

BAB IV ANALISIS STRUKTUR

4.1 Umum

Analisis Struktur dilaksanakan untuk mengetahui besarnya gaya dan momen yang terjadi pada portal akibat beban yang bekerja pada portal tersebut. Analisis struktur pada studi kasus ini dikerjakan dengan bantuan program komputer "Structural Analysis Program 1990" (SAP 90). SAP 90 dipilih sebagai analisis struktur karena mempunyai fasilitas analisis struktur portal 3 dimensi. Analisis struktur portal 3 dimensi digunakan untuk dasar perhitungan analisis elemen struktur karena dalam masa layan beban yang bekerja pada portal dianggap membebani kesemua arah.

4.2. Data Bahan dan Sifat-sifat Tampang

- Kolom tipe 1 dinamakan sebagai Material 1

$$f'c = 45 \text{ Mpa}$$

$$A = 400 \text{ mm} \cdot 650 \text{ mm} = 260000 \text{ mm}^2$$

$$I_x = 1/12 \cdot 400 \cdot 600^3 = 9,1542 \cdot 10^9 \text{ mm}^4$$

$$I_y = 1/12 \cdot 400^3 \cdot 600 = 3,4667 \cdot 10^9 \text{ mm}^4$$

$$\begin{aligned} E_c &= 4700 \cdot \sqrt{f'c} = 4700 \cdot \sqrt{45} \\ &= 31528,56 \text{ N/mm}^2 \end{aligned}$$

- Kolom tipe 2 dinamakan sebagai Material 2

$$f_c = 45 \text{ Mpa}$$

$$A = 500 \text{ mm} \cdot 500 \text{ mm} = 250000 \text{ mm}^2$$

$$I_x = I_y = 1/12 \cdot 500 \cdot 500 = 5,2083 \cdot 10^9 \text{ mm}^4$$

$$E_c = 31528,56 \text{ N/mm}^2$$

- Balok Induk dinamakan sebagai Material 3

$$f_c = 35 \text{ Mpa}$$

$$A = 250 \text{ mm} \cdot 600 \text{ mm} = 240000 \text{ mm}^2$$

$$I_x = 1/12 \cdot 400 \cdot 600 = 7,2 \cdot 10^9 \text{ mm}^4$$

$$E_c = 4700 \cdot \sqrt{35} = 27805,58 \text{ N/mm}^2$$

4.3 Beban Gravitasi Pada Portal

Beban gravitasi yang terjadi pada portal tersebut berupa beban terpusat dan beban merata. Beban-beban tersebut adalah berat pelat dan beban berguna yang bekerja diatas pelat serta berat sendiri balok yang didukung oleh balok tersebut. Beban-beban tersebut diterapkan sebagai beban yang didukung balok dengan menggunakan metoda amplop.

Beban merata dari berat sendiri balok tersebut adalah sebagai berikut ini.

1. Balok Induk:

Untuk tebal pelat 130 mm

$$q_{BI} = (600-130) \cdot 400 \cdot 24 \cdot 10^{-6}$$

$$= 4,512 \text{ N/mm}$$

Untuk tebal pelat 120 mm

$$\begin{aligned} q_{BI} &= (600-120).250.24.10^{-6} \\ &= 4,806 \text{ N/mm} \end{aligned}$$

Beban sendiri yang akan dimasukkan ke perhitungan analisis struktur harus dikalikan faktor beban sebesar 1,2, jadi

untuk tebal pelat 130 mm

$$q_{BI} = 1,2 \cdot 4,512 = 5,4144 \text{ N/mm}$$

untuk tebal pelat 120 mm

$$q_{BI} = 1,2 \cdot 4,608 = 5,5296 \text{ N/mm}$$

2. Balok Anak:

Untuk tebal pelat 130 mm

$$\begin{aligned} q_{BA} &= (600-130).250.24.10^{-6} \\ &= 2,82 \text{ N/mm} \end{aligned}$$

Untuk tebal pelat 120 mm

$$\begin{aligned} q_{BA} &= (600-120).250.24.10^{-6} \\ &= 2,88 \text{ N/mm} \end{aligned}$$

Pembebanan Pelat Lantai menurut tebal pelat seperti berikut ini.

1. Untuk pelat 130 mm

-Beban Mati (DL)

$$\begin{aligned} q_{DL} &= 130.24.10^{-6} \\ &= 3.23.10^{-3} \text{ N/mm}^2 \end{aligned}$$

2. Untuk pelat 120 mm

- Beban Mati (DL)

$$\begin{aligned} q_{DL} &= 120 \cdot 24 \cdot 10^{-6} \\ &= 2.88 \cdot 10^{-6} \end{aligned}$$

3. Beban Hidup (LL)

Beban hidup yang bekerja pada lantai parkir menurut peraturan pembebanan untuk gedung 1983 adalah sebesar

$$q_{LL} = 400 \text{ kg/m}^2 = 4 \cdot 10^{-3} \text{ N/mm}^2$$

faktor beban :

$$q_u = 1,2 \cdot q_{DL} + 1,6 \cdot q_{LL}$$

-Untuk tebal pelat 130 mm

$$q_u = 1,2 \cdot 3,12 \cdot 10^{-3} + 1,6 \cdot 4 \cdot 10^{-3} = 10,44 \cdot 10^{-3} \text{ N/mm}^2$$

-Untuk tebal Pelat 120 mm

$$q_u = 1,2 \cdot 2,88 \cdot 10^{-3} + 1,6 \cdot 4 \cdot 10^{-3} = 9,856 \cdot 10^{-3} \text{ N/mm}^2$$

4.4 Perhitungan Beban Ekuivalen Yang Bekerja Pada Balok

4.4.1 Balok "Basement" - I. Untuk As - J

1. Beban Merata Bentang A-B/elemen.53 (gambar1, di lampiran No.2)

$$R_A = R_B = 5072865,88 \cdot q$$

$$x = \frac{\frac{1}{2} \cdot 2931,1621 \cdot 1465,5 + \frac{1}{2} \cdot 5575 \cdot 2787,5 \cdot 5718,5}{10145731,75}$$

$$x = 4722,68 \text{ mm}$$

$$\begin{aligned}
 M_{\frac{1}{2}'} &= \left[R_A \cdot 4253 - 2931.1621.0,5.2787,5 - \frac{(1322)^3}{6} \right] q \\
 &= 1,4568.10^{10} \cdot 10,144.10^{-3} \text{ N.mm} \\
 &= 147776867,10 \text{ N.mm}
 \end{aligned}$$

$$\begin{aligned}
 M_x &= \left[R_A \cdot 4722,68 - 0,5.2931.1621.3257,18 - \frac{(1791,68)^3}{6} \right] q \\
 &= 1,5621.10^{10} \cdot 10,144.10^{-3} \\
 &= 154810235,6 \text{ N.mm} \rightarrow M \text{ maksimum}
 \end{aligned}$$

$$\begin{aligned}
 M_{\text{maks}} &= \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2 \\
 q_{\text{ex}} &= \frac{8.154810235,6}{(8506)^2} = 17,1175 \text{ N/mm}
 \end{aligned}$$

