UNIVERSITAS MUHAMMADIYAH METRO
FAKULTAS TEKNIK
JURUSAN TEKNIK SIPIL

TUGAS KONSTRUKSI BAJA III

Merencanakan Jembatan Rangka

Diberikan kepada mahasiswa :
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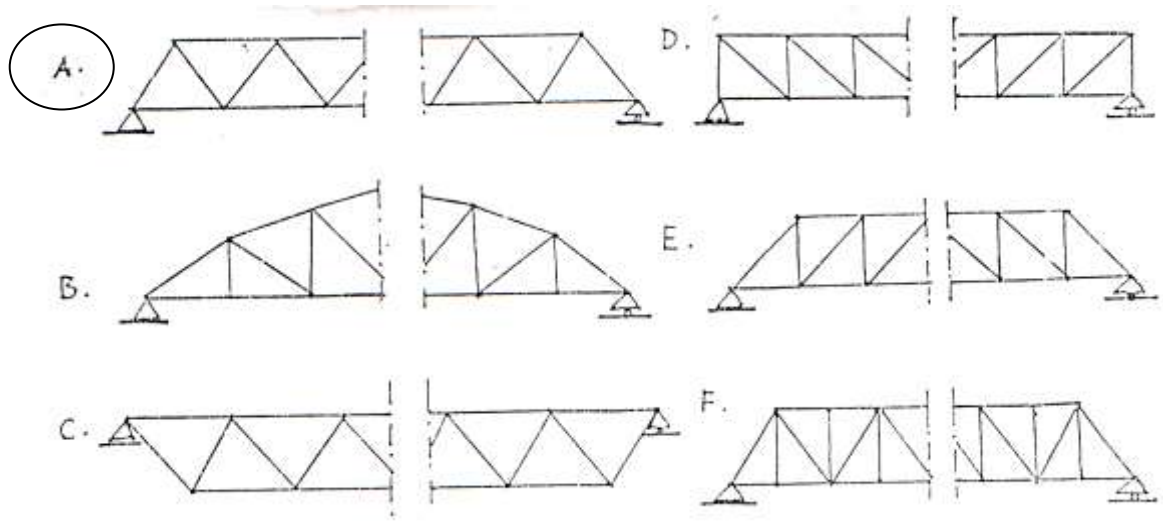
NPM : ---
Semester : ---
Diketahui : Sebuah " Jembatan Rangka Baja "



A. Bentang teoritis : 30^{00} M, Jembatan terbuka/ tertutup
B. Lantai kendaraan :
   - Lebar : 70^{00} Meter
   - Banyak jalur : 2 (Dua) jalur
   - Untuk lalu lintas : jalan raya / ~~jalan kereta api~~
   - Kelas : I
C. Jarak antara garis dalam gelegar kepala = 0,5 meter
D. Trotoir :
   - Lebar : 1,10 Meter
   - Terletak : di dalam / di luar gelegar kepala
E. Ketentuan lain : Peraturan Bina marga (PMJJR 1987)
   V.O.S.B
   Peraturan untuk jembatan kereta api

Diminta :
- Perhitungan lantai kendaraan
- Perhitungan gelagar
- Perhitungan ikatan angin
- Dimensionering gelagar induk
- Perhitungan sambungan (titik simpul)
- Sambungan (gelagar melintang dengan gelagar induk, pelat badan dengan pelat penyambung, pelat penyambung dengan gelagar induk)
- Kontrol lendutan
- Gambar lengkap (tampak detail)

Metro, Oktober 2004
Dosen/ Asisten

Ir. MASHERNI

I. PERHITUNGAN PLAT LANTAI KENDARAAN DAN TROTOIR

Sesuai dengan rencana dimuka, lantai kendaraan dan lantai trotoit menggunakan plat beton bertulang yang dikompositkan dengan gelagar memanjang profil baja. Pengertian komposit disini hanya terjadi pada gelagar memanjang dan plat lantai beton bertulang, sedangkan untuk gelagar melintang digunakan metode biasa. Tidak mendukung plat lantai langsung sehingga perhitungan moment yang terjadi pada plat lantai di analisa dengan menggunakan tabel Bittner.

Dasar-dasar perhitungan :

- Jarak gelagar memanjang = 1,75 Meter
- Tabal lapisan Finishing/ Pavement
  - Bagian tepi/ pinggir = 4 Cm
  - Kemiringan/ slape = ± 1: 75
- Tebal plat lantai beton bertulang, diambil = 18 Cm
- Mutu beton bertulang

- K. 225 → σ_b^1 = 75 Kg/ cm^2

  τ_b = 6,5 Kg/ cm^2

  σ_{bk}^1 = 225 Kg/ cm^2

- U. 24 → σ_a = σ_a^1 = 1400 Kg/ cm^2

  σ_{an} = 2080 Kg/ cm^2

γ Beton bertulang = 2500 Kg/ M^3

γ Beton tumbuk = 2200 Kg/ M^3

γ Pas. Ubin + tegel = 180 Kg/ M^3

γ Aspal beton = 2500 Kg/ M^3

γ Air hujan = 1000 Kg/ M^3

I.1. ANALISA MUATAN/ BEBAN

1.1.1 Beban Tetap Lantai Kendaraan dan Trotoar

* Aspal beton

$h = 4 + \frac{1}{75} \cdot 350 = 8{,}67 \sim 8{,}0$ cm

h. Rata-rata $= \frac{1}{2} (8 + 4) = 6{,}0$ cm

γ Aspal beton $= 2500$ Kg/ M^3

- Beton bertulang $= \gamma$ b.t $= 2500$ Kg/ M^3
- Beton tumbuk $= \gamma$ tumbuk $= 2200$ Kg/ M^3
- Pas. Ubin/ tegel $= \gamma$ u/ t $= 180$ Kg/ M^3
- Air hujan $= \gamma$ air hujan $= 1000$ Kg/ M^3

* Beban Tetap Lantai Kendaraan

* Berat air hujan (tebal 5 cm) $= 0{,}05 \cdot 1000 = 50$ Kg/ M^2

* Aspal beton $= 0{,}06 \cdot 2500 = 150$ Kg/ M^2

* Plat Lt. kendaraan $= \underline{0{,}18 \cdot 2500 = 450 \text{ Kg/ } M^2} +$

Jumlah $= 650{,}-$ Kg/ M^2

Toeslaag $\underline{10\% \cdot 650 = 65{,}-\text{ Kg/ } M^2} +$

qbs $= 715{,}-$ Kg/ M^2

* Beban Tetap Lantai Trotoir

Berat air hujan (t = 5 cm) $= 0{,}05 \cdot 100 = 50$ kg/ m^2

Berat pas. Bata $= 180$ kg/ m^2

Berat beton tumbuk $= 0{,}10 \cdot 2200 = 220$ kg/ m^2

Berat plat Lt. trotoit $= \underline{0{,}18 \cdot 2500 = 450 \text{ kg/ } m^2}$

Jumlah $= 900$ kg/ m^2

Toslaag $\underline{10\% \cdot 900 = 90 \text{ kg/ } m^2}$

qbs $= 990$ kg/ m^2

1.1.2 BEBAN BERGERAK/ SEMENTARA PADA PLAT LT. KENDARAAN

* T. Loding

Itentitas tekanan gandar pada jembatan jalan raya kelas I = 20 ton

Beban roda = $\frac{20}{2}$ = 10 ton

Analisa bidang kontak

B1 = 20 + 2 (6 + 9) = 50 cm

B2 = 50 + 2 (6 + 9) = 80 cm

- Luas bidang kontak = B1 x B2 = 50 x 80 = 4000 cm^2 = 0,48 m^2
- Koef kejut = $1 + \frac{20}{50 + L} = 1 + \frac{20}{50 + 30} = 1{,}25$
- Beban roda = P = 10 . K = 10 . 1,25 = 12,5 ton
- qt = $P \diagup A = \frac{12{,}5}{0{,}48}$ = 26,04 Ton/ m^2

Selanjutnya guna mendapatkan vektor momen yang akan terjadi akibat inten sitas beban kendaraan secara bervariasi, maka untuk ini digunakan faktor moment motoda BITTNER yang diperoleh dengan melakukan interpolasi tabel Bittner.

* Kondisi 1

Roda yang memikul beban P tepat berada ditengah-tengah plat lantai ditumpu oleh dua gelagar memanjang.

tx = 80 cm

ty = 50 cm

Lx = 175 cm

Ly = ~

$$\frac{tx}{Lx} = \frac{80}{175} = 0{,}45 = 0{,}5; \frac{ty}{Lx} = \frac{50}{175} = 0{,}286 = 0{,}3$$

- Fxm = 0,1477
- Fym = 0,0227
- Mx K_1 = Fxm . q T . tx . ty

  = 0,1477 . 26,04 . 0,50 . 0,80 = 1,5384 Ton $^{m}/_{m'}$
- My K_1 = Fym . qT . tx . ty

  = 0,0227 . 26,04 . 0,50 . 0,80 = 0,2364 Ton $^{m}/_{m'}$

* Kondisi 2

Saat dua kendaraan berdekatan dan roda belakangnya berada diatas plat lantai yang ditumpu diatas dua gel. Memanjang (lihat gambar sketsa).

Diagram Analogi

tx = 80 cm

ty = 50 cm

Lx = 175 cm

ty = 50 cm

tx = 175 cm

Lx = 175 cm

ty = 50 cm

tx = 15 cm

Lx = 175 cm

A. $\frac{ty}{Lx} = \frac{50}{175} = 0{,}3$; $\frac{tx}{Lx} = \frac{175}{175} = 1$

Fx MA = 0,0910

Fy MA = 0,0608

B. $\frac{ty}{Lx} = \frac{50}{175} = 0{,}3$; $\frac{tx}{Lx} = \frac{15}{175} = 0{,}0857$

Fx MB = $\left\{0{,}1937 - \frac{333}{1000}(0{,}1937 - 0{,}1926)\right\} = 0{,}1933$

Fy MB = $\left\{0{,}1558 - \frac{333}{1000}(0{,}1558 - 0{,}1422)\right\} = 0{,}1513$

Fy M = 0,1513 – 0,0608 = 0,0905

Fx M = 0,1933 – 0,0910 = 0,1023

My. K_2 = Fy M . qT . txA . ty

= 0,0905 . 26,04 . 1,75 . 0,05 = 2,062 Ton $^{m}/_{m'}$

Mx. K_2 = Fx M . qT . txA . ty

= 0,1023 . 26,04 . 175 . 50 = 2,331 Ton $^{m}/_{m'}$

1.1.3 ANALISA MOMENT PADA PLAT LANTAI KENDARAAN AKIBAT BERAT SENDIRI

Mx = α . qL^2

Mx = Mmax = 0,106 . q Bs . L^2

= 0,106 . 715 . $1{,}75^2$

= 232,1068 Kg $^{m}/_{m'}$ $\rightarrow$ 0,2321068 Ton $^{m}/_{m'}$

My = 0,20 . Mx

= 0,20 . 232,1068 = 46,4214 Kg $^{m}/_{m'}$ $\rightarrow$ 0,0464214 Ton $^{m}/_{m'}$

1.1.4 ANALISA MOMENT PADA PLAT LANTAI TROTOIR AKIBAT BERAT SENDIRI DAN MUATAN HIDUP

qLL = 500 kg/m^2 . 1,10 = 550 kg/m'

qBs = 990 kg/m^2 . 1,10 = 1089 kg/m'

Moment akibat qBs

MBs = $1/8$. qBs . L^2 = 164,71125 Kg m/m'

Moment akibat qLL

MLL = $1/8$. qLL . L^2 = 83,1875 Kg m/m'

* Rekapitulasi Moment Akibat Beban Tetap Pada Plat Lantai Kendaraan

Mx. Bs = 235,1068 Kg m/m' = 0,2321068 Ton m/m'

My. Bs = 46,4214 Kg m/m' = 0,0464214 Ton m/m'

Mx. K_1 = 1,5384 Ton m/m' = 1538,4 Kg m/m'

My. K_1 = 0,2364 Ton m/m' = 2364 Kg m/m'

Mx. K_2 = 2,062 Ton m/m' = 2062 Kg m/m'

My. K_2 = 2,331 Ton m/m' = 2331 Kg m/m'

My_{total} = My.Bs + Mx . K_2 = 2294, 1068 Kg m/m'

Mx_{total} = Mx.Bs + My . K_2 = 2377,4214 Kg m/m'

* Pada Plat Lantai Trotoir

Mx. Bs = 164,71125 Kg m/m'

My. Bs = 32,94225 Kg m/m'

Mx. LL = 83,1875 Kg m/m'

My. LL = 16,6375 Kg m/m'

Mx_{total} = 274,89875 Kg m/m'

My_{total} = 49,57975 Kg m/m'

1.1.5 PERHITUNGAN PENULANGAN PLAT LANTAI AKIBAT BEBAN TETAP

- Tebal plat lantai = ht = 18 cm
- Tebal beton deking = d = 3 cm
- h = ht – d = 18 – 3 = 15 cm
- σ_{bk} = 225 kg/ cm^2
- σ_{an} = 2080 kg/ cm^2
- Pembebanan tetap → Ko = 0,50

* Penulangan Arah Y (Arah Melebar Jembatan)

- My_{total} = 2294, 1068 Kg m/m'
- γs = 1,50
- Mu = Mx_{total} . γs = 3441,1602 Kg m/m'
- Cu = $\frac{h}{\sqrt{\frac{Mu}{2.Ko.\sigma_{bk}.b}}} = \frac{15}{\sqrt{\frac{3441,1602}{2.0,5.225.1}}} = 3,8363$

- Direncanakan tulangan tekan diambil 40% tulangan tarik sehingga diambil $\gamma = 0,4$

Dari tabel wiratman didapat : Cu = 3,89

$qu = 0,07083 > q_{min} = 0,0446$ ……..→ O.K

$< q_{max} = 0,39$ ……→ O.K

$\xi u = 0,935 < \xi_{max} = 0,954$ ……→ O.K

- Amin = $\frac{12bh}{\sigma_{an}} = \frac{12.100.15}{2080} = 8,654 \text{ cm}^2$

- A = qu x $\frac{2.Ko.\sigma_{bk}.b.h}{\sigma_{an}} = \frac{2.0,5.225.100.15}{2080} x0,07083 = 11,4928 \text{ cm}^2$

- A = $\frac{Mu}{\sigma_{an}\xi u.h} = \frac{3441,1602}{2080.0,935.0,15} = 11,7961 \text{ cm}^2$

- Diambil A = 11,7961 cm^2

Dipakai besi ϕ 14 – 13, dengan A = 11,84 cm^2

- $A^1 = \gamma . A = 0,4 . 11,7961 = 4,72 \text{ cm}^2$

Dipakai besi ϕ 12 – 20, dengan A^1 = 5,56 cm^2

* Penulangan Arah Y (Arah Memanjang Jembatan)

- Mx_{total} = 2377,4214 Kg m/m'

- γs = 1,50

- Mu = $My_{total} . \gamma s$ = 3566,1321 Kg m/m'

- Cu = $\frac{15}{\sqrt{\frac{3566,1321}{2.0,5.225.1}}} = 3,855$

- γ = 0,4

Dari tabel wiratman didapat : Cu = 3,89

qu = 0,07083 > q_{min} = 0,0446 ……..→ O.K

< q_{max} = 0,39 ……→ O.K

ξu = 0,935 < ξ_{max} = 0,954 ……→ O.K

- A = 11,7861 cm^2

  Digunakan ϕ 14 – 13 ; A = 11,84 cm^2

- A^1 = γ. A = 4,72 cm^2

  Digunakan ϕ 12 – 20 ; A^1 = 5,56 cm^2

1.1.6 PERHITUNGAN PENULANGAN PLAT TROTOIR AKIBAT BEBAN TETAP

* Penulangan Arah X (Arah Melebar Jembatan)

- Mx_{total} = 274,89875 Kg m/m'
- γs = 1,5
- Mu = 421,3481 Kg m/m'

Cu > 5 → gunakan $A_{min} = \frac{12.b.h}{\sigma_{an}} = A$

- γ = 0,4
- A = 8,654 cm^2

  Digunakan ϕ 14 – 17,50 ; A = 8,79 cm^2

- A^1 = 0,4 . 8,654 = 3,462 cm^2

  Digunakan ϕ 10 – 20 ; A^1 = 3,93 cm^2

* Penulangan Arah Y (Arah Memanjang Jembatan)

- My_{total} = 49,57975 Kg m/m'
- γs = 1,5

- Mu = My . γs = 74,37 Kg m/m'

- Cu = $\frac{15}{\sqrt{\frac{74,37}{2.0,5.225.1}}} = 26,0869$

  Cu > 5 → gunakan $A_{min} = \frac{12.b.h}{\sigma_{an}} = A$

- γ = 0,4
- A = 8,654 cm^2

  Digunakan ϕ 14 – 17,5 ; A = 8,79 cm^2
- A^1 = γ . A = 3,462 cm^2

  Digunakan ϕ 10 – 20 ; A^1 = 3,93 cm^2

1.1.7 ANALISA INTENSITAS MOMENT AKIBAT SISTEM PEMBEBANAN SEMENTARA

Yang diaksud beban sementara disi adalah beban akibat angin yang bekerja secara horizontal terhadap tubuh kendaraan sepanjang 5 M. (Anggapan)

- Reaksi Pada roda akibat angin horizontal Max

  = $\frac{(100.2.5.1)}{1,75} + 10 = 10,5714286$ Ton
- PT = 10,5714286 . 1,25 = 13,214285 Ton
- qt = $\frac{PT}{A} = \frac{13,214285}{0,050.0,80} = 33,0357$ Ton

