | Daerah di luar sendi plastis | | | | | | | | | |
|--------|--------|------------------------|----------------------|--------------------|---------|--------------------|---------|-----------------|-------------------|------------------------------|-------|------------|---------|----------------------|----------|-----------------|-------------------|----------------|----------------------|
| | | | n tul | Vu,b terpakai (kN) | Vc (kN) | Vs = Vu,b/0,6 (kN) | S (mm) | S terpakai (mm) | Vs terpasang (kN) | cek Vu,b/0,6 < Vc+Vs | n tul | Vu,bt (kN) | Vc (kN) | Vs = Vub/0,6 Vc (kN) | S (mm) | S terpakai (mm) | Vs Terpasang (kN) | Vs t + Vc (kN) | cek Vu,b/0,6 < Vs+Vc |
| Sloof | 38 | 10 | 1 | 88,42 | 0 | 147,371 | 166,344 | 100 | 490,285714 | OK | 1 | 69,2002 | 102,774 | 12,55971445 | 1951,82 | 200 | 122,571429 | 225,3455 | OK |
| | 41 | 10 | 1 | 83,59 | 0 | 139,32 | 175,957 | 100 | 490,285714 | OK | 1 | 65,4199 | 102,774 | 6,259076765 | 3916,6 | 200 | 122,571429 | 225,3455 | OK |
| | 47 | 10 | 1 | 50,24 | 0 | 83,734 | 292,764 | 100 | 490,285714 | OK | 1 | 14,3544 | 102,774 | -78,850021 | -310,898 | 200 | 122,571429 | 225,3455 | OK |
| | 52 | 10 | 1 | 50,24 | 0 | 83,734 | 292,764 | 100 | 490,285714 | OK | 1 | 14,3544 | 102,774 | -78,850021 | -310,898 | 200 | 122,571429 | 225,3455 | OK |
| | 58 | 10 | 1 | 83,59 | 0 | 139,319 | 175,958 | 100 | 490,285714 | OK | 1 | 65,4194 | 102,774 | 6,258316155 | 3917,07 | 200 | 122,571429 | 225,3455 | OK |
| | 61 | 10 | 1 | 88,42 | 0 | 147,37 | 166,345 | 100 | 490,285714 | OK | 1 | 69,1998 | 102,774 | 12,55895384 | 1951,94 | 200 | 122,571429 | 225,3455 | OK |
| 1 | 108 | 10 | 1 | 211,22 | 0 | 352,039 | 69,6351 | 100 | 490,285714 | OK | 1 | 165,305 | 102,774 | 172,7350645 | 141,918 | 200 | 122,571429 | 225,3455 | OK |
| | 111 | 10 | 1 | 173,80 | 0 | 289,669 | 84,6286 | 100 | 490,285714 | OK | 1 | 136,018 | 102,774 | 123,9233928 | 197,818 | 200 | 122,571429 | 225,3455 | OK |
| | 117 | 10 | 1 | 27,60 | 0 | 45,996 | 532,966 | 100 | 490,285714 | OK | 1 | 7,88503 | 102,774 | -89,6323154 | -273,498 | 200 | 122,571429 | 225,3455 | OK |
| | 122 | 10 | 1 | 27,60 | 0 | 45,996 | 532,966 | 100 | 490,285714 | OK | 1 | 7,88503 | 102,774 | -89,6323154 | -273,498 | 200 | 122,571429 | 225,3455 | OK |
| | 128 | 10 | 1 | 193,33 | 0 | 322,223 | 76,0787 | 100 | 490,285714 | OK | 1 | 151,304 | 102,774 | 149,4001421 | 164,085 | 200 | 122,571429 | 225,3455 | OK |
| | 131 | 10 | 1 | 211,22 | 0 | 352,038 | 69,6354 | 100 | 490,285714 | OK | 1 | 165,305 | 102,774 | 172,7336931 | 141,92 | 200 | 122,571429 | 225,3455 | OK |
| 2 | 178 | 10 | 1 | 215,00 | 0 | 358,329 | 68,4127 | 100 | 490,285714 | OK | 1 | 168,259 | 102,774 | 177,657712 | 137,986 | 200 | 122,571429 | 225,3455 | OK |
| | 181 | 10 | 1 | 170,03 | 0 | 283,38 | 86,5068 | 100 | 490,285714 | OK | 1 | 133,065 | 102,774 | 119,0014244 | 206 | 200 | 122,571429 | 225,3455 | OK |
| | 187 | 10 | 1 | 46,16 | 0 | 76,9387 | 318,621 | 100 | 490,285714 | OK | 1 | 13,1895 | 102,774 | -80,7915328 | -303,426 | 200 | 122,571429 | 225,3455 | OK |
| | 192 | 10 | 1 | 46,16 | 0 | 76,9387 | 318,621 | 100 | 490,285714 | OK | 1 | 13,1895 | 102,774 | -80,7915328 | -303,426 | 200 | 122,571429 | 225,3455 | OK |
| | 198 | 10 | 1 | 189,56 | 0 | 315,933 | 77,5934 | 100 | 490,285714 | OK | 1 | 148,351 | 102,774 | 144,4775052 | 169,675 | 200 | 122,571429 | 225,3455 | OK |
| | 201 | 10 | 1 | 215,00 | 0 | 358,327 | 68,4132 | 100 | 490,285714 | OK | 1 | 168,258 | 102,774 | 177,6556606 | 137,988 | 200 | 122,571429 | 225,3455 | OK |
| 3 | 248 | 10 | 1 | 182,83 | 0 | 304,72 | 80,4485 | 100 | 490,285714 | OK | 1 | 143,086 | 102,774 | 135,702819 | 180,647 | 200 | 122,571429 | 225,3455 | OK |
| | 251 | 10 | 1 | 151,89 | 0 | 253,143 | 96,8397 | 100 | 490,285714 | OK | 1 | 118,867 | 102,774 | 95,33787694 | 257,131 | 200 | 122,571429 | 225,3455 | OK |
| | 257 | 10 | 1 | 49,18 | 0 | 81,9656 | 299,08 | 100 | 490,285714 | OK | 1 | 14,0512 | 102,774 | -79,3552934 | -308,918 | 200 | 122,571429 | 225,3455 | OK |
| | 262 | 10 | 1 | 49,18 | 0 | 81,9656 | 299,08 | 100 | 490,285714 | OK | 1 | 14,0512 | 102,774 | -79,3552934 | -308,918 | 200 | 122,571429 | 225,3455 | OK |
| | 268 | 10 | 1 | 151,87 | 0 | 253,125 | 96,8467 | 100 | 490,285714 | OK | 1 | 118,859 | 102,774 | 95,32355212 | 257,169 | 200 | 122,571429 | 225,3455 | OK |
| | 271 | 10 | 1 | 182,82 | 0 | 304,702 | 80,4533 | 100 | 490,285714 | OK | 1 | 143,078 | 102,774 | 135,6884826 | 180,668 | 200 | 122,571429 | 225,3455 | OK |
| 4 | 318 | 10 | 1 | 132,95 | 0 | 221,587 | 110,63 | 100 | 490,285714 | OK | 1 | 104,05 | 102,774 | 70,64210781 | 347,021 | 200 | 122,571429 | 225,3455 | OK |
| | 321 | 10 | 1 | 99,70 | 0 | 166,168 | 147,527 | 100 | 490,285714 | OK | 1 | 78,0269 | 102,774 | 27,27075314 | 898,922 | 200 | 122,571429 | 225,3455 | OK |
| | 327 | 10 | 1 | 51,14 | 0 | 85,2273 | 287,634 | 100 | 490,285714 | OK | 1 | 14,6104 | 102,774 | -78,4233751 | -312,589 | 200 | 122,571429 | 225,3455 | OK |
| | 332 | 10 | 1 | 51,14 | 0 | 85,2273 | 287,634 | 100 | 490,285714 | OK | 1 | 14,6104 | 102,774 | -78,4233751 | -312,589 | 200 | 122,571429 | 225,3455 | OK |
| | 338 | 10 | 1 | 99,69 | 0 | 166,158 | 147,536 | 100 | 490,285714 | OK | 1 | 78,0219 | 102,774 | 27,26252472 | 899,194 | 200 | 122,571429 | 225,3455 | OK |
| | 341 | 10 | 1 | 132,95 | 0 | 221,577 | 110,636 | 100 | 490,285714 | OK | 1 | 104,045 | 102,774 | 70,6338794 | 347,061 | 200 | 122,571429 | 225,3455 | OK |
| Ring | 382 | 10 | 1 | 43,10 | 0 | 71,8365 | 341,251 | 100 | 490,285714 | OK | 1 | 33,7319 | 102,774 | -46,5541658 | -526,576 | 200 | 122,571429 | 225,3455 | OK |
| | 385 | 10 | 1 | 31,09 | 0 | 51,8192 | 473,074 | 100 | 490,285714 | OK | 1 | 24,3325 | 102,774 | -62,2198941 | -393,994 | 200 | 122,571429 | 225,3455 | OK |
| | 388 | 10 | 1 | 18,92 | 0 | 31,5259 | 777,591 | 100 | 490,285714 | OK | 1 | 5,40444 | 102,774 | -93,7666187 | -261,439 | 200 | 122,571429 | 225,3455 | OK |

| | | | | | | | | | | | | | | | | | | |
|-----|----|---|-------|---|---------|---------|-----|-----------|----|---|---------|---------|-------------|----------|-----|-----------|----------|----|
| 391 | 10 | 1 | 18,92 | 0 | 31,5259 | 777,591 | 100 | 490,28571 | OK | 1 | 5,40444 | 102,774 | -93,7666187 | -261,439 | 200 | 122,57143 | 225,3455 | OK |
| 394 | 10 | 1 | 31,09 | 0 | 51,8151 | 473,111 | 100 | 490,28571 | OK | 1 | 24,3306 | 102,774 | -62,2231024 | -393,974 | 200 | 122,57143 | 225,3455 | OK |
| 397 | 10 | 1 | 43,10 | 0 | 71,8324 | 341,271 | 100 | 490,28571 | OK | 1 | 33,73 | 102,774 | -46,5573742 | -526,539 | 200 | 122,57143 | 225,3455 | OK |

Tabel 6.29. Penulangan geser balok portal As - 2 & 5

| Lantai | Elemen | diameter tulangan (mm) | Daerah sendi plastis | | | | | | | Daerah di luar sendi plastis | | | | | | | | | |
|--------|--------|------------------------|----------------------|--------------------|---------|--------------------|---------|-----------------|------------------|------------------------------|-------|------------|---------|----------------------|----------|-----------------|-------------------|----------------|----------------------|
| | | | n tul | Vu,b terpakai (kN) | Vc (kN) | Vs = Vu,b/0,6 (kN) | S (mm) | S terpakai (mm) | Vs terpakai (kN) | cek Vu,b/0,6 < Vc+Vs | n tul | Vu,bt (kN) | Vc (kN) | Vs = Vub/0,6 Vc (kN) | S (mm) | S terpakai (mm) | Vs Terpasang (kN) | Vs t + Vc (kN) | cek Vu,b/0,6 < Vs+Vc |
| Sloof | 32 | 10 | 1 | 124,63 | 0 | 155,794 | 108,935 | 100 | 339,428571 | OK | 1 | 105,854 | 106,727 | 69,69709473 | 243,503 | 200 | 84,8571429 | 191,584 | OK |
| | 33 | 10 | 1 | 124,83 | 0 | 156,036 | 108,766 | 100 | 339,428571 | OK | 1 | 106,019 | 106,727 | 69,97191729 | 242,546 | 200 | 84,8571429 | 191,584 | OK |
| | 39 | 10 | 1 | 125,27 | 0 | 156,589 | 108,382 | 100 | 339,428571 | OK | 1 | 106,395 | 106,727 | 70,59773606 | 240,396 | 200 | 84,8571429 | 191,584 | OK |
| | 40 | 10 | 1 | 123,94 | 0 | 154,931 | 109,542 | 100 | 339,428571 | OK | 1 | 105,268 | 106,727 | 68,71969369 | 246,966 | 200 | 84,8571429 | 191,584 | OK |
| | 48 | 10 | 1 | 194,44 | 0 | 243,051 | 69,8265 | 100 | 339,428571 | OK | 1 | 108,887 | 106,727 | 74,75153089 | 227,038 | 200 | 84,8571429 | 191,584 | OK |
| | 51 | 10 | 1 | 194,44 | 0 | 243,051 | 69,8265 | 100 | 339,428571 | OK | 1 | 108,887 | 106,727 | 74,75153089 | 227,038 | 200 | 84,8571429 | 191,584 | OK |
| | 59 | 10 | 1 | 123,95 | 0 | 154,931 | 109,542 | 100 | 339,428571 | OK | 1 | 105,268 | 106,727 | 68,72058021 | 246,963 | 200 | 84,8571429 | 191,584 | OK |
| | 60 | 10 | 1 | 125,27 | 0 | 156,589 | 108,381 | 100 | 339,428571 | OK | 1 | 106,395 | 106,727 | 70,59862259 | 240,393 | 200 | 84,8571429 | 191,584 | OK |
| | 66 | 10 | 1 | 124,83 | 0 | 156,036 | 108,766 | 100 | 339,428571 | OK | 1 | 106,019 | 106,727 | 69,97130863 | 242,548 | 200 | 84,8571429 | 191,584 | OK |
| | 67 | 10 | 1 | 124,63 | 0 | 155,793 | 108,936 | 100 | 339,428571 | OK | 1 | 105,854 | 106,727 | 69,69648607 | 243,505 | 200 | 84,8571429 | 191,584 | OK |
| 1 | 102 | 10 | 2 | 273,64 | 0 | 342,049 | 143,338 | 100 | 490,285714 | OK | 1 | 214,152 | 205,548 | 151,3722494 | 161,947 | 150 | 163,428571 | 368,9766 | OK |
| | 103 | 10 | 2 | 277,80 | 0 | 347,25 | 141,191 | 100 | 490,285714 | OK | 1 | 217,409 | 205,548 | 156,7998275 | 156,341 | 150 | 163,428571 | 368,9766 | OK |
| | 109 | 10 | 2 | 300,86 | 0 | 376,077 | 130,368 | 100 | 490,285714 | OK | 1 | 235,457 | 205,548 | 186,860107 | 131,177 | 150 | 163,428571 | 368,9766 | OK |
| | 110 | 10 | 2 | 292,61 | 0 | 365,756 | 134,047 | 100 | 490,285714 | OK | 1 | 228,995 | 205,548 | 176,1108757 | 139,198 | 150 | 163,428571 | 368,9766 | OK |
| | 118 | 10 | 2 | 399,48 | 0 | 469,975 | 104,322 | 100 | 490,285714 | OK | 1 | 114,137 | 205,548 | -15,3200646 | -1600,14 | 150 | 163,428571 | 368,9766 | OK |
| | 121 | 10 | 2 | 399,48 | 0 | 469,975 | 104,322 | 100 | 490,285714 | OK | 1 | 114,137 | 205,548 | -15,3200646 | -1600,14 | 150 | 163,428571 | 368,9766 | OK |
| | 129 | 10 | 2 | 292,61 | 0 | 365,762 | 134,045 | 100 | 490,285714 | OK | 1 | 228,999 | 205,548 | 176,1169836 | 139,193 | 150 | 163,428571 | 368,9766 | OK |
| | 130 | 10 | 2 | 300,87 | 0 | 376,083 | 130,366 | 100 | 490,285714 | OK | 1 | 235,461 | 205,548 | 186,8662265 | 131,172 | 150 | 163,428571 | 368,9766 | OK |
| | 136 | 10 | 2 | 277,80 | 0 | 347,246 | 141,193 | 100 | 490,285714 | OK | 1 | 217,406 | 205,548 | 156,7954828 | 156,346 | 150 | 163,428571 | 368,9766 | OK |
| | 137 | 10 | 2 | 273,64 | 0 | 342,044 | 143,34 | 100 | 490,285714 | OK | 1 | 214,15 | 205,548 | 151,3679047 | 161,952 | 150 | 163,428571 | 368,9766 | OK |
| 2 | 172 | 10 | 2 | 275,79 | 0 | 344,742 | 142,218 | 100 | 490,285714 | OK | 1 | 215,838 | 205,548 | 154,1822758 | 158,995 | 150 | 163,428571 | 368,9766 | OK |
| | 173 | 10 | 2 | 275,65 | 0 | 344,559 | 142,294 | 100 | 490,285714 | OK | 1 | 215,724 | 205,548 | 153,9921867 | 159,192 | 150 | 163,428571 | 368,9766 | OK |
| | 179 | 10 | 2 | 301,81 | 0 | 377,267 | 129,957 | 100 | 490,285714 | OK | 1 | 236,202 | 205,548 | 188,1219817 | 130,311 | 150 | 163,428571 | 368,9766 | OK |
| | 180 | 10 | 2 | 291,65 | 0 | 364,563 | 134,486 | 100 | 490,285714 | OK | 1 | 228,248 | 205,548 | 174,8656038 | 140,189 | 150 | 163,428571 | 368,9766 | OK |
| | 188 | 10 | 2 | 399,48 | 0 | 469,975 | 104,322 | 100 | 490,285714 | OK | 1 | 114,137 | 205,548 | -15,3200646 | -1600,14 | 150 | 163,428571 | 368,9766 | OK |
| | 191 | 10 | 2 | 399,48 | 0 | 469,975 | 104,322 | 100 | 490,285714 | OK | 1 | 114,137 | 205,548 | -15,3200646 | -1600,14 | 150 | 163,428571 | 368,9766 | OK |
| | 199 | 10 | 2 | 291,66 | 0 | 364,572 | 134,482 | 100 | 490,285714 | OK | 1 | 228,254 | 205,548 | 174,8751114 | 140,182 | 150 | 163,428571 | 368,9766 | OK |
| | 200 | 10 | 2 | 301,82 | 0 | 377,276 | 129,954 | 100 | 490,285714 | OK | 1 | 236,208 | 205,548 | 188,1314894 | 130,304 | 150 | 163,428571 | 368,9766 | OK |
| | 206 | 10 | 2 | 275,64 | 0 | 344,553 | 142,296 | 100 | 490,285714 | OK | 1 | 215,72 | 205,548 | 153,9854564 | 159,199 | 150 | 163,428571 | 368,9766 | OK |
| | 207 | 10 | 2 | 275,79 | 0 | 344,735 | 142,221 | 100 | 490,285714 | OK | 1 | 215,834 | 205,548 | 154,1755455 | 159,002 | 150 | 163,428571 | 368,9766 | OK |
| | 242 | 10 | 2 | 269,46 | 0 | 336,821 | 145,563 | 100 | 490,285714 | OK | 1 | 210,879 | 205,548 | 145,9176186 | 168,001 | 150 | 163,428571 | 368,9766 | OK |
| | 243 | 10 | 2 | 266,80 | 0 | 333,499 | 147,013 | 100 | 490,285714 | OK | 1 | 208,799 | 205,548 | 142,4510728 | 172,089 | 150 | 163,428571 | 368,9766 | OK |
| | 249 | 10 | 2 | 302,57 | 0 | 378,216 | 129,631 | 100 | 490,285714 | OK | 1 | 236,796 | 205,548 | 189,1123438 | 129,628 | 150 | 163,428571 | 368,9766 | OK |

