مراجعة طرق
(٤)
م/ عمرو شالشه

٤

طرق - ثالثه مدنى

ملزمة الامتحانات

حل امتحان 2013
حل امتحان 2012
حل امتحان 2011

Eng.Amr Shalkamy

الفصل الدراسى الاول ٢٠١٢
المادة هندسة الطرق والمطارات
ثالثة مدنى

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
PUBLIC WORKS DEPARTMENT
3rd Year, Civil Engineering

1st Semester, 2012-2013 **Course Code: *CEP 371*** ***Time : 3.00 Hrs***

Highway and Airports Engineering

The Exam Consists of **Six** Questions in **Four** Pages.

Answer all questions and assume any missing data

Question (1): ***(Marks = 20%)***

a. Derive a relationship to determine the minimum radius of a horizontal curve as a function of vehicle speed, superelevation, acceleration of gravity, and coefficient of side friction.

b. A horizontal curve on a two-lane highway (3.6-m lanes) has PC at station 3+765 and PT at station 3+940. The central angle is 34 degrees, the superelevation is 0.08, and 6 m are cleared (for sight distance) from the inside edge of the inner lane. Determine a maximum safe speed to the nearest 10 km/h. Assume the coefficient of longitudinal friction = 0.33 and the coefficient of side friction = 0.14.

Question (2): ***(Marks = 20%)***

a. Define following terms:
- Stopping Sight Distance.
- Passing Sight Distance

b. A sag vertical curve connects a –2.0% grade with a +2.5% grade on a rural arterial highway. If the criterion selected for design is the minimum stopping sight distance, and the design speed of the highway is 100 km/h, compute the elevation of the curve at 50-m intervals if the grades intersect at station (14 + 000) at an elevation of 280 m.

Question (3): ***(Marks = 15%)***

A 24-inch plate bearing test was performed on a clay subgrade soil. Two consolidation tests were performed: The first at saturation moisture content and the second at partially saturated content. Results were as follows:

Load (1b)	2900	4600	6100	6700	7300	7900
Deformation (inch)	0.007	0.018	0.05	0.07	0.1	0.14

Consolidation test:

Saturated						
Stress (psi)	3	5	8	11	12	16
Deformation (in)	0.0025	0.007	0.011	0.018	0.02	0.027
Partially saturated						
Stress (psi)	3	5	8	11	12	16
Deformation (in)	0.005	0.008	0.011	0.014	0.0165	0.022

Determine the design modulus of sub grade reaction. (**Please draw in the graph paper**)

Question (4): ***(Marks = 15%)***

If the acceptable range of Air voids (Vv) is from 3% to 5%, and the acceptable range of voids filled with bitumen (VFB) is from 75% to 85%. Assume absorption of bitumen in aggregates is zero:

a) Find the acceptable range of bitumen percent by volume (Vb).

b) If the specific gravity of the mix is 2.4; find the range of theoretical specific gravity.

Question (5): ***(Marks = 20%)***

A pavement cross section was estimated to comprise the following:

- The AC course having a thickness of 6 inch and a modulus of elasticity of 250000 psi
- The base course is a crushed stone having a thickness of 12 inch and a CBR value of 80
- The bottom layer is a sandy gravel subbase with a thickness of 16 inch and a CBR value of 30

Evaluate the above pavement section, whether it is under designed or over designed. The actual input parameters needed for design are:

- The effective resilient modulus of the subgrade is 12000 psi
- The expected drop in the serviceability is 1.9
- The estimated ESAL during the design life = $4*10^6$
- The reliability level proposed by the highway authorities is 90%
- All drainage coefficients are equal to one and $S_0 = 0.45$

If you find out that pavement is over designed; estimate how much money you could save for a length of 1 km and a width of 1 lane (3.5 m) .If you find out that the pavement is under designed, estimate how much money you need (per 1 km per lane) in order to assure that no failure will occur during the entire pavement life. In estimating the cost, the following unit rate price can be assumed:

- Cost of AC for 1 inch thick = 12 E.P / m^2
- Cost of base course for 1 inch thick = 2.5 E.P / m^2
- Cost of subbase course for 1 inch thick = 0.75 E.P / m^2

Question (6): ***(Marks = 10%)***

Draw details for the contraction and expansion joints in rigid pavement of truck parking lot showing the function of each type. How is the maximum slab length determined?

Formulas

Stopping Sight Distance (SSD)

$$SSD = 0.278vt + \frac{v^2}{254 * (f \pm G)}$$

Vertical Curve

$- y = Ax^2/200L$

Horizontal Curve

$$- R_{min} = \frac{u^2}{127(e + f_s)} \qquad - m = R\left[1 - \cos\frac{90S}{\pi R}\right]$$

Tables and Charts

K Factors to Provide Stopping Sight Distance on Sag Vertical Curve

Design Speed (km/h)	Rate of Vertical Curvature (k)
30	6
40	9
50	13
60	18
70	23
80	30
90	38
100	50
110	55

Chart for Estimating Structural Layer Coefficient of Dense-Graded/Asphalt Concrete Based on the Elastic (Resilient) Modulus

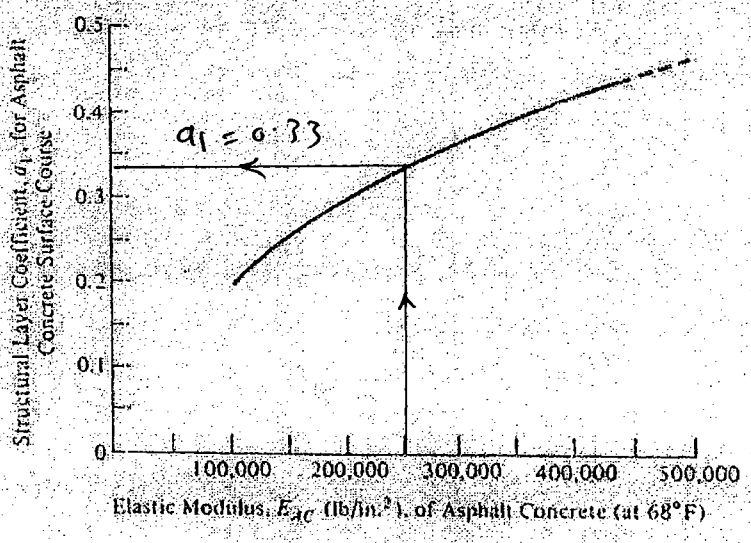

Fig (6.12)

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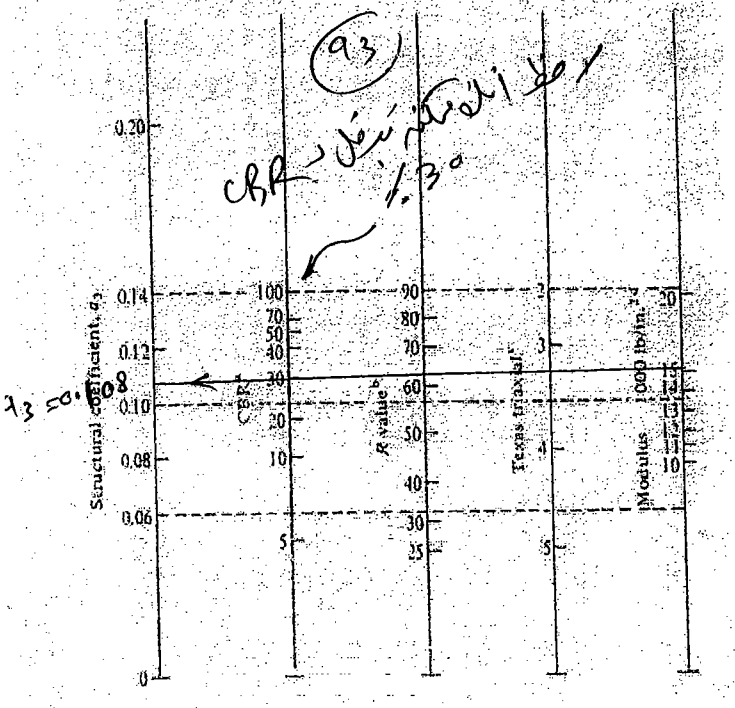
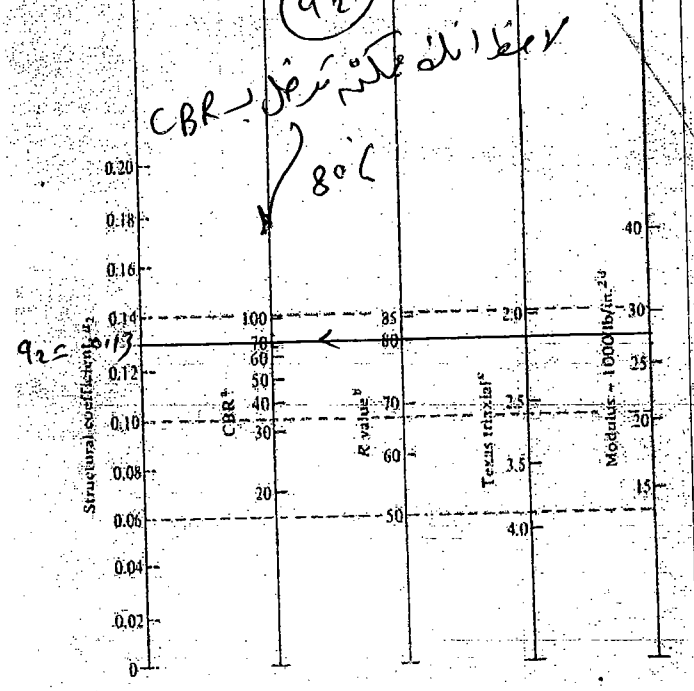
Highway and Airports Engineering

