UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	PAVEMENT ENGINEERING
COURSE CODE	:	BFT 40203
PROGRAMME	:	BFF
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS
INSTRUCTION	1.	ANSWER ALL QUESTIONS.
	2.	THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND 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 **TEN (10)** PAGES

Q1 (a) Briefly discuss an environment factor as one of design considerations procedure to evaluate the pavement performance according to the American Association of State Highway and Transportation Officials (AASHTO) for flexible pavements.

(6 marks)

(b) Describe a consideration in flexible pavement design procedure where the design was primarily based on empirical or experience.

(6 marks)

(c) A concrete pavement designed for a four-lane urban express constructed on 6 in. thickness of an untreated sub-base with resilient modulus of 30,000 psi (206.8 MPa) and roadbed resilient modulus of 7,000 psi (48.3 MPa). The road is proposed for a plain concrete pavement with construction joints and load transfer on asphalt shoulder. The initial and terminal serviceability indices are 4.2 and 2.5, respectively. Take the overall standard deviation S_o as 0.29 and the standard normal deviate, Z_R considered as -1.645. The working stress of the concrete is 650 psi (4.5 MPa) and the concrete elastic modulus is 5.0 x106 psi (34.5 GPa). The Equivalent Standard Single Axle Load (ESAL) was designed according on **Table Q1(c)(i)**. It is estimated that the water removed within 2 hours from a base layer, which pavement exposure to moisture is 30 percent.

Refer **Table Q1(c)(ii)** to **Table Q1(c)(vii)** and **Figure Q1(c)(i)** to **Figure Q1(c)(iii)** in your calculation, based on the American Association of State Highway and Transportation Officials (ASSHTO) design method;

(i) Suggest a suitable of concrete slab thickness.

(10 marks)

(ii) Analyse the relative damage of rigid pavement

(3 marks)

Q2 (a) Discuss the phenomenon of pumping and its effects on rigid pavements.

(5 marks)

(b) Explain **THREE (3)** characteristics of soils considered as unsuitable material for road subgrade and for each mentioned characteristic briefly discuss why the soils shall not be used as subgrade material.

(6 marks)

(c) The differential shrinkage and variable expansion in concrete pavement are serious problem that can lead to joint deterioration and distress phenomenon in the transverse joints, consequently induced critical stresses and cracking in pavement slabs. With the sketch of diagrams;

(i) Discuss in detail this phenomenon in jointed concrete pavement.

(8 marks)

(ii) Based on the answer in **Q2(c)(i),** propose the most appropriate solution how to prevent this phenomenon.

(6 marks)

Q3 (a) Propose and explain the appropriate maintenance method that are commonly used to measure the vertical deflection response of a flexible pavement layer without destructing the pavement structure.

(5 marks)

(b) Fatigue cracking and stresses on asphalt structure induced to an interlaced cracking pattern and longitudinal cracks in the top layer of the surface asphalt pavement. Discuss a possible cause of this deterioration and suggest the probable treatment for each cause.

(10 marks)

(c) Increasing emissions and awareness on issues related to global climate change have forced road pavement engineers to consider reusing the materials in existing distressed pavements, rather than to open up new quarries and import material to reconstruct the road pavement. Propose and explain in detail the method and typical process involved to restore the road pavement layer.

(10 marks)

Q4 (a) Discuss the implementation of network level in Pavement Management System (PMS) for a newly developed network of pavement works rehabilitation program.

(8 marks)

(b) Road pavement shall be properly constructed and maintained in order to provide a data maintenance and information for future government decision makers to the investment strategies. Based on this statement;

(i) Propose with detail explanation, a suitable analysis tool to evaluate the investment strategies to maximize performance within constrained funding levels.

(8 marks)

(ii) Based on the answer in **Q4(b)(i)**, discuss in detail the benefits of the selected tool analysis.