* Analisa Kondisi Beban Extreem

- Kondisi 1

- Fxm = 0,1477
- Fym = 0,0227
- Mx K_1 = Fxm . q t . tx . ty

= 0,1477 . 33,0357 . 0,50 . 0,80 = 1,952 Ton $^{m}/_{m'}$

- My K_1 = Fym . qt . tx . ty

  = 0,0227 . 33,0357 . 0,50 . 0,80 = 0,300 Ton $^{m}/_{m'}$

- Kondisi 2

- Fym = 0,0905
- Mx K_2 = Fym . q t . txA . ty

  = 0,0905 . 33,0357 . 1,75 . 0,50 = 2,616 Ton $^{m}/_{m'}$
- My M = 0,1023
- Mx K_2 = 0,1023 . 33,0357 . 0,50 . 1,75 = 2,957 Ton $^{m}/_{m'}$

- Rekapitulasi Moment Akibat Beban Sementara

- Mx Bs = 232,1068 Kg $^{m}/_{m'}$
- My Bs = 46,4214 Kg $^{m}/_{m'}$
- Mx K_1 = 1952 Kg $^{m}/_{m'}$
- My K_1 = 300 Kg $^{m}/_{m'}$
- Mx K_2 = 2957 Kg $^{m}/_{m'}$
- My K_2 = 2616 Kg $^{m}/_{m'}$
- My_{total} = 232,1068 + 2957 = 3189,1068 Kg $^{m}/_{m'}$
- Mx_{total} = 46,4214 + 2616 = 2662,4214 Kg $^{m}/_{m'}$

- Penulangan Plat Lantai Akibat Beban Sementara

- h = 15 cm
- σ_{bk} = 225 kg/ cm^2
- σ_{an} = 2080 kg/ cm^2

- Pembebanan sementara → Ko = 0,50

- Penulangan Arah X (Melebar Jembatan)

- Mx_{total} = 3189,1068 Kg m/m'
- γs = 1,5
- Mu = Mx_{total} . γs = 4783,6602 Kg m/m'
- $Cu = \frac{15}{\sqrt{\frac{4783,6602}{2.0,5.225.1}}} = 3,254$
- γ = 0,40

Dari tabel wiratman didapat : Cu = 3,29

qu = 0,100 > q_{min} = 0,0446 ……..→ O.K

< q_{max} = 0,3900 ……→ O.K

ξu = 0,935 < ξ_{max} = 0,954 ……→ O.K

A_{min} = 8,654 cm^2

$A = 0,100.\frac{2.0,5.225.100.15}{2080} = 16,23\ cm^2$

$A = \frac{4783,6602}{2080.0,924.0,15} = 16,59\ cm^2$

Diambil A = 16,59 cm^2

Digunakan ϕ 12 – 16 ; A = 16,76 cm^2

$A^1 = \gamma . A = 0,4 . 16,59 = 6,64\ cm^2$

Digunakan ϕ 12 – 17 ; A^1 = 6,65 cm^2

- Penulangan Arah Y (Memanjang Jembatan)

- My_{total} = 2662,4214 Kg m/m'
- γs = 1,5
- Mu = My_{total} . γs = 3993,6321 Kg m/m'

- $Cu = \dfrac{15}{\sqrt{\dfrac{3993,6321}{2.0,5.225.1}}} = 3,560$
- $\gamma = 0,4$

Dari tabel wiratman didapat : Cu = 3,59

$qu = 0,08333 > q_{min} = 0,0446$ ……..→ O.K

$< q_{max} = 0,3900$ ……→ O.K

$\xi u = 0,930 < \xi_{max} = 0,954$ ……→ O.K

$A_{min} = 8,654\ cm^2$

$A = 0,08333.\dfrac{2.0,5.225.100.15}{2080} = 13,52\ cm^2$

$A = \dfrac{3993,6321}{2080.0,930.0,15} = 13,76\ cm^2$

Diambil $A = 13,76\ cm^2 \rightarrow$ Digunakan ϕ 16 – 14,5

$A^1 = \gamma . A = 0,4 . 13,76 = 5,504\ cm^2 \rightarrow$ Digunakan ϕ 12 – 20

- Kesimpulan Penulangan

* Penulangan Arah X (Melintang Jembatan)

pada daerah tarik besi ϕ 16 – 12

pada daerah tekan besi ϕ 12 – 17

* Penulangan Arah Y (Memanjang Jembatan)

pada daerah tarik besi ϕ 16 – 14,5

pada daerah tekan besi ϕ 12 – 20

- Lantai Trotoir

Pada arah X = arah Y

Tarik digunakan besi ϕ 14 – 17,5

Tekan digunakan besi ϕ 10 – 20

II. PERHITUNGAN GELAGAR MEMANJANG DAN GELAGAR MELINTANG

Data :

Panjang jembatan = 30,00 meter

Lebar lantai kend. = 7,00 meter

II.1 Sistem Pembebanan dan Analisa Muatan

Menurut SKBI 378/ KPTS/ 1987 dalam perhitungan gelagar harus menggunakan sistem muatan jalur (D.Loding) muatan jalur D.Loding ini merupakan susunan muatan terbagi rata (PR) dan muatan garis (PG).

- Muatan terbagi rata (PR)

Koef. Kejut = K = $1\frac{20}{50+L} = 1{,}25$

PR = P . K = 2,1 x 1,25 = 2,625 ton/m'

qPR = 2,10 x 1,75 = 3,675 ton/m'

- Muatan garis (PG)

Koef. Kejut = 1,25

PG = $\frac{1{,}75}{2{,}75}.12.1{,}25 = 9{,}5454$ ton

- Sistem pembebanan pada gel. Memanjang
- Sistem pembebanan gel. Melintang

II.2 Pengamatan Jumlah Medan Gel. Melintang

Perhitungan jumlah medan gel. Melintang didasarkan dari total berat yang paling riang dari seluruh profil (ekonomis) untuk efisiensi panjang stantar gelagar menampang, dicoba mengobservasi jumlah medan, sebagai berikut :

Diambil panjang profil standar = 6 M $\rightarrow \frac{30}{6} = 5$ medan

Jumlah medan yang akan diopserpasi = 5, 7, 9 medan

2.1 Observasi 5 medan gelagar melintang

jarak gel. Melintang = $\lambda = \frac{30}{5} = 6M$

jarak gel. Memanjang = 1,75 M

Perhitungan gelagar memanjang :

Dicoba menggunakan INP . 50

F = 179 cm^2

G = 141 kg

Wx = 2759 cm^3

Ix = 68740 cm^4

Wx.netto = 0,8 . Wx = 2200 cm^3

- Beban mati (Dead Load)

* Berat lantai kendaraan = 1,75 . 900 = 1575 kg/m'

* Berat gelagar memanjang = 141 kg/m'

= 1716 kg/m'

qDL = 1,1 . 1716 = 1887,6 kg/m'

$M_{max} = \frac{1}{8}.qDL.\lambda^2 = 8494{,}2$ kgM

- Beban hidup (Live Load)

qPR = 3,675 ton/m'

PG = 9,5454 ton

M_{max} . LL = $\frac{1}{8}.qPR.\lambda^2 + \frac{1}{4}.PG.\lambda$

= 30,85560 Ton M $\rightarrow$ 30855,60 Kg M

M_{tot} = (M_{max}DL + M_{max} LL) . 75% . 100

= (8494,2 + 30855,6) . 100 . 75 % → 2.947.860 Kg Cm

Kontrol σLt = $\frac{M}{Wx.n} = \frac{2947860}{2.200} = 1340\ {}^{kg}\!/_{cm^2} < \sigma Lt$ …….. O.K

- Perhitungan Gelagar Melintang

* Lihat Free body balok A – B

RA = RB = ½ . qDL + ½ . qPR . λ + ½ . PG

= ½ . λ (qDL + qPR) + ½ . PG

= ½ . 6 (1887,6 . 3675) + ½ . 9545,4 → 21460,50 kg

RA = P = 21460,50 kg

2P = 42921 kg

Dicoba menggunakan profil susun dengan ho = 700 mm

3 ϕ 180 . 10

4 L . 75 . 75 . 8

ho = 700 mm

γ = 10 mm

q = 176 kg/m^1

Wx.n = 5310 cm^3

qBs = q + toeslag 10%

= 1,1 (176) = 193,6 kg/m^1

M_{max} = $\frac{1}{8} qBs.L^2 + \frac{4PL}{2} - \frac{PL}{2} - \frac{2PL}{4}$

= $\frac{1}{8}(193,6).7^2 + PL\left(\frac{8}{4} - \frac{2}{4} - \frac{2}{4}\right)$

= 1185,8 + (21460,5) . 7 . 100 → 15140930 KgCm

Kontrol : σLt = $\frac{M}{Wx.n}$ = 2851,40 KgCm^2 → "Berbahaya"

- Dicoba lagi profil susun ho = 850 mm

3 ϕ 200 . 12

4 L . 80 . 12 . 8

ho = 850 mm

γ = 10 mm

q = 236 kg/m^1

Wx.n = 8910 cm^3

qBs = q + toeslag 10%

= 1,1 (236) = 259,60 kg/m^1

$M_{max} = \frac{1}{8} qBs.L^2 + RA.L$

= 121813,55 kgM → 12.181.355 KgCm

Kontrol : $\sigma Lt = \frac{12181355}{8910} = 1367{,}155$ KgCm^2 < σLt …….. O.K

- Kesimpulan perhitungan berat konstruksi dengan pembagian medan = 5 buah

* Gelagar memanjang INP 50

Berat gelagar = 5. 30 . 141 = 21150 kg

* Gelagar melintang → profil tersusun

3 ϕ 200 . 12

4 L . 80 . 80 . 12

ho = 850 mm

γ = 10 mm

q = 236 kg/m^1

Wx.n = 8910 cm^3

Berat gelagar melintang = (n + 1). 7 . q → (5 + 1) 7 . 236 = 9912 kg

Total berat = 31062 kg

2.2 Observasi 7 Medan Gelagar Melintang

Jarak gelagar melintang = $\lambda = {}^{30}\!/_{7} = 4{,}2857$

Jarak gelagar memanjang = 1,75 M

- Perhitungan Gelagar Memanjang

* Dicoba INP 45

F = 179 cm^2

q = 115 kg

Wx = 2040 cm^3

Wx.n = 1632 cm^3

qPR = 3675 kg/m^3

PG = 9545,4 kg

MLL = $\frac{1}{8}.3675.(4{,}2857)^2 + \frac{1}{4}.9.545{,}4.4{,}2857$

= 18.664,62 Kg M $\rightarrow$ 1866462 Kg Cm

M_{tot} total = (M_{max}DL + M_{max} LL) . 75%

= 1.719.952,5 Kg Cm

Kontrol σLt = $\frac{M}{Wx.n} = \frac{1719952{,}5}{1632} = 1054\ {}^{kg}\!/_{cm^2} < \sigma Lt$ …….. O.K

- Perhitungan Gelagar Melintang

Reaksi perletakan = $\frac{1}{2}.\lambda(qDL + qPR) + \frac{1}{2}PG = P$

P = $\frac{1}{2}4{,}2857(1859 + 3675) + \frac{1}{2}9545{,}4$ = 16631,232 kg

2 P = 33262,46 kg

Dicoba menggunakan profil susun dengan ho = 750 mm

3 ϕ 200 . 12

4 L . 80 . 80 . 12

ho = 750 mm

γ = 10 mm

q = 229 kg/m^1

Wx.n = 7690 cm^3

qBs = (q + 10%)

= 1,1 (229) = 251,9 kg/m^1

$M_{max} = \frac{1}{8} 251{,}9x7^2 + 16631{,}23x7$

= 117961,51 KgM → 11.796.151 KgCm

Kontrol : $\sigma Lt = \frac{M}{Wx.n} = 1312{,}959$ $KgCm^2$ < σLt …….. O.K

- Berat konstruksi pada bentang jembatan dalam 7 medan

Gelagar memanjang INP 450

Berat gelagar = 5. 30. 115 = 17250 kg

Gelagar melintang ho = 750

Berat gelagar = (n + 1). 7. 229

= (7 + 1) 7. 229 = 12824 kg +

Berat total = 30074 kg

2.3 Observasi 9 Medan Gelagar Melintang

jarak gelagar melintang $\lambda = \frac{30}{9} = 3{,}333M$

jarak gelagar memanjang = 1,75 M

* Perhitungan gelagar memanjang

- Dicoba INP 360

F = 97 cm^2

q = 76,1 kg

Wx = 1090 cm^3

Wx.net = 872 cm^3

qPR = 3675 kg/m^1

PG = 9545,5 kg

qDL = 1816,21 kg/m^1

$M_{max}DL = \frac{1}{8}.1816,21.(3,333)^2 = 2522\,KgM \rightarrow 252200\,KgCm$

$M_{max}LL = \frac{1}{8}.3675.(3,333)^2 + \frac{1}{4}.9.545,4.3,333$

= 13056,85 Kg M $\rightarrow$ 13056685 Kg Cm

M_{tot} total = ($M_{max}DL$ + M_{max} LL) . 75%

= 1168413,75 Kg Cm

Kontrol $\sigma Lt = \frac{M}{Wx.n} = \frac{1168413,75}{872} = 1339,92\,kg/cm^2 < \sigma Lt$ …….. O.K

- Perhitungan Gelagar Melintang

Reaksi perletakan :

Reaksi perletakan = $\frac{1}{2}.\lambda(qDL + qPR) + \frac{1}{2}PG = P$

P = $\frac{1}{2}.3,333(1816,21 + 3675) + \frac{1}{2}9.545,4$ = 13923,90 kg

2 P = 27847,60 kg

Dicoba menggunakan profil susun dengan ho = 700 mm

3 ϕ 200 . 12

4 L . 80 . 80 . 12

ho = 700 mm

γ = 10 mm

q = 228 kg/m^1

Wx.n = 7090 cm^3

qBs = (q + 10%)

= 1,1 (228) = 250,80 kg/m^1

$M_{max} = \frac{1}{8}250,8x7^2 + 13923,80x7$

= 99002,75 KgM $\rightarrow$ 9900275 KgCm

Kontrol : $\sigma Lt = \frac{M}{Wx.n} = 1396,37$ KgCm^2 < σLt …….. O.K

- Berat Kontruksi Dengan 9 Medan

Gelagar memanjang INP 360

Berat gelagar memanjang = 5. 30. 76,1 = 11415 kg

Gelagar melintang → profil susun

3 ϕ 200 . 12 → ho = 700 mm

Berat gelagar melintang = (n + 1). 7. q

= (9 + 1) 7. 228 = 15960 kg +

Berat total = 27375 kg

2.4 Rekapitulasi Hasil Observasi Medan

Item	5 Medan	7 Medan	9 Medan
- Jarak gelagar rmemanjang	1,75 M	1,75 M	1,75 M
- Jarak gelagar melintang	6,00 M	4,2857 M	3,333 M
- Jenis profil gelagar memanjang	INP. 500	INP. 450	INP. 360
- Elemen profil gelagar melintang	2 x 3 ϕ 200 .12 2 x 2L. 80. 8. 12 γ = 10 MM ho = 850 MM	2 x 3 ϕ 200 .12 2 x 2L. 80. 80. 12 γ = 10 MM ho = 750 MM	2 x 3 ϕ 200 .12 2 x 2L. 80. 8. 12 γ = 10 MM ho = 700 MM
Berat konstruksi	31.062 Kg	30.074 Kg	27.375 Kg

* Kesimpulan :

Digunakan hasil observasi pada pembagian bentang jembatan dalam 9 medan, dengan total berat konst.

