Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	HIGHWAY ENGINEERING
COURSE CODE	:	BFC 31802
PROGRAMME	:	BFF
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	2 HOUR AND 30 MINUTES
INSTRUCTIONS	:	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) (i) State the road surface layer

(2 marks)

(ii) Briefly explain the materials that been used to produce of this road surface layer including their roles.

(3 marks)

(b) (i) Define the soil stabilization.

(2 marks)

(ii) Based on definition of the soil stabilization, elaborate the purpose of the soil stabilisation in engineering.

(3 marks)

(c) There is a new road construction project from Kg. Rahmat to Sri Gading Batu Pahat Johor. Currently, it needs to establish the formation level of the road. Samples of the natural existing soil are sent to the laboratory to determine their strength. California Bearing Ratio (CBR) test was conducted to the soils sample. Three (3) samples were prepared with the different compaction effort to achieve different dry density. The dry density of Sample 1, 2 and 3 are 1.178 g/cm^3, 1.326 g/cm^3 and 1.393 g/cm^3 respectively. The maximum dry density of the soil is 1.368 g/cm^3. **Table Q1(c)** shows the CBR test penetration data result. The calibration factor of the CBR machine is 0.046 kN/div. Based on the test result, determine:

(i) CBR value of each sample.

(6 marks)

(ii) Plot the relationship between the CBR value and the density of the soil.

(5 marks)

(iii) Determine the CBR value that need to be achieved at site if the formation level need to be constructed at 95% of the maximum dry density of the soil.

(4 marks)

Q2 (a) The responsibility of the highway and traffic engineer involves creating predictions about the demand for travel, assessing different options based on economic and non-economic factors, and finding potential solutions for short, medium, and long- range purposes. The visibility of the road ahead of the driver will help in the safe and efficient operation of the vehicles. Explain the basic types of Sight Distance at the design stage.

(5 marks)

(b) Discuss the typical composition of rigid pavement structures in Malaysia and when were PCC surfaces introduced. Additionally, elaborate the **THREE (3)** types of rigid pavement designs and explain each of them

(12 marks)

(c) Determine the flexible pavement thickness required for a 4-lane highway with a flexible pavement designed to last for 20 years, given an average daily traffic of 4000 vehicles with 10% of them being commercial vehicles that weigh more than 1.5 tons when unladen, a California Bearing Ratio (CBR) of 10%, an Annual Traffic Growth of 5%, a Lane Distribution Factor and Terrain Factor of 1.0 each, and designed in accordance with the Arahan Teknik Jalan, ATJ 5/85 (Rev. 2013).

Refer to **Table Q2(c)(i)** to **Table Q2(c)(iv)** and **Figure Q2(c)(i)** to **Figure Q2(c)(v)** for your calculation.

(8 marks)

Q3 (a) The reason of site investigation is to inspect the safety of existing works. List **FIVE (5)** activities that able to affect the existing works

(5 marks)

(b) **Table Q3 (b)** provide the estimated area of cut and fill at 100 m intervals along 0.6 km segmented of roadway. Based on the data;

(i) Calculate the cumulative volume with shrinkage factor 10%.

(10 marks)

(ii) Plot mass haul diagram with the data.

(4 marks)

(iii) Identify volume of soil wasted or borrowed.

(2 marks)

(c) The main function of drainage is to divert and removes water from the pavement surface. Illustrate and describe **TWO (2)** systems for surface drainage.

(4 marks)

Q4 (a) Briefly discuss how a minimum requirement strategy can improve the pavement maintenance technique on pavement segments

(5 marks)

(b) Propose and explain an alternative maintenance techniques to improve the road surface deterioration.

(5 marks)

(c) **Table Q4 (c)** shows a pavement condition survey for Parit Samijan road. Given the sample area is 5m x 100m. The defects obtained from the survey denoted as 01-Aligator cracking, 07-Edge cracking and 10-Longitudinal & transverse cracking, respectively. By using the data and Refer to **Figure Q4(i)** to **Figure Q4(v)** in your calculation.