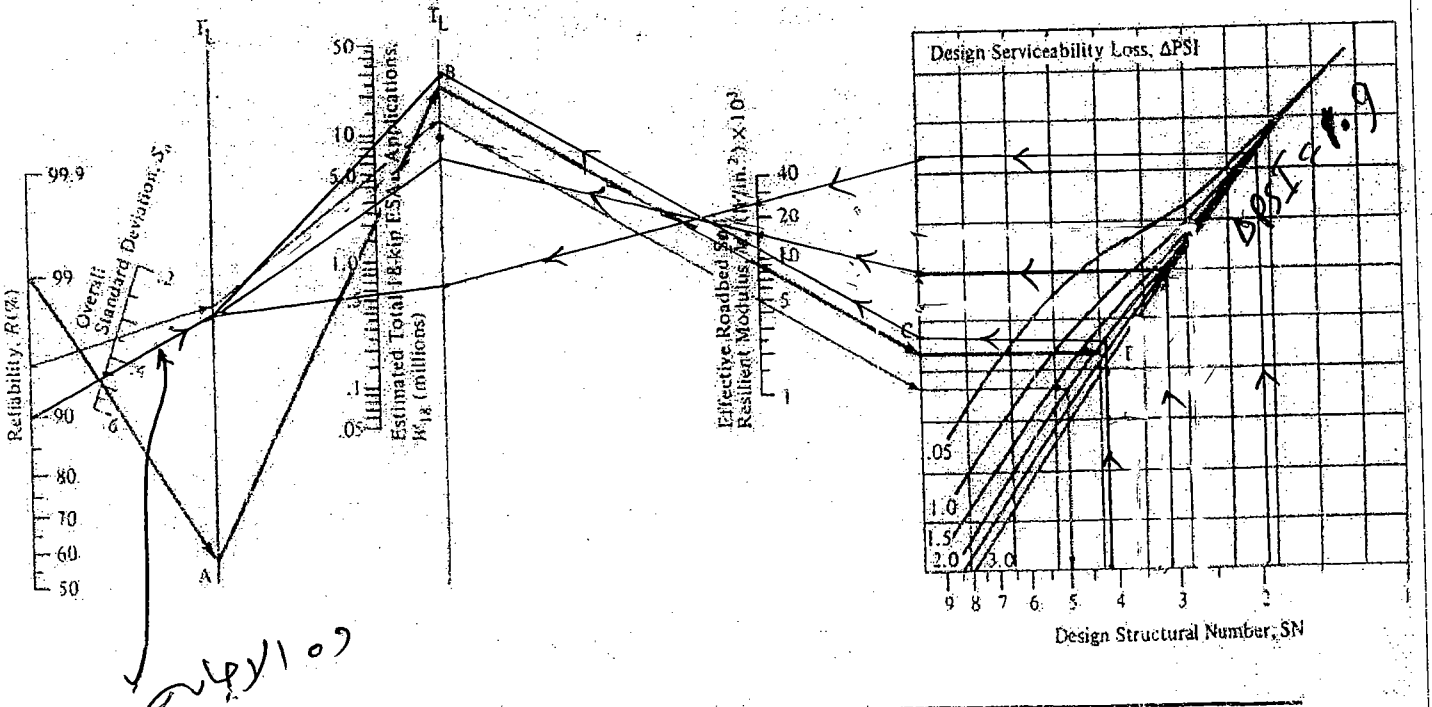
The Exam Consists of Six Questions in Four Pages. 4/4

Variation in Granular Subbase Layer Coefficient, a_3, with Various Subbase Strength Parameters



Variation in Granular Base Layer Coefficient a_2 with Various Subbase Strength Parameters





Question(1) :-

(a) Derive $e + F_s = \frac{V^2}{127R}$ (horizontal alignment طريقة المشي)

(b) "تكرم علوه"

Pc station = 3+765

PT station = 3+940

Central angle (Δ) = 34°

$C = 6_{given} + \frac{3.6}{2} = 7.8$ m

f_s side friction = 0.14

f_s longitudnel = 0.33

Two lane , 3.6m lane width , e=0.08

" horizontal curve "

Req : V_{max} = ?? ⟶ سرعة لأقرب 10 كم/ساعة

الحل

هنجيب سرعتين من معادلتين لأن لازم أحقق إحداثيتين وهنأخد السرعة الأقل.

$e + f_s = \frac{V_1^2}{127R}$ ⟶ V_1 = ✓

$C = R_1\left(1 - \cos\frac{28.65\,S'}{R_1}\right)$ ⟶ S' = ✓ ⟶ V = ✓

steps First : Balance equation :-

$e + f_s = \frac{V^2}{127R}$ ⟶ (V = ?? , R = ??)

$L_c = R + \Delta + \frac{\pi}{180}$, L_c = STA (PT) − STA (PC)

= 3940 − 3765 = 175 m

$\therefore 175 = R * 34 * \frac{\pi}{180}$ ⟶ $R = 295$ m

$0.08 + 0.14 = \frac{V_1^2}{127 * 295}$ ⟶ $V_1 = 90.79$ km/h

Second Sight distance equation :-

$R_1 = R - 0.5$ lane width (two lane)

$= 295 - 0.5 * 3.6 = 293.2\ m$

$C = R_1 \left(1 - \cos \frac{28.65\ S'}{R_1}\right) \longrightarrow S' = ??$

$7.8 = 293.2 \left(1 - \cos \frac{28.65\ S'}{293.2}\right) \longrightarrow S' = 135.55\ m$

$S' = 0.278 * V_0 * t_1 + \frac{V_0^2 - V_f^2}{254(f+G)}$

$135.55 = 0.278 * V_0 * 2.5 + \frac{V_0^2 - 0}{254(0.33+0)}$

$V_0 = 81.4\ km/h$

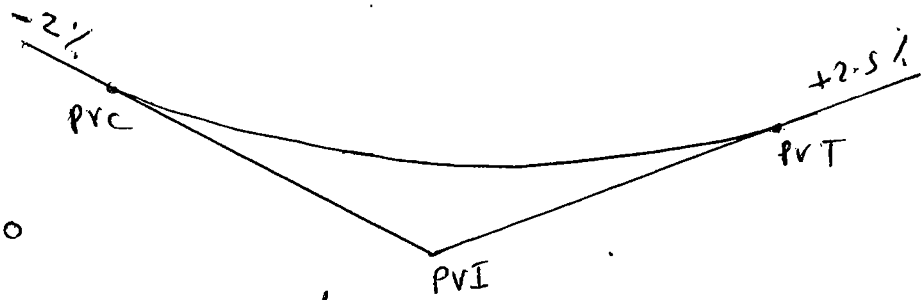
$V_{max} = \text{min of } V_1, V_0 = \text{min of } (90.79, 81.4)\ km/h$

$V_{max} = 80\ km/h$ (تقريب لأقرب ١٠ كم/س للأقل)

Question (2) :-

ⓐ Define SSD & PSD — (sight distance) ملزمة الشرح

ⓑ given :-



Min SSD

$V = 100$ kph

PVI STA = 14+000

PVI Elev = 280 m

Req : elevations at 50 m-Intervals.

" solution "

في البداية لا بد من حساب طول المنحنى

مهم جداً ← معطى لك جدول لحساب (K) في كل الامتحانات عليك تذكره

لازم تشوف أولاً قبل بدء الحل بالطريقة العادية

$V = 100$ kph $\xrightarrow{\text{Table}}$ $K = 50$

$L = KA$, $A = |(-2) - (2.5)| = |-4.5| = 4.5$

$L = 50 \times 4.5 = 225$ m

$STA(PVC) = STA(PVI) - \frac{L}{2} = 14000 - \frac{225}{2} = 13+887.5$

$STA(PVT) = STA(PVI) + \frac{L}{2} = 14000 + \frac{225}{2} = 14+112.5$

$y = \frac{Ax^2}{200L} = \frac{4.5\,x^2}{200 \times 225} = 1 \times 10^{-4} x^2$, $elev(PVC) = elev(PVI) + \frac{L}{2} \times \frac{2}{100} = 282.25$

station	x = station − STA (PVC)	y	elev(m) = elev(PVC) − $\frac{2}{100}x$ + y
13+887.5	0	0	282.25
13+900	12.5	0.015	282.015
13+950	62.5	0.39	281.39
14+000	112.5	1.27	281.27
14+050	162.5	2.64	281.64
14+100	212.5	4.52	282.52
14+112.5	225	5.06	282.81

Question ③

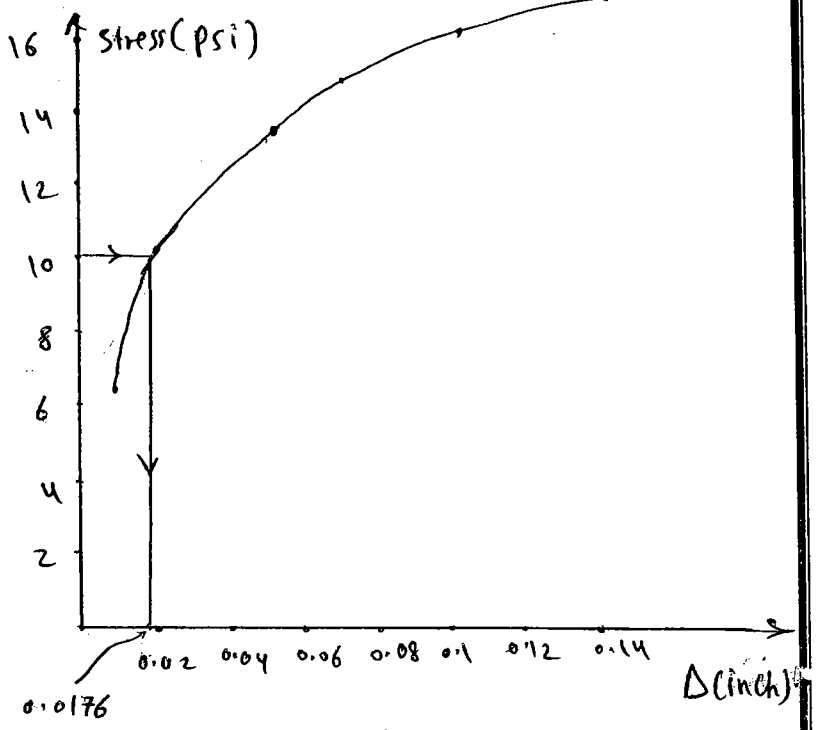
Load (lb)	2900	4600	6100	6700	7300	7900
stress (psi)	6.41	10.16	13.48	14.81	16.14	17.46
Δ(inch)	0.007	0.018	0.05	0.07	0.1	0.14