Untuk pembebanan pada kedua sisi balok :

$$\begin{aligned}
 q_{\text{ex A-B}} &= 17,1175 \cdot 2 \text{ N/mm} \\
 &= 34,2350 \text{ N/mm} \quad (\text{"Basement" I})
 \end{aligned}$$

2 - Untuk bentang B - F sama dengan pada balok "Ground Floor" hanya satu sisi , maka beban merata untuk bentang B - F:

$$\begin{aligned}
 q_{\text{ex B-C}} &= 8,5360 \text{ N/mm, Elemen 54} \\
 q_{\text{ex C-D}} &= 6,3448 \text{ N/mm, Elemen 55} \\
 q_{\text{ex D-E}} &= 9,3016 \text{ N/mm, Elemen 56} \\
 q_{\text{ex E-F}} &= 22,8932 \text{ N/mm, Elemen 57}
 \end{aligned}$$

3- Beban Merata Bentang B - E (Ramp.) / el. 141,142 dan 143

(gambar2, di lampiran No. 2)

$$\begin{aligned}
 \text{tg} \alpha^\circ &= \frac{3000}{17725} = 0,1693 \\
 \alpha^\circ &= \text{Arc.tg } 0,1693 = 9,606^\circ
 \end{aligned}$$

$$R_B = R_E = \frac{2300 \cdot (2300 + 13125)}{2} \cdot q$$

$$R_B = 17738728,38 \cdot q$$

$$M_{\text{maks}} = -\left[\frac{1}{2} \cdot 2300^2 \cdot 7329,2 + \frac{1}{2} \cdot 2300(6562,5)^2\right] \cdot q + R_B \cdot 8862,5$$

$$= 8,8297 \cdot 10^{10} \cdot q$$

$$= 870258968,1$$

$$M_{\text{maks}} = 870258968,1 \cdot \cos 9,606^\circ$$

$$= 858056690,9 \text{ N/mm}$$

$$M_{\text{maks}} = \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2$$

$$q_{\text{ex}} = \frac{8 \cdot 858056690,9}{17725^2} = 21,8491 \text{ N/mm}$$

4.4.2 Balok "Basement" - I. Untuk As - K

1 - Bentang Q - R /elemen 58(gambar3, di lampiran No. 2)

$$q_{\text{ex}} \text{ Q-R} = 22,8982 \text{ N/mm}$$

2 - Balok Ramp./el.138,139 dan140 (gambar4, di lampiran No.2)

$$q_{\text{ex}} = 21,8491 \text{ N/mm}$$

4.4.3 Balok "Basement" - I. Untuk As - 1A

1 - Bentang A - B./elemen 70(gambar5, di lampiran No.2)

Beban Merata q_{ex} :

$$R_A = R_B = 4404804 \cdot q$$

$$M_{\frac{1}{2}l} = \left[4404804 \cdot 3025 - 0,5 \cdot 3025 \cdot \left(\frac{3025 \cdot 2476}{3068} \right) \frac{3025}{3} \right] q$$

$$M_{\frac{1}{2}l} = 960129947,4 \cdot q$$

$$= 9601299474 \cdot 10,144 \cdot 10^{-3}$$

$$= 97395581,86 \text{ N/mm}$$

$$R_A = R_B = 2906348 \cdot q$$

$$M_{\frac{1}{2}l} = \left[2906348 \cdot 3025 - \frac{1}{2} \cdot 1382 \cdot 1198 \cdot 2104 - \frac{(1643)^2 \cdot 1198}{2} \right] q$$

$$= 5433003677 \cdot 9,856 \cdot 10^{-3}$$

$$= 53547684,24 \text{ N/mm}$$

M_{maks} dua sisi pembebanan balok :

$$M_{\text{maks}} = 97395581,86 + 53547684,24 = 150943266,10 \text{ N.mm}$$

$$M_{\text{maks}} = \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2 \quad \rightarrow \quad q_{\text{ex}} = \frac{8 \cdot 150943266,10}{(6050)^2}$$

$$q_{\text{ex A-B}} = 32,9908 \text{ N/mm}$$

2 - Beban Merata Bentang B - D/elemen 71,72 (gambar 6, di lampiran No.2)

$$R_B = R_D = 4469164 \cdot q$$

$$M_{\frac{1}{2}l} = \left[R_B \cdot 4600 - \frac{1}{2} \cdot (2788)^2 \cdot 2741 \cdot \frac{(1812)^2}{2} \right] q$$

$$= 1,5977 \cdot 10^{10} \cdot q$$

$$= 1,5977 \cdot 10^{10} \cdot 10,144 \cdot 10^{-3} = 162073593,2 \text{ N.mm}$$

$$M_{\text{maks}} = \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2$$

$$q_{\text{ex}} = \frac{162073593,2 \cdot 8}{(9200)^2} = 15,3188 \text{ N/mm}$$

$$R_B = R_C = \frac{2300 \cdot 4600}{4} q = 2645000 \cdot q$$

$$\begin{aligned}
 M_{\frac{1}{2},} &= 0,0417 \cdot q \cdot (L_x)^3 \\
 &= 0,0417 \cdot (9,856 \cdot 10^{-3} \cdot \cos 9,7445) (4600)^3 \\
 &= 39427453,24 \text{ N.mm} \\
 M_{\text{maks}} &= \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2 \\
 q_{\text{ex}} &= \frac{8 \cdot 39427453,24}{(4600)^2} = 14,9064 \text{ N/mm}
 \end{aligned}$$

Maka di dapat :

$$\begin{aligned}
 q_{\text{ex B-C}} &= 15,3188 + 14,9064 = 30,2253 \text{ N/mm} \\
 q_{\text{ex C-D}} &= 15,3188 \text{ N/mm}
 \end{aligned}$$

3 - Beban Merata Bentang D - E/elemen.73 (gambar7, di lampiran No.2)

$$\begin{aligned}
 R_D = R_E &= \frac{5697000}{2} \cdot q = 2848500 \cdot q \\
 M_{\frac{1}{2},} &= (2848500 \cdot 3375 - \frac{1}{2} \cdot 1688 \cdot 3375 \cdot 1688) \cdot q \\
 &= 4805419500 \cdot q \\
 M_{\text{maks}} &= \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2 \\
 q_{\text{ex}} &= \frac{8(4805419500 \cdot 9,856 \cdot 10^{-3} + 4805419500 \cdot 10,144 \cdot 10^{-3})}{(6750)^2} \\
 &= 16,8750 \text{ N/mm}
 \end{aligned}$$