(i) Determine the Pavement Condition Index for this sample

(12 marks)

(ii) Based on the results from **Q4 (c) (i)** suggest an appropriate maintenance method

(3 marks)

- END OF QUESTIONS -

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Table Q1(c): CBR test – penetration data

Penetration (mm)	Load		
	Sample 1 (div)	Sample 2 (div)	Sample 3 (div)
0	0	0	0
1.0	8	16	17
2.0	12	18	26
2.5	14	22	33
3.0	15	29	48
3.5	16	42	65
4.0	25	75	80
4.5	32	82	100
5.0	41	91	140
5.5	50	100	176
6.0	59	140	228
6.5	65	202	285
7.0	70	254	350

Table Q3(b): Volume of cut and fill

Chainage (m)	Volume of cutting (m^3)	Volume of fill (m^3)
0		
100	22275	
200	13902	
300		2268
400		17744
500		14256
600		900

Table Q4(c): Pavement condition survey data

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

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Table Q2(c)(i): Annual Growth Rate (%)

Design Period (Years)	2	3	4	5	6	7
10	10.95	11.46	12.01	12.58	13.18	13.82
15	17.29	18.60	20.02	21.58	23.28	25.13
20	24.30	26.87	29.78	33.06	36.79	41.00
25	32.03	36.46	41.65	47.73	54.86	63.25
30	40.57	47.58	56.08	66.44	79.06	94.46

Table Q2(c)(ii): Classes of subgrade strength (based on CBR) used as input in the pavement catalogue of ATJ 5/85 (Amendment 2013) manual

Sub-Grade	CBR (%)	Elastic Modulus (MPa)	Design Input Value
		Range	
SG1	5 to 12	50 to 20	60
SG2	12.1 to 20	80 to 140	120
SG3	20.1 to 30.0	100 to 160	140
SG4	>30.0	120 to 180	180

Table Q2(c)(iii): Traffic categories used in this manual (EAL =80 kN)

Traffic category	Design Traffic (ESAL x 10^6)	Probability (Percentile Applied to Properties of Subgrade Material
T1	≤1.0	≥ 60%
T2	1.1 to 2.0	≥ 70%
T3	2.1 to 10.0	≥ 85%
T4	10.1 to 30.0	≥ 85%
T5	>30.0	≥ 85%

Table Q2(c)(iv): Conceptual outline of pavement structures used in ATJ 5/85 (Amendment 2013)

Pavement Structure	Traffic Category (based on million ESALs@ 80kN)				
	≤ 1	1 to 2	2.1 to 10	10.1 to 30	>30
	T1	T2	T3	T4	T5
Combined Thickness of Bituminous Layers					24 cm
				20 cm	
			18 cm		
		10 cm			
	5 cm				
Crushed Aggregate Road Base + Sub-base for Subgrade CBR of:					
○ 5 to 12	23+15 cm	20+15 cm	20+20 cm	NR	NR
○ 12.1 to 20	20+15 cm	20+15 cm	20+20 cm	20+20 cm	20+20 cm
○ 20.1 to 30	20+10 cm	20+10 cm	20+15 cm	20+15 cm	20+15 cm
○ >30	20 cm	20+10 cm	20+10 cm	20+10 cm	20+10 cm

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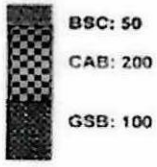
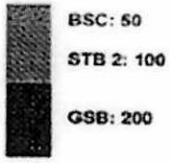
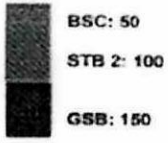
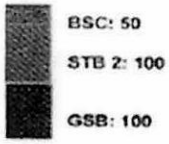
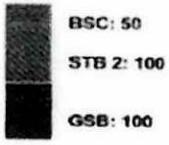
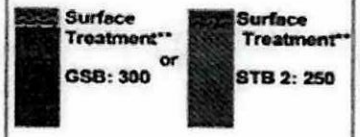
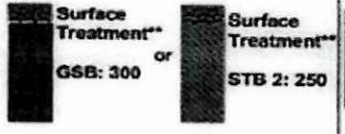
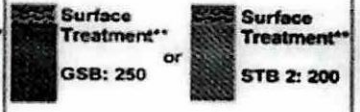
Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base				
Deep Strength: Stabilised Base				
Stabilised Base with Surface Treatment*				

