CHAPTER III

METHODOLOGY

3.1. Average Daily Traffic

Average daily traffic (LHR) is the main data of designing. This calculation need the amount of vehicle from surveying. And then the growth rate of vehicle. The calculations are as follows:

$$\text{LHR} = Vehicle\ amount(1 + i)^n \quad \text{(Eq 3-1)}$$

Where:

i = Growth rate (%)

3.2. Traffic Load

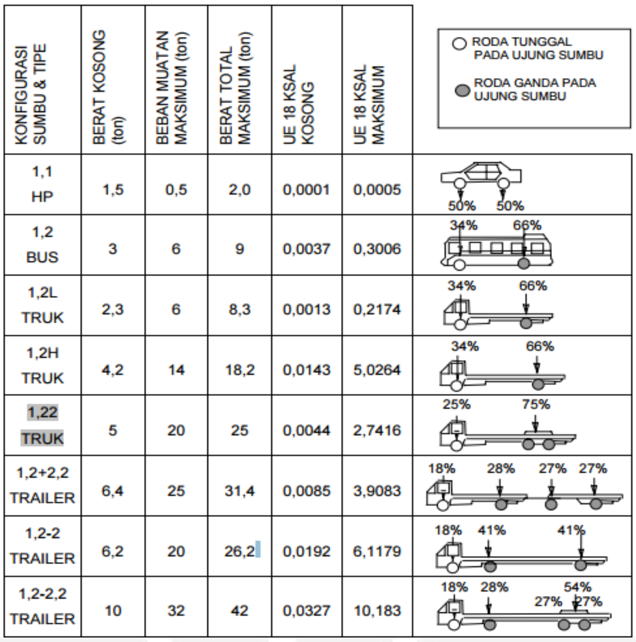
Traffic load is a load from vehicle. Dimension, vehicle weight and load will create force on the vehicle axis. The axle load will transmit to the pavement surface and contribute to damage the road. Traffic load can be converted into axle load configuration. The axle load configuration can be seen in figure 3.1. Each type of vehicle has different axle load configuration.

For rigid pavement purposes, only commercial vehicles having a minimum total weight of 5 tons. And the vehicle will separate into 3 axles configuration:

a) *Sumbu Tunggal Roda Tunggal* (STRT)

b) *Sumbu Tunggal Roda Ganda* (STRG)

c) *Sumbu Tandem Roda Ganda* (STdRG)



KONFIGURASI SUMBU & TIPE	BERAT KOSONG (ton)	BEBAN MUATAN MAKSIMUM (ton)	BERAT TOTAL MAKSIMUM (ton)	UE 18 KSAL KOSONG	UE 18 KSAL MAKSIMUM	○ RODA TUNGGAL PADA UJUNG SUMBU ● RODA GANDA PADA UJUNG SUMBU
1,1 HP	1,5	0,5	2,0	0,0001	0,0005	50% 50%
1,2 BUS	3	6	9	0,0037	0,3006	34% 66%
1,2L TRUK	2,3	6	8,3	0,0013	0,2174	34% 66%
1,2H TRUK	4,2	14	18,2	0,0143	5,0264	34% 66%
1,22 TRUK	5	20	25	0,0044	2,7416	25% 75%
1,2+2,2 TRAILER	6,4	25	31,4	0,0085	3,9083	18% 28% 27% 27%
1,2-2 TRAILER	6,2	20	26,2	0,0192	6,1179	18% 41% 41%
1,2-2,2 TRAILER	10	32	42	0,0327	10,183	18% 28% 54% 27% 27%

Figure 3.1. Axle Load Configuration
Source : Bina Marga, 1993. Manual Perkerasan Jalan Dengan Alat Berat Benkelman Beam No. 01/MN/BM/83

3.3. Slab Thickness

The flexible pavement will be demolished and changing into the rigid pavement, there are several types of steps for designing the thickness of rigid pavement:

3.3. 1. Number of Commercial Vehicle Axle (JSKN)

$$JSKN = 365 \times JSKNH \times R$$ .... **(Eq 3-2)**

$$R = \frac{(1+i)^n - 1}{i}$$ .... **(Eq 3-3)**

Where:

n = Life Planning

i = Grow rate (%)

Table 3.1. Growth rate (i)

