MACHAKOS UNIVERSITY

University Examinations for 2021/2022

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING & CIVIL ENGINEERING

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECV 409: HIGHWAY ENGINEERING II

DATE **TIME**

INSTRUCTIONS

*This paper comprises of FIVE questions. Answer **THREE** questions*

*Question one is **compulsory** and carry 30 marks*

*Answer any other **TWO** questions*

Use charts and tables attached herein

QUESTION ONE (30MKS)

a) Discuss the Stresses in flexible pavements and wheel load characteristics (5 marks)

b) Discus the following types of asphalt concrete (5 marks)

i. Dense graded asphalt concrete

ii. Gap graded asphalt concrete

c) Discuss **any five** road construction materials (5 marks)

d) Discuss **any five** road construction plants and machinery (5 marks)

e) Machakos county has tendered for a road project whose design life is 18years. The traffic Annual growth rate is 5%. If the Initial ADT (ADT_o) is 1960 cv/day with axle loading survey of 2.25 SA/CV while Subbase CBR is 30% and Subgrade CBR is 6%, design the vertical cross-section of this road when road base material is DBM. (10 marks)

QUESTION TWO (20 MARKS)

a) Discuss the term Stage construction as applied in road construction (2 marks)

b) Discuss the assumptions and application of BOUSSINESQ THEORY and BURMISTER THEORY in road stress distribution. (6 marks)

c) Thika-Makutano road A2 is scheduled for design as a dual carriage highway. Soil sample were collected on trial pits dug at intervals of 300m along the alignment and when tested, the CBR was 15%. The Subbase is CBR 45% mean while CSA is 2.5MSA. if the design life is 15yrs, design and sketch the pavement structure using RDM III design methods.

(12 marks)

QUESTION THREE (20 MARKS)

a) List **any four** reasons of pavement designs (2 marks)

b) Discuss the main groups of geometric road design methods (8 marks)

c) A road in Kitui is set to be upgraded from marrum road to bitumen standards. Soils were sampled for laboratory analysis. Wet subgrade soil has the following characteristics L_L is 51%, PI is 26%. The grading was such that 98% passes ¾" sieve, 62% passes sieve NO.7 46% passes sieve NO. 36 and 53% passes sieve No. 200. Design and sketch the geometric cross-section of the pavement for an expected traffic of 300 cv/day if the surfacing is 50mm asphalt concrete (AC) (10 marks)

QUESTION FOUR (20 MARKS)

a) Using Figure 1 for pavement deflection for a road in Tala township, determine

(10 marks)

i. Δ_s, Δ_i and Δ_p using the Burminster theory

ii. Δ_s and σ_z at the top of the bottom layer, σ_r at the bottom of top layer using Bossinesq theory.

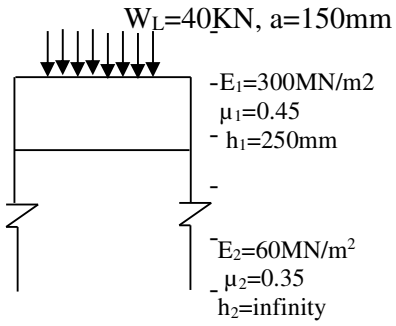


Figure 1: Pavement deflection

b) A road in Kiambu county, whose projected design life is 12 years, was investigated and the following was established.

