



UTHM

Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION SEMESTER II SESSION 2021/2022

COURSE NAME : HIGHWAY ENGINEERING

COURSE CODE : BFC 31802

PROGRAMME CODE : BFF

EXAMINATION DATE : JULY 2022

DURATION : 2 HOUR AND 30 MINUTES

- 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 **EIGHTEEN (18)** PAGES

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Q1 (a) Emulsion bitumen is one of the types of bitumen that is used in the production of asphalt concrete mixture for road construction. Discuss about the production and criteria of the emulsified bitumen.

(5 marks)

(b) Compaction is one of the methods for soil stabilization where it contributes to the enhancement of the engineering properties such as density, shear and strength. It is necessary to identify the important properties from the compaction test as a control measure in the compaction works of the soil.

(i) Conclude the soil properties that can be obtained from the compaction test of the soil.

(2 marks)

(ii) **Figure Q1(b)** shows the results of soil compaction test with different numbers of blows. Based on the test result, describe the correlation that can be obtained from the test.

(3 marks)

(c) Asphalt concrete mixture of AC 14 will be used to construct the wearing course layer. The coarse aggregate, fine aggregate and filler are used as materials to produce the asphalt concrete mixture. The aggregate gradation will be blended to fulfill the gradation limit according to JKR standard specification as shown in **Table Q1(c)(i)**. Based on this statement, conclude the result of sieve analysis test of blended aggregate as shown in **Table Q1(c)(ii)**.

(15 marks)

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- Q3** (a) Based on the diagram given in **Figure Q3(a)**, explain clearly the followings:
- (i) The meanings of rising and falling curves in a Mass Haul Diagram
(2 marks)
 - (ii) The equation used to calculate the shaded areas and its meaning
(2 marks)
- (b) In order to ensure that road subgrade is prepared in accordance to the appropriate standard, soil density must be measured. Explain briefly **ONE (1)** method used to determine the field density of subgrade.
(4 marks)
- (c) The followings are the results from a Laboratory Compaction Test for a road construction project in Batu Pahat, Johor:

Max. dry density	= 1.75 Mg/m ³
Optimum moisture content	= 10%

Borrowed material properties:

Bulk density	= 1.60 Mg/m ³
Water content	= 5%
Bulking factor	= 1.20

Specification:

Soil is to be compacted to minimum of 95% of the maximum dry density determined in BS 1377 compaction test.

Based on the data, determine:

- (i) Volume of borrow material required for 1 cubic meter of compacted road embankment
(3 marks)
 - (ii) Volume of additional water required for the entire volume of embankment.
(3 marks)
 - (iii) The total number of truckloads of soil required for the project if hauling capacity per truck is 10 m³.
(3 marks)
- (d) In Malaysia, the monsoon rain causes tremendous challenges to engineers and contractors especially when constructing roads at hillsides. The reasons are hills are usually subjected to intermittent continuous rains throughout the year thus, the risk of slips and landslides are high. Explain briefly **FOUR (4)** types of maintenance related to roads at hillsides.
(8 marks)

- Q4** (a) Sustainable materials for road maintenance can be also defined as a way to use a resource so that the latter is not depleted or permanently damaged.
- (i) List **TWO (2)** types of sustainable materials that can be applied for road maintenance activities.
(1 mark)
- (ii) Propose and explain **TWO (2)** strategies that can be applied by the government to increase number of projects using sustainable materials in road maintenance.
(4 marks)
- (b) Pavement recycling is a technique where an existing degraded pavement is modified and transformed into a homogeneous structure that can support the traffic requirements.
- (i) Explain **TWO (2)** unique advantages of pavement recycling.
(2 marks)
- (ii) List **TWO (2)** type of additives used to improve base in Full Depth Reclamation (FDR).
(1 mark)
- (iii) Propose a solution if the in-place material in Full Depth Reclamation (FDR) is not sufficient to provide the desired depth of the treated base.
(2 marks)
- (c) There is high complaint for a road at Batu Pahat. As a road engineer at JKR Batu Pahat, you and the technical team are required to conduct a Pavement Condition Index (PCI) Survey to check the real condition of the road. **Table Q4(c)** shows a PCI data survey for a sample unit with 5-meter width and 100-meter length. By using that data:
- (i) Identify the PCI value for this sample unit. Refer **Figure Q4(c)(i)** to **Figure Q4(c)(v)** for the analysis.
(13 marks)
- (ii) Based on the results from **Q4(c)(i)**, suggest an appropriate maintenance method. Justify your answer.
(2 marks)

