Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME : HIGHWAY ENGINEERING

COURSE CODE : BFC 31802

PROGRAMME CODE : BFF

EXAMINATION DATE : FEBRUARY 2023

DURATION : 2 HOUR AND 30 MINUTES

INSTRUCTION :

1. ANSWER **ALL** QUESTIONS.
2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.**
3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FOURTEEN (14)** PAGES

Q1 (a) Illustrate a cross-sectional for state road and describe the function of road median.

(5 marks)

(b) **Table Q1(b)** presents the result of bitumen tested at highway engineering laboratory. Based on the results, classified the penetration grade of bitumen and explain the bitumen properties for wearing coarse in road construction.

(5 marks)

(c) The point of intersection of two tangent lines is station 1115+20. The radius of curvature is 275 meter and the angle of deflection is 52°. Based on this statement, calculate the following parameters:

(i) Length of the curve

(3 marks)

(ii) Length of the long chord

(3 marks)

(iii) Length of the middle ordinate

(3 marks)

(iv) Length of external distance

(3 marks)

(v) The station for the point of curvature and point of tangency

(3 marks)

Q2 (a) Describe the required parameters to determine the optimum bitumen content for produce dense asphalt mixture according to Marshall mix design standard test procedure.

(5 marks)

(b) In SPJ/JKR/2008, the CBR value for base layer cannot be less than 80%. After CBR in-situ testing at an area of Parit Nipah, Parit Raja, the value of CBR recorded as 75%. Based on the statement, propose **TWO (2)** methods to improve the acceptable standard requirement.

(5 marks)

(c) A new road of 15 km was proposed to be constructed from Muar to Batu Pahat, Johor. Predict and sketch a design of layer thickness for the flexible pavement using the AASHTO design method. Refer **Table Q2(c)** and **Figure Q2(c)(i)** to **Figure Q2(c)(v)** in your calculation. The following data have been provided:

Equivalent Single Axle Load (ESAL)	=	1.5×10^6
Initial Present Serviceability Index, PSI_i	=	4.5
Terminal Present Serviceability Index, PSI_t	=	2.5
Resilient modulus of asphalt concrete, MR_1	=	400,000 psi
CBR of crushed stone base	=	100%
CBR of gravel subbase	=	30%
CBR of subgrade	=	7%
Exposure to moisture	=	30% of the time
Quality of drainage	=	Surface layer – Good
Base layer	=	Fair
Subbase layer	=	Fair
Reliability, R	=	99%
Standard deviation, S_o	=	0.35

(15 marks)

Q3 (a) Road drainage is an important component in road. Due to unproper drainage, the accident can occur. Define the mechanism of the loss of traction which can lead to an accident with the aid of diagram.

(5 marks)

(b) **Figure Q3(b)** shows the longitudinal profile of a site for a proposed highway. The distance and corresponding volume of soil to be cut or filled are indicated in the figure. Assume that the shrinkage and bulking factors are equal to 1.0.

(i) Construct a Mass Haul Diagram.

(5 marks)

(ii) Determine the volume and direction of haul using table in **Figure Q3(b)**.

(5 marks)

(c) The embankment of a proposed alternative road from Parit Raja to Batu Pahat is 10 km long. The average cross section of the embankment is shown in **Figure Q3(c)**. The specification requires the embankment to be compacted to 95% of the maximum dry density according to the B.S 1377 Compaction Test (2.5 kg rammer method). **Table Q3(c)** present the density of laboratory and borrow material at various conditions.

(i) Determine the volume of borrow pit material needed for 1 m^3 of the compacted road embankment.

(5 marks)

(ii) Calculate the additional water volume needed for the total volume of embankment.

(5 marks)

Q4 (a) Describe sustainability in road construction.

(2 mark)

(b) Elaborate **THREE (3)** current practices in terms of sustainable highways with suitable examples. Define the sustainable elements in each example.

(12 marks)

(c) Hot in-place recycling (HIPR) has been described as an on-site, in-place method that rehabilitates deteriorated asphalt pavements and thereby minimizes the use of new materials.

(i) Name **THREE (3)** types of HIPR recycling processes.

(3 marks)

(ii) Explain **FOUR (4)** steps of HIPR process.