Grafik Pembagian Medan

II.3 Perhitungan Gelagar Memanjang

Dari hasil observasi/ penyelidikan jumlah medan diatas yang ekonomis, yaitu pada penyelidikan 9 medan dimana :

jarak gelagar melintang = $30/9 = 3{,}333M$

jarak gelagar memanjang = 1,75 M

Digunakan profil INP. 360

F = 97 cm^2

q = 76,1 kg

Wx = 1090 cm^3

Wy = 114 cm^3

Ix = 19610 cm^4

Iy = 818 cm^4

ix = 14,2 cm

iy = 2,90 cm

Sx = 638 cm^3

3.1 Perhitungan Muatan

- Muatan mati (Dead load)

* Lihat 1.1.1

* Berat lantai kendaraan = 1,75 . 900 = 1575 kg/m'

* Berat gelagar memanjang INP = q = 76,1 kg/m'

Jumlah = 1651,1 kg/m'

* Toeslag 10% (termasuk buat shear coneector) = 165,11 kg/m'

qDL = 1816,21 kg/m'

* $M_{max} = (\frac{1}{8}.qDL.\lambda^2).75\%$

$= (\frac{1}{8}.1816{,}21.3{,}333^2).75\% = 1891{,}51KgM$

- Beban hidup (Live Load)

Lihat 2.1

qPR = 3,675 ton/m'

PG = 9545,4 ton

M_{max} . LL = $(\frac{1}{8}.qPR.\lambda^2 + \frac{1}{4}.PG.\lambda).75\%$

= 9792,64 Kg M

3.2 Perhitungan Plat Lantai Komposit

* Mencari B. Effective

b^1/L	0,05	0,10	0,15	0,20	0,25	0,30
λ/b^1	1,00	0,89	0,78	0,68	0,59	0,50

L = 3,333 M

L = 333,3 Cm

$2.b^1$ = 175 – bf

= 175 – 14,3 = 160,7 cm

b^1 = 80,35 cm

$$\frac{b^1}{L} = \frac{80,35}{333,3} = 0,241$$

$$\frac{\lambda}{b^1} = 0,68 - \frac{0,241 - 0,20}{0,25 - 0,20} x(0,68 - 0,59) = 0,61$$

$$\lambda = 0,61.b^1 = 0,61.80,35 = 49,01Cm$$

* B.eff = 2. λ + bf = 2 . 49,01 + 14,30 =112,32 cm

* Check Thdp spesifikasi AASHTO

B.eff $\rightarrow \leq \frac{1}{4}.L = \frac{1}{4} x333,3 = 83,325cm$

$\leq S = 175cm$

$\leq .12.tebalplat = 12x18 = 216cm$

Diambil B.eff = 83,325 cm

Tegangan yang bekarja :

Luas slob beton = AC = B.eff . t → 83,325 x 18 = 1499,85 cm^2

Luas INP. 360 = Af = 79 cm^2

* Moment sebelum komposit M.PRC = M_{max} . DL

= 1891,51 kgm → 189151 kgcm

* Moment sesudah komposit Mpost = M_{max} . DL + M_{max} . LL

= 1891,51 + 9792,64 → 1168415 kgcm

* Tegangan-tegangan yang terjadi sebelum kampasit/ tanpa cover plate

$$\sigma SL = \frac{M.PRE}{Wx} = \frac{189151}{1090} = +173{,}53\, {kg}/{cm^2}\,(tarik)$$

σSL = …… = - 173,53 kg/cm^2 (tekan)

* Tegangan Setelah Komposit

AC = B.eff . t = 83,325 . 18 = 1499,85 cm^2

$$IC = \frac{1}{12}.Beff.t^3 = \frac{1}{12}x83{,}325x18^3 = 40495{,}95cm^4$$

$$d = \frac{18 + 36{,}00}{2} = 27cm$$

AF = 79 cm^2 → pembebanan tetap n = 21

$$dc = \frac{AF.d}{AF + \frac{AC}{n}} = \frac{79x27}{79 + \frac{1499{,}85}{21}} = 14{,}18cm$$

ds = d – dc = 27 – 14,18 = 12,82 cm

$$IF + AF.ds^2 + \frac{1}{n}(IC + AC.dc^2)$$

$$Iv = = 19610 + 79(12{,}82)^2 + \frac{1}{21}(40495{,}95 + 1499{,}85x14{,}18^2)$$

$$= 32593{,}84 + 16289{,}26 = 48883{,}10cm^4$$

$$Ycu = -\frac{18}{2} - 14{,}18 = -23{,}18cm$$

$$Ysu = \frac{18}{2} - 14{,}18 = -5{,}18cm$$

$$Ysl = \frac{18}{2} + 36 - 14{,}18 = 30{,}82cm$$

$$\sigma cu = \frac{Mpost.Ycu}{Iv.n} = \frac{1168415\,x(-23{,}18)}{48883{,}10} = 26{,}384kg/cm^2$$

$$\sigma^1 cu = 26{,}384kg/cm^2 < \sigma^1 b = 75kg/cm^2 \rightarrow O.K$$

$$\sigma su = \frac{Mpost.Ysu}{Iv} = \frac{1168415\,x(-7{,}697)}{48883{,}10} = -183{,}975kg/cm^2 < \sigma a^1 = 1400\,kg/cm^2$$

$$\sigma sl = \frac{Mpost.Ysl}{Tv} = \frac{1168415\,(30{,}82)}{48883{,}10} = 736{,}63kg/cm^2 < \sigma a \rightarrow O.K$$

* Tegangan total

σsu = -173,53 – 183,975 = 357,505 kg/cm^2 < σa^1

σsl = 173,53 + 736,67 = 910,200 kg/cm^2 < σa^1

Ternyata tegangan yang terjadi setelah komposit, ternyata lebih kecil dari tegangan profil yang di izinkan. Sehingga flans bawah profil tidak perlu diperkuat dengan cover plate.

" Kontrol Lendutan "

- Akibat Dead Load (DL)

- $\gamma PRC = \frac{5.MPRC.L^2}{48.E.Iv} = \frac{5x189151x333{,}3^2}{48x2{,}1.10^6\,x48883{,}1} = 0{,}002cm$

- Akibat DL + LL

$$\gamma post = \frac{5.MPRC.L^2}{48.E.Iv} = \frac{5x1168415\,x333{,}3^2}{48x2{,}1.10^6\,x48883{,}1} = 0{,}013cm$$

Total :

$\gamma = 0{,}002 + 0{,}013 = 0{,}015cm$

$\xi = \frac{L}{500} = \frac{333{,}3}{500} = 0{,}667cm$ $\qquad \gamma < \xi \rightarrow$ O.K

3.3 Perhitungan Shear Connector

Shear connector/ penghubung geser dipakai baja canal CNP. 8 hubungan dengan gelagar memanjang memakai las listrik, panjang baja kanal sebagai shear connector diambil las listrik, panjang INP. 36 dengan b = 14,30.

Kekuatan shear connector

$$Q = 20\left(h + \frac{t}{2}\right)(L)\sqrt{\sigma b'}$$

Dimana :

h = tebal fleus baja canal (cm)

t = tebal web. panjang canal (cm)

l = panjang shear connector (cm)

σb' = tegangan beton tekan yang diizinkan $\left(kg/cm^2\right)$

$$Q = 20 \bullet \left(0{,}8 + \frac{0{,}6}{2}\right)(14{,}30)\sqrt{75}$$

$$= 2724{,}51kg \approx 2724kg$$

- Perhitungan Gaya Geser

$$q.Bs = 1816{,}21\left(kg/M'\right)$$

$$q.PR = 3675\left(kg/M'\right)$$

$$PG = 9545{,}4\ kg$$

$$DA = \begin{matrix} PG + \frac{1}{2}.qPR.L + \frac{1}{2}.qBs.L \\ 9545{,}4 + \frac{1}{2}x3675x3{,}333 + \frac{1}{2}x1816{,}21x3{,}333 = 18696{,}5Kg \end{matrix}$$

$$DB = \begin{matrix} \frac{3.qBS.L}{10} + \frac{4.qPR.L}{25} + PG \\ \frac{3x1816{,}21x\,3{,}333}{10} + \frac{4x3675x3{,}333}{25} + 9545{,}5 = 13321{,}23Kg \end{matrix}$$

$$DC = \frac{\frac{q.BS.L}{10} + \frac{9.3675.3{,}333}{50} + PG}{\frac{1816{,}21.3{,}333}{10} + \frac{9.3675.3{,}333}{50} + 9545{,}4 = 12355{,}756\ kg}$$

PERHITUNGAN JARAK SHEAR CONNECTOR

Iv = 48883,20 cm^4

Ac = 1499,85 cm^2

c = 14,18 cm

n = 21

- $S = \left(\frac{AC}{n}\right).dc = \left(\frac{1499{,}85}{21}\right).14{,}18 = 1012{,}756 cm^3$

  $Q = 2724 kg$

- Gaya geser memanjang maksimal = $q\ .\ \frac{Ds}{Iv}$

$$q\,AB = \frac{18696{,}5.1012{,}756}{48883{,}10} = 387{,}352\ {}^{kg}\!/_{cm}$$

$$q\,BC = \frac{13321{,}5.1012{,}756}{48883{,}10} = 275{,}988\ {}^{kg}\!/_{cm}$$

$$q\,CD = \frac{12355{,}52.1012{,}756}{48883{,}10} = 255{,}980\ {}^{kg}\!/_{cm}$$

jarak pemasangan shear connector pada amsing-masing section

$$L\,AB = \frac{Q}{qAB} = \frac{2724}{387{,}352} = 7{,}03\ {}^{kg}\!/_{cm}$$

$$L\,BC = \frac{Q}{q.BC} = \frac{2724}{275{,}988} = 9{,}86\ {}^{kg}\!/_{cm}$$

$$L\,CD = \frac{Q}{q.CD}\ \frac{2724}{255{,}980} = 10{,}64\ {}^{kg}\!/_{cm}$$

II.4 Perhitungan Gelagar Melintang

4.1. Perhitungan Muatan dan Momen

λ = 3,333 m

$$PG = \frac{L}{2,75}.12.1,25.1000\,(kg)$$

q PR = 3675 kg/M'

q DL = 1887,60 kg/M'

$$P_2 = \lambda.(qDL + qPR) + \frac{L}{2,75}.12.1,25.1000$$

$$= 3,333(1887,60+3675) + \frac{1,25}{2,75}\cdot 12\cdot 1,25\cdot 1000 = 27085\,kg$$

$$P_1 = \frac{0,875}{1,75}\cdot 3,333\,(1887,60 + 3675) + \frac{0,875}{2,75}\cdot 12\cdot 1,125\cdot 1000 = 14042\,kg$$

$$RA = RB = \frac{1}{2}(2P_1 + 3P_2) = P_1 + 1,5P_2$$

= 54669,50 kg

- MA = 0
- M_1 = RA . 1,75 – P_1 . 1,75
  = 54669,5 . 1,75 – 14042.1,75
  = 71098,125 kg.m
- M_2 = (RA – P_1) . 3,5 – P_2 . 1,75
  = 94797,50 kg.m
- q BS = 228 kg/m'
- Mmax BS = $\frac{1}{8}\cdot qBS\cdot L^2$
  = $\frac{1}{8}\cdot 228\cdot 7^2$
- Mmax total = M_2 + $Mmax_{BS}$ =
  = 94797,5 + 1396,5

= 96194 kg.m

= 96196400 kg.cm

Lihat 2.2.4 direncanakan menggunakan profil tersusun dengan

ho = 700mm

2x3.200 12

2xL.80.80.12

δ = 10mm

Wxn = 7090cm^4

q BS = 228 kg/m^1

$$\sigma Lt = \frac{M}{W} \le \sigma Lt = 1400\,kg/cm^2$$

$$\xi Lt = \frac{9619400}{7090} = 1357\,kg/cm^2 \le \xi Lt \rightarrow O.K$$

4.2 Perhitungan Overlap Flens Profil Tersusun

MA = 0

$$\left(\frac{1}{2}.qBS.L\right).1{,}75 - \frac{1}{2}qBs.(1{,}75)^2 + 71098{,}125$$

$$MA = (1/2\, x228x7).1{,}75 - 1/2\, x228(1{,}75)^2 + 71098{,}125$$

$$72145{,}50\,Kgm = 7214550\,KgCm$$

$$Wperlu = \frac{M}{0{,}8.\xi Lt} = \frac{7214550}{1120} = 6441{,}56Cm^3$$

M_2 . M_{max} . total = 9619400 Kg Cm

$$Wperlu = \frac{M}{0{,}8.\xi Lt} = 8588{,}75Cm^3$$

Melalui tabel profil tersusun untuk profil ϕ. 200. 12

Ho = 700 mm

L = 80. 80. 12

γ = 10 mm

W1. plat = 4240 cm^3

W2. plat 5660 cm^3

W3. plat = 7090 cm^3

$\xi Lt = 1400\ kg/cm^2$

M = ξLt . W

- M1 Plat = 1400 . 4240 = 5936000 Kg Cm
- M2 Plat = 1400 . 5660 = 7924000 Kg Cm
- M3 Plat = 1400 . 7090 = 9926000 Kg Cm

Panjang overlapping plane

L1 = 4 . 1,75 = 7,00 M

$$L2 = 3{,}5 + 2\frac{(7214550 - 5936000)x1{,}75}{7214550} \rightarrow 3{,}5 + 2x0{,}13 = 3{,}75M$$

$$L3 = 2x\frac{(9619400 - 7924000)}{(9619400 - 7214550)}x1{,}75 \rightarrow 2x1{,}23375 = 2{,}4675 \Rightarrow 2{,}5M$$

4.3 Perhitungan Sambungan Pada Flens Overlapping Profil Tersusun

M2. plat = 7924000 KgM

W3. plat = 7090 cm^3

$$\sigma Lt = \frac{M}{W} = \frac{7924000}{7090} = 1117{,}63 kg/cm^2 \langle \xi Lt$$

ϕ Rivet = d = 25 mm

FN = 20 . 1,2 – 2 . 2,5 . 1,20 = 18 cm^2

- Gaya pada fleus = K = FN . σ_{lt}

  = 18 . 117,63 = 20117,34 kg

- Jumlah rivet yang diperlukan

- ng = $\frac{k}{FR \cdot 0{,}8\xi} = \frac{20117{,}34}{\frac{1}{4}\pi\ (2{,}5)^2 \cdot 0{,}8 \cdot 1400} = 3{,}67 \approx 6 buah$

- nt = $\frac{k}{d \cdot \delta \cdot 2 \cdot \xi} = \frac{20117{,}34}{2{,}5 \cdot 1{,}2 \cdot 2 \cdot 1400} = 2{,}4 buah$

- Digunakan 2 x 3 = 6buah

M_1plat = 5936000 kg.cm

W_2plat = 5660 cm^3

$\sigma_{lt} = \frac{5936000}{5660} = 1048{,}76 \quad kg/cm^3$

- Jumlah rivet yang diperlukan :
- ng = $\frac{k}{\frac{1}{4}\pi d^2 \cdot 0{,}8 \cdot \sigma} = \frac{18877{,}74}{\frac{1}{4}\pi (2{,}5)^2 \cdot 0{,}8 \cdot 1400} = 3{,}44 \approx 6\, buah$
- nt = $\frac{18877{,}74}{2{,}5 \cdot 1{,}2 \cdot 2 \cdot 1400} = 2{,}25\, buah$
- digunakan 2 x 3 = 6 rivet

4.4 Perhitungan Jarak Rivet

- RA = RB = 54669,50 kg ……lihat 2.4.1
- Berat Sendiri Gelagar Melintang = q BS = 1,1 . 228 = 250,8 kg/m'
- RA . BS = $\frac{1}{2} \cdot qBS \cdot L = \frac{1}{2} \cdot 250{,}8 \cdot 7 = 877{,}80\, kg$
- DA = RA + RABS

  = 54669,50 + 877,80 = 55547,30 kg

- sx = sxfleus + sx ⌋⌊

  = F $\left(h/2 + df/2\right) + 2\,(F) \cdot \left(h/2 - 2{,}41\right)$

  = $20 \cdot 1{,}2\left(7/2 + 1{,}2/2\right) + 2\,(17{,}9)\left(7/2 - 2{,}41\right) = 2021{,}122\, cm^3$

  keterangan gambar :

  t = jarak pasang rivet

  Ix = 165900 cm^4 ⟶ tabel = 1x 1pelat $tepi/F\ lens$

  Da = gaya lintang max = 55547,30 kg

  Sx = static moment flens +⌋⌊ siku = 2021,122 cm^3

  Terhadap titik berat /as gelagar melintang.

- Kekuatan pikul RIVET (NR).

- N geser = 2.fa.0,8.ξ = 2 $\frac{0.2,5^2}{4} x0,8x1400 = 10995,60Kg$

- Ntumpu = 2 . Ft. $\xi = 2(2,5x1,2)x1400 = 8400Kg$

- Diambil $\lfloor$ NR = Ntumpuan = 8400 Kg

- Jarak pasang river (t)

- $t \leq \frac{NR.Ix}{DA.Sx} = \frac{8400x765900}{55547,30x2021,122} = 12,41Cm$

- Syarat jarak pemasangan PPBBI/ 1984

2,5 $\phi \leq t \leq 7\ \phi$

6,25 cm $\leq t \leq$ 17,50 cm

diambil t = 10 cm

Jarak paku keliling ke ujung plat = 5 cm

- Panjang overlap = 2 . 10 + 5 = 25 cm
- Panjang plat tepi atas = 2,50 + 2 . 25 = 3,00 M
- Panjang plat tepi kedua = 3,75 + 2 . 25 = 4,25 M

4.5 Sambungan Gelagar Memanjang Dengan Gelagar Melintang

- Gelagar Memanjang INP. 360

h = 360 mm

b = 143 mm

tF = 19,5 mm ; t_{10} = 13 mm

F = 97,00 cm^2

Ix = 19610 cm^4

Wx = 1090 cm^3

- Gelagar melintang

ho = 700 M

2 x 3 ϕ 200. 12

γ = 10 mm

Wxn = 7090 cm^3

- Penyanbungan digunakan rivet/ paku keliling dan dalam perhitungan standar sfesifikasi untuk jembatan jalan raya type gabungan No. 01/ 1969.
- Gaya-gaya yang dianggap dipikul oleh satu paku keeling/ rivet.

