Propertis Bata

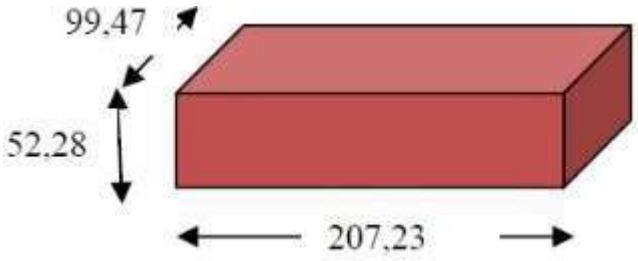
Dalam studi ini digunakan bata merah sebagai material dinding pengisi. Karakteristik dinding bata yang digunakan dalam studi ini didasarkan pada karakteristik dinding bata hasil pengujian laboraturium yang dilakukan oleh Aryanto (2008). Berdasarkan eksperimen diperoleh data sebagai berikut:

1. Parameter individu bata dan mortar:
a. Kuat tekan unit bata 4,57 MPa
b. Kuat tekan rata-rata mortar 10,45 MPa
2. Parameter dinding pengisi (pasangan bata):
   c. Kuat tekan rata-rata pasangan bata (fm') 3,54 MPa
   d. Modulus elastisitas dinding pengisi 2478 MPa
   e. Kuat lekat/bond pasangan bata 0,39 MPa
   f. Regangan pada tegangan maksimum, $\varepsilon_c = 0{,}002$

Propertis fisik bata merah yang digunakan di tunjukkan pada Tabel L.1 dan Gambar L.1

Tabel L1: Rata-rata propertis fisik bata merah (Aryanto, 2008)

Propertis	Dimensi	Satuan
Panjang	207,23	mm
Tinggi	52,28	mm
Tebal	99,47	mm
Berat jenis	1473,55	kg/m^3



Gambar L1: Rata-rata dimensi bata merah (Aryanto 2008).

Perhitungan Dimensi *Strut*

Pada studi ini pemodelan dinding bata menggunakan metode *diagonal compression strut,* dinding bata akan dianggap sebagai *bracing* diagonal tekan. *Diagonal compression strut* memodelkan kekakuan ekivalen non linier dinding pengisi bata dengan menggunakan batang tekan diagonal sehingga dengan metode seperti ini akan mempermudah analisa perhitungan. Dimensi ekivalen *diagonal compression strut* didapat dengan menggunakan formula FEMA 273.

A. Bentang Portal 6 x 4 m

Diketahui:

f'_c = 30 MPa

E_{fe} = 25742,960 MPa

E_{me} = 2478 MPa

E_m = 3,54 MPa

l_b = 6000 mm

l_c = 4000 mm

l_{inf} = 100 mm

h_{inf} = 3500 mm

l_{inf} = 5300 mm

l_{inf} = 6351,378 mm

I_c = $2x10^{10}$ mm^4

$$\theta = \tan^{-1}\frac{h_{inf}}{l_{inf}} = \tan^{-1}\frac{3500}{5300} = 33{,}44°$$

$$\lambda_1 = \left[\frac{E_{me} \times E_{inf} \times \sin 2\theta}{4E_{fe} \times I_c \times h_{inf}}\right]^{1/4}$$

$$\lambda_1 = \left[\frac{2478 \times 100 \times \sin 2(33{,}44°)}{4(25742{,}960) \times (2\square 10\text{^}10) \times 3500}\right]^{1/4}$$

$\lambda_1 = 0{,}000422$

$$\alpha = 0{,}175(\lambda_1 \times h_c)^{-0{,}4} \times l_{inf}$$

$$\alpha = 0{,}175(0{,}000422 \times 4000)^{-0{,}4} \times 6351{,}378$$

Maka lebar dari *diagonal strut* arah X = Y adalah:

α = 901,482 mm = 0,901 m

B. Bentang Portal 6 x 3,5 m

Diketahui:

f'_c = 30 MPa

E_{fe} = 25742,960 MPa

E_{me} = 2478 MPa

E_m = 3,54 MPa

l_b = 6000 mm

l_c = 3500 mm

t_{inf} = 100 mm

h_{inf} = 3000 mm

l_{inf} = 5300 mm

d_{inf} = 6090,156 mm

I_c = $2x10^{10}$ mm^4

$$\theta = \tan^{-1}\frac{h_{inf}}{l_{inf}} = \tan^{-1}\frac{3000}{5300} = 29{,}511°$$

$$\lambda_1 = \left[\frac{E_{me} \times E_{inf} \times \sin 2\theta}{4E_{fe} \times I_c \times h_{inf}}\right]^{1/4}$$

$$\lambda_1 = \left[\frac{2478 \times 100 \times \sin 2(29{,}511°)}{4(25742{,}960) \times (2\square 10\text{^}10) \times 3000}\right]^{1/4}$$

$\lambda_1 = 0{,}000430$

$\alpha = 0{,}175(\lambda_1 \times h_c)^{-0{,}4} \times d_{inf}$

$\alpha = 0{,}175(0{,}000430 \times 3500)^{-0{,}4} \times 6090{,}156$

Maka lebar dari *diagonal strut* arah X = Y adalah:

α = 905,007 mm = 0,905 m

Perhitungan Kekuatan *Diagonal Strut* Saneinejad-Hobbs (1995)

A. *Diagonal Strut dengan* Bentang Portal 6 x 4 m

Penetapan Parameter

μ = 0,4 (diambil dari ketentuan ACI 530-88)

ε_c = 0,002

f'm = 3,54 Mpa

$r = \frac{h_{inf}}{Z_{inf}} = \frac{3500}{5300} = 0{,}660$

$\theta = \tan^{-1}\left(\frac{h_{inf}}{l_{inf}}\right) = 33{,}44^{o}$

Tegangan tekan efektif dinding pengisi

$f_c = 0{,}6\ \emptyset f'_m$

f_c = 0,6 x 0,65 x 3,54 =1,381 Mpa

Batas atas tegangan kontak nominal

$$\sigma_{co} = \frac{f_c}{J\sqrt{1 + 3\theta^2 r^4}}$$

$$\sigma_{co} = \frac{1{,}381}{J\sqrt{1 + 3 \cdot 0{,}4^2 \cdot 0{,}660^4}} = 1{,}322 \text{ Mpa}$$

$$\sigma_{bo} = \frac{f_c}{J\sqrt{1 + 3\theta^2}}$$

$$\sigma_{bo} = \frac{1{,}381}{J\sqrt{1 + 3 \cdot 0{,}4^2}} = 1{,}135 \text{ Mpa}$$

Mn pada kolom = 286443000 Nmm, jika $M_{pc} = \varphi\ M_n$ dengan φ = 1 maka M_{pc} = 286443000 Nmm. Sedangkan Mn pada balok = 351212000 Nmm, jika $M_{pb} = \varphi\ M_n$ dengan φ = 1 maka M_{pb} = 351212000 Nmm. Dengan menggunakan Pers. 2.33 dan Pers. 2.34:

$$\alpha_c h = J\frac{\sqrt{2\ M_{pj} + 2\theta_o\ M_{pc}}}{\sigma_{co}\theta} \le 0{,}4h'$$

$$\alpha_c h = J\frac{\sqrt{2 \cdot 286443000 + 2 \cdot 0{,}2 \cdot 286443000}}{1{,}322 \cdot 100} \le 0{,}4 \cdot 3500$$

$\alpha_c h = 22{,}80 \le 1400$

Ambil nilai $\alpha_c h$ = 1400, sehingga diperoleh α_c = 0,35

$$\alpha_b l = \sqrt{\frac{2\,M_{pj} + 2\,\phi_o M_{pb}}{\sigma_{bo}\,\phi}} \le 0{,}4l'$$

$$\alpha_b l = \sqrt{\frac{2 \times 286443000 + 2 \times 0{,}2 \times 351212000}{1{,}135 \times 100}} \le 0{,}4 \times 5300$$