Traffic Annual growth rate = 4%

Initial ADT (ADT_o) = 132 cv/day

Equivalent factor = 2.05 SA/CV

Subbase CBR = 30%

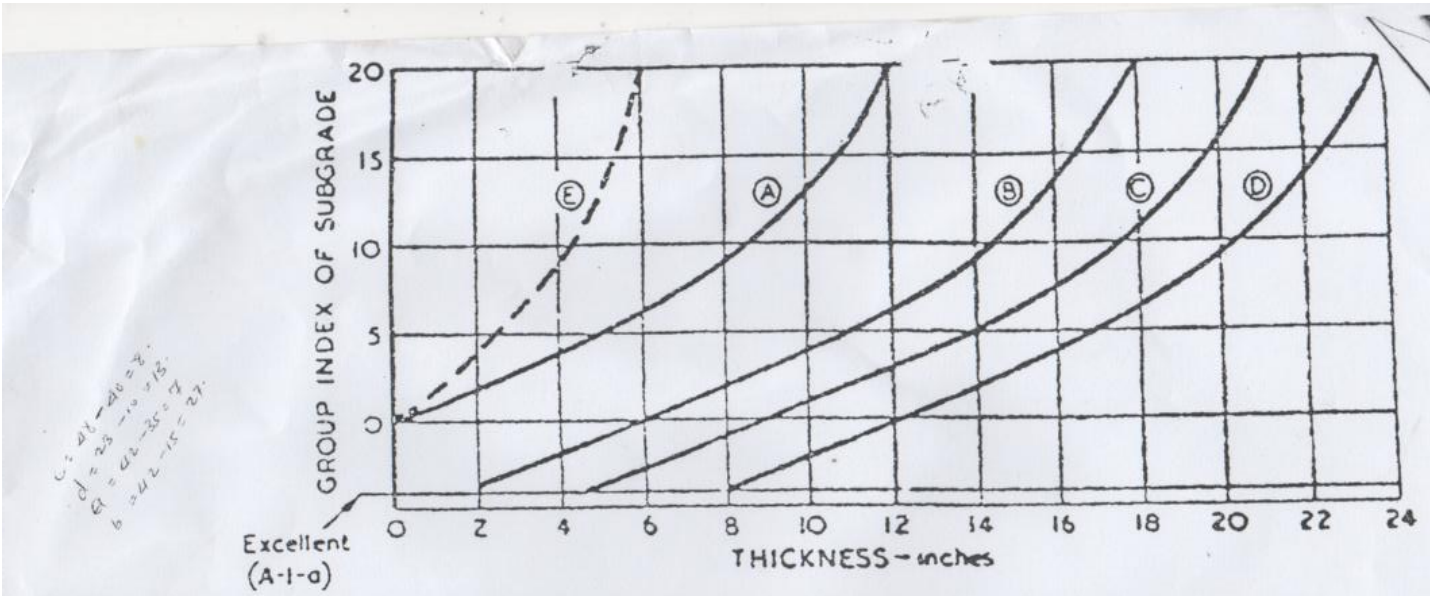
Subgrade CBR = 6%

Road base material is made of hot dense bituminous AC

Determine and sketch the pavement structure by single stage construction (10 marks)

QUESTION FIVE (20 MARKS)

a) Discuss in details road maintenance techniques. (5 marks)
b) Discuss **three types** of soil stabilization materials used in road construction. (15 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