– $\bar{P}_1$ single shear = F.0,8. $\bar{\sigma} = \pi/4 \cdot (2{,}6)^2 \cdot 0{,}8 \cdot 1600 = 6796\,kg$

– $\bar{P}_2$ *tumpuan Web* = $Inp \cdot 360 = 1{,}30 \cdot 2{,}6 \cdot 2 \cdot 1600 = 10816\,kg$

– $\bar{P}_3$ *tumpuan Web profil tersusun* = $2{,}6 \cdot 1{,}0 \cdot 2 \cdot 1600 = 8320\,kg$

– $\bar{P}_4$ *tumpuan pleus INP* $\cdot 360 = 2{,}6 \cdot 1{,}95 \cdot 2 \cdot 1600 = 16224\,kg$

– $\bar{P}_5$ *tarik Rivet* $= \pi/4 \cdot (2{,}6)^2 \cdot 0{,}8 \cdot 1600 = 6796\,kg$

- R = $PG + 2\left(½ \cdot qPR \cdot L + ½ \cdot qBS \cdot L\right)$
  = $9545{,}4 + 2\left(½ \cdot 3675 \cdot 3{,}333 + ½ \cdot 1816{,}21 \cdot 3{,}333\right)$
  = 27847,60 kg
- RA = RB = 18696,5 kg …..(lihat 2.3.3)
- SAMBUNGAN PADA PELAT BADAN
  - digunakan alat penyambung Rivet dan diperkaku dengan double baja siku
  - jumlah Rivet untuk sambungan antara pelat badan INP 360 denagn profil baja siku yang menghubungkan gelagar memanjang dan melintang.

    $$n_2 = \frac{RA}{2 \cdot P_1} = \frac{18696{,}50}{2 \cdot 6796} = 1{,}37 \approx 2\,buah$$

  - jumlah Rivet untuk sambungan antara pelat badan profil tersusun dengan profil baja siku.

    $$n_2 = \frac{R}{2 \cdot P_1 \cdot 2} = \frac{27847{,}50}{2 \cdot 6796 \cdot 2} = 1{,}02 \approx 2\,buah$$

- SAMBUNGAN PADA FLEN ATAS
  - Direncanakan menggunakan pelat penyambung flens dengan : δ 25mm

- M = $Mmax_{DL}$+ $Mmax_{LL}$

  = 1891,51 + 9792,64 = 11684,15 kg.m…..(lihat 2.3.1)

- $Y = h \cdot INP \cdot 360 + \frac{\delta}{2} = 36 + \frac{2,5}{2} = 37,25\,cm = 0,3625\,meter$

- Gaya yang bekerja pada pelat penyambung flens = F

  - $F = \frac{M}{Y} = \frac{11684,15}{0,3725} = 31366,84\,kg$

  - A Flens perlu = $F = \frac{F}{\overline{\sigma}} = \frac{31366,84}{1600} = 19,60\,cm^2$

  - A ada = A pelat penyambung = tf x b = 2,5.14,3 = 35,75cm^2

    = 5,71cm^2

    Anetto = 30,04cm^2

    A netto > A perlu ⟶ OKEY

- Jumlah Rivet yang dibutuhkan = n ⟶ Single Shear

  $n = \frac{F}{\overline{P_1}} = \frac{31366,84}{7696} = 4,61 \approx 6\,buah$

- System pamasangan Rivet = 2 jalur ,yaitu 2x3 = 6buah ϕ 25mm
- System dan jumlah ini, juga digunakan untuk pelat penyambung bawah gelagar mamanjang.

- PENGAKU ANTARA GELAGAR MELINTANG
  - PPBI 1984

    $\frac{bp}{tp} \le 70$

    $\frac{70}{1,0} \le 70$

    bp = panjang pelat yang dibebani
    tp = tebal Web
    ap = panjang pelat yang tidak dibebani

  - Tidak perlu di chek terhadap bahaya pelipatan
  - Tidak perlu diberi pengaku antara pada Web

- KONTROL KIP GELAGAR MELINTANG

$$-\frac{h}{tb}=\frac{70}{1{,}0}=70<75$$

$$-\frac{L}{h}\cdot\frac{t}{b}=\frac{175}{70}\cdot\frac{3\cdot 1{,}2}{14{,}30}=0{,}63<1{,}25$$

$\frac{h}{tb}=70<75\rightarrow$ Gelagar melintang tidak akan mengalami deformasi

Gelagar melintang adalah statis tertentu dimana pada perletakan plat badan gelagar diberi pengaku samping

- $C_1=\frac{L\cdot h}{B\cdot t}=\frac{175\cdot 70}{14{,}3\cdot 3}$ =237,96<250

$\bar{\sigma}_{kip}=\bar{\sigma}$ =1600 kg/cm^3

Tegangan yg terjadi = 1357 kg/cm^3 < $\bar{\sigma}_{kip}$ (hal 32)

II.5. PERHITUNGAN TROTOIR

- Letak trotoir di luar gelagar kepala dan direncanakan menggunakan konstruksi balok konsol / katilever

5.1. PERHITUNGAN LANTAI TROTOIR

- Lihat 1.6. diperoleh
- Penulangan arah X (melintang trotoir)
  - Daerah tarik digunakan ∅14 – 17,5
  - Daerah tarik digunakan ∅10 – 20
- Penulangan arah X (melintang trotoir)
  - Daerah tarik digunakan ∅14 – 17,5
  - Daerah tarik digunakan ∅10 – 20
  -
- PEMERIKSAAN / PERHITUNGAN GELAGAR MEMANJANG TROTOIR

- Skema pembebanan

- Muatan lihat 1.4

qLL = 550 kg/m′ ; q_{BS} = 1089 kg/m^1 (hal 8)

A = $\frac{0,275}{110}$. (550 + 1089) = 409,75 kg/m^1

B = $\frac{0,55}{110}$. (550 + 1089) = 819,50 kg/m^1

- Rencana pemilihan profil gelagar memanjang tengah

- VOSB pasal 37 sistem struktur dapat dianggap balok sederhana dengan memperhitungkan hanya 75% M_{max} sebagai moment design

- M_{max} = 75% . ⅛ . q L

= 75% . ⅛ . 819,50 . $3,333^2$ = 853,475 kg.m

= 85347,50 kg.m

W = $\frac{M}{\sigma}$ = $\frac{85347,50}{1400}$ = 60,96 cm^3

Digunakan profil [NP 14

Wx = 86,4 cm^3

Cr = 16 kg/m

$q._{BS}$ = 1,10 . 16 = 17,6 kg/m^1

Wxz = 0,8 x 86,4 = 69,12 cm^3

Kontrol :

M = ⅛ (819,50) + 17,60) . $3,333^2$. 75% = 871,80 kg.m

= 87180 kg.cm

σ yang terjadi = $\frac{M}{Wn}$ = $\frac{87180}{69,12}$ =1261,29 kg/cm^2 → Okey

5.2 PERHITUNGAN TIANG SANDARAN

- Balok sandaran

- Digunakan pipa besi ϕ 2”,tebal pipa = 0,3 cm

- Beban rencana balok sandaran = 100 kg/m’

(SKSBI 378/KPTS/1987)

- Pipa besi assental ϕ 2”

  D = 2.2,54 = 5.08cm

  d = 5,08 – 2.0,3 = 4,48cm

  $Wxn = 0{,}8 \frac{\pi}{32}\left(\frac{D^4 - d^4}{D}\right) = 0{,}8 \frac{\pi}{32}\left(\frac{5{,}08^4 - 4{,}48^4}{5{,}08}\right)$

  $= 4{,}07 \text{ cm}^3$

  $M_{max} = 75\% \cdot \frac{1}{8} \cdot 100 \cdot 1{,}667^2 = 26{,}052 \text{ kg.m}$

  $Wx_{perlu} = \frac{M_{max}}{\sigma} = \frac{2605{,}2}{1400} = 1{,}86 \text{ cm}^3$

  $Wx_{perlu} < Wx_{ada} \rightarrow$ Okey

Kontrol :

$\sigma = \frac{M}{Wx \approx} = \frac{2605{,}2}{4{,}07} = 640{,}09 \text{ kg/cm}^2 < \sigma_{Lt} = 1400 \text{ kg/cm}^2$

- P = 100 . 3,333 = 333,3 kg
- River A_1 diasumsikan sumbu rotasi
- M A_1 = P1,32 = 333,3 . 1,32
  = 439,956 kgm
  = 43995,6 kg.cm

  $W_{min} = \frac{M}{\sigma} = \frac{43995{,}6}{1400} = 31{,}43 \text{ cm}^3$

  (Profil ganda)

Direncanakan Profil Tiang Sandaran

Dipilih ⌋⌊ . 100 . 100 .14

$Wx_1 = 33{,}50 \text{ cm}^3$

$Wxn = 0{,}80 \cdot 2 \cdot 33{,}50 = 53{,}60 \text{ cm}^3$

$G_1 = 20{,}6 \text{ kg/m}^1$

$Q = 1{,}1 \cdot 2 \cdot 20{,}6 \cdot 1{,}42 = 64{,}35 \text{ kg}$

$F_1 = 26{,}2 \text{ cm}^2$

Digunakan rivet ϕ 20 mm = 2 cm

F.rivet = ϕ rivet . tebal baja⌊

= 2 . 1,4 = 2,8

$Fnetto = 2 (26{,}2 - 2{,}8) = 46{,}80 \text{ cm}^2$

- Berat belah sandaran pipa ϕ 2” = 100 kg/cm2
- Berat tiang sandaran Q pipa ϕ 2” = 46,80 kg
- Berat balok sandaran = 3.100.3,333 = 999,90 kg

Berat total N = 1046,70 kg

Kontrol :

$$* \sigma yg.terjadi = \frac{N}{FN} + \frac{M}{WN} \rightarrow \frac{1046,70}{46,80} + \frac{43995,6}{53,60} = 843,18 kg/cm^2$$

$$* \sigma yg.terjadi = \frac{D}{Fn} = \frac{333,3}{46,80} = 7,12 kg/cm^2$$

$$* \sigma ideel = \sqrt{\sigma^2 + 3.\tau^2} \rightarrow \sqrt{(843,18)^2 + 3(7,12)^2}$$

$$\Rightarrow 843,27 kg/cm^2 < \bar{\sigma} = 1400 kg/cm^2 \rightarrow O.K$$

5.3 PERHITUNGAN KONSTRUKSI KONSOL/ KANTILEVER

Skema pembebanan :

- Analisa beban

Beban P1 :

- Berat 3 buah balok snadaran = 3 x 100 x 3,333 = 999,90 kg
- Berat tiang sandaran Q = 46,80 kg
- Berat gelagar memanjang ⊂. 14 = 3,333 . 16 . 1,1 = 58,66 kg
- Berat lantai trotoir + beban hidup = 409,75 x 3,333 = 1365,70 kg

P1 = 2471,06 kg

P1 diambil = 2471 kg

Beban P2 :

- Berat gelagar memanjang ⊂. 14 = 3,333 . 16 . 1,1 = 58,66 kg
- Berat lantai trotoir = 819,50 x 3,333 = 1365,70 kg

P2 = 2790,05 kg

P2 diambil = 2790 kg

- Lihat setelah system kontruksi konsal di mulai, di coba menggunakan :

t1 = 20 cm

t2 = 60 cm

ϕ = 10mm

⌊. 50. 50. 7 ; maka → Berat sendiri balah kansol

- Berat 2. 50. 50. 7 = 1,10 . 2 . 5,14. (1,10 + 1,253 + 0,60) = 33,40 kg
- Berat plat badan ϕ 10 mm

$$= \frac{1}{2}(0{,}20 + 0{,}88)x1{,}10x0{,}10x5500x1{,}1 = 359{,}37kg$$

QK = 392,77 kg

- Perhitungan Sambungan antara Balok Konsol dan Gelagar Kepala

* LQ = 0,55 – X → $\frac{98}{64} = \frac{0{,}55 + X}{0{,}55 - X}$

= 0,55 – 0,1154 1,53125(0,55 – X) = 0,55 + X

= 0,4346 M 0,8422 – 1,53125 X = 0,55 + X

X = 0,115437

P1 = 2471 kg

P2 = 2790 kg

P3 = 2790 kg

Qk = 392,77 kg

PH = 500 kg

- Sumbu rotasi akibat momen konstruksi terjadi pada AS baut 9 sehingga

M 9 = 500 (0,90 + 0,18 + 0,14 + 0,20 + 0,68 – 0,04) + 2471 . 1,10 + 2790 . 0,55

+ 392,77 . 0,4346 = 5513,0038 Kg m → 551300,38 kg cm (⤸)

- Sheer forse (gaya geser) berat trotoit pada bidang AB . DAB = 2471 + 2790 + 392,77 = 8443,77 kg (↑)
- Besar gaya normal yang bekerja pada balok konsol NK = - PH = - 500 kg (←)

- PEMERIKSAAN KEKUATAN RIVET THDGAYA TARIK / CABUT AKIBAT MOMEN

- $NI = \frac{M \times hi}{\sum h^2}$
  - Digunakan Rivet ϕ 20mm = 2cm
  - t = 5d = 5 x 2 = 10cm
  - $1\frac{1}{2} \le t_1 < 3d = 3cm \le t_1 \le 6cm$
  - Diambil t_1 = 4cm

- $\Sigma h^2 + h2^2 + h3^2 + h4^2 + h5^2 + h6^2 + h7^2 + h8^2 = 20400cm^2$
- melalui diagram tegangan tarik Rivet, maka besarnya vektor gaya normal tarik baut max, terjadi pada rivet no 1 N_1.
- $N_1 = \frac{M \times h_1}{\sum h_1} = \frac{551300,38 \times 80}{20400} = 2161,962\,kg \qquad (\rightarrow)$

  N_1 bekerja pada 2 buah rivet
- $N_1 = pada\,1 Rivet = \frac{2161,962}{2} = 1080,981\,kg$
- A. Netto . Rivet = ¼ . π 2^2 = 3,1416cm^2 = A bruto
- $\sigma_{tr} = \frac{N}{AN} = \frac{1080,981}{3,1416} = 344,086\,{}^{kg}\!/_{cm^2} < \overline{\sigma}_{tr} \rightarrow OKKEY$
- Digunakan Rivet 4.6 dengan $\overline{\sigma}_{tr} = 1120\,{}^{kg}\!/_{cm^2}$
- Gaya geser pada sambungan yang dipikul oleh seluruh Rivet = V = DAB = 8443,77kg

  $V_1\ Rivet = \frac{V}{N} = \frac{8443,77}{2 \cdot 9} = 469,098\,{}^{kg}\!/_{cm^2}$

$$\tau = \frac{V_1\ Rivet}{A\,Rivet} = \frac{4 \times 469{,}089}{\pi \cdot 2^2} = 149{,}39\ {}^{kg}\!/_{cm^2} < \bar{\tau}$$

$$\bar{\tau} = 0{,}80\ \bar{\sigma}_{tr} = 0{,}80 \cdot 1120 = 896\ {}^{kg}\!/_{cm^2}$$

- PEMERIKSAAN KEKUATAN RIVET TERHADAP GAYA NORMAL TEKAN YANG DIAKIBATKAN MOMENT
  - M = 551300,38kg.cm
  - Moment yang bekerja dengan sumbu rotasi atau Rivet No 9 juga pada sambungan antara plat badan balok konsol dengan profil penyambung ke gelagar kepala, dengan sumbu rotasi adalah Rivet No 5.
- Moment kapasitas yang mampu dipikul oleh seluruh Rivet = M

  $M = N_1.h_1 + N_2.h_2 + N_3.h_3 + N_4.h_4$ ..... (1)
- Melalui diagram tegangan dapat diperoleh rumusan

  $N_1 : N_2 : N_3 : N_4$, analog dengan $h_1 : h_2 : h_3 : h_4$ atau
  - $N_1 : N_4 = h_1 : h_4$

    $N_1, h_1 = N_4 \cdot h_4 \quad \rightarrow N_1 = \frac{h_1}{h_4} \times N_4$ .....(2)
  - $N_2 : N_4 = h_2 : h_4$

    $N_2, h_2 = N_4 \cdot h_4 \quad \rightarrow N_2 = \frac{h_2}{h_4} \times N_4$ .....(3)
  - $N_3 : N_4 = h_3 : h_4$

    $N_3, h_3 = N_4 \cdot h_3 \quad \rightarrow N_3 = \frac{h_3}{h_4} \times N_4$ .....(4)
  - $N_4 : N_4 = h_4 : h_4$

$\rightarrow N_4 = N_4$

- Substitusikan persamaan 2,3,4 dan 5 ke dalam persamaan 1

$$M = \left(h_1 / h_4 \times N_4\right) h_1 + \left(h_2 / h_4 \times N_4\right) h_2 + \left(h_3 / h_4 \times N_4\right) h_3 + h_4 \cdot N_4$$

$$N_4 \left(\frac{h_1^2}{h_4} + \frac{h_2^2}{h_4} + \frac{h_3^2}{h_4} + \frac{h_4^2}{h_4} \right) = \frac{N_4}{h_4} \left(h_1^2 + h_2^2 + h_3^2 + h_4^2 \right)$$

$$M = \frac{N_4}{h_4}, \ \sum h^2 atau$$

$$N_4 = \frac{M \times h_4}{\sum h^2} = \frac{551300,38}{\left(80^2 + 60^2 + 40^2 + 20^2\right)} = 918,83 kg \left(\leftarrow\right)$$

- N . Max terjadi pada Rivet No_1
- $N_1 = h_1/h_4 \ . \ N_4 = 80/20 \ . \ 918,83 = 3675,32kg.$
- $V_1 = 469,098kg \times 2 = 938,196kg.$
- $NK = 500kg \ (\leftarrow) \ . \rightarrow AN = Nk/N = 500/9 = 55,56kg$
- $N_{tot} = N_1 + AN = 3750,88kg$

  Resultan ® gaya normal tekan yang terjadi :

$$R = \sqrt{\left(N_{tot}\right)^2 + \left(V_1\right)^2} = 3847,03 kg$$

  $t_1 = 4cm \rightarrow 1,5d \leq t_4 \leq 2d \rightarrow 3cm \leq t_1 \leq 4cm$

  maka $\overline{\sigma}_{tp} = 1,6 \times \overline{\sigma} = 1,6 \times 1400 = 2240 \, {}^{kg}/_{cm^2}$

- Gaya tumpuan izin pada pelat badan = $t_1 = \overline{N}_{tp}$

$$\overline{N}_{tp} = \overline{\sigma}_{tp} \times = A \, \overline{\sigma}_{tp} \times t_1 \times d$$

$$= 2240 \times 4 \times 1 = 8960 kg > R = 3847,03 kg \quad \rightarrow \quad AMAN.$$

- Gaya geser Rivet (Double Shear) 12cm $\overline{N}_{gs}$

$$\overline{N}_{gs} = \overline{N}_2 = 2 \times A \times \overline{\tau}\ Rivet$$

$$= 2 \times \left(\tfrac{1}{4} \times \pi\ 2^2 \right) \times \left(0{,}8 \times 1400 \right)$$

$$= 7037{,}17\,kg > R = 3847{,}03\,kg \ldots\ldots\ldots\ldots\ AMAN$$

jadi konstruksi cukup aman dengan menggunakan Rivet ϕ 20mm.