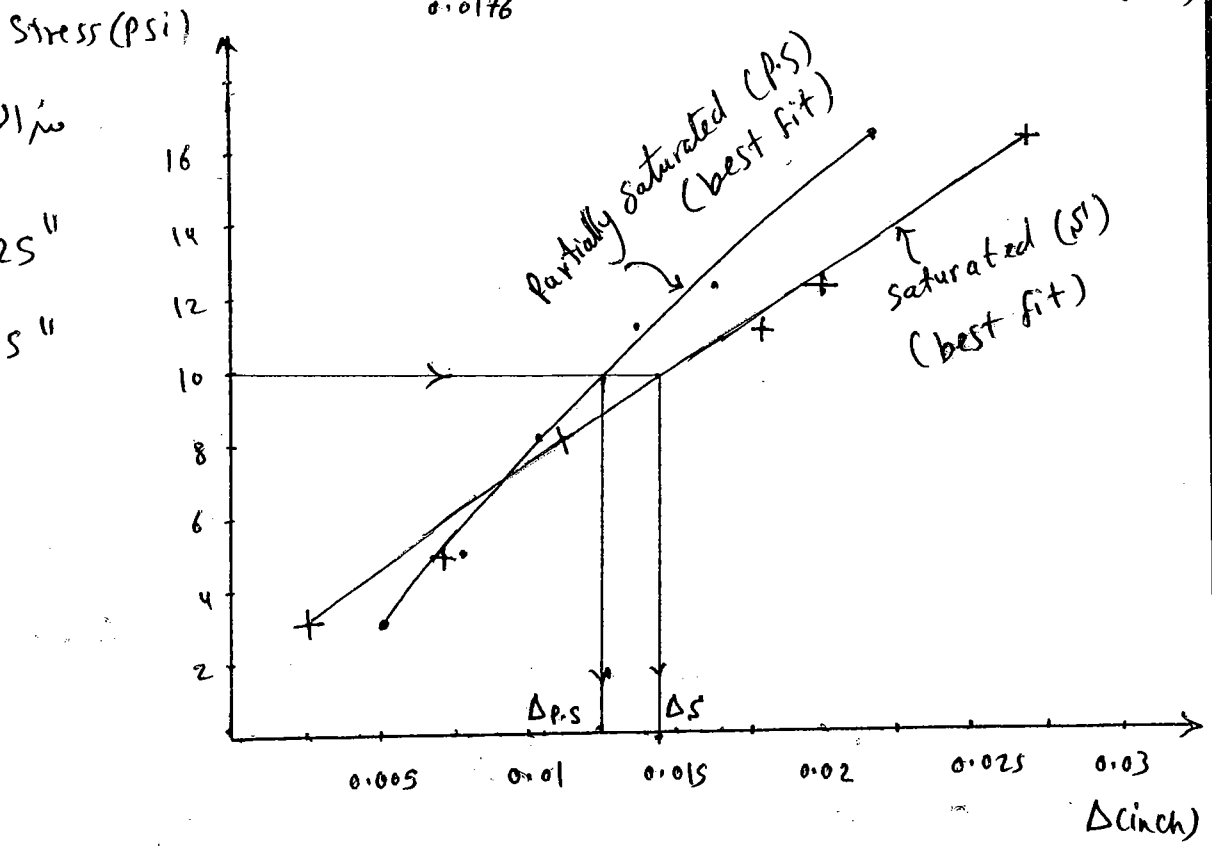
$$\text{Stress} = \frac{\text{load}}{\text{Area}} = \frac{\text{load}}{0.25\pi(24)^2}$$

(انت طبعاً مترسم بمقياس رسم أنت)

$$K_{\text{calculated}} = \frac{10}{\Delta}$$

$$= \frac{10}{0.0176} = 568.18 \text{ lb/inch}^3$$





سؤال رسم

$\Delta_{P.S} = 0.0125''$

$\Delta_S = 0.015''$

$$K_{design} = K_{calculated} * \frac{\Delta_{P.S}}{\Delta_S} = 568.18 * \frac{0.0125}{0.015} = 447.48 \text{ lb/inch}^3$$

⊛ **Question (4)** :- given : $\% V_v$ range $= 3 \sim 5 \%$

$\% VFB$ range $= 75 \sim 85 \%$

Req : (a) $\% V_b$ range

(b) G_t range = ?? ; given $G_m = 2.4$

(a) Solution

$$VFB = \frac{\% V_v}{\% V_v + \% V_b} * 100 \longrightarrow \% V_b = \frac{\% V_v}{\left(\frac{\% VFB}{100}\right)} + \% V_v$$

لاحظ أن تناسب V_b ، V_v طردي . و تناسب V_b ، VFB عكسي

$$\therefore Min\ \% V_b = \frac{3}{85/100} + 3 = 6.53 \%$$

(at Min A_v, Max VFB)

$$Max\ \% V_b = \frac{5}{75/100} + 5 = 11.67 \%$$

(at Max A_v, Min VFB)

→ $\therefore \% V_b$ range $(6.53 \sim 11.67)$

(b)

$$\% V_v = \frac{G_t - G_m}{G_t} * 100$$

$$3 = \frac{G_{t\,min} - 2.4}{G_{t\,min}} * 100 \longrightarrow G_{t\,min} = 2.474$$

$$5 = \frac{G_{t\,max} - 2.4}{G_{t\,max}} * 100 \longrightarrow G_{t\,max} = 2.53$$

G_t range $= 2.474 \sim 2.53$

Question (5) :: (given data):-

$M_R = 3000\ CBR^{0.65}$ (IF CBR > 10 %)

$M_{R\,base} = 3000\ (80)^{0.65} = 26832\ Ib/in^2$

$M_{R\,subbase} = 3000\ (30)^{0.65} = 16431\ Ib/in^2$

6"	$M_{R\,w.s} = 250000\ Ib/in^2$
12"	$M_{R\,base} = 26832\ Ib/in^2$
16"	$M_{R\,subbase} = 16431\ Ib/in^2$

$M_{R\cdot subgrade} = 12000\ Ib/in^2$

الأرقام دي خطأ حسابي لكن هنكمل حل بيهم

$\Delta PSI = 1.9$, $ESAL = 4 * 10^6$

$R = 90$, $S_o = 0.45$, $m_1 = m_2 = m_3 = 1$

Req ① Evaluate This pavement (under designed or overdesigned)

يعني هنحسب ال ESAL اللي يقدر الطريق ده يتحمله بالقطاع المعطى لنا .
سواء ال ESAL الناتج هو ال max اللي يقدر يشيله القطاع وهنقارنه
بال ESAL المطلوب في التصميم (4 *106) ونقارن بينهم

If
- $ESAL = 4 * 10^6 < ESAL_{max}$ (overdesigned)
- $ESAL = 4 * 10^6 > ESAL_{max}$ (under designed)

② If overdesigned ⟶

المطلوب الثاني ← لو انت صممت بزيادة احسب الفلوس اللي كان ممكن توفرها
في طول 1 كم ، عرض الحارة 3.5 متر .

If underdesigned ⟶

لو انت لقيت تصميمك أقل من المطلوب احسب انت عايز فلوس أد إيه
علشان تبقى safe ومايحدث انهيار في الطريق .

(solution)

① steps for design (هنحل مسأله عادي جداً)

- $ESAL = 4 \times 10^6$ (for design)

هنحسب بقا $ESAL_{max}$ اللي يقدر يشيله القطاع :

$MR_{u.s} = 25000 \xrightarrow{\text{Fig 6.12}} a_1 = 0.33$

$MR_{base} = 26832 \xrightarrow{\text{Fig 6.13}} a_2 = 0.13$

$MR_{subbase} = 16431 \xrightarrow{\text{Fig 6.14}} a_3 = 0.108$

انظر لل figures مرفقة مع ورقة الأسئلة

- $m_1 = m_2 = m_3 = 1$ (given)
- $S_o = 0.45$, $R = 90$, $\Delta PSI = 1.9$ (From Monography)

$SN_{base} = a_1 m_1 t_1 = 0.33 \times 1 \times 6 = 1.98$

$SN_{subbase} = a_1 m_1 t_1 + a_2 m_2 t_2 = 1.98 + 0.13 \times 1 \times 9 = 3.15$

$SN_{sub.gr} = a_1 m_1 t_1 + a_2 m_2 t_2 + a_3 m_3 t_3 = 3.15 + 0.108 \times 1 \times 10 = 4.23$

هنا مطلوب ESAL يعني هندخل الشكل بالعكس من ناحيتين من الناحية الشمال ب R و So ومن الناحية اليمين ٣ مرات بال SN بتاع كل طبقة مع MR بتاع الطبقة دي ونشوف في أنهي حته نجيب ESAL ٣ مرات وناخد الأقل فيهم

By $SN_{base} = 1.98$, $\Delta PSI = 1.9$ & $MR_{base} = 26832\ lb/inch^2$ (انظر الشكل المرفق مع ورقة الأسئلة)

get $\boxed{ESAL_1 = 0.56 \times 10^6}$

By $SN_{sub.b} = 3.15$, $MR_{sub.b} = 16431$ get $\boxed{ESAL_2 = 3.5 \times 10^6}$

By $SN_{sub.gr} = 4.23$, $MR_{s.G} = 12000$ get $\boxed{ESAL_3 = 8 \times 10^6}$

$ESAL_{max}$ (اللي يقدر يشيله القطاع المعطى) $= \min$ of $ESAL_{1,2,3} = 0.56 \times 10^6$

$ESAL)_{given} = 4 \times 10^6 > ESAL_{max}$ (un safe)

∴ the section is underdesigned

يعني محتاجين طبقات ذات سمك غير المعطى علشان نبقا (safe)

- t_1, t_2, t_3 هنحل تصميم كامل وكسب

- $ESAL = 4 * 10^6$

$a_1 = 0.33$, $a_2 = 0.13$, $a_3 = 0.108$

$S_o = 0.45$, $\Delta PSI = 1.9$, $R = 90$, $m_1 = m_2 = m_3 = 1$

هنحل الـ chart كام مرة عشان نوصل للحل

$MR_{base} = 26832 \frac{lb}{in^2} \longrightarrow SN_{base} = 2.8$

$MR_{subbase} = 16431 \frac{lb}{in^2} \longrightarrow SN_{subbase} = 3.4$

$MR_{sub.g} = 12000 \frac{lb}{in^2} \longrightarrow SN_{subgrade} = 3.75$

$SN_{base} = a_1 m_1 t_1 = 2.8 = 0.33 * 1 * t_1 \longrightarrow t_1 = 8.5'' > t_{1\,min} = 2''$

$SN_{sub.base} = a_1 m_1 t_1 + a_2 m_2 t_2$

$3.4 = 0.33 * 1 * 8.5 + 0.13 * 1 * t_2 \longrightarrow t_2 = 4.6'' > t_{2\,min} = 4''$

$SN_{sub.g} = a_1 m_1 t_1 + a_2 m_2 t_2 + a_3 m_3 t_3$

$3.75 = 0.33 * 1 * 8.5 + 0.13 * 1 * 4.6 + 0.108 * 1 * t_3$

$t_3 = 3.2'' < t_{3\,min} = 6'' \longrightarrow t_3 = 6''$

* كده دلوقتي عندنا قطاعين :

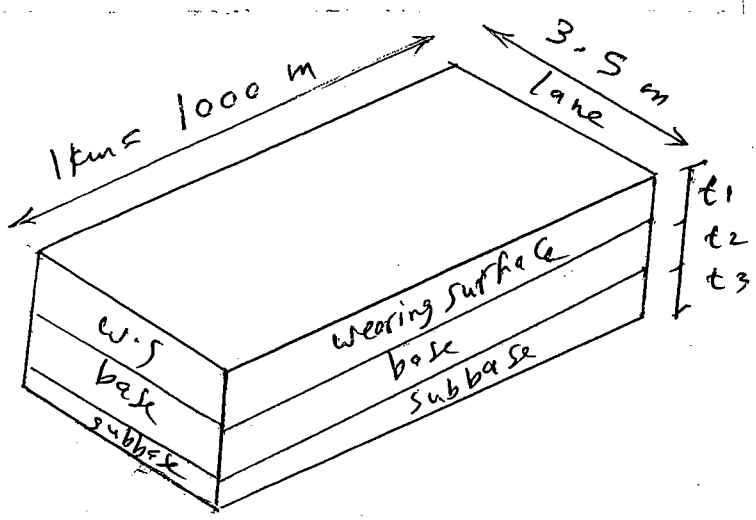
6" w.s
12" base
16" subbase
S.G

underdesigned "Not safe"

8.5" w.s
4.6" base
6" subbase
S.G

designed "safe"

* يبقا كده هحسب تكلفه مرتبه مره لكل قطاع فى طول ١ كم
وعرضه عباره عن ٣,٥ متر وتشوف عايزين فلوس اد ايه علشان
يبقى التصميم بتاعنا (Safe)



* Cost of Materials :-

* proposed section (المقترح) | * Required section (المطلوب)

Cost = (Area * (cost/m²/inch) * thickness)
↳ given

Cost = (3.5 * 1000 * 12 * 6)
+
(3.5 * 1000 * 2.5 * 12)
+
(3.5 * 1000 * 0.75 * 16)
= 399,000 L.E/km/lane

Cost = (3.5 * 1000 * 12 * 8.)
+
(3.5 * 1000 * 2.5 * 4.)
+
(3.5 * 1000 * 0.75 * 6)
= 413,000 L.E/km/lane

The required cost to be Safe :-

= 413,000 − 399,000 = 14000 L.E/km/lane

AIN SHAMS UNIVERSITY
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3rd year Civil Engineering Students

جامعة عين شمس
كلية الهندسة
قسم هندسة الطرق والمطارات

Highway and Airport Engineering Exam

January 2012 — هندسة الطرق والمطارات — *Time : 3.00 Hrs*

- **This exam consists of 6 (six) questions in 3 (three) pages**
- **students are asked to answer all questions, any missing data can be reasonably assumed.**

على الطلبة ضرورة الإلتزام بإجابة كل سؤال في المكان المخصص له بكراسة الإجابة.