(8 marks)

- END OF QUESTIONS -

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Table Q1(b): Results of bitumen

Properties	Value	Requirements
Penetration at 25C (dmm)	61.5	60 - 70
Softening point, °C	49.8	48 - 56
Viscosity at 135°C (Pa.s)	0.6	Max 3 Pa.s
Ductility at 25°C (cm)	102	Min 100 cm
Flash point, °C	258	Min 250°C

Table Q2(c): Recommended m value for modifying structural layer coefficient of untreated base and subbase materials in flexible pavement

Percent of Time Pavement Structure is Exposed to Moisture Levels Approaching Saturation				
Quality of drainage	**Less than 1%**	**1%-5%**	**5%-25%**	**Greater than 25%**
Excellent	1.40-1.35	1.40-1.35	1.40-1.35	1.40-1.35
Good	1.35-1.25	1.35-1.25	1.35-1.25	1.35-1.25
Fair	1.25-1.15	1.25-1.15	1.25-1.15	1.25-1.15
Poor	1.15-1.05	1.15-1.05	1.15-1.05	1.15-1.05
Very Poor	1.05-0.95	1.05-0.95	1.05-0.95	1.05-0.95

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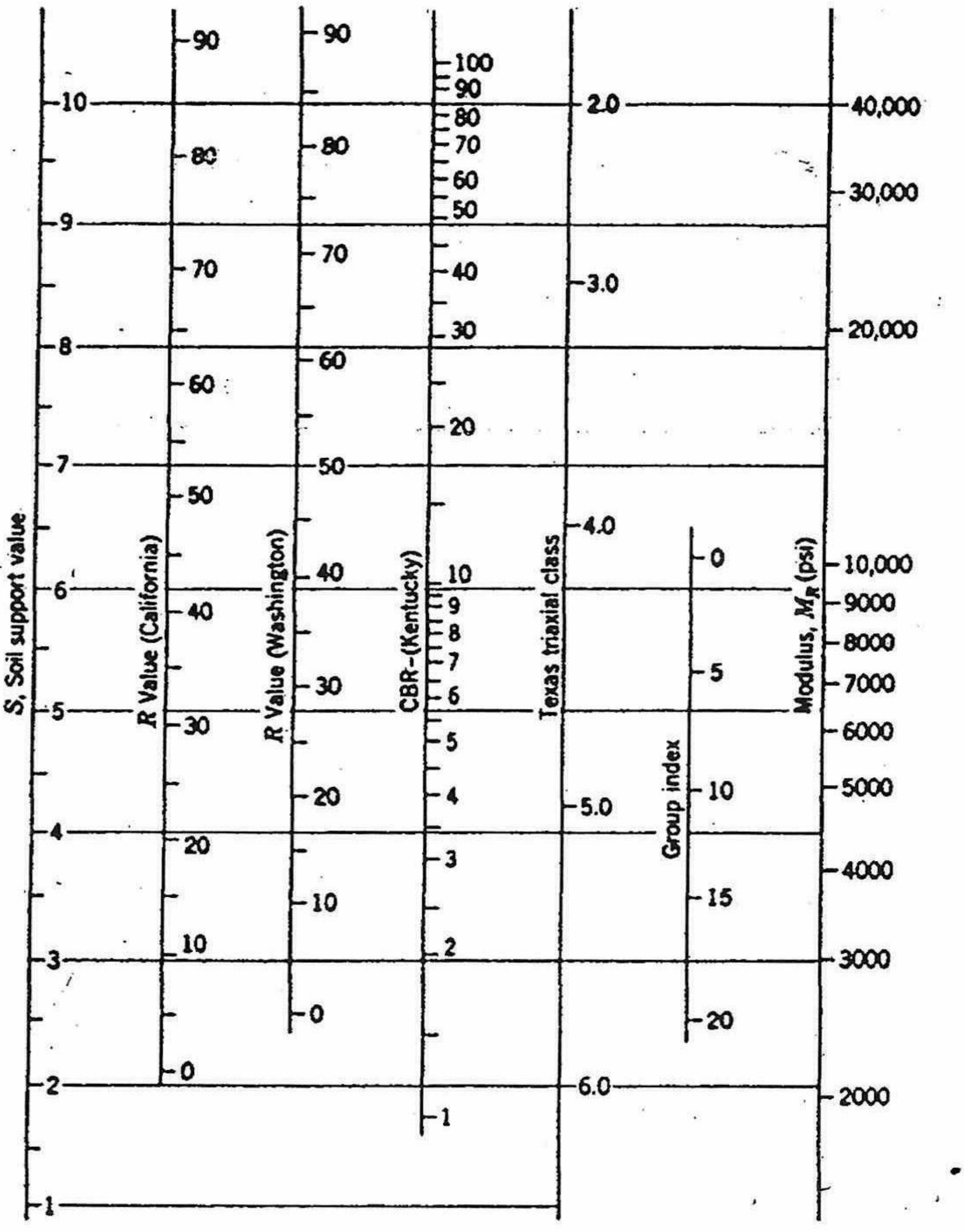

