MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING AND CIVIL ENGINEERING

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECV 409: HIGHWAY ENGINEERING II

DATE: 26/8/2022 **TIME: 11.00-1.00 PM**

INSTRUCTIONS:

(a) This paper contains FIVE (5) questions.
(b) You are required to answer THREE (3) questions only.
(c) Question ONE is compulsory.
(d) Attempt any other TWO questions.
(e) Question ONE carries 30 marks and the others carry 20 marks each.

QUESTION ONE (30 MARKS)

a) Using relevant diagram discuss the functions of all the layers of a flexible pavement. (8 marks)

b) Briefly describe how the following factors influence the properties of cement stabilised soils:

i. Soil type
ii. Cement content
iii. Moisture content
iv. Compaction and mixing
v. Curing (10 marks)

c) A two-way rural road passing through varying terrain with subgrade soil of CBR of 10 is proposed to be designed to bitumen standard. Axel load surveys indicate that expected traffic loading on opening the road in both directions with a 60/40 percent directional distribution be as in the table below:

Axle load (Tonnes)	6.35	7.26	8.16	9.07	9.98	10.89	11.79	12.70
No. Of axles expected in both directions per day	340	316	246	197	108	76	32	20

Historical traffic data indicate an annual traffic growth rate of 5%. Determine the pavement structure for this road section for a design period of 20 years using RN29 design criteria

(12 marks)

QUESTION TWO (20 MARKS)

a) A flexible pavement of 100mm Asphaltic Concrete (AC) surfacing, 250mm GCS Road base, 200mm NGR subbase, subgrade of 6%, has carried 2MSA since it was constructed. Design a overlay for the section of this road having a characteristic deflection of $45x10^{-2}$mm to carry 10MSA in future with a 0.90probability of achieving life. (10 marks)

b) Discuss any **four** highways design variables (8 marks)

c) State four traffic loading characteristics (2 marks)

QUESTION THREE (20 MARKS)

a) Describe the functions of the following components of a bituminous mix

i. Coarse aggregates

ii. Fine aggregates

iii. Mineral filler

iv. Binder (12 marks)

b) A pavement element along Thika road of 100x150x200 mm was subjected to an equal all-round pressure of 120kn/m^2 and axial load of 2.5KN in the X-direction. The changes in length are 0.92mm in X-direction, 0.27mm in the Y-direction and 0.18mm in the Z-direction. Calculate the

i. Elastic theory ratio, E

ii. Poisson's ratio, μ

iii. Bulk Modulus, K (8 marks)

QUESTION FOUR (20 MARKS)

a) Briefly discuss the Boussinesq theory; single layer system (8 marks)

b) A two-layer pavement on C91 road has a top layer of depth 300mm. A wheel load of 45KN is applied through a circular area of radius of 150mm on this pavement. Estimate the following under the centre of the loaded wheel. (E_1= 100mN/m^2 and E_2= 20mN/m^2)

i. surface deflection, Δ_s

ii. interface deflection, Δ_i

iii. Deflection, Δ_p (12 marks)

QUESTION FIVE (20 MARKS)

