BAB IV

PERENCANAAN BALOK KOMPOSIT PRATEGANG MENGGUNAKAN PERANCAH

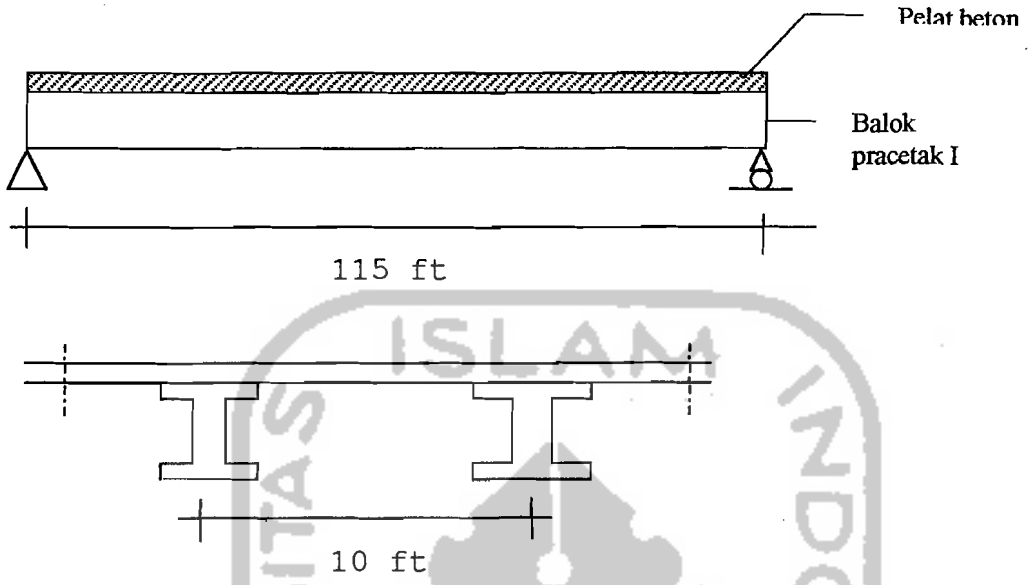
4.1 Pendahuluan

Untuk membuktikan dan memperjelas uraian yang telah diungkapkan sebelumnya, pada bab ini akan diberikan contoh perencanan balok prategang komposit menggunakan perancah. Pembahasan yang akan dilakukan meliputi perhitungan kapasitas penampang balok terhadap perilaku-perilaku struktur seperti lentur, geser dan defleksi.

Kondisi tumpuan diasumsikan bahwa balok menumpu sederhana pada kolom . Kondisi struktur tumpuan tidak termasuk dalam analisis dan perencanaan.

Panjang bentang balok yang dianalisis bervariasi, yaitu 66 ft,82 ft, 98,5 ft dan 115 ft. Balok pracetak yang digunakan adalah tampang I simetris dan beton cor ditempat (pelat) setebal 5 in. Panjang bentang yang diambil untuk contoh perhitungan lengkap adalah 115 ft.

4.2 Perencanaan Balok Komposit Prategang



Balok prategang sederhana mendukung pelat lantai dengan panjang bentang 115 ft. Ruang digunakan untuk ruangan olah raga dan jarak antar balok 10 ft. Balok direncanakan menjadi satu (komposit) dengan pelat lantai. Tebal pelat lantai adalah 5 inci. Pelat dilapisi dengan lantai terasso.

Data balok pracetak dan pelat lantai:

- *Balok pracetak:*
  - f'_c = 6000 psi.
  - f'_{ci} = 5000 psi.
  - f_{ci} = 0,6 f'ci = 0,6.5000 = 3000 psi.
  - $f_{ti} = 3\sqrt{f'ci} = 3\sqrt{5000}$ = 212 psi.
  - $f_{ts} = 6\sqrt{f'c} = 6\sqrt{6000}$ = 465 psi.