Figure Q2(c)(i): Correlation chart for estimating resilient modulus of subgrade soil

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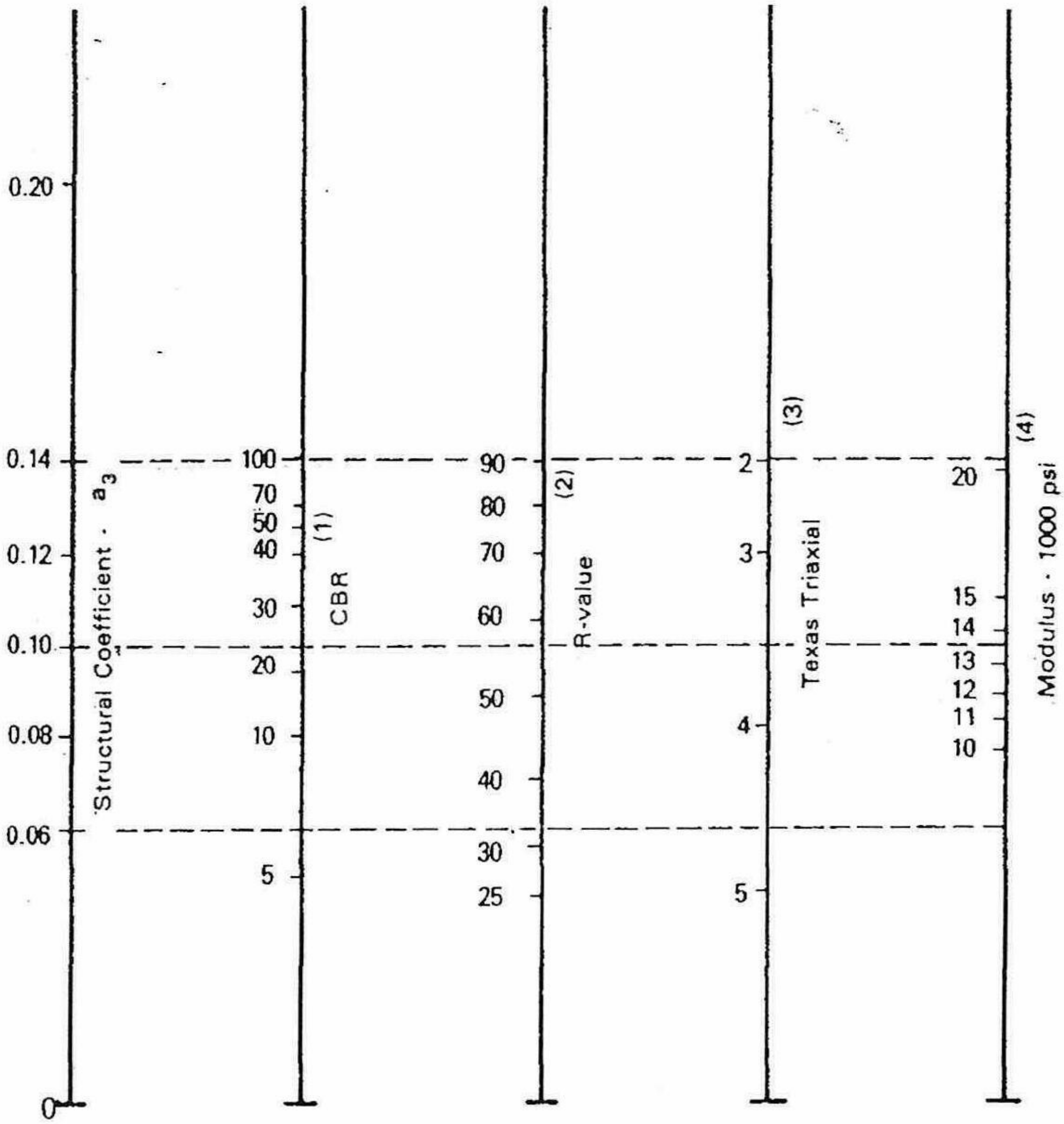

(1) Scale derived from correlations from Illinois.

