Data:

CBR of subgrade = 8%

Design of pavement by:

1) Flexible pavement by Asphalt Institute method
2) Flexible pavement by AASHTO Method
3) Flexible pavement by Road Note 31
4) Rigid pavement by Portland cement association method.
5) Rigid pavement by AASHTO Method

Computation of ESAL's						
Urban interstate highway						
Growth rate=r=	4	%				
Y=	20	years				
Vehicle type	**Traffic volume**	**Truck factor**	**GY**	**D**	**L**	**ESAL**
Animal driven	136	0.0001524	29.78	0.5	1	0
M.C & Rickshaws	3882	0.0000544	29.78	0.5	1	3
Cars and pickups	17073	0.000422	29.78	0.5	1	107
Mini buses and wagons	2242	0.012	29.78	0.5	1	401
Buses	448	0.57	29.78	0.5	1	3802
Truck 2 axle (4-tire)	614	3.8	29.78	0.5	1	34741
Truck 3 axle	110	4.54	29.78	0.5	1	7436
Tractors	48	2.15	29.78	0.5	1	1537
Tractor trollies 3 axle	360	6.5	29.78	0.5	1	34843
Tractor trollies 4 axle	0	3.85	29.78	0.5	1	0
Trailer units 4 axle	33	0.98	29.78	0.5	1	482
Trailer units 5 axle	14	1.07	29.78	0.5	1	223
Trailer units 6 axle	13	1.05	29.78	0.5	1	203
Motorized traffic	24837	0.00154	29.78	0.5	1	570
						84348

$ESAL = 8.4348 \times 10^4$

$\approx 8.5 \times 10^4$

Subgrade $CBR = 8\%$ $\Rightarrow$ From eq 7.6

$M_R = 1500\,(CBR)$

$= 1500 \times 8 = 12000\,psi$

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Computation of truck factors:

⇒ **A.D vehicle:**

$$Tf = \left(\frac{2}{18}\right)^4 = 1.52 \times 10^{-4}$$

⇒ **Motor cycle and Rickshaws:**

900 lbs (M.C wt.)
+ 440 lbs (Passengers)
―――――――
1340 lbs
670 lbs on each tire

1300 lb ↓ O   1300 lb ↓ O

$$Tf = \left(\frac{1.3}{18}\right)^4 \times 2 = 5.44 \times 10^{-5}$$

Rickshaw
1500 lbs (wt)
1100 lbs (passengers)
―――――――
2600 lbs
1300 lb on each tire

⇒ **Cars and Pickups:**

$$T_f = \left(\frac{2.17}{18}\right)^4 \times 2 = 4.22 \times 10^{-4}$$

2170 lb ↓ O   2170 lbs ↓ O

wt. of pickups = 1300 kg = 2900 lbs
Cargo wt. allowed = 650 kg = 1440 lbs
―――――――
4340 lbs

⇒ **Mini buses and wagon:**

5000 lb ↓ O   5000 lb ↓ O

wt. of hiace van = 2800 kg
wt. of passengers = 1400 kg
―――――――
≈ 10,000 lb

$$T_f = \left(\frac{5}{18}\right)^4 \times 2 = 0.012$$

⇒ **Buses:**

$$Tf = 0.57$$

6) Truck 2 axle:

Hino 2 axle truck

Max. load = 17.5t

$$T_f = \left(\frac{5.0 \times 2}{18}\right)^4 + \left(\frac{12.5 \times 2}{18}\right)^4 = 3.8$$

7) Truck 3 axles:

Hino 3 axle truck

6t 24t

Max load = 29.5 t

$$T_f = \left(\frac{6 \times 2}{18}\right)^4 + \left(\frac{24 \times 2}{32}\right)^4 \times 0.857 = 4.54$$

8) Tractor:

8t 10t

18 tonnes total

$$T_f = \left(\frac{8 \times 2}{18}\right)^4 + \left(\frac{10 \times 2}{18}\right)^4 = 2.15$$

