Bengal Engineering and Science University, Shibpur
M.E. (Civil) First Semester Examination, 2013
Pavement Design - I (CE-919)

Full Marks : 70 **Time : 3 hours**

Answer any *FIVE* Questions
The questions are of Equal Value
Assume data reasonably, if required.

1(a) Illustrate with the help of a sketch the general concept of a multilayered elastic system, showing the stresses acting on a typical element. Clearly state the assumptions involved.

(b) With the help of Burmister's two-layer theory show the variation of vertical stress with depth , and compare it with that from Boussinesq's one-layer theory.

(c) Describe the steps in the design of base course thickness following Burmister method.
(d) What additional information can be obtained from Huang's extension of Burmister's solution? (14)

2. From a designer's point of view, discuss in detail how you would approach to find optimum values of layer thicknesses and the values of modulus of elasticity of the layer materials representing the quality of the layer materials. (14)

3. For a three-layer pavement structure, the following are the layer details:
i) Asphalt concrete surface of thickness 150 mm and modulus of elasticity of 2.8×10^6 kPa
ii) Granular base of thickness 600 mm and modulus of elasticity of 1.4×10^5 kPa
iii) Subgrade of modulus of elasticity of 0.7×10^5 kPa.
Assuming a Poisson's ratio of 0.5 for all the layers, calculate the following strains along the centre line of of a 283 kN wheel load with 1000 kPa tyre pressure. Clearly show the interpolations, if any.
a) the vertical compressive strain at the top of the subgrade

b) the horizontal tensile strain at the bottom of the asphalt concrete layer.

c) Is there any other strain to be calculated as per IRC: 37-2001 stipulations? (2x5+4)
[Note: Use of Peattie's chart and Jone's tables are allowed.]

OR

3.(a) With the help of a neat sketch show the critical locations for checking of strains in flexible pavements as per IRC :37-2012.

(b) Describe with sketches the phenomena of (i) fatigue failure and (ii) rutting failure in pavements.

(c) State the fatigue criteria and rutting criteria stipulated in IRC: 37-2012.

(d) What are the recommendations for obtaining the modulus of elasticity of subgrade, sub-base and base layers? (14)

4. a) Derive the analytical relationship between the ESWL and single wheel load by using the clear distance between the tyres and depth of the pavement.

(P.T.O.)

b) A set of dual tyres is spaced at 800 mm center to center and caries a total load of 10 kN with a tyre pressure of 700 kPa. Assuming the pavement to be a homogeneous half-space, determine the ESWL for a pavement of 635 mm using by the Foster and Ahlvin method and Boussinesq's theory. (6+8)

5. a) Discuss the principal parameters to be considered in the design of flexible pavements.

b) The existing pavement (two lanes) of a road has 380 mm of granular materials. The Subgrade CBR is 3%. The traffic on the road is 400 CVPd. The rate of growth being 7% per annum. The design life is 15 years after completion. The period of completion being 3 years. The VDF is 2.5. Calculate the overlay needed.

Cumulative Traffic (msa)	Total Pavement thickness (mm)	PAVEMENT COMPOSITION			
		Bituminous Surfacing (mm)		Granular base (mm)	Granular sub-base(mm)
		Wearing course	Binder course		
1	550	20PC		225	335
2	610	20PC	50 BM	225	335
3	645	20PC	60 BM	250	335
5	690	25 SDBC	60 DBM	250	335
10	760	40 BC	90 DBM	250	380
20	790	40 BC	120 DBM	250	380
30	810	40 BC	1400 DBM	250	380
50	830	40 BC	1600 DBM	250	380
100	860	50 BC	1800 DBM	250	380
150	890	50 BC	2100 DBM	250	380

(5+9)

6. a) Explain with neat sketch the subsurface drainage system.

b) Consider a permeable base layer resting on a soil layer. Their gradations are shown in the table. Determine if there is a need for an intermediate filter layer between the two.