4.4.4 Balok "Ground Floor As" - 1A

1 - Bentang B - C/elemen.113,114 (gambar8, di lampiran No.2):

$$\begin{aligned}
 R_B = R_C &= 2645000 \cdot q \\
 M_{\frac{1}{2},} &= [R_B \cdot 2300 - \frac{1}{6}(2300)^2] \cdot q = 4055666667 \cdot q \text{ N.mm} \\
 R_B = R_C &= 1669195,5 \cdot q
 \end{aligned}$$

$$M_{\frac{1}{2}} = \left[R_B \cdot 2300 - \frac{1}{2} \cdot (903)^2 \cdot 1698 - 903 \cdot \frac{(1397)^2}{2} \right] = 2265715946 \text{ q N.mm}$$

$$M_{\text{maks}} = \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2$$

$$q_{\text{ex}} = \frac{(4055666667 + 2265715946) \cdot 9,856 \cdot 10^{-3} \cdot 8}{(4600)^2} = 23,5552 \text{ N/mm}$$

2 - Bentang D - E /elemen 115,116 (gambar9, di lampiran No.2):

$$R_D = 3233212,5 \cdot q$$

$$R_E = 2284912,5 \cdot q$$

$$x = \frac{1,5424 \cdot 10^{10}}{5518125,0} = 2795 \text{ mm}$$

$$M_{\text{maks}} = \left[R_E \cdot (6750 - x) - \frac{1}{2} \cdot (6750 - x) \cdot \frac{(6750 - x) \cdot 1635}{5115} \cdot \frac{(6750 - x)}{3} \right] \cdot q$$

$$= 5741032864 \cdot q \text{ N.mm}$$

$$R_D = R_E = 2639920,5 \cdot q$$

$$M_{\text{maks}} = \left[R_D \cdot 3375 - \frac{1}{2} \cdot (903)^2 \cdot 2773 - 903 \cdot \frac{(2472)^2}{2} \right] \cdot q = 5020148133 \cdot q$$

$$M_{\text{maks}} = \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2$$

$$q_{\text{ex}} = \frac{8(5741032864 + 5020148132) \cdot 9,856 \cdot 10^{-3}}{(6750)^2} = 18,6227 \text{ N/mm}$$

Untuk beban terpusat akibat tritisan / list plank.

$$P = 200 \cdot 800 \cdot \frac{4769}{2} \cdot 24 \cdot 10^{-6} = 9156,48 \text{ N}$$

$$P = 9,1565 \text{ KN}$$

Untuk tinjauannya dengan manual (jepit satu tumpuan)

$$q = 8,6227 + 5,5296 = 24,1523 \text{ N/mm}$$

4.4.5 Balok "Ground Floor" untuk As - K

1 - Beban Merata Balok A - C ("Ground Floor")/El.89 :

(gambar 10, di lampiran No.2)

$$R_A = R_C = 4954037,8 \cdot q$$

$$x = \frac{(2931 \cdot 1627 \cdot 0,5) \left(\frac{2931}{2} + 5575 \right) + (975 + 2300) 2300 \left(\frac{5575}{2} \right)}{9908075,6}$$

$$= 3807,21 \text{ mm}$$

Cek momen : $\frac{1}{2} \ell$:

$$\left[R_A \cdot \frac{1}{2} \ell - 0,5 \cdot 2931 \cdot 1621 \left(\frac{1}{2} \ell - \frac{2931}{2} \right) \left[\left(\frac{1}{2} \ell - 2931 \right) \frac{2300 \left(\frac{1}{2} \ell - 2931 \right)}{2300} \cdot 0,5 \cdot \frac{\left(\frac{1}{2} \ell - 2931 \right)}{3} \right] \right] q$$

$$(4954037,8 \cdot 4253 - 0,5 \cdot 2931 \cdot 1621 \cdot 2787,5 - 873842 \cdot 1418) q =$$

$$M_{\frac{1}{2} \ell} = 1,32088 \cdot 10^{10} \cdot 9,856 \cdot 10^{-3} = 130185828,1 \text{ N.mm}$$

Cek momen :

$$M_x = R_A \cdot 4698,79 - 0,5 \cdot 2931 \cdot 1621 \cdot 3233,3 - (1767,8)^2 \cdot 0,5 \cdot \frac{1767,8}{3}$$

$$M_x = 1,46763 \cdot 10^{10} \cdot 9,856 \cdot 10^{-3} = 144649485,1 \text{ N.mm} \rightarrow M \text{ maksimum}$$

$$M_{\text{maks}} = \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2$$

$$q_{\text{ex}} = \frac{8 \cdot 144649485,1}{(2931 + 5575)^2} = 15,9921 \text{ N/mm}$$

Untuk dua sisi beban maka :

$$q_{\text{ex A-C}} = 2 \cdot 15,9921 = 31,9842 \approx 32 \text{ N/mm (Ground Floor)}$$

2 - Beban Merata Balok C - E. ("Ground Floor")/elemen.90

(gambar 11, di lampiran No.2)

$$R_C = R_E = 1505496 \cdot q$$

$$x = \frac{\frac{1}{2} \cdot 1806.903.903 + \frac{1}{2} \cdot 2963.1482.3288}{3010992} = 26421,1 \text{ mm}$$

$$\begin{aligned} M_x &= R_C \cdot x - 0,5 \cdot 903.1806 (x - 903) - 0,5 (x - 1806)^2 \left(\frac{x - 1806}{3} \right) \\ &= (1505496 \cdot 26421,1 - 1418077792 - 97414458,3) \text{ q} \\ &= 2462178731 \cdot 9,856 \cdot 10^{-3} \text{ N.mm} \\ &= 24267233,58 \text{ N.mm} \rightarrow M \text{ maks.} \end{aligned}$$

$$\begin{aligned} M_{\text{maks}} &= \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2 \\ q_{\text{ex}} &= \frac{8.24267233,58}{(4769)^2} = 8,5360 \text{ N/mm} \end{aligned}$$

Untuk dua sisi beban pada balok, maka

$$q_{\text{ex C-E}} = 2 \cdot 8,5360 = 17,0720 \text{ N/mm}$$

3 - Beban Merata Balok E - G. ("Ground Floor") elemen 91 (gambar12, di lampiran No.2)

$$\begin{aligned} R_E = R_G &= (0,5 \cdot 2575 \cdot 1287,5) \text{ q} \\ &= 1657656,25 \cdot \text{q} \end{aligned}$$

Cek momen pada $\frac{1}{2}$ segitiga ($\frac{1}{4} \ell$) :

$$\begin{aligned} M_{\frac{1}{4}} &= \left[1657656,25 \cdot 1287,5 - 0,5 \cdot (1287,5)^2 \cdot \frac{1287,5}{3} \right] \text{ q} \\ &= 1778527018 \cdot 9,856 \cdot 10^{-3} \text{ N.mm} \\ &= 17529162,29 \text{ N.mm} \end{aligned}$$