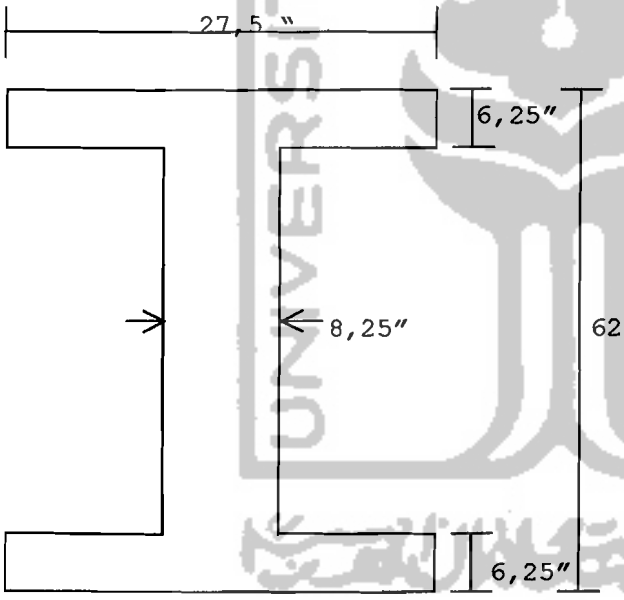
- f_{cs} = 0,45 f'c = 0,45.6000 = 2700 psi.
- γ_{bt} = 150 lb/in^3.

• *Baja:*

- f_{pu} = 270 ksi.
- f_y = 60 ksi.

• *perhitungan perencanaan:*

Dicoba profil balok pracetak seperti dibawah ini.



Data penampang balok I pracetak prategang (dari tabel pada lampiran halaman 1):

b = 27,5"

h = 62,5"

b_w = 0,3.b = 8,25"

h_f = 0,1.h = 6,25"

$A_{cp} = 0,44.b.h_f = 756,25 in^2$

$c_{tp} = 0,5h = 31,25''$

$c_{bp} = 0,5h = 31,25''$

$r^2_p = 0,121.h^2 = 472,6563\ in^2$

$I_{cp} = 0,0535.b.h^3 = 359191,8945\ in^4$

$s_{tp} = {}^{I}/_{c_{tp}} = 11494,6035\ in^3$

$s_{bp} = {}^{I}/_{c_{bp}} = 11494,6035\ in^3$

$L = 115$ ft

- *Menentukan eksentrisitas tendon.*

Konstruksi berada pada ruang tertutup dan berhubungan langsung dengan udara, jadi penutup beton setebal 1,5" (tabel pada lampiran) dan digunakan sengkang Ø ½". Jarak kotor antara sengkang dengan baja prategang 1" titik berat baja prategang sebesar 6,75"

  - $d_{sp} = 1,5 + 0,5 + 1,0 + 6,75 = 9,75''$
  - $e_{mak} = Cbp - dsp = 31,25-9,75 = 21,5''$

- *Menentukan berat gelagar/balok dan momen gelagar:*

  - $W_D = A_{cp}.\gamma_{bt} = 756,25 \times 150 = 113437,5$ lb/in

    $= 787,7604$ plf.

- $M_D = \frac{1}{8} \cdot W_{dp} \cdot L^2 = \frac{1}{8} \cdot 787{,}7604 \cdot 115^2$

  $= 1302266{,}4388$ lb-ft.

  $= 1302{,}2664$ kips-ft

- *Menentukan tegangan pada pusat (sentral):*

  - $f_{cent} = f_{ti} - \frac{C_{tp}}{h}(f_{ti} - f_{ci}) = 212 - \frac{23{,}75}{47{,}5}(212 + 3000)$

    $= -1393{,}9340$ psi.

- *Gaya prategang awal:*

  - $Po = A_{cp}.f_{cent} = 756{,}25 \times 1394 = 1054162{,}588$ lb.

    $= 1054{,}1626$ kips

- *Mencari jumlah kabel prategang.*

Digunakan kabel untaian 7 buah kawat Ø1/2", dengan

Pi = 28,9 kips, fpi=0,7.fpu = 189 ksi.

Jumlah kabel (strand) = Po/Pi

$= 1054{,}1626/28{,}9$

$= 36{,}4762$ strand.

Digunakan 36 buah strand.

- Sehingga Po yang digunakan adalah:

  Po = 36 x 28,9 = 1040,4000 kips.

- Kehilangan gaya prategang sebesar 20%.

  Pe = (1-0,2)x 1040,4 = 832,320 kips.

- *Menghitung eksentrisitas akibat Po dan momen akibat berat sendiri balok.*

  - $e_1 = (f_{ti} - f_{cent})\frac{S_{tp}}{P_o} + \frac{M_D}{P_o}$

  - $e_1 = (212 + 1394)\frac{11494,1406}{1040400} + \frac{1302,2664 \cdot 12 \cdot 10^3}{1040400} = 32,76"$

  - $e_2 = (f_{cent} - f_{ci})\frac{S_{bp}}{P_0} + \frac{M_D}{P_0}$

  - $e_2 = (-1394 + 3000)\frac{11494,1406}{1040400} + \frac{1302,2664 \cdot 12 \cdot 10^3}{1040400} = 32,76"$

$e_{mak} < e$, sehingga digunakan $e_{mak} = 21,5"$.