Table: Gradation for soil

Sieve (mm)	% passing	Sieve (mm)	% passing
10.00	100	600μ	48
4.75	90	300μ	35
2.00	72	150μ	25
1.00	63	75μ	12

(6+8)

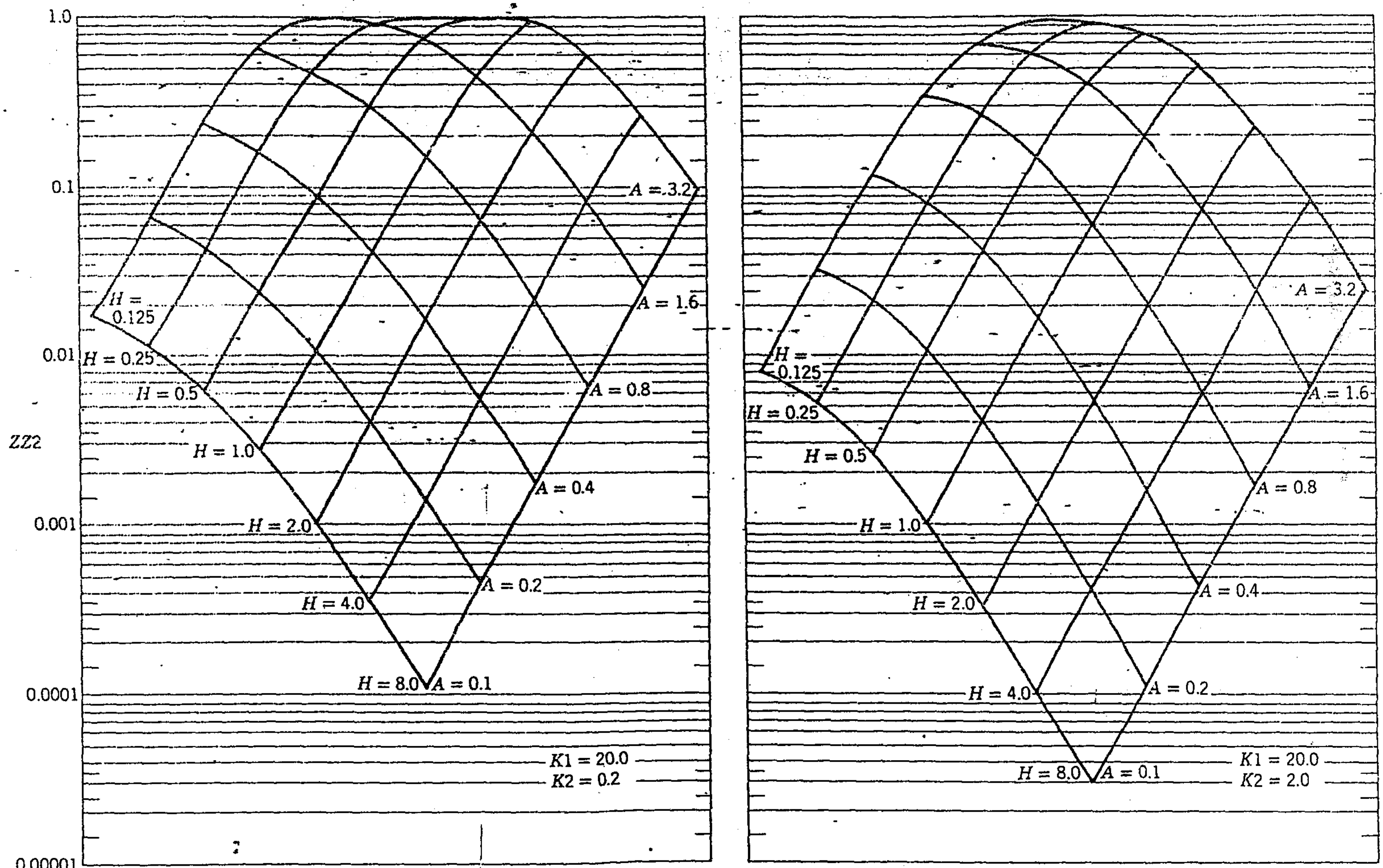
7. Write short notes on

a) Distribution of commercial traffic over the carriageway as per IRC-37 guidelines.

b) Utilization of geo-textiles as drainage materials

c) Required corrections on the measured deflection by BBD method

d) Camber in roadway pavements (3+4+4+3)


