University of Asia Pacific
Department of Civil Engineering
Final Examination Fall 2012
Program: B.Sc. Engineering (Civil)

Course Title: Transportation Engineering II: Highway Design & Railways | Course Code: CE 451

Time : 3 Hours | Full Marks: 100 (=5x20)

There are SIX questions. Answer any FIVE

1. (a) What is ballast? What are the different requirements of good ballast? (1+4)
   (b) What are the different techniques to improve railway embankment stability? (4)
   (c) Describe different types of materials used as ballast in a railway track. (7)
   (d) Write a short note on ballast cushion. (4)

2. (a) State the function of Railway Signal. (5)
   (b) Discuss the classification of Fixed Signals. (10)
   (c) What is interlocking? (5)

3. (a) Elaborately explain different type of distresses in rigid and flexible pavement. Also discuss the causes of these distresses and relevant remedial measures. (12)
   (b) Design a minimum thickness of flexible pavement (i.e. thickness of different layers) for the following traffic condition: (8)

Daily Count	Axle load (kips)
2000 (Single Axle)	12
2000 (Single Axle)	20
100(Single Axle)	34
100 (Tandem Axle)	50

Given:
Sub grade soil CBR value is 5
Design life is 20 years
Traffic growth rate is 6% per annum
Reliability is 90%
Overall standard deviation is 0.45
Design serviceability loss is 3.0
Available material:

- Hot mix asphalt surface concrete (a_1=0.44)
- Crushed stone base course (a_2=0.14, m_2=0.4 & Mr_2= 35 ksi)
- Crushed stone sub base (a_3=0.11, m_3=0.9 & Mr_3= 15.5 ksi)

Note: AASHTO Design Chart is in Fig 1.

4. (a) Describe different stresses that development in rigid pavement. What is pumping of joints? (3+4)

(b) What are the fundamental properties of bituminous mixture? (2)

(c) Given below the requirements of a specification related to the grading of the mineral aggregates in an asphaltic concrete mixture and the sieve analyses of the two aggregates (A and B) that are economically available for this use. Determine the range of blends of aggregates A and B will produce a combined aggregate that will meet the limits of the specification and given the gradings of the aggregate combinations selected. (8)

Sieve Designation	Percentage passing (by weight)		
	Aggregate A	Aggregate B	Mix
2"	100	-	-
1"	100	100	100
3/8"	68	45	50-85
# 4	42	28	35-65
#10	30	17	25-50
# 40	28	7	15-30
#200	11	3	5-15

(d) What is air – entrained concrete mixture? (3)

5. (a) Compare the rigid and flexible pavement systems from various criteria. (5)

(b) Write a short note on slump test. (2)

(c) For a four –lane expressway between Dhaka and Chittagong, the outer lanes have been decided to be cement concrete rigid pavement to carry heavy vehicles. Combined K of the sub grade and a 4 inch thick untreated granular base is 100 lb/in^3. Design period is 20 years. Over this period, the expected loadings of heavy vehicle in each direction are tabulated below. Determine the minimum thickness of slab that can be used safely for the outer lanes if the modulus of rupture of concrete is 650 psi (28 days). Assumed doweled joints and no concrete shoulder. Show calculations in a tabular form (at least two trials). Assume reasonable value for missing data, if any. (13)

Axle load, kips		Expected repetitions
Single axle	30	20,000
	26	75,000
	22	3500,000
	18	1000,00
	14	900,000
Tandem Axle	52	920,00
	48	1500,00
	32	2500,000
	40	4600,000
	36	9500,000
	32	Unlimited

Note: PCA Method design tables and figures are attached.

6. (a) Discuss the outcomes of AASHO Road Test. (5)
(b) Explain "Pavement Serviceability Concept." (3)
(c) An asphalt concrete surface course mixture is being designed by Marshall Method for heavy traffic. Test results for different asphalt contents are given in the following table: (12)

Asphalt content (%)	Unit wt. of specimens, (pcf)	Marshall stability (lbs)	Marshall flow value	V_a (%)	VMA (%)
4.5	150.32	1732	8.0	5.40	16.30
5.0	151.63	1785	9.0	3.10	14.90
5.5	152.88	1808	11.0	2.45	15.45
6.0	152.56	1652	14.0	1.90	15.19
6.5	151.63	1426	18.0	0.82	16.30