- END OF QUESTIONS -

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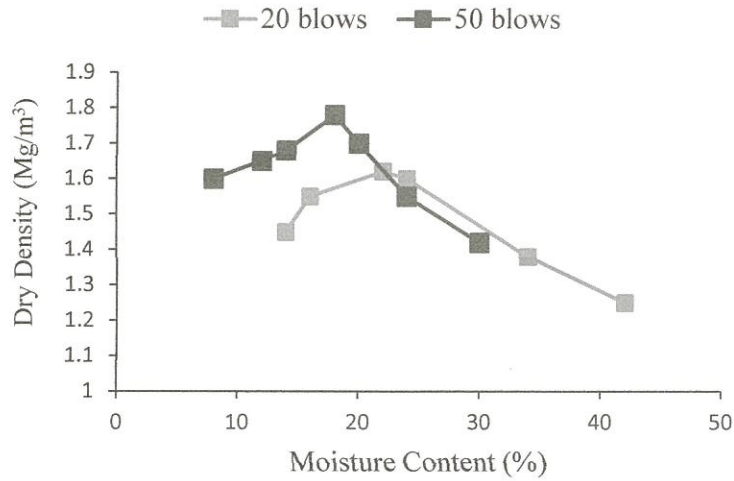


Figure Q1(b): Compaction test result of the soil





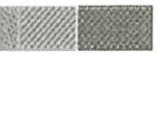

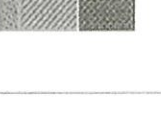

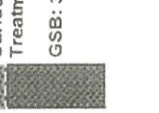


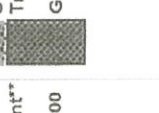
Table Q1(c)(i): Gradation specification for AC 14 mixture

BS Sieve Size (mm)	Percentage passing by weight
28.0	
20.0	100
14.0	90 – 100
10.0	76 – 86
5.0	50 – 62
3.35	40 – 54
1.18	18 – 34
0.425	12 – 24
0.150	6 – 14
0.075	4 – 8

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Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base	 <p>BSC: 50 CAB: 250 GSB: 150</p>	 <p>BSC: 50 CAB: 200 GSB: 150</p>	 <p>BSC: 50 CAB: 200 GSB: 100</p>	 <p>BSC: 50 CAB: 100 GSB: 100</p>
Deep Strength: Stabilised Base	 <p>BSC: 50 STB 2: 100 GSB: 200</p>	 <p>BSC: 50 STB 2: 100 GSB: 150</p>	 <p>BSC: 50 STB 2: 100 GSB: 100</p>	 <p>BSC: 50 STB 2: 100 GSB: 100</p>
Stabilised Base with Surface Treatment*	 <p>Surface Treatment** GSB: 300 STB 2: 250</p>	 <p>Surface Treatment** GSB: 300 STB 2: 250</p>	 <p>Surface Treatment** GSB: 250 STB 2: 200</p>	 <p>Surface Treatment** GSB: 250 STB 2: 200</p>

Notes:

* Full Depth Asphalt Concrete Pavement is not recommended for this Traffic Category.

** Single or Double Layer Chip Seal or Micro-Surfacing.

FIGURE Q2(b)(i): Pavement structure for traffic category T1: <1 million ESALs (80kN)

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Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base	BSC: 140 CAB: 200 GSB: 150	BSC: 140 CAB: 200 GSB: 150	BSC: 120 CAB: 200 GSB: 100	BSC: 100 CAB: 200 GSB: 100
Deep Strength: Stabilised Base	BSC: 120 STB 2: 150 GSB: 200	BSC: 120 STB 2: 150 GSB: 150	BSC: 100 STB 2: 120 GSB: 150	BSC: 100 STB 2: 120 GSB: 150
Full Depth: Asphalt Concrete Base	BSC: 50 BB: 100 GSB: 250	BSC: 50 BB: 100 GSB: 200	BSC: 50 BB: 100 GSB: 150	BSC: 50 BB: 80 GSB: 150