A- Geometric Design

Question 1:

a. Derive a relationship to determine the minimum radius of a horizontal curve as a function of vehicle speed, superelevation, acceleration of gravity, and coefficient of side friction.

b. A 360-m-long crest vertical curve has a *PVC* at station 3+040 and elevation 280m. The initial grade is 3.5% and the final grade is -6.5%. Determine the elevation and station of the highest point, *PVI*, and *PVT*.

Question 2:

A temporary diversion has been constructed on a highway of +4 percent gradient due to major repairs that are being undertaken on a bridge. The maximum speed allowed on the diversion is 10 mph. Determine the minimum distance from the diversion that a road sign should be located informing drivers of the temporary change on the highway.

- Maximum allowable speed on highway = 70 mph
- Letter height of road sign = 4 in.
- Coefficient of friction between tires and pavement = 0.2
- Perception-reaction time = 2.5 sec

Assume that a driver can read a road sign within his or her area of vision at a distance of 40 ft for each inch of letter height.

Equations:

- $SSD\ (ft) = 1.47\ P\ u_o + (u_o^2 - u_f^2) / [30\ (f \pm G)]$
- $X_h = g_1 * L/A$

Question 3:

a) Define all the ways to overcome the conflict points of road intersections.
b) Explain the concept of lane balance.
c) What are the design factors to be considered to increase the degree of awareness in road design.

B- Road construction materials

Question 4:

The specific gravities and weight proportions for aggregate and bitumen are as under for the preparation of Marshall Mix design. Assuming absorption of bitumen in aggregate is zero.

ITEM	Coarse Aggregate	Fine Aggregate	FILLERS	BITUMEN
Wt (gm)	2040	310	100	105
SPECIFIC GRAVITY	2.55	2.45	2.44	1.05

Given that the weight in water was 1440 gm, Find V_v, V_b, VMA and VFB.

Question 5:

A repeated load triaxial test is conducted on a soil specimen 4 (in) diameter 8 (in) height a triaxial lab equipment, clamps of (LVDT) where placed 1 (in) from each base of the specimen. The total & deviator stresses where 16 (psi) and 10 (psi) respectively.

After 400 load repetition the relation between time & strain was measured to be:

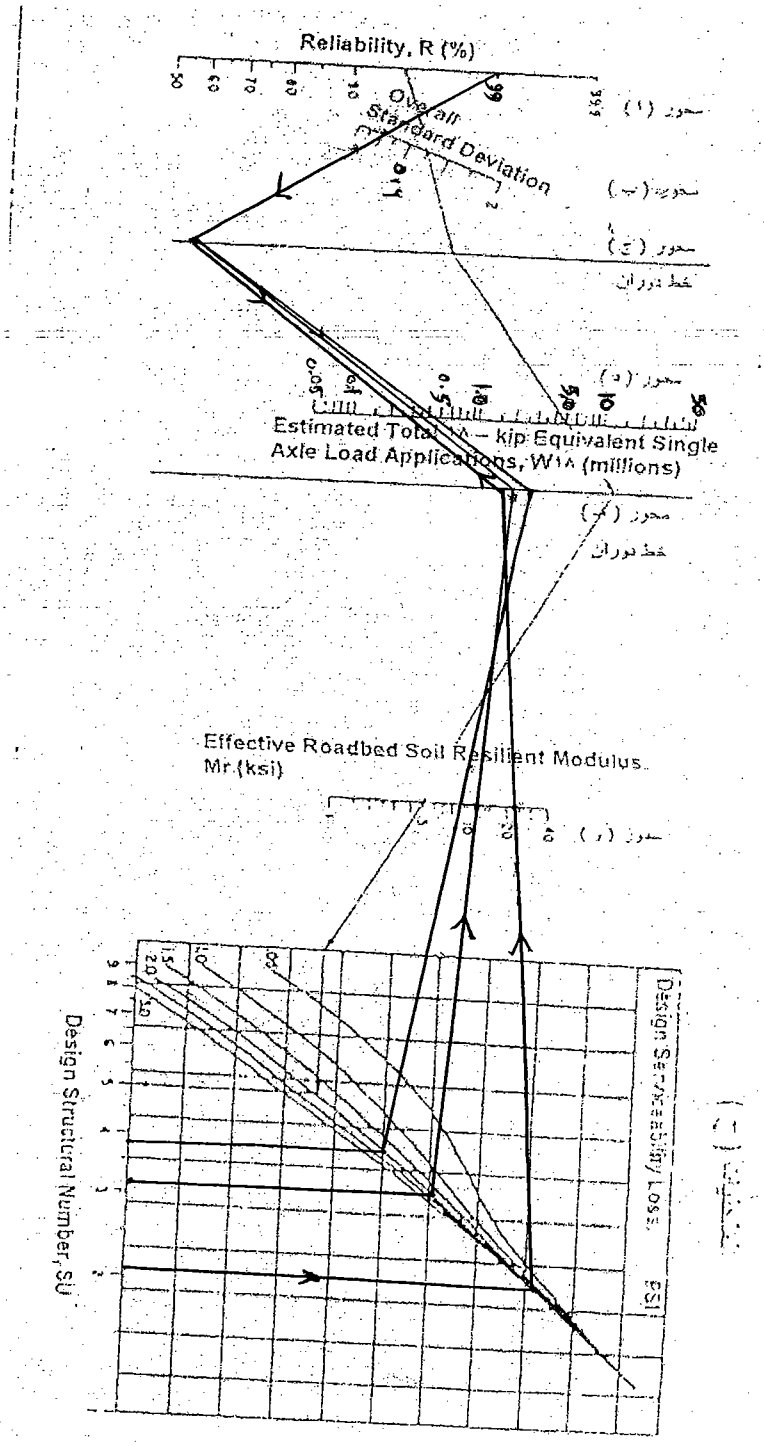
Time (sec)	0	0.45	0.9	1	1.45
strain	0	$5.5*10^{-4}$	$9.33*10^{-5}$	$9.33*10^{-5}$	$6*10^{-4}$
Time (sec)	1.9	2	2.45	2.9	3
strain	$1.433*10^{-4}$	$1.433*10^{-4}$	$6.8*10^{-4}$	$2.233*10^{-4}$	$2.233*10^{-4}$

Determine the resilient modules.

C- Pavement design

Question 6:

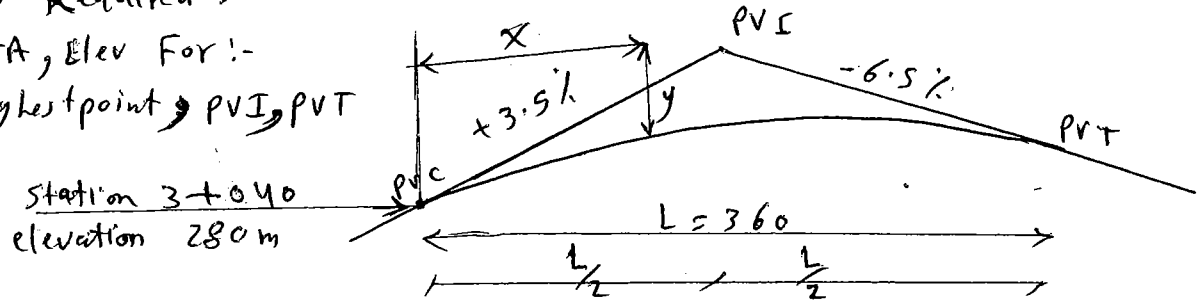
A flexible pavement is constructed with 5" of hot mix asphalt wearing surface (a_1= 0.42), 9" of granular base (a_2 = 0.12 and resilient modulus = 25,000 psi), and 10" of a granular subbase (a_3=0.10 and resilient modulus = 13,500 psi). The subgrade has a resilient modulus of 10,000 psi. The drainage coefficients are 0.9 and 0.8 for the base and subbase respectively. The reliability factor = 99 %, the overall standard deviation = 0.5, p_i = 4.5, and p_t = 2.5. Determine the maximum 18-kips ESAL applications that can be carried safely by this pavement structure according to the AASHTO design method.