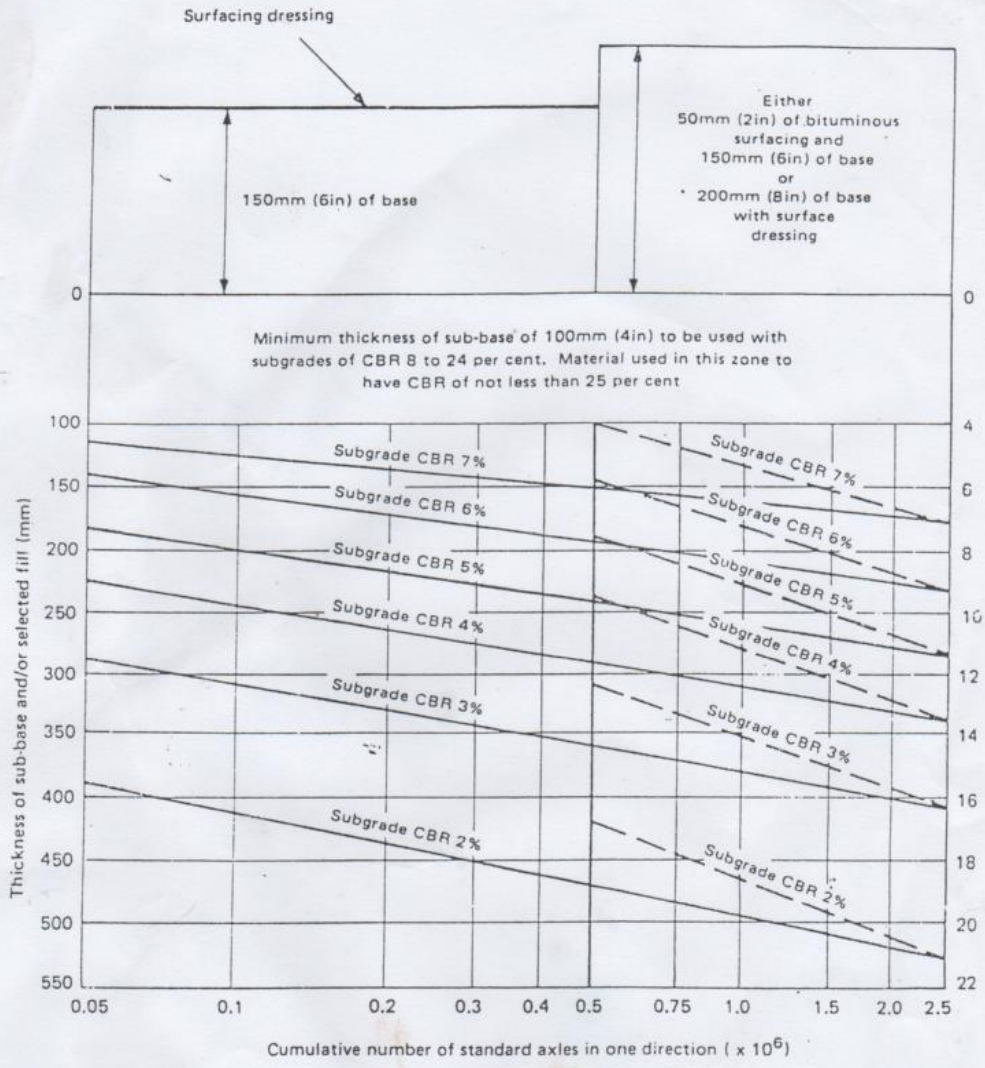
Curve E. Thickness of additional base which may be substituted for sub-base of Curve A

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.