(9 marks)

- END OF QUESTIONS -

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Table Q1(c)(i): Traffic analysis (AASTHO, 1986)

Vehicle Type	Number of Vehicles	Truck Factor	Growth Factor
Single units' trucks			
2 axles (4 tires)	87,700	0.003	29.8
2 axles (6 tires)	53,200	0.25	29.8
3 axles or more	18,800	0.86	29.8
Tractor semitrailers and combinations			
4 axles or less	34,900	0.92	29.8
5 axles	61,200	1.25	29.8
6 axles or more	21,300	1.54	29.8

Table Q1(c)(ii): Load transfer coefficient for various pavement types and design conditions *(AASTHO, 1986)*

Type of Shoulder	Asphalt		Tied Portland Cement Concrete	
Load Transfer Devices	Yes	No	Yes	No
JPCP and JRCP	3.2	3.8 – 4.4	2.5 – 3.1	3.6 – 4.2
CRCP	2.9 – 3.2	N/A	2.3 – 2.9	N/A

Table Q1(c)(iii): Suggested levels of reliability for various functional classifications

Functional Classification	Recommended level of reliability	
	Urban	Rural
Interstate and other freeway	85 – 99.9	80 – 99.9
Principal arterials	80 – 99	75 – 95
Collectors	80 – 95	75 – 95
Local	50 – 80	50 – 80

Source: After AASTHO (1986)

Table Q1(c)(iv): Recommended drainage coefficient for untreated bases and sub bases in road pavements

Quality of drainage		Percentage of time pavement structure is exposed to moisture levels approaching saturation			
Rating	Water removed within	Less than 1%	1 – 5%	2 – 25%	Greater than 25%
Excellent	2 hours	1.40 – 1.35	1.35 – 1.30	1.30 -1.20	1.20
Good	1 day	1.35 – 1.25	1.25 – 1.15	1.15 – 1.00	1.00
Fair	1 week	1.25 – 1.15	1.15 – 1.05	1.00 – 0.80	0.80
Poor	1 month	1.15 – 1.05	1.05 – 0.80	0.80 – 0.60	0.60
Very poor	Never drain	1.05 – 0.95	0.95 – 0.75	0.75 – 0.40	0.40

Source: After AASTHO (1986)

Table Q1(c)(v): Minimum thickness for asphalt surface and aggregate base

Traffic (ESAL)	Asphalt Concrete (in.)	Aggregate Base (in.)
< 50,000	1.0	4
50,000 – 150,000	2.0	4
150,001 – 500,000	2.5	4
500,001 – 2,000,000	3.0	6
2,000,001 – 7,000,000	3.5	6
> 7,000,000	4.0	6

Source: After AASTHO (1986)

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Table Q1(c)(vi): Standard normal deviation for various levels of reliability
Source: After AASTHO (1986)

Reliability (%)	Standard normal deviate *(ZR)*	Reliability (%)	Standard normal deviate *(ZR)*
50	0.000	93	-1.476
60	-0.253	94	-1.555
70	-0.524	95	-1.645
75	-0.674	96	-1.751
80	-0.841	97	-1.881
85	-1.037	98	-2.054
90	-1.282	99	-2.327
91	-1.340	99.9	-3.090
92	-1.405	99.99	-3.750

Table Q1(c)(vii): Ranges of loss of support factors for various types of materials
Source: After AASTHO (1986)

Type of Material	Loss of Support (LS)
Cement-treated granular base (E = 1,000,000 to 2,000,000 lb/in.^{2})	0.0 to 1.0
Cement aggregate mixtures (E = 500,000 to 1,000,000 lb/in.^{2})	0.0 to 1.0
Asphalt-treated base (E = 350,000 to 1,000,000 lb/in.^{2})	0.0 to 1.0
Bituminous stabilized mixtures (E = 40,000 to 300,000 lb/in.^{2})	0.0 to 1.0
Lime-stabilized mixtures (E = 20,000 to 70,000 lb/in.^{2})	1.0 to 3.0
Unbound granular materials (E = 15,000 to 45,000 lb/in.^{2})	1.0 to 3.0
Fine-grained or natural subgrade materials (E = 3,000 to 40,000 lb/in.^{2})	2.0 to 3.0

Note: E in this table refers to the general symbol for elastic or resilient modulus of the material.
SOURCE: Adapted from B.F. McCullough and Gary E. Elkins, *CRC Pavement Design Manual*, Austin Research Engineers, Inc., Austin, Tex., October 1979.