- *Hitung tegangan ijin balok pada saat awal (transfer) dan saat akhir (layan).*

  - Tegangan saat awal

    - $f_t = -\frac{P_0}{A_c}\left(1 - \frac{e \cdot c_t}{r^2}\right) - \frac{M_D}{S_t}$

      $f_t = -\frac{1040400}{756,250}\left(1 + \frac{21,25 \cdot 31,25}{472,6563}\right) - \frac{1302,2664 \cdot 12 \cdot 10^3}{11494,1406}$

      $= -779,7240 \text{ psi} \leq 212 \text{ psi}.$ Aman !

    - $f_b = -\frac{P_0}{A_c}\left(1 + \frac{e \cdot c_b}{r^2}\right) + \frac{M_D}{S_b}$

      $f_b = -\frac{1040400}{756,250}\left(1 + \frac{21,25 \cdot 31,25}{472,6563}\right) + \frac{1302,2664 \cdot 12 \cdot 10^3}{11494,1406}$

      $= -1917,7471 \text{ psi} \leq -3000 \text{ psi}.$ Aman!

- Tegangan pada saat akhir

- $f_t = -\frac{P_e}{A_c}\left(1 - \frac{e \cdot c_t}{r^2}\right) - \frac{M_D}{S_t}$

$f_t = -\frac{832320}{756{,}25}\left(1 - \frac{21{,}25 \cdot 31{,}25}{472{,}6563}\right) - \frac{1302{,}2664 \cdot 12 \cdot 10^3}{114941406}$

$= -895{,}6951$ psi ≤ -2700 psi. Aman!

- $f_b = -\frac{P_e}{A_c}\left(1 + \frac{e \cdot c_b}{r^2}\right) + \frac{M_D}{S_b}$

$f_b = -\frac{832320}{756{,}25}\left(1 + \frac{21{,}25 \cdot 31{,}25}{472{,}6563}\right) + \frac{1302{,}2664 \cdot 12 \cdot 10^3}{114941406}$

$= -1305{,}4818$ psi ≤ 465 psi. Aman!

- ***Balok menjadi tampang T Komposit.***

Pelat lantai dengan tebal 5 inci, dengan kekuatan beton f'c = 3500 psi.

- *menghitung lebar efektif (be)*

  - be = bw + 16.hf = 8,25 + 16.5 = 88,25″
  - be = 2.(0,5.Lc) = 2.(0,5.10).12 = 120″
  - be = L/4 = (115.12)/4 = 345″

dipakai lebar efektif yang terkecil, be = 88,25″.

Karena kekuatan beton keduanya yang berbeda maka perlu adanya faktor modifikasi,"n" untuk lebar sayap "bm".

- $n = \frac{4730\sqrt{f'c_{pelat}}}{4730\sqrt{f'c_{pracetak}}}$

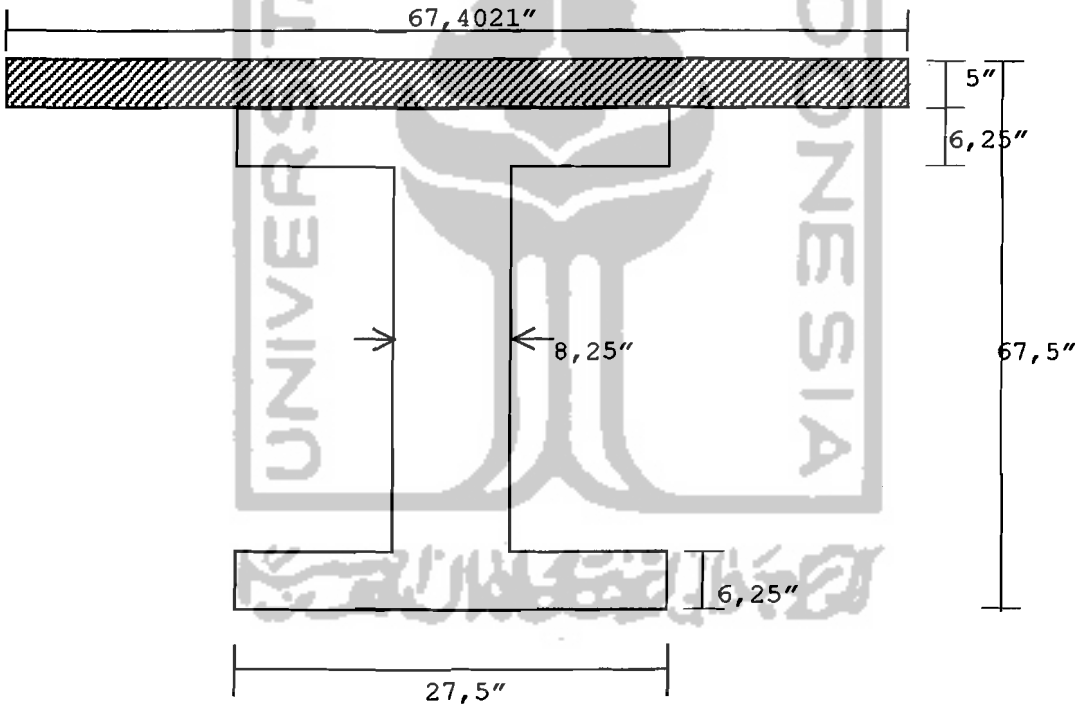
- $n = \frac{4730\sqrt{3500}}{4730\sqrt{6000}} = 0{,}7638$

