First Semester Examination
2021/2022 Academic Session

February/March 2022

EAL337 – Pavement Engineering

Duration : 2 hours

Please check that this examination paper consists of **EIGHT (8)** pages of printed material including appendix before you begin the examination.

Instructions : This paper contains **FOUR (4)** questions. Answer **ALL** questions.

All questions **MUST BE** answered on a new page.

1. (a). Asphalt mixture consists of coarse aggregate, fine aggregate, filler, and bitumen that are mixed together at a specified job formula. Alteration of the particle size distribution, or gradation of aggregates produces different types of asphalt mixtures.

Illustrate the aggregate gradations of asphaltic concrete (dense-graded) and porous asphalt (open-graded). Then, for porous asphalt, explain the mechanism that describes the benefits of the mixture in terms of reduction of “splash and spray”, and reduced noise level on road sections, as compared to dense asphaltic concrete.

[9 marks]

(b). The aggregate composition in mix type asphaltic concrete AC10 incorporating hydrated lime as filler, is shown in **Table 1**. Asphalt mixtures were compacted and tested for volumetric properties and Marshall properties. The laboratory test results are shown in **Table 2**, while **Table 3** shows the Malaysian Public Works Department specification limits.

[16 marks]

Table 1

Material	Percentage (%)	Specific Gravity (g/cm^3)
Coarse Aggregate	46.0	2.66
Fine Aggregate	52.0	2.69
Filler (Hydrated Lime)	2.0	2.78
Bitumen	Variety	1.03

Table 2

Sample No.	Sample Height/ *(mm)*	Bitumen Content (%)	Mass in Air (g)	Mass in Water (g)	Mass Saturated Surface Dried (g)	Measured Stability - Corrected (kN)	Flow (mm)	VFB (%)
1	58.7	4.5	1206.8	658.1	1176.2	7.2	2.0	38.1
2	63.5	5.5	1216.9	698.2	1211.9	13.9	2.8	71.4
3	66.1	6.5	1280.4	655.4	1199.6	8.3	3.9	80.4

Table 3

Property	Specification
Stability, kN	$\geq$ 8
Flow, mm	$\leq$ 2 - 4
Stiffness, kN/mm	>2kN/mm
Air Voids, %	3 - 5
Voids Filled with Bitumen, %	70 - 80

From the results shown in **Table 2** and **Table 3**, calculate the specific gravity of aggregate mixture and plot the following relationships:

- Mix density versus bitumen content
- Mix air voids versus bitumen content
- Mix stability versus bitumen content
- Flow versus bitumen content
- Mix voids filled with bitumen versus bitumen content

From the graphs plotted, determine the Optimum Bitumen Content (OBC) and stiffness value at OBC. Compare the value obtained with the JKR specifications and write down your comments.

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2. (a). Binder is one of the essential components for the production of flexible pavement's mixtures. It is a dark brown to black, highly viscous, and consisted of hydrocarbon compounds. Specify **FIVE (5)** differences between binder made of tar and bitumen.

[15 marks]

(b). Explain **TWO (2)** reasons why modified binders are developed. Elaborate **THREE (3)** roles of the modifier to make modified bitumen as an ideal bitumen for all road applications.

[10 marks]

3. (a). Asphalt mixtures are typically produced by drum mixing plant or batch mixing plant. The former is most commonly assembled in Malaysia due to various reasons including relatively lower operating cost, lower initial investment cost and higher cost-effectiveness.

i) Specify **TWO (2)** major differences between asphalt batch mixing plant with asphalt drum mixing plant.

[6 marks]

ii) Based on your understanding, explain **TWO (2)** advantages of batch mixing plant as compared to drum mixing plant. Provide any sketches if necessary.

[7 marks]

(b). In the context of asphalt paving practice at site, describe the best practices during the following road construction activities and state the reasons for carrying out these practices.

i) Application of bituminous prime coat
ii) Surface preparation and cleaning before applying tack coat
iii) Transporting asphaltic concrete from premix plant to the constuction site
iv) Compaction of the longitudinal joint by the roller compactor.

[12 marks]

4. A flexible pavement structural design for a federal road is required to be designed using AASHTO guide procedure to carry a design ESAL of 1.5 x 10^6. The relevant information is given underneath:

Resilience modulus of base course material M_R = 25,000 lb/in^2
Resilience modulus of subbase course material M_R = 17,000 lb/in^2
CBR value of subgrade material = 6
a_1 = 0.40; a_2 = 0.12; a_3 = 0.12
m_2 = 1.0; m_3 = 0.90
Design serviceability loss, ΔPSI = 2.0
Reliability level (R) = 90%
Standard deviation (S_o) = 0.45

Based on all the given information, provide answers for the following questions.

i) Determine an appropriate pavement structure. State all assumptions made and attach the nomograph **(APPENDIX 1)** together with your answer sheets.