Cek momen ditengah ben tang $\frac{1}{2} \ell$:

$$\begin{aligned} M_{\frac{1}{2}} &= (1657656,25 \cdot 2575 - 0,5 \cdot 2575 \cdot 1287,5 \cdot 1287,5) \text{ q} \\ &= 2134232422 \cdot 9,856 \cdot 10^{-3} \text{ N.mm} \\ &= 21034994,75 \text{ N.mm} \rightarrow M \text{ maks.} \end{aligned}$$

Untuk pembebanan pada dua sisi balok E - G

$$q_{ex \text{ E-G}} = 2 \cdot 6,3448 = 12,6896 \text{ N/mm}$$

4 - Beban Merata Balok G - I/eleman 92 (gambar13, di lampiran No.2).

$$\begin{aligned} R_G = R_I &= \frac{1}{2} \cdot 3,775 \cdot 1887,5 \cdot q \\ &= 3562656,25 \cdot q \end{aligned}$$

Momen ditengah bentang $\frac{1}{2} \ell$:

$$\begin{aligned} M &= \left[R_G \cdot 3,775 - \left(0,5 \cdot 3,775 \cdot 1887,5 \right) \frac{1}{2} \cdot 3,775 \right] q \\ &= 6724513672 \cdot 9,856 \cdot 10^{-3} \text{ N.mm} \\ &= 66276806,75 \text{ N.mm} \rightarrow M \text{ maks.} \end{aligned}$$

$$M_{maks} = \frac{1}{8} \cdot q_{ex} \cdot \ell^2$$

Beban Merata Bentang G - I.

$$q_{ex} = \frac{8 \cdot 66276806,75}{(7550)^2} = 9,3016 \text{ N/mm}$$

Untuk pembebanan pada kedua sisi :

$$q_{ex \text{ G-I}} = 2 \cdot 9,3016 = 18,6032 \text{ N/mm}$$

5 - Beban Merata Balok I - K./el.93 ("Ground Floor") (gbr14, dilampiran No.2)

$$R_I = R_K = 2281328,125 \cdot q$$

$$x = \frac{0,5 \cdot 2000 \cdot (1000)^2 + 0,5 \cdot 3,775 \cdot 1887,5 (2000 + 1887,5)}{4562656,25} = 3254,65 \text{ mm}$$

Cek momen pada $\frac{1}{2}$ bentang

$$\begin{aligned} M_{\frac{1}{2}} &= \left[2281328,125 \cdot 2887,5 - \left(0,5 \cdot 2000 \cdot 1000 \right) 1887,5 - 0,5 \cdot \frac{(887,5)^3}{3} \right] q \\ &= 4583327474 \cdot 9,856 \cdot 10^{-3} = 45173275,58 \text{ N.mm} \end{aligned}$$

$$\begin{aligned}
 M_x &= \left[2281328,125 \cdot 3254,65 - 0,5 \cdot 2000 \cdot 1000 \cdot 2254,65 - \frac{(1254,5)^3}{3} \right] q \\
 &= 4841618738 \cdot 9,856 \cdot 10^{-3} = 47718994,28 \text{ N.mm} \rightarrow M_{\text{maks.}} \\
 M_{\text{maks}} &= \frac{1}{8} \cdot q_{\text{ex}} \cdot \ell^2 \\
 q_{\text{ex}} &= \frac{8 \cdot 47718994,28}{(5775)^2} = 11,4466 \text{ N/mm}
 \end{aligned}$$

Untuk dua sisi pembebanan :

$$q_{\text{ex 1-K}} = 2 \cdot 11,4466 = 22,8932 \text{ N/mm}$$

4.4.6 Balok "Ground Floor" untuk As - J.

Beban merata untuk tiap bentangan balok As-J sama dengan pembebanan balok As - K. perbedaan hanya pada panjang bentang A - B dan besarnya beban terpusat dari balok anak.

4.4.7 Beban Merata Portal Membujur As - 2A.

1. "GroundFloor" /elemen.74,117 (gambar15,di lampiranNo.2)

$$\begin{aligned}
 R_A &= \frac{1288(3353+1288)}{2} q = 2988804 q \\
 M_{x'} &= \left[R_A \cdot 2965 - \frac{1}{2} \cdot (1288)^2 \cdot 2106 - 1288 \frac{(1677)^2}{2} \right] q \\
 &= 5303795952 \cdot 9,856 \cdot 10^{-3} = 52274212,9 \text{ N.mm} \\
 q_{\text{ex}} &= \frac{8 \cdot 522744212,9}{(5929)^2} = 11,8964 \text{ N/mm}
 \end{aligned}$$

2 .elemen. 118,119 (gambar 16,di lampiran No.2)

$$R_A = \frac{1482(1482+2965)}{2} q = 3295227 q$$

$$\begin{aligned}
 M_{\frac{1}{2}l} &= \left[R_A \cdot 2965 - \frac{1}{2} (1482)^2 \cdot 1977 - 1482 \frac{(1482)^2}{2} \right] q \\
 &= 5969608632 \cdot 9,856 \cdot 10^{-3} = 58836462,68 \text{ N.mm} \\
 q_{\text{ex}} &= \frac{8 \cdot 58836462,68}{(5929)^2} = 13,3898 \text{ N/mm} \\
 q_{\text{ex total}} &= 11,8964 + 13,3898 = 25,2862 \text{ N/mm}
 \end{aligned}$$

3. elemen .120,121(gambar 17, di lampiran No.2)

$$\begin{aligned}
 R_D &= \frac{1482 (1482 + 3786)}{2} q = 3903588 \text{ N/mm} \\
 M_{\frac{1}{2}l} &= \left[R_D \cdot 3375 - \frac{1}{2} (1482)^2 \cdot 2387 - 1482 \cdot \frac{(1893)^2}{2} \right] q \\
 &= 7897961097 \cdot 9,856 \cdot 10^{-3} = 77842304,57 \text{ N.mm} \\
 q_{\text{ex}} &= \frac{8 \cdot 77842304}{(6750)^2} = 13,6678 \text{ N/mm} \\
 R_D &= \frac{1288 (1288 + 4178)}{2} q = 352010,4 q \\
 M_{\frac{1}{2}l} &= \left[R_D \cdot 3375 - \frac{1}{2} (1288)^2 \cdot 2516 - 1288 \frac{(2087)^2}{2} \right] q \\
 &= 6988413012 \cdot 9,856 \cdot 10^{-3} = 68877798,65 \text{ N.mm} \\
 q_{\text{ex}} &= \frac{8 \cdot 68877798,65}{(6750)^2} = 12,0938 \text{ N/mm} \\
 q_{\text{ex total}} &= 13,6678 + 12,0938 = 25,7616 \text{ N/mm}
 \end{aligned}$$