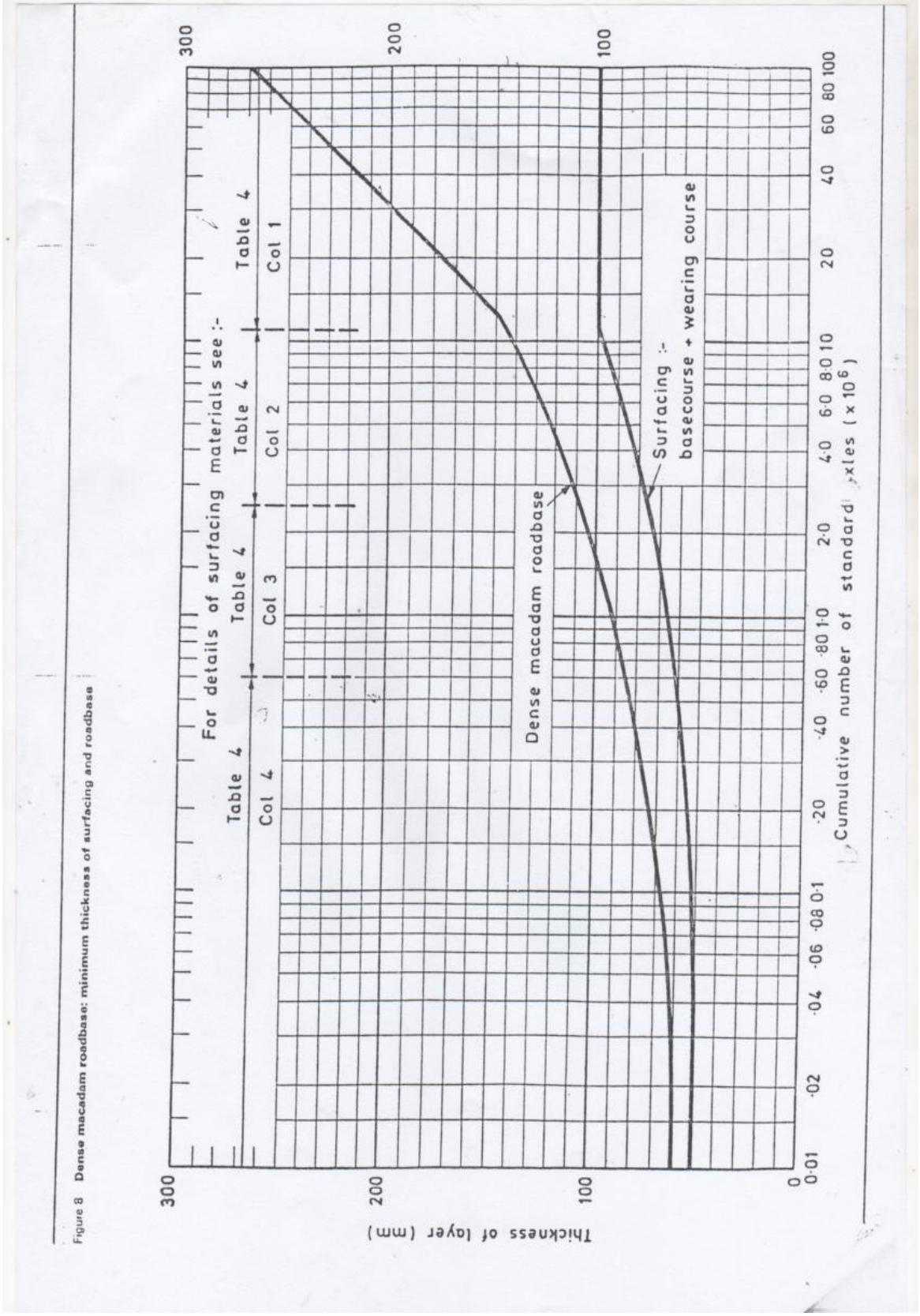


Figure 8 **Dense macadam roadbase: minimum thickness of surfacing