1.0
0.1
0.01
0.001
0.0001
0.00001
ZZ2
H = 0.125
H = 0.25
H = 0.5
H = 1.0
H = 2.0
H = 4.0
H = 8.0
A = 0.1
A = 0.2
A = 0.4
A = 0.8
A = 1.6
A = 3.2
K1 = 20.0
K2 = 0.2
H = 0.125
H = 0.25
H = 0.5
H = 1.0
H = 2.0
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(g)

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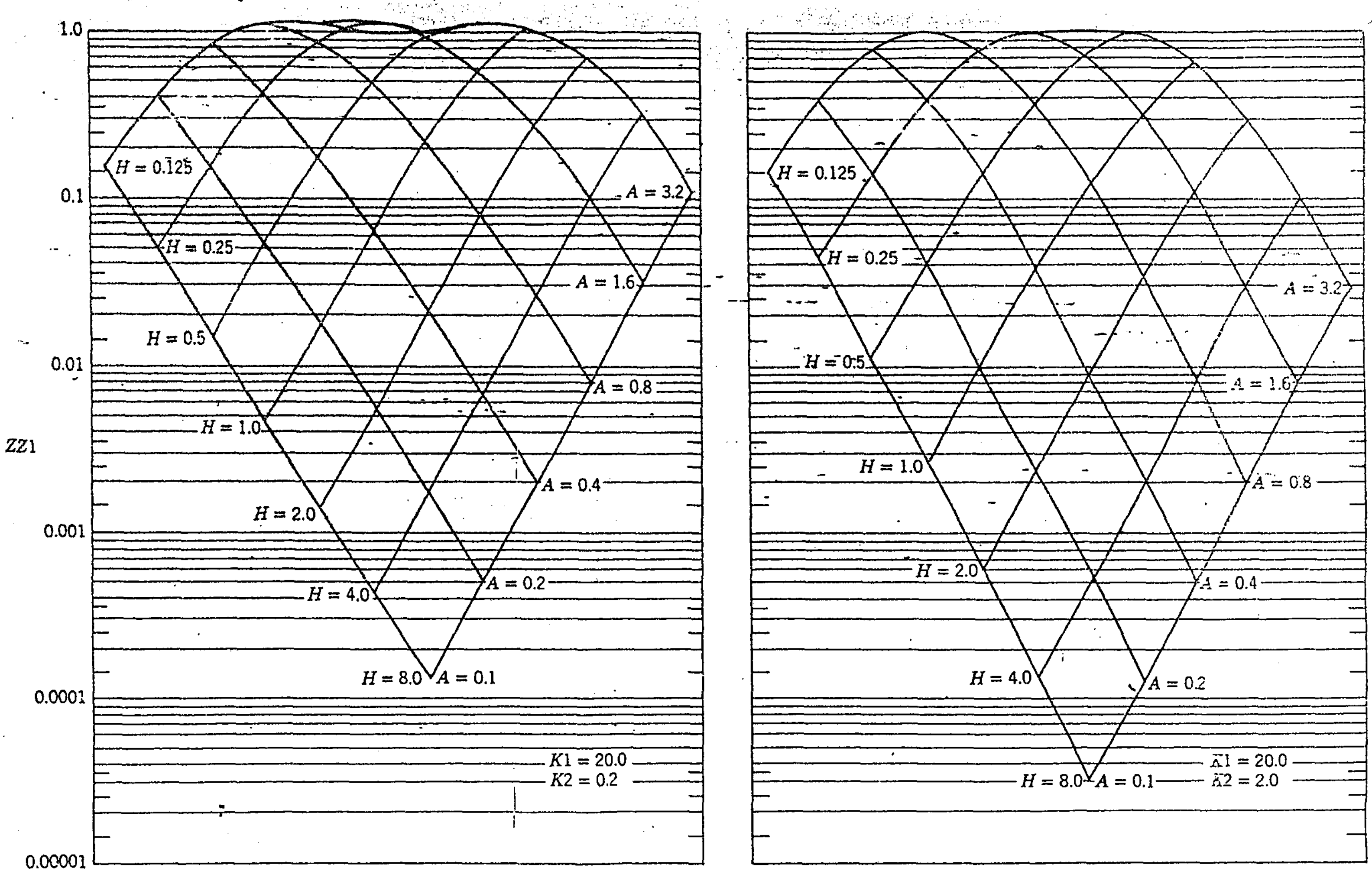