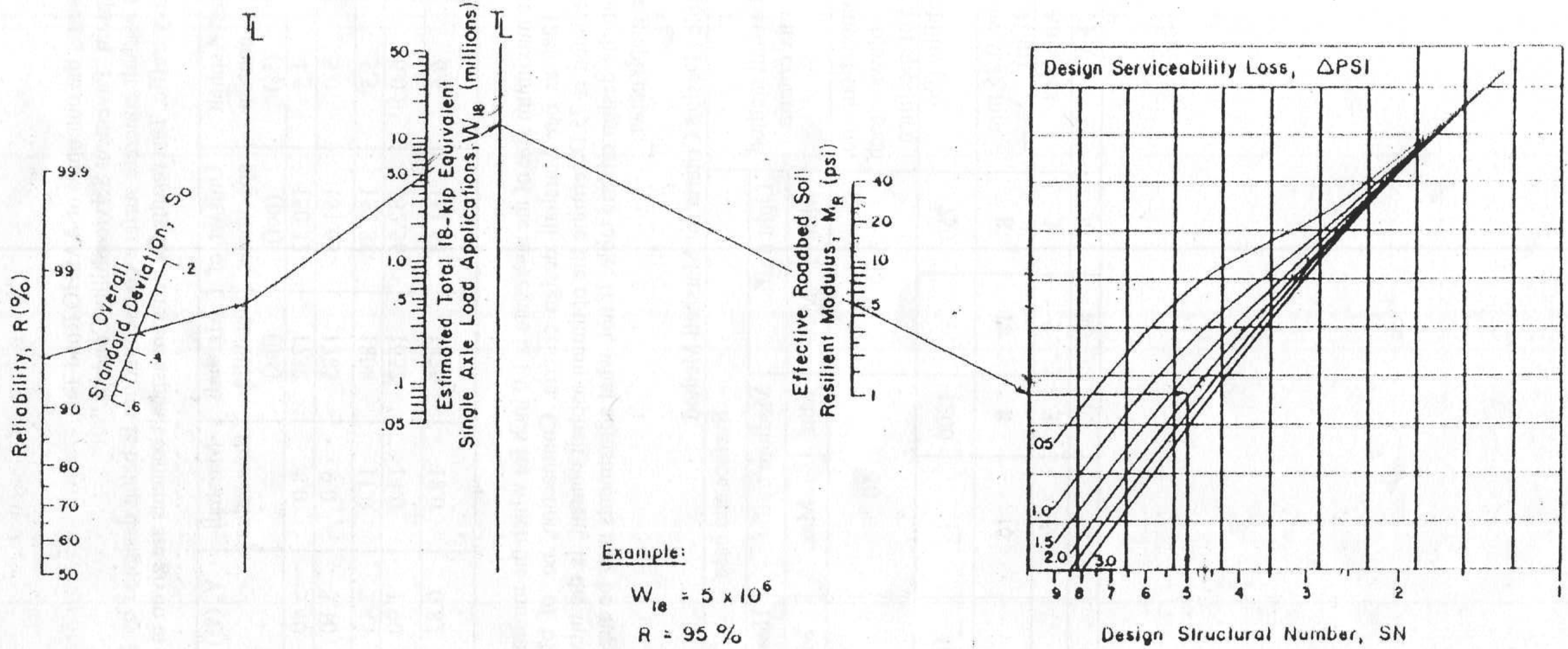
The maximum size of the aggregate is 1.0 inch for which the minimum VMA% should be 12% as per Marshall design criteria. Compaction, no. of blows in each end of specimen is 75.Determine the optimum asphalt content. Is the mix satisfactory? Check from the design criteria table. If not, what adjustments may be suggested? To plot data, use graph paper.

Table : Design Criteria for Marshall Method

Marshall method mix criteria	Surface and base					
	Light traffic		Medium traffic		Heavy traffic	
	Min.	Max.	Min.	Max.	Min.	Max.
Compaction, no. of blows each end of specimen	35		50		75	
Stability (lb)	750	-	1200	-	1800	-
Flow, 0.25 mm (0.01 in)	8	18	8	16	8	14
% Air voids	3	5	3	5	3	5
% VFA	70	80	65	78	65	75

NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R * S_o + 9.36 * \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10} M_R - 8.07$$



Example:

$W_{18} = 5 \times 10^6$

$R = 95\ \%$

$S_o = 0.35$

$M_R = 5000$ psi

$\Delta PSI = 1.9$

Solution: SN = 5.0

FIGURE [redacted] AASHTO design chart for flexible pavements based on using mean values for each input. (Courtesy American Association of Highway and Transportation Officials.)

