

## BAB V

### PERHITUNGAN

#### 5.1 Data Peninjauan Konstruksi

Data perencanaan kerja proyek pada P. 244 Jalan Tol Jakarta – Cikampek II *Elevated* ini meliputi data konstruksi dan data tanah. Data tersebut adalah sebagai berikut :

##### 5.1.1 Data Konstruksi

1. Data Struktur Atas

Bentang antar pilar	: 60 m
Lebar <i>Pier head</i>	: 18,05 m
Panjang <i>Steel Box Girder</i>	: 60 m
Lalu lintas jalan	: 2 Jalur 4 lajur
Tinggi pilar	: beton prategang
Tinggi pilar	: 15,609 m

2. Data Struktur Bawah

Panjang <i>Bore Pile</i>	: 33,5 m
Diameter <i>Bore Pile</i>	: 1,2 m
Jenis konstruksi	: beton bertulang
Berat jenis beton bertulang ( $\gamma$ )	: 2,5 t/m <sup>2</sup>
Mutu beton borepile ( $f_c'$ )	: 30 Mpa
Mutu baja tulangan ( $f_y$ )	: 392 Mpa

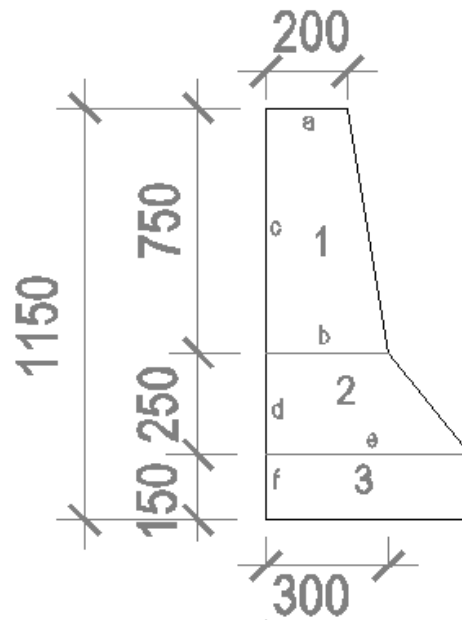
3. Data Tanah

<i>Standart Penetration Test (SPT)</i>	: Terlampir
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## 5.2 Perhitungan Beban Konstruksi

### 5.2.1 Beban Mati

#### 1. Berat Barrier



Gambar 5.1 Barrier

Bentang = 60m

Berat jenis beton ( $\gamma$ ) = 2,5 t/m<sup>3</sup>

Jumlah Barrier = 4 buah

$$\begin{aligned} \text{Luas 1} &= \frac{1}{2} x (a + b) x c \\ &= \frac{1}{2} x (0,2 + 0,3) x 0,75 \\ &= 0,188 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas 2} &= \frac{1}{2} x (b + e) x d \\ &= \frac{1}{2} x (0,3 + 0,5) x 0,25 \end{aligned}$$