bm = n.be

= 0,7638.88,25

= 67,4021"

- *Menghitung dimensi balok komposit*



$$C_{bc} = \frac{5.67{,}40.65 + 756{,}25.31{,}25}{5.67{,}40 + 756{,}25} = 41{,}6538"$$

C_{tc} = (62,5 + 5) - 41,6538 = 25,8462"

A_{cc} = 756,25 + (67,4021 x 5) = 1093,2603 in^2

$$Icc = 359191,89 + 756,25\left(41,65 - 31,25\right)^2 + \frac{67,40.5^3}{12}$$

$$+ 67,4.5.\left(25,85 - 2,5\right)$$

$$= 625435,5565\ in^4.$$

$$r^2 = \frac{I_{cc}}{A_{cc}} = \frac{625435,5565}{1093,2603} = 572,083\ in^2$$

$$S_{tc} = \frac{I_{cc}}{C_{tc}} = \frac{625435,5565}{25,8462} = 24198,3863\ in^3$$

$$S_{bc} = \frac{I_{cc}}{C_{bc}} = \frac{625435,5565}{41,6538} = 15015,0785\ in^3$$

- *Menghitung tegangan balok komposit*

  - $$f_t = -\frac{Pe}{Ac}\left(1 - \frac{e.c_{tp}}{r_p^2}\right) - \frac{Md}{S_{tp}} - \frac{M_{sd} + M_{csd} + M_l}{S_{tc}}$$

$$f_t = -\frac{832320}{756,25}\left(1 - \frac{21,5.31,25}{472,6563}\right) - \frac{1302,2664.12.10^3}{11494,1406}$$

$$- \frac{\left(580,3334 + 204,2736 + 928,5297\right).12.10^3}{24198,3863}$$

$$= -1745,2410\ psi \leq -2700\ psi.Aman!$$

  - $$f_b = -\frac{Pe}{Ac}\left(1 + \frac{e.c_{bp}}{r_p^2}\right) + \frac{Md}{S_{bp}} + \frac{M_{sd} + M_{csd} + M_l}{S_{bc}}$$

$$f_b = -\frac{832320}{756,25}\left(1 + \frac{21,5.31,25}{472,6563}\right) + \frac{1302,2664.12.10^3}{11494,1406}$$

$$- \frac{\left(580,3334 + 204,2736 + 928,529\right).12.10^3}{15015.0785}$$

$$= 63,6514\ psi \leq 465\ psi.\ Aman!$$

- *Kontrol bila balok tidak menjadi komposit*

$$- \quad f_t = -\frac{Pe}{Ac}\left(1 - \frac{e.c_{tp}}{r_p^2}\right) - \frac{Md + M_{csd} + M_{sd} + M_l}{S_{tp}}$$

$$f_t = -\frac{832320}{756,25}\left(1 - \frac{21,5.31,25}{472,6563}\right) - \frac{(3015,402).12.10^3}{11494,1406}$$

$$= -2471,8505 \text{ psi} < -2700 \text{ psi. Aman!}$$

$$- \quad f_t = -\frac{Pe}{Ac}\left(1 + \frac{e.c_{tp}}{r_p^2}\right) + \frac{Md + M_{csd} + M_{sd} + M_l}{S_{tp}}$$

$$f_t = -\frac{578.10^3}{522,5}\left(1 + \frac{16,4.23,75}{273}\right) + \frac{(3015,402)12.10^3}{6035,5}$$

$$= 483,0505 \text{ psi} > 465 \text{ psi. } \textbf{\textit{Tidak aman!!!}}$$

Berarti tampang cukup ekonomis digunakan sebagai komponen balok komposit.