- PEMERIKSAAN KEKUATAN PELAT BADAN BALOK KONSOL PADA SAMBUNGAN DI GALAGAR KEPALA

$Ix_{brutto} = 1/12 \cdot b \cdot h^3 = 1/12 \cdot 1\ 88^3$

$= 56789{,}33 cm^4$

$\Delta Ix = 9 \cdot 1/12 \cdot b \cdot d^3 + 2 \cdot (b \cdot d) \cdot \Sigma h^2$

$= 9.1/12.1.20^3 + 2(1.2,0).(40^2 + 30 + 20^2 + 10^2)$

$= 13207{,}986 cm^4$

$Ix_{netto} = Ix_{brutto} + \Delta Ix$

$= 43581{,}347 cm^4$

- $Wx_{netto} = \dfrac{Ix_{netto}}{\frac{1}{12} h} = 990{,}485 cm^3$

- $F_{brutto} = (b.h) - 9\ (b.d)$

$= (1.88) - 9\ (1.2,0) = 70 cm^4$

Kontrol :

$$\sigma_{tr} = \frac{NK}{FN} \pm \frac{Mg}{W_N} = \frac{500}{70} \pm \frac{551300{,}38}{990{,}485}$$

$$\sigma_{tr} = 7{,}1428 \pm 556{,}96$$

$$\sigma tr^{+} = 563{,}7\ {}^{kg}\!/_{cm^2}$$

$$\sigma tr^{-} = 549{,}82\ {}^{kg}\!/_{cm^2}$$

$$\tau = \frac{DAB}{Fn} = \frac{8443{,}77}{70} = 120{,}63\ {}^{kg}\!/_{cm^2}$$

$$\sigma_{ideal} = \sqrt{\sigma tr^2 + 3\tau^2} = \sqrt{(563{,}74)^2 + 3(120{,}63)^2} = 361{,}87\ {}^{kg}\!/_{cm^2} < \bar{\sigma} \rightarrow AMAN$$

- PERHITUNGAN SAMBUNGAN ANTARA TIANG SANDARAN DENGAN PELAT BADAN KONSOL

  V = 1046,70kg (lihat 2.5.2)

  M= 43995,6kg.cm

  - $N = \frac{M \cdot h}{\sum h^2} = \frac{43995{,}6 \times 12}{12^2} = 366{,}3kg$

  - $V_1 = \frac{V}{n} = \frac{1046{,}70}{3} = 348{,}9\,kg$

  - $AN = \frac{500}{3} = 166{,}67kg$

  - $N_{tot} = N + AN = 4015{,}2$ kg

  - $R = \sqrt{(N_{tot})^2 + V_1^2}$

    $R = \sqrt{(4015{,}2)^2 + (348{,}9)^2}$

    = 4030,33kg

- Gaya tumpu izin

  $\bar{N}tp \rightarrow t_1 > 2d \rightarrow \bar{\sigma}_{tp} = 2 \,.\, \bar{\sigma}$

$$\overline{N}\,tp = \overline{\sigma}_{tp} \cdot a = \overline{\sigma}_{tp} \cdot t_1 \cdot d$$

$= 2 \,.\, 1400 \,.\, 5 \,.\, 1 = 14000\text{kg} > \text{R} = 4030{,}33 \text{ kg}$……..AMAN!!!

- Gaya geser Rivet (Double Shear) izin = $\overline{N}qs$

$$\overline{N}qs = 2 \times A \times \overline{\tau}\, Rivet$$

$$= 2 \times \left(\tfrac{1}{4} \times \pi \times 2^2\right) \times \left(0{,}8 \times 1400\right)$$

$$= 7037{,}17\, kg > R = 4030{,}33\, kg \quad \ldots\ldots\ AMAN!!!!!$$

III. PERHITUNGAN IKATAN ANGIN

Direncanakan jembatan terbuka, sehingga dalam hal ini dibutuhkan sistem ikatan angin bawah

3.1 Analisa Muatan Angin

Tinggi gelagar kepala yang ekonomis ditaksir h =1/4 – 1/5 $\llcorner$ dimana $\llcorner$ = panjang batang teoritis jembatan :

$\llcorner$ 30M

$$h = \left(\tfrac{1}{5} \times 30\right) - \left(\tfrac{1}{4} \times 70\right) = 6m - 7{,}5m$$

diambil h = 6m.

$$\alpha = {}_{arc}\,.\tan \frac{6{,}0}{1{,}665} = 74^0 \times 28' \times 38{,}52''$$

- Tinggi gelagar melintang = 70 + 2 . 3 . 10 = 76cm
- Tebal lantai kendaraan = 18cm

- Tebal perkerasan rata – rata $\frac{\text{= 6cm}}{\text{t = 100cm}}$

- L_1 = 30m

- $L_2 = 30 - 2 \times \frac{t}{\tan \alpha} = 29{,}495\, m$

- $L_3 = 30 - 2 \times \frac{t+2}{\tan \alpha} = 27{,}889\, m$

- $L_4 = 30 - 2 \times \frac{h}{\tan \alpha} = 26{,}667\, m$

INTENSITAS TEKANAN ANGIN

- Bidang $A_1 \rightarrow W_1$ = 100 % $\{\frac{1}{2}(L_1 + L_2) \times t\}$ x 100 = 2972,25kg
- Bidang $A_2 \rightarrow W_2$ = 100 % $\{\frac{1}{2}(L_2 + L_3) \times 2\}$ x 100 = 4261,15kg
- Bidang $A_3 \rightarrow W_3$ = 100 % $\{\frac{1}{2}(L_3 + L_4) \times 3\}$ x 100 = 2455,02kg

$\Sigma MN = 0$

$W_3 . 4{,}5 + W_2 . 1{,}5 + W_1 . 0{,}5 - Akn . 7 = 0$

$$Akn = \frac{2455{,}02 \cdot 4{,}5 + 4261{,}15 \cdot 4{,}5 + 2972{,}25 \cdot 0{,}5}{7} = 2703{,}63kg$$

3.1.1 Muatan angin yang bekerja pada gelagar induk :

Jumlah medan = 9medan

Gaya angin vertikal yang bekerja pada satu titik kumpul bagian atas gelagar induk

$$W = {}^{AKN}\!/_{M} = \frac{2703{,}63}{9} = 300{,}40\, kg$$

$$\frac{W}{2} = \frac{300,4}{2} = 150,2\,kg$$

3.1.2 Muatan angin yang bekerja pada ikatan angin bawah :

Jumlah medan = 9

Σh = 0

$W_A + W_B - W_3 - W_2 - W_1 = 0$

$W_B = W3 + W2 + W1 - Wa = \rightarrow W_A = W_A.6 - W_3.4,5 + W_2.1,5 + W_1.0,5 = 0$

$= 9688,42 - 3154,24 \qquad W_A = 3154,24kg$

$= 6534,18kg$

$$W_B\,tengah = \frac{6534,18}{9} = 726\,kg \quad , \quad \frac{W_B}{2} = 363\,kg$$

INVESTASI GAYA DALAM BATANG – IKATAN ANGIN

- BATANG TEPI ATAS (A)

A_1 = - 1379,40	Dan	0	Diambil = - 1379,40kg
A_2 = - 1379,40	Dan	2468,40	Diambil = - 2468,40kg
A_3 = - 3121,80	Dan	2468,40	Diambil = - 3121,80kg
A_4 = - 3121,80	Dan	3484,80	Diambil = - 3484,80kg
A_5 = - 3121,80	Dan	3484,80	Diambil = - 3484,80kg

- BATANG TEPI BAWAH

B_1 = 0	Dan	1452	Diambil = 1452kg
B_2 = 2395,80	Dan	1452	Diambil = 2395,8kg
B_3 = 2395,80	Dan	3121,80	Diambil = 3121,8kg
B_4 = 3484,80	Dan	3121,80	Diambil = 3484,8kg
B_5 = 3484,80	Dan	3121,80	Diambil = 3484,8kg

- BATANG TEPI VERTIKAL (V)

$V_1 = 3630$	Dan	3630	Diambil = 3630kg
$V_2 = 726$	Dan	0	Diambil = 726kg
$V_3 = 0$	Dan	2178	Diambil = 2178kg
$V_4 = 726$	Dan	1452	Diambil = 1452kg
$V_5 = 0$	Dan	1452	Diambil = 1452kg

- BATANG DIAGONAL (D)

D_1 = - 3194,4kg	D_6	3194,4kg
D_2 = 2395,8kg	D_7	- 2468,4kg
D_3 = - 1597,2kg	D_8	1597,2kg
D_4 = 871,2kg	D_9	- 871,2kg
D_5 = - 871,2kg	D_{10}	871,2kg

- BATANG VERTIKAL
  - Pmax = 3194,4kg = 3,1944 Ton
  - LK = 7,00m = 700cm
  - Imin = 1,69 . P . LK^2 = 1,69 . 3,1944 . 7^2 = 264,528cm^4
  - Diambil Profil ⌊⌐ 60.60.8 dimana

    F_1 = 9,03cm^2 ; I ε_1 = 46,10cm^4

    iε_1 = 2,26cm;

    i η_1 = 1,16cm; I η_1 = 12,1cm^4

    digunakan pelat kopel tebal = d = 8mm

    V_1 = 2,50cm

- Data batang majemuk

F = 2 . F_1 = 18,06cm^2

I ξ = 2 . I ξ_1 = 92,2cm^4

iξ = 2 . I . ξ_1 = 4,25cm

$$I\eta = 2\left\{12{,}1 + 9{,}03 \times \left(2{,}50 + \tfrac{1}{2}\sqrt{2{,}08}\right)^2\right\}$$

$$i\eta = \sqrt{\frac{I\eta}{F}} = \sqrt{\frac{194}{18{,}06}} = 3{,}28\,cm$$

$$\lambda\eta = \frac{LK}{i\eta} = \frac{700}{3{,}28} = 213{,}414 > 100 \rightarrow EULER$$

λη = 213,414

$$\lambda q = \pi\sqrt{\frac{E}{0{,}7\cdot\sigma\gamma}} = \pi\cdot\sqrt{\frac{2{,}1\cdot 10^6}{0{,}7\cdot 2400}} = 111$$

$$\lambda s = \frac{\lambda\eta}{\lambda q} = 1{,}923 > \rightarrow \omega = 2{,}881\cdot\lambda s^2$$

$$< 1 \rightarrow \omega = \frac{1{,}41}{1{,}593 - \lambda s}$$

w = 2,381 $(1{,}923)^2$ = 8,805

$$\overline{P} = \frac{F\cdot\overline{\sigma}}{w} = \frac{18{,}06\cdot 1600}{8{,}805} = 3281{,}77\,kg > P = 3194\,kg \rightarrow OKEY!!!!$$

- Pelat Kopel

λη = 213,414

- Krohn $\rightarrow \overline{P} = \frac{280}{280 - \lambda\eta} \cdot \frac{F_1}{F} \cdot P$

- $\overline{P} = \frac{140}{240 - 213{,}414} \cdot 3194{,}4 = 6716{,}37\, kg$

- $\overline{\sigma}_{k1} = \frac{\overline{P}}{F_1} = \frac{6716{,}37}{9{,}03} = 743{,}78\, {}^{kg}\!/_{cm^2}$

- $\lambda_{batas\eta} = \frac{1746 - \overline{\sigma}_{k1}}{11{,}54} = \frac{1746 - 743{,}78}{11{,}54} = 86{,}85$

- Jumlah medan = $m = \frac{Lk}{\lambda_{batas\,\eta 1}} = \frac{700}{86{,}85} = 8{,}05 \approx 9\, buah$

- Lki sebenarnya = $\frac{700}{9} = 77{,}78\, cm$

- Jumlah pelat kopel = m + 1 = 10buah

- D pelat kopel = D max = 0,02 P = 0,02 . 3194,4 = 64kg

- Tebal pelat kopel di ambil = d = 0,8cm

- $\frac{Ik}{h} > 10\, \frac{Ii}{L_4} \quad \cdot \quad \tau < \overline{\tau} \quad \cdot \; \overline{\lambda} \leq 50$

- $\lambda_1 = \frac{L_{k1}}{i_{\min}} = \frac{77{,}78}{3{,}28} = 23{,}71 < \overline{\lambda} \;\rightarrow\; OKEY!!!!!$

- $i\gamma = \sqrt{i_{0\gamma} + \left(\frac{1}{2} \cdot h_A\right)^2}$

  $= \sqrt{2{,}26 + \left(\frac{1}{2} \cdot h_A\right)^2}$ .....(1)

- $\lambda\gamma_1 = \sqrt{\lambda\gamma^2 + \frac{M}{2} \cdot \lambda_1^2} \leq \lambda\eta = 213{,}414$

  $= \sqrt{\lambda\gamma^2 + \frac{2}{2}(23{,}71)^2} < 213{,}414$

$$213{,}44 = \sqrt{\lambda\gamma^{\,2} + (23{,}71)^2}$$

$$213{,}44 \;=\; \lambda\gamma^{\,2} \;+\; (23{,}71)^2$$

$$\lambda\gamma^{2} = (213{,}44)^2 - (23{,}71)^2$$

$$\lambda\gamma^{\,2} = 44994{,}47$$

$$\lambda\gamma \;<\; 212{,}12$$

$$\lambda\gamma = \frac{L\gamma}{i\gamma} = \frac{700}{i\gamma} \le 212{,}12$$

$$i\gamma \;\ge\; 3{,}3 \;\ldots\ldots\ldots\ldots\ldots..(2)$$

- Substitusikan pers (2) ke (1)

$$\sqrt{2{,}26 + \left(\tfrac{1}{2} \cdot h_A\right)^2} \;\ge\; 3{,}3$$

$$hA \;\ge\; 4{,}33 \quad \text{diambil} \quad hA = 5cm$$

- DIMENSI PELAT KOPEL

Didasarkan atas kekuatan pelat kopel

$$Ik \ge 10 \,.\, h_A \,.\, I\eta / L_1$$

$$Ik = \tfrac{1}{12} \cdot t \cdot h^3 \ge 10\; h \cdot I\eta / L_1$$

$$h^3 \ge 10 \cdot 5 \cdot \frac{8 \cdot 213{,}414}{60 \cdot 8} = 178\,cm^3$$

$$h \;\ge\; 5{,}63cm$$

Diambil pelat kopel dengan h = 15cm, t = 0,8cm

- PERHITUNGAN RIVET

Digunakan ϕ 16mm = 1,6 cm

e_1 = 2 . d = 1,6 x 2 = 3,2cm

$hA = 3{,}5 + \frac{5}{2} \cdot 2 = 8{,}5\,cm$

D.Max = 64kg

L.max =

$$\frac{D\max \cdot Lk}{h} = \frac{64 \cdot 77{,}78}{5} = 995{,}58\,kg$$

$$N\max = \frac{L\max \cdot hn}{e} = \frac{995{,}58 \cdot 8{,}5}{5} = 1692{,}49kg$$

$$R = \tfrac{1}{4} \cdot \sqrt{L\max^2 + N\max} = 490{,}9\,kg$$

I pelat kopel = $\tfrac{1}{12} \cdot 0{,}8 \cdot 11{,}4^3 = 98{,}77cm^4$

I lubang = $2\left(\tfrac{1}{12} \cdot 0{,}8 \cdot 1{,}6^3 + 0{,}8 \cdot 16 \cdot 2{,}5^2\right) = 16{,}55cm^4$

I netto = 82,22 cm^4

- $WN = \frac{IN}{\gamma/2} = \frac{2 \cdot I_N}{\gamma} = \frac{2 \cdot 82{,}22}{11{,}4} = 14{,}42\,cm^3$

- $\sigma = \frac{M}{Wn} = \frac{N/4 \cdot e}{Wn} = \frac{423{,}12 \cdot 6}{14{,}42} = 176{,}07\,kg/cm^2$

- $\tau = R/F\,Rivet = \frac{490{,}90}{\frac{1}{4} \cdot \pi \cdot 1{,}6^2} = 244{,}28\,kg/cm^2$

- $\sigma_{\uparrow} = \tfrac{1}{2} \cdot \sigma + \tfrac{1}{2}\sqrt{\sigma^2 + 4\tau^2} = 347{,}695\,KG/CM^2 < 0{,}6\,\bar{\sigma}\ okey$!!!

- BATANG DIAGONAL

  - P max = 3194,4kg

  - $Lk = \sqrt{3{,}333^2 + 7^2} = 7{,}753m$

  - Direncanakan ⌐¬ 60.60.8

    $F_1 = 9{,}03cm^2$; $I\,\xi_1 = 46{,}10cm^4$

    $i\xi_1 = 2{,}26cm$; $i\xi_1 = 1{,}16cm$ $I\eta_1 = 12{,}1cm^4$

  - d pelat kopel = 0,8cm

    $I\eta = 194\ cm^4$

    $F = 18{,}06cm^2$

    $$I\,\eta = \sqrt{\frac{I\eta}{F}} = 3{,}28cm$$

    $$\lambda\,\eta = \frac{Lk}{i\,\eta} = \frac{7{,}753}{3{,}28} = 236{,}4$$

    $\lambda q = 111$

    $$\lambda\,s = \frac{\lambda\,\eta}{\lambda\,q} = \frac{236{,}4}{111} = 2{,}13\ >\ 1` \rightarrow w = 2{,}381 \cdot \lambda\,s^2$$

    $w = 2{,}381 .\ (2{,}13)^2 = 8{,}80$

    $$\sigma = \frac{P \cdot w}{F} = \frac{3194{,}4 \cdot 8{,}80}{18{,}06} = 1556{,}52\ {}^{kg}\!/_{cm^2} < \overline{\sigma} = 1600\ {}^{kg}\!/_{cm^2} \rightarrow OKEY\ !!!!!$$

    Pmax = 3194,4 kg

    $F = 18{,}06\ cm^2$

    $F_N = 0{,}8 \times 18{,}06 = 14{,}45cm^2$

    $$\sigma = \frac{P}{FN} = 221{,}10\ {}^{kg}\!/_{cm^2} < \overline{\sigma} = 1600\ {}^{kg}\!/_{cm^2}\ \ OKEY$$

IV. PERHITUNGAN GELAGAR KEPALA/INDUK

Intensitas beban yang diperhitungkan untuk perencanaan dan perhitungan gelagar kepala :

- berat sendiri jembatan
- muatan angin
- beban jalur (D Loading)

4.1 Analisa beban dan gaya dalam batang

4.1.1 Berat sendiri jembatan

Dalam menghitung berat sendiri jembatan ini, perlu diadakan asumsi perhitungan, mengingat belum adanya rencana yang pasti yang akan dipergunakan sebagai pembentuk rangka batang gelagar induk. Sejalan dengan kondisi di atas maka dalam tugas perencanaan ini digunakan metode Prof.Ir.LOA.WAN Kianis dalam membuat asumsi benar total jembatan.