4.4.8 Beban Merata Portal Membujur As - 3A.

(1).elemen.76,122(gambar 18, di lampiran No,2)

$$R_D = \frac{1288 (1288 + 4178)}{2} q = 3520104 \cdot q$$

$$M_{\frac{1}{2}l} = \left[R_D \cdot 3375 - \frac{1}{2} (1288)^2 \cdot 2516 - 1288 \cdot \frac{(2087)^2}{2} \right] q$$

$$= 6988413012 \cdot 9,856 \cdot 10^{-3} = 68877798,65 \text{ N.mm}$$

$$q_{\text{ex}} = \frac{8 \cdot 68877798,65}{(6750)^2} = 12,0938 \text{ N/mm}$$

$$R_D = \frac{1888 (1888 + 2974)}{2} q = 4589728 \cdot q$$

$$M_{\frac{1}{2}l} = \left[R_D \cdot 3375 - \frac{1}{2} (1888)^2 \cdot 2116 - 1888 \cdot \frac{(1487)^2}{2} \right] q$$

$$= 9631700912 \cdot 9,856 \cdot 10^{-3} = 94930044,19 \text{ N.mm}$$

$$q_{\text{ex}} = \frac{8 \cdot 94930044,19}{(6750)^2} = 16,6681 \text{ N/mm}$$

$$q_{\text{ex total}} = 12,0938 + 16,6681 = 28,7619 \text{ N/mm}$$

(2).elemen.123,124 (gambar 19, di lampiran No.2)

$$R_A = \frac{1288 (1288 + 3353)}{2} q = 2988804 \cdot q$$

$$M_{\frac{1}{2}l} = \left[R_A \cdot 2964,5 - \frac{1}{2} (1288)^2 \cdot 2106 - 1288 \cdot \frac{(1676)^2}{2} \right] q$$

$$= 5304460882 \cdot 9,856 \cdot 10^{-3} = 52280766,45 \text{ N.mm}$$

$$q_{\text{ex}} = \frac{8 \cdot 52280766,45}{(5929)^2} = 11,8979 \text{ N/mm}$$

$$R_A = \frac{1888 (1888 + 2153)}{2} q = 3814704 \cdot q$$

$$\begin{aligned}
 M_{\frac{1}{2}l} &= \left[R_A \cdot 2964,5 - \frac{1}{2} (1888)^2 \cdot 1706 - 1888 \cdot \frac{(1077)^2}{2} \right] q \\
 &= 7173161000 \cdot 9,856 \cdot 10^{-3} = 70698674,82 \text{ N.mm} \\
 q_{\text{ex}} &= \frac{8 \cdot 70698674,82}{(5929)^2} = 16,0893 \text{ N/mm} \\
 q_{\text{ex total}} &= 11,8979 + 16,0893 = 27,9872 \text{ N/mm}
 \end{aligned}$$

(3).elemen .125,126(gambar 20, di lampiran No.2)

$$\begin{aligned}
 R_C &= \frac{1288(1288+2024)}{2} q = 2132928 \cdot q \\
 M_{\frac{1}{2}l} &= \left[R_C \cdot 2300 - \frac{1}{2} (1288)^2 \cdot 1441 - 1288 \cdot \frac{(1012)^2}{2} \right] q \\
 &= 305091651,20 \cdot 9,856 \cdot 10^{-3} = 30069833,14 \text{ N.mm} \\
 q_{\text{ex}} &= \frac{8 \cdot 30069833,14}{(4600)^2} = 11,3686 \text{ N/mm} \\
 R_C &= \frac{1888(1888+824)}{2} q = 2560128 \cdot q \\
 M_{\frac{1}{2}l} &= \left[R_C \cdot 2300 - \frac{1}{2} (1888)^2 \cdot 1041 - 1888 \cdot \frac{(412)^2}{2} \right] q \\
 &= 3872710912 \cdot 9,856 \cdot 10^{-3} = 38169438,75 \text{ N.mm} \\
 q_{\text{ex}} &= \frac{8 \cdot 38169438,75}{(4600)^2} = 14,4308 \text{ N/mm} \\
 q_{\text{ex total}} &= 11,3686 + 14,4308 = 25,7994 \text{ N/mm}
 \end{aligned}$$

4.4.9 Beban Merata Portal Membujur As-4A

$$\begin{aligned}
 \text{elemen.78,127} \longrightarrow & R_A = 3814704 \text{ q} \\
 & M_{\frac{1}{2}l} = 70698674,82 \text{ N.mm} \\
 & q_{\text{ex}} = 16,0893 \text{ N/mm} \\
 & q_{\text{ex total}} = 16,0893 + 11,8979 = 27,9872 \text{ N/mm}
 \end{aligned}$$

$$\text{elemen.128,129} \quad R_B = \frac{903(903+2794)}{2} q = 1669195,50 \cdot q$$

$$M_{\frac{1}{2}} = \left[R_B \cdot 2300 - \frac{1}{2} (903)^2 \cdot 602 - 903 \cdot \frac{(1397)^2}{2} \right] q$$

$$= 2712560078 \cdot 9,856 \cdot 10^{-3} = 26734992,12 \text{ N.mm}$$

$$q_{\text{ex}} = \frac{8 \cdot 26734992,12}{(4600)^2} = 10,1077 \text{ N/mm}$$

$$q_{\text{ex total}} = 10,1077 + 14,4308 = 24,5385 \text{ N/mm}$$

$$\text{elemen.130,131} \quad R_D = \frac{1575(1575+3600)}{2} q = 4075312,5 \cdot q$$

$$M_{\frac{1}{2}} = \left[R_D \cdot 3375 - \frac{1}{2} (1575)^2 \cdot 2325 - 1575 \cdot \frac{(1800)^2}{2} \right] q$$

$$= 8318953125 \cdot 9,856 \cdot 10^{-3} = 81991602 \text{ N.mm}$$

$$q_{\text{ex}} = \frac{8 \cdot 81991602}{(6750)^2} = 14,3963 \text{ N/mm}$$

$$q_{\text{ex total}} = 14,3963 + 8,6876 = 23,0839 \text{ N/mm}$$

(1).Element. 59 (gambar 21, di lampiran No.2)

$$R_A = \frac{\frac{1}{2} [2998 \cdot 1563 \cdot 2562 + (1563)^2 \cdot 1042]}{4561} q$$

$$= 1595130,77 q$$

$$M_x = \left[R_A \cdot x - \frac{1}{2} x \left(\frac{x \cdot 1563}{2998} \right) \frac{x}{3} \right] q$$

$$\frac{dM_x}{dx} = R_A - \frac{3}{6} \cdot \frac{1563 \cdot x^2}{2998}$$

$$x = \sqrt{1595130,77 \cdot 2998 \cdot 2} = 2473,71 \text{ mm}$$

$$\begin{aligned}
 M_x &= \left[R_A \cdot 2473,71 - \left(\frac{1563 \cdot x^3}{6 \cdot 2998} \right) \right] q \\
 &= 2630598106 \cdot 10,144 \cdot 10^{-3} = 26684787,19 \text{ N.mm} \\
 q_{ex} &= \frac{8 \cdot 26684787,19}{(4561)^2} = 10,2620 \text{ N/mm}
 \end{aligned}$$