(2) Scale derived from correlations obtained from The Asphalt Institute, California, New Mexico and Wyoming.

(3) Scale derived from correlations obtained from Texas.

(4) Scale derived on NCHRP project *(3)*.

Figure Q2(c)(ii): Variation in granular subbase layer coefficient (a3)

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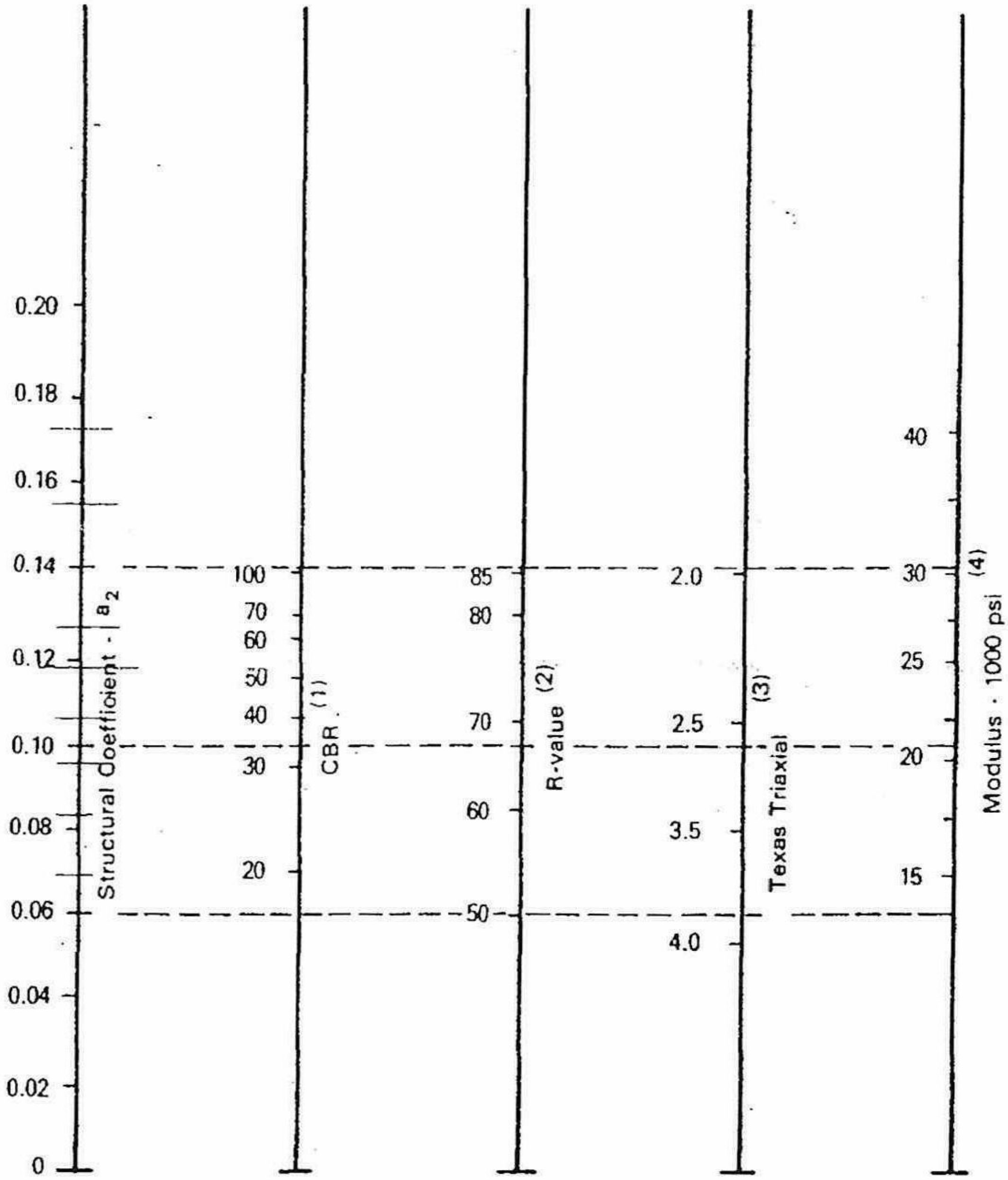