Reliability, R (%)
Overall Standard Deviation
Estimated Total 18 – kip Equivalent Single Axle Load Applications, W18 (millions)
Effective Roadbed Soil Resilient Modulus Mr (ksi)
Design Structural Number, SN
Design Serviceability Loss, PSI

Question (1) :-

(a) Derive :- $e + f_s = \frac{V^2}{127 R}$ ⟶ تأثير الشرع Horizontal alignment

(b) Required :-
STA, Elev For :-
highest point, PVI, PVT



Solution :

• highest point :-

$$X_{h.p} = \frac{g_1 L}{A} \quad , A = |(3.5) - (-6.5)| = |10| = 10$$

$$x_{h.p} = \frac{3.5 * 360}{10} = 126 \text{ m}$$

$$y_{h.p} = \frac{A x_{h.p}^2}{200 L} = \frac{10 * 126^2}{200 * 360} = 2.205 \text{ m}$$

$$STA(h.p) = STA(PVC) + x_{h.p} = 3040 + 126 = 3166 = \underline{3+166}$$

$$elev_{h.p} = elev(PVC) + \frac{g_1 x_{h.p}}{100} - y_{h.p} = 280 + \frac{3.5 * 126}{100} - 2.205 = \underline{282.205 \text{ m}}$$

• PVI

$$STA(PVI) = STA(PVC) + \frac{L}{2} = 3040 + 180 = 3220 = \underline{3+220}$$

$$elev(PVI) = elev(PVC) + \left(\frac{L}{2}\right) * \frac{g_1}{100} = 280 + 180 * \frac{3.5}{100} = \underline{286.3 \text{ m}}$$

• PVT

$$STA(PVT) = STA(PVC) + L = 3040 + 360 = 3400 = \underline{3+400}$$

$$elev(PVT) = elev(PVI) - \frac{L}{2} * \frac{g_2}{100} = 286.3 - 180 * \frac{6.5}{100} = \underline{274.6 \text{ m}}$$

⊛ **Question 2** :- $G = +4\%$, diversion due to repairs

هيعملوا تحويله للطريق علشان في صيانه

$V_{highway} = 70$ mph $= 70 * 1.6 = 112$ Kph

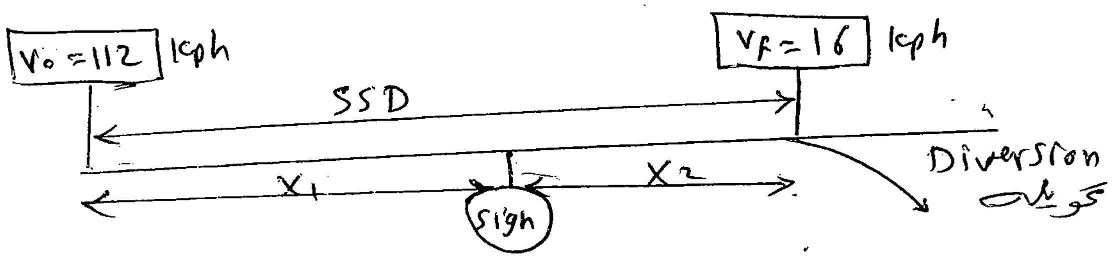
$V_{Diversion} = 10$ mph $= 10 * 1.6 = 16$ kph

$t = 2.5$ sec , $f_s = 0.2$

Letter height of Road Sign = 4 inch

letters visible at distance 40 ft for each inch of letter height.

(القصه) ← نتيجة لصيانه هيحصل تحويل للطريق وتهديئه للسرعه من سرعة الطريق الى سرعة التحويله 16 ، السائق هيبتدي يهدي سرعته لما يقدر يقرأ الحروف المكتوبه على الاشاره .



Required :- $X_2 = ??$ (Distance between sign & diversion location)

$$SSD = 0.278\, V_o t_1 + \frac{V_o^2 - V_f^2}{254(f + G)}$$

$$= 0.278 * 112 * 2.5 + \frac{112^2 - 16^2}{254(0.2 + 0.04)} = 279.4 \text{ m}$$

X_1 ⟶ البعد الي السائق منه يقرأ الاشاره

X_1 = text height * Readiablity ⟶ كده احنا هنطلع بال (ft)

(X_1 in ft, text height in inch, Readiablity in ft/inch)

$= 4_{inch} * 40$ ft/inch $= 160$ ft $= 160 * 0.3048$ m $= 48.77$ m

$\therefore X_2 = SSD - X_1 = 279.4 - 48.77 = 230.63$ m

(OR) ⟶ حل بالمعادلة ونستخدم وحداته (حل آخر)

$$SSD\,(ft) = 1.47\,\rho\,u_0 + \frac{u_0^2 - u_f^2}{30(f + G)}$$

(ρ in sec, u_0 in mph)

$$= 1.47 * 2.5 * 70 + \frac{70^2 - 10^2}{30(0.2 + 0.04)} = 923.92\ ft$$

$$x_1\,(ft) = \text{text height}_{(inch)} * \text{Readability}_{(ft/inch)}$$

$$= 4 * 40 = 160\ ft$$

$$x_2 = SSD - x_1 = 923.92 - 160 = 763.92\ ft$$

$$= 232.8\ m$$

(فرق بسيط جداً في النتائج نتيجة التقريب في استنتاج المعادلة الأساسية والمعامل 1.47 من تحويل الوحدات).

⊛ Question ④ :-

$$G_t = \frac{W_1 + W_2 + W_3 + W_B}{\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_b}{G_b}}$$

$$= \frac{2040 + 310 + 100 + 105}{\frac{2040}{2.55} + \frac{310}{2.45} + \frac{100}{2.44} + \frac{105}{1.05}} = 2.39$$

$$G_m = \frac{W_m}{V_m} = \frac{W_m}{W_m - W_w}$$

$$W_m = 2040 + 310 + 100 + 105 = 2555 \text{ gm}$$

$$G_m = \frac{2555}{2555 - 1440} = 2.29$$

$$\% V_V = \frac{G_t - G_m}{G_t} * 100$$

$$= \frac{2.39 - 2.29}{2.39} * 100 = 4.18 \%$$

$$\% V_b = \frac{V_b}{V_m} * 100 = \frac{W_b / G_b}{W_m / G_m} * 100$$

$$= \frac{105/1.05}{2555/2.29} * 100 = 8.96 \%$$

$$\% VMA = \% V_V + \% V_V = 4.18 + 8.96 = 13.14 \%$$

$$\% VFB = \frac{\% V_b}{\% VMA} * 100$$

$$= \frac{8.96}{13.14} * 100 = 68.19 \%$$

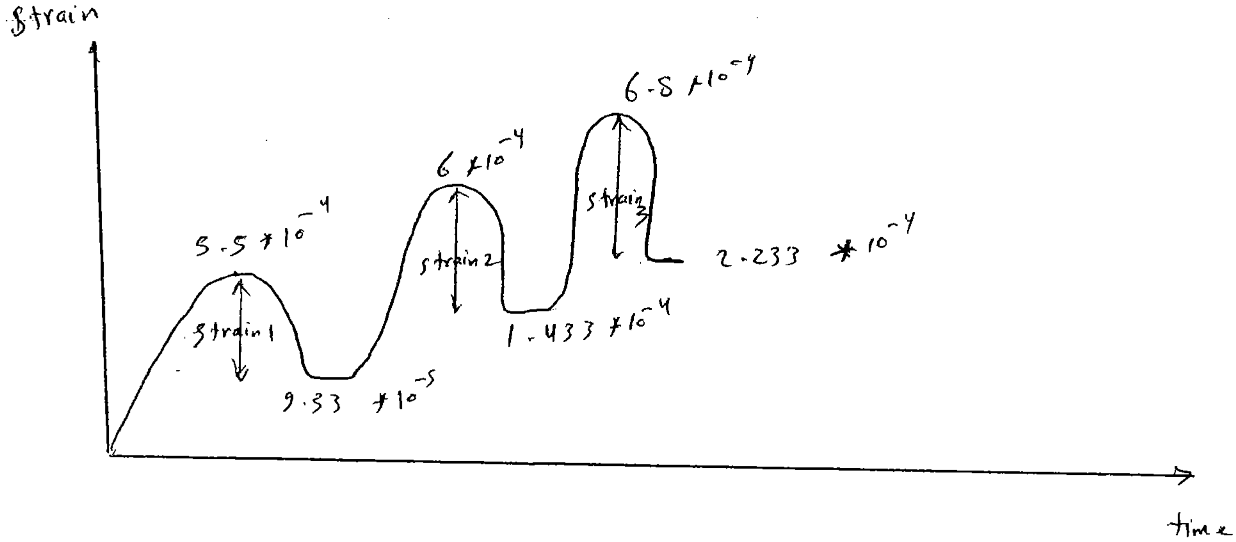
Question 5:

A repeated load triaxial test is conducted on a soil specimen 4 (in) diameter 8 (in) h triaxial lab equipment, clamps of (LVDT) where placed 1 (in) from each base specimen. The total & deviator stresses where 16 (psi) and 10 (psi) respectively.

After 400 load repetition the relation between time & strain was measured to be:

Time (sec)	0	0.45	0.9	1	1.45
strain	0	5.5*10^-4^	9.33*10^-5^	9.33*10^-5^	6*10^-4^
Time (sec)	1.9	2	2.45	2.9	3
strain	1.433*10^-4^	1.433*10^-4^	6.8*10^-4^	2.233*10^-4^	2.233*10^-4^

Determine the resilient modules.



$\text{Recov. Strain}_1 = 5.5 * 10^{-4} - 9.33 * 10^{-5} = 4.567 * 10^{-4}$

$\text{Recov. Strain}_2 = 6 * 10^{-4} - 1.433 * 10^{-4} = 4.567 * 10^{-4}$

$\text{Recov. Strain}_3 = 6.8 * 10^{-4} - 2.233 * 10^{-4} = 4.567 * 10^{-4}$

(LVDT ثابت لأنه ∴ strain [illegible])

Max recovered strain = max of (Recov. Strian 1, 2, 3)

Max recovered strain = $4.567 * 10^{-4}$

Deviator stress = Total stress - Confining Stress = 16 - 10 = 6 psi

$$M_r = \frac{\textit{Deviator stress}}{\text{Max recovered strain}} = \frac{6}{4.567 * 10^{-4}} = 13137.7 \text{ psi}$$

Question 6 :- (مهمه الفكره غير مباشره)

given :-

$m_2 = 0.9$, $m_3 = 0.8$

$R = 0.99$, $S_o = 0.5$

$P_i = 4.5$, $P_t = 2.5$

Req ESAL = ??

5"	$a_1 = 0.42$	W.S
9"	$a_2 = 0.12$, $MR_{base} = 25{,}000$ Ib/in²	base
10"	$a_3 = 0.1$, $MR_{subbase} = 13{,}500$ Ib/in²	Subbase
	$MR = 10{,}000$ Ib/in²	Subgrade

Sol

هنا مطلوب ال ESAL يعني المساله بالعكس هنحسب SN للـ٣ طبقات وندخل من الكيرف من الناحيتين بـ SN لكل طبقة مع MR للقشر الطبقة من ناحيه ومن الناحيه الاخرى باستخدام R و So ونجيب ESAL ٣ مرات وناخد الاقل .

$SN_{base} = m_1 a_1 t_1 = 1 * 0.42 * 5 = 2.1$, $MR_{base} = 25{,}000$ Ib/inch²

$\Delta PSI = 4.5 - 2.5 = 2$, $S_o = 0.5$, $R = 0.99$

انظر ال (chart) المرفقه مع الكتابه

$$ESAL_1 = 0.25 * 10^6$$

$SN_{subbase} = m_1 a_1 t_1 + m_2 a_2 t_2 = 1 * 0.42 * 5 + 0.9 * 0.12 * 9$
$= 3.07$, $MR_{subbase} = 13500$ Ib/inch²

$$ESAL_2 = 0.35 * 10^6$$

$SN_{subgrade} = m_1 a_1 t_1 + m_2 a_2 t_2 = 1 * 0.42 * 5 + 0.9 * 0.12 * 9$
$+ 0.8 * 0.1 * 10 = 3.87$, $MR_{subgrade} = 10{,}000$ Ib/in²

$$ESAL_3 = 0.43 * 10^6$$

$\therefore$ Max ESAL is the min of $ESAL_{1,2,3}$

$$\text{Max ESAL} = \text{Max } W_{18} = 0.25 * 10^6$$

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
PUBLIC WORKS DEPARTMENT

3rd Civil Engineering *January 2011* *Time : 3.00 Hrs*

Highway and Airport Engineering

Notes:

- The exam consists of six questions in four pages.
- Equations and charts are provided in page 4.
- Answer all questions and assume any missing data.
- Answer each question as one part and do not overlap answers from different questions.