(2). Element 94 (gambar 22, di lampiran No.2)

$$\begin{aligned}
 R_C &= \frac{\frac{1}{2} [2926 \cdot 1563 \cdot 2610 + (1635)^2 \cdot 1090]}{4561} q \\
 &= 1627957,403 q \\
 M_x &= \left[R_A \cdot x - \frac{1}{2} x \left(\frac{x \cdot 1635}{2926} \right) \frac{x}{3} \right] q \\
 \frac{dM_x}{dx} &= 0 \Rightarrow x = 2413,88 \text{ mm} \\
 M_x &= 2619790583 \cdot 9,856 \cdot 10^{-3} = 25820655,98 \text{ N.mm} \\
 q_{ex} &= \frac{8 \cdot 25820655,98}{(4561)^2} = 9,9272 \text{ N/mm}
 \end{aligned}$$

(3). Element 59 (gambar23, di lampiran No.2)

$$\begin{aligned}
 R_E &= \frac{\frac{1}{2} \cdot 5575 (2788)^2}{5575} q = 3886472 q \\
 M_{\frac{1}{2}l} &= \left[R_E \cdot 2788 - \frac{1}{2} (2788)^2 \frac{(2788)^2}{3} \right] q \\
 &= 7223655957 \cdot 10,144 \cdot 10^{-3} = 73276766,03 \text{ N.mm} \\
 q_{ex} &= \frac{8 \cdot 73276766,03}{(5575)^2} = 18,8611 \text{ N/mm}
 \end{aligned}$$

(4).Element 94 (gambar 24, di lampiran No.2)

$$R_G = \frac{2300(2300 + 975)^2}{2} q = 3766250 q$$

$$M_{\frac{1}{2}l} = \left[R_G \cdot 2788 - \frac{1}{2}(2300)^2 \cdot 1254 - 2300 \frac{(487,5)^2}{2} \right] q$$

$$= 6910170313 \cdot 9,856 \cdot 10^{-3} = 68106638,6 \text{ N.mm}$$

$$q_{ex} = \frac{8 \cdot 68106638,6}{(5575)^2} = 17,5272 \text{ N/mm}$$

(5).Elemen 60,61,66 dan 67(gambar 25, di lampiran No.2)

$$R_1 = \frac{1688(1688 + 1394)^2}{2} q = 2601208 q$$

$$M_{\frac{1}{2}l} = \left[R_1 \cdot 2385 - \frac{1}{2}(1688)^2 \cdot 1260 - 1688 \frac{(697)^2}{2} \right] q$$

$$= 3998771564 \cdot 9,856 \cdot 10^{-3} = 39411892,53 \text{ N.mm}$$

$$q_{ex} = \frac{8 \cdot 39411892,53}{(4769)^2} = 13,8632 \text{ N/mm}$$

4.5 Beban Terpusat yang Bekerja Pada Balok

4.5.1 Beban Terpusat pada Balok "Ground Floor" As - K

1 - Titik B/elemen.89 (gambar 26, di lampiran No.2)

$$P_B = 16537175 \cdot 9,856 \cdot 10^{-3} = 162990,40 \text{ N}$$

$$P_B = \frac{\frac{1}{2} [3962 \cdot 901 + (1218)^2 + (1267)^2 + 2 \cdot 4600 \cdot 2300] + 2115 + \frac{(1267 + 1218)}{2}}{2} \cdot q$$

$$= \frac{16537175 q}{2} = \frac{16537175 \cdot 10,144 \cdot 10^{-3}}{2} = \frac{167753,10}{2} \text{ N}$$

$$= 83876,55 \text{ N}$$

2 - Titik D/elemen.90 (gambar 27,di lampiran N0.2)

$$\begin{aligned} P_D &= [903 (2794 + 903) + 1482 (1482 + 1636)] \\ &= 7959267 \cdot q = 7959267 \cdot 9,856 \cdot 1 \\ &= 78446,54 \quad N \end{aligned}$$

3 - Titik E /elemen portal 2 dimensi (gambar28 , di lampiran No.2)

$$\begin{aligned} P_E &= q (1482 + 1636) 1482 + 1288 (1288 + 2024) \\ &= 8886732 \cdot q = 8886732 \cdot 9,856 \cdot 10^{-3} \\ &= 87587,63 \quad N \end{aligned}$$

4 - Titik F/elemen.91 (gambar29, di lampiran No.2)

$$\begin{aligned} P_F &= 2 (2024 + 1288) 1288 \cdot q = 8531712 \cdot q \\ &= 8531712 \cdot 9,856 \cdot 10^{-3} = 84088,55 \quad N \end{aligned}$$

5 - Titik G/elemen portal 2 dimensi (gambar30, di lampiran No.2)

$$\begin{aligned} P_G &= q [(1288 + 2024) 1288 + 1888 (824 + 1888)] \\ &= 9386112 \cdot q = 9386112 \cdot 9,856 \cdot 10^{-3} = 92509,52 \quad N \end{aligned}$$

6 - Titik H / elemen 92 (gambar31, di lampiran No.2)

$$\begin{aligned} P_H &= 2 \cdot (1888 + 824) 1888 \cdot q = 10240512 \cdot q \\ &= 10240512 \cdot 9,856 \cdot 10^{-3} = 100930,49 \quad N \end{aligned}$$

7 - Titik I dan J /elemen 93(gambar32, di lampiran No.2)

$$\begin{aligned} P_I &= q [(1888 + 824) 1888 + (1000 + 2600) 1000] \\ &= 8720256 \cdot q = 8720256 \cdot 9,856 \cdot 10^{-3} = 85946,84 \quad N \end{aligned}$$

4.5.2 Beban Titik Terpusat A - J.

1- Titik 1./elemen .53(gambar33, di lampiran No.2)

$$\begin{aligned}
 P &= \left[\frac{1}{2} (2300)^2 + 2115 \frac{(1267+1218)}{2} + \frac{1}{2} [(1267)^2 + (1218)^2] \right] q \\
 &= 6817294 \cdot 10,144 \cdot 10^{-3} = 69154,6303 \text{ N} \\
 P &= \left[\frac{1}{2} [(1878)^2 + (1621)^2] + \frac{(1878+1621)}{2} 2430 \right] q + \\
 &\quad \left[\frac{1}{2} [(2507)^2 + (2404)^2 + \frac{(2507+2404)}{2}] 1018 \cdot q \right] \\
 &= 15860379 \cdot q = 15860379 \cdot 10,144 \cdot 10^{-3} \\
 &= 160887,69 \text{ N Basement I}
 \end{aligned}$$

$$\text{"Ground Floor"} : 15860379 \cdot 9,856 \cdot 10^{-3} = 156319,90 \text{ N}$$