Table : 1

Ta[redacted]. Equivalent Stress — No Concrete Shoulder (Single Axle/Tandem Axle)

Slab thickness, in.	k of subgrade-subbase, pci						
	50	100	150	200	300	500	700
4	825/679	726/585	671/542	634/516	584/486	523/457	484/443
4.5	699/586	616/500	571/460	540/435	498/406	448/378	417/363
5	602/516	531/436	493/399	467/376	432/349	390/321	363/307
5.5	526/461	464/387	431/353	409/331	379/305	343/278	320/264
6	465/416	411/348	382/316	362/296	336/271	304/246	285/232
6.5	417/380	367/317	341/286	324/267	300/244	273/220	256/207
7	375/349	331/290	307/262	292/244	271/222	246/199	231/186
7.5	340/323	300/268	279/241	265/224	246/203	224/181	210/169
8	311/300	274/249	255/223	242/208	225/188	205/167	192/155
8.5	285/281	252/232	234/208	222/193	206/174	188/154	177/143
9	264/264	232/218	216/195	205/181	190/163	174/144	163/133
9.5	245/248	215/205	200/183	190/170	176/153	161/134	151/124
10	228/235	200/193	186/173	177/160	164/144	150/126	141/117
10.5	213/222	187/183	174/164	165/151	153/136	140/119	132/110
11	200/211	175/174	163/155	154/143	144/129	131/113	123/104
11.5	188/201	165/165	153/148	145/136	135/122	123/107	116/98
12	177/192	155/158	144/141	137/130	127/116	116/102	109/93
12.5	168/183	147/151	136/135	129/124	120/111	109/97	103/89
13	159/176	139/144	129/129	122/119	113/106	103/93	97/85
13.5	152/168	132/138	122/123	116/114	107/102	98/89	92/81
14	144/162	125/133	116/118	110/109	102/98	93/85	88/78

Table : 2

[redacted]. Equivalent Stress — Concrete Shoulder (Single Axle/Tandem Axle)

Slab thickness, in.	k of subgrade-subbase, pci						
	50	100	150	200	300	500	700
4	640/534	559/468	517/439	489/422	452/403	409/388	383/384
4.5	547/461	479/400	444/372	421/356	390/338	355/322	333/316
5	475/404	417/349	387/323	367/308	341/290	311/274	294/267
5.5	418/360	368/309	342/285	324/271	302/254	276/238	261/231
6	372/325	327/277	304/255	289/241	270/225	247/210	234/203
6.5	334/295	294/251	274/230	260/218	243/203	223/188	212/180
7	302/270	266/230	248/210	236/198	220/184	203/170	192/162
7.5	275/250	243/211	226/193	215/182	201/168	185/155	176/148
8	252/232	222/196	207/179	197/168	185/155	170/142	162/135
8.5	232/216	205/182	191/166	182/156	170/144	157/131	150/125
9	215/202	190/171	177/155	169/146	158/134	146/122	139/116
9.5	200/190	176/160	164/146	157/137	147/126	136/114	129/108
10	186/179	164/151	153/137	146/129	137/118	127/107	121/101
10.5	174/170	154/143	144/130	137/121	128/111	119/101	113/95
11	164/161	144/135	135/123	129/115	120/105	112/95	106/90
11.5	154/153	136/128	127/117	121/109	113/100	105/90	100/85
12	145/146	128/122	120/111	114/104	107/95	99/86	95/81
12.5	137/139	121/117	113/106	108/99	101/91	94/82	90/77
13	130/133	115/112	107/101	102/95	96/86	89/78	85/73
13.5	124/127	109/107	102/97	97/91	91/83	85/74	81/70
14	118/122	104/103	97/93	93/87	87/79	81/71	77/67

Table : 3

[redacted]. Erosion Factors — Doweled Joints, No Concrete Shoulder (Single Axle/Tandem Axle)