9) Tractor trollies 3 axle

8t 10t 13t

$$T_f = \left(\frac{8 \times 2}{18}\right)^4 + \left(\frac{10 \times 2}{18}\right)^4 + \left(\frac{13 \times 2}{18}\right)^4 = 6.5$$

10) Tractor trollies 4 axle

8t 10t 19t

$$T_f = \left(\frac{8 \times 2}{18}\right)^4 + \left(\frac{10 \times 2}{18}\right)^4 + \left(\frac{19 \times 2}{32}\right)^4 \times 0.857$$

$$T_f = 3.853$$

1) Trailer units 4 axles:

$T_f = 0.98$ Pg 269 Book

2) Trailer units 5 axles:

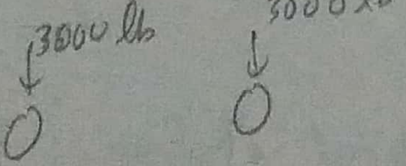
$T_f = 1.07$ (Pg 269)

3) Trailer units 6 axles:

$T_f = 1.0523$ (Pg 269)

4) Motorized vehicles:

Assuming 3000 lb/axle



$$T_f = \left(\frac{3}{18}\right)^4 \times 2 = 1.54 \times 10^{-3}$$

1) Design of flexible pavement by Asphalt Institute method:

i) Determine thickness of HMA (Full depth) for pavement.

For ESAL = 8.5×10^4 and $M_R = 12000$ psi

From fig 11.11 ⇒ Thickness of full depth HMA = 4 in (Min)

ii) Determine thickness of pavement with a HMA surface over type I emulsified asphalt base.

For ESAL = 8.5×10^4 and $M_R = 12000$ psi

From fig 11.12 ⇒ Thickness of HMA + Emulsified asphalt base = 4 in

Table 11.12 ⇒ Thickness of HMA ≠ 1.5 in

Thickness of emulsified asphalt base = 2.5 in

iii) Determine thickness of pavement with a HMA surface over type II emulsified asphalt.

From fig 11.13 ⇒ Combined thickness = 4 in

Table 11.12 Thickness of HMA ⇒ = 2 in

Thickness of emulsified asphalt base = 2 in

iv) Determine thickness of pavement with a HMA surface over type III emulsified asphalt:

From fig 11.14 ⇒ Combined thickness = 5.5 in

Table 11.12 Thickness of HMA = 2 in

Thickness of emulsified asphalt base = 3.5 in

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) Thickness of HMA over untreated aggregate base:

Untreated aggregate base thickness (in)	HMA thickness (in)
4	4 (min)
6	4 (min)
8	4 (min)
10	4 (min)
12	4 (min)
18	4 (min)

2) Design of flexible pavement by AASHTO Method:

Data:

$ESAL = 8.5 \times 10^4$ $\qquad m_2 = m_3 = 1$

$Z_R = -1.645$

$R = 95\%$

$\Delta PSI = 2.1$

$S_0 = 0.35$

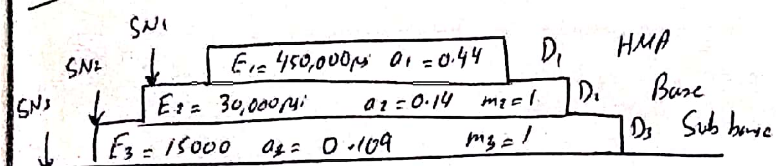
Subgrade M_R = 12000 psi

HO
t
$a_1 = 0.44$ $\qquad E_1 = 450{,}000$ psi (HMA)

$a_2 = 0.14$ $\qquad E_2 = 30{,}000$ psi (Untreated and stabilized base courses)

$a_3 = 0.109$ $\qquad E_3 = 15000$ (Granular subbase course)

Sol:



Using eq 11.37

$$\log(8.5\times10^4) = -1.645\times0.35 + 9.36\log(SN_1+1) - 0.2 + \frac{\log\left[\frac{2.1}{4.2-1.5}\right]}{0.4 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\log(30{,}000) - 8.07$$