$\alpha_b l = 2507{,}031 \le 2120$

Ambil nilai $\alpha_b l = 2120$, sehingga diperoleh $\alpha_b = 0{,}353$

Tegangan kontak

$A_c = r^2 \sigma_{co} \alpha_c (1 - \alpha_c - \phi r)$

$A_c = 0{,}660^2 \; x \; 1{,}322 \; x \; 0{,}35 \; (1 - 0{,}35 - 0{,}4 \; x \; 0{,}660)$

$A_c = 0{,}07779$

$A_b = r^2 \sigma_{bo} \alpha_b (1 - \alpha_b - \phi r)$

$A_b = 0{,}660^2 \; x \; 1{,}135 \; x \; 0{,}353 \; (1 - 0{,}353 - 0{,}4 \; x \; 0{,}660)$

$A_b = 0{,}06684$

Karna $A_c > A_b$, maka

$\sigma_b = \sigma_{bo} = 1{,}135$ Mpa

$$\sigma_c = \sigma_{co} \left(\frac{A_b}{A_c}\right) = 1{,}322 \left(\frac{0{,}06684}{0{,}07779}\right) = 1{,}135 \text{ Mpa}$$

Dan sesuai Pers. 2.29

$\tau_b = \phi \, \phi_b$

$\tau_b = 0{,}4 \times 1{,}135 =$ [illegible] Pa

Keruntuhan sudut/ujung diagonal (CC), dihitung menggunakan Pers. 2.45.

$$R = R_{CC} = \frac{(1-\phi_c)\,\phi_c \; t \; h \; \phi_c + \phi_b \; t \; l \; \phi_b}{\cos e}$$

$$R = R_{CC} = \frac{(1-0{,}35)\; 0{,}35 \; x \; 100 \; x \; 4000 \; x \; 1{,}135 + 0{,}353 \; x \; 100 \; x \; 6000 \; x \; 0{,}454}{\cos 33{,}44}$$

$R = R_{CC} = 239006 \; N = 239{,}006$ kN

Keruntuhan tekan diagonal (DC), dihitung menggunakan Pers. 2.47, 2.48, dan 2.49

$$l_{eff} = \sqrt{\left(1 - \left(\frac{c}{\;}\right)\right)^2 h'^2 + \phi'^2}$$

$l_{eff} = \sqrt{(1 - 0{,}35)^2 \cdot 3500^2 + 5300^2}$

l_{eff} = 5767,635 mm

$f = f_c [1 - (\frac{\varepsilon_{eff}}{40 \varepsilon})^2]$

$f = 1{,}381 [1 - (\frac{5767{,}635}{40 \times 100})^2]$

f_{ε} = 1,49023 MPa

Maka,

$R = R_{DC} = \frac{0{,}5\, h' t f_{\varepsilon}}{\cos e}$

$R = R_{DC} = \frac{0{,}5 \text{ x } 3500 \text{ x } 100 \text{ x } 1{,}49023}{\cos (33{,}44)}$

$R = R_{DC}$ = 312524,5 *N* = 312,524 k*N*

Keruntuhan geser (s) dihitung menggunakan Pers. 2.50 dan 2.51

$\varepsilon' = (1 - [c) \frac{h'}{\varepsilon'}$

$\varepsilon' = (1 - 0{,}35) \frac{3500}{5300} = 0{,}43$

$R = R_s = \frac{\gamma\, v\, t\, l'}{(1 - 0{,}45\, x \tan e)\tan e} < \frac{0{,}83\, \gamma\, t\, l'}{\cos e}$

$R = R_s = \frac{1\, x\, 0{,}39\, x\, 100\, x\, 5300}{(1 - 0{,}45\, x\, 0{,}43) \tan 33{,}44} < \frac{0{,}83\, x\, 1\, x\, 100\, x\, 5300}{\cos 33{,}44}$

$R = R_s$ = 388098,33 < 527165,152

$R = R_s$ = 388098,33 *N* < 388,098 k*N*

Jadi H dapat dihitung dengan Pers.