Slab thickness, in.	k of subgrade-subbase, pci					
	50	100	200	300	500	700
4	3.74/3.83	3.73/3.79	3.72/3.75	3.71/3.73	3.70/3.70	3.68/3.67
4.5	3.59/3.70	3.57/3.65	3.56/3.61	3.55/3.58	3.54/3.55	3.52/3.53
5	3.45/3.58	3.43/3.52	3.42/3.48	3.41/3.45	3.40/3.42	3.38/3.40
5.5	3.33/3.47	3.31/3.41	3.29/3.36	3.28/3.33	3.27/3.30	3.26/3.28
6	3.22/3.38	3.19/3.31	3.18/3.26	3.17/3.23	3.15/3.20	3.14/3.17
6.5	3.11/3.29	3.09/3.22	3.07/3.16	3.06/3.13	3.05/3.10	3.03/3.07
7	3.02/3.21	2.99/3.14	2.97/3.08	2.96/3.05	2.95/3.01	2.94/2.98
7.5	2.93/3.14	2.91/3.06	2.88/3.00	2.87/2.97	2.86/2.93	2.84/2.90
8	2.85/3.07	2.82/2.99	2.80/2.93	2.79/2.89	2.77/2.85	2.76/2.82
8.5	2.77/3.01	2.74/2.93	2.72/2.86	2.71/2.82	2.69/2.78	2.68/2.75
9	2.70/2.96	2.67/2.87	2.65/2.80	2.63/2.76	2.62/2.71	2.61/2.68
9.5	2.63/2.90	2.60/2.81	2.58/2.74	2.56/2.70	2.55/2.65	2.54/2.62
10	2.56/2.85	2.54/2.76	2.51/2.68	2.50/2.64	2.48/2.59	2.47/2.56
10.5	2.50/2.81	2.47/2.71	2.45/2.63	2.44/2.59	2.42/2.54	2.41/2.51
11	2.44/2.76	2.42/2.67	2.39/2.58	2.38/2.54	2.36/2.49	2.35/2.45
11.5	2.38/2.72	2.36/2.62	2.33/2.54	2.32/2.49	2.30/2.44	2.29/2.40
12	2.33/2.68	2.30/2.58	2.28/2.49	2.26/2.44	2.25/2.39	2.23/2.36
12.5	2.28/2.64	2.25/2.54	2.23/2.45	2.21/2.40	2.19/2.35	2.18/2.31
13	2.23/2.61	2.20/2.50	2.18/2.41	2.16/2.36	2.14/2.30	2.13/2.27
13.5	2.18/2.57	2.15/2.47	2.13/2.37	2.11/2.32	2.09/2.26	2.08/2.23
14	2.13/2.54	2.11/2.43	2.08/2.34	2.07/2.29	2.05/2.23	2.03/2.19

Table : 4

[redacted] Erosion Factors — Aggregate-Interlock Joints, No Concrete Shoulder (Single Axle/Tandem Axle)

Slab thickness, in.	k of subgrade-subbase, pci					
	50	100	200	300	500	700
4	3.94/4.03	3.91/3.95	3.88/3.89	3.86/3.86	3.82/3.83	3.77/3.80
4.5	3.79/3.91	3.76/3.82	3.73/3.75	3.71/3.72	3.68/3.68	3.64/3.65
5	3.66/3.81	3.63/3.72	3.60/3.64	3.58/3.60	3.55/3.55	3.52/3.52
5.5	3.54/3.72	3.51/3.62	3.48/3.53	3.46/3.49	3.43/3.44	3.41/3.40
6	3.44/3.64	3.40/3.53	3.37/3.44	3.35/3.40	3.32/3.34	3.30/3.30
6.5	3.34/3.56	3.30/3.46	3.26/3.36	3.25/3.31	3.22/3.25	3.20/3.21
7	3.26/3.49	3.21/3.39	3.17/3.29	3.15/3.24	3.13/3.17	3.11/3.13
7.5	3.18/3.43	3.13/3.32	3.09/3.22	3.07/3.17	3.04/3.10	3.02/3.06
8	3.11/3.37	3.05/3.26	3.01/3.16	2.99/3.10	2.96/3.03	2.94/2.99
8.5	3.04/3.32	2.98/3.21	2.93/3.10	2.91/3.04	2.88/2.97	2.87/2.93
9	2.98/3.27	2.91/3.16	2.86/3.05	2.84/2.99	2.81/2.92	2.79/2.87
9.5	2.92/3.22	2.85/3.11	2.80/3.00	2.77/2.94	2.75/2.86	2.73/2.81
10	2.86/3.18	2.79/3.06	2.74/2.95	2.71/2.89	2.68/2.81	2.66/2.76
10.5	2.81/3.14	2.74/3.02	2.68/2.91	2.65/2.84	2.62/2.76	2.60/2.72
11	2.77/3.10	2.69/2.98	2.63/2.86	2.60/2.80	2.57/2.72	2.54/2.67
11.5	2.72/3.06	2.64/2.94	2.58/2.82	2.55/2.76	2.51/2.68	2.49/2.63
12	2.68/3.03	2.60/2.90	2.53/2.78	2.50/2.72	2.46/2.64	2.44/2.59
12.5	2.64/2.99	2.55/2.87	2.48/2.75	2.45/2.68	2.41/2.60	2.39/2.55
13	2.60/2.96	2.51/2.83	2.44/2.71	2.40/2.65	2.36/2.56	2.34/2.51
13.5	2.56/2.93	2.47/2.80	2.40/2.68	2.36/2.61	2.32/2.53	2.30/2.48
14	2.53/2.90	2.44/2.77	2.36/2.65	2.32/2.58	2.28/2.50	2.25/2.44