$$= 0,1 \text{ m}^2$$

Luas 3 = e x f

$$= 0,5 \times 0,15$$

$$= 0,075 \text{ m}^2$$

Volume = ( Luas 1 + Luas 2 + Luas 3 ) x Bentang

$$= ( 0,188 + 0,1 + 0,075 ) \times 60$$

$$= 0,363 \times 60$$

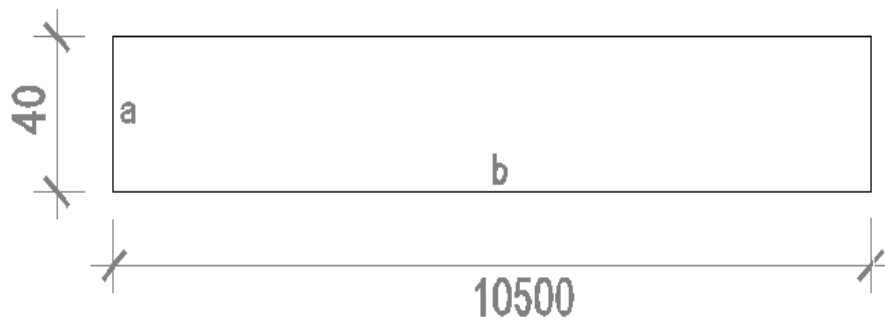
$$= 21,780 \text{ m}^2$$

Berat = Volume x  $\gamma$  x Jumlah Barrier

$$= 21,780 \times 2,5 \times 4$$

$$= 217,80 \text{ t}$$

## 2. Berat Aspal



Gambar 5.2 Aspal

Bentang = 60 m

Berat Jenis Aspal ( $\gamma$ ) = 2,3 t/m<sup>3</sup>

Luas = a x b

$$= 0,04 \times 10,50$$

$$= 0,42 \text{ m}^2$$

Volume = Luas x bentang

$$= 0,42 \times 60$$

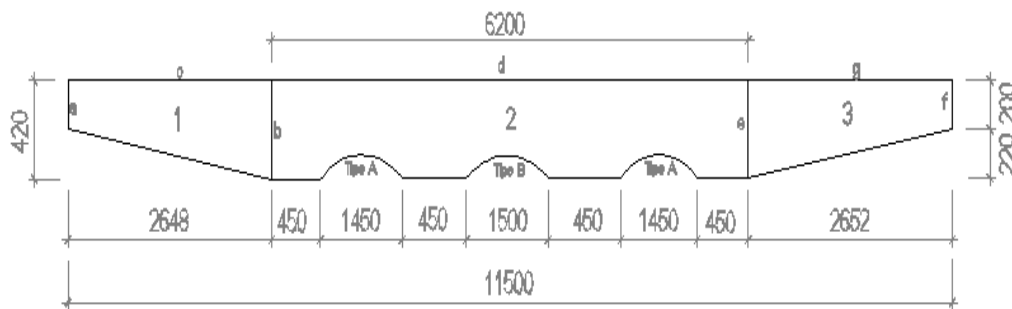
$$= 25,2 \text{ m}^3$$

Berat = Volume x  $\gamma$  x jumlah

$$= 25,2 \times 2,3 \times 2$$

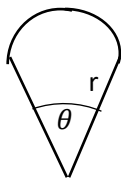
$$= 115,92 \text{ t}$$

### 3. Berat Slab



Gambar 5.3 Slab

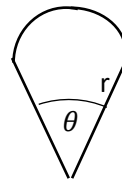
Type A



$$r = 1,6995 \text{ m}$$

$$\text{busur} = 1,7285 \text{ m}$$

Type B



$$r = 1,8003 \text{ m}$$

$$\text{busur} = 1,7781 \text{ m}$$

Bentang = 60 m

Berat jenis beton ( $\gamma$ ) = 2,5 t/m<sup>3</sup>

$$\text{Luas 1} = \frac{1}{2} \times (a + b) \times c$$

$$= \frac{1}{2} \times (0,2 + 0,42) \times 2,648$$

$$= 0,821 \text{ m}^2$$

Luas 2 = Luas persegi panjang – ( 2x luas Tembereng Tipe A ) – Luas Tembereng

Tipe B

$$\begin{aligned}
 \text{- Luas Persegi Panjang} &= b \times d \\
 &= 0,4 \times 6,2 \\
 &= 2,48 \text{ m}^2
 \end{aligned}$$

- Luas Tembereng Tipe A:

$$\text{Busur} = \frac{\theta}{360^\circ} \times 2 \pi r$$

$$\theta = \frac{\text{Busur} \times 360^\circ}{2 \pi r}$$

$$\theta = \frac{1,7285 \times 360}{2 \times 3,14 \times 1,6995}$$

$$\theta = 58,303^\circ$$

$$\begin{aligned}
 \text{- Luas Juring} &= \frac{\theta}{360^\circ} \times \pi \times r^2 \\
 &= \frac{58,303}{360^\circ} \times 3,14 \times 1,6995^2 \\
 &= 1,469 \text{ m}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{- Luas segitiga} &= \frac{1}{2} \times r^2 \times \sin \theta \\
 &= \frac{1}{2} \times 1,6995^2 \times \sin 58,303^\circ \\
 &= 1,229 \text{ m}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{- Luas Tembereng Tipe A} &= \text{Luas juring} - \text{luas segitiga} \\
 &= 1,469 - 1,229 \\
 &= 0,24 \text{ m}^2
 \end{aligned}$$