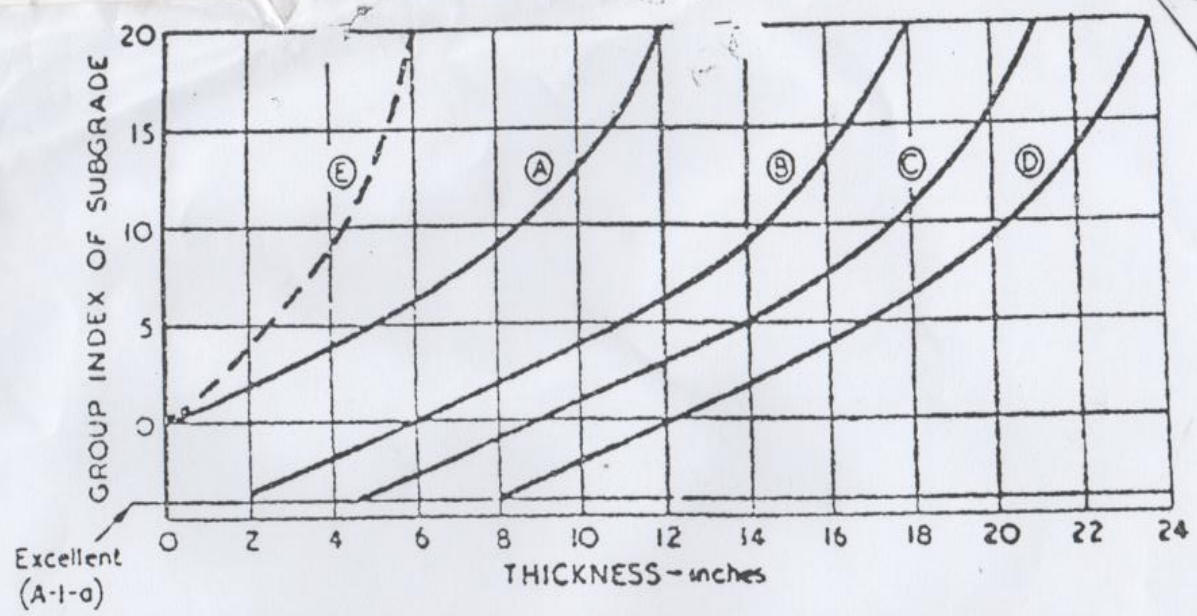
a) Distinguish between naturally occurring bitumen and petroleum refinery bitumen with particular reference to their modes of formation and composition. (8 marks)

b) The table below shows the grading of aggregates used in making a dense bituminous mix. The specific gravity of coarse and fine aggregates are 2.6 and 2.7 respectively while that of bitumen is 1.04

c)

Sieve size	25mm	20mm	13mm	6mm	No. 7	No.52	No.100	No.200
% Passing	100	98	78	61	44	26	16	0

Estimate the bitumen content to produce a mix that meets the following specifications among others: Voids in mix = 3 to 5%, voids filled with bitumen = 75 to 85% and compacted density of mixed aggregates = 2.20 (12 marks)



Curve A. Thickness of sub-base required

Curve B Total thickness of surface, base and sub-base – Light traffic

Curve C. Total thickness of surface, base and sub-base – Medium traffic

Curve D. Total thickness of surface, base and sub-base – Heavy traffic

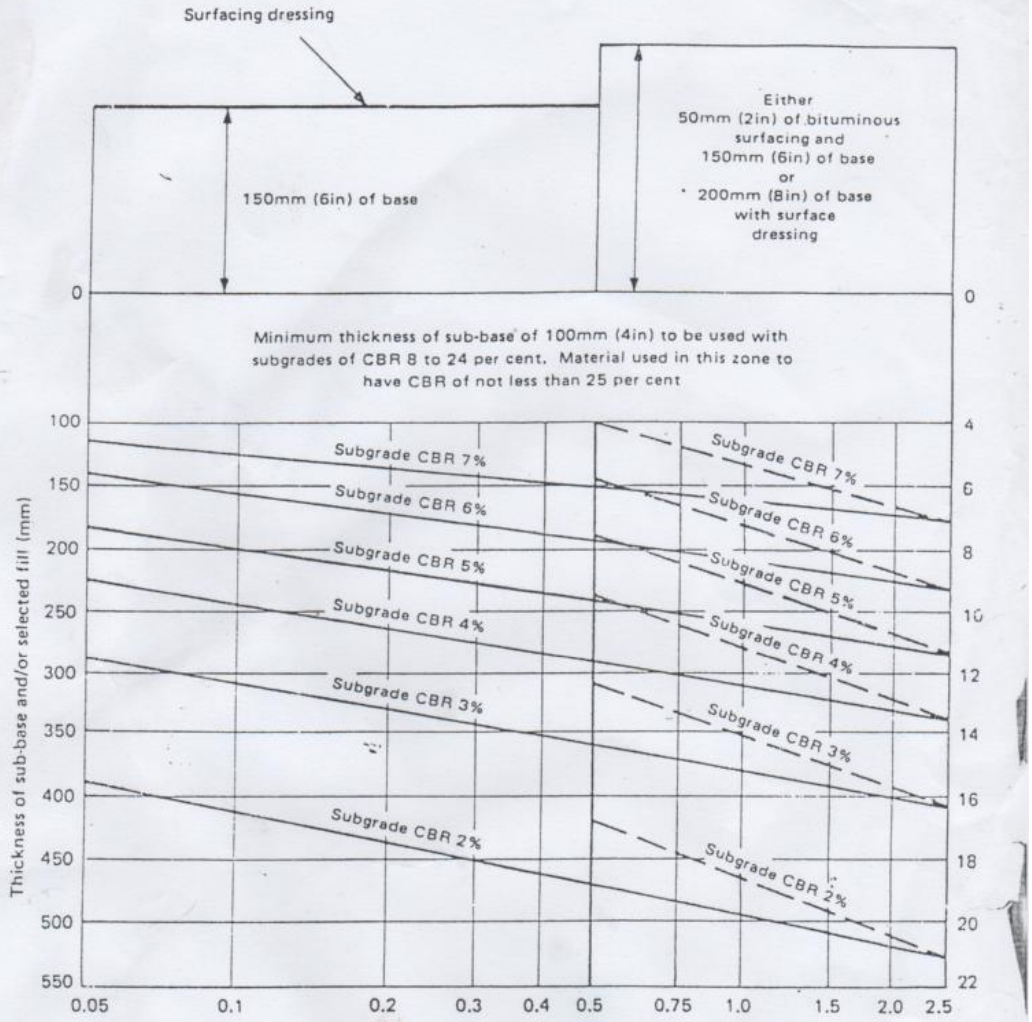
Curve E. Thickness of additional base which may be substituted for sub-base of Curve A