- *Menghitung kapasitas momen nominal*

$Mu = 1,4(M_D + M_{SD} + M_{CSD}) + 1,7\ M_L$

$Mu = 1,4\ (\ 1302,2664 + 580,3334 + 204,2736\ )$

$+ 1,7.(928,5297)$

$= 4500,1232$ kip-ft.

$= 54001481,6188$ lb-in

$$Mn1 = \frac{Mu}{0,9} = \frac{4500,1232}{0,9} = 5000,1369 \text{ kip} - \text{ft}$$

$= 60001646,2431$ lb-in.

Luas kabel baja prategang, Aps = jumlah kabel x luas tiap kabel.

Aps = 36 x 0,153 = 5,5080 in2

Rasio tulangan = $\rho = \frac{Aps}{b_m.d_p} = \frac{5,5080}{67,40215.57,75} = 0,014$

$f'c$ = 6000 psi > 4000 psi, maka β_1

$$\beta_1 = 0,85 - 0,05\frac{(f'c - 4000)}{1000} = 0,85 - 0,05\frac{(6000 - 4000)}{1000} = 0,75$$

$$\frac{f_{py}}{f_{pu}} = \frac{229500}{270000} = 0,85 \text{ ,maka } \gamma p = 0,4$$

$$f_{ps} = f_{pu}\left(1 - \frac{\gamma_p.\rho_p.f_{pu}}{0,75.f'c}\right)$$

$$f_{ps} = 270000\left(1 - \frac{0,4.0,0014.270000}{0,75.6000}\right) = 260830,5384 \text{ psi}$$

Persamaan Keseimbangan Gaya Dalam C = T.

$T = A_{ps}.f_{ps}$

$= 5,5080.260830,5384$

$= 1436654,6053$ lb.

$C = 0,85.f'c.b_m.h_s$

$= 0,85.6000.67,4021.5$

$= 1718752,2966$ lb.

C > T, maka gaya desak ditahan oleh sayap (pelat).

$$a = \frac{A_{ps}.f_{ps}}{0,85.f'c.bm} = \frac{1436654,6053}{0,85.6000.67,4021.5} = 4,1794 \text{ in} < h_s = 5\text{in}$$

Karena $a < h_s$, maka analisa momen nominal didasarkan pada tampang persegi.

$M_{n2} = A_{ps}.f_{ps}(d_p - a/2)$

$=1436654,6053.(57,75-{}^{4,1794}/_{2})$

$= 79964659,8970$ lb-in $> 60001646,2431$ lb.Aman!

- *Perhitungan Tegangan geser dan perencanaan begel.*

$W_U = 1,4\ (\ W_D + W_{SD} + W_{CSD}\ ) + 1,7\ W_L.$

$W_U = 1,4\ (787,7604 + 351,0523 + 123,5682)$

$+ 1,7.561,6815$

$= 2722,1919$ plf

$$V_u = \frac{W_u L}{2} = \frac{2722,1919.115}{2} = 156526,0343 \text{ lb}$$

$$V_n = \frac{V_u}{0,85} = \frac{156526,0343}{0,85} = 184148,2749 \text{ lb}$$

Diasumsikan Vu terjadi pada setengah tinggi tampang.

$0,5d_p = 0,5.(57,75/12) = 2,4062$ ft

$$V_{nh} = V_n \left(\frac{\frac{L}{2} - \frac{d_p}{2}}{\frac{L}{2}} \right)$$

$$V_{nh} = 184148,2749 \left(\frac{\frac{115}{2} - 2,4062}{\frac{115}{2}} \right) = 176442,42 \text{ lb}$$

$V_u = 0,85.V_{nh}$

$= 0,85.176442,23 = 149975,8955$ lb

$f_{pe} = 0,8.f_{pi} = 0,8.189000$

$f_{pe} = 151200$ psi

$0,4$ fpu $= 0,4.270000 = 108000$ psi

$f_{pe} > 0,4.f_{pu}$

$$Mu = 156526,0337 \times 2,4063 - \left(\frac{2722,1919 \times (2,4063)^2}{2}\right)$$

$=368767,4687$ ft-lb

$=4425209,624$ in-lb

$$V_c = b_w.d_p\left(0.6\lambda\sqrt{fc} + 700\frac{V_u d_p}{M_u}\right)$$

$d_p = 57.75$ } syarat, bila $d_p > 0,8h$ maka yang dipakai

$0,8h = 54$ } adalah $d_p = 57,75''$.