- Luas Tembereng Tipe B:

$$\text{Busur} = \frac{\theta}{360^\circ} \times 2 \pi r$$

$$\theta = \frac{\text{busur} \times 360}{2 \pi r}$$

$$\theta = \frac{1,7781 \times 360}{2 \times 3,14 \times 1,8003}$$

$$\theta = 56,618^\circ$$

$$\begin{aligned} \text{Luas Juring} &= \frac{\theta}{360^\circ} \times \pi \times r^2 \\ &= \frac{56,618}{360^\circ} \times 3,14 \times 1,8003^2 \\ &= 1,601 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas segitiga} &= \frac{1}{2} \times r^2 \times \sin \theta \\ &= \frac{1}{2} \times 1,8003^2 \times \sin 56,618^\circ \\ &= 1,353 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas Tembereng Tipe B} &= \text{Luas juring} - \text{luas segitiga} \\ &= 1,601 - 1,353 \\ &= 0,248 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas 2} &= \text{Luas persegi} - (2 \times \text{Luas Tembereng Tipe A}) - \text{Luas Tembereng Tipe B} \\ &= 2,48 - (2 \times 0,24) - 0,248 \\ &= 1,752 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas 3} &= \frac{1}{2} \times (e + f) \times g \\ &= \frac{1}{2} \times (0,2 + 0,42) \times 2,652 \\ &= 0,822 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas Total} &= \text{luas 1} + \text{luas 2} + \text{luas 3} \\ &= 0,821 + 1,752 + 0,822 \\ &= 3,395 \text{ m}^2 \end{aligned}$$