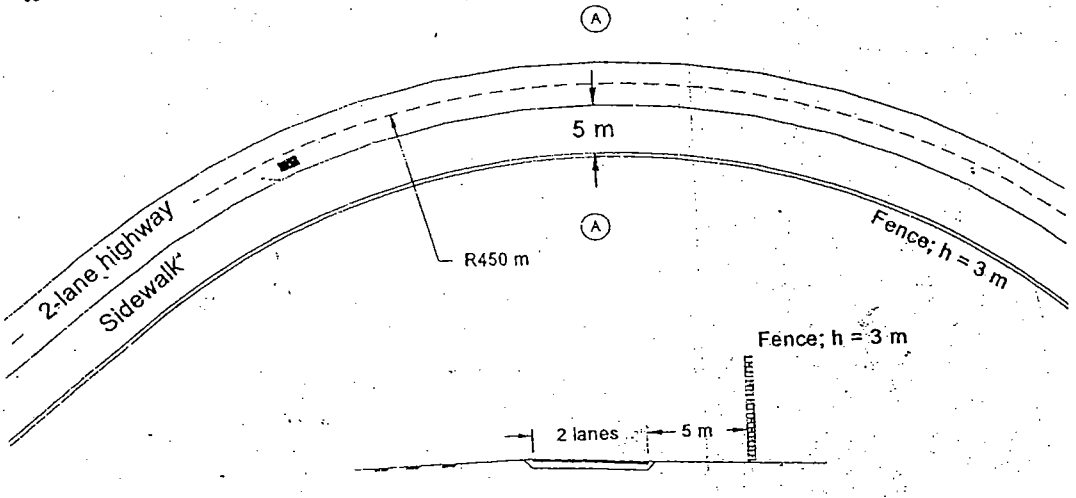
Question 1 [20]

The figure below shows a horizontal curve that is located on a two-lane highway and has a curve radius of 450 m. A 3-m-height fence is also located at a distance of 5 m from the inside road edge. The accident records on this road section showed a higher accident rate than normal. Considering a speed of 100 km/h, you were asked to:

a. check if the stopping sight distance is adequately provided and, if required, list all possible actions supported by numbers to satisfy the stopping sight distance.

b. check the suitability of the existing 4% superelevation on this curve and, if required, list all possible actions to satisfy the vehicle balance.

(Assume a lane width of 3.6 m, longitudinal friction coefficient of 0.29, and side friction coefficient of 0.12)



Cross Section A-A

[15]

Question 2

A vertical curve connects a +2 % grade with a -1 % grade on a two-lane highway. The station of VPC is 8+110.80 and the station of VPT is 8+270.50. If the grades of the curve intersect at an elevation of 200 m, compute and display in a tabular format the station and elevation of the curve at a 25-m interval. In the same table, show the station and elevation of VPC, VPI, VPT, and the highest point.

[20]

Question 3

Define the following using sketches:-

a. Recovery distance
b. Speed profile
c. Consistency of alignment
d. The methods of avoiding the conflict points in intersections

[15]

Question 4

a. Discuss the main purpose of soil classification and explain how to classify the soil according to the AASHTO method.

b. A C.B.R. test was performed on a subgrade soil & the following results were obtained:

Penetration (inch)	0.05	0.1	0.15	0.2	0.25	0.3	0.35
Load before soaking (1b)	60	338	535	635	725	740	770
Load after soaking (1b)	120	265	400	505	580	625	655

Determine the design C.B.R. value for this soil.

c. The results of Marshall test for five specimens are given below. Find the optimum bitumen content of the mix.

Bitumen content (%)	Stability (kg)	Flow (0.01")	Air voids (%)	Voids filled with bitumen (%)	Bulk specific gravity (Gm)
3.5	520	9.0	12.5	34	2.17
4	720	9.5	7.2	65	2.21
4.5	835	11.5	3.9	84	2.26
5	750	16	2.4	91	2.23
5.5	640	21	1.9	93	2.18

Question 5

[15]

A 30-inch plate bearing test was performed on a cohesive subgrade soil and the results were as follows:

Load (lb)	2874	4565	6085	6676	7293	7851
Deformation (in)	0.008	0.019	0.039	0.064	0.092	0.139

To determine the saturation correction, two consolidation tests were performed in the laboratory, the first at saturation moisture content and the second at natural moisture content. The results were as follows:

Saturated sample						
Stress (psi)	3	5	8	11	12	16
Deformation (in)	0.0025	0.007	0.011	0.018	0.02	0.027
Sample at natural moisture content						
Stress (psi)	3	5	8	11	12	16
Deformation (in)	0.003	0.005	0.011	0.014	0.017	0.021

Determine the design modulus of subgrade reaction (K).

Question 6

[25]

You have been asked to do the structural design for a new road. The road will have 3 lanes in each direction. Based on current traffic estimates, the one-way traffic volume during the first year of operation will be as follows:

- Single-unit trucks = 1872 /day ; $T_F = 1.9$
- Double-unit trucks = 1762 /day ; $T_F = 3.1$
- Truck trains = 247 /day ; $T_F = 4.6$

Based on historical averages, the traffic is expected to grow by 4% per year for the foreseeable future. Assume a design life of 30 years and design for a terminal serviceability level of 3.0. The basic pavement design will be as follows:

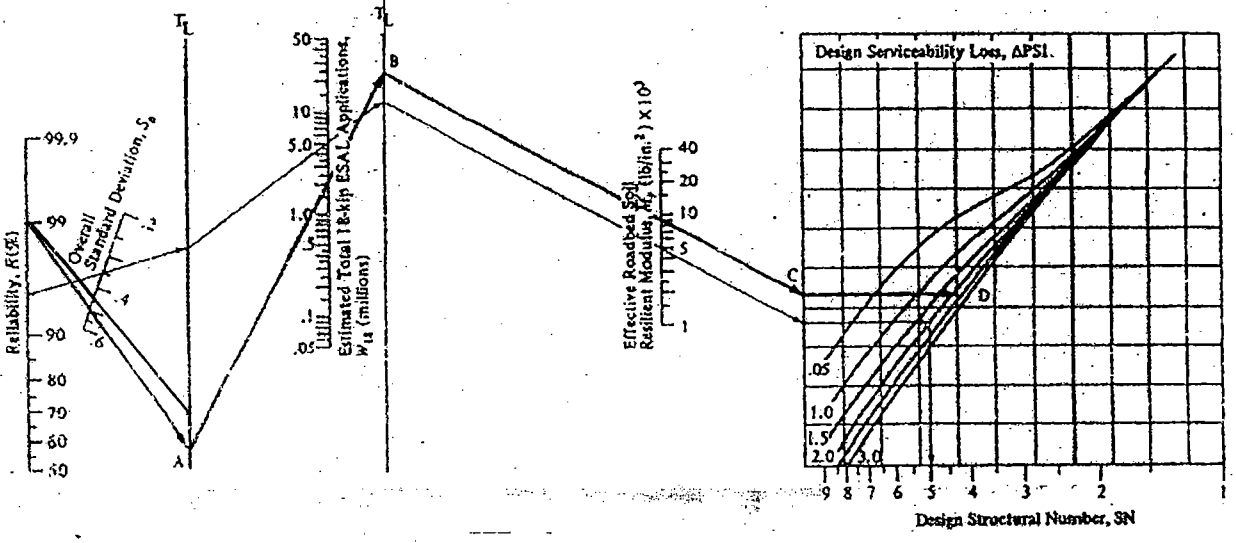
- Surface course: 12.5-mm dense-graded HMA mix with E = 440,000 psi (1" minimum)
- Binder course: 25-mm dense-graded HMA mix with E = 440,000 psi (3" minimum)
- Base course: Crushed stone aggregate with ESB = 28,000 psi (6" minimum)

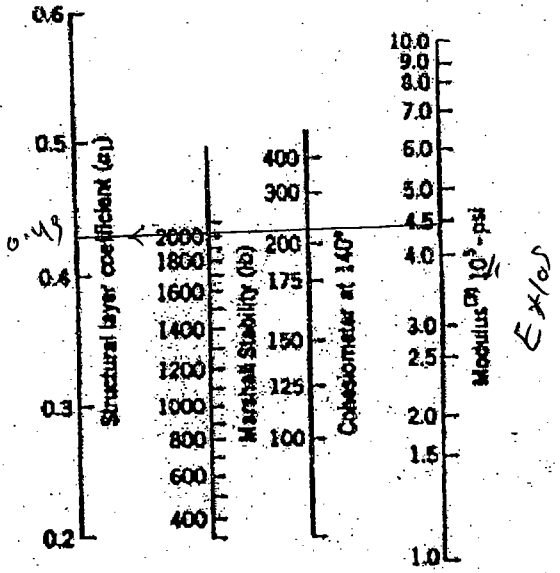
The average CBR of existing subgrade soil is 8. Assume the pavement has excellent drainage and stays saturated for less than 1% of the time.