Notes:

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

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

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

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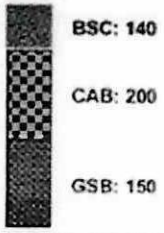
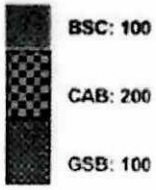
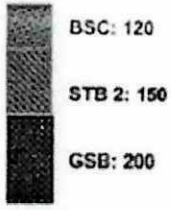
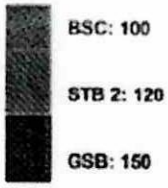
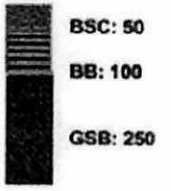
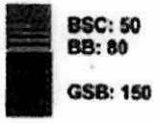
Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base	 BSC: 140 CAB: 200 GSB: 150	 BSC: 140 CAB: 200 GSB: 150	 BSC: 120 CAB: 200 GSB: 100	 BSC: 100 CAB: 200 GSB: 100
Deep Strength: Stabilised Base	 BSC: 120 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 Q1(c)(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 Q1(c)(iii): Pavement structure for traffic category T3: 2.0 to 10.0 million ESALs (80kN)

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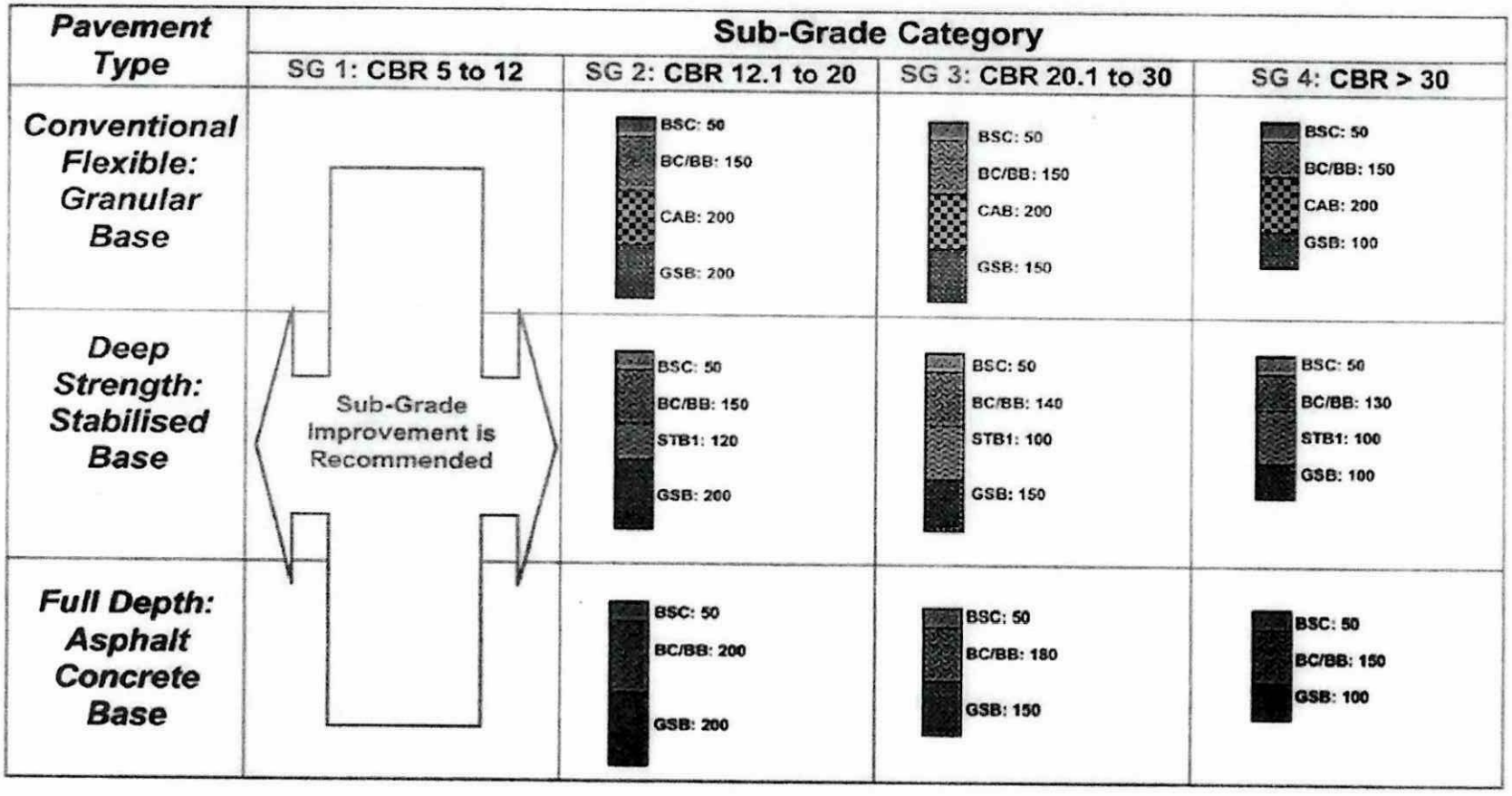