FIGURE Q2(b)(ii): Pavement structure for traffic category T2: 1.0 to 2.0 million ESALs



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Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base	BSC: 50 BC: 130 CAB: 200 GSB: 200 	BSC: 50 BC: 130 CAB: 200 GSB: 200 	BSC: 50 BC: 130 CAB: 200 GSB: 150 	BSC: 50 BC: 130 CAB: 200 GSB: 100 
Deep Strength: Stabilised Base	BSC: 50 BC: 100 STB 1: 150 GSB: 200 	BSC: 50 BC: 100 STB 1: 150 GSB: 150 	BSC: 50 BC: 100 STB 1: 100 GSB: 150 	BSC: 50 BC: 100 STB 1: 100 GSB: 100 
Full Depth: Asphalt Concrete Base	BSC: 50 BC/BB: 160 GSB: 200 	BSC: 50 BC/BB: 150 GSB: 150 	BSC: 50 BC/BB: 130 GSB: 150 	BSC: 50 BC/BB: 130 GSB: 100 

Figure Q2(b)(iii): Pavement structure for traffic category T3: 2.0 to 10.0 million ESALs (80kN)

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Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base	<p>BSC: 50 BC/BB: 150 CAB: 200 GSB: 200</p>	<p>BSC: 50 BC/BB: 150 CAB: 200 GSB: 150</p>	<p>BSC: 50 BC/BB: 150 CAB: 200 GSB: 100</p>	<p>BSC: 50 BC/BB: 130 STB1: 100 GSB: 100</p>
Deep Strength: Stabilised Base	<p>BSC: 50 BC/BB: 150 STB1: 120 GSB: 200</p>	<p>BSC: 50 BC/BB: 140 STB1: 100 GSB: 150</p>	<p>BSC: 50 BC/BB: 180 GSB: 150</p>	<p>BSC: 50 BC/BB: 150 GSB: 100</p>
Full Depth: Asphalt Concrete Base	<p>BSC: 50 BC/BB: 200 GSB: 200</p>	<p>BSC: 50 BC/BB: 200 GSB: 200</p>	<p>BSC: 50 BC/BB: 180 GSB: 150</p>	<p>BSC: 50 BC/BB: 150 GSB: 100</p>

Sub-Grade Improvement is Recommended

Figure Q2(b)(iv): Pavement structure for traffic category T4: 10.0 to 30.0 million ESALs (80 kN)



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Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base	<p>BSC: 50 BC/BB: 190 CAB: 200 GSB: 200</p>	<p>BSC: 50 BC/BB: 190 CAB: 200 GSB: 150</p>	<p>BSC: 50 BC/BB: 190 CAB: 200 GSB: 100</p>	<p>BSC: 50 BC/BB: 190 CAB: 200 GSB: 100</p>
Deep Strength: Stabilized Base	<p>BSC: 50 BC/BB: 160 STB1: 150 GSB: 200</p>	<p>BSC: 50 BC/BB: 140 STB1: 150 GSB: 150</p>	<p>BSC: 50 BC/BB: 140 STB 1: 150 GSB: 100</p>	<p>BSC: 50 BC/BB: 140 STB 1: 150 GSB: 100</p>
Full Depth: Asphalt Concrete Base	<p>BSC: 50 BC/BB: 210 GSB: 200</p>	<p>BSC: 50 BC/BB: 200 GSB: 150</p>	<p>BSC: 50 BC/BB: 200 GSB: 150</p>	<p>BSC: 50 BC/BB: 180 GSB: 100</p>

Figure Q2(b)(v): Pavement structure for traffic category T5: > 30.0 million ESALs (80 k