$\frac{V_u d_p}{M_u} = \frac{149975,8955.57,75}{4425209,624} = 1,96 \rangle 1$, maka digunakan $\frac{V_u.d_p}{M_u} = 1$

$V_c = 8,75.57,75\left(0,6.1\sqrt{6000} + 700.1\right) = 377203,553$ lb

$V_{cmin} = 2\lambda.\ \sqrt{6000}.8,25.57,75 = 73809,380$ lb.

$V_{cmax} = 5\lambda.\ \sqrt{6000}.8,25.57,75 = 184523,4503$ lb.

$V_c > V_{cmax}$, maka digunakan $V_c = 184523,4503$ lb.

$V_U/\varnothing = Vn = 176422,42 > 0,5.V_c = 88527,3645$ lb, maka perlu digunakan tulangan geser.

Tulangan geser minimum, dengan jarak maksimum antar tulangan 24 in.

$$Av = \frac{A_{ps} \cdot f_{ps} \cdot s}{80 \cdot fy \cdot dp}\sqrt{\frac{dp}{bw}}, \quad \text{atau} \quad Av = \frac{50 \cdot bw \cdot s}{fy}$$

$$Av = \frac{5,508 \cdot 270000 \cdot 24}{80 \cdot 60000 \cdot 57,75}\sqrt{\frac{57,75}{8,25}} = 0,0,3407 \text{ in}^2/\text{in atau}$$

$$Av = \frac{50 \cdot 8{,}25 \cdot 24}{60000} = 0{,}1650 \text{ in}^2$$

digunakan Av minimum = 0,1650 in^2

Digunakan tulangan geser #3 dengan Av = 0,11 in^2 x 2 = 0,22 in^2 > 0,1650 in^2

Maka digunakan tulangan geser #3-24 in.

- *Perhitungan Tegangan Geser Horisantal dan Perencanaan dowel*

  b_v = 27,5 in

  $$L_{vh} = \frac{115 \times 12}{2} = 690 \text{ in}$$

  Cc = 0,85.3500.5.67,4021 = 1002606,2380 lb.

  Cc < $Aps.f_{ps}$, digunakan Fh = 1002606,2380 lb

  $80b_v l_{vh}$ = 80.27,5.690 = 1518000 lb > Fh, maka permukaan singgung dianggap halus (μ =0,6) dan untuk itu diperlukan dowel minimum dengan luasan dowel,

  $$Vnh = \frac{Vu}{0{,}85} = \frac{149975{,}8955}{0{,}85} = 176442{,}23 \text{ lb}$$

$Vnh = 80 \cdot b_v \cdot d_{pc} = 80 \cdot 27{,}75 \cdot 57{,}75 = 128205$ lb<176442,23 lb

Vnh < Fh.

$$\text{Total } A_{vf} = \frac{Fh}{0{,}6 f_y} = \frac{176422{,}23}{0{,}6 \cdot 60000} = 4{,}9 \text{ in}^2$$

$$\text{Min } A_{vf} = \frac{50 \cdot b_v \cdot l_{vh}}{f_y} = \frac{50 \cdot 27{,}75 \cdot 57{,}75}{60000} = 1{,}33 \text{ in}^2$$

Digunakan A_{vf} = 4,9 in^2 dan menggunakan dowel #3 dengan Av = 0,22 in^2, jarak antar dowel:

$s = \frac{l_{vh} \cdot A_v}{A_{vf}} = \frac{690 \cdot 0{,}22}{4{,}9} = 30{,}98$ in, jarak maksimum antar dowel = 24 in

Digunakan dowel #3-24.

- *Defleksi yang terjadi :*

$$\Delta_1 = \frac{1}{8}\frac{P.e_e.L^2}{EI} + \frac{5}{48}\frac{P.e_c.L^2}{EI}$$

$$\Delta_1 = \frac{1}{8}\frac{832{,}320 \times 10^3 \times 4{,}2 \times 115^2 \times 12^2}{3663842264 \times 625435{,}5565} + \frac{5}{48}\frac{832{,}320 \times 10^3 \times 31{,}9038 \times 115^2 \times 12^2}{3663842264 \times 625435{,}5565}$$

$= 26{,}6190$ in

$$\Delta_2 = \frac{5}{48}\frac{P.e_c.L^2}{EI}$$

$$= \frac{5}{48}\frac{1040{,}4 \times 10^3 \times 31{,}9038 \times 115^2 \times 12^2}{3663842264 \times 625435{,}5565}$$

$= 22{,}9870$ in

Defleksi total:

$$\Delta_t = \Delta_1 - \Delta_2 \leq \frac{L}{360}$$

$= 26{,}6190 \quad 22{,}9870$

$= 3{,}632$ in $\leq \frac{115 \times 12}{240} = 5{,}75$ in Aman.