Life plan (years)	Growth rate (%)					
	0	2	4	6	8	10
5	5	5.2	5.4	5.6	5.9	6.1
10	10	10.9	12	13.2	14.5	15.9
15	15	17.3	20	23.3	27.2	31.8
20	20	24.3	29.8	36.8	45.8	57.3
25	25	32	41.6	54.9	73.1	98.3
30	30	40.6	56.1	79.1	113.3	164.5
35	35	50	73.7	111.4	172.3	271
40	40	60.4	95	154.8	259.1	442.6

Source: Departemen Permukiman dan Prasarana Wilayah. 2003. Pedoman Konstruksi dan Bangunan Perencanaan Perkerasan Beton Semen

3.3. 2. Planning JSKN

$$Planning\ JSKN = JSKN \times distribution\ coef$$ .... **(Eq 3-4)**

Table 3.2. Distribution Coefficient

Width of Pavement	lane	Commercial vehicle	
		1 line	2 lines
Lp<5.50 m	1 Lane	1	1
5.50 m ≤ Lp < 8.25 m	2 Lanes	0.70	0.50
8.25 m ≤ Lp < 11.25 m	3 Lanes	0.50	0.475
11.25 m ≤ Lp < 15.00 m	4 Lanes	-	0.45
15.00 m ≤ Lp < 18.75 m	5 Lanes	-	0.425
18.75 m ≤ Lp < 22.00 m	6 Lanes	-	0.40

Source: Departemen Permukiman dan Prasarana Wilayah. 2003. Pedoman Konstruksi dan Bangunan Perencanaan Perkerasan Beton Semen

3.3. 3. Load Proportion

$$\text{Load Proportion} = \frac{\text{amount of axle}}{\text{total of axle amount}}$$ .... **(Eq 3-5)**

3.3. 4. Axle Proportion

$$\text{Axle Proportion} = \frac{\text{Total of axle amount}}{\text{JSKNH}}$$ .... **(Eq 3-6)**

3.3. 5. Repetition Occur

the equation of repetition occur will be at below:

$$Repetition\ Occur = Load\ proportion \times Axle\ proportion \times Planning\ JSKN$$ .... **(Eq 3-7)**

3.3. 6. Safety Factor

To know the safety factor, the value can be seen in Table 3.3.

Table 3.3. Safety Factor (FK)

Road	**Safety Factor (FK)**
Toll	1.2
Artery	1.1
Collector	1.0
Local	-

Source: Departemen Permukiman dan Prasarana Wilayah. 2003. Pedoman Konstruksi dan Bangunan Perencanaan Perkerasan Beton Semen

3.3. 7. Flexural tensile Strength

the equation of flexural tensile strength will be at below:

$$F_{cf} = K\sqrt{F_c'}$$ .... **(Eq 3-8)**

Where:

K= Constant (aggregate not break 0.7 and break aggregate 0.75)

3.3. 8. Thickness of Base Foundation

Thickness of base foundation can get from relation between CBR and repetition occur. See figure 3.2.

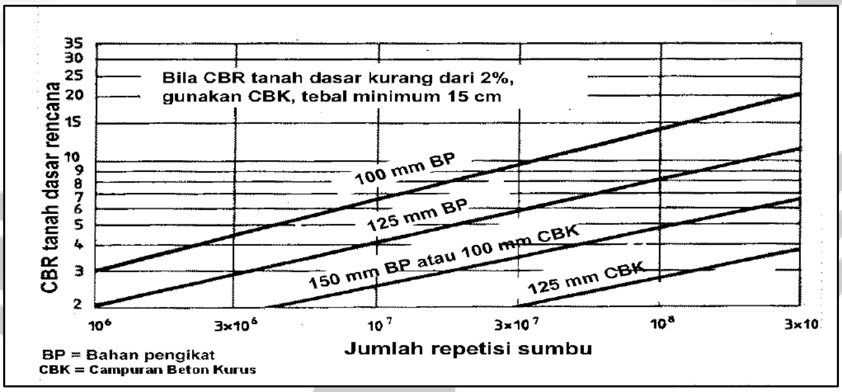


Figure 3.2. Thickness of Base Foundation
Source: Departemen Permukiman dan Prasarana Wilayah. 2003. Pedoman Konstruksi dan Bangunan Perencanaan Perkerasan Beton Semen

3.3. 9. Effective CBR

Effective CBR can get from relation between base foundation and CBR. See figure 3.3.