1.0
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A = 0.8
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A = 3.2
K1 = 20.0
K2 = 0.2
H = 0.125
H = 0.25
H = 0.5
H = 1.0
H = 2.0
H = 4.0
H = 8.0
A = 0.1
A = 0.2
A = 0.4
A = 0.8
A = 1.6
A = 3.2
K1 = 20.0
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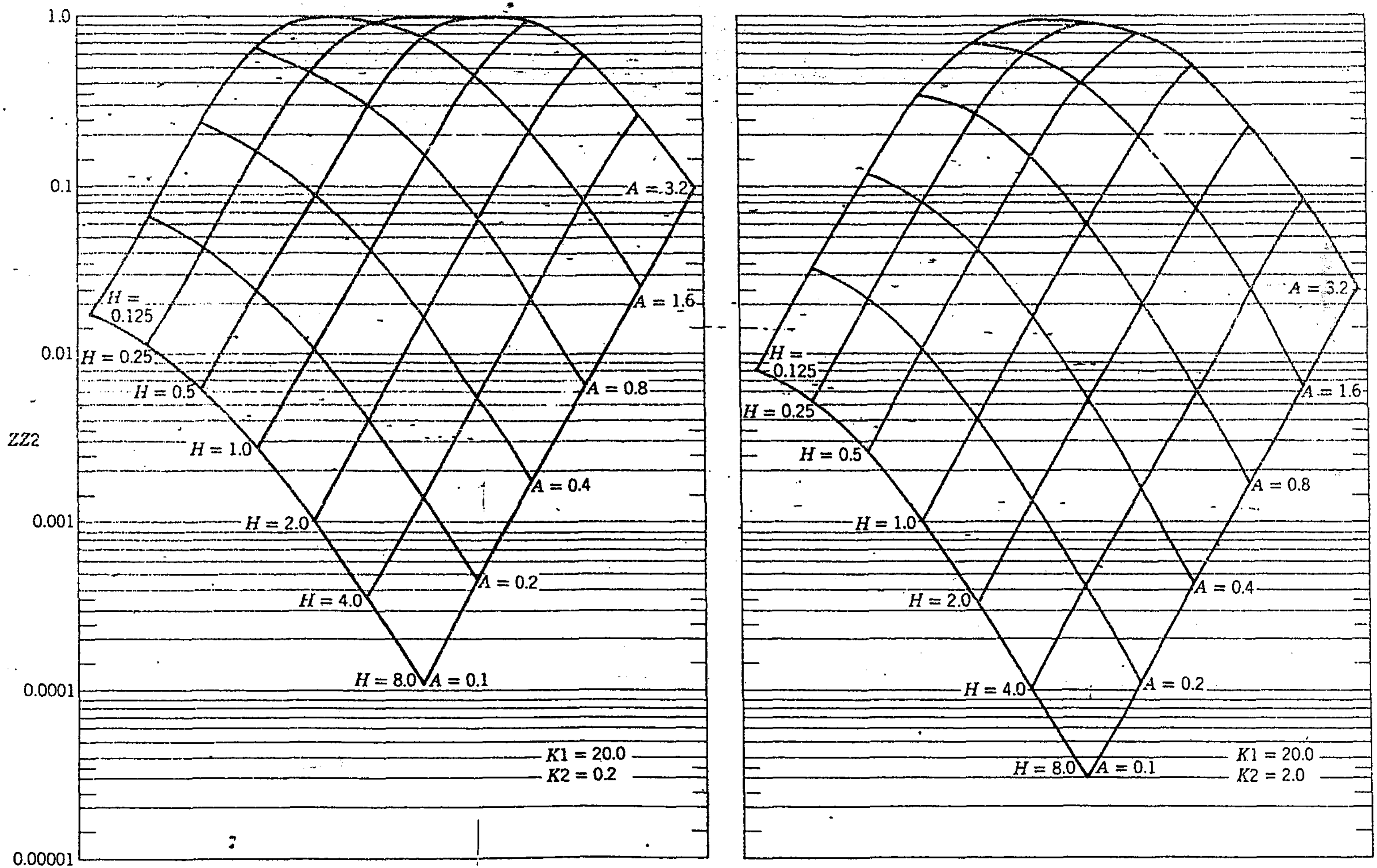
(c)