[20 marks]

ii) Check the required design layer thicknesses with the AASHTO recommended minimum thickness of highway layers (**APPENDIX 2**), propose a new layer thickness if the calculated thicknesses are not sufficient.

[5 marks]

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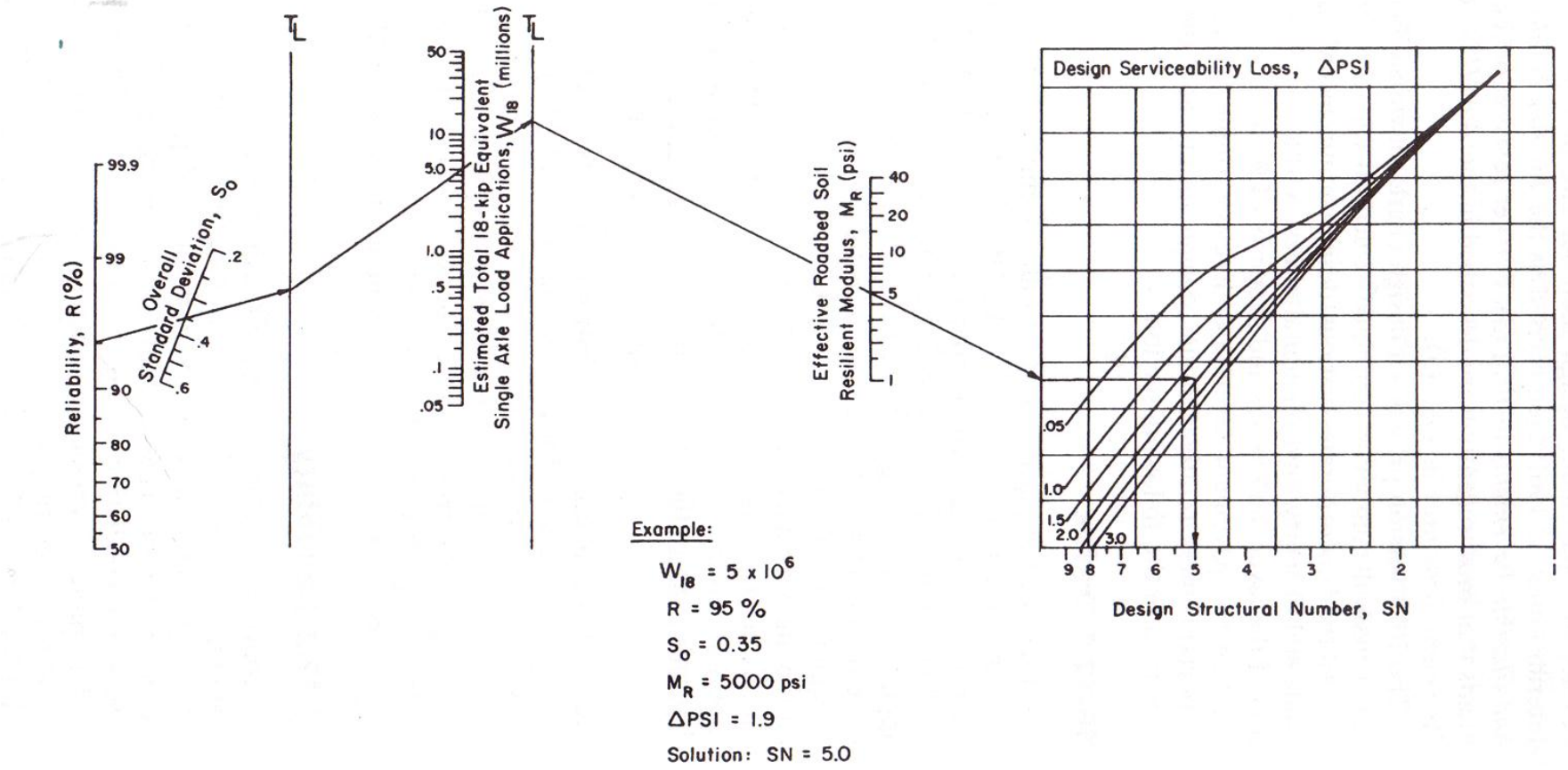
APPENDIX 1: Nomograph (AASHTO Method)



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APPENDIX 2

AASHTO recommended minimum thickness of highway layers

Traffic ESALs	Minimum thickness (in)	
	Asphalt concrete	Aggregate base
Less than 50, 000	1.0 (or surface treatment)	4
50,001 – 150,000	2	4
150,001 – 500,000	2.5	4
500,001 – 2,000,000	3	6
2,000,001- 7,000,000	3.5	6
Greater than 7,000,000	4	6

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