Figure Q1(c)(iv): Pavement structure for traffic category T4: 10.0 to 30.0 million ESALs (80 kN)

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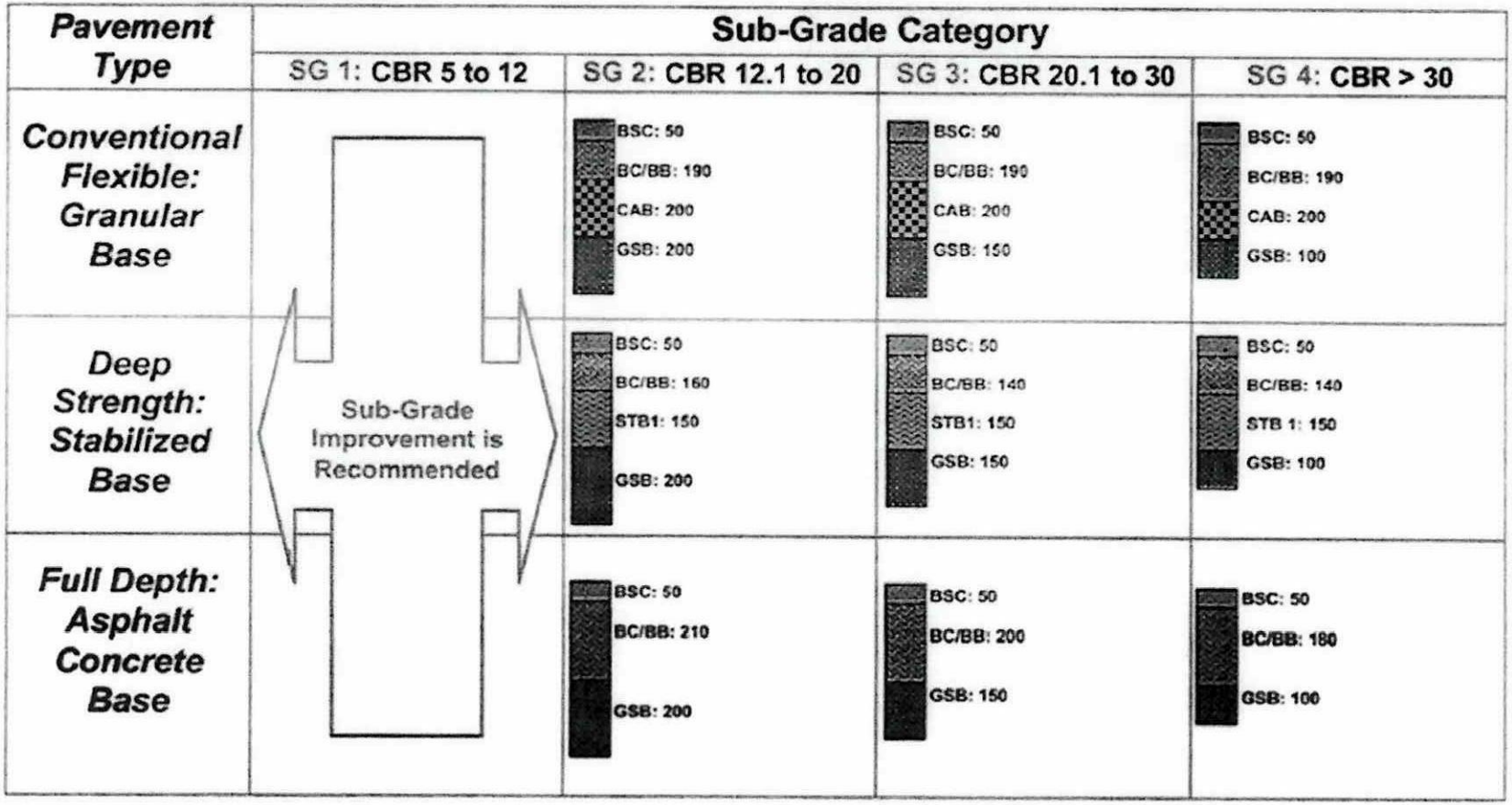