- Berat Sendiri gelagar kepala (QA)

  Lebar jalur kendaraan = 7,00m

  b = 7 + 2 . 1,1 = 9,2m

  Lebar trotoir = 1,10m

- Panjang teoritis jembatan = 30m = L

  QA = (20 + 3L) . L . b

  = (20 + 3.30) . 30 . 9,2 = 30,360kg

- Berat sendiri konstruksi lain – lain nya

  QB = 10 . b . 9,2 . 30 . 9,2 = 25,392kg

- Berat sendiri kendaraan (QC_1)

  qbs = 650 $^{kg}/_{m^2}$

$Q.C_1 = 650 . 30 . 9,2 = 179400kg$

- Berat sendiri lantai trotoir (QC_2)

  $q_{BS} = 900kg/cm^2$

  $QC_1 = 900 . 30 . 2 . 1,1 = 59400kg$

- Berat Sendiri Sandaran (QD)

  $QD = 2 . (3 . 40) . 30 = 7200kg$

- Total Berat sendiri = $Q = QA + QB + QC_1 + QC_2 + QD = 310752kg$.

- Beban pada tiap gelagar kepala = $\frac{Q}{2} = \frac{310752}{2} = 155376\,kg$

- Jumlah titik kumpul dibagian atas gelombang kapala = n = 9 buah

- Beban untuk tiap titik kumpul = W

$$W = \frac{155376}{9} = 17264\,kg$$

$$RA = RB = \frac{9W}{2} = 4,5W = 4,5x17264 = 77688\,KG$$

Selanjutnya untuk menganalisa vektor gaya dalam batang, digunakan metode cremona

Batang Atas dan Bawah	Batang Diagonal
$A_1 = A_8 =$ - 39707,2 kg	$D_1 = D_{18} =$ - 80277,6 kg
$A_2 = A_7 =$ - 69919,2 kg	$D_2 = D_{17} =$ 63013,6 kg
$A_3 = A_6 =$ - 89772,8 kg	$D_3 = D_{16} =$ - 63013,6 kg
$A_4 = A_5 =$ - 100131,2 kg	$D_4 = D_{15} =$ 45749,6 kg
$B_1 = B_9 =$ 22443,2 kg	$D_5 = D_{14} =$ - 45749,6 kg
$B_2 = B_8 =$ 35391,2 kg	$D_6 = D_{13} =$ 26759,2 kg

$B_3 = B_7 =$ 25032,8 kg	$D_7 = D_{12} =$ - 26759,2 kg
$B_4 = B_6 =$ 15537,6 kg	$D_8 = D_{11} =$ 8632,0 kg
$B_5 = B_5 =$ 5179,2 kg	$D_9 = D_{10} =$ - 8632,0 kg

4.1.2 Beban Angin

- Pengaruh angin vertikal
- Pengaruh angin horizontal

- Angin vertikal

lihat 3.1. pada pada prinsipnya pengaruh angin V. adalah merupakan fungsi berat sendiri jembatan sehingga dalam hal ini diperoleh koefisien pengaruh terhadap gaya dalam batang akibat berat sendiri jembatan

W3 = 2455,02 kg

W2 = 4261,15 kg RAW = $\frac{L}{2} = W3x4{,}5 + W2x1{,}5 + W1x0{,}5$

W1 = 2972,25 kg RAW = $\frac{30}{2} = 11047{,}59 + 6391{,}752 + 1486{,}125$

RAW = 15 = 18925,44 $\rightarrow$ 1261,70 kg

- Reaksi akibat beban berat sendiri konstanta jembatan = RBS

RBS = 77688 kg……..(4.11)

G = $\frac{RAW}{RBS} = \frac{1261{,}70}{77688} = 0{,}0162$

Selanjutnya nilai gaya batang akibat angin vertikal pada masing-masing batang yaitu = gaya dalam batang akibat berat sendiri x C

$A_1 = A_8 =$ - 643,26 kg	$D_1 = D_{18} =$ - 1300,5 kg
$A_2 = A_7 =$ - 1132,69 kg	$D_2 = D_{17} =$ 1020,82 kg
$A_3 = A_6 =$ - 1454,32 kg	$D_3 = D_{16} =$ - 1020,82 kg
$A_4 = A_5 =$ - 1622,12 kg	$D_4 = D_{15} =$ 741,14 kg
$B_1 = B_9 =$ 363,58 kg	$D_5 = D_{14} =$ - 741,14 kg
$B_2 = B_8 =$ 573,34 kg	$D_6 = D_{13} =$ 433,50 kg
$B_3 = B_7 =$ 405,53 kg	$D_7 = D_{12} =$ - 433,50 kg
$B_4 = B_6 =$ 251,71 kg	$D_8 = D_{11} =$ 139,84 kg
$B_5 = B_5 =$ 84,0 kg	$D_9 = D_{10} =$ - 139,84 kg

- Angin horizontal

lihat 3.1.2 dan 3.2.1 diperoleh dari hasil analisa gaya batang ikatan angin bawah yang memberikan kontribusi gaya dalam batang tepi bawah gelagar induk

4.1.3 Beban Jalur (D. Loading)

- Melalui akibat beban jalur dinamis 2.1 diperoleh :

qPR = 3,675 tan/m^1

P garis = 3,5/2,75 x 12 x 1,25 = 19,09 ton

- Melalui 1.4 diperoleh beban bergerak pada trotoir = qLL

qLL = 0,55 ton/m^1

- Beban yang bekerja pada satu gelagar induk :

q = 3,675 + 0,55 = 4,225 ton/m^1 = 4225 kg/m^1

P = 19,09 ton = 19090 kg

- Selanjutnya guna mendapatkan vektor gaya dalam batang akibat beban bergerak, digunakan analisa dengan Metode Garis Pengaruh

- Analisa Garis pengaruh

- α = arc tan 6/1,6665 = 74^0.28'.38,52"

- d = 3,333 sin α = 3,2114 m

- L diagonal = 6 . 1/ sin α = 6,22273 m

- H = 6,00 m

* Potongan I – I

GP . D1

P berada dikiri potongan $\rightarrow 0 \leq X \leq 3{,}333$

$\Sigma V = 0 \rightarrow RB - D1 \sin \alpha = 0$

$D1 = RB \cdot 1/\sin \alpha = 1{,}0379 \cdot RB$

$RB = \frac{\lambda}{L} = 0{,}1111$

P berada dikanan potongan $\rightarrow 3{,}333 \leq X \leq 30$

$\Sigma V = 0 \rightarrow RA + D1 \sin \alpha = 0 \quad \rightarrow RA = \left(\frac{L-\lambda}{L}\right) p = 0{,}8889x1$

$D1 = - 1{,}0379 \cdot RA$

$X = 3{,}333 \rightarrow D1 = - 1{,}0379 \cdot 0{,}8889 = - 0{,}9226$

$X = 30 \text{ m} \rightarrow D1 = 0$

GP . B1

* Pdi kiri potongan $\rightarrow 0 \leq X \leq 3{,}333$

$\Sigma MKB1 = 0 \rightarrow - RB \left(30 - \frac{3{,}333}{2}\right) + B1 \times h = 0$

$$B1 = \frac{RB}{n}\left(30 - \frac{3{,}333}{2}\right) = \frac{RB}{6}\left(30 - \frac{3{,}333}{2}\right) = 4{,}722.RB$$

$X = 0 \rightarrow B1 = 0 : X = 3{,}333 \rightarrow B1 = 0{,}5246$

* P berada dikanan potongan $\rightarrow 3{,}333 \leq X \leq 30$

$\Sigma MKB1 = 0 \rightarrow RA\left(\frac{3{,}333}{2}\right) - B1 \times h = 0$

$$B1 = \frac{RA}{n}\left(\frac{3{,}333}{2}\right) = \frac{RAx1{,}6665}{6} = 0{,}2778.$$

$$X = 3{,}333 \rightarrow B1 = 0{,}2778\left(\frac{30 - 3{,}333}{30}\right) = 0{,}2469.$$

$X = 70 \rightarrow B1 = 0$

Tan α =3,6

Sin α = 0,9635

$\alpha = 74^0.28'.38{,}52"$

Potongan II – II

GP . D2

P berada dikiri potongan $\rightarrow 0 \leq X \leq 3{,}333$

$\Sigma V = 0 \rightarrow RB + D2 \sin\alpha = 0$

$D2 = -1{,}0379 . RB \rightarrow RB = 0{,}111$

$X = 0 \rightarrow D2 = 0$; $X = 3{,}333 \rightarrow D2 = 0{,}1152$

P berada dikanan potongan $\rightarrow 5 \leq X \leq 30$

$\Sigma V = 0 \rightarrow RA - D2 \sin\alpha = 0 \rightarrow RA = 0{,}8889$

D2 = 1,0379 . RA

X = 3,333 $\rightarrow$ D2 = 1,0379 . 0,8889 = 0,9226

X = 30 m $\rightarrow$ D2 = 0

- Gambar Potongan A_1
  - P berada di kiri potongan $0 \leq X \leq 3,333 \rightarrow RB = 0,1111$

    $\sum M_{KA1} = \rightarrow \quad -RB(30-3,333) - A_1 \cdot 6 = 0$

    $$A_1 = -\left(\frac{26,667}{6}\right) \cdot RB = -4,4445$$

    $X = 0 \rightarrow A_1 = 0$

    $X = 3.333 \rightarrow A_1 = -0,4938$

  - P berada di kanan potongan $3,333 \leq X \leq 30$

    $\sum M_{KA1} = 0 \rightarrow \quad RA \cdot 3,333 + A_1 \cdot 6 = 0$

    $$A_1 = -\frac{3,333}{6} \cdot RA \rightarrow RA = 0,8889$$

    $X = 3,333 \rightarrow \quad A_1 = \left(\frac{3,333}{6}\right) \cdot 0,8889 = -0,4938$

    $X = 30 \rightarrow \quad A_1 = 0$

POTONGAN III – III

Gambar Potongan D_3

P berada di kiri potongan $0 \leq x \leq 3,333$

$\sum V = 0 \rightarrow RB + D_3 \sin\alpha = 0$

$D_3 = 1,0379 \cdot RB \rightarrow RB = 0,1151$

P berada di kanan potongan $6,6667 \le x \le 30$

$\sum V = 0 \rightarrow RA + D_3 \sin\alpha = 0$

$D_3 = - 1,0379 \,.\, RA$

$X = 6,6667 \rightarrow D_3 = - 1,0379 \,.\, 0,7778 = -0,807$

$X = 30 \rightarrow D_3 = 0$

- Gambar Potongan B_2
  - P dikiri potongan $0 \le x \le 3,333$

$$\sum M_{KB2} = 0 \rightarrow -RB \cdot \left(30 - 6,666 + \frac{3,333}{2} \right) + RB \cdot 6 = 0$$

$$B_2 = \frac{21.6675}{6} \cdot RB = 3,6113\, RB$$

$X = 0 \rightarrow B_2 = 0$

$3,333 \rightarrow B_2 = 3,6113 \,.\, 0,1111 = 0,4012$

  - P berada di kanan potongan $6,666 \le x \le 30$

$$\sum M_{KB2} = 0 \rightarrow RA \cdot \left(3,333 + \frac{3,333}{2} \right) - B_2 \cdot 6 = 0$$

$$B_2 = \frac{4,3335}{6} \cdot RA = 0,8333 \cdot RA \rightarrow RA = \left(\frac{L - 2X}{L} \right) \cdot P$$

$X = 6,666 \rightarrow B_2 = 0,8333 \,.\, 0,7778 = 0,648$

$X = 30 \rightarrow B_2 = 0$

POTONGAN IV – IV

Garis potongan D_4

P berada di kanan potongan $0 \le x \le 3,333$

$\sum V = 0 \rightarrow \quad RB + D_4 \sin\alpha = 0$

$D_4 = 1,0379\ RB$

$X = 0 \rightarrow \quad D_4 = 0$

$X = 3,333 \rightarrow \quad D_4 = 0$

- P berada di kiri potongan $0 \le x \le 3{,}333$

  $\sum M_{KA2} = 0 \rightarrow$ - RB . (30 – 6,666) . A_2 . 6 = 0

  $$A_2 = \frac{23{,}334}{6} \cdot RB = -3{,}889\,RB$$

  $X = 0 \rightarrow A_2 = 0$

  $X = 3{,}333 \rightarrow A_2 = -3{,}889 \,.\, 0{,}1111 = -0{,}431$

- P berada di kanan potongan $6{,}666 \le x \le 30$

  $\sum M = 0 \rightarrow$ RA . 6,666 + A_2 . 6 = 0

  $A_2 = -1{,}111RA$

  $X = 6{,}666 \rightarrow A_2 = -1{,}111 \,.\, 0{,}7778 = -0{,}8641$

  $X = 30 \rightarrow A_2 = 0$

POTONGAN V – V

- Gambar Potongan D_5

  - P berada di kiri potongan $0 \le x \le 6{,}666$

    $\sum V = 0 \rightarrow RB - D_5 \,.\, \sin\alpha = 0$

    $$D_5 = 1{,}0379 \,.\, RB \rightarrow RB = \left(\frac{L - 7\lambda}{L}\right) \cdot P = 0{,}2223$$

    $X = 0 \rightarrow D_5 = 0$

    $X = 6{,}666 + D_5 = 1{,}0379 \,.\, 0{,}2223 = 0{,}2370$

  - P berada di kanan potongan, $9{,}999 \le x \le 30$

    $\sum V = 0 \rightarrow RA + D_5 \,.\, \sin\alpha = 0$

    $$D_5 = -\,1{,}0379 \,.\, RA \rightarrow RA = \left(\frac{L - 3\lambda}{L}\right) \cdot P = 0{,}6667$$

    $X = 9{,}999 \rightarrow D_5 = -\,1{,}0379 \,.\, 0{,}6667 = -0{,}6919$

    $X = 30 \rightarrow D_5 = 0$

- Gambar Potongan D_3
  - P berada di kiri potongan $0 \le x \le 6{,}666$

$$\sum M_{KB3} = 0 \rightarrow -RB\left(30 - 9{,}999 + \frac{3{,}333}{2} + B_3 \cdot 6 = 0\right)$$

$B_3 = 3{,}056\ RB \rightarrow RB = 0{,}2223$

$X = 9{,}999 \rightarrow B_3 = 0$

$X = 30 \rightarrow 3{,}056 \,.\, 0{,}2223 = 0{,}6793$

  - P berada di kanan potongan, $9{,}999 \le x \le 30$

$\sum M_{KB3} = 0 \rightarrow RA \,.\, 8{,}3325 - B_3 \,.\, 6 = 0$

$B_3 = 1{,}389 \,.\, RA \rightarrow RA = 0{,}6667$

$X = 9{,}999 \rightarrow B_3 = 1{,}389 \,.\, 0{,}6667 = 0{,}9260$

$X = 30 \quad B_3 = 0$

POTONGAN VI – VI

- Gambar Potongan D_6

  - P berada di kiri potongan, $0 \le x \le 6{,}666$

$\sum V = 0 \rightarrow RB + D_6 \,.\, \sin\alpha = 0$

$D_6 = -1{,}0379 \,.\, RB \rightarrow RB = 0{,}2223$

$X = 0 \rightarrow D_6 = 0$

$X = 6{,}666 \rightarrow D_6 = -1{,}0379 \,.\, 0{,}2223 = -0{,}2307$

  - P berada di kanan potongan, $9{,}999 \le x \le 30$

$\sum V = 0 \rightarrow RA - D6 \,.\, \sin\alpha = 0$

$D_6 = 1{,}0379 \,.\, RA \rightarrow RA = 0{,}6667$

$X = 9{,}999 \rightarrow D_6 = 1{,}0379 \,.\, 0{,}6667 = 0{,}6919$

$X = 30 \rightarrow D_6 = 0$

- Gambar Potongan A_3

  - P berada di kiri potongan, $0 \le x \le 6{,}666$

    $\sum M_{KA3} = 0 \rightarrow$ $-RB \,.\, (30 - 9{,}999) - A_3 \,.\, 6 = 0$

    $A_3 = -\,3{,}3335 \,.\, RB \rightarrow RB = 0{,}2223$

    $X = 0 \rightarrow A_3 = 0$

    $X = 6{,}666 \rightarrow A_3 = -\,3{,}3335 \,.\, 0{,}2223 = -\,0{,}7410$

  - P berada di kanan potongan $9{,}999 \le x \le 30$

    $\sum M_{KA3} = 0 \rightarrow$ $RA \,.\, 9{,}999 + A_3 \,.\, 6 = 0$

    $$A_3 = -\frac{9{,}999}{6} \cdot RA = -1{,}6665\, RA$$

    $X = 0 \rightarrow A_3 = -\,1{,}6665 \,.\, 0{,}6667 = -\,1{,}1110$

    $X = 30 \rightarrow A_3 = 0$

POTONGAN VII – VII

- Gambar Potongan D_7

  - P berada di kiri potongan, $0 \le x \le 9{,}999$

    $\sum V = 0 \rightarrow$ $RB - D_7 \,.\, \sin\alpha = 0$

    $D_7 = 1{,}0379 \,.\, RB \rightarrow$ $$RB\left(\frac{L - 6\lambda}{L}\right) \cdot P = 0{,}333$$