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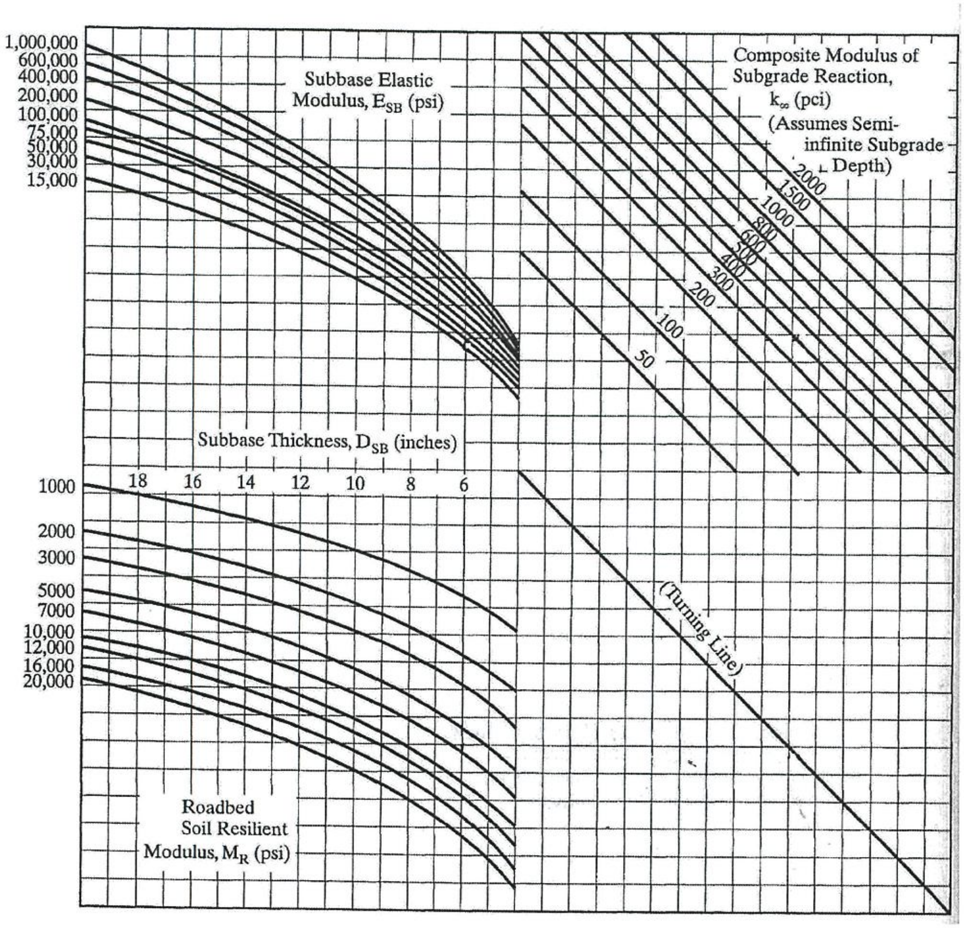

Figure Q1(c)(i): Design chart for estimating composite modulus of sub-grade reaction (AASHTO, 1986)

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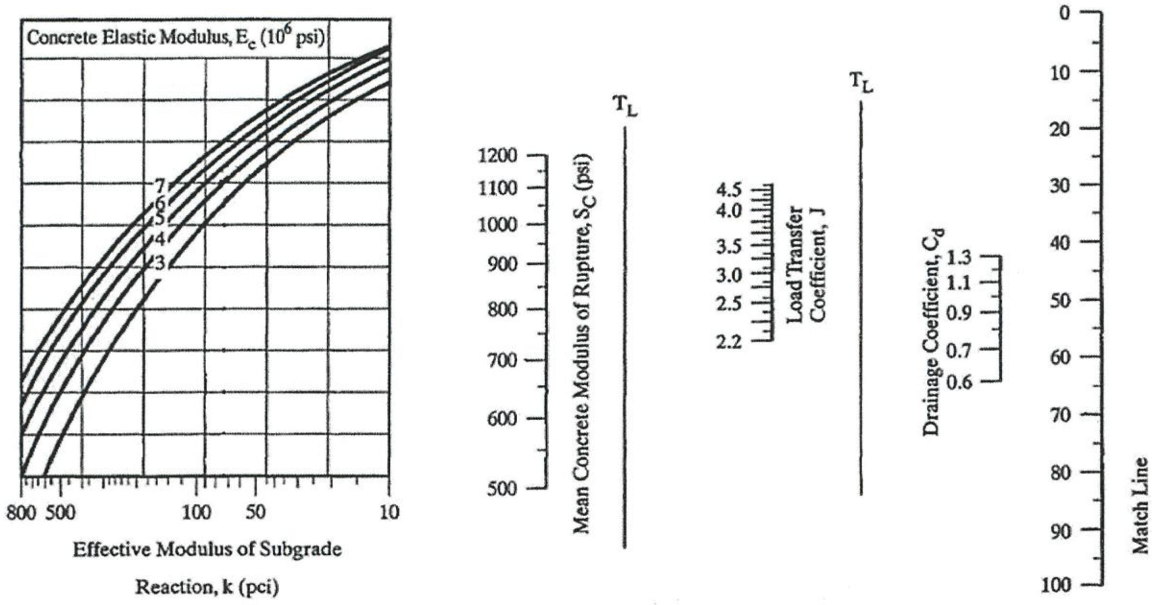