and roadbase**

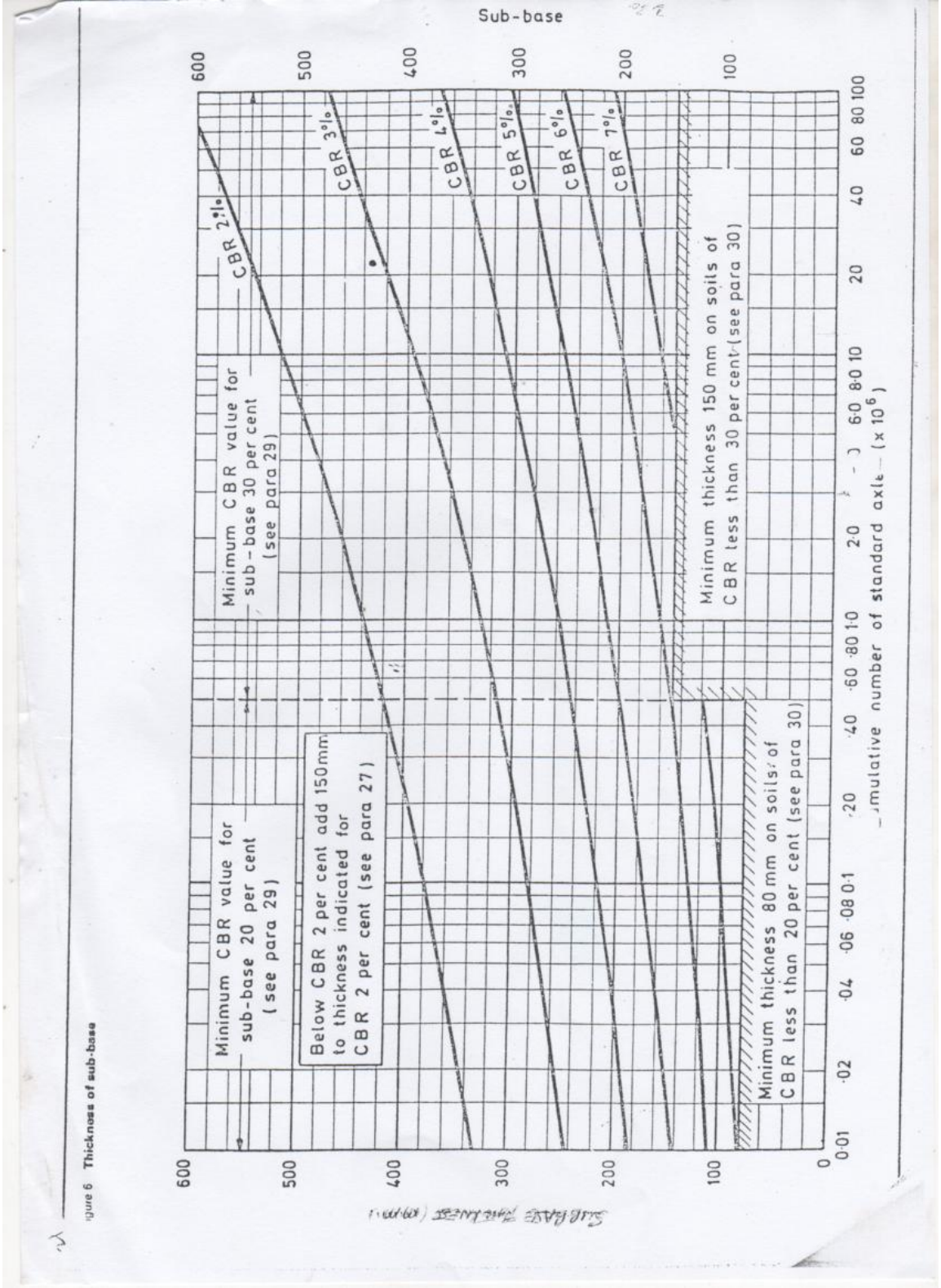
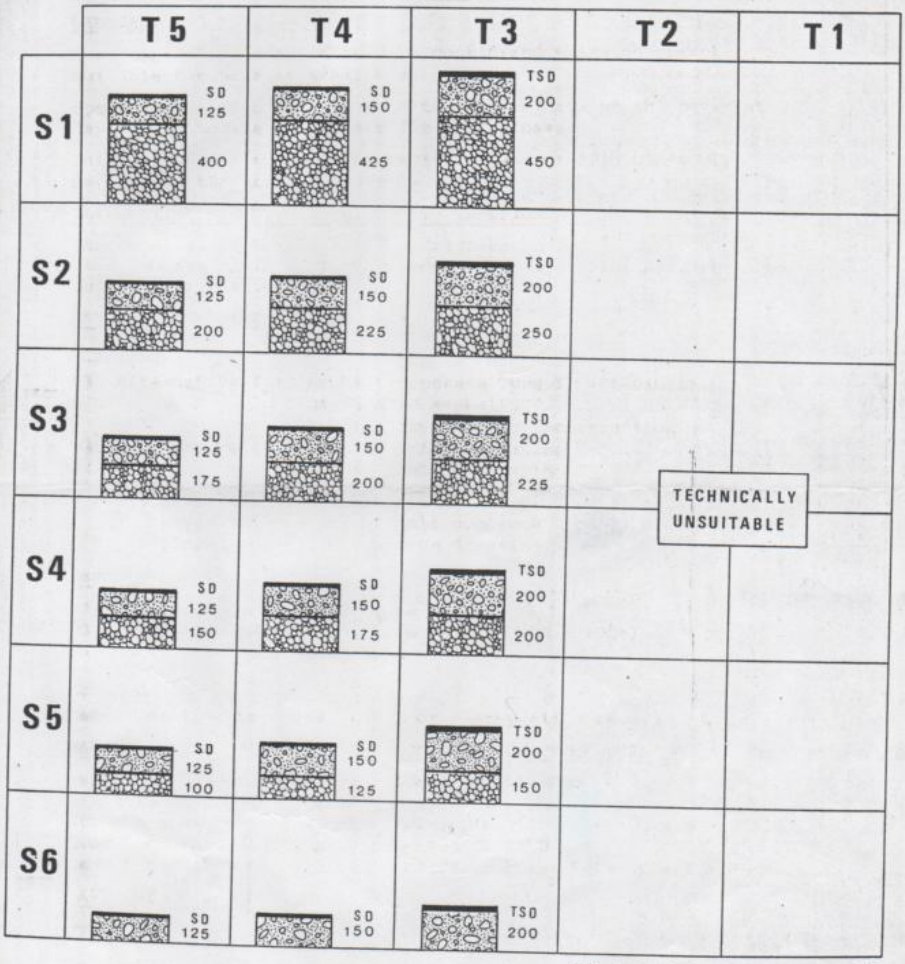