Light traffic = < 50 commercial vehicles / day

Medium traffic = 50 – 300 commercial vehicles / day

Heavy traffic = > 300 commercial vehicles / day

FIG. 20·4 TENTATIVE DESIGN CURVES, U.S. HIGHWAY ENGINEERS GROUP INDEX METHOD



If it is desired to provide at the time of construction a pavement capable of carrying more than 0.5 million standard axles, the designer may choose either a 150mm (6in) base with a 50mm (2in) bituminous surfacing or a 200mm (8in) base with a double surface dressing. For both of these alternatives, the recommended sub-base thickness is indicated by the broken line.

Alternatively, a base 150mm (6in) thick with a double surface dressing may be laid initially and the thickness increased when 0.5 million standard axles have been carried The extra thickness may consist of 50mm (2in) of bituminous surfacing or at least 75mm (3in) of crushed stone with a double surface dressing. The largest aggregate size in the crushed stone must not exceed 19mm (¾in) and the old surface must be prepared by scarifying to a depth of 50mm (2in). For this stage construction procedure, the recommended thickness of sub-base is indicated by the solid line.

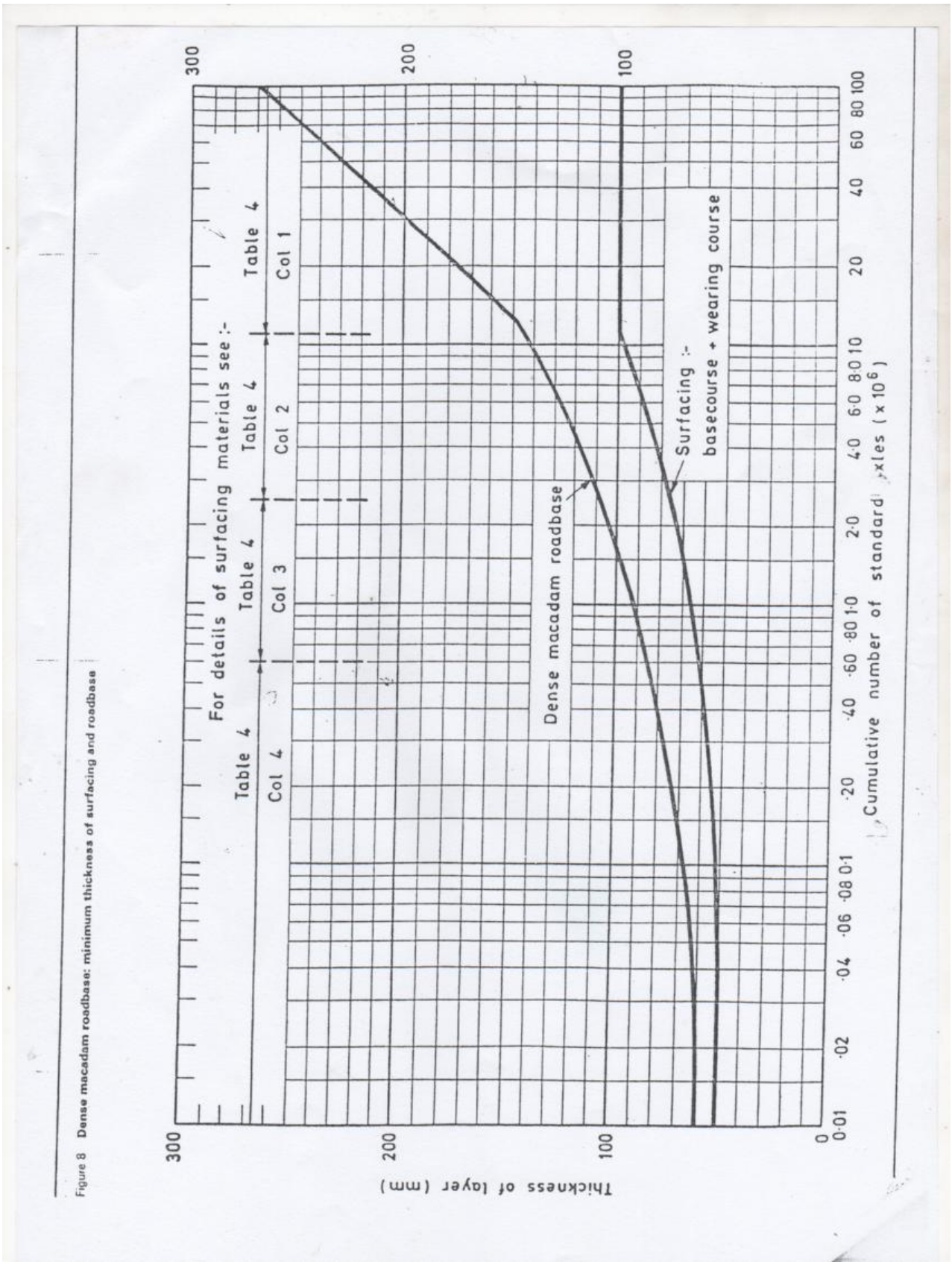


Figure 8 **Dense macadam roadbase: minimum thickness of surfacing and roadbase**

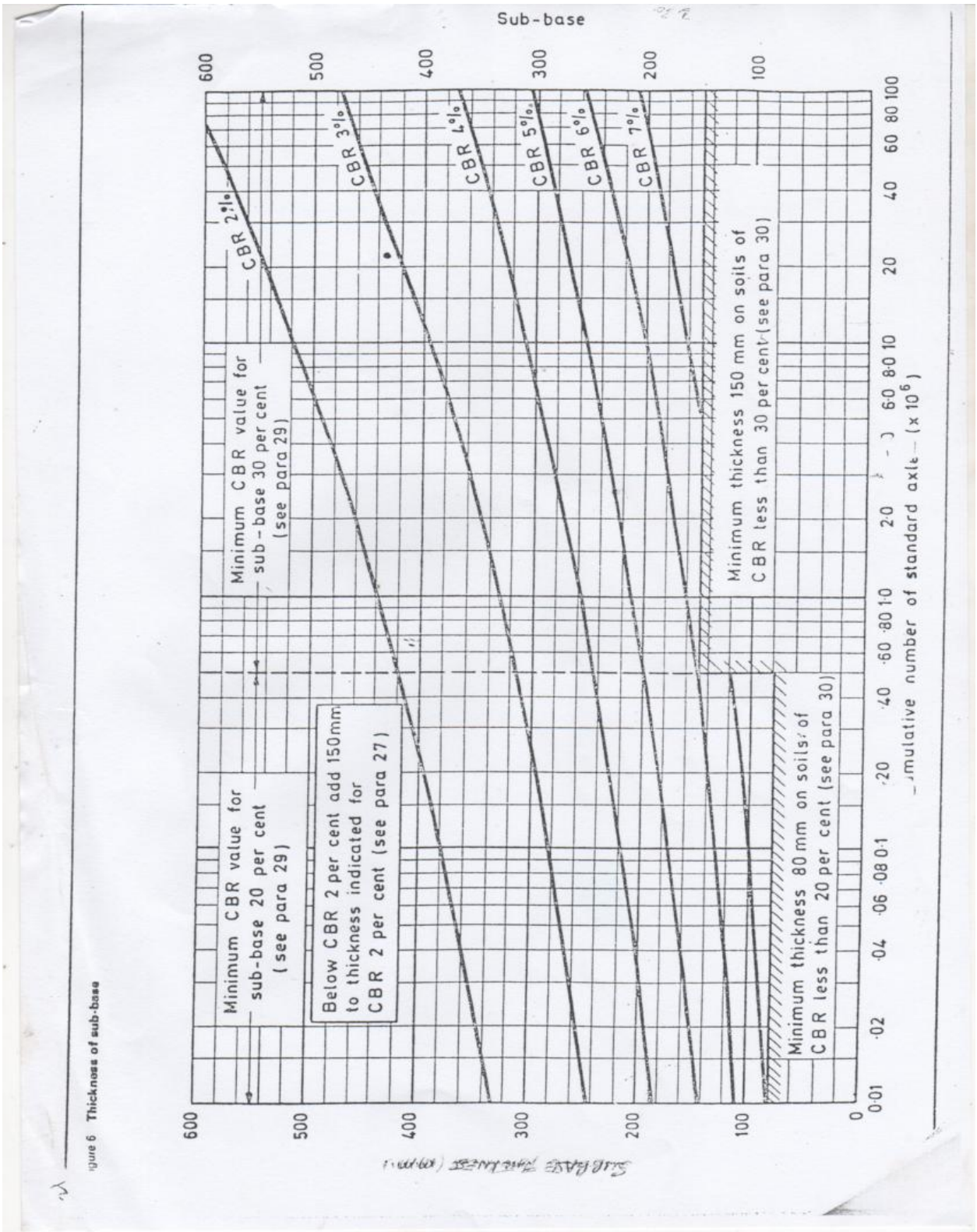
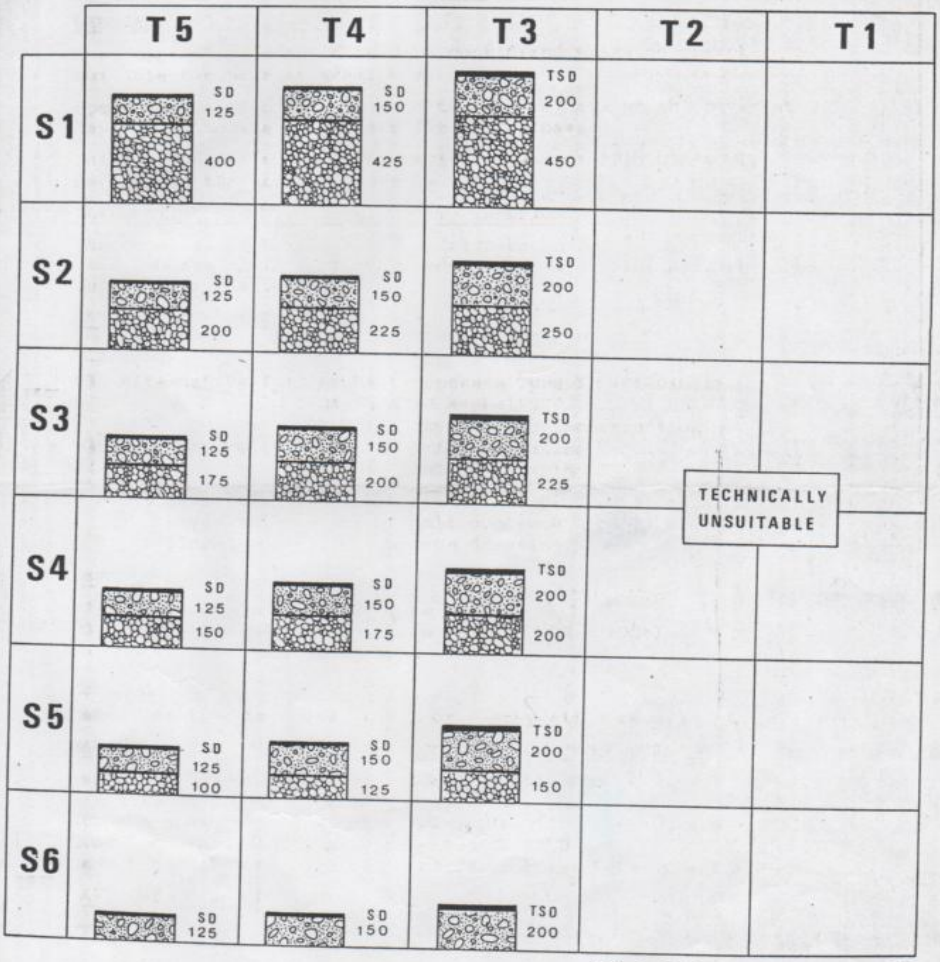