| | | | | | | | | | | | | | | | | | | | |
|------|-----|----|---|--------|---|---------|---------|-----|-----------|----|---|---------|---------|-------------|----------|-----|-----------|----------|----|
| 3 | 250 | 10 | 2 | 290,89 | 0 | 363,612 | 134,838 | 100 | 490,28571 | OK | 1 | 227,653 | 205,548 | 173,8731212 | 140,99 | 150 | 163,42857 | 368,9766 | OK |
| | 258 | 10 | 2 | 313,67 | 0 | 392,083 | 125,047 | 100 | 490,28571 | OK | 1 | 89,6189 | 205,548 | -56,1832256 | -436,327 | 150 | 163,42857 | 368,9766 | OK |
| | 261 | 10 | 2 | 313,67 | 0 | 392,083 | 125,047 | 100 | 490,28571 | OK | 1 | 89,6189 | 205,548 | -56,1832256 | -436,327 | 150 | 163,42857 | 368,9766 | OK |
| | 269 | 10 | 2 | 290,90 | 0 | 363,623 | 134,833 | 100 | 490,28571 | OK | 1 | 227,66 | 205,548 | 173,8847378 | 140,98 | 150 | 163,42857 | 368,9766 | OK |
| | 270 | 10 | 2 | 302,58 | 0 | 378,227 | 129,627 | 100 | 490,28571 | OK | 1 | 236,803 | 205,548 | 189,1239719 | 129,62 | 150 | 163,42857 | 368,9766 | OK |
| | 276 | 10 | 2 | 267,32 | 0 | 334,151 | 146,726 | 100 | 490,28571 | OK | 1 | 209,208 | 205,548 | 143,131346 | 171,271 | 150 | 163,42857 | 368,9766 | OK |
| | 277 | 10 | 2 | 269,98 | 0 | 337,473 | 145,281 | 100 | 490,28571 | OK | 1 | 211,288 | 205,548 | 146,5978803 | 167,221 | 150 | 163,42857 | 368,9766 | OK |
| 4 | 312 | 10 | 2 | 176,86 | 0 | 221,074 | 221,774 | 100 | 490,28571 | OK | 1 | 138,412 | 205,548 | 25,13814935 | 975,183 | 150 | 163,42857 | 368,9766 | OK |
| | 313 | 10 | 2 | 175,73 | 0 | 219,663 | 223,199 | 100 | 490,28571 | OK | 1 | 137,528 | 205,548 | 23,66545789 | 1035,87 | 150 | 163,42857 | 368,9766 | OK |
| | 319 | 10 | 2 | 226,14 | 0 | 282,675 | 173,445 | 100 | 490,28571 | OK | 1 | 176,979 | 205,548 | 89,41689953 | 274,157 | 150 | 163,42857 | 368,9766 | OK |
| | 320 | 10 | 2 | 212,77 | 0 | 265,96 | 184,346 | 100 | 490,28571 | OK | 1 | 166,514 | 205,548 | 71,97535721 | 340,593 | 150 | 163,42857 | 368,9766 | OK |
| | 328 | 10 | 2 | 138,94 | 0 | 173,672 | 282,306 | 100 | 490,28571 | OK | 1 | 39,6964 | 205,548 | -139,387412 | -175,872 | 150 | 163,42857 | 368,9766 | OK |
| | 331 | 10 | 2 | 138,94 | 0 | 173,672 | 282,306 | 100 | 490,28571 | OK | 1 | 39,6964 | 205,548 | -139,387412 | -175,872 | 150 | 163,42857 | 368,9766 | OK |
| | 339 | 10 | 2 | 212,81 | 0 | 266,013 | 184,309 | 100 | 490,28571 | OK | 1 | 166,547 | 205,548 | 72,03052447 | 340,332 | 150 | 163,42857 | 368,9766 | OK |
| | 340 | 10 | 2 | 226,18 | 0 | 282,728 | 173,413 | 100 | 490,28571 | OK | 1 | 177,012 | 205,548 | 89,47206678 | 273,988 | 150 | 163,42857 | 368,9766 | OK |
| | 346 | 10 | 2 | 173,77 | 0 | 217,217 | 225,713 | 100 | 490,28571 | OK | 1 | 135,997 | 205,548 | 21,11284002 | 1161,11 | 150 | 163,42857 | 368,9766 | OK |
| | 347 | 10 | 2 | 174,90 | 0 | 218,628 | 224,256 | 100 | 490,28571 | OK | 1 | 136,88 | 205,548 | 22,58553148 | 1085,4 | 150 | 163,42857 | 368,9766 | OK |
| Ring | 378 | 10 | 1 | 44,41 | 0 | 55,509 | 305,742 | 100 | 339,42857 | OK | 1 | 37,7157 | 106,727 | -43,8673709 | -386,88 | 200 | 84,857143 | 191,584 | OK |
| | 379 | 10 | 1 | 67,37 | 0 | 84,2147 | 201,526 | 100 | 339,42857 | OK | 1 | 57,2198 | 106,727 | -11,3604586 | -1493,9 | 200 | 84,857143 | 191,584 | OK |
| | 383 | 10 | 1 | 70,49 | 0 | 88,1133 | 192,609 | 100 | 339,42857 | OK | 1 | 59,8688 | 106,727 | -6,94554599 | -2443,5 | 200 | 84,857143 | 191,584 | OK |
| | 384 | 10 | 1 | 66,78 | 0 | 83,4785 | 203,303 | 100 | 339,42857 | OK | 1 | 56,7196 | 106,727 | -12,1941515 | -1391,77 | 200 | 84,857143 | 191,584 | OK |
| | 389 | 10 | 1 | 50,29 | 0 | 62,8581 | 269,996 | 100 | 339,42857 | OK | 1 | 28,1604 | 106,727 | -59,7928436 | -283,837 | 200 | 84,857143 | 191,584 | OK |
| | 390 | 10 | 1 | 50,29 | 0 | 62,8581 | 269,996 | 100 | 339,42857 | OK | 1 | 28,1604 | 106,727 | -59,7928436 | -283,837 | 200 | 84,857143 | 191,584 | OK |
| | 395 | 10 | 1 | 66,82 | 0 | 83,5262 | 203,187 | 100 | 339,42857 | OK | 1 | 56,752 | 106,727 | -12,1401581 | -1397,96 | 200 | 84,857143 | 191,584 | OK |
| | 396 | 10 | 1 | 70,53 | 0 | 88,161 | 192,505 | 100 | 339,42857 | OK | 1 | 59,9012 | 106,727 | -6,89155268 | -2462,64 | 200 | 84,857143 | 191,584 | OK |
| | 400 | 10 | 1 | 65,78 | 0 | 82,2305 | 206,388 | 100 | 339,42857 | OK | 1 | 55,8717 | 106,727 | -13,6073904 | -1247,22 | 200 | 84,857143 | 191,584 | OK |
| | 401 | 10 | 1 | 42,82 | 0 | 53,5248 | 317,076 | 100 | 339,42857 | OK | 1 | 36,3675 | 106,727 | -46,1143027 | -368,03 | 200 | 84,857143 | 191,584 | OK |

Tabel 6.30. Penulangan geser balok portal As - 3 & 4

| Lantai | Elemen | diameter tulangan (mm) | Daerah sendi plastis | | | | | | | | Daerah di luar sendi plastis | | | | | | | | |
|--------|--------|------------------------|----------------------|--------------------|---------|--------------------|---------|-----------------|-------------------|----------------------|------------------------------|------------|---------|----------------------|----------|-----------------|-------------------|----------------|----------------------|
| | | | n tul | Vu,b terpakai (kN) | Vc (kN) | Vs = Vu,b/0,6 (kN) | S (mm) | S terpakai (mm) | Vs terpasang (kN) | cek Vu,b/0,6 < Vc+Vs | n tul | Vu,bt (kN) | Vc (kN) | Vs = Vub/0,6 Vc (kN) | S (mm) | S terpakai (mm) | Vs Terpasang (kN) | Vs t + Vc (kN) | cek Vu,b/0,6 < Vs+Vc |
| Sloof | 35 | 10 | 1 | 59,84 | 0 | 99,733 | 207,984 | 100 | 414,857143 | OK | 1 | 59,0726 | 173,925 | -75,4708869 | -274,846 | 200 | 103,714286 | 277,6396 | OK |
| | 36 | 10 | 1 | 59,84 | 0 | 99,3955 | 208,69 | 100 | 414,857143 | OK | 1 | 58,8727 | 173,925 | -75,8040979 | -273,638 | 200 | 103,714286 | 277,6396 | OK |
| | 49 | 10 | 1 | 102,07 | 0 | 170,122 | 121,929 | 100 | 414,857143 | OK | 1 | 85,0609 | 173,925 | -32,1571411 | -645,047 | 200 | 103,714286 | 277,6396 | OK |
| | 50 | 10 | 1 | 102,07 | 0 | 170,122 | 121,929 | 100 | 414,857143 | OK | 1 | 85,0609 | 173,925 | -32,1571411 | -645,047 | 200 | 103,714286 | 277,6396 | OK |
| | 63 | 10 | 1 | 59,84 | 0 | 99,3954 | 208,69 | 100 | 414,857143 | OK | 1 | 58,8727 | 173,925 | -75,8041827 | -273,637 | 200 | 103,714286 | 277,6396 | OK |
| | 64 | 10 | 1 | 59,84 | 0 | 99,7329 | 207,984 | 100 | 414,857143 | OK | 1 | 59,0726 | 173,925 | -75,4709717 | -274,846 | 200 | 103,714286 | 277,6396 | OK |
| 1 | 105 | 10 | 2 | 286,01 | 0 | 476,683 | 102,854 | 100 | 490,285714 | OK | 1 | 282,246 | 205,548 | 264,862688 | 92,5547 | 150 | 163,428571 | 368,9766 | OK |
| | 106 | 10 | 2 | 288,77 | 0 | 481,282 | 101,871 | 100 | 490,285714 | OK | 1 | 284,97 | 205,548 | 269,4014605 | 90,9954 | 150 | 163,428571 | 368,9766 | OK |
| | 119 | 10 | 2 | 164,59 | 0 | 274,325 | 178,725 | 100 | 490,285714 | OK | 1 | 123,446 | 205,548 | 0,1955875 | 125337 | 150 | 163,428571 | 368,9766 | OK |
| | 120 | 10 | 2 | 164,59 | 0 | 274,325 | 178,725 | 100 | 490,285714 | OK | 1 | 123,446 | 205,548 | 0,1955875 | 125337 | 150 | 163,428571 | 368,9766 | OK |
| | 133 | 10 | 2 | 288,77 | 0 | 481,284 | 101,87 | 100 | 490,285714 | OK | 1 | 284,971 | 205,548 | 269,4031122 | 90,9948 | 150 | 163,428571 | 368,9766 | OK |
| | 134 | 10 | 2 | 286,01 | 0 | 476,684 | 102,853 | 100 | 490,285714 | OK | 1 | 282,247 | 205,548 | 264,8641923 | 92,5542 | 150 | 163,428571 | 368,9766 | OK |
| 2 | 175 | 10 | 2 | 281,32 | 0 | 468,872 | 104,567 | 100 | 490,285714 | OK | 1 | 277,622 | 205,548 | 257,1546262 | 95,329 | 150 | 163,428571 | 368,9766 | OK |
| | 176 | 10 | 2 | 283,22 | 0 | 472,037 | 103,866 | 100 | 490,285714 | OK | 1 | 279,496 | 205,548 | 260,2779043 | 94,185 | 150 | 163,428571 | 368,9766 | OK |
| | 189 | 10 | 2 | 164,59 | 0 | 274,325 | 178,725 | 100 | 490,285714 | OK | 1 | 123,446 | 205,548 | 0,1955875 | 125337 | 150 | 163,428571 | 368,9766 | OK |
| | 190 | 10 | 2 | 164,59 | 0 | 274,325 | 178,725 | 100 | 490,285714 | OK | 1 | 123,446 | 205,548 | 0,1955875 | 125337 | 150 | 163,428571 | 368,9766 | OK |
| | 203 | 10 | 2 | 283,22 | 0 | 472,032 | 103,867 | 100 | 490,285714 | OK | 1 | 279,493 | 205,548 | 260,2733917 | 94,1867 | 150 | 163,428571 | 368,9766 | OK |
| | 204 | 10 | 2 | 281,32 | 0 | 468,868 | 104,568 | 100 | 490,285714 | OK | 1 | 277,619 | 205,548 | 257,1502611 | 95,3306 | 150 | 163,428571 | 368,9766 | OK |
| 3 | 245 | 10 | 2 | 262,42 | 0 | 437,37 | 112,099 | 100 | 490,285714 | OK | 1 | 258,969 | 205,548 | 226,0670019 | 108,438 | 150 | 163,428571 | 368,9766 | OK |
| | 246 | 10 | 2 | 263,23 | 0 | 438,71 | 111,756 | 100 | 490,285714 | OK | 1 | 259,763 | 205,548 | 227,3898545 | 107,807 | 150 | 163,428571 | 368,9766 | OK |
| | 259 | 10 | 2 | 99,14 | 0 | 165,238 | 296,716 | 100 | 490,285714 | OK | 1 | 74,3569 | 205,548 | -81,6199203 | -300,347 | 150 | 163,428571 | 368,9766 | OK |
| | 260 | 10 | 2 | 99,14 | 0 | 165,238 | 296,716 | 100 | 490,285714 | OK | 1 | 74,3569 | 205,548 | -81,6199203 | -300,347 | 150 | 163,428571 | 368,9766 | OK |
| | 273 | 10 | 2 | 263,24 | 0 | 438,734 | 111,75 | 100 | 490,285714 | OK | 1 | 259,777 | 205,548 | 227,4128601 | 107,796 | 150 | 163,428571 | 368,9766 | OK |
| | 274 | 10 | 2 | 262,44 | 0 | 437,393 | 112,093 | 100 | 490,285714 | OK | 1 | 258,983 | 205,548 | 226,0898601 | 108,427 | 150 | 163,428571 | 368,9766 | OK |
| 4 | 315 | 10 | 2 | 234,92 | 0 | 391,528 | 125,224 | 100 | 490,285714 | OK | 1 | 231,826 | 205,548 | 180,8286958 | 135,566 | 150 | 163,428571 | 368,9766 | OK |
| | 316 | 10 | 2 | 242,02 | 0 | 403,361 | 121,55 | 100 | 490,285714 | OK | 1 | 238,832 | 205,548 | 192,5051382 | 127,344 | 150 | 163,428571 | 368,9766 | OK |
| | 329 | 10 | 2 | 27,58 | 0 | 45,9587 | 1066,8 | 100 | 490,285714 | OK | 1 | 20,6814 | 205,548 | -171,079018 | -143,292 | 150 | 163,428571 | 368,9766 | OK |
| | 330 | 10 | 2 | 27,58 | 0 | 45,9587 | 1066,8 | 100 | 490,285714 | OK | 1 | 20,6814 | 205,548 | -171,079018 | -143,292 | 150 | 163,428571 | 368,9766 | OK |
| | 343 | 10 | 2 | 241,96 | 0 | 403,27 | 121,578 | 100 | 490,285714 | OK | 1 | 238,778 | 205,548 | 192,4152983 | 127,403 | 150 | 163,428571 | 368,9766 | OK |
| | 344 | 10 | 2 | 234,86 | 0 | 391,437 | 125,253 | 100 | 490,285714 | OK | 1 | 231,772 | 205,548 | 180,7387084 | 135,634 | 150 | 163,428571 | 368,9766 | OK |

C. Perhitungan Penulangan Kolom

1. Penulangan lentur kolom

a. Momen rencana dan Gaya aksial rencana kolom.

1. *Momen rencana kolom.*

-- Kuat lentur kolom portal dengan daktilitas penuh yang ditentukan pada bidang muka balok $M_{u,k}$ harus dihitung berdasarkan terjadinya kapasitas lentur sendi plastis pada kedua ujung balok yang bertemu dengan kolom tersebut sebagai berikut :

$$\sum M_{u,k} = 0,7 \cdot \omega_d \cdot \sum M_{kap..b}$$

atau

$$M_{u,k} = 0,7 \cdot \omega_d \cdot \alpha_k (M_{kap,ki} + M_{kap,ka})$$

tetapi dalam segala hal tidak perlu lebih besar dari :

$$M_{u,k} = 1,05 \cdot \left[M_{D,k} + M_{L,k} + \frac{4,0}{K} M_{E,k} \right]$$

Perhitungan momen lentur kolom: .

$$\phi_o = 1,25$$

$$K = 1$$

$\omega_d = 1,3$ kecuali untuk kolom lantai satu dan kolom paling atas yang memungkinkan terjadi sendi plastis pada kolom, $\omega_d = 1$.

$$h = 3800 \text{ mm}$$

$$h_n = 3100 \text{ mm}$$

$$l_{ki,x} = 9600 \text{ mm}$$

$$l_{nki,x} = 8900 \text{ mm}$$

$$l_{ka,x} = 2400 \text{ mm}$$

$$l_{nka,x} = 1700 \text{ mm}$$

$$l_{ki,y} = 7200 \text{ mm}$$

$$l_{nki,y} = 6500 \text{ mm}$$

$$l_{ka,y} = 7200 \text{ mm}$$

$$l_{nka,y} = 6500 \text{ mm}$$

$$M_{E,k2xatas} = 133,23 \text{ kNm.}$$

$$M_{E,k1xbawah} = 110,95 \text{ kNm.}$$

$$M_{E,k2xbawah} = 138,26 \text{ kNm.}$$

$$M_{E,k1yatas} = 237,77 \text{ kNm.}$$

$$M_{E,k2yatas} = 198,59 \text{ kNm.}$$

$$M_{E,k1ybawah} = 164,35 \text{ kNm.}$$

$$M_{E,k2ybawah} = 200,14 \text{ kNm.}$$

$$\alpha_{ka} = \frac{(M_{E,k2xatas} + 0,3M_{E,k2yatas})}{(M_{E,k1xbawah} + 0,3M_{E,k1ybawah}) + (M_{E,k2xatas} + 0,3M_{E,k2yatas})}$$

$$\alpha_{kb} = \frac{(M_{E,k1xbawah} + 0,3M_{E,k1ybawah})}{(M_{E,k1xbawah} + 0,3M_{E,k1ybawah}) + (M_{E,k2xatas} + 0,3M_{E,k2yatas})}$$

$$\alpha_{k1a} = \frac{(160,30 + 0,3 \cdot 198,59)}{(110,95 + 0,3 \cdot 184,35) + (160,30 + 0,3 \cdot 198,59)}$$

$$= 0,57$$

$$\alpha_{k2b} = \frac{(110,95 + 0,3 \cdot 184,35)}{(110,95 + 0,3 \cdot 184,35) + (133,23 + 0,3 \cdot 198,59)}$$

$$= 0,43$$

$$M_{nak,bxki} = 1170 \text{ kNm}$$

$$M_{nak,byki} = 598 \text{ kNm}$$

$$M_{nak,bxka} = 598 \text{ kNm}$$

$$M_{nak,bxka} = 598 \text{ kNm}$$

$$M_{U,kaxi} = \frac{h}{h_n} \cdot 0,7 \cdot \omega_d \cdot \phi_o \cdot \alpha_a \left[\left(\frac{l_{ki}}{l_{n,ki}} M_{nak,bxki} + \frac{l_{ka}}{l_{n,ka}} M_{nak,bxka} \right) + 0,3 \cdot \left(\frac{l_{ki}}{l_{n,ki}} M_{nak,byki} + \frac{l_{ka}}{l_{n,ka}} M_{nak,byka} \right) \right]$$

$$M_{U,kbxi} = \frac{h}{h_n} \cdot 0,7 \cdot \omega_d \cdot \phi_o \cdot \alpha_b \left[\left(\frac{l_{ki}}{l_{n,ki}} M_{nak,bxki} + \frac{l_{ka}}{l_{n,ka}} M_{nak,bxka} \right) + 0,3 \cdot \left(\frac{l_{ki}}{l_{n,ki}} M_{nak,byki} + \frac{l_{ka}}{l_{n,ka}} M_{nak,byka} \right) \right]$$

$$M_{U,kayi} = \frac{h}{h_n} \cdot 0,7 \cdot \omega_d \cdot \phi_o \cdot \alpha_a \left[0,3 \cdot \left(\frac{l_{ki}}{l_{n,ki}} M_{nak,bxki} + \frac{l_{ku}}{l_{n,ku}} M_{nak,bxka} \right) + \left(\frac{l_{ki}}{l_{n,ki}} M_{nak,byki} + \frac{l_{ka}}{l_{n,ka}} M_{nak,byka} \right) \right]$$

$$M_{U,kbyi} = \frac{h}{h_n} \cdot 0,7 \cdot \omega_d \cdot \phi_o \cdot \alpha_b \left[0,3 \cdot \left(\frac{l_{ki}}{l_{n,ki}} M_{nak,bxki} + \frac{l_{ka}}{l_{n,ka}} M_{nak,bxka} \right) + \left(\frac{l_{ki}}{l_{n,ki}} M_{nak,byki} + \frac{l_{ka}}{l_{n,ka}} M_{nak,byka} \right) \right]$$

$$M_{U,kax1} = \frac{3,8}{3,1} \cdot 0,7 \cdot 1,3 \cdot 1,25 \cdot 0,57 \cdot \left[\left(\frac{9,6}{8,9} \cdot 1170 + \frac{2,4}{1,7} \cdot 598 \right) + 0,3 \cdot \left(\frac{7,2}{6,5} \cdot 598 + \frac{7,2}{6,5} \cdot 598 \right) \right]$$

$$= 1989,89 \text{ kNm.}$$

$$M_{U,kbx1} = \frac{3,8}{3,1} \cdot 0,7 \cdot 1,3 \cdot 1,25 \cdot 0,43 \cdot \left[\left(\frac{9,6}{8,9} \cdot 1170 + \frac{2,4}{1,7} \cdot 598 \right) + 0,3 \cdot \left(\frac{7,2}{6,5} \cdot 598 + \frac{7,2}{6,5} \cdot 598 \right) \right]$$

$$= 1501,15 \text{ kNm.}$$

$$M_{U,kay1} = \frac{3,8}{3,1} \cdot 0,7 \cdot 1,3 \cdot 1,25 \cdot 0,57 \cdot \left[0,3 \cdot \left(\frac{9,6}{8,9} \cdot 1170 + \frac{2,4}{1,7} \cdot 598 \right) + \left(\frac{7,2}{6,5} \cdot 598 + \frac{7,2}{6,5} \cdot 598 \right) \right]$$

$$= 1555,13 \text{ kNm.}$$

$$M_{U,kby1} = \frac{3,8}{3,1} \cdot 0,7 \cdot 1,3 \cdot 1,25 \cdot 0,43 \cdot \left[0,3 \cdot \left(\frac{9,6}{8,9} \cdot 1170 + \frac{2,4}{1,7} \cdot 598 \right) + \left(\frac{7,2}{6,5} \cdot 598 + \frac{7,2}{6,5} \cdot 598 \right) \right]$$

$$= 1173,17 \text{ kNm.}$$

Pada lantai dasar dan lantai atas nilai ω_d yang digunakan adalah 1 dimana sendi plastis diijinkan terjadi. Sehingga nilai momen kolom bawah lantai dasar adalah :

$$M_{u,kbx} = M_{E,kx1a} + 0,3 M_{E,kyl a}$$

$$= 160,30 + 0,3 \cdot 237,77$$

$$= 231,631 \text{ kNm.}$$

$$M_{u,kby} = 0,3 M_{E,kx1a} + M_{E,kyl a}$$

$$= 0,3 \cdot 160,30 + 237,77$$

$$= 285,86 \text{ kNm.}$$

Dalam segala hal momen kolom tidak perlu lebih dari:

$$M_{u,kax1} = 1,05 \cdot \sum \left[M_{D,k1xa} + M_{L,k1xa} + \frac{4,0}{K} (M_{E,k1xa} + 0,3 M_{E,k1ya}) \right]$$

$$M_{u,kbx1} = 1,05 \cdot \sum \left[M_{D,k1xb} + M_{L,k1xb} + \frac{4,0}{K} (M_{E,k1xb} + 0,3 M_{E,k1yb}) \right]$$

$$M_{u,kayl} = 1,05 \cdot \sum \left[M_{D,k1ya} + M_{L,k2ya} + \frac{4,0}{K} (M_{E,k1ya} + 0,3 \cdot M_{E,k1xa}) \right]$$

$$M_{u,kbyl} = 1,05 \cdot \sum \left[M_{D,k1yb} + M_{L,k1yb} + \frac{4,0}{K} (M_{E,k1yb} + 0,3 \cdot M_{E,k1xb}) \right]$$

$$M_{E,k1xb} = 160,30 \text{ kNm.}$$

$$M_{E,k1xa} = 110,95 \text{ kNm.}$$

$$M_{E,k1yb} = 237,77 \text{ kNm.}$$

$$M_{E,k1ya} = 184,35 \text{ kNm.}$$

$$M_{D,k1xb} = 0,02 \text{ kNm.}$$

$$M_{D,k1xa} = 0,20 \text{ kNm.}$$

$$M_{D,k1yb} = 44,87 \text{ kNm.}$$

$$M_{D,k1ya} = 73,37 \text{ kNm.}$$

$$M_{L,k1xb} = 0,04 \text{ kNm.}$$

$$M_{L,k1xa} = 0,17 \text{ kNm.}$$

$$M_{L,k1yb} = 10,38 \text{ kNm.}$$

$$M_{L,k1ya} = 31,23 \text{ kNm.}$$

$$M_{u,kaxl} = 1,05 \cdot \sum \left[0,2 + 0,17 + \frac{4,0}{1} (110,95 + 0,3 \cdot 164,35) \right]$$

$$= 602,52 \text{ kNm}$$

$$M_{u,kbxl} = 1,05 \cdot \sum \left[0,02 + 0,04 + \frac{4,0}{1} (160,5 + 0,3 \cdot 237,77) \right]$$

$$= 961,153 \text{ kNm}$$

$$M_{u,kayl} = 1,05 \cdot \sum \left[73,37 + 33,23 + \frac{4,0}{1} (164,35 + 0,3 \cdot 110,95) \right]$$

$$= 774,797 \text{ kNm}$$

$$M_{u,kbyl} = 1,05 \cdot \sum \left[44,87 + 10,38 + \frac{4,0}{1} (237,77 + 0,3 \cdot 160,3) \right]$$

$$= 1216,62 \text{ kNm}$$

$$M_{u,ky} = 774,797 \text{ kNm}$$

Hasil perhitungan momen rencana kolom selanjutnya dapat dilihat pada tabel 6.31 s/d 6.33, sedangkan hasil perhitungan momen maksimal kolom selanjutnya dapat dilihat pada tabel 6.34 s/d 6.36