    $X = 0 \rightarrow D_7 = 0$

    $X = 9{,}999 \rightarrow D_7 = 1{,}0379 \,.\, 0{,}333 = 0{,}3459$

  - P berada di kanan potongan, $0 \le x \le 30$

    $\sum V = 0 \rightarrow$ $RA + D_7 \,.\, \sin\alpha = 0$

    $D_7 = -\,1{,}0379 \,.\, RA \rightarrow$ $$\left(\frac{L - 4\lambda}{L}\right) \cdot P = 0{,}5556$$

    $X = 0 \rightarrow D_7 = -\,1{,}0379 \,.\, 0{,}5556 = -\,0{,}5766$

    $X = 30 \rightarrow D_7 = 0$

- Gambar Potongan B_4

  - P berada di kiri potongan, $0 \le x \le 9{,}999$

    $\sum V = 0 \rightarrow \quad -RB \cdot \left(30 - 13{,}332 + \frac{3{,}333}{2}\right) + B_4 \cdot 6 = 0$

    $B_4 = 2{,}5 \,.\, RB$

    $X = 0 \rightarrow B_4 = 0$

    $X = 9{,}999 \rightarrow B_4 = 2{,}5 \,.\, 0{,}3333 = 0{,}8332$

  - P berada di kanan potongan, $13{,}332 \le x \le 30$

    $\sum V = 0 \rightarrow RA\ (11{,}6655) - B_4 \,.6 = 0$

    $B_4 = 1{,}944 \,.\, RA$

    $X = 13{,}332 \rightarrow B_4 = 1{,}944 \,.\, 0{,}5556 = 1{,}080$

    $X = 30 \quad \rightarrow B_4\ 0$

POTONGAN VIII – VIII

- Gambar Potongan D_8

  - P berada di kiri potongan, $0 \le x \le 9{,}999$

    $\sum V = 0 \rightarrow \quad RB + D_8 \,.\, \sin\alpha = 0$

    $D_8 = -1{,}0379 \,.\, RB$

    $X = 0 \rightarrow D_8 = 0$

    $X = 9{,}999 \rightarrow D_8 - 1{,}0379 \,.\, 0{,}3333 = 0{,}3459$

  - P berada di kanan potongan

    $\sum V = 0 \rightarrow \quad RA - D_8 \,.\, \sin\alpha = 0$

    $D_8 = 1{,}0379 \,.\, RA \rightarrow 0{,}5766$

    $X = 13{,}332 \rightarrow D_8 = 1{,}0379 \,.\, 0{,}5766 = 0{,}5766$

    $X = 30 \quad \rightarrow D_8 = 0$

- Gambar Potongan A_4

  - P berada di kiri potongan, $0 \le x \le 9{,}999$

    $\sum M_{KA4} = 0 \rightarrow \quad RB \,.\, 16{,}668 - A_4 \,.\, 6 = 0$

    $A_4 = -\,2{,}778 \,.\, RB$

    $X = 0 \rightarrow A_4 = 0$

    $X = 9{,}999 \rightarrow A_4 = -\,2{,}778 \,.\, 0{,}3333 = -\,0{,}9259$

  - P berada dikanan potongan, $13{,}332 \le x \le 30$

    $\sum M_{KA4} = 0 \rightarrow \quad RA \,.\, 13{,}332 + A_4 \,.\, 6 = 0$

    $A_4 = -\,2{,}222 \,.\, RA$

    $X = 13{,}332 \rightarrow A_4 = -\,2{,}222 \,.\, 0{,}5766 = -\,1{,}2812$

    $X = 30 \rightarrow \quad A_4 = 0$

POTONGAN IX – IX

- Gambar Potongan D_9

  - P berada di kiri potongan, $0 \le x \le 13{,}332$

    $\sum V = 0 \rightarrow \quad B - D_9 \,.\, \sin\alpha = 0$

    $D_9 = 1{,}0379 \,.\, RB \rightarrow RB = \left(\frac{L - 5\lambda}{L}\right) \cdot P = 0{,}4445$

    $X = 0 \rightarrow D_9 = 0$

    $X = 13{,}332 \rightarrow D_9 = 1{,}0379 \,.\, 0{,}4444 = 0{,}4613$

  - P berada di kanan potongan, $16{,}665 \le x \le 30$

    $\sum V = 0 \rightarrow \quad RA + D_9 \,.\, \sin\alpha = 0$

    $D_9 = -\,1{,}0379 \,.\, RA \rightarrow RA = \left(\frac{L - 4{,}5\lambda}{L}\right) \cdot P = 0{,}4445$

    $X = 16{,}665 \rightarrow D_9 = -\,1{,}0379 \,.\, 0{,}5 = -0{,}5189$

$X = 30 \rightarrow D_9 = 0$

- Gambar Potongan B_5
  - P berada di kiri potongan, $0 \le x \le 13{,}332$

$$\sum M_{KB5} = 0 \rightarrow \quad -RB \cdot \left(30 - 16{,}665 + \frac{3{,}333}{2}\right) + B_5 \cdot 6 = 0$$

$$B_5 = 1{,}945 \,.\, RB$$

$$X = 0 \rightarrow B_5 = 0$$

$$X = 13{,}332 \rightarrow B_5 = 1{,}945 \,.\, 0{,}4445 = 0{,}8645$$

  - P berada di kanan potongan

$$\sum M_{KB5} = 0 \rightarrow RA \,.\, 14{,}9985 - B_5 \,.6 = 0$$

$$B_5 = 2{,}5 \,.\, RA$$

$$X = 16{,}665 \rightarrow B_5 = 2{,}5 \,.\, 0{,}5 = 1{,}25$$

$$X = 30 \rightarrow B_5 = 0$$

4.2 ANALISA DIMENSI PROFIL DAN PELAT KOPEL GELAGAR INDUK

4.2.1 Batang Tepi Atas

$\overline{P}\ Max = -210.892{,}17\ kg$

$\overline{P}\ Min = \ -39.707{,}20\ kg$

$LK = 333{,}3\ cm$

Dicoba menggunakan profil separuh terbuka sebagai berikut :

F = 168cm

G = 132kg/m’

ix = 12,1cm

iy = 12,8cm $\rightarrow$ ıy $\qquad$ ⊏ 30 = 2,9cm

Ix = 24.640cm^4

Iy = 27.370cm^4

Wx = 1.250cm^3

D = 10mm

Kontrol :

$$X = \left|\frac{\bar{\sigma}_{\min}}{\bar{\sigma}_{\max}}\right| = \frac{P\min/F}{P\max/F} = \frac{-39707{,}12/168}{-210892{,}17/168}$$

$$= \frac{236{,}35}{1255{,}31} = 0{,}2 \quad \text{untuk } \xi = 0{,}7$$

$$\bar{\sigma} = 2533\ {}^{kg}\!/_{cm^2}$$

Baja Wals Fe . 52

$$\lambda = \frac{LK}{\mathrm{Im}\,in} = \frac{333{,}3}{12{,}4} = 27{,}5 \qquad \rightarrow \quad W = 0{,}875$$

$$\sigma = \frac{W \cdot P}{F} = \frac{0{,}875 \cdot 210892{,}17}{168} = 1098{,}4\ {}^{kg}\!/_{cm^2} \ < \ \bar{\sigma} = 2533\ {}^{kg}\!/_{cm^2}$$

Jadi profil aman di pakai.

Kontrol terhadap sumbu Y – Y Rencana dipasang pelat kopel setiap jarak 112cm, Jumlah medan :

$$(n) = \frac{333{,}3}{112} = 2{,}97 = 3\ Medan$$

$$\lambda = \frac{LK}{iy} = \frac{333{,}3}{12{,}8} = 26$$

$$\lambda_1 = \frac{LK_1}{i_1} = \frac{112}{2{,}9} = 39$$

$$\lambda_{yi} = \sqrt{26^2 + 39^2} = 47 \ \rightarrow \ W = 1{,}17$$

$$\sigma_{yi} = \frac{1{,}17 \times 210892{,}17}{168} = 1469\ {}^{kg}\!/_{cm^2} \qquad \rightarrow \quad OKEY$$

PELAT KOPEL

Tebal pelat kopel direncanakan 12mm, hubungan pelat dengan profil dilaksanakan dengan paku keeling Φ 22mm.

D.Max = 1,5% . 210892,17 = 3163kg

$$L = \frac{D.Max \cdot L}{h_n} = \frac{3163 \cdot 111,1}{28} = 12550,33kg$$

$$N = \frac{L \cdot h_n}{c} = \frac{12550,33 \cdot 28}{30} = 11714kg$$

$$K = \sqrt{\left(N/4\right)^2 + \left(L/6\right)^2} = 3599kg$$

Dalam VOSB 1963 ditetapkan $\rightarrow$ Φ paku 22mm

$\rightarrow$ diameter pelat 12mm

$\rightarrow$

σ_S = 0,8 x 1600 kg/cm^2

σ_{ST} = 2 x 1600 kg/cm^2

sehingga gaya yang diizinkan $\bar{\sigma}_{ST} = 5310\,kg$

$\bar{\sigma}_{ST} = 8830\,kg$

Jadi K = 3599kg tidak melampaui gaya yang diizinkan

M = $\frac{1}{2}$ x L x h_n

= $\frac{1}{2}$ x 12 x 550,33 x 28 = 175704,62kg

$$Wx = \frac{Ix}{\frac{1}{2} \times h} = \frac{\frac{1}{2} \cdot 1,2 \cdot 40^3 - \left(1,2 \cdot 2,3 \cdot 15^2\right)}{\frac{1}{2}\ 40} = 257,90cm^3$$

$$\sigma = \frac{M}{W} = \frac{175 \cdot 704,62}{257,90} = 681,3\,kg/cm^2 < \bar{\sigma} = 1600\,kg/cm^2$$

Jadi profil dan pelat kopel yang direncanakan aman dipakai.

4.2.2 Batang Tepi Bawah (B)

$\overline{P}\max = +124.830,11kg\ (Tarik)$

$\overline{P}\min = +15.537,60\,kg\quad (Tarik)$

$LK\quad = 333,3cm$

Dipakai profil tersusun tergambar

F = 118cm^2

Cr = 92,3 kg/m`

ix = 11,7cm

iy = 13cm

IX = 16.060cm^4

IY = 19.960cm^4

Wx = 1.070cm^3

$$X = \left|\frac{\sigma \min}{\sigma \max}\right| = \frac{P\min / F}{P\max / F} = 0,12$$

Karena batang tarik tidak pakai pelat kopel maka F = 118cm^2

$$\text{Control} = \sigma = \frac{P}{F\ netto} = \frac{124.830,11}{118} = 1058\ {}^{kg}\!/_{cm^2} \ < \ \overline{\sigma}$$

4.2.3 Batang Diagonal (D)

$\overline{P}\max = -115.080,15kg$

$\overline{P}\min = -63.013,60\,kg$

$LK = 623cm$

Data profil :

F = 84,6cm^2

G = 66,4kg/m`

ix = 9,22cm $\rightarrow$i

iy = 10,50cm $\rightarrow$ iy = [24 = 2,42cm

IX = 7200cm^4

IY = 9350cm^4

Wx = 600cm^3

$$X = \left|\frac{\sigma \min}{\sigma \max}\right| = \frac{P \min / F}{P \max / F} = \left|\frac{63013{,}60 / 84{,}6}{115080{,}15 / 84{,}6}\right| = 0{,}55 \rightarrow \xi = 0{,}7 \ (VOSB\,1963)$$

$$\bar{\sigma} = 2355 \, {}^{kg}\!/_{cm^2}$$

$$\lambda = \frac{LK}{i \min} = \frac{623}{9{,}22} = 67{,}57 \rightarrow W = 1{,}49$$

$$\sigma = \frac{W \cdot P}{F} = \frac{1{,}49 \cdot 115080{,}15}{84{,}6} = 2027 \, {}^{kg}\!/_{cm^2} \; < \bar{\sigma} = 2533 \, {}^{kg}\!/_{cm^2} \; AMAN!!!!$$

Control terhadap sumbu Y – y

Rencana dipasang pelat kopel setiap jarak 125cm, jumlah medan

$$= \frac{623}{125} = 4{,}984 \approx 5 \, medan$$

$$\lambda = \frac{LK}{iy} = \frac{623}{10{,}5} = 67{,}57 \approx 68$$

$$\lambda_1 = \frac{L_1}{iy} = \frac{125}{2{,}42} = 59$$

$$\lambda_{yi} = \sqrt{68^2 + 59^2} = 90$$

$$\sigma_{yi} = \frac{\times 115080{,}15}{84{,}60} = \qquad {}^{kg}\!/_{cm^2}$$

Pelat kopel :

- tebal pelat kopel direncanakan = 12mm
- ϕ pelat keeling = 22mm

D.Max = 1,5% x 115080,15

= 3164kg

$$L = \frac{D \max \cdot L}{Hn} = \frac{3164 \cdot 124{,}6}{28}$$

$$= 14.079{,}80 kg$$

$$K = \sqrt{\left({}^{N}\!/_{4}\right)^2 + \left({}^{L}\!/_{6}\right)^2} = 4037 kg$$

VOSB 1963 → diameter paku = 22mm

→ diameter pelat = 12mm

Gaya yang diizinkan $\bar{\sigma}_s = 5310 \, kg \ (tunggal)$

$$\overline{\sigma}_{ST} = 8830\,kg$$

Ternyata K tidak melampaui gaya yang diizinkan.

Control tebal pelat kopel :

$$M = \tfrac{1}{2} \times L \times hn$$
$$= \tfrac{1}{2} \times 14079 \times 28$$
$$= 197.117{,}2\,kg.cm$$

$$Wx = \frac{Ix}{W} = \frac{197117{,}20}{257{,}90} = 764{,}32\ {}^{kg}\!/_{cm^2} < \overline{\sigma} = 1600\ {}^{kg}\!/_{cm^2}$$

Jadi profil dan pelat kopel dapat dipakai.

V PERHITUNGAN SAMBUNGAN TITIK SIMPUL

- Paku keling diameter 20mm
- Pelat simpul dengan δ = 12mm
- Kekuatan dasar paku keling VOSB 1963

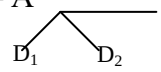
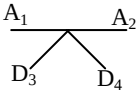
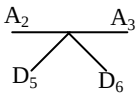
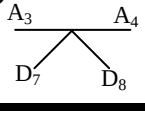
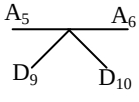
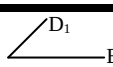
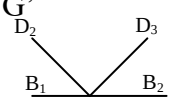
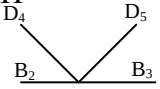
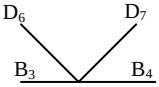
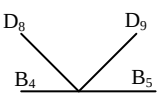
  Untuk satu buah paku ϕ 20mm = 6020kg

  Daya desak = 9600kg
- Diambil N = 6020kg
- Jumlah paku keling yang dibutuhkan pada suatu batang dalam P yaitu :

$$\boxed{n = \frac{P}{N}} \quad \text{(Buah)}$$

- Selanjutnya perhitungan di masukkan dalam table, karena double plat simpul / profil, maka $n = \frac{\frac{1}{2}P}{N} =$ *buah*.

TABEL PERHITUNGAN PAKU KELING

Simpul	Batang Yang Akan Di Sambung	Gaya Dalam Batang Yang Di Sambung		Bahan Penyambung		
		Tekan	Tarik	Ø Paku	Kekuatan	Jumlah Bh.
A – A' 	A1	82.451,07	-	20mm	6020kg	8
	D1	63.965,67	-		6020kg	6
	D2	81.646.85	-		6020kg	6
B – B' 	A1	82,451,07	-	20mm	6020kg	6
	A2	144.778,30	-		6020kg	12
	D3	115.080,15	-		6020kg	10
	D4	-	97.536,47		6020kg	10
C – C' 	A2	144.778,30	-	20mm	6020kg	12
	A3	185.967,54	-		6020kg	16
	D5	90.683,99	-		6020kg	8
	D6	-	71.033,04		6020kg	6
D – D' 	A3	185.967,54	-	20mm	6020kg	16
	A4	210.892,17	-		6020kg	18
	D7	49.670,57	-		6020kg	6
	D8	-	31.249,71		6020kg	4
E 	A4	210.892,17	-	20mm	6020kg	18
	A5	210.892,17	-		6020kg	18
	D9	35.192,74	-		6020kg	4
	D10	35.192,74	-		6020kg	4
F – F' 	D1	63.965,67	-	20mm	6020kg	6
	B1	-	49.920,67		6020kg	6
G – G' 	B1	-	49.920,67	20mm	6020kg	6
	B2	-	91.797,66		6020kg	8
	D2	81.646,85	-		6020kg	6
	D3	115.080,16	91.797,66		6020kg	10
H – H' 	B2	-	104.922,72	20mm	6020kg	10
	B3	-	97.536,47		6020kg	10
	D4	-	-		6020kg	12
	D5	90.683,99	104.922,72		6020kg	8
I – I' 	B3	-	124.830,11	20mm	6020kg	10
	B4	-	71.033,04		6020kg	12
	D6	-	-		6020kg	6
	D7	49.670,57			6020kg	6
J – j' 	B4	-	124.830,11	20mm	6020kg	12
	B5	-	107.050,77		6020kg	10
	D8	-	31.249,71		6020kg	4
	D9	35.192,74	-		6020kg	4
Total paku keling ½ = $2\,[624] =$ 1248 *buah paku*						
Total paku keling untuk 36 titik simpul $= 2 \times 1248 =$2496 *buah paku*						
Dengan Diameter 20mm dengan δ pelat = 12mm						

VI SAMBUNGAN GELAGAR MELINTANG DENGAN GELAGAR KEPALA ATAU INDUK

6.1 Data Sambungan (2.4)

- Gelagar Melintang
  - h_0 = 70mm
  - Pelat tepi 2 x 3 200.12
  - Pengsku flens 2 x 2L . 80.80.12
  - Ξ pelat badan = 10mm
  - Wxn = 7090cm^3
  - Qbs = 228 kg/m`
- Batang Bawah Gelagar Induk

  Lihat (2.3.3)
  - Beban gelagar kepala = 2 x 18 x 696,5 = 37,393kg
  - Berat sendiri gelagar melintang = ½ . (10 . 228) . 7 = 877,8kg
  - Berat trotoar yang terletak di luar = (2.5.3) = 8443,77kg

    Gaya vertikal total = 46.717,57kg
  - Gaya horizontal = 500kg
  - $R = \sqrt{H^2 + V^2} = \sqrt{500^2 + 46714{,}57^2} = 46717{,}24\,kg$

6.2 Sambungan Antara Pelat Badan Gelagar Melintang Dengan Profil Baja ∟ 120 . 120 . 15

- Hubungan antara pelat badan gelagar melintang dengan pelat badan gelagar induk dipikul oleh profil baja ∟ 120 . 120 . 15.
- Penyambung digunakan Rivet Φ 26mm → (lihat 2.4.5).
- $\overline{P}$ tarik Rivet = 6796kg (Fe.32).
- Reaksi yang harus dipikul oleh gelagar melintang =RA.