Figure Q1(c)(ii). Design Chart for Rigid Pavement

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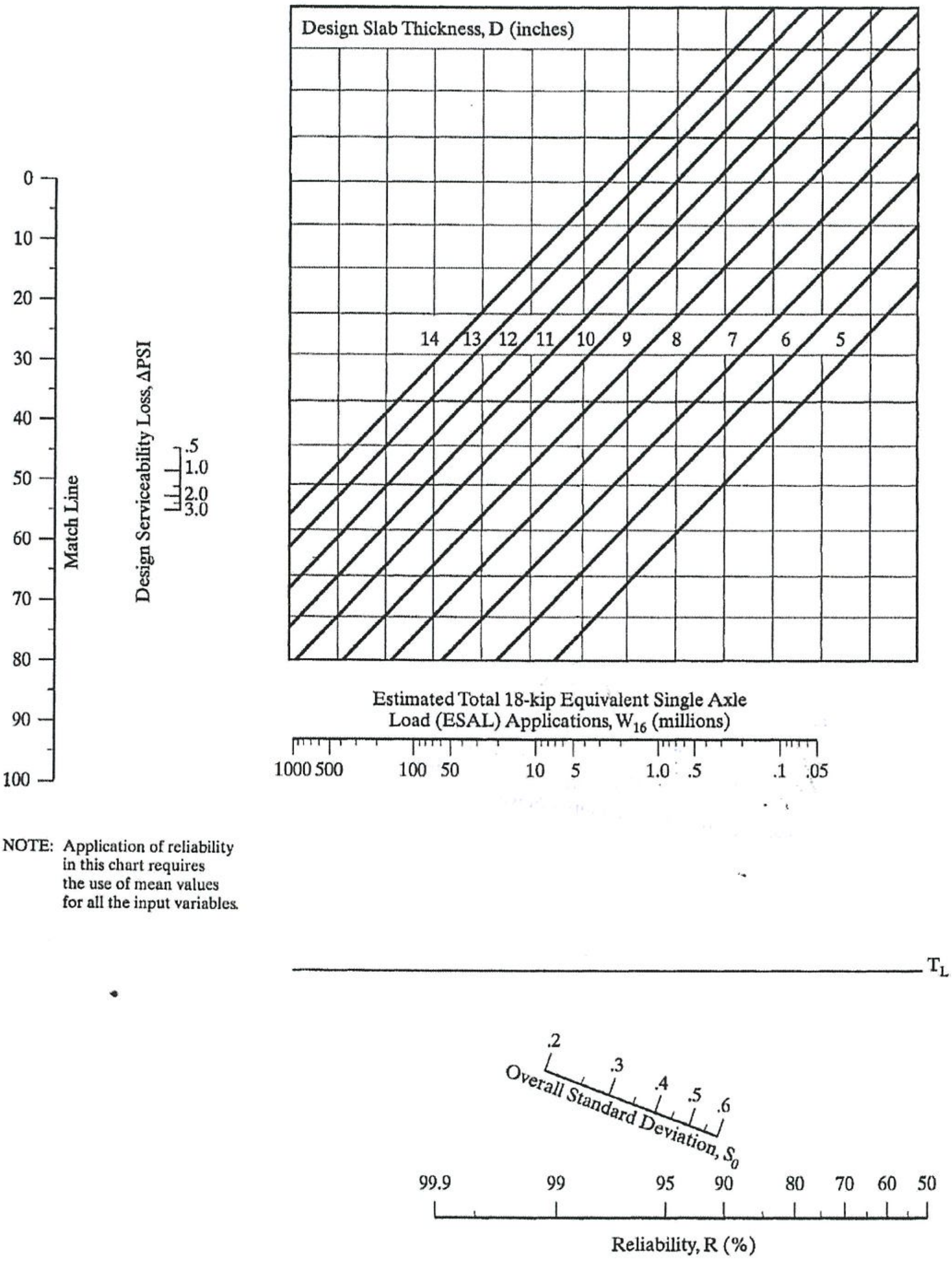

Figure Q1(c)(iii). Design Chart for Rigid Pavement