Figure Q2(c)(v): Pavement structure for traffic category T5: > 30.0 million ESALs (80 kN)

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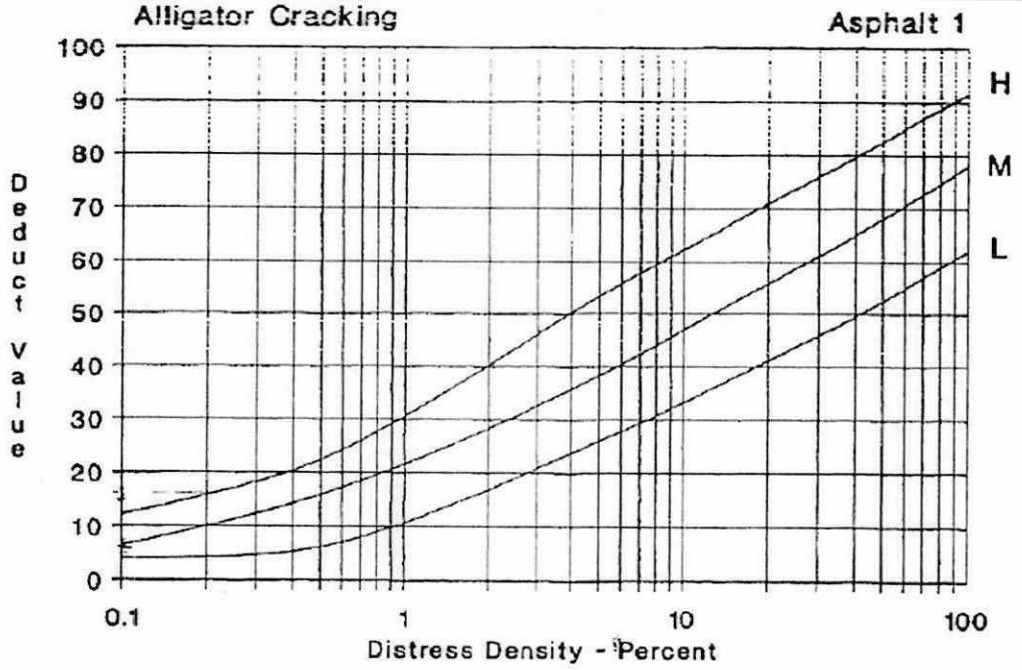
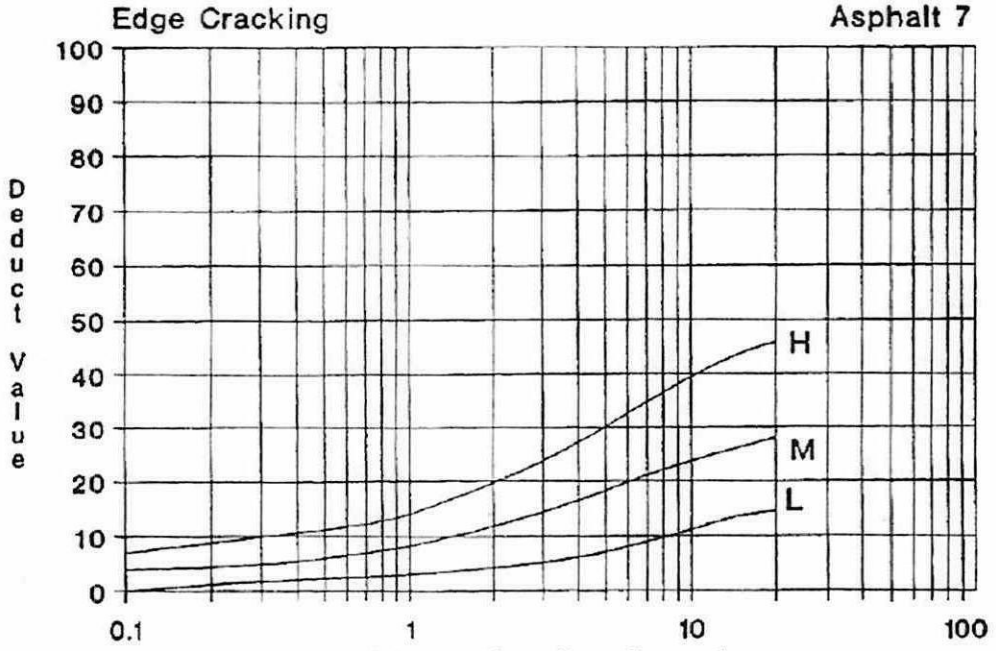