(1) Scale derived by averaging correlations obtained from Illinois.
(2) Scale derived by averaging correlations obtained from California, New Mexico and Wyoming.
(3) Scale derived by averaging correlations obtained from Texas.
(4) Scale derived on NCHRP project *(3)*.

Figure Q2(c)(iii): Variation in granular base layer coefficient (a2)

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NOMOGRAPH SOLVES:

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

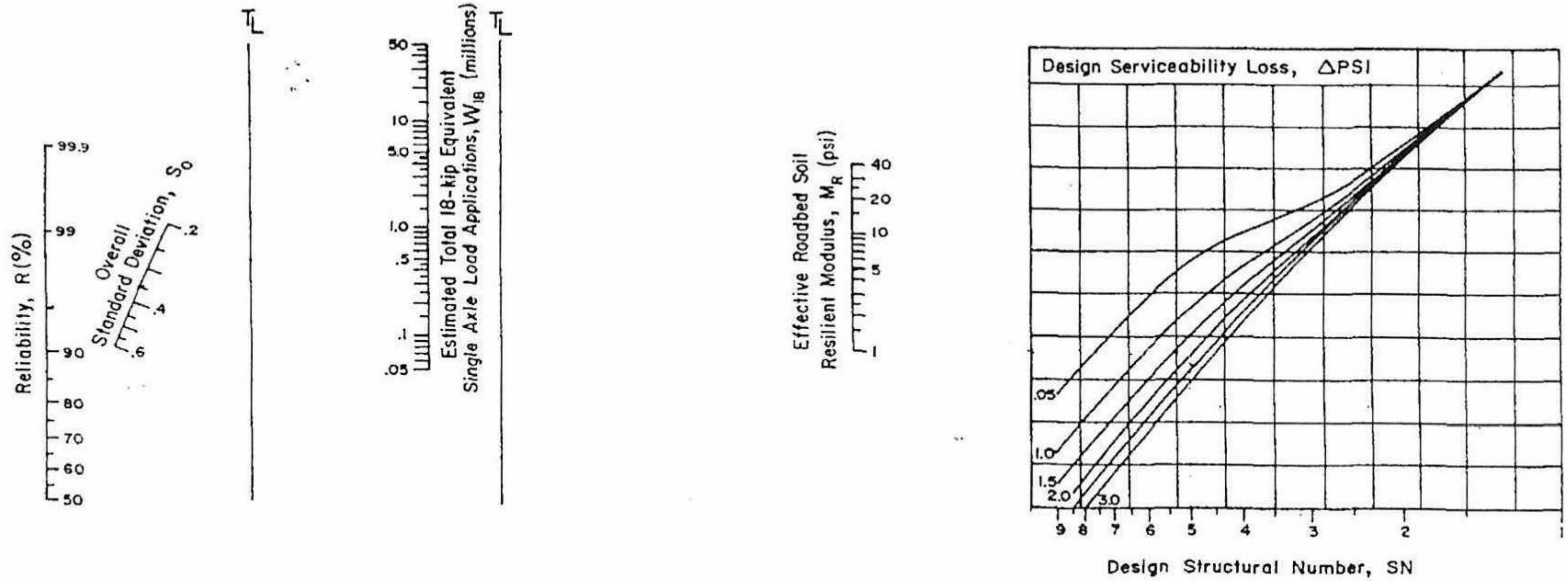

Figure Q2(c)(iv): AASHTO design chart for flexible pavement based on using mean values for each input