- *Tata letak tendon*

  Po = 1040,4000 kip

  Pe = 0,8.Po = 832,3200 kip.

  M_D = 25042,4808 kip-in.

  M_T = 36184,8372 kip-in.

- Momen pada ¼ bentang.

M_D = 0,75.25042,4808 = 18781,8606 kip-in.

M_T = 0,75.36184,8372 = 27138,6279 kip-in.

$k_b = r_c^2/c_{tc}$ = 22,1341 in.

$k_t = r_c^2/c_{bc}$ = 13,7342 in.

- *Daerah bawah (lower envelope)*

  - tengah bentang

$$a_{min} = \frac{M_D}{P_O} = \frac{25042,4808}{1040,4} = 24,0701 \text{ in.}$$

$e_1 = k_b + a_{min}$ = 22,1341 + 24,0701 = 46,2042 in.

  - ¼ bentang

$$a_{min} = \frac{M_D}{P_O} = \frac{18781,8608}{1040,4} = 18,0526 \text{ in.}$$

e_2 = 22,1341 + 18,0526 = 40,1867 in .

  - dukungan

$e_3 = k_b$ = 22,1341 in.

- *Daerah atas (upper envelope)*

  - setengah bentang

$$a_{mak} = \frac{M_T}{P_e} = \frac{36184,8372}{832,32} = 43,4747 \text{ in.}$$

$$e_1 = a_{mak} - k_t = 43,4747 - 13,7342 = 29,7405 \text{ in.}$$

  - ¼ bentang

$$a_{mak} = \frac{M_T}{P_e} = \frac{36184,8372}{832,32} = 32,6060 \text{ in.}$$

$$e_2 = 32,6060 - 13,7342 = 18,8718 \text{ in.}$$

  - dukungan

$$e_3 = k_t = 13,7342 \text{ in.}$$

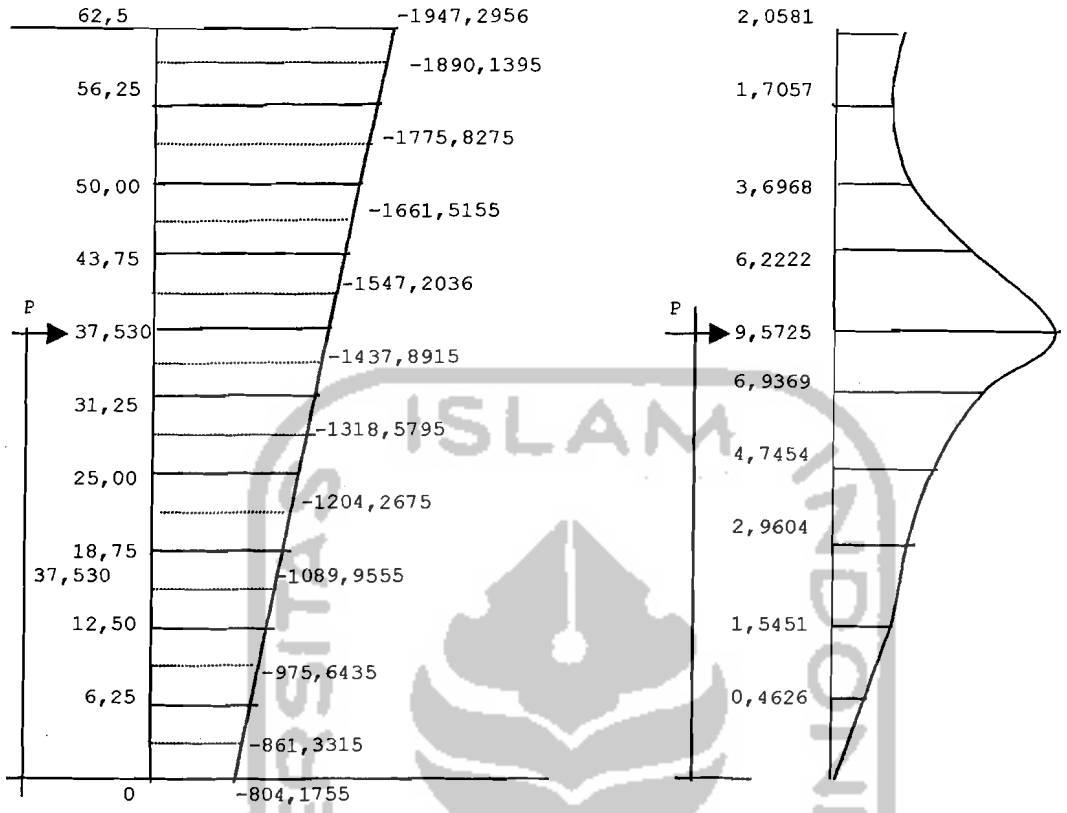
- *Pengangkuran ujung (end block)*

$$f_t = -\frac{P_0}{A_c}\left(1 - \frac{e_e.C_t}{r^2}\right)$$

$$f_t = -\frac{1040,4.10^3}{756,25}\left(1 - \frac{-6,2038.31,25}{472,6563}\right) = -1947,2956 \text{ psi}$$

$$f_b = -\frac{P_0}{A_c}\left(1 + \frac{e_e.C_t}{r^2}\right)$$

$$f_b = -\frac{1040,4.10^3}{756,25}\left(1 + \frac{-6,2038.31,25}{472,6563}\right) = -804,1755 \text{ psi}$$



Tabel 4.1: *Perhitungan tegangan dan momen pada blok ujung*