Figure 6 Thickness of sub-base

STANDARD PAVEMENT STRUCTURE TYPE 6

BASE : Graded crushed stone
SUBBASE : Natural material



SD = DOUBLE SURFACE DRESSING
TSD = TRIPLE SURFACE DRESSING

SUBGRADE CLASS	SUBGRADE CBR (%)	TRAFFIC CLASS	TRAFFIC ESA x 10^6
S1	2 - 5	T1	25 - 60
S2	5 - 10	T2	10 - 25
S3	7 - 13	T3	3 - 10
S4	10 - 18	T4	1 - 3
S5	15 - 30	T5	0·25 - 1
S6	> 30		

IMROVED SUBGRADE (Reproduced from Table 6.3.1)												
Native Subgrade Class		S1						S2			S3	
Improved Subgrade	Material	S2	S3		S4			S3	S4		S4	S5
	Thickness (mm)	400	350	425	275	325	450	300	200	350	300	150	350
New Class		S2	S2	S3	S2	S3	S4	S3	S3	S4	S4	S4	S5

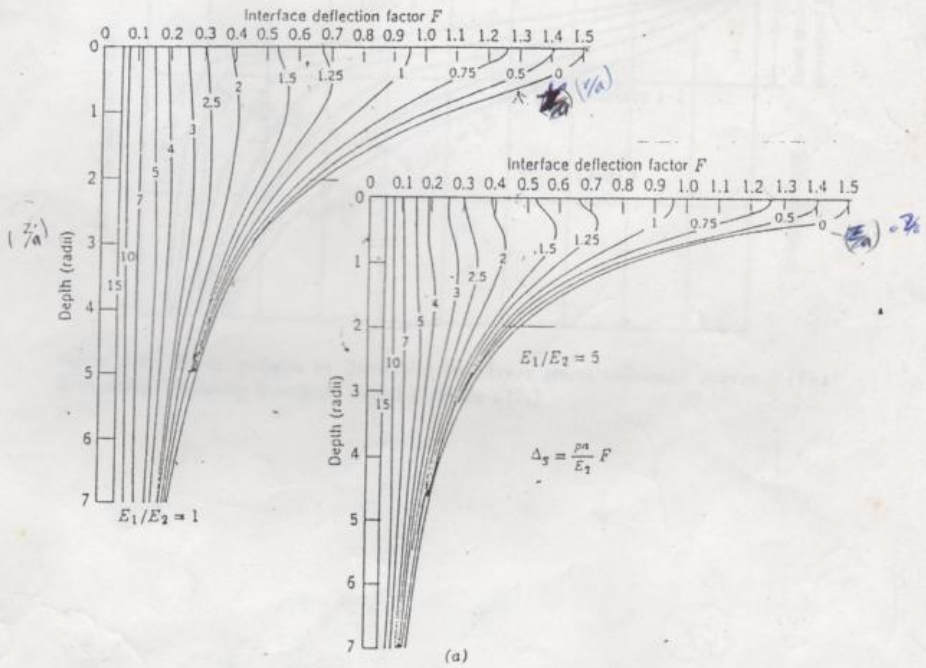


Figure 2.8. Vertical deflection at the interface of a two-layer system. Deflection values are obtained from Equation 2.10. Numbers on curves indicate offset distances in radii. Curves are for various modular ratios as follows. (*a*) $E_1, E_2 = 1; 5$; (*b*) $E_1, E_2 = 10; 25$; (*c*) $E_1, E_2 = 50; 100$. (From Huang.)