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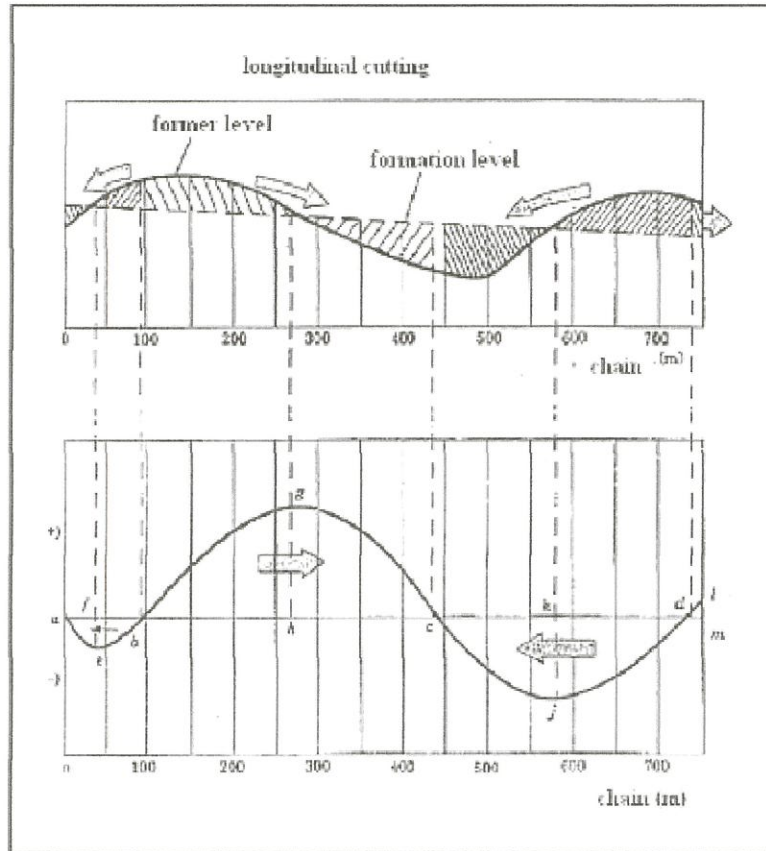


Figure Q3(a): Mass Haul Diagram of a road construction

TABLE Q4(c): PCI data

Distress severity	Quantity		
	01H (m ²)	1.9	
01M (m ²)	0.19	328	0.56
07H (m)	4.0	5.5	1.4
07M (m)	0.8	0.25	0.5
10H (m)	1.98		
10M (m)	0.15		

- 10. Longitudinal & transverse cracking, 07. Edge cracking, 01. Alligator cracking



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The formula that may required:

$$\gamma_d = \gamma_b / (1 + w)$$

$$DOC = \frac{\gamma_d}{\gamma_{dmax}}$$

$$m = 1 + (9/98)(100 - HDV)$$

$$PCI = 100 - CDV_{max}$$

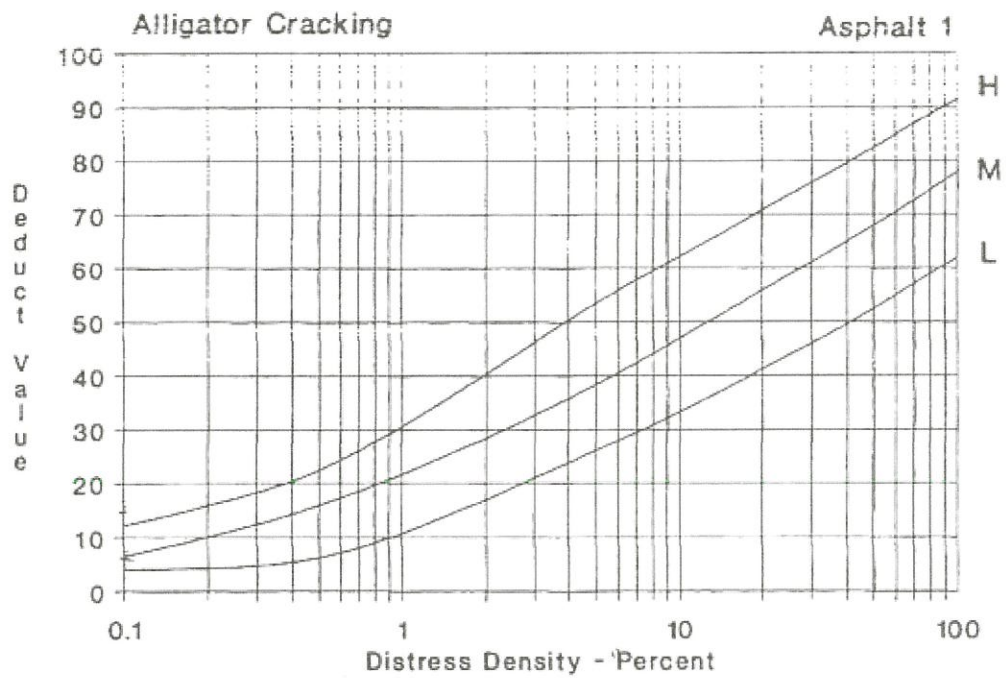


FIGURE Q4(c)(i): Aligator cracking

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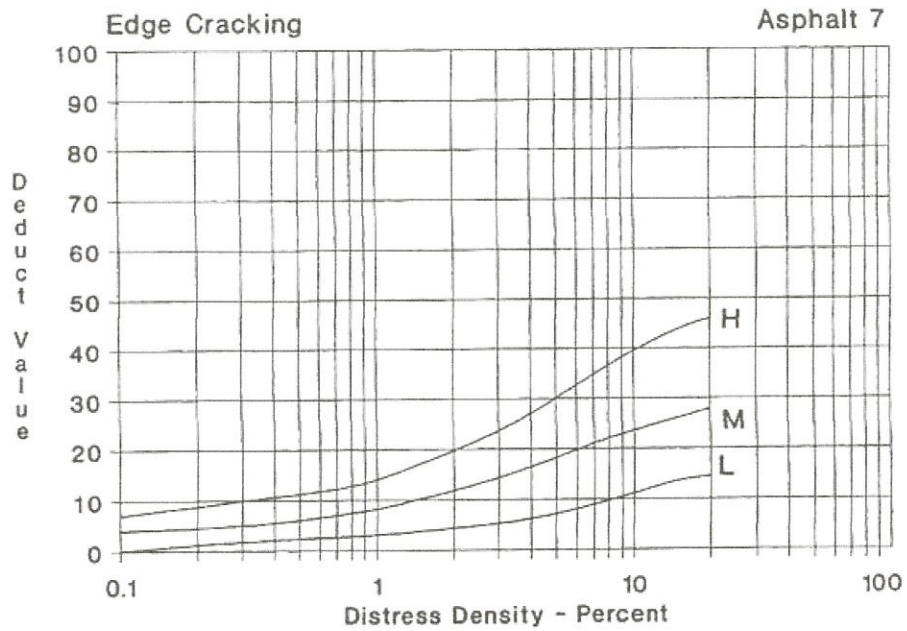


FIGURE Q4(c)(ii): Edge cracking

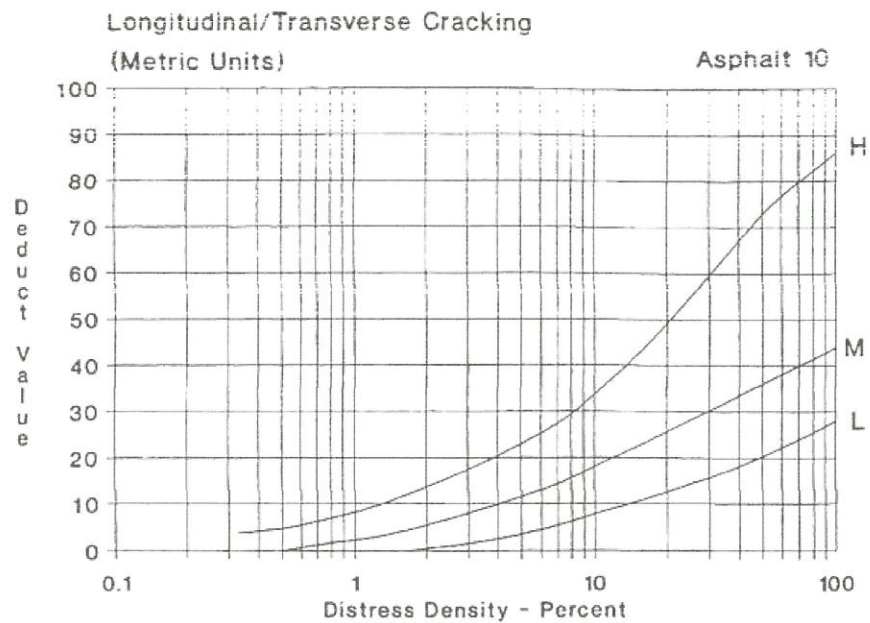


FIGURE Q4(c)(iii): Longitudinal /Transverse cracking

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