jarak (in)	b (in)	tegangan (psi)	Kekuatan beton (lb) 10^{-4}	momen akibat Po (lb in) 10^{-6}	momen akibat teqanqan beton (lb-in) 10^{-6}	selisih momen (lb-in) 10^{-6}
0	27,5	-804,1755	-13,8217	0	0	0
6,25	27,5	-861,3315	-14,8041	0	0,4626	0,4626
12,50	8,25	-975,6435	-5,0307	0	1,5451	1,5451
18,75	8,25	-1089,9555	-5,6021	0	2,9604	2,9604
25,00	8,25	-1204,2675	-6,2095	0	4,7454	4,7454
31,25	8,25	-1318,5795	-6,7989	0	6.9369	6.9369
37,50	8,25	-1437,8915	-7,4141	0	9,5725	9,5725
43,75	8,25	-1547,2036	-7,9777	-6,4670	12,6892	6,2222
50,00	8,25	-1661,5155	-8,5672	-12,9698	16,6666	3,6968
56,25	27,25	-1775,8275	-30,5220	-19,4723	21,1780	1,7057
62,50	27,50	-1947,2956	-33,4691	-25,9748	28,0329	2,0581

- *Perhitungan penulangan ujung dan pelat ujung*

  h = 62,5 in.

  $^{h}/_{4}$ = 15,625 in.

M_{mak}= 9,5725.106 lb-in

T_1= $9,5725.10^6$/ (62,5-15,625) = 204213,3333 lb.

fs = 20000 psi.

At = T/fs = 204213,3333/20000 = 10,2107 in^2.

dicoba stirrup #8 dengan As = 2 x 0,76 = 1,58 in^2.

jumlah sitrrup = 10,2107/1,58 = 6,46 ≈ 7 buah.

Dipasang sepanjang h/2 = 33,75 in.

- *Kontrol pelat*

  - Saat transfer

$$f_b = 0{,}8 \times f'ci \times \sqrt{\frac{A_2}{A_1}} - 0{,}2 \leq 1{,}25f'ci$$

dipakai A_1 = 3,5"x10" = 35 in^2

A_2 = 8,25"X10"= 82,5 in^2

$f'ci$ = 5000 psi

1,25$f'ci$ = 6250 psi

$$f_b = 0{,}8 \times 5000 \times \sqrt{\frac{82{,}5}{35}} - 0{,}2 = 5874{,}8860 \text{ psi} \leq 6250 \text{ psi}.\text{Aman}$$

  - Saat layan/akhir

$$f_b = 0{,}6 \times f'ci \times \sqrt{\frac{A_2}{A_1}} \leq f'ci$$

$$f_b = 0{,}6 \times 5000 \times \sqrt{\frac{82{,}5}{35}} = 4605{,}8968 \text{ psi} \leq 5000 \text{ psi}$$

Jadi digunakan pelat bantalan dengan ukuran:

A = 3,5" x 10" = 35 in^2.