Figure Q4 (i): Alligator Cracking



Appendix B: Formulas

These formulas may be useful to you. The symbols have their usual meaning.

Figure Q4 (ii): Edge cracking

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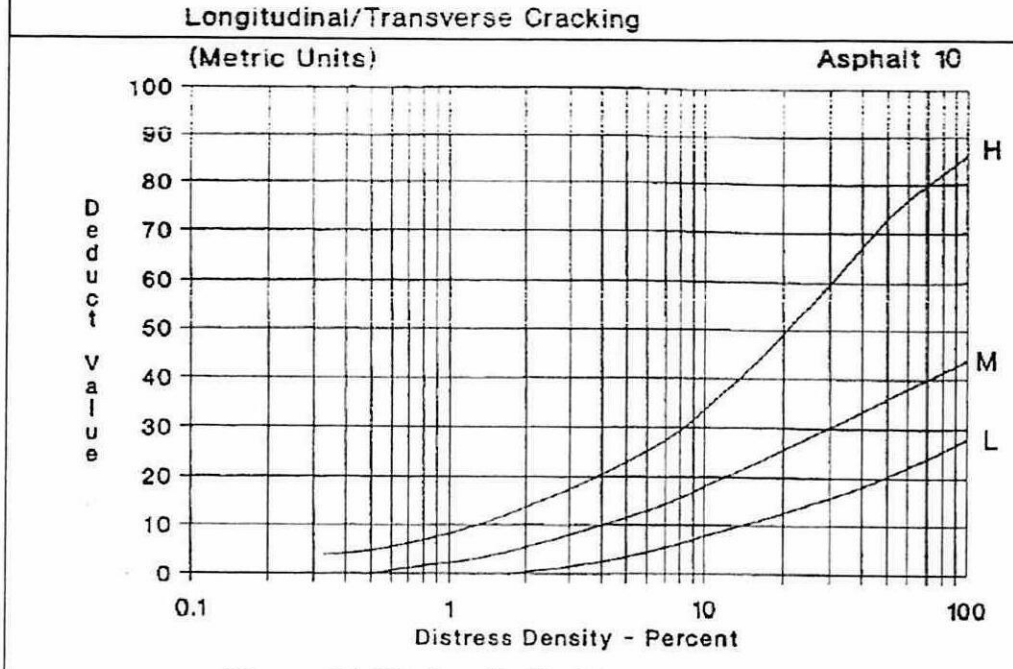