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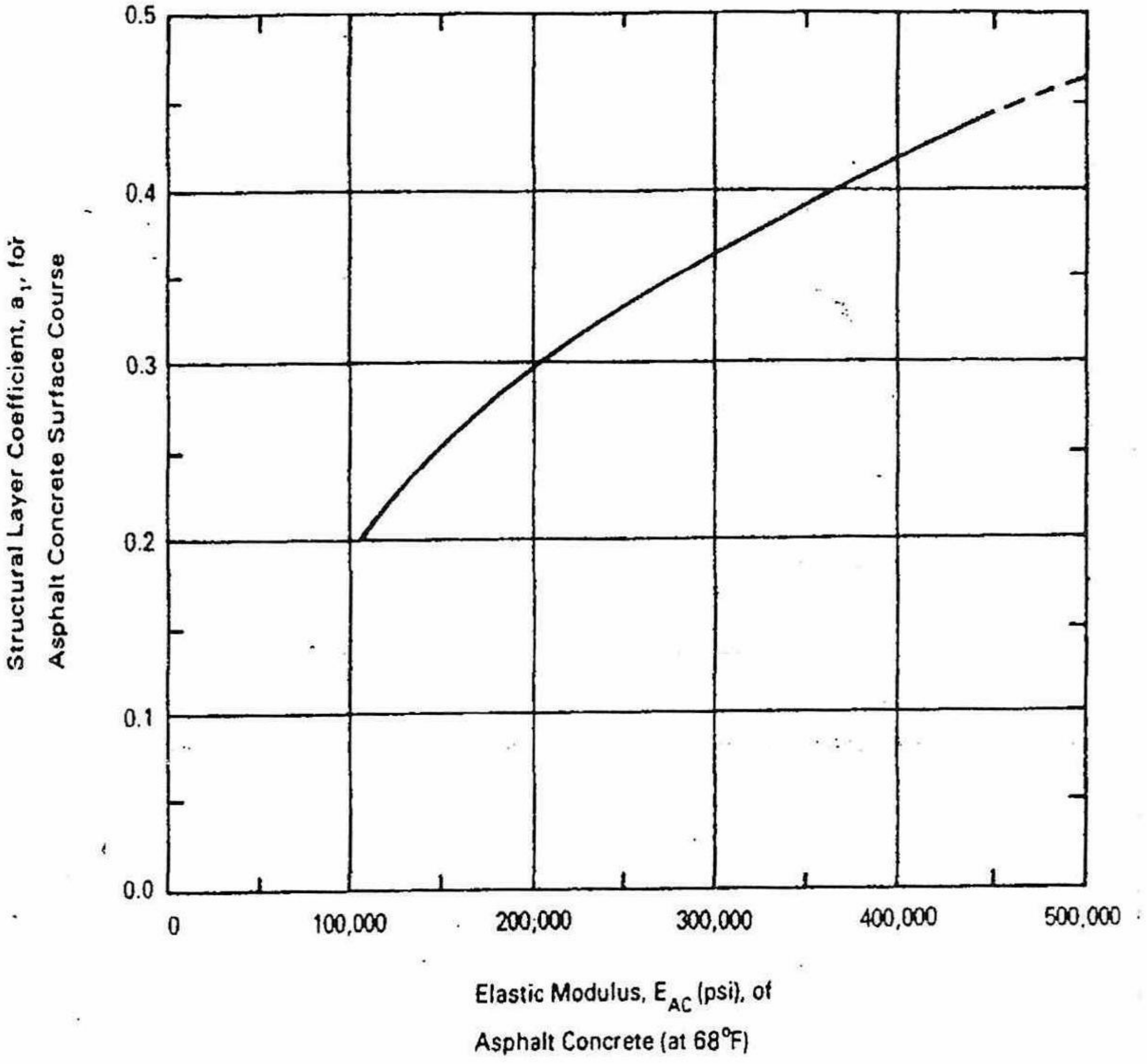

Figure Q2(c)(v): Chart for estimating structural layer coefficient of dense graded asphalt concrete base on the elastic (resilient modulus)