2. Gaya aksial rencana kolom

Beban aksial rencana, $N_{u,k}$ yang bekerja pada kolom portal dengan daktilitas penuh dihitung dari :

$$N_{u,k} = \frac{0,7.R_n \cdot \sum M_{kap,b}}{l_b} + 1,05.N_{g,k}$$

tetapi dalam segala hal tidak perlu lebih dari :

$$N_{u,k} = 1,05 \left(N_{g,k} + \frac{4,0}{K} \cdot N_{E,k} \right)$$

dengan

R_n = faktor reduksi yang ditentukan sebesar :

1,0 untuk $1 < n < 4$

$1,1 - 0,025n$ untuk $4 < n < 20$

0,6 $n > 20$

n = jumlah lantai

Dalam segala hal gaya aksial rencana harus memperhitungkan kombinasi pembebanan terfaktor antara beban gravitasi dan beban gempa dalam 2

$$N_{u, kx \text{ maks}} = 1,05 N_{g, k} + 0,7\phi/\ln \left[\sum (M_{nak, bxti} - M_{nak, bxta}) + 0,3.(M_{nak, byki} - M_{nak, byka}) \right]$$

$$N_{u, kx \text{ min}} = 1,05 N_{g, k} - 0,7\phi/\ln \left[\sum (M_{nak, bxti} - M_{nak, bxta}) + 0,3.(M_{nak, byki} - M_{nak, byka}) \right]$$

$$N_{u, ky \text{ maks}} = 1,05 N_{g, k} + 0,7\phi/\ln \left[\sum 0,3.(M_{nak, bxti} - M_{nak, bxta}) + (M_{nak, byki} - M_{nak, byka}) \right]$$

$$N_{u, ky \text{ min}} = 1,05 N_{g, k} - 0,7\phi/\ln \left[\sum 0,3.(M_{nak, bxti} - M_{nak, bxta}) + (M_{nak, byki} - M_{nak, byka}) \right]$$

$$N_{u, kx \text{ maks}} = 1,05 (1621,95 + 466,95) + 0,7.1,25/9,6 \left[\sum (1170 - 598) + 0,3(598 - 598) \right]$$

$$= 2025,48 \text{ kN}$$

$$N_{u, kx \text{ min}} = 1,05 (1621,95 + 466,95) - 0,7.1,25/9,6 \left[\sum (1170 - 598) + 0,3(598 - 598) \right]$$

$$= 2141,41 \text{ kN}$$

$$N_{u, ky \text{ maks}} = 1,05 (1621,95 + 466,95) + 0,7.1,25/9,6 \left[\sum 0,3(1170 - 598) + (598 - 598) \right]$$

$$= 2209,9 \text{ kN}$$

$$N_{u, ky \text{ min}} = 1,05 (1621,95 + 466,95) - 0,7.1,25/9,6 \left[\sum 0,3(1170 - 598) + (598 - 598) \right]$$

$$= 2012,61 \text{ kN}$$

Tidak perlu lebih besar dari :

$$N_{u, kxa} = 1,05 \left(N_{g, k} + \frac{4,0}{K} . (N_{E, kx} + 0,3.N_{E, ky}) \right)$$

$$N_{u, kxb} = 1,05 \left(N_{g, k} - \frac{4,0}{K} . (N_{E, kx} + 0,3.N_{E, ky}) \right)$$

$$N_{u, kya} = 1,05 \left(N_{g, k} + \frac{4,0}{K} . (0,3N_{E, kx} + N_{E, ky}) \right)$$

$$N_{u, kyb} = 1,05 \left(N_{g, k} - \frac{4,0}{K} . (0,3.N_{E, kx} + N_{E, ky}) \right)$$

$$N_{u, kxa} = 1,05 \left((1621,95 + 466,95) + \frac{4,0}{K} . (2,51 + 0,3.420,31) \right)$$

$$= 2733,48 \text{ kN.}$$

$$N_{u, kxb} = 1,05 \left((1621,95 + 466,95) - \frac{4,0}{K} . (2,51 + 0,3.420,31) \right)$$

$$= 1653,21 \text{ kN.}$$

$$N_{u,kyu} = 1,05 \left((1621,95 + 466,95) + \frac{4,0}{K} \cdot (0,3 \cdot 2,51 + \cdot 420,31) \right)$$
$$= 3961,81 \text{ kN.}$$

$$N_{u,kyb} = 1,05 \left((1621,95 + 466,95) - \frac{4,0}{K} \cdot (0,3 \cdot 2,51 + \cdot 420,31) \right)$$
$$= 424,88 \text{ kN.}$$

Jadi digunakan gaya aksial rencana :

$$N_{u,kx} = 2025,48 \text{ kN}$$

$$N_{u,ky} = 2012,61 \text{ kN}$$

Hasil perhitungan gaya aksial rencana kolom selanjutnya dapat dilihat pada tabel 6.37 s/d 39 sedangkan hasil perhitungan gaya aksial maksimum kolom selanjutnya dapat dilihat pada tabel 6.40 s/d 6.42

Tabel 6.31.Momen rencana kolom As 1 & 6

| LANTAI | KOLOM | ELEMEN | h | ω_d | ϕ_o | Me,kx (kNm) | | Me,ky (kNm) | | α_{ka} | α_{kb} | M nak,b-x (kNm) | | M nak,b-y (kNm) | | M u,k-x (kNm) | | M u,k-y (kNm) | |
|--------|------------------|------------------------------------|-----|------------|----------|-------------|------------------|----------------------------|-------|---------------|---------------|-----------------|---------|-----------------|---------|---------------|--------|---------------|--------|
| | | | | | | bawah | atas | bawah | atas | | | kiri | kanan | kiri | kanan | atas | bawah | atas | bawah |
| | | | | | | 1 | POJOK PINGGIR | 75,78,91,94 79,84,85,90 | 3,8 | | | 1 | 1,25 | 38,768 | 0 | 37,261 | 0 | 0,5148 | 0 |
| 2 | POJOK PINGGIR | 145.148.161.164 149.154.155.160 | 3,8 | 1,3 | 1,25 | 54,449 | 50,714 | 48,578 | 36,65 | 0,4003 | 0,4852 | 0 | 404,375 | 0 | 404,375 | 348,184 | 422,11 | 337,372 | 409 |
| 3 | POJOK PINGGIR | 215.218.231.234 219.224.225.230 | 3,8 | 1,3 | 1,25 | 48,157 | 33,324 | 48,425 | 33,32 | 0,3982 | 0,5997 | 0 | 404,375 | 0 | 404,375 | 346,371 | 521,73 | 335,616 | 505,53 |
| 4 | POJOK PINGGIR | 285.288.301.304 289.294.295.300 | 3,8 | 1,3 | 1,25 | 34,361 | 17,106 | 72,255 | 36,46 | 0,0586 | 0,6018 | 0 | 404,375 | 0 | 404,375 | 51,0149 | 523,54 | 49,4308 | 507,28 |
| 5 | POJOK PINGGIR | 355.358.357.370 359.362.363.366 | 3,8 | 1,3 | 1,25 | 9,6421 | 4,0317 | 15,411 | 3,934 | 1 | 0,9414 | 0 | 404,375 | 0 | 404,375 | 869,913 | 818,9 | 842,9 | 793,47 |
| | | | 3,8 | 1,3 | 1,25 | 3,339 | 0,6591 | 7,4471 | 7,091 | 1 | 0,7654 | 0 | 214,298 | 404,375 | 404,375 | 782,527 | 598,96 | 1518,42 | 1162,2 |

Tabel 6.32.Momen rencana kolom As 2 & 5

| LANTAI | KOLOM | ELEMEN | h | ω_d | ϕ_o | Me,kx (kNm) | | Me,ky (kNm) | | α_{ka} | α_{kb} | M nak,b-x (kNm) | | M nak,b-y (kNm) | | M u,k-x (kNm) | | M u,k-y (kNm) | |
|--------|-----------------|---|-----|------------|----------|-------------|-----------------|--|-------|---------------|---------------|-----------------|---------|-----------------|---------|---------------|--------|---------------|--------|
| | | | | | | bawah | atas | bawah | atas | | | kiri | kanan | kiri | kanan | atas | bawah | atas | bawah |
| | | | | | | 1 | POJOK TENGAH | 71,74,95,98 76,77,80,83,86,89,92,93 | 3,8 | | | 1 | 1,25 | 65,068 | 0 | 114,44 | 0 | 0,5065 | 0 |
| 2 | POJOK TENGAH | 141.144.165.168 146,147, 150,153, 156,159, 162,163 | 3,8 | 1,3 | 1,25 | 79,895 | 71,189 | 129,56 | 116,1 | 0,3802 | 0,4935 | 533,6 | 0 | 0 | 533,603 | 399,752 | 518,97 | 411,843 | 534,67 |
| 3 | POJOK TENGAH | 211.214.235.238 216,217,220,223,226,229,232, 233, | 3,8 | 1,3 | 1,25 | 108,35 | 116,44 | 177,27 | 184,2 | 0,4636 | 0,5064 | 533,6 | 533,603 | 533,603 | 533,603 | 1043,79 | 1140,3 | 1098,39 | 1199,9 |
| 4 | POJOK TENGAH | 281.284.305.308 286,287,290,293, 296,299,302,303 | 3,8 | 1,3 | 1,25 | 80,146 | 48,12 | 116,93 | 79,72 | 0,2249 | 0,6198 | 533,6 | 0 | 0 | 533,603 | 236,503 | 651,8 | 243,656 | 671,52 |
| 5 | POJOK TENGAH | 351.354.371.374 356, 357,360,361, 364,365,368,369 | 3,8 | 1,3 | 1,25 | 40,871 | 14,81 | 82,889 | 36,46 | 0,0951 | 0,7751 | 533,6 | 0 | 0 | 533,603 | 100,052 | 815,05 | 103,078 | 839,71 |
| | | | 3,8 | 1,3 | 1,25 | 67,277 | 55,764 | 134,99 | 101,6 | 0,1838 | 0,5789 | 533,6 | 533,603 | 533,603 | 533,603 | 413,795 | 1303,4 | 435,439 | 1371,6 |
| | | | 3,8 | 1,3 | 1,25 | 18,897 | 27,991 | 15,438 | 1,608 | 1 | 0,9049 | 214,3 | 0 | 0 | 533,603 | 573,795 | 519,2 | 940,034 | 850,59 |
| | | | 3,8 | 1,3 | 1,25 | 9,604 | 16,192 | 34,719 | 30,08 | 1 | 0,8162 | 214,3 | 214,298 | 214,298 | 214,298 | 904,251 | 738,07 | 951,55 | 776,67 |

Tabel 6.34.Momen maksimum kolom As 1 & 6

| LANTAI | KOLOM | ELEMEN | MD, KX | | MD, KY | | ML, KX | | ML, KY | | ME, KX | | ME, KY | | MU, KX | | MU, KY | |
|--------|------------------|------------------------------------|------------------|------------------|----------------------------|------------------|------------------|--------------------|------------------|------------------|--------------------|--------------------|------------------|--------------------|--------------------|--------------------|--------------------|----------------------|
| | | | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah |
| | | | 1 | POJOK PINGGIR | 75,78,91,94 79,84,85,90 | 21,615 3,017 | 14,553 2,345 | 9,263 4,715 | 6,9377 4,8382 | 3,3698 0,4951 | 0,94516 0,21477 | 1,201 0,314 | 0,5745 0,3136 | 48,9868 63,4113 | 69,5642 53,2643 | 47,72 23,03 | 88,6432 23,0885 | 225,64 225,2 |
| 2 | POJOK PINGGIR | 145,148,161,164 149,154,155,160 | 25,995 3,2968 | 26,723 3,4848 | 11,49 4,281 | 11,279 4,423 | 4,7561 0,6813 | 5,17627 0,72537 | 2,129 0,555 | 2,5304 1,9136 | 54,4463 72,6393 | 50,7128 74,5034 | 48,58 25,28 | 36,6542 25,3712 | 249,7 256,88 | 227,878 263,082 | 218,78 153,35 | 232,3543 207,0868 |
| 3 | POJOK PINGGIR | 215,218,231,234 219,224,225,230 | 26,743 2,9462 | 26,005 3,03 | 12,43 3,96 | 12,031 4,0691 | 4,811 0,6124 | 4,59037 0,62527 | 2,563 0,663 | 2,6958 2,3559 | 48,1568 56,4544 | 33,3237 51,4272 | 48,42 20,86 | 26,0172 20,706 | 230,59 201,28 | 161,68 185,401 | 213,79 123,91 | 166,7233 158,5098 |
| 4 | POJOK PINGGIR | 285,288,301,304 289,294,295,300 | 26,531 2,7901 | 26,982 2,8273 | 12,81 2,05 | 12,782 3,0224 | 4,5002 0,578 | 4,77008 0,58896 | 2,249 0,688 | 2,9496 2,4098 | 34,3607 33,1311 | 14,1943 25,8286 | 36,51 13,84 | 7,6569 13,6471 | 175,32 120,98 | 85,287 97,8437 | 163,29 77,79 | 66,56222 95,56544 |
| 5 | POJOK PINGGIR | 355,358,357,370 359,362,363,366 | 32,256 1,8836 | 28,924 2,3227 | 14,24 7,597 | 13,451 4,1621 | 7,0352 0,5588 | 5,52776 0,56311 | 4,079 0,757 | 3,2554 2,566 | 9,64209 3,33903 | 4,03171 0,65912 | 15,41 7,447 | 3,93391 7,09125 | 86,192 20,12 | 52,5917 11,8075 | 76,886 35,385 | 39,14449 37,67831 |

Tabel 6.35.Momen maksimum kolom As 2 & 5

| LANTAI | KOLOM | ELEMEN | MD, KX | | MD, KY | | ML, KX | | ML, KY | | ME, KX | | ME, KY | | MU, KX | | MU, KY | |
|--------|-----------------|---|------------------|------------------|--|------------------|------------------|--------------------|------------------|------------------|--------------------|--------------------|-----------------|--------------------|--------------------|--------------------|--------------------|----------------------|
| | | | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah |
| | | | 1 | POJOK TENGAH | 71,74,95,98 76,77,80,83,86,89,92,93 | 23,289 19,707 | 15,631 11,936 | 52,74 25,39 | 36,018 11,777 | 4,0766 4,5945 | 1,03768 1,49555 | 2,322 0,45 | 2,2535 3,339 | 65,0682 125,141 | 136,301 171,463 | 114,4 217,3 | 194,725 257,837 | 289,66 525,17 |
| 2 | POJOK TENGAH | 141,144,165,168 146,147, 150,153, 156,159, 162,163 | 28,637 23,115 | 29,224 24,877 | 63,6 33,84 | 65,188 35,825 | 6,2365 6,0957 | 6,61488 6,76118 | 4,558 0,859 | 13,931 17,387 | 78,8949 148,896 | 71,1889 146,945 | 129,6 247 | 116,121 244,088 | 348,37 616,04 | 315,947 611,17 | 474,58 679,57 | 443,9534 661,033 |
| 3 | POJOK TENGAH | 211,214,235,238 216,217,220,223,226,229,232, 233, | 27,872 20,942 | 28,01 21,289 | 63,22 31,27 | 62,694 31,734 | 5,9701 5,3445 | 5,9372 5,43803 | 5,441 1,069 | 12,446 16,309 | 66,7883 103,849 | 40,1 85,499 | 97,44 169,8 | 79,7234 177,933 | 287,59 433,74 | 203,689 392,62 | 318,8 455,46 | 271,5782 477,9678 |
| 4 | POJOK TENGAH | 281,284,305,308 286,287,290,293, 296,299,302,303 | 34,326 22,779 | 30,804 21,634 | 72,39 38,94 | 67,718 34,615 | 7,4669 6,0361 | 6,68019 5,62216 | 6,624 1,324 | 13,806 18,226 | 34,0588 73,1403 | 12,342 46,4701 | 52,36 74,99 | 36,4639 61,3673 | 174,52 281,3 | 100,472 198,93 | 214,37 245,83 | 169,95 213,6297 |
| 5 | POJOK TENGAH | 351,354,371,374 356, 357,360,361, 364,365,368,369 | 20,22 15,594 | 27,632 19,975 | 53,53 12,2 | 57,064 17,181 | 5,9357 3,36 | 6,63833 4,98589 | 3,348 0,653 | 11,714 11,483 | 15,7476 3,37414 | 23,3255 1,34915 | 15,44 30,33 | 1,608 22,7892 | 80,958 52,647 | 98,4796 47,6971 | 102,06 79,321 | 90,28918 78,80418 |

Tabel 6.36.Momen maksimum kolom As 3 & 4

| LANTAI | KOLOM | ELEMEN | MD, KX | | MD, KY | | ML, KX | | ML, KY | | ME, KX | | ME, KY | | MU, KX | | MU, KY | |
|--------|---------|-----------------|--------|--------|--------|--------|--------|---------|--------|--------|---------|---------|--------|---------|--------|---------|--------|----------|
| | | | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah | atas | bawah |
| 1 | PINGGIR | 72,73,96,97 | 111,76 | 47,391 | 0,972 | 0,6158 | 37,386 | 8,8881 | 0,014 | 0,1055 | 113,115 | 161,021 | 75,98 | 144,665 | 584,71 | 703,018 | 347,26 | 608,6176 |
| | | 81,82,87,88 | 93,371 | 44,874 | 0,116 | 0,0247 | 31,226 | 10,3835 | 0,016 | 0,0364 | 110,955 | 121,345 | 154,5 | 197,535 | 626,32 | 626,928 | 591,62 | 736,9703 |
| 2 | PINGGIR | 142.143.166.167 | 129,26 | 160,55 | 4,078 | 2,5571 | 54,134 | 54,134 | 0,035 | 1,0717 | 139,533 | 135,704 | 86,49 | 66,829 | 713,83 | 716,037 | 408,63 | 342,5619 |
| | | 151.152.157.158 | 122,46 | 135,39 | 0,961 | 0,2929 | 43,337 | 46,7315 | 0,035 | 0,7027 | 108,373 | 103,387 | 160,3 | 169,388 | 666,91 | 676,967 | 608,28 | 632,3183 |
| 3 | PINGGIR | 212.213.236.237 | 114,56 | 127,67 | 6,396 | 5,8938 | 41,337 | 45,6948 | 0,01 | 1,9698 | 124,834 | 124,834 | 45,91 | 87,5774 | 454,77 | 499,36 | 181,79 | 270,8149 |
| | | 221.222.227.228 | 103,84 | 110,48 | 1,866 | 1,7253 | 36,169 | 38,4339 | 0,021 | 1,4923 | 121,843 | 121,843 | 128,3 | 131,4 | 483,69 | 495,014 | 348,1 | 356,0787 |
| 4 | PINGGIR | 282.283.306.307 | 141,27 | 167,6 | 9,509 | 8,0452 | 87,85 | 60,9062 | 0,321 | 2,5534 | 79,442 | 54,1629 | 65,79 | 14,8679 | 448,85 | 363,044 | 198,54 | 76,47387 |
| | | 291.292.297.298 | 133,38 | 137,84 | 2,246 | 2,1076 | 63,936 | 48,0072 | 0,053 | 2,1753 | 101,24 | 61,8202 | 93,17 | 58,986 | 478,49 | 362,125 | 261,86 | 167,3144 |
| 5 | PINGGIR | 352.353.372.373 | 1,5252 | 5,7879 | 3,825 | 4,5452 | 0,5534 | 2,1132 | 0,005 | 1,6635 | 31,6448 | 40,7471 | 0,275 | 0,60309 | 68,81 | 94,2449 | 24,536 | 33,45625 |