2 - Titik 2./elemen 54 (gambar34, di lampiran No.2)

$$\begin{aligned}
 P &= \left[(4123+903) 903 + \frac{1}{2} [(1354)^2 + (994)^2] + 3581 \cdot \frac{(1354+994)}{2} \right] q \\
 &= 10153248 \cdot q = 10153248 \cdot 9,856 \cdot 10^{-3} = 100070,41 \text{ N}
 \end{aligned}$$

3 - Titik 3./elemen portal 2 dimensi (gambar35, di lampiran No.2)

$$\begin{aligned}
 P &= q [(1288+3353) 1288 + (1482+2965) 1482] \\
 &= 12568062 \cdot q = 12568062 \cdot 9,586 \cdot 10^{-3} \\
 &= 123870,82 \text{ N}
 \end{aligned}$$

4 -Titik 4./elemen .55 (gambar36, di lampiran No.2)

$$\begin{aligned}
 P &= 2 \cdot q [(3353+1288) 1288] = 11955216 \cdot q \\
 &= 11955216 \cdot 9,586 \cdot 10^{-3} = 117830,61 \text{ N}
 \end{aligned}$$

5 -Titik 5 /elemen portal 2 dimensi(gambar37, di lampiran No.2)

$$\begin{aligned}
 P &= q [(1288+3353) 1288 + (1888+2153) 1888] \\
 &= 13607016 \cdot q = 13607016 \cdot 9,586 \cdot 10^{-3} \\
 &= 134110,75 \text{ N}
 \end{aligned}$$

6 - Titik 6 /elemen.56 (gambar38, di lampiran No.2)

$$P = 2 \cdot q \left[(2153 + 1888) 1888 \right] = 15258816 \cdot q$$

$$= 15258816 \cdot 9,586 \cdot 10^{-3} = 150390,89 \text{ N}$$

7 - Titik 7/elemen portal 2 dimensi (gambar39, di lampiran No.2)

$$P = \left[(1888 + 2153) 1888 + \frac{1}{2} \left[(1000)^2 + (1611)^2 \right] + 3318 \cdot \frac{(1000 + 1611)}{2} \right] q$$

$$= 13758717,5 \cdot q = 13758717 \cdot 9,856 \cdot 10^{-3} = 135605,92 \text{ N}$$

8 - Titik 8 /elemen .57(gambar40, di lampiran No.2)

$$P = \left[\frac{1}{2} \cdot 1205 \cdot 1819 + \frac{1}{2} \cdot 2435 \cdot 1819 + 2547 \cdot 1819 + \right.$$

$$\left. \frac{1}{2} \cdot 2163 \cdot 1612 + \frac{1}{2} \cdot 845 \cdot 1134 + 3179 \cdot \frac{(1612 + 1134)}{2} \right]$$

$$= 14530833 \cdot 9,856 \cdot 10^{-3} = 143215,89 \text{ N}$$

9 -Ramp. Ujung elemen.58,63 (gambar41, di lampiran No.2)

$$P_I = \frac{1}{2} \cdot q \cos 9,606^\circ \cdot 4600 \cdot 2300$$

$$= 5212826,62 \cdot 9,856 \cdot 10^{-3}$$

$$= 51407,19 \text{ N}$$

$$P_{II} = (2600 + 1000) 1000 \cdot q$$

$$= 3600000 \cdot q = 3600000 \cdot 9,856 \cdot 10^{-3}$$

$$= 35481,6 \text{ N}$$

10 - Beban Merata Balok "Basement" untuk Bentang A-C As-K. el.balok susulan (gambar42, di lampiran No.2)

$$M_x = 1,46763 \cdot 10^{10} \cdot 10,144 \cdot 10^{-3} = 148876387,2$$

$$q_{ex} = \frac{8 \cdot 148876387,2}{(8506)^2} = 16,4613 \text{ N/mm}$$

Untuk Beban pada kedua sisi balok :

$$q_{ex} = 2 \cdot 16,4613 = 32,9227 \text{ N/mm}$$

11 - Beban Merata dan Beban titik Balok Anak. (gambar 43, di lampiran No.2)

$$\begin{aligned} \text{Beban terpusat } P &= \frac{1}{2} \cdot q (8292 \cdot 1210) + (2788 + 3624) 2788 q = 22893316 \cdot q \\ &= 22893316 \cdot 10,144 \cdot 10^{-3} = 232229,8 \text{ N} \end{aligned}$$

$$\begin{aligned} R_p &= \frac{[0,5 (1210)^2 \cdot 7485 + 0,5 \cdot 7082 \cdot 1210 \cdot 4721 + (2788 + 3624) 2788 \cdot 3692]}{8292} q \\ &= 11059774,72 q \\ x &= \frac{(2788 + 3624) 2788 \cdot 4600 + \frac{1}{2} (1210)^2 \frac{1210 \cdot 2}{3} + \frac{7028 \cdot 1210}{2} \left(1210 + \frac{7028}{3}\right)}{22893316} q \\ &= 4286,06 \text{ mm} \\ M_x &= \left[11059774,72 \cdot 4286,06 - \frac{1}{2} (2788)^2 \cdot 2427,4 - 2788 \cdot \frac{(1498,06)^2}{2} - \frac{1}{2} \cdot (1210)^2 \cdot 3479,4 - \right. \\ &\quad \left. \left[\frac{2796 \cdot 1210}{7028} + 1210 \right] 0,5 \cdot \frac{(3076)^2}{2} \right] q \\ &= 2,83012 \cdot 10^{10} \cdot 10,144 \cdot 10^{-3} = 287086962,50 \text{ N.mm} \\ q_{ex} &= \frac{8 \cdot 287086962,50}{(8292)^2} = 33,4030 \text{ N/mm} \end{aligned}$$

12-.Beban merata balok anak, dengan balok suslan (gambar 44, lampiran 2)

$$\begin{aligned} R_A &= \frac{\left[\frac{1}{2} \cdot 4600 \cdot 2300 \cdot 6446 + \frac{1}{2} \cdot 4600 \cdot 2300 \cdot 2300 + \frac{1}{2} \cdot 901 \cdot 3692 \cdot 6006,75 + \frac{1}{2} (1218)^2 \cdot 371 \right. \\ &\quad \left. + \frac{1}{2} (1267)^2 \cdot 845 + \frac{(1267 + 1218)}{2} \cdot 2115 \cdot 2324,5 \right] q}{8292} \\ &= 8029935,78 q \\ R_B &= 16415540 q - 8029935,78 q = 8385604,22 q \\ x &= \frac{8029935,78 \cdot 8292}{16415540} = 4056,17 \text{ mm} \end{aligned}$$