Figure Q4 (iii): Longitudinal / Transverse cracking

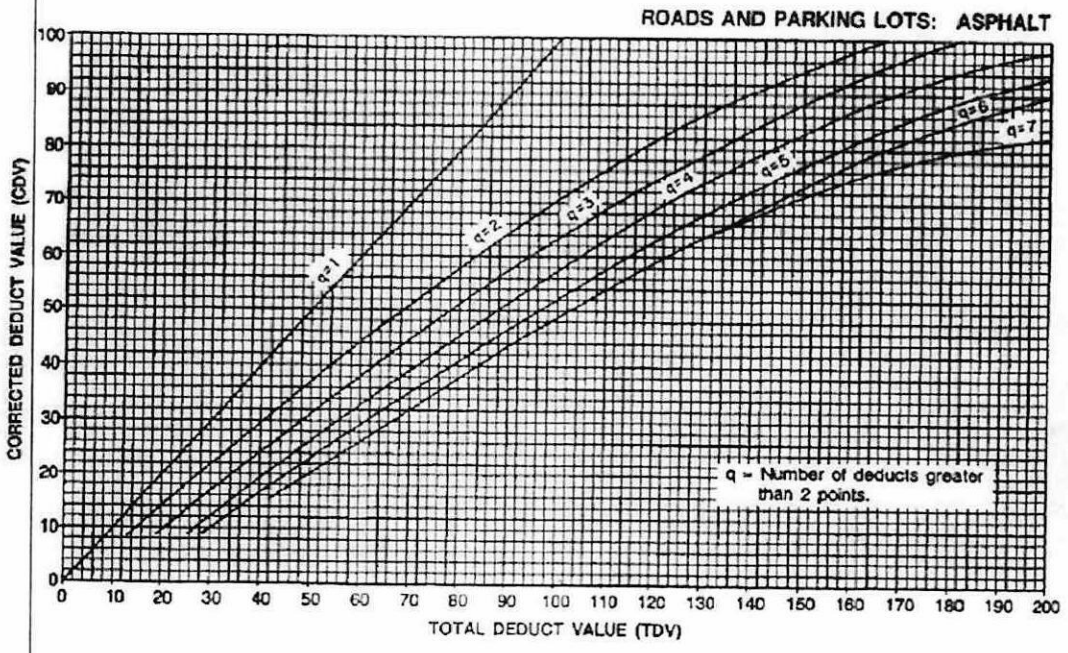

Figure Q4 (iv): Corrected deduct value

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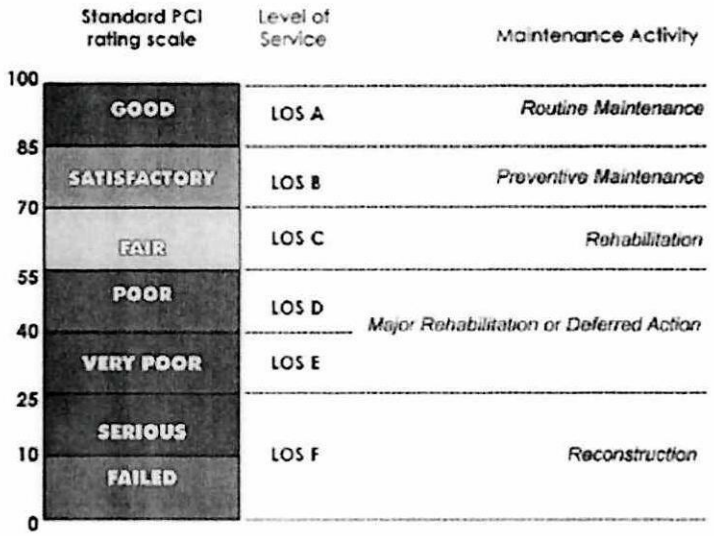

FIGURE Q4(v) Pavement Condition Index (PCI) Rating Scale and corresponding Level of Service and Maintenance Activity