Tabel 6.37. Gaya aksial rencana kolom As 1 & 6

| LANTAI | KOLOM | ELEMEN | ND,k (kN) | NL,k (kN) | M nak,b-x (kNm) | | | | M nak,b-y (kNm) | | | | Ng, k (kN) | Nu,kx (kN) | | Nu,ky (kN) | |
|--------|---------|-----------------|-----------|-----------|-----------------|---|---------|-----|-----------------|-----|---------|-----|------------|------------|-----------|------------|-----------|
| | | | | | kiri | I | kanan | I | kiri | I | kanan | I | | maks | min | maks | min |
| | | | | | | | | | | | | | | | | | |
| 1 | POJOK | 75,78,91,94 | 523,099 | 65,993 | 0 | 1 | 404,375 | 3,6 | 0 | 1 | 404,375 | 4,8 | 589,092 | 498,147 | 738,94668 | 515,34694 | 721,7467 |
| | PINGGIR | 79,84,85,90 | 491,049 | 68,033 | 0 | 1 | 533,603 | 3,6 | 404,38 | 4,8 | 404,375 | 2,4 | 559,082 | 435,2266 | 738,84539 | 474,41327 | 699,65875 |
| 2 | POJOK | 145.148.161.164 | 711,056 | 96,486 | 0 | 1 | 404,375 | 3,6 | 0 | 1 | 404,375 | 4,8 | 807,543 | 727,5198 | 968,31949 | 744,71974 | 951,11951 |
| | PINGGIR | 149.154.155.160 | 380,489 | 53,9 | 0 | 1 | 533,603 | 3,6 | 404,38 | 4,8 | 404,375 | 2,4 | 434,388 | 304,2985 | 607,91723 | 343,4851 | 568,73058 |
| 3 | POJOK | 215.218.231.234 | 300,919 | 38,783 | 0 | 1 | 404,375 | 3,6 | 0 | 1 | 404,375 | 4,8 | 339,702 | 236,2869 | 477,0866 | 253,48685 | 459,88662 |
| | PINGGIR | 219.224.225.230 | 275,097 | 38,783 | 0 | 1 | 533,603 | 3,6 | 404,38 | 4,8 | 404,375 | 2,4 | 313,88 | 177,7641 | 481,38291 | 216,95079 | 442,19627 |
| 4 | POJOK | 285.288.301.304 | 186,721 | 24,334 | 0 | 1 | 404,375 | 3,6 | 0 | 1 | 404,375 | 4,8 | 211,055 | 101,2077 | 342,00744 | 118,40769 | 324,80745 |
| | PINGGIR | 289.294.295.300 | 163,558 | 23,789 | 0 | 1 | 533,603 | 3,6 | 404,38 | 4,8 | 404,375 | 2,4 | 187,347 | 44,90536 | 348,52414 | 84,092009 | 309,33749 |
| 5 | POJOK | 355.358.357.370 | 71,2859 | 9,5402 | 0 | 1 | 404,375 | 3,6 | 0 | 1 | 404,375 | 4,8 | 80,8261 | -35,5325 | 205,26722 | -18,332522 | 188,06724 |
| | PINGGIR | 359.362.363.366 | 58,3243 | 9,354 | 0 | 1 | 214,298 | 3,6 | 404,38 | 4,8 | 404,375 | 2,4 | 67,6782 | -3,138427 | 145,26268 | -18,277963 | 160,40222 |

Tabel 6.38. Gaya aksial rencana kolom As 2 & 5

| LANTAI | KOLOM | ELEMEN | ND,k (kN) | NL,k (kN) | M nak,b-x (kNm) | | | | M nak,b-y (kNm) | | | | Ng, k (kN) | Nu,kx (kN) | | Nu,ky (kN) | |
|--------|--------|---------------------------------|-----------|-----------|-----------------|-----|---------|-----|-----------------|-----|---------|-----|------------|------------|-----------|------------|-----------|
| | | | | | kiri | I | kanan | I | kiri | I | kanan | I | | maks | min | maks | min |
| | | | | | | | | | | | | | | | | | |
| 1 | POJOK | 71,74,95,98 | 911,33 | 121,74 | 533,603 | 7,2 | 0 | 1 | 0 | 1 | 533,603 | 4,8 | 1033,07 | 1120,393 | 1049,0608 | 1006,9099 | 1162,544 |
| | TENGAH | 76,77,80,83,86,89,92,93 | 1302,58 | 250,83 | 533,603 | 7,2 | 533,603 | 3,6 | 533,6 | 4,8 | 533,603 | 2,4 | 1553,41 | 1537,053 | 1725,1108 | 1514,3563 | 1747,8075 |
| 2 | POJOK | 141.144.165.168 | 413,464 | 52,807 | 533,603 | 7,2 | 0 | 1 | 0 | 1 | 533,603 | 4,8 | 468,271 | 525,2502 | 453,91793 | 411,76701 | 567,40116 |
| | TENGAH | 146,147,150,153,156,159,162,163 | 1008,06 | 190,84 | 533,603 | 7,2 | 533,603 | 3,6 | 533,6 | 4,8 | 533,603 | 2,4 | 1198,9 | 1164,812 | 1352,8703 | 1142,1157 | 1375,5669 |
| 3 | POJOK | 211.214.235.238 | 506,708 | 69,825 | 533,603 | 7,2 | 0 | 1 | 0 | 1 | 533,603 | 4,8 | 576,533 | 641,0259 | 569,69354 | 527,54263 | 683,17678 |
| | TENGAH | 216,217,220,223,226,229,232,233 | 713,242 | 131,55 | 533,603 | 7,2 | 533,603 | 3,6 | 533,6 | 4,8 | 533,603 | 2,4 | 844,792 | 793,0024 | 981,06036 | 770,30578 | 1003,757 |
| 4 | POJOK | 281.284.305.308 | 300,036 | 42,513 | 533,603 | 7,2 | 0 | 1 | 0 | 1 | 533,603 | 4,8 | 342,549 | 395,3423 | 324,01001 | 281,85909 | 437,49324 |
| | TENGAH | 286,287,290,293,296,299,302,303 | 417,891 | 72,418 | 533,603 | 7,2 | 533,603 | 3,6 | 533,6 | 4,8 | 533,603 | 2,4 | 490,309 | 420,7953 | 608,85323 | 398,09865 | 631,54987 |
| 5 | POJOK | 351.354.371.374 | 93,8151 | 15,379 | 214,298 | 7,2 | 0 | 1 | 0 | 1 | 533,603 | 4,8 | 109,194 | 111,5151 | 117,79166 | 25,195005 | 204,11181 |
| | TENGAH | 356,357,360,361,364,365,368,369 | 121,809 | 13,103 | 214,298 | 7,2 | 214,298 | 3,6 | 214,3 | 4,8 | 214,298 | 2,4 | 134,912 | 103,8945 | 179,41965 | 94,779422 | 188,53475 |

Tabel 6.39. Gaya aksial rencana kolom As 3 & 4

| LANTAI | KOLOM | ELEMEN | ND,k (kN) | NL,k (kN) | M nak,b-x (kNm) | | | | M nak,b-y (kNm) | | | | Ng, k (kN) | Nu,kx (kN) | | Nu,ky (kN) | |
|--------|-------------------|-----------------|--------------|--------------|-----------------|-----|---------|-----|-----------------|-----|---------|-----|---------------|------------|-----------|------------|-----------|
| | | | | | kiri | l | kanan | l | kiri | l | kanan | l | | maks | min | maks | min |
| 1 | PINGGIR TENGAH | 72,73,96,97 | 1728,79 | 359,04 | 533,603 | 7,2 | 533,603 | 7,2 | 0 | 1 | 1263,43 | 9,6 | 2087,83 | 2157,679 | 2226,7734 | 2077,0695 | 2307,3831 |
| | | 81,82,87,88 | 1621,95 | 466,95 | 533,603 | 7,2 | 533,603 | 7,2 | 1263,4 | 9,6 | 1263,43 | 2,4 | 2088,9 | 2089,704 | 2296,9859 | 1847,8744 | 2538,8152 |
| 2 | PINGGIR TENGAH | 142.143.166.167 | 1331,41 | 273,07 | 533,603 | 7,2 | 533,603 | 7,2 | 0 | 1 | 1263,43 | 9,6 | 1604,48 | 1650,156 | 1719,2505 | 1569,5467 | 1799,8603 |
| | | 151.152.157.158 | 1216,09 | 349,58 | 533,603 | 7,2 | 533,603 | 7,2 | 1263,4 | 9,6 | 1263,43 | 2,4 | 1565,67 | 1540,315 | 1747,5972 | 1298,4856 | 1989,4265 |
| 3 | PINGGIR TENGAH | 212.213.236.237 | 935,934 | 187,48 | 533,603 | 7,2 | 533,603 | 7,2 | 0 | 1 | 1263,43 | 9,6 | 1123,42 | 1145,042 | 1214,1362 | 1064,4323 | 1294,7459 |
| | | 221.222.227.228 | 811,33 | 233,06 | 533,603 | 7,2 | 533,603 | 7,2 | 1263,4 | 9,6 | 1263,43 | 2,4 | 1044,39 | 992,972 | 1200,2543 | 751,14274 | 1442,0836 |
| 4 | PINGGIR TENGAH | 282.283.306.307 | 541,382 | 101,99 | 533,603 | 7,2 | 533,603 | 7,2 | 0 | 1 | 1263,43 | 9,6 | 643,373 | 640,9944 | 710,08848 | 560,38463 | 790,69825 |
| | | 291.292.297.298 | 407,315 | 117,1 | 533,603 | 7,2 | 533,603 | 7,2 | 1263,4 | 9,6 | 1263,43 | 2,4 | 524,415 | 446,9942 | 654,27646 | 205,1649 | 896,10576 |
| 5 | PINGGIR | 352.353.372.373 | 149,332 | 17,415 | 533,603 | 7,2 | 533,603 | 7,2 | 0 | 1 | 1263,43 | 9,6 | 166,747 | 140,5369 | 209,631 | 59,92715 | 290,24077 |

Tabel 6.40. Gaya aksial maksimum kolom As 1 & 6

| LANTAI | KOLOM | ELEMEN | ND,k (kN) | NL,k (kN) | Ng, k (kN) | NE, k-X (kN) | NE, k-Y (kN) | Nu,k-x (kN) | | Nu,k-y (kN) | | Nu, k-x max (kN) | Nu, k-y max (kN) |
|--------|---------|-----------------|-----------|-----------|------------|--------------|--------------|-------------|-------------|-------------|-------------|------------------|------------------|
| | | | | | | | | atas | bawah | atas | bawah | | |
| 1 | POJOK | 75,78,91,94 | 523,0989 | 65,99331 | 589,09221 | 172,5119 | 74,31477 | 1539,006734 | -301,913093 | 1678,201166 | 22,873914 | 1539,006734 | 1678,201166 |
| | PINGGIR | 79,84,85,90 | 491,049 | 68,03291 | 559,08191 | 213,6973 | -0,1602769 | 1596,528555 | -422,456544 | 1899,671671 | 284,8773911 | 1596,528555 | 1899,671671 |
| 2 | POJOK | 145.148.161.164 | 711,0561 | 96,4864 | 807,5425 | 68,06697 | 181,034 | 1426,151753 | 269,6874968 | 1266,020988 | -103,950955 | 1426,151753 | 1266,020988 |
| | PINGGIR | 149.154.155.160 | 380,4889 | 53,89952 | 434,38842 | 132,9122 | 5,696075 | 1092,192172 | -179,97649 | 1272,52103 | 240,7908431 | 1092,192172 | 1272,52103 |
| 3 | POJOK | 215.218.231.234 | 300,9191 | 38,78255 | 339,70165 | 63,56942 | 26,97477 | 695,2889785 | 18,08448653 | 747,1618949 | 139,1212914 | 695,2889785 | 747,1618949 |
| | PINGGIR | 219.224.225.230 | 275,097 | 38,78255 | 313,87955 | -63,53991 | 26,97477 | 67,58418923 | 591,5628658 | -60,7203697 | 292,1855617 | 591,5628658 | 292,1855617 |
| 4 | POJOK | 285.288.301.304 | 186,7211 | 24,33373 | 211,05483 | 26,37093 | 11,17167 | 393,2546105 | 81,16908503 | 455,5836479 | 131,4406375 | 393,2546105 | 455,5836479 |
| | PINGGIR | 289.294.295.300 | 163,5579 | 23,78948 | 187,34738 | 16,05098 | 3,582723 | 277,6341394 | 115,7953586 | 295,3078937 | 157,0341187 | 277,6341394 | 295,3078937 |
| 5 | POJOK | 355.358.357.370 | 71,28586 | 9,540198 | 80,826058 | 7,232887 | 2,997062 | 123,2910874 | 46,44363444 | 129,2953693 | 60,45362563 | 123,2910874 | 129,2953693 |
| | PINGGIR | 359.362.363.366 | 58,32425 | 9,353966 | 67,678216 | 0,3644162 | -1,118306 | 71,19879459 | 70,92545901 | 73,30055331 | 75,82956269 | 71,19879459 | 75,82956269 |

Tabel 6.41. Gaya aksial maksimum kolom As 2 & 5

| LANTAI | KOLOM | ELEMEN | ND,k (kN) | NL,k (kN) | Ng, k (kN) | NE, k-X (kN) | NE, k-Y (kN) | Nu,k-x (kN) | | Nu,k-y (kN) | | Nu, k-x max (kN) | Nu, k-y max (kN) |
|--------|--------|-------------------|-----------|-----------|------------|--------------|--------------|-------------|-------------|-------------|-------------|------------------|------------------|
| | | | | | | | | atas | bawah | atas | bawah | | |
| 1 | POJOK | 71,74,95,98 | 911,3298 | 121,7435 | 1033,0733 | 102,1377 | 272,5331 | 1953,643267 | 215,8106633 | 1712,107787 | -188,605557 | 1953,643267 | 1712,107787 |
| | TENGAH | 78,83,86,89,92,93 | 1302,584 | 250,8273 | 1553,4113 | 118,8497 | 258,258 | 2558,727413 | 703,4363175 | 2361,116147 | 396,647643 | 2558,727413 | 2361,116147 |
| 2 | POJOK | 141.144.165.168 | 413,4635 | 52,80706 | 466,27056 | 114,8747 | 48,91791 | 1101,708183 | -122,540007 | 1195,201933 | 139,386744 | 1101,708183 | 1195,201933 |
| | TENGAH | 156,159,162,163 | 1008,06 | 190,8365 | 1198,8965 | 69,82577 | 137,5824 | 1958,774412 | 733,8915098 | 1830,714381 | 593,0147748 | 1958,774412 | 1830,714381 |
| 3 | POJOK | 211.214.235.238 | 508,7081 | 69,82495 | 576,53305 | 37,5404 | 98,15646 | 1027,379932 | 288,8445305 | 912,8155785 | 145,8016665 | 1027,379932 | 912,8155785 |
| | TENGAH | 226,229,232,233 | 713,2421 | 131,5497 | 844,7918 | 28,92634 | 43,97791 | 1152,385582 | 688,0157461 | 1123,938115 | 665,8769796 | 1152,385582 | 1123,938115 |
| 4 | POJOK | 281.284.305.308 | 300,0359 | 42,51283 | 342,54873 | 15,26198 | 38,04579 | 527,7331836 | 233,6334037 | 484,6717827 | 180,6537537 | 527,7331836 | 484,6717827 |
| | TENGAH | 296,299,302,303 | 417,8911 | 72,41772 | 490,30882 | 5,863545 | 4,070832 | 559,458467 | 481,3486065 | 562,8466946 | 490,3386999 | 559,458467 | 562,8466946 |
| 5 | POJOK | 351.354.371.374 | 93,81506 | 15,37866 | 109,19372 | 3,447321 | 5,994445 | 147,7010294 | 89,86788849 | 142,886965 | 85,13311254 | 147,7010294 | 142,886965 |
| | TENGAH | 364,365,368,369 | 121,8085 | 13,10301 | 134,91151 | 2,202105 | 3,319263 | 161,8037541 | 126,5470841 | 159,6923255 | 124,9415286 | 161,8037541 | 159,6923255 |

Tabel 6.42. Gaya aksial maksimum kolom As 3 & 4

| LANTAI | KOLOM | ELEMEN | ND,k (kN) | NL,k (kN) | Ng, k (kN) | NE, k-X (kN) | NE, k-Y (kN) | Nu,k-x (kN) | | Nu,k-y (kN) | | Nu, k-x max (kN) | Nu, k-y max (kN) |
|--------|---------|-----------------|-----------|-----------|------------|--------------|--------------|-------------|-------------|-------------|-------------|------------------|------------------|
| | | | | | | | | atas | bawah | atas | bawah | | |
| 1 | PINGGIR | 72,73,96,97 | 1728,79 | 359,0446 | 2087,8346 | 8,008978 | 92,48129 | 2361,16098 | 2023,29168 | 2241,421477 | 1743,899508 | 2361,16098 | 2241,421477 |
| | TENGAH | 81,82,87,88 | 1621,951 | 466,9488 | 2088,8998 | 2,531279 | 420,3535 | 2801,15617 | 1585,53341 | 2208,893171 | 203,5864145 | 2801,15617 | 2208,893171 |
| 2 | PINGGIR | 142.143.166.167 | 1331,412 | 273,0675 | 1604,4795 | 4,819875 | 63,94828 | 1798,124071 | 1571,282879 | 1714,309557 | 1375,715679 | 1798,124071 | 1714,309557 |
| | TENGAH | 151.152.157.158 | 1216,092 | 349,5804 | 1565,8724 | 2,91899 | 235,8936 | 1992,127426 | 1295,784614 | 1661,885916 | 525,2210917 | 1992,127426 | 1661,885916 |
| 3 | PINGGIR | 212.213.236.237 | 935,9335 | 187,4847 | 1123,4182 | 2,631032 | 36,6214 | 1243,931571 | 1115,246649 | 1195,750224 | 1002,823507 | 1243,931571 | 1195,750224 |
| | TENGAH | 221.222.227.228 | 811,3297 | 233,0638 | 1044,3935 | 2,639127 | 88,90523 | 1235,106214 | 958,1201364 | 1112,824013 | 672,7950007 | 1235,106214 | 1112,824013 |
| 4 | PINGGIR | 282.283.306.307 | 541,3821 | 101,9907 | 643,3728 | 1,4477 | 14,86944 | 703,4592537 | 647,6236263 | 684,4339373 | 603,2312213 | 703,4592537 | 684,4339373 |
| | TENGAH | 291.292.297.298 | 407,3145 | 117,1001 | 524,4146 | 1,877946 | 9,704064 | 573,2641356 | 528,0065244 | 562,1706133 | 502,1216391 | 573,2641356 | 562,1706133 |
| 5 | PINGGIR | 352.353.372.373 | 149,3318 | 17,41483 | 166,74663 | 0,2705914 | 0,312276 | 176,8051571 | 173,3627659 | 176,7460892 | 173,2248941 | 176,8051571 | 176,7460892 |

b. Perancangan penulangan lentur kolom

$$f_c' = 22,5 \text{ Mpa}$$

$$f_y = 400 \text{ Mpa}$$

$$b = 700 \text{ mm}$$

$$h = 700 \text{ mm}$$

$$d' = 50 \text{ mm}$$

$$d = 650 \text{ mm}$$

$$\frac{1}{P_n} = \frac{1}{P_{n-kx}} + \frac{1}{P_{n-ky}} - \frac{1}{P_{no}}$$

$$P_{n,kx} = \frac{2025,48}{0,7} = 2893,54 \text{ kN}$$

$$P_{n,ky} = \frac{2012,61}{0,7} = 2875,16 \text{ kN}$$

$$P_{u_o} = 0,85 \cdot f_c' \cdot (A_g - A_s) + A_s \cdot f_y$$

$$P_{u_o} = 0,85 \cdot 22,5 \cdot (490000 - 28 \cdot 490,1) + 28 \cdot 490,1 \cdot 400$$

$$= 14597921,45 \text{ N}$$

$$P_{no} = \frac{14597,92}{0,7} = 20854,17 \text{ kN}$$

$$\frac{1}{P_n} = \frac{1}{2893,554} + \frac{1}{2875,16} - \frac{1}{20854,17}$$

$$P_n = 1549,30 \text{ kN}$$

$$M_{u,kx} = 602,52 \text{ kNm}$$

$$M_{n,kx} = \frac{M_{u,kx}}{\phi} = \frac{602,52}{0,7} = 860,74 \text{ kNm}$$

$$M_{u,ky} = 774,797 \text{ kNm}$$

$$M_{n,ky} = \frac{M_{u,ky}}{\phi} = \frac{774,797}{0,7} = 1106,85 \text{ kNm}$$

Eksentrisitas ekivalen terhadap sumbu y karena momen arah y lebih besar :

$$\frac{M_{n,ky}}{M_{n,kx}} = \frac{1106,85}{860,85} = 1,29$$

Diasumsikan faktor kontur interaksi $\beta = 0,8$ sesuai dengan yang disarankan pada perencanaan.