Volume = luas total x bentang

$$= 3,395 \times 60$$

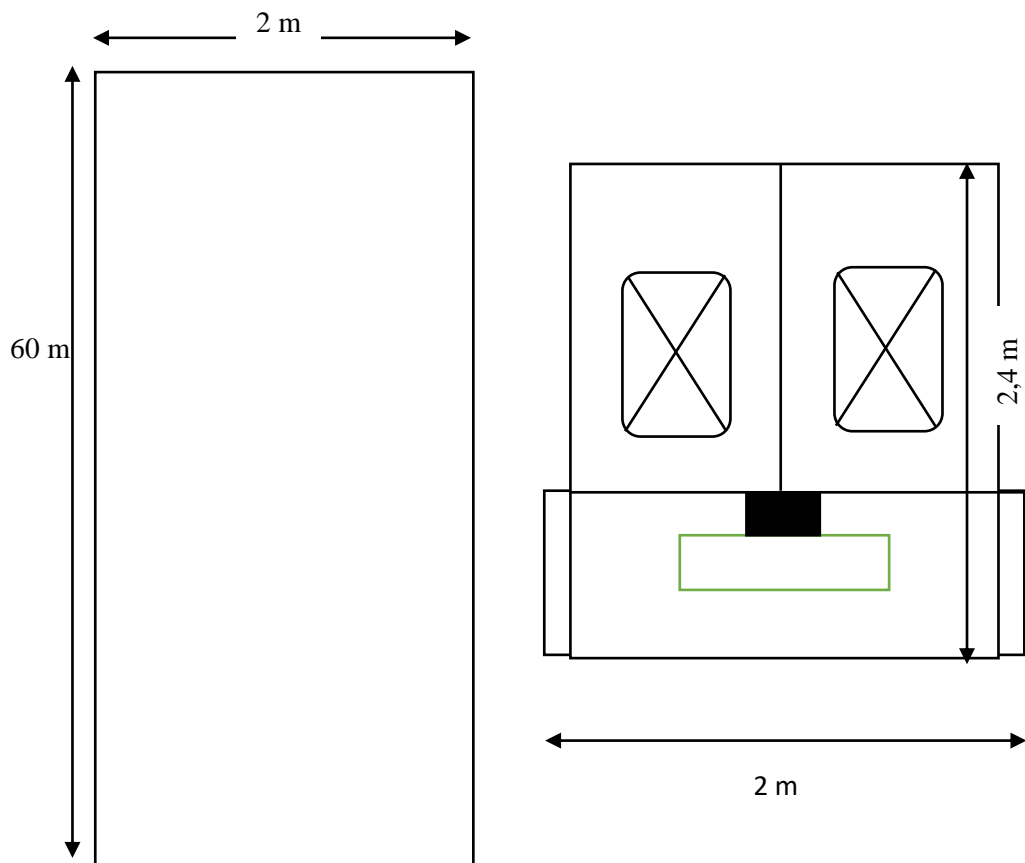
$$= 203,70 \text{ m}^3$$

Berat Slab = Volume x  $\delta$  x jumlah slab

$$= 203,70 \times 2,5 \times 2$$

$$= 1.018,50 \text{ t}$$

#### 4. Berat *Steel Box Girder*



Gambar 5.4 *Steel Box Girder*

Jumlah *Girder* = 4 buah

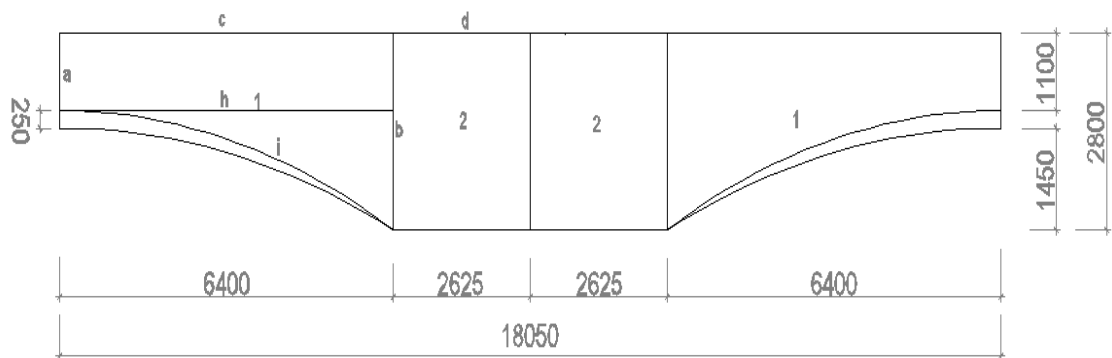
Berat 1 *Girder* = 75.911,29 kg

$$= 75,911 \text{ t}$$

$$\text{Berat 2 Girder} = 2 \times 75,911$$

$$= 151,822 \text{ t}$$

### 5. Berat Pier Head



Gambar 5.5 Pier Head

$$\text{Bentang} = 3 \text{ m}$$

$$\text{Berat Jenis Beton } (\gamma) = 2,5 \text{ t/m}^3$$

$$\text{Volume 1} = \left( \frac{1}{2} \times (a + b) \times c \right) \times \text{Bentang}$$