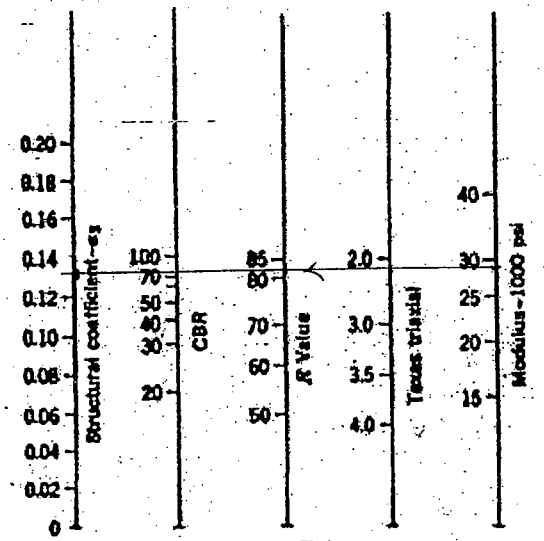
Design the pavement for a reliability level of 90%.

$$HSO = R\left[1 - \cos\frac{28.65\,S}{R}\right]$$

$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.5-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$







⊛Question ①:- $C = 5 + \frac{3.6}{2} = 6.8$ m

→ $R = 450$ m, $R_1 = R - 0.5$ Lane width

→ $v = 100$ kph $= 450 - (0.5 * 3.6) = 448.2$ m

f_s long $= 0.29$

f_s side friction $= 0.12$

Req :- ⓐ check SSD safe or not ? what required to satisfy it ?? (If Not safe)

ⓑ $e = 4\%$ → check the suitability ?? and If required list allactions to satisfy The vehicle balance

Solution

Req ⓐ :-

$$C = R_1 \left(1 - \cos \frac{28.65\, S}{R_1}\right)$$

$$6.8 = 448.2 \left(1 - \cos \frac{28.65 * S}{448.2}\right) \rightarrow S = 156.33 \text{ m}$$ Existing

$$S_{required} = 0.278 * V_0 * t + \frac{V_0^2 - V_f^2}{254 (f \pm G)}$$

$$= 0.278 * 100 * 2.5 + \frac{100^2 - 0}{254 (0.29 + 0)} = 205.26 \text{ m}$$

$S_{Existing} = 156.33$ m $<$ $S_{required} = 205.26$ m → Not safe

⊛ Solutions To satisfy (SSD) required :—

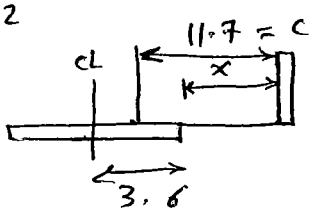
① Increase clearance (C) :—

SSD = 205.26

$$C = 448.2 \left(1 - \cos \frac{28.65 * 205.26}{448.2}\right) = 11.7 \text{ m}$$

$x = 11.7 - \frac{3.6}{2} = 9.9$ m

Distance between the fence required to be 9.9 m → من المركز



② post sign on the road to Decrease the speed :-

نضع بتقليل السرعة على الطريق

$$SSD_{Existing} = 156.33 = 0.278 * V_o * 2.5 + \frac{V_o^2 - 0}{254\,(0.29 + 0)}$$

$$V_o = 84.7 \text{ km/hr}$$

Req ⓑ :-

$$e_{required} + f_s = \frac{V^2}{127 R}$$

$$e_{required} + 0.12 = \frac{100^2}{127 * 450} \longrightarrow e_{required} = 5.5\% > e_{existing} = 4\%$$

Not Safe

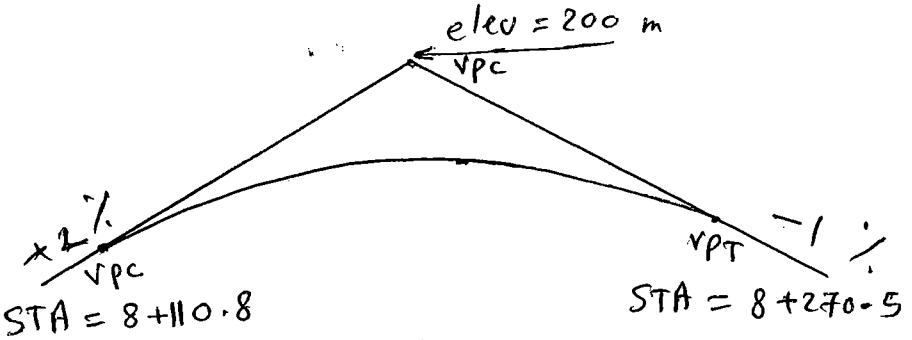
④ Solutions To satisfy balance :-

① Increase e to 5.5 %.

② Decrease (V) :-

$$0.04 + 0.12 = \frac{V^2}{127 * 450} \longrightarrow V = 95.62 \text{ km/h}$$

Question (2) :-



Req :- Station & elevation at 25-m interval, VPC, VPI, VPT, highest point.

Solution

$L_C = 8270.5 - 8110.8 = 159.7\ m$

$A = |(2) - (-1)| = |3| = 3\ \%$

$elev(VPC) = 200 - \left(\frac{159.7}{2} * \frac{2}{100}\right) = 198.403$

$elev(VPT) = 200 - \left(\frac{159.7}{2} * \frac{1}{100}\right) = 199.2015$

$X_{h.p} = \frac{g_1 L}{A} = \frac{2 * 159.7}{3} = 106.467\ m$

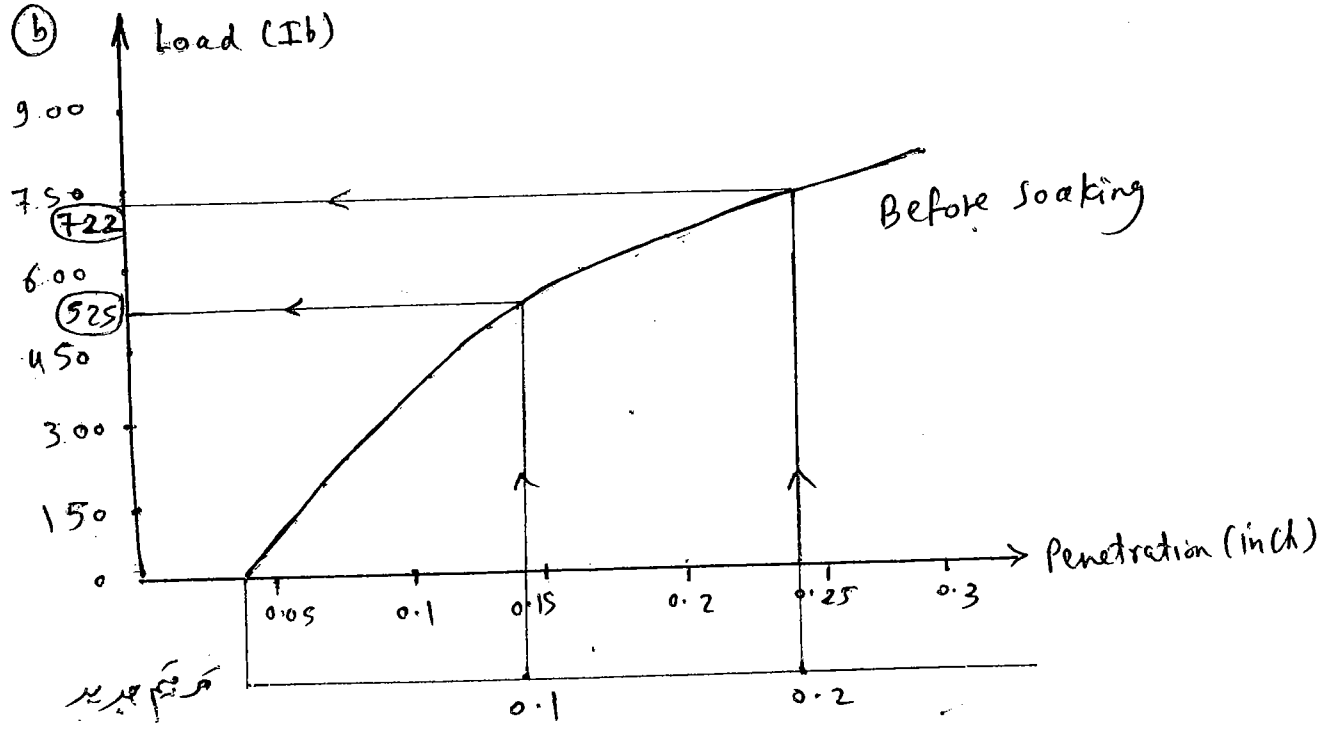
$y = \frac{A x^2}{200 L} = \frac{3 x^2}{200 * 159.7} = 9.393 * 10^{-5} x^2$

Station	x = Station − (VPC)station	y (m)	Elev = elev(VPC) + $\frac{2}{100}$ * x − y
8+110.8 (VCP)	0	0	198.403
8+125	14.2	0.01894	198.668
8+150	39.2	0.14433	199.043
8+175	64.2	0.38713	199.30
8+190.65 (VPI)	79.85	0.59887	199.401
8+200	89.2	0.7473	199.439
8+217.267 (h.p)	106.467	1.06467	199.467
8+225	114.20	1.22495	199.462
8+250	139.20	1.81997	199.367
8+270.5 (VPT)	159.70	2.3955	199.202

⊛ Question (4) :-

(a) ملزمة ① قبل إبريم وصل شيك ①

(b)



$$CBR_{0.1} = \frac{P_{0.1}}{3000} * 100 = \frac{525}{3000} * 100 = 17.5\ \%$$

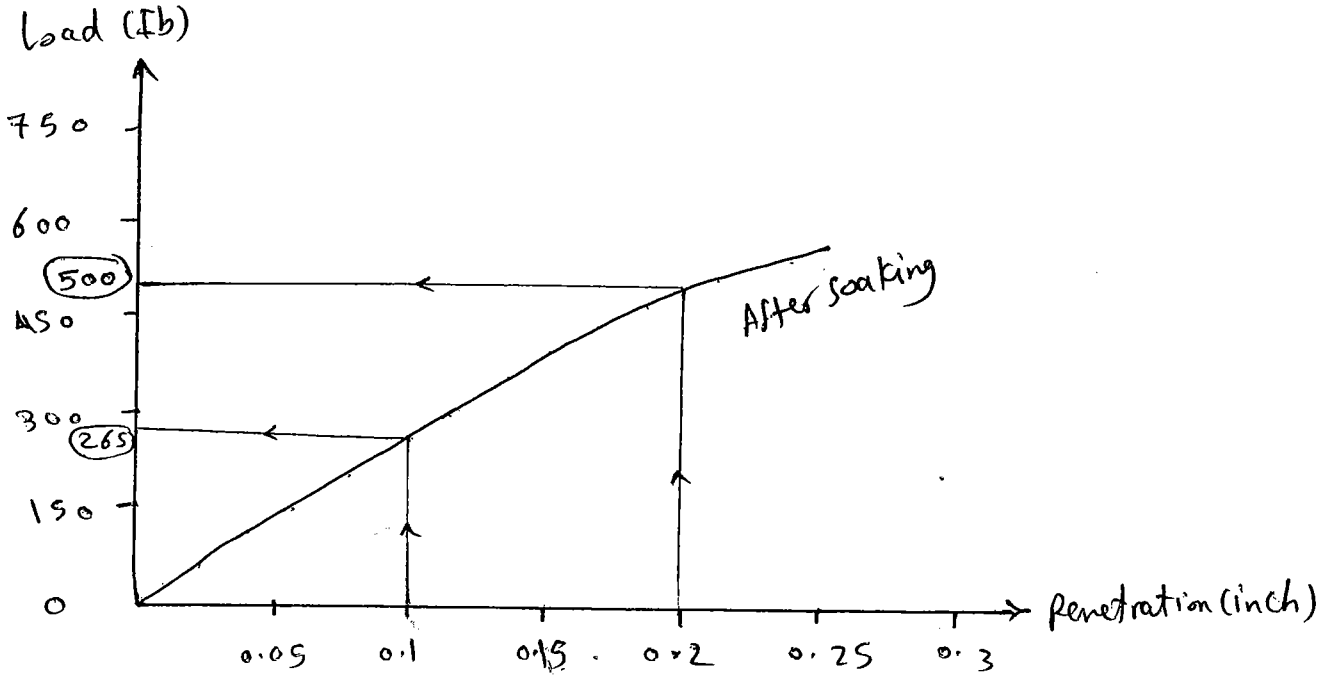
$$CBR_{0.1} = \frac{P_{0.2}}{4500} * 100 = \frac{722}{4500} * 100 = 16\ \%$$

$$\therefore CBR_{\text{Before Soaking}} = \text{Max of } (16, 17.5) = \underline{17.5\ \%}$$

⊛ يطلب أن :-

1- نرسم العلاقة بين الحمل والاختراقة لأول عينتنا على 3000 & 4500 .