Momen uniaksial ekivalen yang diperlukan dihitung sebagai berikut :

$$M_{oy,perlu} = M_{n,ky} + M_{n,kx} \left(\frac{b}{h} \right) \frac{1-\beta}{\beta}$$

$$M_{oy,perlu} = 1106,85 \cdot 10^6 + 860,74 \cdot 10^6 \left(\frac{700}{700} \right) \frac{1-0,8}{0,8}$$

$$= 1223035000 \text{ Nmm}$$

$$= 1223,035 \text{ kNm}$$

Dicoba penulangan $\rho = \rho' = 0,007$

$$A_s = A_s' = 0,007 \cdot 650 \cdot 700 = 3185 \text{ mm}^2.$$

Diameter tulangan digunakan = 25 mm

A_s tiap tulangan = 490,1 mm².

Dicoba menggunakan tulangan 8 D25 ($A_s = A_s' = 3920,8 \text{ mm}^2$) pada masing masing sisi yang sejajar dengan sumbu y. Untuk mengetahui jenis keruntuhan yang terjadi, dianalisis dengan kondisi balance :

$$C_b = \frac{600d}{600 + f_y} = \frac{600 \cdot 650}{600 + 400} = 390 \text{ mm}$$

$$a_b = \beta_1 \cdot C_b = 0,85 \cdot 390 = 331,5 \text{ mm}$$

$$f_s' = 600 \left(\frac{C_b - d'}{C_b} \right) = 600 \left(\frac{390 - 50}{390} \right)$$

$$= 523,08 \text{ Mpa} > f_y = 400 \text{ Mpa}$$

Dengan demikian digunakan $f_s' = f_y = 400 \text{ Mpa}$.

$$P_{nb} = 0,85 \cdot f_c' \cdot b \cdot a_b + A_s' \cdot f_s' - A_s \cdot f_y$$

$$= 0,85 \cdot 22,5 \cdot 700 \cdot 331,5$$

$$= 4437956,25 \text{ N} > P_n \text{ perlu}$$

maka keruntuhan yang menentukan adalah lelehnya tulangan tarik.

Selanjutnya analisis tampang terhadap beban yang bekerja.

$$\rho = \frac{A_s}{b.d} = \frac{3920,8}{700.650} = 0,0086$$

$$m = \frac{f_y}{0,85.f_c'} = \frac{400}{0,85.22,5} = 20,91$$

$$e = \frac{M_{oy}}{P_n} = \frac{1223035000}{1549300} = 789,41 \text{ mm}$$

$$\frac{h-2e}{2d} = \frac{700 - 2.789,41}{2.650} = -0,67$$

$$1 - \frac{d'}{d} = 1 - \frac{50}{650} = 0,923$$

$$P_n = 0,85.f_c'.b.d \left[\frac{h-2e}{2d} + \sqrt{\left(\frac{h-2e}{2d} \right)^2 + 2m\rho \left(1 - \frac{d'}{d} \right)} \right]$$

$$= 0,85.22,5.700.650.[-0,67 + \sqrt{-0,67^2 + 2.20,91.0,0086.0,923}]$$

$$= 1859261,32 \text{ N}$$

$$= 1859,261 \text{ kN} > 1549,30 \text{ kN}$$

$$P_r = \theta.P_n$$

$$= 0,7.1859,261$$

$$= 1301,5 \text{ kN}$$

$$P_r > 0,1.A_g.f_c'^2$$

$$\text{Luas kotor penampang kolom } (A_g) = 700 \times 700 = 490000 \text{ mm}^2.$$

$$> 0,1.22,5.490000$$

$$> 1102500 \text{ N}$$

$$> 1102,50 \text{ kN}$$

Maka tetap dipakai $\theta = 0,7$.

Cek apakah benar tegangan pada tulangan desak $f_s' \geq f_y$

$$a = \frac{P_n}{0,85.f_c'.b} = \frac{1869261}{0,85.22,5.700} = 139,62 \text{ mm}$$

$$C = \frac{139,62}{0,85} = 164,27 \text{ mm}$$

$$f_s' = 600 \left(\frac{164,27 - 50}{164,27} \right) = 417,37 \text{ Mpa} > f_y = 400$$

Kemudian dihitung momen tahanan nominal aktual $M_{o,yn}$ untuk lentur uniaksial ekuivalen terhadap sumbu y ($M_{oy} = 0$). Keruntuhan yang terjadi adalah keruntuhan tarik. Dengan menganggap bahwa pada keadaan beban P_n yang diperlukan tulangan tekan telah leleh, maka didapat :

$$a = \frac{P_n}{0,85 \cdot f_c' \cdot b} = \frac{1549300}{0,85 \cdot 22,5 \cdot 700} = 115,73 \text{ mm}$$

$$C = \frac{115,73}{0,85} = 136,15 \text{ mm}$$

$$f_s' = 600 \left(\frac{136,15 - 50}{136,15} \right) = 380 \text{ Mpa} < f_y = 400 \text{ asumsi salah sehingga}$$

$$P_n = 0,85 f_c' \cdot a \cdot b + A_s' \left(\frac{a - 0,85 \cdot d'}{a} \right) 600 - A_s \cdot f_y$$

$$1549300 = 0,85 \cdot 22,5 \cdot a \cdot 700 + 3920,8 \left(\frac{a - 0,85 \cdot 50}{a} \right) \cdot 600 - 3920,8 \cdot 400$$

$$13387,5 a^2 - 765140 a - 99980400 = 0$$

dengan rumus abc didapat :

$$a = 119,6 \text{ mm}$$

$$C = \frac{119,6}{0,85} = 140,70 \text{ mm}$$

$$f_s' = 600 \left(\frac{140,70 - 50}{140,70} \right) = 386,79 \text{ Mpa} < f_y = 400 \text{ ok}$$

$$M_{o,yn} = P_u \cdot e$$

$$= 0,85 \cdot f_c' \cdot b \cdot a \left(\frac{h}{2} - \frac{a}{2} \right) + A_s' \cdot f_s' \left(\frac{h}{2} - d' \right) + A_s \cdot f_y \left(d - \frac{h}{2} \right)$$

$$= 0,85 \cdot 22,5 \cdot 700 \cdot 119,6 \left(\frac{700}{2} - \frac{119,6}{2} \right) + 3920,8 \cdot 386,79 \left(\frac{700}{2} - 50 \right)$$

$$+ 3920,8 \cdot 400 \left(650 - \frac{700}{2} \right)$$

$$= 1390100333,81 \text{ Nmm}$$

$$= 1390,1 \text{ kNm} > m_{oy} = 1223,035 \text{ kNm. Ok}$$

Selanjutnya menentukan momen tahanan nominal aktual M_{oxn} untuk momen lentur uniaksial ekuivalen terhadap sumbu x dimana $M_{oy} = 0$.

Dalam kondisi ini $A_s = A_s' = 3920,8 \text{ mm}^2$.

Menentukan tinggi blok tegangan a atau tinggi garis netral dengan coba-coba dan penyesuaian sehingga P_n yang dihitung mendekati P_n yang diperlukan.

Dicoba :

$$a = 120 \text{ mm}$$

$$c = \frac{120}{0,85} = 141,18 \text{ mm}$$

$$f_s' = 600 \left(\frac{141,18 - 50}{141,18} \right) = 387,5 \text{ Mpa} < f_y = 400$$

$$f_s = 600 \left(\frac{650 - 141,18}{141,18} \right) = 2162,85 \text{ Mpa} > f_y = 400 \text{ Mpa}$$

Digunakan $f_s' = 387,5 \text{ Mpa}$ dan $f_s = 400 \text{ Mpa}$.

$$P_n = 0,85 f_c' a b + A_s' f_s' - A_s f_s$$

$$P_n = 0,85 \cdot 22,5 \cdot 120 \cdot 700 + 3920,8 \cdot 387,5 - 3920,8 \cdot 400$$

$$P_n = 1557490 \text{ N}$$

$$= 1557,49 \text{ kN. } \approx 1549,30 \text{ kN ok.}$$

Dengan demikian digunakan $a = 120 \text{ mm}$ untuk menghitung M_{oxn}

$$M_{oxn} = P_n \cdot e$$

$$= 0,85 \cdot f_c' \cdot b \cdot a \left(\frac{h}{2} - \frac{a}{2} \right) + A_s' \cdot f_s' \left(\frac{h}{2} - d' \right) + A_s \cdot f_y \left(d - \frac{h}{2} \right)$$

$$= 0,85 \cdot 22,5 \cdot 700 \cdot 120 \cdot \left(\frac{700}{2} - \frac{120}{2} \right) + 3920,8 \cdot 387,5 \left(\frac{700}{2} - 50 \right)$$

$$+ 3920,8 \cdot 400 \left(650 - \frac{700}{2} \right)$$

$$= 1392174000 \text{ Nmm}$$

$$= 1392,174 \text{ kNm}$$

kemudian untuk mencari M_{nx} diperlukan data M_{ny}/M_{oy} dan faktor β yang selanjutnya diplotkan pada diagram faktor kontur.

$$\frac{M_{ny}}{M_{oy}} = \frac{1106,85}{1390,1} = 0,79$$

$$\beta = 0,8$$

Dari kedua data tersebut diperoleh :

$$\frac{M_{nx}}{M_{ox}} = 0,81$$

$$M_{nx} = 0,81 \cdot 1106,85$$

$$M_{nx} = 896,55 \text{ kNm} > M_{nx} \text{ perlu} = 860,85 \text{ kNm} \dots \text{ok}$$

Jadi ukuran penampang dan penulangannya dapat digunakan.

Hasil perhitungan penulangan kolom selanjutnya dapat dilihat pada tabel

6.43 s/d 6.45

Tabel 6.43. Penulangan lentur kolom As 1 & 6

| LANTAI | KOLOM | ELEMEN | h (mm) | b (mm) | d (mm) | fc' (Mpa) | fy (Mpa) | Pu, x (kN) | Pu, y (kN) | Mu, x (kNm) | Mu, y (kNm) | n tul tot osumsal | D tul (mm) | As tul tot (mm ²) | n tul tiap sisi | As tul (mm ²) | As' tul (mm ²) | Pno (kN) | Pn (kN) | β | Mo, perlu (kNm) | C b (mm) | a b (mm) |
|--------|------------------|-----------------|--------|--------|--------|-----------|----------|------------|------------|-------------|-------------|-------------------|------------|-------------------------------|-----------------|---------------------------|----------------------------|-------------|-------------|-----|-----------------|----------|----------|
| 1 | POJOK PINGGIR | 75,78,91,84 | 700 | 700 | 650 | 22,5 | 400 | 1539,0087 | 1678,2012 | 319,168 | 333,7688 | 18 | 25 | 8839,2857 | 5,5 | 2700,893 | 2700,8929 | 18197,01849 | 1444,182095 | 0,8 | 523,4946 | 390 | 331,5 |
| | | 79,84,85,90 | 700 | 250 | 650 | 22,5 | 400 | 1596,5288 | 1899,6717 | 225,196 | 199,4942 | 16 | 25 | 7857,1429 | 5 | 2455,357 | 2455,3571 | 9056,377551 | 1720,459656 | 0,8 | 343,32761 | 390 | 331,5 |
| 2 | POJOK PINGGIR | 145,148,161,164 | 700 | 700 | 650 | 22,5 | 400 | 1426,1519 | 1268,021 | 249,701 | 232,3543 | 18 | 25 | 8839,2857 | 5,5 | 2700,893 | 2700,8929 | 18197,01849 | 1190,923742 | 0,8 | 439,69921 | 390 | 331,5 |
| | | 149,154,155,160 | 700 | 250 | 650 | 22,5 | 400 | 1092,1022 | 1272,521 | 263,082 | 207,0868 | 18 | 25 | 7857,1429 | 5 | 2455,357 | 2455,3571 | 9056,377551 | 1098,370711 | 0,8 | 402,24593 | 390 | 331,5 |
| 3 | POJOK PINGGIR | 215,218,231,234 | 700 | 700 | 650 | 22,5 | 400 | 695,28898 | 747,16189 | 230,587 | 213,7883 | 18 | 25 | 8839,2857 | 5,5 | 2700,893 | 2700,8929 | 18197,01849 | 620,7198652 | 0,8 | 405,76255 | 390 | 331,5 |
| | | 218,224,225,230 | 700 | 250 | 650 | 22,5 | 400 | 591,58287 | 442,19627 | 201,279 | 158,5098 | 18 | 25 | 7857,1429 | 5 | 2455,357 | 2455,3571 | 9056,377551 | 442,3395807 | 0,8 | 307,75958 | 390 | 331,5 |
| 4 | POJOK PINGGIR | 285,288,301,304 | 700 | 700 | 650 | 22,5 | 400 | 393,25481 | 455,58365 | 175,322 | 163,2918 | 18 | 25 | 8839,2857 | 5,5 | 2700,893 | 2700,8929 | 18197,01849 | 409,6473187 | 0,8 | 270,1813 | 390 | 331,5 |
| | | 289,294,295,300 | 700 | 250 | 650 | 22,5 | 400 | 348,52414 | 309,33749 | 120,981 | 95,56544 | 18 | 25 | 7857,1429 | 5 | 2455,357 | 2455,3571 | 9056,377551 | 309,8389466 | 0,8 | 165,01973 | 390 | 331,5 |
| 5 | POJOK PINGGIR | 355,358,357,370 | 700 | 700 | 650 | 22,5 | 400 | 205,26722 | 188,06724 | 85,1917 | 78,8863 | 18 | 25 | 8839,2857 | 5,5 | 2700,893 | 2700,8929 | 18197,01849 | 180,2137576 | 0,8 | 724,01561 | 390 | 331,5 |
| | | 359,362,363,366 | 700 | 250 | 650 | 22,5 | 400 | 145,26268 | 160,40222 | 20,12 | 37,87831 | 18 | 25 | 7857,1429 | 5 | 2455,357 | 2455,3571 | 9056,377551 | 128,8555909 | 0,8 | 56,392488 | 390 | 331,5 |

Tabel 6.44. Penulangan lentur kolom As 2 & 5

| LANTAI | KOLOM | ELEMEN | h (mm) | b (mm) | d (mm) | fc' (Mpa) | fy (Mpa) | Pu, x (kN) | Pu, y (kN) | Mu, x (kNm) | Mu, y (kNm) | n tul tot osumsal | D tul (mm) | As tul tot (mm ²) | n tul tiap sisi | As tul (mm ²) | As' tul (mm ²) | Pno (kN) | Pn (kN) | β | Mo, perlu (kNm) | C b (mm) | a b (mm) |
|--------|-----------------|---------------------------------|--------|--------|--------|-----------|----------|------------|------------|-------------|-------------|-------------------|------------|-------------------------------|-----------------|---------------------------|----------------------------|-------------|-------------|------|-----------------|----------|----------|
| 1 | POJOK TENGAH | 71,74,85,98 | 700 | 700 | 650 | 22,5 | 400 | 1953,8433 | 1712,1078 | 409,68 | 422,0718 | 16 | 25 | 7857,1429 | 5 | 2455,357 | 2455,3571 | 17862,62755 | 1830,99889 | 0,8 | 617,04926 | 390 | 331,5 |
| | | 78,77,80,83,88,89,92,93 | 700 | 700 | 650 | 22,5 | 400 | 2558,7274 | 2381,1161 | 687,24 | 827,7206 | 12 | 25 | 5892,8571 | 4 | 1964,286 | 1964,2857 | 16593,84566 | 2579,793154 | 0,8 | 1124,7481 | 390 | 331,5 |
| 2 | POJOK TENGAH | 141,144,165,168 | 700 | 700 | 650 | 22,5 | 400 | 1101,7082 | 1195,2019 | 348,37 | 474,579 | 18 | 25 | 7857,1429 | 5 | 2455,357 | 2455,3571 | 17862,62755 | 1107,687956 | 0,8 | 680,79005 | 390 | 331,5 |
| | | 148,147,150,153,158,159,162,163 | 700 | 700 | 650 | 22,5 | 400 | 1958,7744 | 1830,7144 | 616,037 | 679,5654 | 12 | 25 | 5892,8571 | 4 | 1964,286 | 1964,2857 | 16593,84566 | 1919,556441 | 0,8 | 980,87593 | 390 | 331,5 |
| 3 | POJOK TENGAH | 211,214,235,238 | 700 | 700 | 650 | 22,5 | 400 | 1027,3799 | 912,81558 | 287,591 | 318,7996 | 12 | 25 | 5892,8571 | 4 | 1964,286 | 1964,2857 | 16593,84566 | 927,9791628 | 0,8 | 446,85773 | 390 | 331,5 |
| | | 216,217,220,223,226,229,232,233 | 700 | 700 | 650 | 22,5 | 400 | 1152,3856 | 1123,9381 | 433,738 | 477,9876 | 12 | 25 | 5892,8571 | 4 | 1964,286 | 1964,2857 | 16593,84566 | 1103,316438 | 0,77 | 690,36962 | 390 | 331,5 |
| 4 | POJOK TENGAH | 281,284,306,308 | 700 | 700 | 650 | 22,5 | 400 | 527,73318 | 484,67178 | 174,519 | 214,373 | 12 | 25 | 5892,8571 | 4 | 1964,286 | 1964,2857 | 16593,84566 | 472,4293563 | 0,8 | 293,18486 | 390 | 331,5 |
| | | 286,287,290,293,298,299,302,303 | 700 | 700 | 650 | 22,5 | 400 | 608,85323 | 631,54987 | 281,302 | 245,8336 | 12 | 25 | 5892,8571 | 4 | 1964,286 | 1964,2857 | 16593,84566 | 644,0577561 | 0,8 | 389,50046 | 390 | 331,5 |
| 5 | POJOK TENGAH | 351,354,371,374 | 700 | 700 | 650 | 22,5 | 400 | 147,70103 | 204,11181 | 88,4786 | 102,0591 | 12 | 25 | 5892,8571 | 4 | 1964,286 | 1964,2857 | 16593,84566 | 173,1724297 | 0,8 | 143,95345 | 390 | 331,5 |
| | | 356,357,360,361,364,365,368,369 | 700 | 700 | 650 | 22,5 | 400 | 179,41965 | 188,53475 | 52,8472 | 79,32055 | 12 | 25 | 5892,8571 | 4 | 1964,286 | 1964,2857 | 16593,84566 | 168,8501844 | 0,8 | 105,09358 | 390 | 331,5 |

| fs' (kN) | fs' digunakan (kN) | runtuh menentukan | Pn, b (kN) | > Pn perlu | Analisis tumpang tnd beban | | | Pn Dengan anggapan As' leleh | | | ket | a | C | fs' | ket | Momen tahanan nominal asumsi As' leleh | | | | Q | C | fs' | ket | fs' terpakai | Mo, n |
|----------|--------------------|-------------------|------------|------------|----------------------------|--------|--------|------------------------------|----------|-----------|-------|--------|---------|---------|-------|--|---------|---------|-------------|---------|---------|---------|-------------|--------------|----------|
| | | | | | p | m | e (mm) | Pn | Pr | 0,1 Ag.fc | | | | | | a | c | fs' | ket | | | | | | |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,005936 | 20,915 | 362,49 | 4002,25 | 2801,577 | 1102,5 | tetap | 298,95 | 351,711 | 514,703 | benar | 107,875 | 126,912 | 363,816 | belum leleh | 113,038 | 132,986 | 374,412 | belum leleh | 374,411712 | 1055,049 |
| 523,077 | 400 | tulangan | 1881,2305 | ok | 0,0151099 | 20,915 | 189,56 | 3198,73 | 2239,808 | 393,75 | tetap | 669,22 | 787,322 | 581,896 | benar | 358,835 | 423,335 | 529,134 | leleh | 300,679 | 353,74 | 515,192 | leleh | 400 | 881,8061 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,005936 | 20,915 | 369,21 | 3918,82 | 2741,774 | 1102,5 | tetap | 292,57 | 344,203 | 512,842 | benar | 88,9579 | 104,856 | 313,348 | belum leleh | 100,036 | 117,689 | 345,091 | belum leleh | 345,090993 | 987,5755 |
| 523,077 | 400 | tulangan | 1584,9844 | ok | 0,0151099 | 20,915 | 388,22 | 2297,54 | 1608,276 | 393,75 | tetap | 480,53 | 565,33 | 546,934 | benar | 229,725 | 270,264 | 488,998 | leleh | 194,385 | 228,888 | 468,817 | leleh | 400 | 847,5541 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,005936 | 20,915 | 853,7 | 1755,44 | 1228,808 | 1102,5 | tetap | 131,13 | 154,265 | 405,529 | benar | 48,3856 | 54,5477 | 50,0228 | belum leleh | 74,7967 | 87,9961 | 259,078 | belum leleh | 259,075695 | 736,3895 |
| 523,077 | 400 | tulangan | 1584,9844 | ok | 0,0151099 | 20,915 | 695,75 | 1239,6 | 887,7175 | 393,75 | tetap | 259,28 | 305,014 | 501,844 | benar | 92,5155 | 103,842 | 324,37 | belum leleh | 109,452 | 128,767 | 367,021 | belum leleh | 367,02053 | 699,35 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,005936 | 20,915 | 659,55 | 1732,1 | 1212,487 | 1102,5 | tetap | 129,38 | 152,214 | 402,909 | benar | 30,5992 | 35,9991 | -233,35 | belum leleh | 67,0159 | 78,8423 | 219,494 | belum leleh | 219,493533 | 639,0648 |
| 523,077 | 400 | tulangan | 1584,9844 | ok | 0,0151099 | 20,915 | 597,15 | 1470 | 1029,002 | 393,75 | tetap | 307,45 | 361,708 | 517,06 | benar | 64,8029 | 76,2387 | 206,499 | belum leleh | 97,0408 | 114,166 | 337,224 | belum leleh | 337,224 | 641,4489 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,005936 | 20,915 | 888,16 | 1688,96 | 1308,272 | 1102,5 | tetap | 139,6 | 164,241 | 417,342 | benar | 13,4613 | 15,8369 | -1294,3 | belum leleh | 59,5306 | 70,036 | 171,649 | belum leleh | 171,648822 | 525,0505 |
| 523,077 | 400 | tulangan | 1584,9844 | ok | 0,0151099 | 20,915 | 437,64 | 1891,49 | 1384,045 | 393,75 | tetap | 416,52 | 490,025 | 538,779 | benar | 26,9502 | 31,7061 | -346,19 | belum leleh | 82,8618 | 97,2492 | 281,514 | belum leleh | 281,51423 | 552,7374 |