11 - Beban Merata dan Beban titik Balok Anak. (gambar 43, di lampiran No.2)

$$\begin{aligned} \text{Beban terpusat } P &= \frac{1}{2} \cdot q (8292 \cdot 1210) + (2788 + 3624) 2788 q = 22893316 \cdot q \\ &= 22893316 \cdot 10,144 \cdot 10^{-3} = 232229,8 \text{ N} \end{aligned}$$

$$\begin{aligned} R_p &= \frac{[0,5 (1210)^2 \cdot 7485 + 0,5 \cdot 7082 \cdot 1210 \cdot 4721 + (2788 + 3624) 2788 \cdot 3692]}{8292} q \\ &= 11059774,72 q \end{aligned}$$

$$\begin{aligned} x &= \frac{(2788 + 3624) 2788 \cdot 4600 + \frac{1}{2} (1210)^2 \frac{1210 \cdot 2}{3} + \frac{7028 \cdot 1210}{2} \left(1210 + \frac{7028}{3}\right)}{22893316} q \\ &= 4286,06 \text{ mm} \end{aligned}$$

$$\begin{aligned} M_x &= \left[11059774,72 \cdot 4286,06 - \frac{1}{2} (2788)^2 \cdot 2427,4 - 2788 \cdot \frac{(1498,06)^2}{2} - \frac{1}{2} \cdot (1210)^2 \cdot 3479,4 - \right. \\ &\quad \left. \left[\frac{2796 \cdot 1210}{7028} + 1210 \right] 0,5 \cdot \frac{(3076)^2}{2} \right] q \\ &= 2,83012 \cdot 10^{10} \cdot 10,144 \cdot 10^{-3} = 287086962,50 \text{ N.mm} \\ q_{ex} &= \frac{8 \cdot 287086962,50}{(8292)^2} = 33,4030 \text{ N/mm} \end{aligned}$$

12-.Beban merata balok anak, dengan balok suslan (gambar 44, lampiran 2)

$$\begin{aligned} R_A &= \frac{\left[\frac{1}{2} \cdot 4600 \cdot 2300 \cdot 6446 + \frac{1}{2} \cdot 4600 \cdot 2300 \cdot 2300 + \frac{1}{2} \cdot 901 \cdot 3692 \cdot 6006,75 + \frac{1}{2} (1218)^2 \cdot 37 \right. \\ &\quad \left. + \frac{1}{2} (1267)^2 \cdot 845 + \frac{(1267 + 1218)}{2} \cdot 2115 \cdot 2324,5 \right]}{8292} q \\ &= 8029935,78 q \end{aligned}$$

$$R_B = 16415540 q - 8029935,78 q = 8385604,22 q$$

$$x = \frac{8029935,78 \cdot 8292}{16415540} = 4056,17 \text{ mm}$$

$$\begin{aligned}
 M_{\text{maks}} &= \left[8029935,78 \cdot 4235,83 - \frac{1}{2} \cdot 4600 \cdot 2300 \cdot 2389,8 - \frac{1}{2} \cdot 901 \cdot 3692 \cdot 1950,58 - \right. \\
 &\quad \left. \frac{1}{2} \cdot 543,83 \cdot 1087,66 \cdot \frac{543,83}{3} \right] q \\
 &= 1,8074 \cdot 10^{10} q = 1,8074 \cdot 10^{10} \cdot 10,144 \cdot 10^{-3} = 183337520,70 \text{ N.mm} \\
 q_{\text{ex}} &= \frac{8 \cdot 183337520,70}{(8292)^2} = 21,3316 \text{ N/mm}
 \end{aligned}$$

13 - Untuk Beban titik / Terpusat. (gambar45, di lampiran No.2)

$$\begin{aligned}
 P &= \frac{\left[\frac{1}{2} \cdot 901 \cdot 2168 + \frac{1}{2} \cdot 1267 \cdot 2168 + 2(975 + 2300) 2300 \right] q}{2} \\
 &= \frac{17415112 \cdot q}{2} = 8707556 \cdot 10,144 \cdot 10^{-3} = 88329,45 \text{ N}
 \end{aligned}$$

14 - Beban Merata untuk Balok susulan. (gambar46, di lampiran No.2)

$$\begin{aligned}
 R_A &= R_B = q(975 + 2300) 2300 \\
 R_A &= 7532500 q ; R_B = 7532500 q \\
 M_{\text{maks}} &= \left[7532500 \cdot 2787,5 - \frac{1}{2} \cdot 2300 \cdot 4600 \left(\frac{2300}{3} + 487,5 \right) - \frac{(487,5)^2}{2} \cdot 2300 \right] \\
 &= 1,4089 \cdot 10^{10} q = 1,4089 \cdot 10^{10} \cdot 10,144 \cdot 10^{-3} = 142918789,6 \text{ N.mm} \\
 q_{\text{ex}} &= \frac{8 \cdot 142918789,6}{(5575)^2} = 36,7866 \text{ N/mm}
 \end{aligned}$$

15 - Beban Terpusat Portal Membujur As - 1A. (gambar47, di lampiran No.2)

$$\begin{aligned}
 P &= \frac{\frac{1}{2} \cdot 961 \cdot 2681 \cdot 10,144 \cdot 10^{-3} + \frac{1}{2} \cdot 1720 \cdot 2681 \cdot 10,144 \cdot 10^{-3} + 2(1688 + 1398) 1688 \cdot 9,856 \cdot 10^{-3}}{2} \\
 &= 69569,72 \text{ N}
 \end{aligned}$$

16 - Balok Ground Floor As - 1A.

Balok A - B : (lihat Balok Basement I)

$$\begin{aligned}
 M_{\text{maks}} &= (9601299474 + 5433003677) q \\
 &= 1,50343 \cdot 10^{10} \cdot 9,856 \cdot 10^{-3} = 148178091,9 \text{ N.mm} \\
 q_{\text{ex}} &= \frac{8 \cdot 148178091,9}{(6050)^2} = 32,3864 \text{ N/mm}
 \end{aligned}$$

4.6 Hasil Analisis Struktur

Hasil Analisis Struktur disini berupa “print out running program SAP90” yang disajikan pada lampiran No.3. Hasil yang disajikan tidak menyeluruh, tetapi hanya meliputi besaran Gaya dan Momen pada elemen struktur disekitar (yang berdekatan) dengan lokasi balok susulan, karena dianggap terkena pengaruh langsung dari perubahan perilaku struktur tersebut.