$$= \left( \frac{1}{2} \times (1,35 + 2,8) \times 6,4 \right) \times 3$$

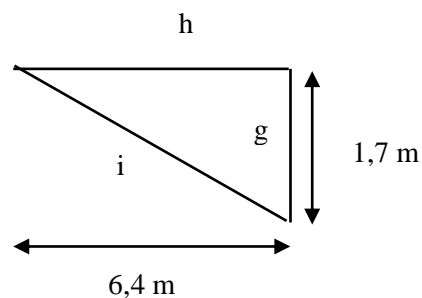
$$= 39,84 \text{ m}^3$$

$$\text{Volume 2} = b \times d \times \text{Bentang}$$

$$= 2,8 \times 2,625 \times 3$$

$$= 22,05 \text{ m}^3$$

$$\text{Panjang i} =$$

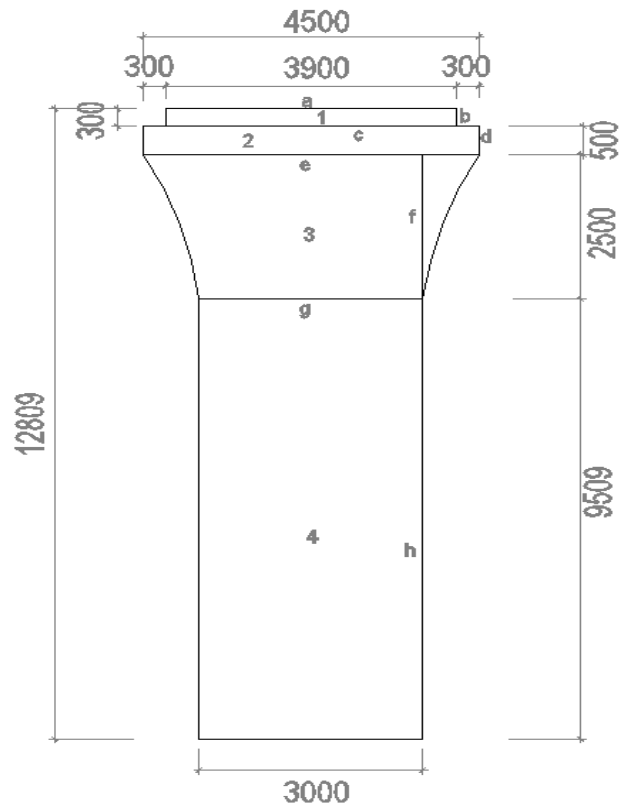


$$\begin{aligned}
 i &= \sqrt{g^2 + h^2} \\
 &= \sqrt{1,7^2 + 6,4^2} \\
 &= \sqrt{43,85} \\
 &= 6,62 \text{ m}
 \end{aligned}$$

$$\begin{aligned}
 \text{Volume 3} &= \left( \frac{1}{2} \times e \times f \right) \times i \\
 &= \left( \frac{1}{2} \times 0,25 \times 1 \right) \times 6,62 \\
 &= 0,828 \text{ m}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{Volume Total} &= ( 2 \times ( \text{volume 1} + \text{volume 2} ) ) - ( 4 \times \text{volume 3} ) \\
 &= ( 2 \times ( 39,84 + 22,05 ) ) - ( 4 \times 0,828 ) \\
 &= ( 2 \times 61,89 ) - ( 3,312 ) \\
 &= 123,78 - 3,312 \\
 &= 120,468 \text{ m}^3
 \end{aligned}$$

$$\begin{aligned}
 \text{Berat} &= \text{Volume Total} \times \gamma \\
 &= 120,468 \times 2,5 \\
 &= 301,17 \text{ t}
 \end{aligned}$$