| fs' (kN) | fs' digunakan (kN) | runtuh menentukan | Pn, b (kN) | > Pn perlu | Analisis tumpang tnd beban | | | Pn Dengan anggapan As' leleh | | | ket | a | C | fs' | ket | Momen tahanan nominal asumsi As' leleh | | | | Q | C | fs' | ket | fs' terpakai | Mo, n |
|----------|--------------------|-------------------|------------|------------|----------------------------|--------|--------|------------------------------|----------|-----------|-------|--------|---------|---------|-------|--|---------|---------|-------------|---------|---------|---------|-------------|--------------|----------|
| | | | | | p | m | e (mm) | Pn | Pr | 0,1 Ag.fc | | | | | | a | c | fs' | ket | | | | | | |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0053964 | 20,915 | 337 | 4150 | 2904,998 | 1102,5 | tetap | 309,99 | 364,695 | 517,739 | benar | 136,769 | 160,905 | 413,555 | leleh | 134,788 | 158,572 | 410,812 | leleh | 400 | 1104,923 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0043171 | 20,915 | 435,98 | 2583,53 | 1808,473 | 1102,5 | tetap | 192,98 | 227,036 | 467,863 | benar | 192,702 | 226,708 | 467,671 | leleh | 183,722 | 216,143 | 461,203 | leleh | 400 | 1125,791 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0053964 | 20,915 | 588,55 | 1863,68 | 1304,713 | 1102,5 | tetap | 139,23 | 163,794 | 416,843 | benar | 82,7405 | 97,3417 | 291,807 | belum leleh | 95,1907 | 111,989 | 332,117 | belum leleh | 332,11672 | 881,1479 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0043171 | 20,915 | 510,89 | 2000,84 | 1400,591 | 1102,5 | tetap | 149,46 | 175,831 | 428,381 | benar | 143,384 | 168,687 | 422,156 | leleh | 140,642 | 165,461 | 418,689 | leleh | 400 | 1005,856 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0043171 | 20,915 | 625,72 | 1718,42 | 1563,784 | 1102,5 | tetap | 128,38 | 151,012 | 401,34 | benar | 82,4139 | 96,9576 | 290,586 | belum leleh | 93,2098 | 109,658 | 326,423 | belum leleh | 326,422893 | 768,7671 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0043171 | 20,915 | 620,59 | 1741,74 | 1463,059 | 1102,5 | tetap | 130,1 | 153,061 | 404 | benar | 35,2888 | 41,5163 | -122,61 | belum leleh | 84,2118 | 75,5433 | 202,877 | belum leleh | 202,876864 | 512,2812 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0043171 | 20,915 | 604,78 | 1741,45 | 1402,819 | 1102,5 | tetap | 120,08 | 153,036 | 403,967 | benar | 48,1089 | 56,5987 | 69,9524 | belum leleh | 71,265 | 83,8412 | 242,181 | belum leleh | 242,180588 | 588,3556 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0043171 | 20,915 | 831,27 | 1829,26 | 1280,479 | 1102,5 | tetap | 136,64 | 160,752 | 413,377 | benar | 12,9354 | 15,2181 | -1371,3 | belum leleh | 53,5108 | 62,9538 | 123,46 | belum leleh | 123,460345 | 367,958 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0043171 | 20,915 | 622,41 | 1733,42 | 1334,733 | 1102,5 | tetap | 129,48 | 152,33 | 403,059 | benar | 12,6125 | 14,8383 | -1421,8 | belum leleh | 53,371 | 62,7894 | 122,212 | belum leleh | 122,212456 | 365,7651 |

| ket > Mo | Momen tahanan thd sb lain dgn coba 2x | | | | fs' terpakai | fs | ket | fs terpakai | Mo,n | (Mn/Mo,n) | ket | (Mn/Mo,n) sumbu lain(tabel) | Mn | ket |
|----------|---------------------------------------|--------|--------|-------------|--------------|----------|-------|-------------|----------|-------------|----------|-----------------------------|----------|-----|
| | a coba 2x | C | fs' | ket | | | | | | | | | | |
| ok | 113,0378 | 132,99 | 374,41 | belum leleh | 374,4117 | 2332,648 | leleh | 400 | 1071,604 | 0,400448002 | Mny/Moyn | 0,97 | 409,8174 | ok |
| ok | 300,8791 | 353,74 | 515,19 | leleh | 400 | 502,5041 | leleh | 400 | 876,322 | 0,384787676 | Mnx/Moxn | 0,98 | 315,2743 | ok |
| ok | 100,0357 | 117,69 | 345,09 | belum leleh | 345,0909 | 2713,818 | leleh | 400 | 1005,468 | 0,368669468 | Mnx/Moxn | 0,98 | 349,5812 | ok |
| ok | 194,3845 | 228,89 | 468,82 | leleh | 400 | 1105,383 | leleh | 400 | 824,2455 | 0,443431049 | Mnx/Moxn | 0,97 | 364,5568 | ok |
| ok | 74,79688 | 87,996 | 259,08 | belum leleh | 259,0757 | 3832,016 | leleh | 400 | 847,0485 | 0,447027138 | Mnx/Moxn | 0,97 | 319,5273 | ok |
| ok | 109,4517 | 128,77 | 367,02 | belum leleh | 367,0205 | 2428,733 | leleh | 400 | 719,5145 | 0,411155347 | Mnx/Moxn | 0,98 | 278,9153 | ok |
| ok | 67,01594 | 78,842 | 219,49 | belum leleh | 219,4935 | 4348,584 | leleh | 400 | 785,9047 | 0,342927031 | Mnx/Moxn | 0,98 | 214,7695 | ok |
| ok | 97,04083 | 114,17 | 337,22 | belum leleh | 337,224 | 2816,088 | leleh | 400 | 882,9239 | 0,269437313 | Mnx/Moxn | 1 | 172,8303 | ok |
| ok | 59,53059 | 70,036 | 171,65 | belum leleh | 171,6488 | 4968,585 | leleh | 400 | 718,4048 | 0,193128065 | Mnx/Moxn | 1 | 101,402 | ok |
| ok | 82,86184 | 97,249 | 291,51 | belum leleh | 291,5142 | 3410,315 | leleh | 400 | 631,3688 | 0,097381068 | Mny/Moyn | 1 | 53,82816 | ok |

| ket > Mo | Momen tahanan thd sb lain dgn coba 2x | | | | fs' terpakai | fs | ket | fs terpakai | Mo,n | (Mn/Mo,n) | ket | (Mn/Mo,n) sumbu lain(tabel) | Mn | ket |
|----------|---------------------------------------|--------|--------|-------------|--------------|----------|-------|-------------|----------|-------------|----------|-----------------------------|----------|-----|
| | a coba 2x | C | fs' | ket | | | | | | | | | | |
| ok | 134,7863 | 158,57 | 410,81 | leleh | 400 | 1859,448 | leleh | 400 | 1099,238 | 0,449402387 | Mny/Moyn | 0,975 | 484,1412 | ok |
| ok | 183,7216 | 216,14 | 461,2 | leleh | 400 | 1204,361 | leleh | 400 | 1108,341 | 0,864981688 | Mny/Moyn | 0,82 | 798,5069 | ok |
| ok | 95,19071 | 111,89 | 332,12 | belum leleh | 332,1167 | 2882,483 | leleh | 400 | 924,6565 | 0,633637398 | Mny/Moyn | 0,93 | 519,2453 | ok |
| ok | 140,6421 | 165,48 | 418,89 | leleh | 400 | 1757,048 | leleh | 400 | 998,0211 | 0,794992007 | Mny/Moyn | 0,91 | 727,5347 | ok |
| ok | 84,33598 | 89,219 | 297,64 | belum leleh | 297,6379 | 3330,708 | leleh | 400 | 758,665 | 0,514782539 | Mny/Moyn | 0,95 | 344,1587 | ok |
| ok | 100 | 117,85 | 345 | belum leleh | 345 | 2715 | leleh | 400 | 840,6429 | 0,706514756 | Mny/Moyn | 0,92 | 499,6937 | ok |
| ok | 64,21181 | 75,543 | 202,89 | belum leleh | 202,8768 | 4562,602 | leleh | 400 | 628,5398 | 0,475531227 | Mny/Moyn | 0,96 | 233,8615 | ok |
| ok | 71,265 | 83,841 | 242,18 | belum leleh | 242,1808 | 4051,852 | leleh | 400 | 678,3534 | 0,543313183 | Mnx/Moxn | 0,95 | 303,6783 | ok |
| ok | 53,51076 | 62,954 | 123,46 | belum leleh | 123,4603 | 5595,016 | leleh | 400 | 540,0322 | 0,315188945 | Mny/Moyn | 0,99 | 114,8165 | ok |
| ok | 53,371 | 62,789 | 122,21 | belum leleh | 122,2125 | 5611,239 | leleh | 400 | 538,7419 | 0,246434101 | Mny/Moyn | 1 | 90,13999 | ok |

Tabel 6.45. Penulangan lentur kolom As 3 & 4

| LANTAI | KOLOM | ELEMEN | h (mm) | b (mm) | d (mm) | fc' (Mpa) | fy (Mpa) | Pu, x (kN) | Pu, y (kN) | Mu, x (kNm) | Mu, y (kNm) | n tul total | D tul (mm) | As tul total (mm²) | n tul tiap sisi | As tul (mm²) | As' tul (mm²) | Pno (kN) | Pn (kN) | β | Mo, perlu (kNm) | C b (mm) | a b (mm) |
|--------|---------|-----------------|--------|--------|--------|-----------|----------|------------|------------|-------------|-------------|-------------|------------|--------------------|-----------------|--------------|---------------|-------------|-------------|-----|-----------------|----------|----------|
| 1 | PINGGIR | 72,73,98,97 | 700 | 700 | 650 | 22,5 | 400 | 2361,161 | 2307,3831 | 703,016 | 608,8178 | 24 | 25 | 11785,714 | 7 | 3437,5 | 3437,5 | 19800,19133 | 2156,833943 | 0,8 | 1008,0857 | 390 | 331,5 |
| | TENGAH | 81,82,87,88 | 700 | 700 | 650 | 22,5 | 400 | 2801,1562 | 2538,8152 | 626,828 | 736,9703 | 28 | 25 | 13750 | 8 | 3928,571 | 3928,5714 | 20868,97321 | 2483,793553 | 0,8 | 1051,4146 | 390 | 331,5 |
| 2 | PINGGIR | 142,143,168,167 | 700 | 700 | 650 | 22,5 | 400 | 1788,1241 | 1789,8603 | 716,037 | 408,8343 | 24 | 25 | 11785,714 | 7 | 3437,5 | 3437,5 | 19800,19133 | 1621,965998 | 0,8 | 962,58282 | 390 | 331,5 |
| | TENGAH | 151,152,157,158 | 700 | 700 | 650 | 22,5 | 400 | 1992,1274 | 1989,4285 | 676,967 | 632,3183 | 28 | 25 | 13750 | 8 | 3928,571 | 3928,5714 | 20868,97321 | 1802,249987 | 0,8 | 982,40822 | 390 | 331,5 |
| 3 | PINGGIR | 212,213,236,237 | 700 | 700 | 650 | 22,5 | 400 | 1243,9318 | 1294,7459 | 499,38 | 270,8149 | 20 | 25 | 8821,4286 | 6 | 2948,429 | 2948,4286 | 18731,40944 | 1229,17469 | 0,8 | 644,39027 | 390 | 331,5 |
| | TENGAH | 221,222,227,228 | 700 | 700 | 650 | 22,5 | 400 | 1235,1062 | 1442,0836 | 495,014 | 356,0787 | 24 | 25 | 11785,714 | 7 | 3437,5 | 3437,5 | 19800,19133 | 1288,337948 | 0,8 | 653,67489 | 390 | 331,5 |
| 4 | PINGGIR | 282,283,306,307 | 700 | 700 | 650 | 22,5 | 400 | 710,08848 | 790,69825 | 448,85 | 198,5355 | 20 | 25 | 8821,4286 | 6 | 2948,429 | 2948,4286 | 18731,40944 | 705,8394273 | 0,8 | 568,45854 | 390 | 331,5 |
| | TENGAH | 291,292,297,298 | 700 | 700 | 650 | 22,5 | 400 | 654,27848 | 896,10578 | 478,489 | 281,8609 | 24 | 25 | 11785,714 | 7 | 3437,5 | 3437,5 | 19800,19133 | 712,3087944 | 0,8 | 618,12925 | 390 | 331,5 |
| 5 | PINGGIR | 352,353,372,373 | 700 | 700 | 650 | 22,5 | 400 | 208,831 | 290,24077 | 94,2449 | 33,45625 | 16 | 25 | 7857,1429 | 5 | 2455,357 | 2455,3571 | 17662,62755 | 224,1137725 | 0,8 | 116,60113 | 390 | 331,5 |

| fs' (kN) | fs' digunakan (kN) | runtuh menentukan | Pn, b (kN) | > Pn perlu | Analisis tampang tnd beban | | | Pn Dengan anggapan As' leleh | | | ket | a | C | fa' | ket | Momen tahanan nominal asumsi As' leleh | | | | a | C | fs' | ket | fs' terpakai | Mo. n |
|----------|--------------------|-------------------|------------|------------|----------------------------|--------|--------|------------------------------|----------|-----------|-------|--------|---------|---------|-------|--|---------|---------|-------------|---------|---------|---------|-------------|--------------|----------|
| | | | | | p | m | e (mm) | Pn | Pr | 0,1 Ag.fc | | | | | | a | c | fs' | ket | | | | | | |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0075549 | 20,915 | 468,48 | 3392,84 | 2374,849 | 1102,5 | lepas | 253,42 | 298,139 | 499,378 | benar | 161,108 | 189,539 | 441,721 | leleh | 152,848 | 179,588 | 432,949 | leleh | 400 | 1406,15 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0068342 | 20,915 | 423,31 | 4137,98 | 2898,571 | 1102,5 | lepas | 309,09 | 383,637 | 517,5 | benar | 185,531 | 218,272 | 462,557 | leleh | 170,882 | 200,803 | 450,6 | leleh | 400 | 1581,775 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0075549 | 20,915 | 583,47 | 2480,13 | 1722,09 | 1102,5 | lepas | 183,78 | 216,192 | 461,234 | benar | 121,155 | 142,536 | 389,526 | belum leleh | 123,024 | 144,734 | 392,723 | belum leleh | 392,722985 | 1286,929 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0068342 | 20,915 | 545,1 | 3050,87 | 2135,607 | 1102,5 | lepas | 227,89 | 268,105 | 488,104 | benar | 134,822 | 158,379 | 410,581 | leleh | 132,435 | 155,806 | 407,453 | leleh | 400 | 1452,334 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0064757 | 20,915 | 524,25 | 2604,42 | 1823,092 | 1102,5 | lepas | 194,54 | 228,872 | 468,922 | benar | 91,8151 | 108,018 | 322,268 | belum leleh | 102,533 | 120,527 | 351,3 | belum leleh | 351,300344 | 1037,879 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0075549 | 20,915 | 515,14 | 2883,13 | 2088,191 | 1102,5 | lepas | 222,83 | 262,152 | 485,583 | benar | 96,2344 | 113,217 | 335,022 | belum leleh | 106,412 | 125,19 | 360,364 | belum leleh | 360,364448 | 1173,053 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0064757 | 20,915 | 802,53 | 1750,89 | 1225,622 | 1102,5 | lepas | 130,79 | 153,885 | 405,024 | benar | 52,7238 | 62,028 | 116,347 | belum leleh | 79,3944 | 83,4051 | 278,819 | belum leleh | 278,818508 | 828,4836 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0075549 | 20,915 | 887,78 | 2164,67 | 1515,269 | 1102,5 | lepas | 161,69 | 190,228 | 442,294 | benar | 53,207 | 62,5965 | 120,74 | belum leleh | 81,8492 | 86,2932 | 288,452 | belum leleh | 288,451558 | 940,3238 |
| 523,077 | 400 | tulangan | 4437,9563 | ok | 0,0053984 | 20,915 | 520,28 | 2300,23 | 1610,158 | 1102,5 | lepas | 171,82 | 202,14 | 451,588 | benar | 16,7405 | 19,6947 | -923,25 | belum leleh | 59,1402 | 69,5787 | 188,821 | belum leleh | 188,821404 | 485,5618 |

| ket > Mo | Momen tahanan ttd sb lain dgn coba 2x | | | fs' terpakai | fs | ket | fs terpakai | Mo,n | (Mn/Mo,n) | ket | (Mn/Mo,n) sumbu lain(tabel) | Mn | ket | |
|-----------|---------------------------------------|--------|--------|--------------|----------|----------|-------------|------|-----------|-------------|-----------------------------|------|----------|----|
| a coba 2x | C | fs' | ket | | | | | | | | | | | |
| ok | 152,6478 | 179,59 | 432,95 | leleh | 400 | 1571,666 | leleh | 400 | 1384,277 | 0,588187843 | Mnx/Moxn | 0,94 | 777,4556 | ok |
| ok | 170,6823 | 200,8 | 450,8 | leleh | 400 | 1342,205 | leleh | 400 | 1547,605 | 0,548133548 | Mny/Moyn | 0,95 | 823,6726 | ok |
| ok | 123,0238 | 144,73 | 392,72 | belum leleh | 392,723 | 2094,601 | leleh | 400 | 1292,63 | 0,654578755 | Mnx/Moxn | 0,93 | 783,4265 | ok |
| ok | 132,4349 | 155,81 | 407,45 | leleh | 400 | 1903,117 | leleh | 400 | 1445,996 | 0,548381095 | Mnx/Moxn | 0,95 | 756,6106 | ok |
| ok | 102,6333 | 120,83 | 351,3 | belum leleh | 351,3003 | 2633,096 | leleh | 400 | 1074,157 | 0,546744323 | Mnx/Moxn | 0,95 | 539,0815 | ok |
| ok | 106,4116 | 125,19 | 360,38 | belum leleh | 360,3644 | 2515,262 | leleh | 400 | 1208,934 | 0,479531886 | Mnx/Moxn | 0,95 | 534,3905 | ok |
| ok | 79,39436 | 93,405 | 278,82 | belum leleh | 278,8185 | 3575,359 | leleh | 400 | 829,8455 | 0,815865442 | Mnx/Moxn | 0,94 | 479,453 | ok |
| ok | 81,84923 | 96,293 | 288,45 | belum leleh | 288,4516 | 3450,13 | leleh | 400 | 1048,637 | 0,578244373 | Mnx/Moxn | 0,94 | 511,1128 | ok |
| ok | 59,14023 | 69,577 | 168,82 | belum leleh | 168,8214 | 5005,322 | leleh | 400 | 672,695 | 0,216111291 | Mnx/Moxn | 1 | 107,0965 | ok |

2. Penulangan geser Kolom

a. Gaya geser rencana kolom

$$V_{u,k} = (M_{u,k \text{ atas}} + M_{u,k \text{ bawah}}) / l_n$$

Tetapi tidak perlu lebih besar dari :

$$V_{u,kx} = 1,05 \cdot (V_{d,k} + V_{l,k} + 4/k \cdot (V_{c,kx} + 0,3 V_{c,ky}))$$

$$V_{u,ky} = 1,05 \cdot (V_{d,k} + V_{l,k} + 4/k \cdot (0,3 V_{c,kx} + V_{c,ky}))$$

Dengan harga $K=1$.

Akan tetapi pada lantai dasar dan lantai paling atas yang memperbolehkan terjadinya sendi plastis pada kolom, gaya geser rencana kolom dihitung berdasarkan momen kapasitas dari kolom.

$$V_{u,k \text{ lantai } 1} = (M_{u,k \text{ a lantai } 1} + \phi_o \cdot M_{nak, k \text{ lantai } 1}) / h_n$$

$$V_{u,k \text{ lantai } 5} = (\phi_o \cdot 2 \cdot M_{nak, k \text{ lantai } 5}) / h_n$$

Besar gaya geser yang disumbangkan oleh beton (V_c) dapat dihitung dengan rumus.

$$V_c = (1 + N_u / 14 \cdot A_g) \cdot (\sqrt{f_c'} / 6) \cdot b \cdot d$$

Tulangan geser kolom harus dipasang pada seluruh tinggi kolom dengan jarak maksimum

- $\frac{1}{4}$ dimensi komponen struktur terkecil = $\frac{1}{4} \cdot 700 = 175$ mm
- 8 kali diameter tulangan longitudinal = $8 \cdot 25 = 200$ mm
- 100 mm

Khusus untuk daerah ujung kolom yang diharapkan akan terjadi sendi plastis, kemampuan geser beton diabaikan sehingga semua gaya geser dipikul oleh tulangan geser, sedangkan pada daerah-daerah lain kontribusi nilai V_c tetap diperhitungkan.