1.0
0.1
0.01
0.001
0.0001
0.00001
ZZ2
H = 0.125
H = 0.25
H = 0.5
H = 1.0
H = 2.0
H = 4.0
H = 8.0
A = 0.1
A = 0.2
A = 0.4
A = 0.8
A = 1.6
A = 3.2
K1 = 20.0
K2 = 0.2
K1 = 20.0
K2 = 2.0

(g)

TABLE 2.3. (continued)

	$H = 0.25$			$H = 0.25$			$H = 0.25$			$H = 0.25$		
	$k_1 = 0.2$			$k_1 = 2.0$			$k_1 = 20.0$			$k_1 = 200.0$		
a_1	$(ZZ1-RR1)$	$(ZZ2-RR2)$	$(ZZ2-RR3)$	$(ZZ1-RR1)$	$(ZZ2-RR2)$	$(ZZ2-RR3)$	$(ZZ1-RR1)$	$(ZZ2-RR2)$	$(ZZ2-RR3)$	$(ZZ1-RR1)$	$(ZZ2-RR2)$	$(ZZ2-RR3)$
			$k_2 = 0.2$			$k_2 = 0.2$			$k_2 = 0.2$			$k_2 = 0.2$
0.1	0.05598	0.00274	0.01370	0.28658	0.00277	0.01384	0.61450	0.00202	0.01011	0.86644	0.00090	00.0451
0.2	0.12628	0.01060	0.05302	0.72176	0.01075	0.05377	1.76675	0.00793	0.03964	2.71354	0.00357	0.01784
0.4	0.14219	0.03744	0.18722	1.03476	0.03842	0.19211	3.59650	0.02931	0.14653	6.83021	0.01365	0.06824
0.8	0.12300	0.09839	0.49196	0.88833	0.10337	0.51687	4.58845	0.08771	0.43854	13.19664	0.04624	0.23118
1.6	0.10534	0.13917	0.69586	0.66438	0.14102	0.70510	2.31165	0.14039	0.70194	13.79134	0.10591	0.52955
3.2	0.05063	0.11114	0.55569	0.41539	0.09804	0.49020	1.24415	0.07587	0.37934	2.72901	0.08608	0.43037
			$k_2 = 2.0$			$k_2 = 2.0$			$k_2 = 2.0$			$k_2 = 2.0$
0.1	0.05477	0.01409	0.00704	0.28362	0.01353	0.00677	0.63215	0.00962	0.00481	0.96553	0.00407	0.00203
0.2	0.12136	0.05484	0.02742	0.70225	0.05278	0.02639	1.83766	0.03781	0.01891	3.10733	0.01611	0.00806
0.4	0.12390	0.19780	0.09890	0.96634	0.19178	0.09589	3.86779	0.14159	0.07079	8.37852	0.06221	0.03110
0.8	0.06482	0.56039	0.28019	0.66885	0.55211	0.27605	5.50796	0.44710	0.22355	18.95534	0.21860	0.10930
1.6	−0.00519	0.96216	0.48108	0.17331	0.95080	0.47540	4.24281	0.90115	0.45058	31.18909	0.58553	0.29277
3.2	−0.02216	0.87221	0.43610	−0.05691	0.89390	0.44695	1.97494	0.93254	0.46627	28.98500	0.89191	0.44595
			$k_2 = 20.0$			$k_2 = 20.0$			$k_2 = 20.0$			$k_1 = 20.0$
0.1	0.05192	0.03116	0.00156	0.27580	0.02728	0.00136	0.65003	0.01930	0.00096	1.08738	0.00861	0.00043
0.2	0.11209	0.12227	0.00611	0.67115	0.10710	0.00536	1.90693	0.07623	0.00381	3.59448	0.03421	0.00171
0.4	0.08622	0.45504	0.02275	0.84462	0.39919	0.01996	4.13976	0.29072	0.01454	10.30923	0.13365	0.00668
0.8	−0.07351	1.44285	0.07214	0.21951	1.26565	0.06328	6.48948	0.98565	0.04928	26.41442	0.49135	0.02457
1.6	−0.40234	3.37001	0.16850	−1.22411	2.94860	0.14743	6.95639	2.55231	0.12762	57.46409	1.53833	0.07692
3.2	−0.71901	5.10060	0.25503	−3.04320	4.89878	0.24494	6.05854	4.76234	0.23812	99.29034	3.60964	0.18048
			$k_2 = 200.0$			$k_2 = 200.0$			$k_2 = 200.0$			$k_2 = 200.0$
0.1	0.04956	0.04704	0.00024	0.26776	0.03814	0.00019	0.65732	0.02711	0.00014	1.19099	0.01311	0.00007
0.2	0.10066	0.18557	0.00093	0.63873	0.15040	0.00075	1.93764	0.10741	0.00054	4.00968	0.05223	0.00026
0.4	0.04248	0.70524	0.00353	0.71620	0.57046	0.00285	4.26004	0.41459	0.00207	11.96405	0.20551	0.00103
0.8	−0.24071	2.40585	0.01203	−0.28250	1.92636	0.00963	6.94871	1.46947	0.00735	32.97364	0.77584	0.00388
1.6	−1.00743	6.82481	0.03412	−3.09856	5.35936	0.02680	8.55770	4.36521	0.02183	82.77997	2.63962	0.01320
3.2	−2.54264	15.45931	0.07730	−9.18214	12.64318	0.06322	10.63614	10.93570	0.05468	189.37439	7.60287	0.03801