  RA = 37.393 + 877,8 = 38.279,80kg.
- Jumlah Rivet yang harus diberikan = n.

$$n = \frac{RA}{2P} = \frac{38.270,80}{2 \cdot 6796} = 2,81 \approx 3 buah\ \Phi\ 26\, mm$$

6.3 Sambunagan Antara Gelagar Melintang Dengan Gelagar Kepala

- Sambungan antara gelagar kepala denagn gelagar melintang dilakukan dengan baja ∟ 120 . 120 . 15.
- Sifat sambungan adalah Double Shear (Berpotongan Ganda) denagn rivet Φ 26mm dan δ pelat badan = 10mm.
- $\overline{N} = \left(2 \cdot \tfrac{1}{4} \cdot \pi \cdot 2,6^2\right) \cdot (0,8 \cdot 1600) = 13591,786 kg$
- Akibat P = R = 46717,24kg

  Kx = 0

  $$Ky = \frac{P}{N} = \frac{46717,24}{7} = 6674\, kg$$

  Akibat momen pada gelagar Melintang

  M max = 9619400kg.cm (lihat 2.4.1)

  M = 25% . 9619400 = 2404850kg.cm^2

  $\sum x^2 = 0$

  $\sum y^2 = 2\left[21^2 + 14^2 + 7^2\right] = 1372\, cm^2$

  $\sum x^2 + \sum y^2 = 1377\, cm^2$

  $\sum Ky = 0$

  $$\sum Kx = \frac{M \times Y}{\sum x^2 + \sum y^2} \quad \frac{2404,850 \times 21}{1372} = 36808,93\, kg$$

  $$R = \sqrt{Kx^2 + Ky^2} = \sqrt{0 + (6674)^2 + (36808,93)^2 + 0} = 37409\, kg$$

  R > $\overline{N}$ $\rightarrow$ Berbahaya perencanaan sambungan dirubah

- Di coba menggunakan ∟ 180. 180 .16

  Akibat P = 46.717,24kg

  Kx = 0

$$Ky = \frac{D}{n} = \frac{46717,24}{14} = 3337\,kg$$

Akibat M = 2404850kg.cm

$\sum x^2 = 2\ (7\ .\ 4^2) = 224 cm^2$

$$\sum y^2 = 4\left[21^2 + 14^2 + 7^2\right] = 2744\,cm^2$$

$\sum x^2 + \sum y^2 = 2968 cm^2$

Ky = 0

$$Kx = \frac{M \cdot Y}{\sum x^2 + \sum y^2} = \frac{2404,850 \times 21}{2968} = 17015,45\,kg$$

$$\overline{N} = 2\left(2 \times \tfrac{1}{4} \times \pi \times 2,6^2\right) \cdot \left(0,8 \times 1600\right) = 27183,57\,kg$$

$$R = \sqrt{Kx^2 + Ky^2}$$

$$= \sqrt{0 + (3337)^2 + (17015,45)^2 + 0}$$

$$= 17339,58\,kg < \overline{N} \rightarrow OKEY$$

6.4 Sambungan Antara ∟180. 180 .16 Pada Gelagar Melintang Dengan Gelagar Kepala

Φ Rivet = 26mm

M = 2404,850 kg.cm

$\sum h^2 = \sum h_1^2 + \sum h_2^2 + \sum h_3^2 + \sum h_4^2 + \sum h_5^2 + \sum h_6^2 + \sum h_7^2$

$= 42^2 + 35^2 + 28^2 + 21^2 + 14^2 + 7^2 + 0^2$

$$N_1 = \frac{Mh_1}{\sum h^2} = \frac{2404850 \times 42}{4459} = 22652\,kg$$

N_1 pada 1 Rivet = $N_1/4$ = 5663kg

$A_{\text{netto rivet}} = \tfrac{1}{4}\ .\ \pi\ 2,6_2 = 5,31 cm^2$

$$\sigma_{tr} = \frac{N}{A_h} = \frac{5663}{5,31} = 1066\ {}^{kg}\!/_{cm^2} < \overline{\sigma}_{tr} = 1120\ {}^{kg}\!/_{cm^2}$$

$$V = \frac{D}{N} = \frac{46717,24}{14} = 3367\,kg$$

$$\tau = \frac{V}{A} = \frac{3367}{5,31} = 634\,{}^{kg}\!/_{cm^2} < \bar{\tau}$$

$$\bar{\tau} = 0,80 \times \bar{\tau}_{\,tr} = 896\,{}^{kg}\!/_{cm^2}$$

Control :

$$\sigma_{\,ideal} = \sqrt{\sigma^{\,2} + 3\tau^{\,2}} = \sqrt{1066^{\,2} + 3 \cdot 634^{\,2}}$$

$$= 1530,43\,{}^{kg}\!/_{cm^2} < \bar{\sigma}_{\,tr} = 1600\,{}^{kg}\!/_{cm^2}\ \ OKEY$$

VII PERHITUNGAN PERLETAKAN

Lihat diagram garis pengaruh peletakan

P = 19090kg

Q = 4225kg/m'

RA = P (1+ 0,889 + 0,7777 + +0,6667 + 0,5556 + 0,4444 + 0,3333 + 0,3333 + 0,2222 + 0,1111 + q (1/2 . 1 . 30))

= 19090 . (5) + 4225 . (15) = 158825kg

7.1. Dimensi Blok Landasan

Direncanakan blok landasan dari beton bertulang K = 225 di mana

$$\bar{\sigma}_{\,b}{}' = 75\,{}^{kg}\!/_{cm^2}$$

- $A.Block = \dfrac{DA}{\bar{\sigma}_{\,b}{}'} = \dfrac{158825}{75} = 2188\,cm^2$
- Dicoba menggunakan landasan ukuran :

  C = 50cm

  D = 50cm

  AL = 2500cm^2
- Berat landasan = AL . γ_{beton} . t = WL
- Di taksir tebal blok beton landasan = 20cm

- WL = 2500 . 0,0020 . 25 = 125kg
- Total beban yang bekerja = 15880 + 125 = 158975kg
- $\bar{\sigma}$ pasangan batu kali abotment = 15kg/cm^2
- A Block beton yang diperlukan $= \frac{158675}{15} = 10598\,cm^2$
- Panjang block beton yang ditetapkan = L = L_0 + 40.

  L = L_0 + 40 = 40 + 40 = 80cm

  $b = \frac{10895}{80} = 136\,cm$
- Di peroleh ukuran block beton :

  L = 80cm

  b = 136cm

7.2. Perletakan Rol

- Dimensi rol = 80 x 60cm

  Tebal kursi (s)

  Diktat LOA . V hal 105, maka

  $tebal\,s\,harus \geq \frac{1}{2}\sqrt{\frac{3\times Q\times C}{d\times\bar{\sigma}}} \rightarrow baja\ tulang\ \bar{\sigma} = 1600\,{}^{kg}\!/_{cm^2}$

  $S \geq \frac{1}{2}\sqrt{\frac{3\times 158975\times 50}{50\times 1600}} = 17{,}26\,cm \approx 18\,cm$

- Jari – jari gelinding

  Digunakan baja tuang ST' . 52 , $\bar{\sigma} = 8500\,{}^{kg}\!/_{cm^2}$

  $D' = \frac{0{,}75\times 10^6\times 158975}{60\times(8500)^2} = 27{,}5 \approx 28\,cm$

  $D'' = D' + 2\times 2{,}5 = 28 + 5 = 33\,cm$

- Tebal block beton

  M = ¼ . Q L = ¼ . 158975 . 70 = 2782062,5kg

  W = 1/6 . b . t = 1/6 . 160 . t^2 = 26,67 t^2 = 27 t^2

$$\bar{\sigma} = \frac{M}{W} \rightarrow 75 = \frac{2782062,50}{27\ t^2} \rightarrow t = 37,065 \approx 38\,cm$$

7.3. Perletakan Sendi

- Kursi landasan

  Tabel Muller – Breslan → Diktat LOA V. hal. 106

h/s_2	$b/(as_3)$	W
3	4,0	0,2222 . a . s_3 . h^2
4	4,2	0,2251 . a . $s_{3\,.\,h}{}^2$
5	4,6	0,2286 . a . s_3 . h^2
6	5	0,2315 . a . s_3 . h^2

  Dimana
  A = Banyaknya Rusuk
  L = Lebar Batang Tepi Bawah Gelagar Induk
  B = 1,25L atau 1,50L
  B = 1,50L = 1,50 . 42 = 63cm
  $d_2 = d_1 + 5cm$
  d_3 = ¼ . d Mn → 2cm atau 2,5cm

- b = 63cm
- l = 60cm dan a diambil sebanyak tiga buah rusuk
- Kemudian tetapkan $h/S_2 = 4$; $b/(as_3) = 4,2$
- W = 0,2251 . a h^2
- M = ¼ . Q . L = ¼ . 158975 . 60 = 2384625kg.m

- $W = \frac{M}{\bar{\sigma}} = \frac{2384625}{1600} = 1490{,}4\,cm^3$
- $h = \sqrt{\frac{1490{,}40}{0{,}2251 \times 3 \times 9}} = 15{,}66\,cm^3 \;\infty\; 16\,cm$
- S_2 = ¼ .h = ¼ .16 = 4cm
- S_4 = 1/6 .h = 1/6 . 16 = 2,67cm ∞ 3cm
- S_5 = 1/8 . h = 1/8 . 16 = 2cm
- Jari gelinding

  $R \geq \frac{0{,}8 \times Q}{\bar{\sigma} \times L} \rightarrow diktat\ LAO\ .\ V\ \ hal.106$

  $R \geq \frac{0{,}8 \times 158975}{1600 \times 60} = 1{,}32\,cm$

  $\rightarrow Diktat\ \ LOA\,.\,V\ .\ hal106 \rightarrow R\min = 3{,}5\,cm$

  Diambil :

  R = 5cm

  D_1 = 2R = 10cm

  $D_2 = d_1 + 5$ = 15cm

  D_3 = ¼ . D_2 = 3,75cm

  Gambar perletakan :

VIII Kontrol Lendutan Dan Berat Konstruksi

8.1. Kontrol Lendutan

- Dalam mendeteksi lendutan ini, dikerjakan beban vertikal (semu) sebesar 1 (satu) ton pada setiap titik simpul bagian bawah konstruksi jembatan.
- Sehubungan dengan hal tersebut digunakan rumus – rumus sebagai berikut :

  $\delta = \frac{\xi \times S \times \bar{S}}{E \times F}$

  Di mana :

  δ = Lendutan Vertikal Konstruksi Jembatan Rangka

S = Gaya Batang Akibat Beban Hidup + Beban Mati

$\bar{S}$ = Gaya Batang Akibat Beban vertikal = 1ton

L = Panjang Batang

F = Luas Penampang Profil

E = modulus elastisitas baja = E = $2{,}1.10^6$ kg/cm^2

TABEL PERHITUNGAN

Batang	L (cm)	F (cm^2)	L/F (cm^{-1})	S (ton)	$.\bar{S}$ (ton)	S . $\bar{S}$. L/F (ton/cm)
A1	333,3	118	2,824	-82,45107	-0,4938	114,9772915
A2	333,3	118	2,824	-144,77830	-0,8641	353,2906716
A3	333,3	118	2,824	-185,96754	-1,111	583,4664619
A4	333,3	118	2,824	-210,89217	-1,2812	763,0308161
B1	333,3	118	2,824	49,92067	+0,2469	34,8069675
B2	333,3	118	2,824	91,79766	0,648	167,9853115
B3	333,3	118	2,824	104,92272	0,926	274,3754309
B4	333,3	118	2,824	124,83011	1,080	380,7218491
B5	333,3	118	2,824	107,05077	1,250	377,8892181
D1	623	84,6	7,364	-63,96567	-0,9226	434,5844507
D2	623	84,6	7,364	81,64685	+0,9226	554,7108544
D3	623	84,6	7,364	-115,08015	-0,807	683,8923313
D4	623	84,6	7,364	97,53647	+0,807	579,634662
D5	623	84,6	7,364	-90,68399	-0,6667	445,2201948
D6	623	84,6	7,364	71,38595	+0,6667	350,4749467
D7	623	84,6	7,364	-49,67057	-0,5766	210,9053331
D8	623	84,6	7,364	31,24971	+0,5766	132,6888436
D9	623	84,6	7,364	-35,19274	-0,5189	134,4777802
					Σ =	6577,133414

- Untuk seluruh batang konstruksi, maka :

$$\xi \,.\, S \,.\, \bar{S} \,.\, {}^{L}\!/_{F} = 2 \cdot 6577{,}133414 - 763{,}0308161$$
$$= 16628{,}2052 \; {}^{ton}\!/_{cm}$$

- Lendutan Max = δ

$$\delta = \frac{\xi \times S \times \bar{S} \times {}^{L}\!/_{F}}{E}$$
$$= \frac{6577{,}133414 \times 1000}{2{,}1 \times 10^{6}} = 3{,}132\, cm \; < \; \bar{\delta}$$

$$\bar{\delta} \; = \; \frac{L}{600} = \frac{30 \times 100}{600} = 5\, cm$$

(konstruksi angin dari bahaya lendutan)

8.2 Kontrol Berat Konstruksi

- Berat total konstruksi taksiran (rencana) = 310752kg (4.1.1)
  1. Ikatan angin bawah

     L = 7,751 . 2 . 9 + 10 . 7 = 209,554m

     q = 1,1 x (2 . 7,09) = 15,598kg

     Wi.AB = 210 x 660 = 3268,62kg
  2. Lantai kendaraan

     A = 7 x 30 = 210m^2

     q = 1,1 . (650 – 50) = 660kg/m^2

     WLK = 210 x 660 = 138600kg
  3. Gelagar memanjang lantai kendaraan

     L = 5 x 30 = 70m’

     q =1,1 x 76,1 = 83,71kg/m’

     W.G.Mjk = 83,71 x 150 = 12556,50kg
  4. Gelagar melintang lantai kendaraan

     L = 7 x 10 = 70m’

     q = 1,1 x 228 = 250,80kg/m’

     W_{GLT} = 250,80 x 70 = 17556kg

5. Lantai tritoir

   L = 1,1 x 30 x 2 = 66m^2

   q = 1,1 x (900 – 50) = 935kg/m^2

   W_{LTR} = 935 x 66 = 61710kg

6. Gelagar memanjang trotoir

   L = 3 x 2 x 30 = 180m’

   q = 1,1 x 16 = 17,6kg/m’

   W_{GMTR} = 17,6 x 180 = 3168kg

7. Gelagar melintang trotoir

   n = 2 x 10 = 20buah

   q = 392,77kg

   W_{GMTR} = 392,77 x 20 = 7855,4kg

8. Sandaran + tiang sandaran

   n = (10 – 1) x 2 = 18buah

   q = 1046,70kg

   W_{STS} = 18 x 1046,70 = 18840,6kg

9. Diagonal gelagar induk

   L = 6,23 x 18 x 2 = 22428m’

   q = 1,1 x 66,4 = 73,04kg/m’

   W_{GH} = 73,04 x 224,28 = 16381,41kg

10. Batang atas gelagar induk

    L = 2 x 26,667 = 53,334m’

    q = 168 x 1,1 = 184,8kg/m’

    W_{BAGI} = 129,8 x 53,334 = 9856,12kg

11. Batang bawah gekagar

    L = 2 x 30 = 60m’

    q = 1,1 x 118 = 129,8kg/m’

    W_{BGI} = 129,8 x 60 = 7788kg

BERAT TOTAL KONSTRUKSI

No	ITEM	BERAT
1	WIAB	3.268,62kg
2	WILK	138.600kg
3	WGMJ	12.556,50kg
4	WGLT	17.556kg
5	WLTR	61.710kg
6	WGMTR	3.168kg
7	WGMTR	7.855,40kg
8	WSTS	18.840,60kg
9	WDGI	16.381,41kg
10	WBAGI	9.856,12kg
11	WBGI	7.788kg

W total = 297.580,65kg (Mendekati)

Wrencana = 310.752kg