Daerah-daerah yang berpotensi sendi plastis terletak sepanjang l_o dari muka yang ditinjau, dimana panjang l_o tidak boleh kurang dari :

- h untuk $N_{u,k} < 0,3 \cdot A_g \cdot f_c' = 700$ mm
- $1,5 h$ untuk $N_{u,k} > 0,3 \cdot A_g \cdot f_c' = 1050$ mm
- $1/6$ bentang bersih komponen struktur = $3800/6 = 633$ mm

450 mm

Gaya geser rencana kolom lantai dasar :

$$M_{u,k} = 774,797 \text{ kNm.}$$

$$M_{n,k} = 896,55 \text{ kNm}$$

$$N_{u,k} = 2012,21 \text{ kN.}$$

$$V_{d,k} = 0,029 \text{ kN}$$

$$V_{l,k} = 0,05 \text{ kN}$$

$$V_{e,kx} = 64,17 \text{ kN}$$

$$V_{e,ky} = 111,08 \text{ kN}$$

$$V_{u,k \text{ lantai 1}} = (576,86 \cdot 10^6 + 1,25 \cdot 896,55 \cdot 10^6) / (3800 - 250 - 350)$$

$$V_{u,k \text{ lantai 1}} = 530483,59 \text{ N}$$

$$= 530,48 \text{ kN.}$$

$$V_{u,k \text{ max}} = 1,05 \cdot (0,029 + 0,05 + 4/1 \cdot (64,17 + 0,3 \cdot 111,08))$$

$$= 409,56 \text{ kN}$$

$$V_{u,ky \text{ max}} = 1,05 \cdot (0,029 + 0,05 + 4/1 \cdot (0,3 \cdot 64,17 + 111,08))$$

$$= 547,58 \text{ kN}$$

Hasil perhitungan gaya geser rencana kolom selanjutnya dapat dilihat pada tabel 6.46 s/d 6.48

Tabel 6.46. Gaya geser rencana kolom As 1 & 6

| LANTAI | KOLOM | ELEMEN | h | hn | ϕ_o | Mu,ka (kNm) | Mu,kb (kNm) | Vd,k (kNm) | Vl,k (kNm) | Ve,kx (kNm) | Ve,ky (kNm) | Vu,k (kNm) | Vu,kx max (kNm) | Vu,ky max (kNm) |
|--------|---------|-----------------|-----|-----|----------|----------------|----------------|---------------|---------------|----------------|----------------|---------------|--------------------|--------------------|
| 1 | POJOK | 75,78,91,94 | 3,8 | 3,2 | 1,25 | 225,63619 | 418,26725 | 6,485374 | 0,9039979 | 59,80053 | 41,16122 | 201,21983 | 310,7842 | 255,98463 |
| | PINGGIR | 79,84,85,90 | 3,8 | 3,2 | 1,25 | 225,19592 | 321,70846 | 2,160437 | 0,3783332 | 31,91837 | 12,13624 | 170,90762 | 152,01453 | 93,855063 |
| 2 | POJOK | 145,148,161,164 | 3,8 | 3,2 | 1,25 | 249,70088 | 227,87786 | 10,97014 | 2,377701 | 50,80124 | 22,42964 | 149,24335 | 255,64179 | 172,22928 |
| | PINGGIR | 149,154,155,160 | 3,8 | 3,2 | 1,25 | 256,87774 | 263,08226 | 1,501536 | 1,125805 | 32,8303 | 13,32858 | 162,4875 | 157,43998 | 100,10492 |
| 3 | POJOK | 215,218,231,234 | 3,8 | 3,2 | 1,25 | 230,58671 | 213,78828 | 12,42373 | 2,815349 | 38,20602 | 19,59001 | 138,86718 | 201,14973 | 146,41866 |
| | PINGGIR | 219,224,225,230 | 3,8 | 3,2 | 1,25 | 201,27905 | 185,401 | 1,120534 | 1,373883 | 24,29887 | 10,93801 | 120,83752 | 118,45628 | 79,175356 |
| 4 | POJOK | 285,288,301,304 | 3,8 | 3,2 | 1,25 | 175,32208 | 163,29184 | 14,24896 | 3,301368 | 22,58546 | 11,6231 | 105,81685 | 127,93188 | 95,702544 |
| | PINGGIR | 289,294,295,300 | 3,8 | 3,2 | 1,25 | 120,98118 | 97,843713 | 0,264374 | 1,350937 | 13,53119 | 7,234273 | 68,382779 | 67,642259 | 49,129323 |
| 5 | POJOK | 355,358,357,370 | 3,8 | 3,2 | 1,25 | 86,191692 | 76,886301 | 10,94444 | 2,541703 | 0,6220355 | 3,020273 | 50,961873 | 20,578543 | 27,629361 |
| | PINGGIR | 359,362,363,366 | 3,8 | 3,2 | 1,25 | 35,385443 | 35,385443 | 2,196489 | 1,614806 | 1,126835 | 3,825875 | 22,115902 | 13,555169 | 21,490347 |

Tabel 6.47. Gaya geser rencana kolom As 2 & 5

| LANTAI | KOLOM | ELEMEN | h | hn | ϕ_o | Mu,ka (kNm) | Mu,kb (kNm) | Vd,k (kNm) | Vl,k (kNm) | Ve,kx (kNm) | Ve,ky (kNm) | Vu,k (kNm) | Vu,kx max (kNm) | Vu,ky max (kNm) |
|--------|--------|---------------------------------|-----|-----|----------|----------------|----------------|---------------|---------------|----------------|----------------|---------------|--------------------|--------------------|
| 1 | POJOK | 71,74,95,98 | 3,8 | 3,2 | 1,25 | 409,4688 | 486,62396 | 23,36706 | 2,888935 | 48,18451 | 81,35988 | 280,02899 | 294,34614 | 379,68978 |
| | TENGAH | 76,77,80,83,86,89,92,93 | 3,8 | 3,2 | 1,25 | 696,22353 | 805,62371 | 9,386291 | 3,794376 | 70,39156 | 125,0489 | 500,57726 | 353,74432 | 551,0011 |
| 2 | POJOK | 141,144,165,168 | 3,8 | 3,2 | 1,25 | 474,57901 | 474,57901 | 33,96045 | 7,108378 | 34,23804 | 64,65292 | 296,61188 | 240,22691 | 318,46919 |
| | TENGAH | 146,147,150,153,156,159,162,163 | 3,8 | 3,2 | 1,25 | 679,56539 | 611,17012 | 17,36927 | 9,09319 | 67,35567 | 129,2339 | 363,01936 | 417,79805 | 576,97979 |
| 3 | POJOK | 211,214,235,238 | 3,8 | 3,2 | 1,25 | 368,14144 | 368,14144 | 33,21521 | 6,660477 | 29,46222 | 51,75164 | 230,0884 | 207,19931 | 264,53885 |
| | TENGAH | 216,217,220,223,226,229,232,233 | 3,8 | 3,2 | 1,25 | 539,76144 | 437,50715 | 15,38207 | 8,784045 | 52,3919 | 100,3706 | 305,39643 | 328,57324 | 391,05216 |
| 4 | POJOK | 281,284,305,308 | 3,8 | 3,2 | 1,25 | 239,66444 | 239,66444 | 36,98613 | 7,545013 | 12,36907 | 31,40872 | 149,79028 | 126,84215 | 175,82165 |
| | TENGAH | 286,287,290,293,296,299,302,303 | 3,8 | 3,2 | 1,25 | 335,45064 | 239,07634 | 17,98033 | 10,27823 | 33,55962 | 62,26254 | 179,53968 | 221,64754 | 295,4858 |
| 5 | POJOK | 351,354,371,374 | 3,8 | 3,2 | 1,25 | 104,04334 | 104,04334 | 29,13919 | 6,097273 | 12,69674 | 4,485722 | 65,027086 | 88,604314 | 67,48147 |
| | TENGAH | 356,357,360,361,364,365,368,369 | 3,8 | 3,2 | 1,25 | 79,745694 | 79,745694 | 2,327983 | 1,35846 | 1,013682 | 17,05296 | 49,841059 | 26,396935 | 67,657978 |

Tabel 6.48. Gaya geser rencana kolom As 3 & 4

| LANTAI | KOLOM | ELEMEN | h | hn | ϕ_c | Mu,ka (kNm) | Mu,kb (kNm) | Vd,k (kNm) | Vl,k (kNm) | Ve,kx (kNm) | Ve,ky (kNm) | Vu,k (kNm) | Vu,kx max (kNm) | Vu,ky max (kNm) |
|--------|---------|-----------------|-----|-----|----------|----------------|----------------|---------------|---------------|----------------|----------------|---------------|--------------------|--------------------|
| 1 | PINGGIR | 72,73,96,97 | 3,8 | 3,2 | 1,25 | 584,71198 | 777,45564 | 0,4335627 | 0,128375 | 64,82344 | 65,87475 | 425,67738 | 311,44309 | 314,14758 |
| | TENGAH | 81,82,87,88 | 3,8 | 3,2 | 1,25 | 626,32266 | 815,0024 | 0,0291945 | 0,05359904 | 64,16897 | 111,083 | 450,41408 | 358,37691 | 479,06325 |
| 2 | PINGGIR | 142.143.166.167 | 3,8 | 3,2 | 1,25 | 713,82549 | 408,63428 | 1,74267 | 0,6779004 | 62,08484 | 40,34823 | 350,76868 | 275,18731 | 219,26988 |
| | TENGAH | 151.152.157.158 | 3,8 | 3,2 | 1,25 | 666,91331 | 676,96741 | 0,3314474 | 0,4770078 | 61,2566 | 104,9296 | 419,96272 | 341,65177 | 454,00056 |
| 3 | PINGGIR | 212.213.236.237 | 3,8 | 3,2 | 1,25 | 454,77279 | 181,78758 | 3,205657 | 1,072773 | 51,39068 | 35,12889 | 198,92511 | 232,0827 | 190,24925 |
| | TENGAH | 221.222.227.228 | 3,8 | 3,2 | 1,25 | 483,68977 | 495,01432 | 0,9446972 | 0,8019362 | 50,16925 | 76,33404 | 305,84503 | 270,36424 | 337,67316 |
| 4 | PINGGIR | 282.283.306.307 | 3,8 | 3,2 | 1,25 | 448,84965 | 363,04385 | 4,614463 | 1,455631 | 30,54763 | 21,22661 | 253,71672 | 142,03848 | 118,06015 |
| | TENGAH | 291.292.297.298 | 3,8 | 3,2 | 1,25 | 478,48853 | 362,12516 | 1,093215 | 1,328643 | 38,26743 | 40,04218 | 262,69178 | 187,32226 | 191,8878 |
| 5 | PINGGIR | 352.353.372.373 | 3,8 | 3,2 | 1,25 | 68,809931 | 24,535546 | 2,202185 | 0,756141 | 20,51968 | 0,08626542 | 29,170462 | 78,611174 | 26,046215 |

b. Penulangan geser kolom.

- Daerah sendi plastis

$$S = \frac{A_v \cdot f_y \cdot d}{V_{u,k} / 0,6}$$

Digunakan sengkang 2 ϕ 10 mm dengan mutu baja $f_y = 240$ Mpa

$$A_v = 2 \cdot 78,5 = 314 \text{ mm}^2$$

$$S = \frac{314 \cdot 240 \cdot 650}{358,94 \cdot 10^3 / 0,6}$$

$$= 81,88 \text{ mm}$$

digunakan sengkang 2 ϕ 10 – 75 mm < 81,88 mm, sehingga aman terhadap penggeseran.

- Di luar daerah sendi plastis

$$S = \frac{A_v \cdot f_y \cdot d}{V_{u,k} / 0,6 - V_c}$$

$$V_c = (1 + N_w / 14 \cdot A_g) \cdot (\sqrt{f_c'} / 6) \cdot b \cdot d$$

$$= (1 + 2012,21 \cdot 10^3 / (14 \cdot 700 \cdot 700)) \cdot (\sqrt{22,5'} / 6) \cdot 700 \cdot 650$$

$$= 465220 \text{ N}$$

$$= 465,22 \text{ kN}$$

Digunakan sengkang ϕ 10 mm dengan mutu baja $f_y = 240$ Mpa

$$A_v = 2 \cdot 78,5 = 314 \text{ mm}^2$$

$$S = \frac{157 \cdot 240 \cdot 650}{358,94 \cdot 10^3 / 0,6 - 465,22 \cdot 10^3}$$

$$= 184,1 \text{ mm}$$

digunakan sengkang ϕ 10 – 150 mm < 184,1 mm, sehingga aman terhadap penggeseran.

Hasil perhitungan penulangan geser kolom selanjutnya dapat dilihat pada tabel 6.49 s/d 6.51

| LANTAI | KOLOM | ELEMEN | h (mm) | b (mm) | d (mm) | d' (mm) | fc' (Mpa) | fy (Mpa) | Vu,k (kN) | Nu, k (kN) | Vc (kN) | D tul (mm) | Vu,k/0.6 (kN) | S (mm) | S Terpakai (mm) | Jumlah tul | Vs (kN) | Ket (Vu/k/0.6<Vs) |
|--------|-----------|-----------------|--------|--------|--------|---------|-----------|----------|-----------|------------|---------|------------|---------------|----------|-----------------|------------|---------|-------------------|
| 1 | POJOK b | 75,78,91,94 | 700 | 700 | 650 | 50 | 22,5 | 240 | 201,22 | 1440,92 | -435,3 | 10 | 335,366 | -245,392 | 150 | 1 | 598,69 | ok |
| | POJOK a | 79,84,85,90 | 700 | 700 | 650 | 50 | 22,5 | 240 | 201,22 | 1440,92 | 0 | 10 | 335,366 | 146,194 | 100 | 2 | 490,29 | ok |
| | PINGGIR b | | 700 | 250 | 650 | 50 | 22,5 | 240 | 93,8551 | 1686,638 | 216,9 | 10 | 156,425 | -405,312 | 150 | 1 | 380,34 | ok |
| 2 | POJOK | 145.148.161.164 | 700 | 700 | 650 | 50 | 22,5 | 240 | 149,243 | 1188,704 | 422 | 10 | 156,425 | 313,432 | 100 | 2 | 490,29 | ok |
| | PINGGIR | 149.154.155.160 | 700 | 250 | 650 | 50 | 22,5 | 240 | 100,105 | 1084,487 | 185,3 | 10 | 166,842 | -1325,68 | 150 | 1 | 585,47 | ok |
| 3 | POJOK | 215.218.231.234 | 700 | 700 | 650 | 50 | 22,5 | 240 | 138,867 | 621,3601 | 392,3 | 10 | 231,445 | -152,409 | 150 | 1 | 348,76 | ok |
| | PINGGIR | 219.224.225.230 | 700 | 250 | 650 | 50 | 22,5 | 240 | 79,1754 | 442,3396 | 151,7 | 10 | 131,959 | -1244,19 | 150 | 1 | 555,72 | ok |
| 4 | POJOK | 285.288.301.304 | 700 | 700 | 650 | 50 | 22,5 | 240 | 95,7025 | 361,5331 | 378,7 | 10 | 159,504 | -111,855 | 150 | 1 | 315,09 | ok |
| | PINGGIR | 289.294.295.300 | 700 | 250 | 650 | 50 | 22,5 | 240 | 49,1293 | 309,8389 | 144,7 | 10 | 81,8822 | -390,156 | 150 | 1 | 542,09 | ok |
| 5 | POJOK | 355.358.357.370 | 700 | 700 | 650 | 50 | 22,5 | 240 | 20,5785 | 180,3864 | 0 | 10 | 34,2976 | 714,753 | 150 | 1 | 163,43 | ok |
| | PINGGIR | 359.362.363.366 | 700 | 250 | 650 | 50 | 22,5 | 240 | 13,5552 | 129,1014 | 0 | 10 | 22,5919 | 1085,09 | 150 | 1 | 163,43 | ok |

Tabel 6.50. Penulangan geser Kolom As 2 & 5

| LANTAI | KOLOM | ELEMEN | h (mm) | b (mm) | d (mm) | d' (mm) | fc' (Mpa) | fy (Mpa) | Vu,k (kN) | Nu, k (kN) | Vc (kN) | D tul (mm) | Vu,k/0.6 (kN) | S (mm) | S Terpakai (mm) | Jumlah tul | Vs (kN) | Ket (Vu/k/0.6<Vs) |
|--------|----------|------------------------------------|--------|--------|--------|---------|-----------|----------|-----------|------------|---------|------------|---------------|----------|-----------------|------------|---------|-------------------|
| 1 | POJOK b | 71,74,95,98 | 700 | 700 | 650 | 50 | 22,5 | 240 | 280,029 | 1810,734 | 454,7 | 10 | 466,715 | 2032,91 | 150 | 1 | 618,08 | ok |
| | POJOK a | 76,77,80,83,86,89,92,93 | 700 | 700 | 650 | 50 | 22,5 | 240 | 280,029 | 1810,734 | 0 | 10 | 466,715 | 105,05 | 100 | 2 | 490,29 | ok |
| | TENGAH b | | 700 | 700 | 650 | 50 | 22,5 | 240 | 353,744 | 2516,44 | 491,7 | 10 | 589,574 | 250,367 | 150 | 1 | 655,09 | ok |
| 2 | POJOK a | 141.144.165.168 | 700 | 700 | 650 | 50 | 22,5 | 240 | 353,744 | 2516,44 | 0 | 10 | 589,574 | 83,1593 | 75 | 2 | 653,71 | ok |
| | TENGAH | 146,147, 150,153, 156,159, 162,163 | 700 | 700 | 650 | 50 | 22,5 | 240 | 240,227 | 1100,239 | 417,4 | 10 | 400,378 | -1440,09 | 150 | 1 | 580,83 | ok |
| 3 | POJOK | 211.214.235.238 | 700 | 700 | 650 | 50 | 22,5 | 240 | 363,019 | 1713,192 | 449,5 | 10 | 605,032 | 157,658 | 150 | 1 | 612,97 | ok |
| | TENGAH | 216,217,220,223,226,229,232, 233 | 700 | 700 | 650 | 50 | 22,5 | 240 | 207,199 | 832,5308 | 403,4 | 10 | 345,332 | -422,432 | 150 | 1 | 566,79 | ok |
| 4 | POJOK | 281.284.305.308 | 700 | 700 | 650 | 50 | 22,5 | 240 | 305,396 | 1031,343 | 413,8 | 10 | 508,994 | 257,487 | 150 | 1 | 577,22 | ok |
| | TENGAH | 286,287,290,293, 296,299,302,303 | 700 | 700 | 650 | 50 | 22,5 | 240 | 126,842 | 436,3094 | 382,6 | 10 | 211,404 | -143,205 | 150 | 1 | 546,02 | ok |
| 5 | POJOK | 351.354.371.374 | 700 | 700 | 650 | 50 | 22,5 | 240 | 179,54 | 641,2177 | 393,3 | 10 | 299,233 | -260,516 | 150 | 1 | 556,76 | ok |
| | TENGAH | 356, 357,360,361, 364,365,368,369 | 700 | 700 | 650 | 50 | 22,5 | 240 | 65,0271 | 167,2572 | 0 | 10 | 108,378 | 226,191 | 150 | 1 | 163,43 | ok |
| | | | | | | | | | 26,3969 | 168,7463 | 0 | 10 | 43,9949 | 557,208 | 150 | 1 | 163,43 | ok |

Tabel 6.51. Penulangan geser Kolom As 3 & 4

| LANTAI | KOLOM | ELEMEN | h (mm) | b (mm) | d (mm) | d' (mm) | fc' (Mpa) | fy (Mpa) | Vu,k (kN) | Nu,k (kN) | Vc (kN) | D tul (mm) | Vu,k/0.6 (kN) | S (mm) | S Terpakai (mm) | n tul | Vs (kN) | Ket (Vu,k/0.6 < Vs) |
|--------|-----------|-----------------|-----------|-----------|-----------|------------|--------------|-------------|--------------|--------------|------------|---------------|------------------|-----------|--------------------|----------|------------|------------------------|
| 1 | PINGGIR b | 72,73,96,97 | 700 | 700 | 650 | 50 | 22,5 | 240 | 311,443 | 2144,997 | 472,2 | 10 | 519,072 | 522,824 | 150 | 1 | 635,61 | ok |
| | PINGGIR a | | 700 | 700 | 650 | 50 | 22,5 | 240 | 311,443 | 2144,997 | 0 | 10 | 519,072 | 94,4543 | 75 | 2 | 653,71 | ok |
| | TENGAH b | 81,82,87,88 | 700 | 700 | 650 | 50 | 22,5 | 240 | 358,377 | 2484,222 | 490 | 10 | 597,295 | 228,414 | 150 | 1 | 653,4 | ok |
| | TENGAH a | | 700 | 700 | 650 | 50 | 22,5 | 240 | 358,377 | 2484,222 | 0 | 10 | 597,295 | 82,0844 | 75 | 2 | 653,71 | ok |
| 2 | PINGGIR | 142.143.166.167 | 700 | 700 | 650 | 50 | 22,5 | 240 | 219,27 | 1615,31 | 444,4 | 10 | 365,45 | -310,468 | 150 | 1 | 607,84 | ok |
| | TENGAH | 151.152.157.158 | 700 | 700 | 650 | 50 | 22,5 | 240 | 341,652 | 1802,617 | 454,2 | 10 | 569,42 | 212,818 | 150 | 1 | 617,66 | ok |
| 3 | PINGGIR | 212.213.236.237 | 700 | 700 | 650 | 50 | 22,5 | 240 | 190,249 | 1224,959 | 423,9 | 10 | 317,082 | -229,409 | 150 | 1 | 587,37 | ok |
| | TENGAH | 221.222.227.228 | 700 | 700 | 650 | 50 | 22,5 | 240 | 270,364 | 1288,665 | 427,3 | 10 | 450,607 | 1050,95 | 150 | 1 | 590,71 | ok |
| 4 | PINGGIR | 282.283.306.307 | 700 | 700 | 650 | 50 | 22,5 | 240 | 118,06 | 704,5556 | 396,7 | 10 | 196,767 | -122,641 | 150 | 1 | 560,08 | ok |
| | TENGAH | 291.292.297.298 | 700 | 700 | 650 | 50 | 22,5 | 240 | 187,322 | 714,1809 | 0 | 10 | 312,204 | 157,04 | 150 | 2 | 326,86 | ok |
| 5 | PINGGIR | 352.353.372.373 | 700 | 700 | 650 | 50 | 22,5 | 240 | 26,0462 | 224,0799 | 0 | 10 | 43,4104 | 564,711 | 150 | 1 | 163,43 | ok |

D. Pertemuan Balok Kolom

1. Pertemuan balok kolom luar

a. Perhitungan gaya-gaya dalam diambil pada joint dengan gaya-gaya terbesar.

$$M_{nak, b} = 1266,16 \text{ kNm}$$

$$M_{kap, b} = 1,25 \cdot 1266,16 = 1582,7 \text{ kNm}$$

$$V_{kol} = \frac{0,7 \cdot (l_{ka} / l_{ki} \cdot M_{kap, ki} + l_{ka} / l_{ka} \cdot M_{kap, ka})}{1/2 \cdot (h_{k,a} + h_{k,b})} \quad \text{SKSNI 3.14.6-1.1}$$

dengan

l_{ki} dan l_{ka} = bentang as balok kiri dan kanan joint

l_{ki}' dan l_{ka}' = bentang bersih balok kiri dan kanan joint

$h_{k,a}$ dan $h_{k,b}$ = bentang as ke as kolom di atas dan di bawah joint.