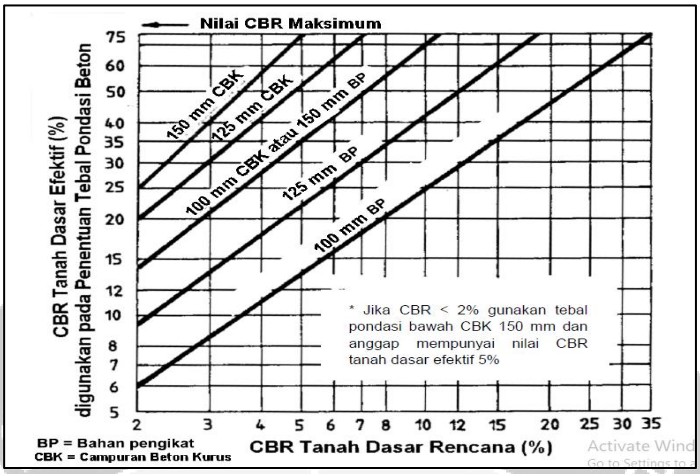


Figure 3.3. Effective CBR

Source: Departemen Permukiman dan Prasarana Wilayah. 2003. Pedoman Konstruksi dan Bangunan Perencanaan Perkerasan Beton Semen

3.3. 10. Thickness of Slab

With using figure 3.4. can determine the slab thickness.

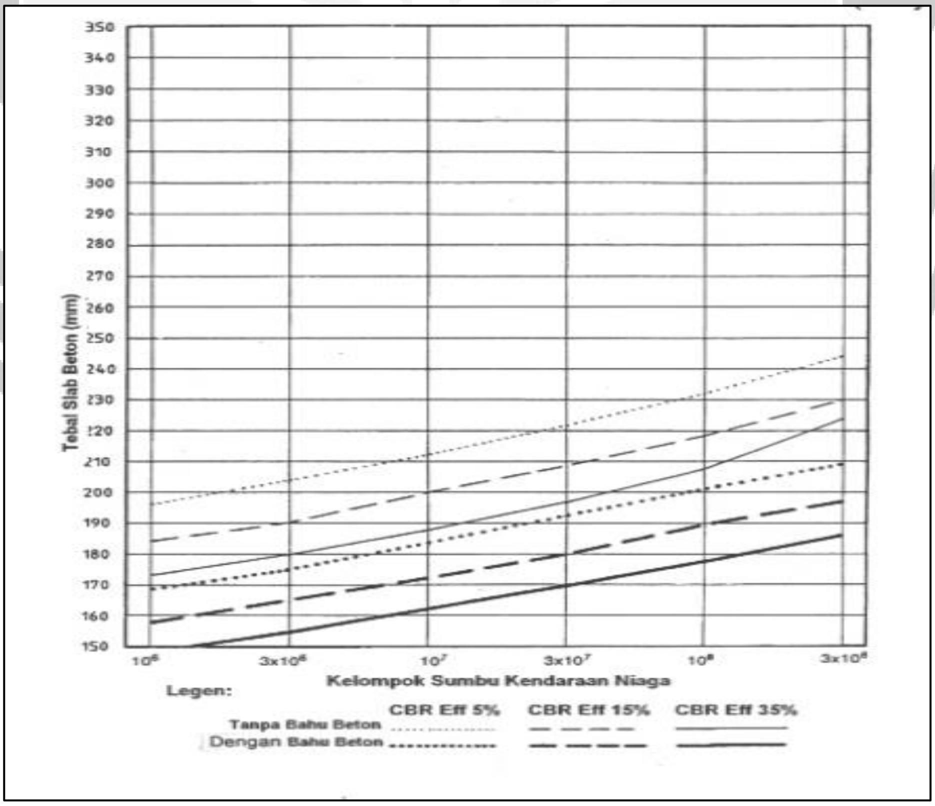


Figure 3.4. Graph of Determining Slab Thickness

Source: Departemen Permukiman dan Prasarana Wilayah. 2003. Pedoman Konstruksi dan Bangunan Perencanaan Perkerasan Beton Semen

3.3. 11. Planning Load per Wheel

the equation of Planning load per wheel will be at below:

$$\text{Load per Wheel} = \frac{\text{Axle Load} \times \text{FK}}{\text{amount of wheel}} \quad \text{...} \quad \textbf{(Eq 3-9)}$$

3.3. 12. Fatigue Analysis

The total of fatigue will be comparison with the standard (100 %). If total of fatigue ≤ 100 %, so the thickness fulfills the standard.

$$Fatigue(\%) = \frac{Repetition\ occur \times 100}{Repetition\ allowed} \quad \text{.......................................} \quad \textbf{(Eq 3-10)}$$

To get the repetition allowed for fatigue can be seen in figure 3.5.