6. Berat Kolom/*Pier*

Gambar 5.6 Kolom

$$\text{Bentang 1} = 2,5 \text{ m}$$

$$\text{Bentang 2} = 3 \text{ m}$$

$$\text{Berat Jenis Beton } (\gamma) = 2,5 \text{ t/m}^3$$

$$\text{Volume 1} = (a \times b) \times \text{Bentang 1}$$

$$= (3,9 \times 0,3) \times 2,5$$

$$= 2,925 \text{ m}^3$$

$$\text{Volume 2} = (c \times d) \times \text{Bentang 2}$$

$$= (4,5 \times 0,5) \times 3$$

$$= 6,75 \text{ m}^3$$

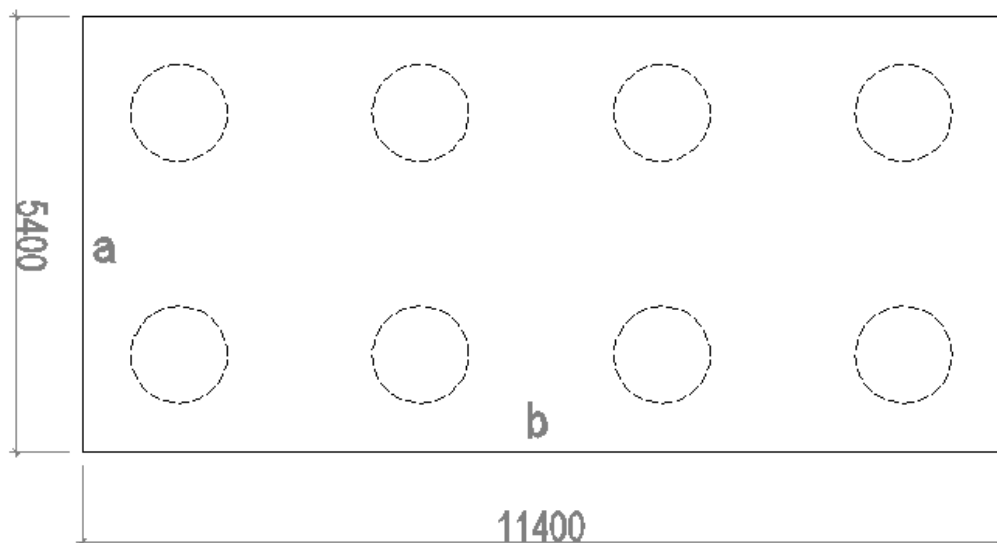
$$\begin{aligned} \text{Volume 3} &= \left( \frac{1}{2} x (e + g) x f \right) \times \text{Bentang 1} \\ &= \left( \frac{1}{2} x (4,5 + 3) x 2,5 \right) \times 2,5 \\ &= 23,438 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Volume 4} &= (g \times h) \times \text{Bentang 1} \\ &= (3 \times 9,509) \times 2,5 \\ &= 71,318 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Volume Total} &= \text{Volume 1} + \text{Volume 2} + \text{Volume 3} + \text{Volume 4} + \text{Volume 5} \\ &= 2,925 + 6,75 + 23,438 + 13,605 + 71,318 \\ &= 104,431 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Berat Kolom} &= \text{Volume Total} \times \gamma \\ &= 104,431 \times 2,5 \\ &= 261,078 \text{ t} \end{aligned}$$

#### 7. Berat *Pile Cap*



Gambar 5.7 *Pile Cap*

$$\text{Tinggi Pile Cap} = 2,5 \text{ m}$$

$$\text{Berat Jenis Beton } (\gamma) = 2,5 \text{ t/m}^3$$

$$\begin{aligned} \text{Volume Pile Cap} &= a \times b \times \text{tinggi pile cap} \\ &= 5,4 \times 11,4 \times 2,5 \\ &= 153,9 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Berat Pile Cap} &= \text{Volume} \times \gamma \\ &= 153,9 \times 2,5 \\ &= 384,75 \text{ t} \end{aligned}$$

### **Total Beban Mati:**

• Berat <i>Barrier</i>	=	217,800 t
• Berat Aspal	=	115,920 t
• Berat Slab	=	1.018,500 t
• Berat <i>Steel Box Girder</i> = 2 x 151,822 t	=	303,644 t
• Berat <i>Pier Head</i>	=	301,170 t
• Berat Kolom	=	261,078 t
• Berat <i>Pile Cap</i>	=	<u>384,750 t</u> +
	=	2.602,862 t

### **5.2.2 Beban Hidup**

a) Beban “ D “

Menghitung menggunakan bentang gelagar

Bentang gelagar ( L ) = 60 m

Untuk bentang 60 m digunakan rumus :

$$q = 2,2 - \frac{1,1}{60} x (L - 30)$$

maka besar nya q adalahh :

$$q = 2,2 - \frac{1,1}{60} x (L - 30)$$

$$q = 2,2 - \frac{1,1}{60} x (60 - 30)$$

$$q = 2,2 - \frac{1,1}{60} x 30$$

$$q = 2,2 - 0,55$$

$$q = 1,65 \text{ t}$$

Beban hidup parameter lebar jembatan, dengan rumus :

$$\text{Beban terbagi rata (Q)} = \frac{q}{2,75}$$

$$\text{Beban garis (P)} = \frac{p}{2,75}$$

Untuk beban garis digunakan nilai P = 12 ( menurut PPPJJR tahun 1987 )

$$Q = \frac{q}{2,75} = \frac{1,65}{2,75} = 0,6 \text{ t}$$

$$P = \frac{p}{2,75} = \frac{12}{2,75} = 4,364 \text{ t}$$

Muatan merata diperhitungkan berdasarkan lebar lantai kendaraan.