Karena pertemuan dengan kolom luar, maka $M_{kap, ki} = 0$

$$V_{kol} = \frac{0,7 \cdot (9,6 / 8,9 \cdot 1582,7)}{1/2 \cdot (3,8 + 3,8)} = 314,48 \text{ kN}$$

$$T = 0,7 \cdot M_{kap, ka} / z_{ka}$$

Dengan

Z = jarak dari titik berat tulangan ke resultan bagian tekan beton

$$= 650 - 128 / 2 = 586 \text{ mm}$$

$$T = 0,7 \cdot 1582,7 / 0,586 = 1890,6 \text{ kN}$$

$$V_{j,h} = T - V_{kol}$$

$$= 1890,6 - 314,48$$

$$= 1576,12 \text{ kN}$$

$$V_{j,v} = d / hc \cdot V_{j,h}$$

$$= 0,65 / 0,7 \cdot 1576,12 = 1463,54 \text{ kN}$$

b. Kontrol tegangan geser horisontal minimal

$$V_{j,h} = \frac{V_{j,h}}{b_j \cdot hc} < 1,5 \sqrt{f_c'} \quad \text{SKSNI 3.14.6-1.2}$$

dengan lebar efektif pertemuan (b_j) diambil sebagai berikut :

a) bila $bc > bb$, maka diambil nilai terkecil antara

$$b_j = bc \text{ atau } bb + 0,5 \cdot hc$$

b) bila $b_b > b_c$, maka diambil nilai terkecil antara

$$b_j = b_b \text{ atau } b_c + 0,5 \cdot h_c$$

dengan $b_c = 70 \text{ cm}$ dan $b_b = 40 \text{ cm}$, berarti $b_c > b_b$, maka:

$$b_j = b_c = 70 \text{ cm}$$

$$V_{j,h} = \frac{1578,12}{0,7 \cdot 0,7} = 3220,65 \text{ kN/m}^2 = 3,22 \text{ N/mm}^2$$

$$1,5 \cdot \sqrt{f_c'} = 1,5 \cdot \sqrt{22,5} = 7,11 \text{ N/mm}^2 > 3,22 \text{ N/mm}^2$$

c. Penulangan Geser Horizontal

$$N_u = 2144,99 \text{ kN}$$

$$\frac{N_u}{A_g} = \frac{2144,99}{0,7 \cdot 0,7} = 4377,53 \text{ kN/m}^2$$

$$= 4,38 \text{ N/mm}^2 > 0,1 f_c' = 2,25 \text{ Mpa}$$

jadi $V_{c,h}$ dihitung menurut SKSNI 3.14.6-1.4

$$V_{c,h} = 2/3 \cdot \sqrt{\{(N_{u,k} / A_g) - 0,1 f_c'\} \cdot 700 \cdot 700}$$

$$V_{c,h} = 2/3 \cdot \sqrt{\{(2144,99 \cdot 10^3 / 700 \cdot 700) - 0,1 \cdot 22,5\} \cdot 700 \cdot 700}$$

$$= 476477,86 \text{ N} = 476,48 \text{ kN}$$

$$V_{s,h} + V_{c,h} = V_{j,h} \quad \text{SKSNI 3.14.6-1.5}$$

$$V_{s,h} = 1576,12 - 476,48 = 1099,64 \text{ kN}$$

$$A_{j,h} = V_{s,h} / f_y$$

$$= 1099,64 \cdot 10^3 / 240$$

$$= 4581 \text{ mm}^2$$

Digunakan sengkang rangkap $\phi 10 \text{ mm}$

Luas yang tersedia 314 mm^2 .

Jumlah lapis sengkang = $4581 / 314 = 14,5 \approx 15$ lapis

d. Penulangan geser vertikal

$$V_{c,v} = A_s \cdot V_{j,h} / A_s \cdot (0,6 + N_u / A_g \cdot f_c')$$

$$= 1576,12 \cdot 10^3 \cdot (0,6 + 2144,99 \cdot 10^3 / 700 \cdot 700 \cdot 22,5)$$

$$= 1252317 \text{ N}$$

$$= 1252,317 \text{ kN}$$

$$V_{s,v} = V_{j,v} - V_{c,v}$$

$$= 1463,54 - 1252,32 = 211,22 \text{ kN.}$$

$$A_{j,v} = V_{s,v} / f_y$$

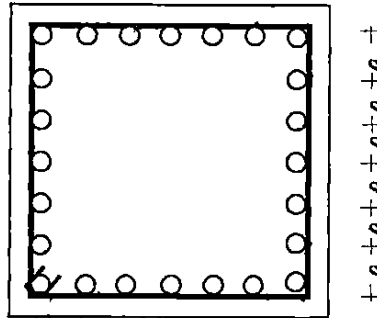
$$= 211,22 \cdot 10^3 / 400$$

$$= 528,05 \text{ mm}^2. < \text{tulangan kolom terpasang} = 7 \text{ D25}$$

e. Kontrol jarak tulangan vertikal

$$6.s = 700 - 2(50 + 10 + \frac{1}{2} \cdot 25) = 555 \text{ mm}$$

$$s = 92,5 \text{ mm}$$



Gambar 6.2. Penampang kolom joint luar

2. Pertemuan balok kolom dalam

a. Perhitungan gaya-gaya dalam diambil pada joint dengan gaya-gaya terbesar.

$$M_{nak, b \text{ kiri}} = 1266,16 \text{ kNm}$$

$$M_{nak, b \text{ kanan}} = 1266,16 \text{ kNm}$$

$$M_{kap, b \text{ kiri}} = 1,25 \cdot 1266,16 = 1582,7 \text{ kNm}$$

$$M_{kap, b \text{ kanan}} = 1,25 \cdot 1266,16 = 1582,7 \text{ kNm}$$

$$V_{kol} = \frac{0,7 \cdot (I_{ki} / I_{ka} \cdot M_{kap, ki} + I_{ka} / I_{ka} \cdot M_{kap, ka})}{1/2 \cdot (h_{k,a} + h_{k,b})} \quad \text{SKSNI 3.14.6-1.1}$$

$$V_{kol} = \frac{0,7 \cdot (2,4 / 1,7 \cdot 1582,7 + 9,6 / 8,9 \cdot 1582,7)}{1/2 \cdot (3,8 + 3,8)} = 726,08 \text{ kN}$$

$$C_{ki} = 0,7 \cdot M_{kap, ka} / z_{ka}$$

$$Z = 650 - 128 / 2 = 586 \text{ mm}$$

$$C_{ki} = 0,7 \cdot 1582,7 / 0,586 = 1890,6 \text{ kN}$$

$$T_{ka} = 0,7 \cdot M_{kap,ka} / z_{ka}$$

$$Z = 650 - 90 / 2 = 286 \text{ mm}$$

$$T_{ka} = 0,7 \cdot 1582,7 / 0,586 = 1890,6 \text{ kN}$$

$$\begin{aligned} V_{j,h} &= T_{ka} + C_{ki} - V_{kol} \\ &= 1890,6 + 1890,6 - 726,08 \\ &= 3055,11 \text{ kN} \end{aligned}$$

$$\begin{aligned} V_{j,v} &= d/hc \cdot V_{j,h} \\ &= 0,65 / 0,7 \cdot 3055,11 = 2836,9 \text{ kN} \end{aligned}$$

b. Kontrol tegangan geser horisontal minimal

$$V_{j,h} = \frac{V_{j,h}}{b_j \cdot hc} < 1,5 \sqrt{f_c'} \quad \text{SKSNI 3.14.6-1.2}$$

$$V_{j,h} = \frac{3055,11}{0,7 \cdot 0,7} = 6234,92 \text{ kN/m}^2 = 6,23 \text{ N/mm}^2.$$

$$1,5 \sqrt{f_c'} = 1,5 \sqrt{22,5} = 7,11 \text{ N/mm}^2 > 6,23 \text{ N/mm}^2.$$

c. Penulangan Geser Horisontal

$$N_u = 2484,22 \text{ kN}$$

$$\frac{N_u}{A_g} = \frac{2484,22}{0,7 \cdot 0,7} = 5069,83 \text{ kN/m}^2$$

$$= 5,07 \text{ N/mm}^2 > 0,1 f_c' = 2,25 \text{ Mpa}$$

jadi $V_{c,h}$ dihitung menurut SKSNI 3.14.6-1.4

$$V_{c,h} = 2/3 \sqrt{\{(N_{u,k} / A_g) - 0,1 f_c'\} \cdot 700 \cdot 700}$$

$$\begin{aligned} V_{c,h} &= 2/3 \sqrt{\{(2484,22 \cdot 10^3 / 700 \cdot 700) - 0,1 \cdot 22,5\} \cdot 700 \cdot 700} \\ &= 548556 \text{ N} = 548,56 \text{ kN} \end{aligned}$$

$$V_{s,h} + V_{c,h} = V_{j,h} \quad \text{SKSNI 3.14.6-1.5}$$

$$V_{s,h} = 3055,11 - 548,56 = 2506,55 \text{ kN}$$

$$\begin{aligned} A_{j,h} &= V_{s,h} / f_y \\ &= 2506,55 \cdot 10^3 / 400 \\ &= 6266 \text{ mm}^2. \end{aligned}$$

Digunakan sengkang rangkap D 22 mm

Luas yang tersedia 780 mm².

Jumlah lapis sengkang = $6266/790 = 7,93 \approx 8$ lapis

d. Penulangan geser vertikal

$$V_{c,v} = A_s' \cdot V_{j,h} / A_s \cdot (0,6 + Nu / Ag \cdot f_c')$$

$$= 3055,11 \cdot 10^3 \cdot (0,6 + 2484,22 \cdot 10^3 / 700 \cdot 700 \cdot 22,5)$$

$$= 2521461,95 \text{ N}$$

$$= 2521,46 \text{ kN}$$

$$V_{s,v} = V_{j,v} - V_{c,v}$$

$$= 2836,9 - 2521,46 = 315,44 \text{ kN}$$

$$A_{j,v} = V_{s,v} / f_y$$

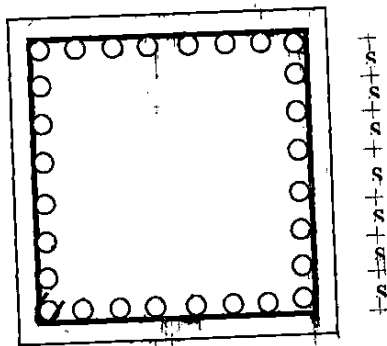
$$= 315,44 \cdot 10^3 / 400$$

$$= 788,6 \text{ mm}^2 < \text{tulangan kolom terpasang} = 8 \text{ D25}$$

e. Kontrol jarak tulangan vertikal

$$7 \cdot s = 700 - 2(50 + 10 + \frac{1}{2} \cdot 25) = 555 \text{ mm}$$

$$s = 73,5 \text{ mm}$$



Gambar 6.3. Penampang kolom join dalam

E. Pendetailan

Sebagai contoh pendetailan diambil pada balok dengan bentang 9,6

meter.

1. - Tulangan lapangan balok

Momen lapangan $M_u = 404,06 \text{ kNm}$

$A_s = 8 \text{ D25}$

$$A_s' = 4 \text{ D25}$$

- Tulangan tumpuan balok

$$\text{Momen tumpuan } M_u = 763,48 \text{ kNm}$$

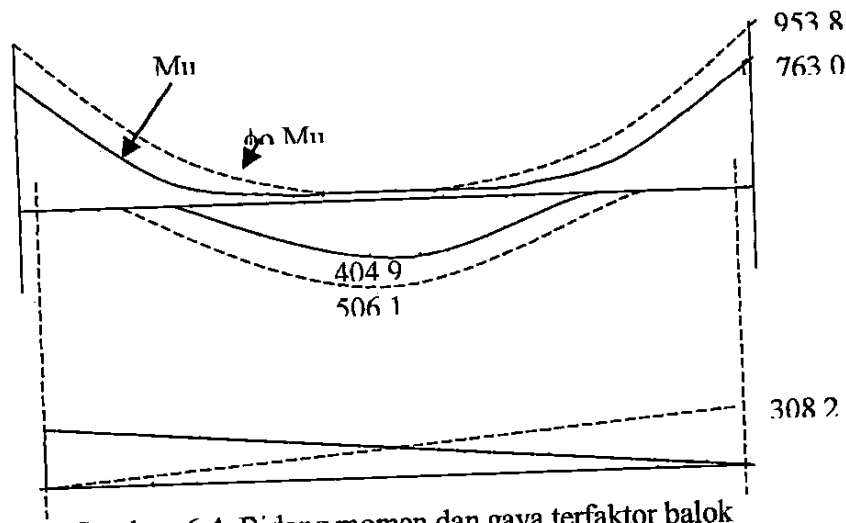
$$A_s = 10 \text{ D25}$$

$$A_s' = 5 \text{ D25}$$

2. Bidang momen dan gaya geser terfaktor balok

Hasil dari analisis struktur untuk ketiga macam pembebanan (terlampir), didapat bidang momen terfaktor seperti gambar di bawah. Bidang gaya geser didapat momen nominal aktual balok dan geser akibat beban gravitasi.

Struktur pada bangunan yang direncanakan dengan daktilitas tingkat tiga (*daktilitas penuh*), pemutusan teoritis didasarkan pada diagram momen terfaktor yang telah dikalikan dengan *faktor overstrength*. Pemutusan tulangan aktual didapat dengan memberikan pengalihan horisontal sebesar d ataupun $12 d_b$ dari bidang $\phi_o M_u$.



Gambar. 6.4. Bidang momen dan gaya terfaktor balok

3. Penentuan jarak antar tulangan.

Jarak bersih antar tulangan sejajar yang diletakkan

$$\text{selapis} \geq d_b$$

$$\geq 25 \text{ mm}$$

Tulangan tumpuan

Tulangan atas terpakai 10 D25 diletakkan dalam 2 lapis. Jumlah tulangan pada lapis atas 6 D25 dengan jarak bersih antar tulangan = $(600 - (100 + 20 + 150)) / 5 = 66 \text{ mm} > 25 \text{ mm}$ dan lapis bawah 4 D25 dengan jarak bersih antar tulangan = $(600 - (100 + 20 + 100)) / 3 = 193 \text{ mm} > 25 \text{ mm}$.

Tulangan bawah terpakai 5 D25 diletakkan dalam satu lapis dengan jarak bersih antar tulangan = $(400 - (100 + 20 + 125)) / 4 = 38,75 \text{ mm} > 25$.

Tulangan lapangan

Tulangan bawah terpakai 8 D25 diletakkan dalam 2 lapis. Jumlah tulangan pada lapis bawah 6 D25 dengan jarak bersih antar tulangan = $(400 - (100 + 20 + 150)) / 5 = 26 \text{ mm} > 25 \text{ mm}$ dan lapis atas 2 D25 dengan jarak bersih antar tulangan = $(400 - (100 + 20 + 50)) / 1 = 230 \text{ mm} > 25 \text{ mm}$.

Tulangan atas terpakai 4 D25 diletakkan dalam satu lapis dengan jarak bersih antar tulangan = $(600 - (100 + 20 + 100)) / 3 = 126,67 \text{ mm} > 25$.

4. Panjang penanaman kait sengkang tertutup untuk sengkang ϕ 10 mm diambil sbesar $6 d_b = 6 \cdot 10 = 60 \text{ mm}$. SK SNI 3.16.6-2
5. Pendetailan tulangan momen positif

Tulangan 8 D25 diteruskan sampai ujung pada balok yang berhubungan dengan kolom eksterior sedang pada daerah yang bertemu dengan kolom interior tulangan diputus dengan jarak $0,1 l_n = 0,1 \cdot 18,9 \text{ m} = 1,89 \text{ m}$ dari muka kolom.

Panjang penyaluran kedalam

$$l_{db} = 0,02 \cdot A_b \cdot f_y / \sqrt{f_c'} > 0,06 \cdot d_b \cdot f_y \text{ SKSNI 3.5.2-2}$$

$$l_{db} = 0,02 \cdot 490 \cdot 400 / \sqrt{22,5} = 828,21 \text{ mm}$$

$$0,06 \cdot d_b \cdot f_y = 0,06 \cdot 25 \cdot 400 = 600 \text{ mm} < 828,21 \text{ mm} \text{ digunakan } l_{db} = 850 \text{ mm.}$$

Faktor modifikasi yang dipakai :

$$\text{Faktor tulangan terpakai lebih dibanding analisa} = 3,85/8 = 0,481$$

$$l_d = 1,4 \cdot 0,481 \cdot 828,21 = 557,72 \text{ kNm.}$$

Panjang penyaluran kait standar dalam tarik l_{db}

$$\text{Panjang penyaluran dasar } l_{hb} = 100 \cdot d_b / \sqrt{f_c'}$$

$$l_{hb} = 100.25 / \sqrt{22,5} = 527,05 \text{ mm.}$$

Faktor modifikasi yang dapat digunakan adalah faktor pelindung beton, untuk kait standar 90° dengan pelindung beton pada perpanjangan yang tidak kurang dari 50 mm.

$$L_{dh} = 0,7.l_{hb} = 0,7.527,05 = 368,93 \text{ mm.}$$

Tempat yang tersedia untuk penyaluran kait standar jika akan digunakan kait standar 90° yang dilingkup oleh sengkang ϕ 10 mm dan pelindung beton 40 mm adalah $700-40-10 = 650 \text{ mm.} > 368,93 \text{ mm.}$

Dipakai $l_{dh} = 650 \text{ mm.}$

Pembengkokan kait standar harus ditambah bagian yang lurus sepanjang $12.d_b = 12.25 = 300 \text{ mm.}$

6. Pendetailan tulangan momen negatif

Tulangan 10 D25 diputus menjadi 5 D25 pada jarak $0,25l_n = 0,25.8,9 = 2,25 \text{ m}$ pada balok yang berhubungan dengan kolom eksterior sedang pada daerah yang bertemu dengan kolom interior tulangan diputus dengan jarak $0,3l_n = 0,3.8,9 = 2,67 \text{ m}$ dari muka kolom.

Panjang penyaluran kedalam

$$l_{db} = 0,02.A_b.f_y / \sqrt{f_c'} > 0,06.d_b.f_y \text{ SKSNI 3.5.2-2}$$

$$l_{db} = 0,02.490.400 / \sqrt{22,5} = 828,21 \text{ mm}$$

$$0,06.d_b.f_y = 0,06.25.400 = 600 \text{ mm} < 828,21 \text{ mm digunakan } l_{db} = 850 \text{ mm.}$$

Faktor modifikasi yang dipakai :

$$\text{Faktor tulangan terpakai lebih dibanding analisa} = 3,85/8 = 0,481$$

$$l_d = 1,4.0,481.828,21 = 557,72 \text{ kNm.}$$

Panjang penyaluran kait standar dalam tarik l_{dh}

$$\text{Panjang penyaluran dasar } l_{hb} = 100.d_b / \sqrt{f_c'}$$

$$l_{hb} = 100.25 / \sqrt{22,5} = 527,05 \text{ mm.}$$

Faktor modifikasi yang dapat digunakan adalah faktor pelindung beton, untuk kait standar 90° dengan pelindung beton pada perpanjangan yang tidak kurang dari 50 mm.

$$L_{dh} = 0,7 \cdot l_{hb} = 0,7 \cdot 527,05 = 368,93 \text{ mm.}$$

Tempat yang tersedia untuk penyaluran kait standar jika akan digunakan kait standar 90° yang dilingkup oleh sengkang ϕ 10 mm dan pelindung beton 40 mm adalah $700 - 40 - 10 = 650 \text{ mm.} > 368,93 \text{ mm.}$

Dipakai $l_{dh} = 650 \text{ mm.}$

Pembengkokan kait standar harus ditambah bagian yang lurus sepanjang $12 \cdot d_b = 12 \cdot 25 = 300 \text{ mm.}$