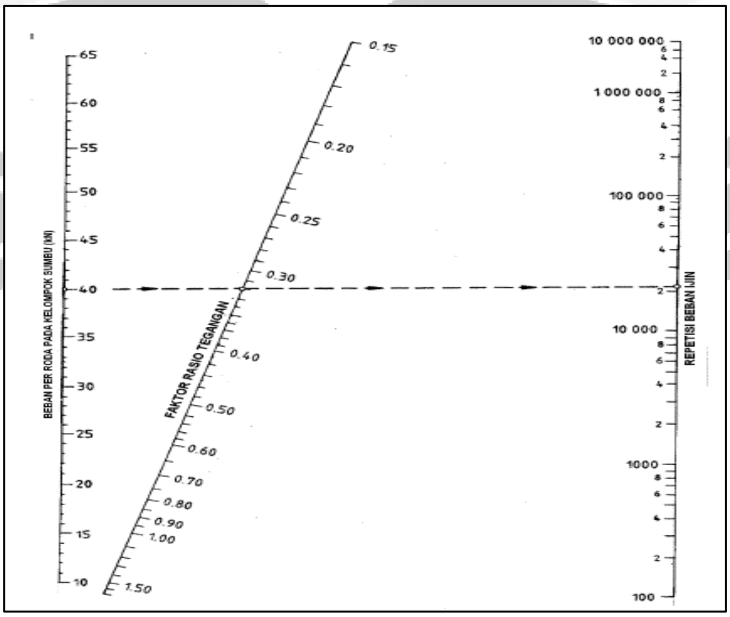


Figure 3.5. Fatigue Analysis and Repetition Allowed
Source: Departemen Permukiman dan Prasarana Wilayah. 2003. Pedoman Konstruksi dan Bangunan Perencanaan Perkerasan Beton Semen

3.3. 13. Erosion Analysis

The total of Erosion will be comparison with the standard (100 %). If total of erosion ≤ 100 %, so the thickness fulfills the standard.

$$Erosion\ (\%) = \frac{Repetition\ occur \times 100}{Repetition\ allowed}$$ ………………………………..….. **(Eq 3-11)**

To get the repetition allowed for fatigue can be seen in figure 3.6.