2- نأخذ مكنة عينة الجدول الحمل على 3 وهي مسافة الـ Piston فيتحول الجدول الحمل الى stress بدلالة الـ Load وكذا عينتنا وكذا عينتنا Penetration & stress الـ على 1000 & 1500 (رابع ملزمة ① شرح قبل إبريم)



$$CBR_{0.1} = \frac{P_{0.1}}{3000} * 100 = \frac{265}{3000} * 100 = 8.83\ \%$$

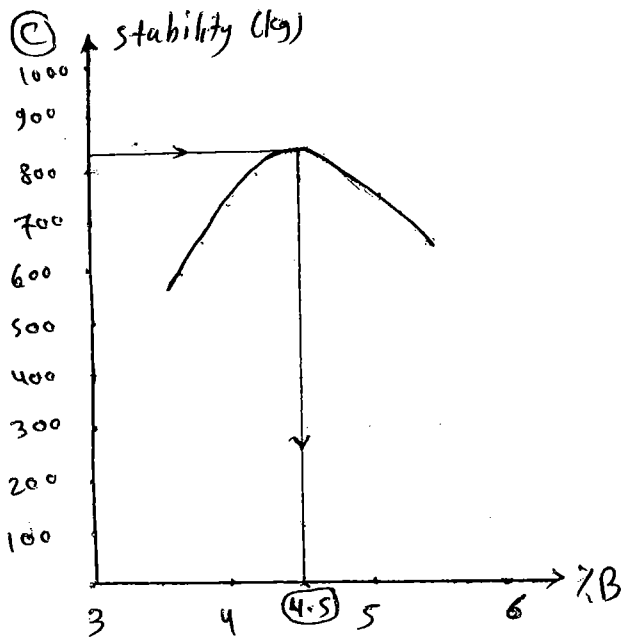
$$CBR_{0.2} = \frac{P_{0.2}}{4500} * 100 = \frac{500}{4500} * 100 = 11.11\ \%$$

$$\therefore CBR_{\text{aftersoaking}} = \text{Max of } (8.83, 11.11) = \underline{11.11\ \%}$$

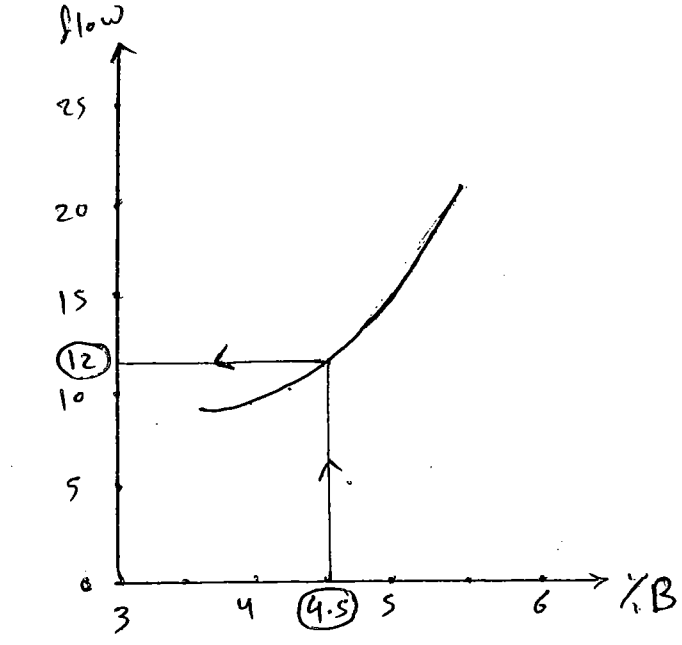
∴ finally :-

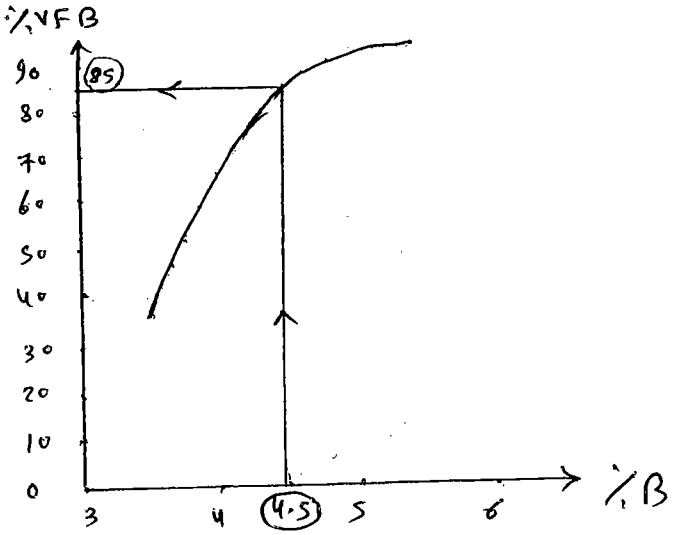
$$CBR = \text{min of } CBR_{\text{before soaking}}, CBR_{\text{after soaking}}$$

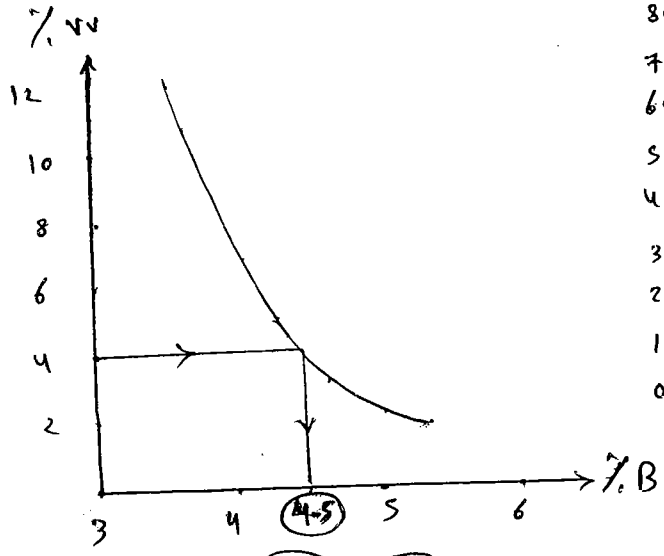
$$= \text{Min of } (17.5, 11.11) = \underline{11.11\ \%}$$



$B_1 = 4.5\%$







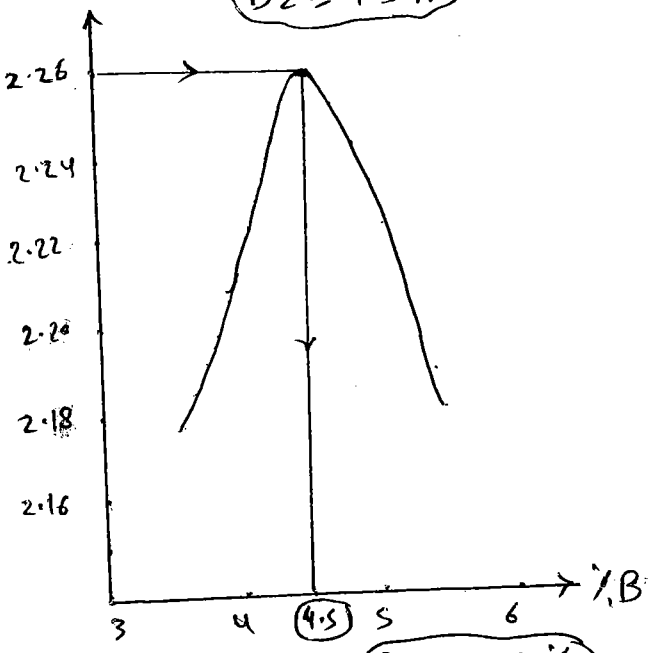
$B_2 = 4.5\%$

$$\text{optimum } \%B = \frac{B_1 + B_2 + B_3}{3} = 4.5$$

Then check :-

by % optimum B = 4.5 get :-

- Flow = 12 (8 ~ 17) o.k
- %VFB = 85% (75 ~ 85)% o.k
- stability = 834 kg > 340 kg o.k
- %VV = 4% (3 ~ 5)% o.k



$B_3 = 4.5\%$

* Question (5) :-

هو نفس سؤال (٣) امتحان (2013).

مع تغيير الأرقام فقط.

Question 6 :- steps for design :-

1 ESAL = ??

$$ESAL = (ADT * \%T) * TF * L * D * 365 * G$$

(D crossed out) مش هنضرب فيها لأنه ذكر في المسألة انه الـ traffic معطى دا لاتجاه واحد

$L = 0.9$
(3 lanes/direction)

$$G = \frac{(1+r)^n - 1}{r} = \frac{(1+0.04)^{30} - 1}{0.04} = 56.085$$

$$ESAL = [(1872 * 1.9) + (1762 * 3.1) + (247 * 4.6)] * 0.9 * 365 * 56.085$$

(ADT * %T, TF, L, G)

= 187,881,938 ?!!

الرقم ده كبير جداً جداً لأنه أكبر رقم في الـ ESAL موجود في الـ chart هو 50,000,000

(ده معناه إن أرقام المسألة غير منطقية) راجع المسألة تاني والحل، المهم اعرف الفكرة والعب بالأرقام في موضوع حساب ESAL

ESAL = ←
$\Delta PSI = P_o - P_t = 4.2 - 3 = 1.2$ (assume, given)
$R = 90\%$, $S_o = 0.45$

2 To get a_1, a_2, a_3 :-

w.s → $M_R = 440,000$ —fig 6.12 (or given figure (ورقة الأسئلة))→ $a_1 = 0.43$

base → $M_R = 28,000$ —fig 6.13→ $a_2 = 0.13$

Asphalt (w.s) كلام ← w.s & Binder ذكر موجود, subbase لوحظ انه لم يذكر موجود

Excellent condition & 1% of time $\xrightarrow[6.1]{Table}$ $m_2 = 1.37$

By using Monograph :-

كما سبق (as before)

هنشتغل مرتين

By MR base ⟶ get $SN_{base} = m_1 t_1 a_1$ ⟶ $t_1 = \;\; > t_{1min}$

MR. subgrade ⟶ get $SN_{S.G} = m_1 t_1 a_1 + m_2 t_2 a_2$ ⟶ $t_2 = \;\; > t_{2min}$

وهو بيقولك في المسألة ان ال (surface course) w.s

(12.5mm = max سمك الطبقة ال)

وبعد كده ال binder وهو برده يعتبر w.s لانه نفس MR

و سمك الطبقة ال (25 mm = max

يعني وانت بترسم القطاع في الأسفلت خد بالك من الاعتبارات دي.