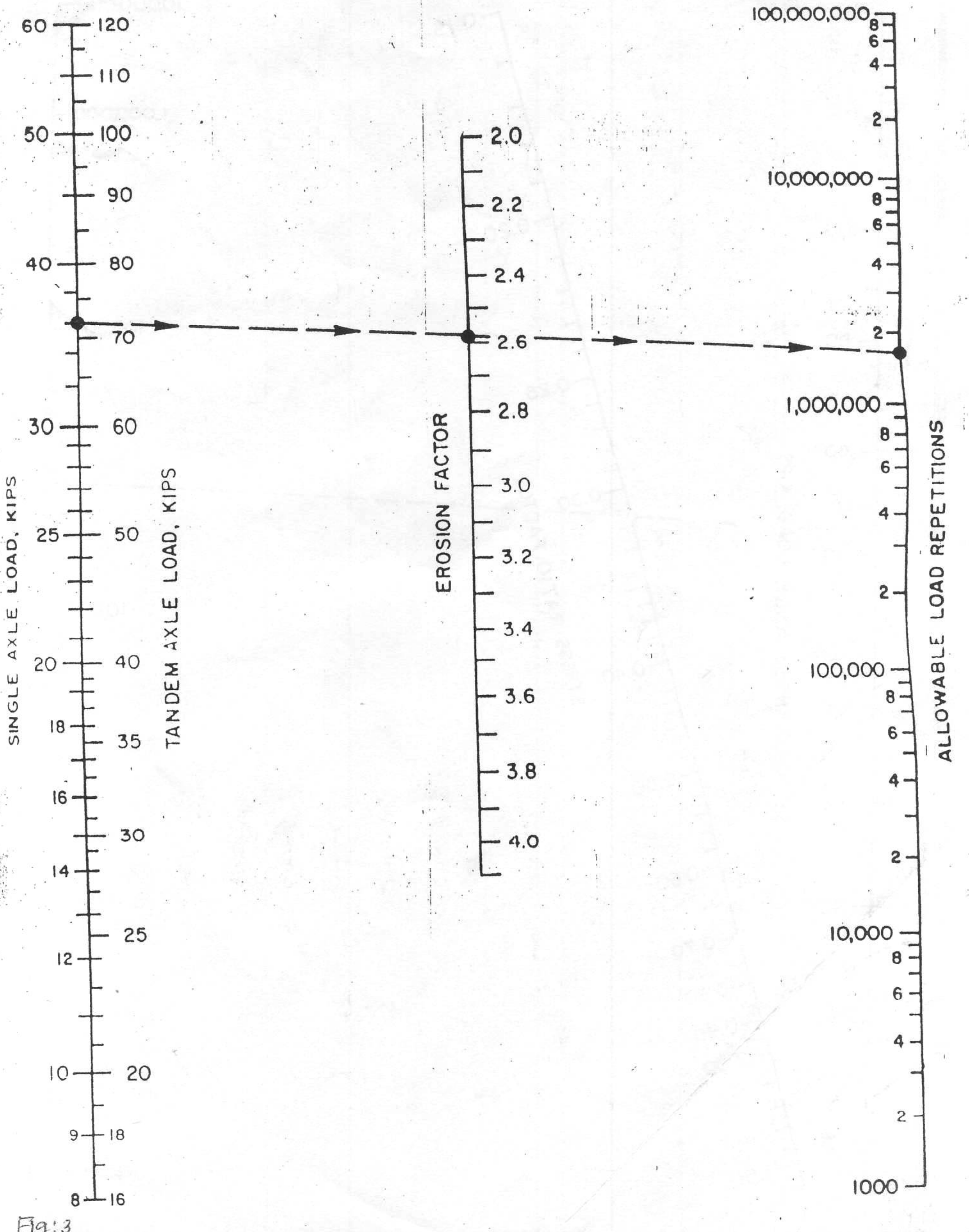


Fig:3

[redacted]/ Erosion analysis—allowable load repetitions based on erosion factor (without concrete shoulder).