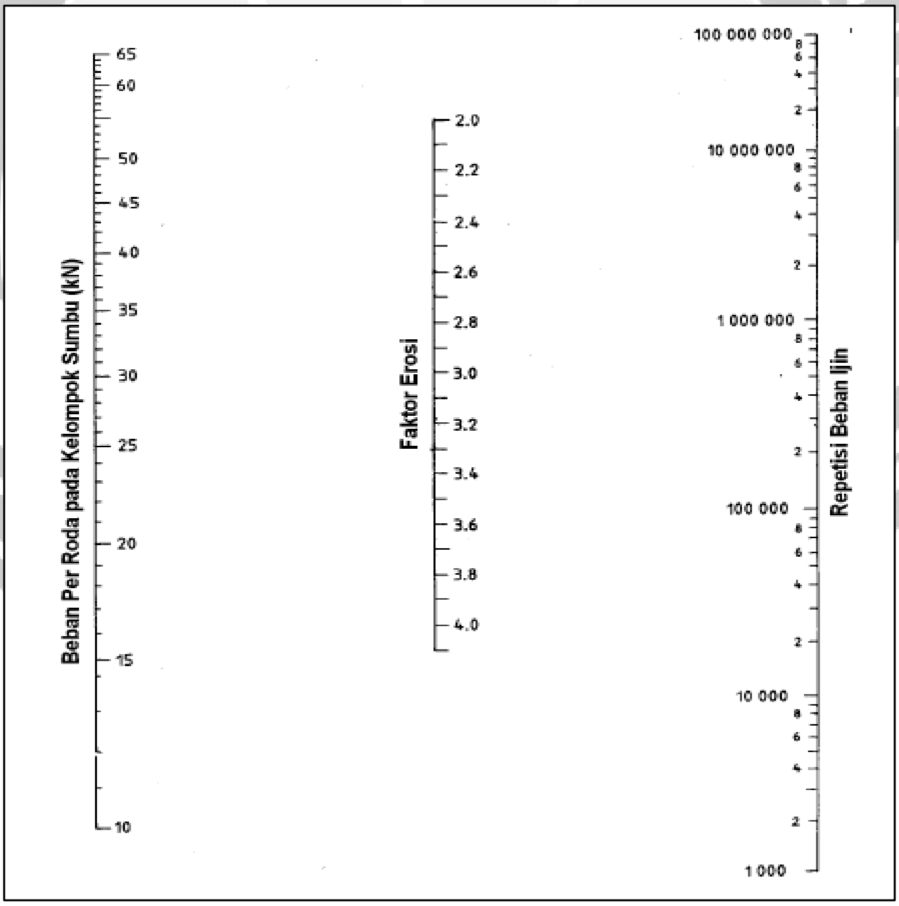


Figure 3.6. Erosion Analysis and Repetition Allowed
Source: Departemen Permukiman dan Prasarana Wilayah. 2003. Pedoman Konstruksi dan Bangunan Perencanaan Perkerasan Beton Semen

3.4. Reinforcement

There are two types of reinforcement that is needed in Continuously Reinforced Concrete Road methods:

3.4. 1. Transverse Reinforcement

$$As = \frac{ɥLMgh}{2\,Fs} \qquad \textbf{(Eq 3-12)}$$

Where:

As = Area of transverse reinforcement (mm2/m)

ɥ = Friction coefficient. See table 3.4.

L = distance (m)

M = mass (kg/m3)

g = Gravity (m/s2)

h = Thickness (m)

f_s = Stress strength (Mpa)

3.4. 2. Longitudinal Reinforcement

$$Ps = \frac{100 \times fct \times [1.3 - (0.2 \times \mu)]}{fy - (n \times fct)} \qquad \textbf{(Eq 3-13)}$$

Where:

P_s = The percentage of longitudinal area that needed to area of concrete (%)

f_{ct} = 0.5 F_{cf} (kg/cm^2)

ɥ = Friction coefficient

f_y = Yield strength (kg/cm^2)

n = Number of equivalence between steel and concrete (Es/Ec). See table 3.5

E_s = Modulus of steel elasticity = 2.1×10^6 (kg/cm^2)

E_c = Modulus of concrete elasticity = $1485\ \sqrt{f_{c'}}$ (kg/cm^2)

For Checking the theoretical distance between cracking:

$$Lcr = \frac{fct^2}{n \times p^2 \times u \times fb\ (\varepsilon s \times Ec - fct)} \qquad \textbf{(Eq 3-14)}$$

Where:

L_{cr} = Theoretical distance between cracking (cm)

p = Comparison reinforcement area with concrete of cross sectional area

u = 4/d

f_b = $(1.97\sqrt{fc'})/d$ (kg/cm^2)

n = Number of equivalence between steel and concrete (Es/Ec). See table 3.5

E_s = Modulus of steel elasticity = 2.1×10^6 (kg/cm^2)

E_c = Modulus of concrete elasticity = $14850\ \sqrt{f_{c'}}$ (kg/cm^2)

Table 3.4. Friction Coefficient

NO	Foundation Type	Friction Coefficient (ɥ)
1	Surface Treatment	2.2
2	Lime stabilization	1.8
3	Asphalt stabilization	1.8
4	Cement V	1.8
5	River gravel	1.5
6	Crushed stone	1.5
7	Sandstone	1.2
8	Natural Subgrade	0.9

Source: AASHTO, 1993. Guide for Design Pavement Structure

Table 3.5. Relation between $f_{c'}$ and Number of Equivalence between Steel and Concrete

$f_{c'}$ (kg/cm^2)	**n**
175 - 225	10
235 - 285	8
290 -	6

Source: Departemen Permukiman dan Prasarana Wilayah. 2003. Pedoman Konstruksi dan Bangunan Perencanaan Perkerasan Beton Semen