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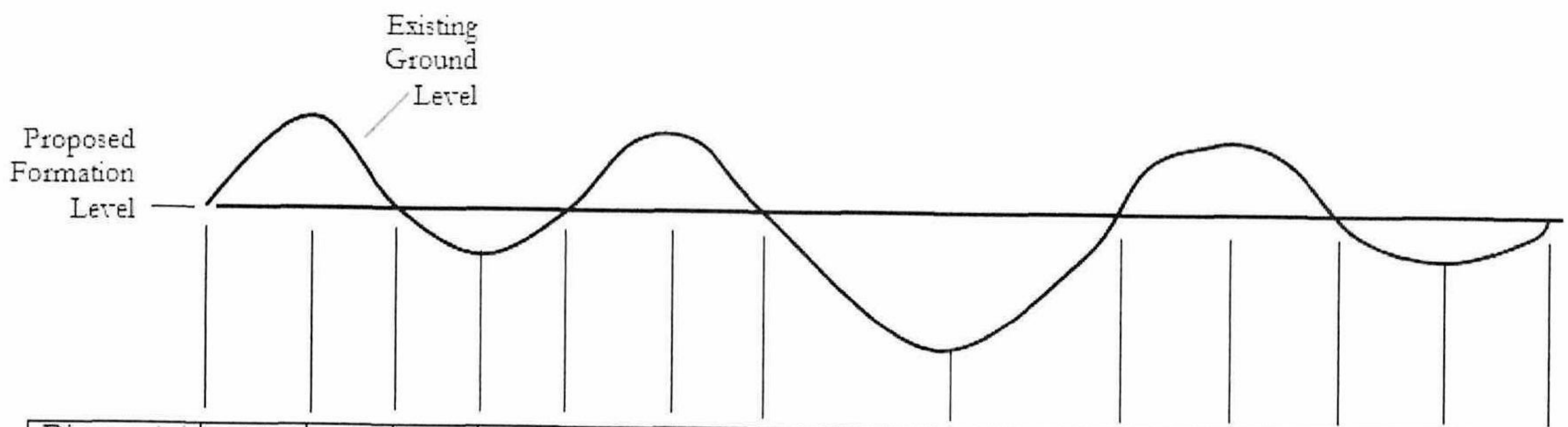

Distance (m)	105	75	70	60	55	50	130	100	50	50	55	50
Volume (m^3)	3,615	3,216	7,012	3,314	9,315	5,622	4,435	4,578	2,077	3,670	4,336	3,282
Cut (m^3)												
Fill (m^3)												
Haul (m^3)												
Borrow (m^3)												
Waste (m^3)												

Figure Q3(b): Longitudinal profile of a site for a proposed highway

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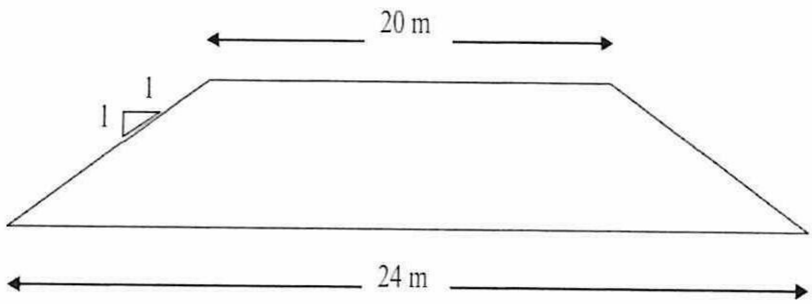

Figure Q3(c): Cross section of the embankment

Table Q3(c): Density and moisture content of the soil

Laboratory Compaction Test		In-situ (borrow pit)	
Maximum dry density (Mg/m^3)	Optimum moisture content (%)	Bulk density (Mg/m^3)	Natural moisture content (%)
1.56	12	1.88	9.6

$$\text{Bulking factor} = \frac{\text{Volume before excavation}}{\text{Volume after excavation}} = 1.25$$

CONFIDENTIAL

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The following information may be useful. The symbols have their usual meaning.

$$T = R \tan(\Delta/2)$$

$$C = R \sin(\Delta/2)$$

$$E = R\,[\sec(\Delta/2) - 1]$$

$$M = R\,[1 - \cos(\Delta/2)]$$

$$L = (\Delta/360)(2\pi R)$$

$$R_{min} = \frac{V^2}{127(e+f)}$$

$$A = h(b + nh)$$

$$\Delta PSI = PSI_i - PSI_t$$

$$D_1 = \frac{SN_1}{a_1 m_1} \qquad SN_1^* \geq SN_1$$

$$D_2 = \frac{SN_2 - SN_1^*}{a_2 m_2} \qquad SN_1^* + SN_2^* \geq SN_2$$

$$D_3 = \frac{SN_a - SN_2^* - SN_1^*}{a_3 m_3} \qquad SN_1^* + SN_2^* + SN_3^* \geq SN_3$$