$SN_1 = 1.31$

$$D_1 \geq \frac{SN_1}{a_1} = \frac{1.31}{0.44}$$

$D_1 = 3$ in

$$\log(8.5\times10^4) = -1.645\times0.35 + 3.36\times\log(SN_2+1) - 0.2 + \frac{\log_{10}\left(\frac{2.1}{4.2-1.5}\right)}{0.4+\frac{1094}{(SN_2+1)^{5.19}}} + 2.32\log(15000) - 8.07$$

$$SN_2 = 1.74$$

$$D_2 \geq \frac{SN_2 - a_1 D_1}{a_2 m_2}$$

Table 11.21

$$= \frac{1.74 - 0.44\times3}{0.14\times1} = 3 \text{ in}$$ (the min thickness of D_2 = 4 in)

$$\log(8.5\times10^4) = -1.645\times0.35 + 3.36\log(SN_3+1) - 0.2 + \frac{\log_{10}\left(\frac{2.1}{4.2-1.5}\right)}{0.4+\frac{1094}{(SN_3+1)^{5.19}}} + 2.32\log(12000) - 8.07$$

$$SN_3 = 1.90$$

$$D_3 \geq \frac{SN_3 - a_1 D_1 - a_2 D_2 m_2}{a_3 m_3}$$

$$D_3 = \frac{1.9 - 0.44\times3 - 0.14\times4\times1}{0.109\times1} = ~~1.47~~ \text{ in} \quad 0.18 \text{ in}$$

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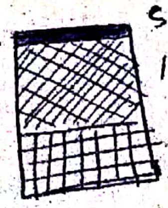
3) Design of flexible pavement by Road note 31:

Traffic class ⇒ $ESAL = 0.085\times10^6$ ⇒ Traffic class = T_1

Subgrade strength class = CBR Range = 8–14 ⇒ Class = S4

Granular Road Base / Surface dressing:



SD

150 mm Granular Road base GB1 - GB3

125 mm Granular Sub base, GS

) Design of Rigid Pavement by PCA method:

Data:

$E_c = 4 \times 10^6$ psi

$\nu_c = 0.15$

dia of dowels = $\frac{1}{8}$ in/in of slab

Dowel spacing = 12 in

Modulus of dowel support = 2×10^6 psi

Spring constant for ~~dowel~~ aggregate interlocking joints = 5000 psi

Spring constant for tied concrete shoulders = 25000 psi

Sol.

Modulus of subgrade reaction.

As CBR = 8% ⟹ K = 180 pci Pg 328

M_R = 12000 psi

MR = 650 psi

Simplified design procedure:

1) Axle load category = 3 (ADTT = 1192)

2) Subgrade soil type = Medium High

3) From table 12.15

Slab thickness = 7 in (With concrete shoulder)

5) Design of Rigid pavement by AASHTO Method:

Data:

$W_{18} = 8.5 \times 10^4$ $C_d = 1$ $S_c = 650\,psi$

$Z_R = -1.645$ $P_t = 2.5$ $K = 180\,pci$

$S_o = 0.35$ $J = 3.2$ $E_c = 4 \times 10^6\,psi$

$\Delta PSI = 4.2 - 2.5 = 1.7$

Sol:

By using eq 12.21

$$\log 8.5\times10^4 = -1.645\times0.35 + 7.35\log(D+1) - 0.06 + \frac{\log\left[\frac{1.7}{4.5-1.5}\right]}{1+\frac{1.624\times10^7}{(D+1)^{8.46}}}$$

$$+ (4.22 - 0.32p_t)\log\left[\frac{650\times1(D^{0.75}-1.132)}{215.63\times3.2\left[D^{0.75}-\frac{18.42}{\left(\frac{4\times10^6}{180}\right)^{0.25}}\right]}\right]$$

$$4.93 = -0.58 + 7.35\log(D+1) - 0.06 + \left[\frac{-0.25}{1+\frac{1.624\times10^7}{(D+1)^{8.46}}}\right]$$

$$+ 3.42\log\left[\frac{650(D^{0.75}-1.132)}{690\left[D^{0.75}-1.51\right]}\right]$$

D = 1.89 in