$\varepsilon = \varepsilon \cos \varepsilon + (\frac{2\, M_{pj}}{h})$

ε = 239,006 cos 33,44 $(\frac{2x286443000}{4000})$

ε = 199,58 kN

Perhitungan Kekuatan *Diagonal Strut* Saneinejad-Hobbs (1995)

B. *Diagonal Strut dengan* Bentang Portal 6 x 3,5 m

Penetapan Parameter

μ = 0,4 (diambil dari ketentuan ACI 530-88)

ε_c = 0,002

f'm = 3,54 Mpa

$$r = \frac{h_{inf}}{Z_{inf}} = \frac{3000}{5300} = 0{,}566$$

$$\theta = \tan^{-1}\left(\frac{h_{inf}}{l_{inf}}\right) = 29{,}51^{o}$$

Tegangan tekan efektif dinding pengisi

$f_c = 0{,}6\ \emptyset f'_m$

$f_c = 0{,}6 \times 0{,}65 \times 3{,}54 = 1{,}381$ Mpa

Batas atas tegangan kontak nominal

$$\sigma_{co} = \frac{f_c}{J\sqrt{1 + 3\theta^2 r^4}}$$

$$\sigma_{co} = \frac{1{,}381}{J\sqrt{1 + 3 \cdot 0{,}4^2 \cdot 0{,}566^4}} = 1{,}348 \text{ Mpa}$$

$$\sigma_{bo} = \frac{f_c}{J\sqrt{1 + 3\theta^2}}$$

$$\sigma_{bo} = \frac{1{,}381}{J\sqrt{1 + 3 \cdot 0{,}4^2}} = 1{,}135 \text{ Mpa}$$

Mn pada kolom = 286443000 Nmm, jika $M_{pc} = \varphi\ M_n$ dengan $\varphi = 1$ maka $M_{pc} = 286443000$ Nmm. Sedangkan Mn pada balok = 351212000 Nmm, jika $M_{pb} = \varphi\ M_n$ dengan $\varphi = 1$ maka $M_{pb} = 351212000$ Nmm. Dengan menggunakan Pers. 2.33 dan Pers. 2.34:

$$\alpha_c h = J\frac{\sqrt{2\ M_{pj} + 2\theta_o M_{pc}}}{\sigma_{co}\theta} \le 0{,}4h'$$

$$\alpha_c h = J\frac{\sqrt{2 \cdot 286443000 + 2 \cdot 0{,}2 \cdot 286443000}}{1{,}348 \cdot 100} \le 0{,}4 \cdot 3000$$

$\alpha_c h = 2258{,}290 \le 1200$

Ambil nilai $\alpha_c h = 1200$, sehingga diperoleh $\alpha_c = 0{,}42$

$$\alpha_b l = J\frac{\sqrt{2\ M_{pj} + 2\theta_o M_{pb}}}{\sigma_{bo}\theta} \le 0{,}4l'$$

$$\alpha_b l = J\frac{\sqrt{2 \cdot 286443000 + 2 \cdot 0{,}2 \cdot 351212000}}{1{,}135 \cdot 100} \le 0{,}4 \cdot 5300$$

$\alpha_b l = 2507{,}031 \le 2120$

Ambil nilai $\alpha_b l = 2120$, sehingga diperoleh $\alpha_b = 0{,}353$

Tegangan kontak

$A_c = r^2 \sigma_{co} \alpha_c (1 - \alpha_c - \square r)$

$A_c = 0{,}566^2 \; x \; 1{,}348 \; x \; 0{,}342 \; (1 - 0{,}34 - 0{,}4 \; x \; 0{,}566)$