Lebar lantai jembatan = 11,50 m

Ketentuan PPPJJR 1987 :

“ Untuk jembatan dengan lebar lantai kendaraan lebih besar dari 5,50 m, beban

“D“ sepenuhnya ( 100% ) dibebankan pada lebar jalur 5,50m. Sedangkan lebar

selebihnya dibebani hanya separuh beban “D” ( 50% )

Sehingga besarnya muatan merata adalah

$$q = ( 100\% \times q \times 5,50 ) + 2 ( 50\% \times q \times 3,0)$$

$$p = ( 100\% \times p \times 5,50 ) + 2 ( 50\% \times p \times 3,0 )$$

dengan berat  $Q = 0,6 \text{ t}$  dan  $P = 4,364 \text{ T}$

$$q = ( 100\% \times 0,6 \times 5,50 ) + 2 ( 50\% \times 0,6 \times 3,0 )$$

$$= 3,3 + 2 ( 0,9 )$$

$$= 3,3 + 1,8$$

$$= 5,1 \text{ t}$$

$$p = ( 100\% \times 4,364 \times 5,50 ) + 2 ( 50\% \times 4,364 \times 3,0 )$$

$$= 24,002 + 2 ( 6,546 )$$

$$= 24,002 + 13,092$$

$$= 37,094 \text{ t}$$

$$Q = q \times L$$

$$= 5,1 \times 60$$

$$= 306 \text{ t}$$

b) Beban Kejut

Untuk memperhitungkan beban kejut digunakan beban “P” dan “Q”. Untuk beban “P” dikalikan dengan koefisien kejut.

Koefisien kejut dirumuskan :

$$K = 1 + \frac{20}{50+L}$$

dimana :

K = koefisien kejut

L = Panjang bentang

Nilai koefisien kejut sebesar :

$$K = 1 + \frac{20}{50+60}$$

$$= 1 + \frac{20}{110}$$

$$= 1 + 0,182$$

$$= 1,182$$

Untuk beban "P" (beban garis) :