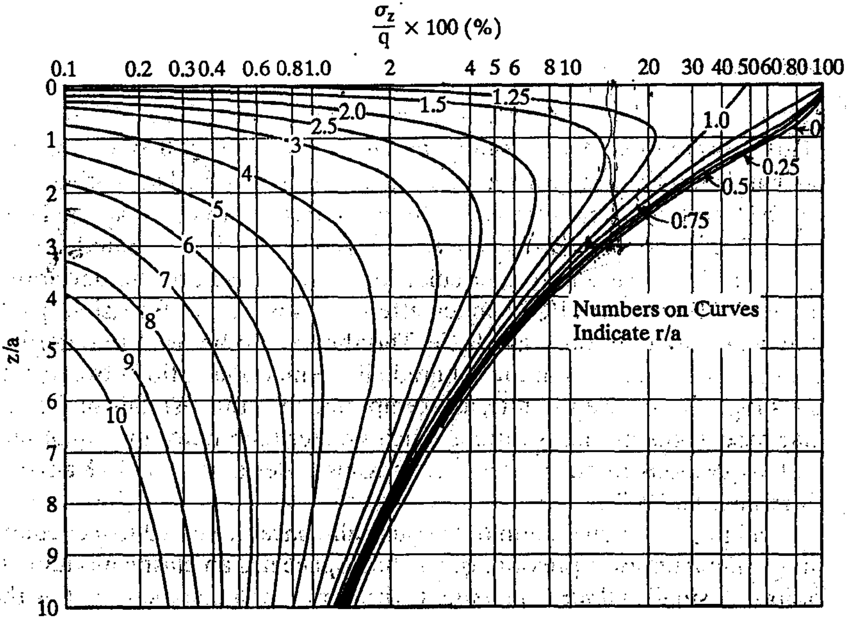


FIGURE 2.2

Vertical stresses due to circular loading. (After Foster and Ahlvin (1954).)