$A_c = 0{,}06374$

$A_b = r^2 \sigma_{bo} \alpha_b (1 - \alpha_b - \square r)$

$A_b = 0{,}566^2 \; x \; 1{,}135 \; x \; 0{,}353 \; (1 - 0{,}353 - 0{,}4 \; x \; 0{,}566)$

$A_b = 0{,}05398$

Karna $A_c > A_b$, maka

$\sigma_b = \sigma_{bo} = 1{,}135$ Mpa

$$\sigma_c = \sigma_{co} \left(\frac{A_b}{A_c}\right) = 1{,}348 \left(\frac{0{,}05398}{0{,}06374}\right) = 1{,}141 \text{ Mpa}$$

Dan sesuai Pers. 2.29

$\tau_b = \square \; \square_b$

$\tau_b = 0{,}4 \text{ x } 1{,}135 =$ [redacted] Pa

Keruntuhan sudut/ujung diagonal (CC), dihitung menggunakan Pers. 2.45.

$$R = R_{CC} = \frac{(1-\square_c) \; \square_c \; t \; h \; \square_c + \square_b \; t \; l \; \square_b}{\cos e}$$

$$R = R_{CC} = \frac{(1-0{,}342) \; 0{,}342 \; x \; 100 \; x \; 3500 \; x \; 1{,}141 + 0{,}353 \; x \; 100 \; x \; 6000 \; x \; 0{,}454}{\cos 29{,}51}$$

$R = R_{CC} = 213756 \; N = 213{,}756$ kN

Keruntuhan tekan diagonal (DC), dihitung menggunakan Pers. 2.47, 2.48, dan 2.49

$$l_{eff} = \sqrt{\left(1 - \square_c\right)^2 h'^2 + \square'^2}$$

$$l_{eff} = \sqrt{\left(1 - 0{,}342\right)^2 \; \square \; 3000^2 + 5300^2}$$

$l_{eff} = 6007{,}109$mm

$$f \square = f_c \; [1 - (\frac{\square eff}{40 \; \square})^2]$$

$$f \square = 1{,}381 \; [1 - (\frac{6003{,}109}{40 \; \square \; 100})^2]$$

$f \square = 1{,}72947$ MPa

Maka,

$$R = R_{DC} = \frac{0{,}5\, h'\, t\, f_{\square}}{\cos e}$$

$$R = R_{DC} = \frac{0{,}5 \text{ x } 3000 \text{ x } 100 \text{ x } 1{,}72947}{\cos (29{,}51)}$$

$R = R_{DC} = 298092{,}061N = 298{,}092$ kN

Keruntuhan geser (s) dihitung menggunakan Pers. 2.50 dan 2.51

$$\square' = (1 - \square c)\, \frac{h'}{\square'}$$

$$\square' = (1 - 0{,}342)\, \frac{3000}{5300} = 0{,}37$$

$$R = R_s = \frac{\gamma\, v\, t\, l'}{(1 - 0{,}45\, x \tan e)\tan e} < \frac{0{,}83\, \gamma\, t\, l'}{\cos e}$$

$$R = R_s = \frac{1\, x\, 0{,}39\, x\, 100\, x\, 5300}{(1 - 0{,}45\, x\, 0{,}37)\tan 29{,}51} < \frac{0{,}83\, x\, 1\, x\, 100\, x\, 5300}{\cos 29{,}44}$$

$R = R_s = 438143{,}10 < 505475{,}46$

$R = R_s = 388098{,}33\ N < 388{,}098$ kN

Jadi H dapat dihitung dengan Pers.

$$\square = \frac{2\, M_{pj}}{\square \cos \square + (\ h}\ )$$

$$\square = 213{,}756 \cos 29{,}51\ \frac{2x286443000}{(\ 3500}\ )$$

$\square = 186{,}18$ kN