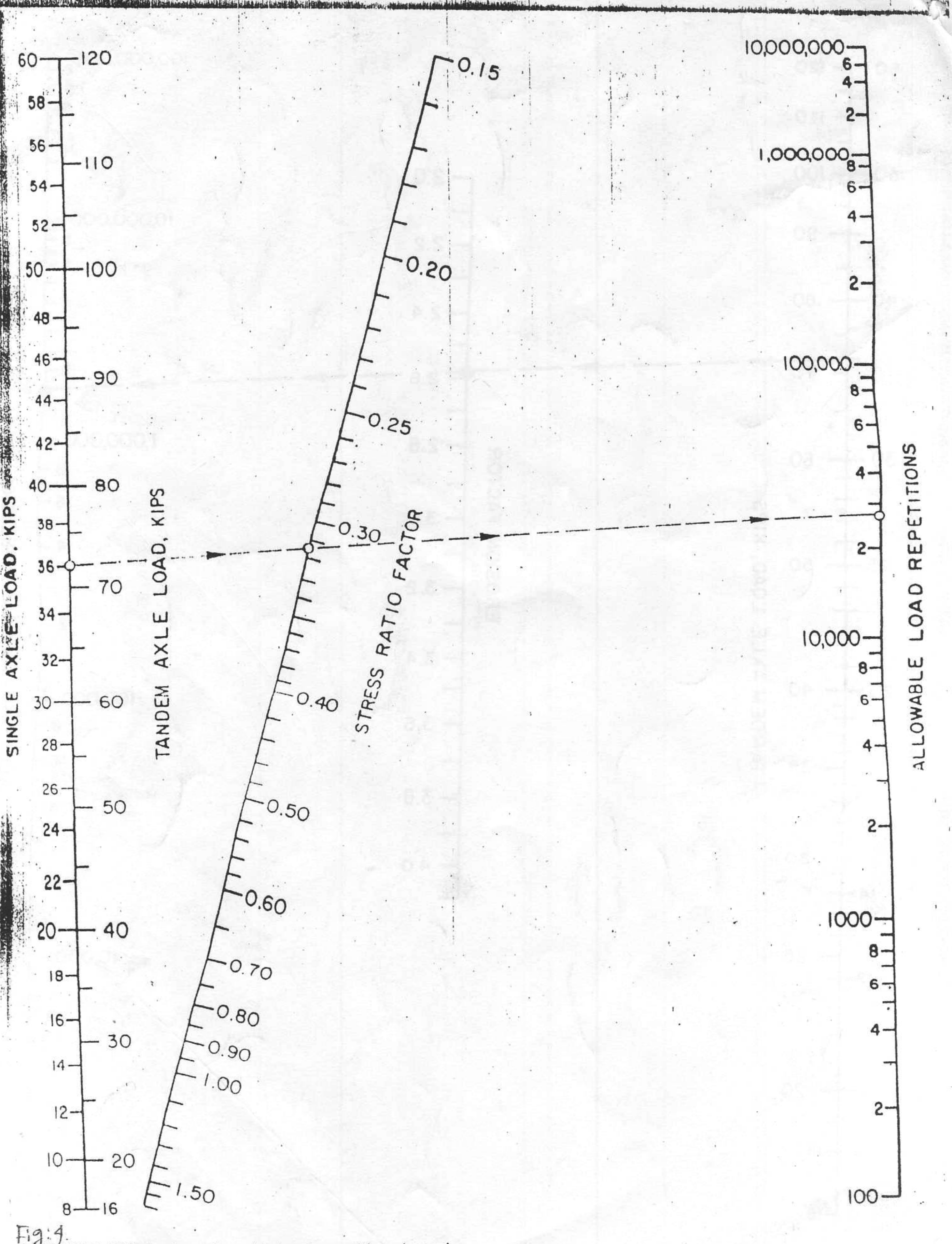


Fig: 4.

Fatigue analysis—allowable load repetitions based on stress ratio factor (with and without concrete shoulder).