Figure 6 Thickness of sub-base

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

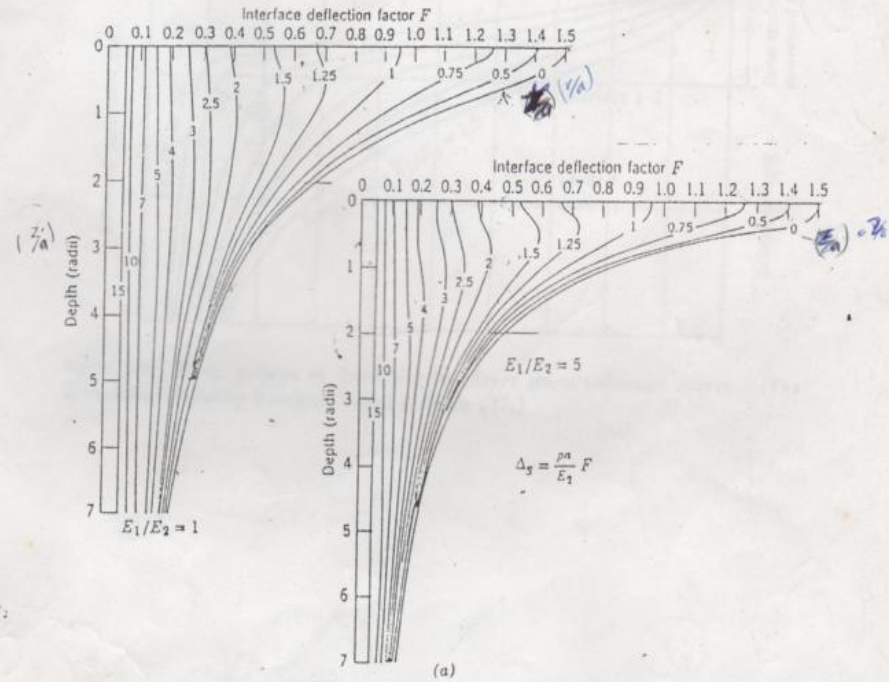


Figure 2.8. Vertical deflection at the interface of a two-layer system. Deflection values are obtained from Equation 2.10. Numbers on curves indicate offset distances in radii. Curves are for various modular ratios as follows. (a) $E_1/E_2 = 1; 5$; (b) $E_1/E_2 = 10; 25$; (c) $E_1/E_2 = 50; 100$. (From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