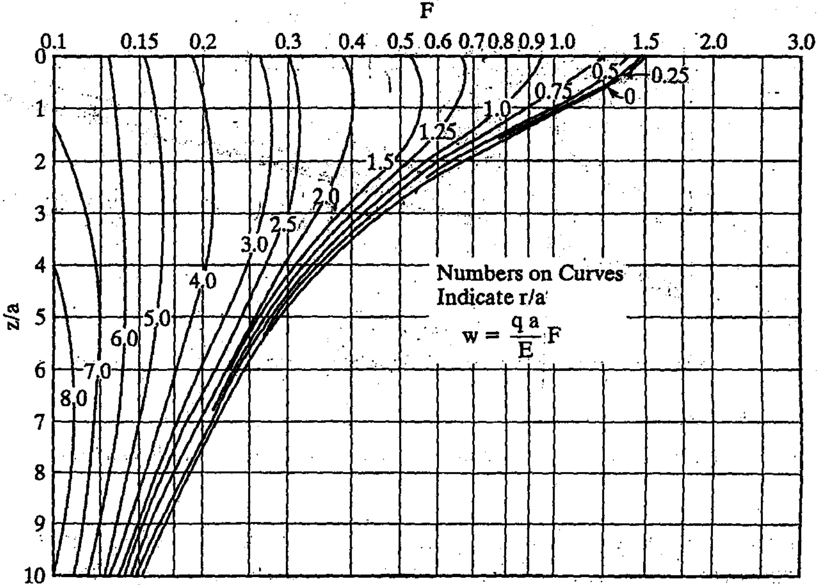


FIGURE 2.6

Vertical deflections due to circular loading. (After Foster and Ahlvin (1954).)

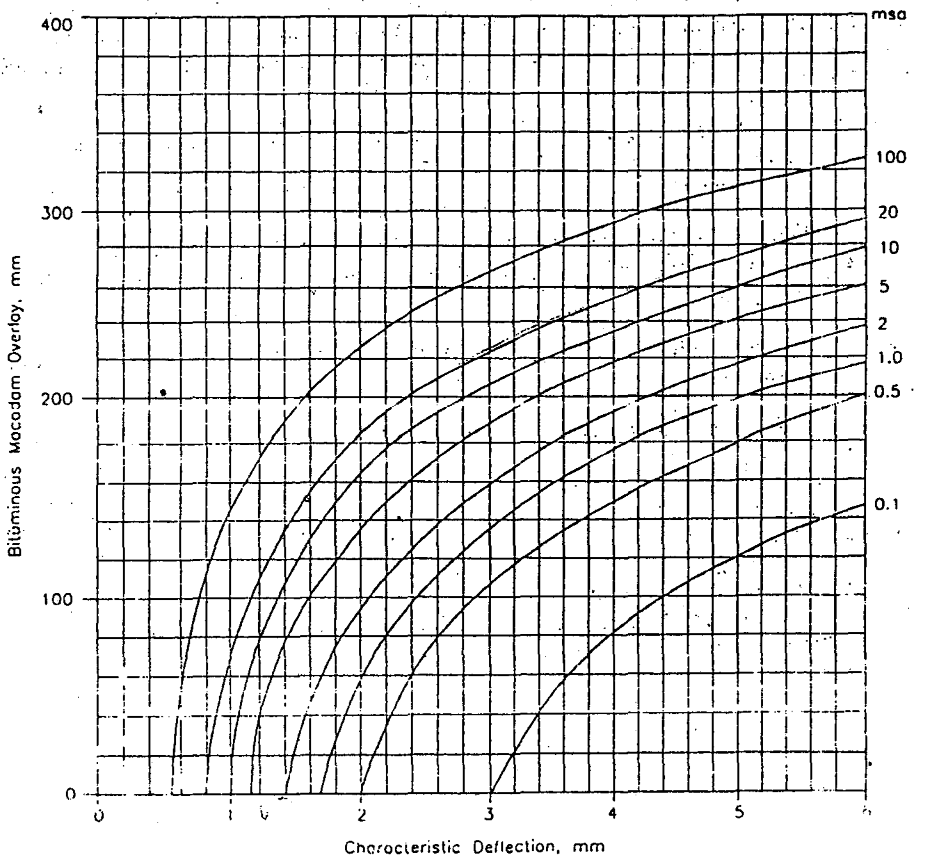


Fig. 9. Overlay Thickness Design Curves