$$P = K \times P$$

$$= 1,182 \times 37,094$$

$$= 43,845 \text{ t}$$

### **$\Sigma$ Beban Hidup:**

$$\text{- Beban D} = 306 \text{ t}$$

$$\text{- Beban P} = \underline{43,845 \text{ t}} +$$

$$= 349,845 \text{ t}$$

### **5.2.3 Beban Sekunder**

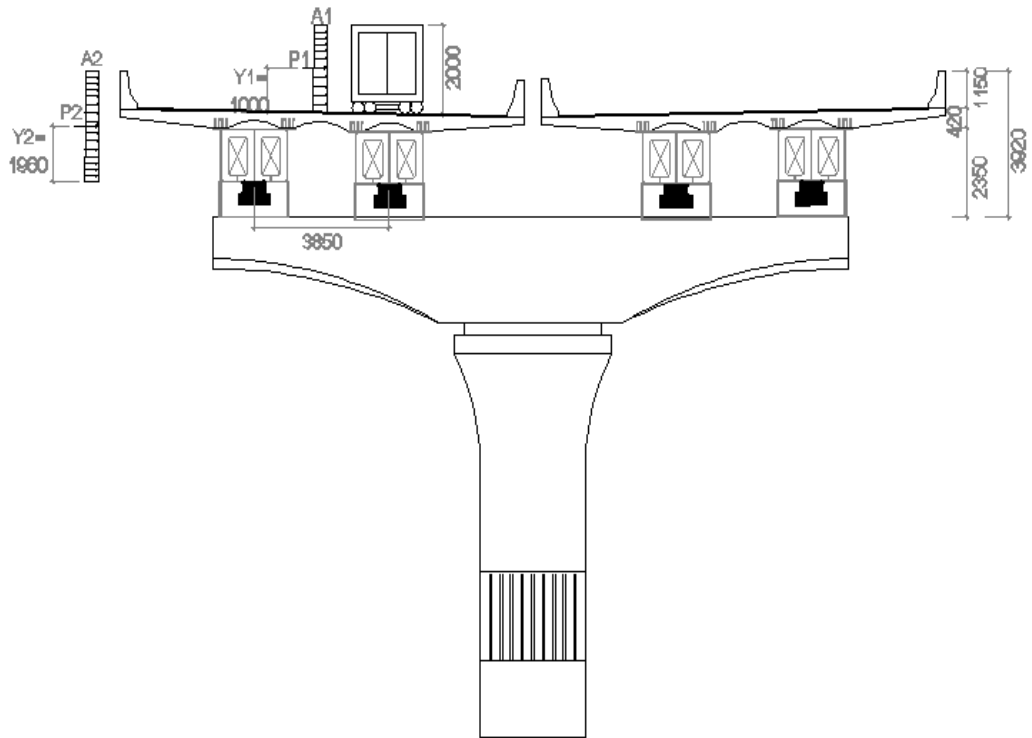
Beban Angin

Pengaruh beban angin sebesar  $150 \text{ kg/m}^2$  pada jembatan

$$W = 150 \text{ kg/m}^2$$

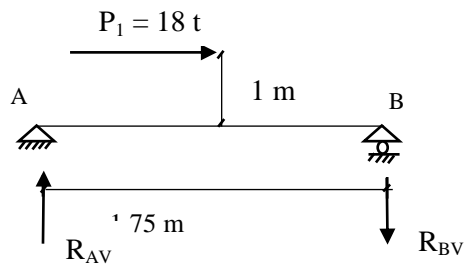
$$W = 0,15 \text{ t/m}^2$$

Bentang = 60 m



Gambar 5.8 Beban Angin

$$\begin{aligned}
 P_1 &= A_1 \times W \times 100\% \\
 &= (2 \times 60) \times 0,15 \times 100\% \\
 &= 120 \times 0,15 \times 100\% \\
 &= 18 \text{ t}
 \end{aligned}$$



$$\Sigma M_B = 0$$

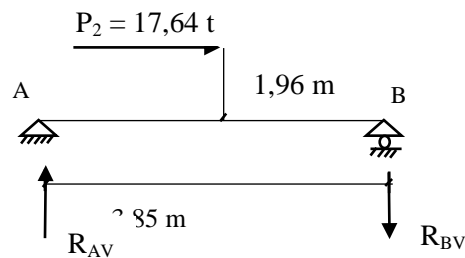
$$R_{AV} \cdot 1,75 - P_1 \cdot Y_1 = 0$$

$$R_{AV} \cdot 1,75 - 18 \cdot 1 = 0$$

$$R_{AV} \cdot 1,75 - 18 = 0$$

$$R_{AV} = \frac{18}{1,75} = 10,286 \text{ t}$$

$$\begin{aligned} P_2 &= A_2 \times W \times 50\% \\ &= (3,92 \times 60) \times 0,15 \times 50\% \\ &= 17,64 \text{ t} \end{aligned}$$



$$\Sigma M_B = 0$$

$$R_{AV} \cdot 3,85 - P_2 \cdot Y_2 = 0$$

$$R_{AV} \cdot 3,85 - 17,64 \cdot 1,96 = 0$$

$$R_{AV} \cdot 1,75 - 34,574 = 0$$

$$R_{AV} = \frac{34,574}{3,85}$$

$$R_{AV} = 8,98 \text{ ton}$$

$$\begin{aligned} \Sigma \text{ beban angin} &= 10,286 \text{ t} + 8,98 \text{ t} \\ &= 19,266 \text{ t} \end{aligned}$$

### TOTAL BEBAN:

$$\text{Beban Mati} = 2.602,862 \text{ t}$$

$$\text{Beban Hidup} = 2 \times 349,845 = 699,690 \text{ t}$$

$$\begin{aligned} \text{Beban Sekunder} &= \underline{19,266 \text{ t}} + \\ &= 3.321,818 \text{ t} \end{aligned}$$