Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022

COURSE NAME	:	HIGHWAY ENGINEERING
COURSE CODE	:	BFC 31802
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JANUARY / FEBRUARY 2022
DURATION	:	2 HOUR AND 30 MINUTES
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **CLOSE BOOK**.

THIS QUESTION PAPER CONSISTS OF **EIGHTEEN (18)** PAGES

Q1 (a) Briefly explain the sign board as road user guideline that can be found in Malaysia.

(5 marks)

(b) Describe **TWO (2)** categories with example about the available of existing road in Malaysia.

(5 marks)

(c) Irdina Construction Sdn Bhd was responsible to upgrade and widening project at Jalan Simpang Lima to Parit Sulong. In order to proceed the surface works, Advanced highway laboratory, UTHM were appointed by AMONA Sdn Bhd to conduct a series of Marshall stability and flow test on the loose specimen obtained from TKC Premix Quarry. The volumetric properties of the Marshall's specimens are tabulated in **Table Q1(c)(i)** and **Table Q1(c)(ii).** Given the specific gravity of aggregate and bitumen are 2.67 and 1.02, respectively. Based on those statements;

(i) Calculate bulk and percentage volume of bitumen, aggregate and voids in **Table Q1(c)(i).**

(6 marks)

(ii) Plot the curve of density, stability, flow, void in total mix (VTM) and void filled with bitumen (VFB), and stiffness against bitumen content in **Figure Q1(c)(ii).**

(6 marks)

(iii) Determine the optimum bitumen content form Figure **Q1(c)(ii).** Justify your answer according to Standard Specification for Roadwork (JKR/SPJ/2008-S4).

(3 marks)

Q2 (a) Briefly discuss **TWO (2)** aspects of sight distance that must be considered when the driver passing a vehicle through an intersection.

(4 marks)

(b) **FIGURE Q2(b)** shows the horizontal curve section of a rural highway with the offset clearance for planting tree is 12 m. The highway is designed for 110km/hr, while the curve length and curve radius are 230 m and 500 m, respectively. If the driver's perception-reaction time is taken as 2.5 s and the coefficient of friction between the tires and the road surface as 0.28, calculate the safe stopping sight distance and suggested the adequate of minimum offset clearance.

(6 marks)

(c) The road flexible pavement designed for 15 years of design life can be presented a traffic volume by 15.1 million, constructed on treated subgrade with mean California Bearing Ratio (CBR) at normal distribution as 25%. If the standard deviation is 4.5 %, design the pavement thickness accordance to 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.

(15 marks)

Q3 (a) Compaction is an important process in the preparation of the road surface layer.

(i) Briefly explain the compaction process and importance of compaction.

(3 marks)

(ii) Define the compaction effort of asphalt layer.

(3 marks)

(iii) Based on your opinion, explain about the effects of the inadequacy of compaction process on road surface.

(3 marks)

(b) **Table Q3 (b)** provides 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)

Q4 (a) Briefly discuss on how to evaluate a pavement maintenance strategy that to improve the pavement maintenance techniques on pavement segments based on minimum maintenance techniques requirement.

(8 marks)

(b) Propose and discuss the alternative of road pavement maintenance techniques or methods to prevent and improve road surface deterioration.

(8 marks)

(c) A continuous heavy traffic and climatic factors contribute to the gradual deterioration of pavements. Delay on maintenance or rehabilitation may influence road pavement performance. Based on these statements, propose a pavement condition characteristics and appropriate treatment that used to evaluate whether the pavement should be rehabilitated.

(9 marks)

- END OF QUESTIONS -

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Table Q1(c)(i): Volumetric properties of compacted specimen

SAMPLE	% Bit. SPEC. NO	WEIGHT (gram)			BULK VOLUME	SPEC. GRAVITY		VOLUME (%)			VOIDS (%)		
		SATURATED	IN AIR	IN WATER		BULK	MAX. THEORY	BITUMEN	AGG.	VOIDS	AGG.	VFB	VTM
	% Bit. By weight of Mix												
Sample 1	5.00	1261.60	1250.90	703.70		2.242	2.470						
Sample 2	5.00	1254.30	1245.20	701.30		2.252	2.470						
AVERAGE						**2.2**	**2.5**						
Sample 1	5.50	1275.60	1263.00	709.00		2.229	2.452						
Sample 2	5.50	1231.90	1230.00	699.80		2.312	2.452						
AVERAGE						**2.3**	**2.5**						
Sample 1	6.00	1265.5	1263.2	709.9		2.274	2.434						
Sample 2	6.00	1270.0	1267.8	709.9		2.264	2.434						
AVERAGE						**2.3**	**2.4**						
Sample 1	6.50	1274.8	1273.6	719.7		2.294	2.416						
Sample 2	6.50	1271.4	1269.8	719.6		2.301	2.416						
AVERAGE						**2.3**	**2.4**						
Sample 1	7.00	1273.2	1271.8	721.9		2.307	2.398						
Sample 2	7.00	1259.1	1257.7	714.1		2.308	2.398						
AVERAGE						**2.3**	**2.4**						

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Table Q1(c)(ii): Stability and flow data

SAMPLE	% Bit. SPEC. NO	CORR FACTOR	STABILITY (Kg)		FLOW mm	STIFFNESS
			MEAN	CORR		
Sample 1	5.00	0.93	12.92		2.33	
Sample 2	5.00	0.93	13.55		2.78	
AVERAGE			**13.2**		**2.6**	
Sample 1	5.50	0.93	8.68		4.46	
Sample 2	5.50	0.93	11.44		2.03	
AVERAGE			**10.1**		**3.2**	
Sample 1	6.00	0.93	9.71		1.98	
Sample 2	6.00	0.93	10.44		1.91	
AVERAGE			**10.1**		**1.9**	
Sample 1	6.50	0.96	11.14		2.27	
Sample 2	6.50	0.93	9.72		2.92	
AVERAGE			**10.4**		**2.6**	
Sample 1	7.00	0.96	8.61		1.97	
Sample 2	7.00	0.96	9.65		2.54	
AVERAGE			**9.1**		**2.3**	

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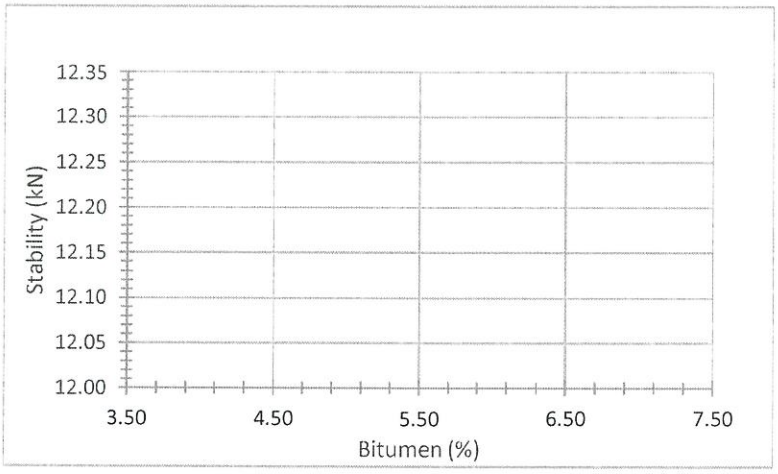
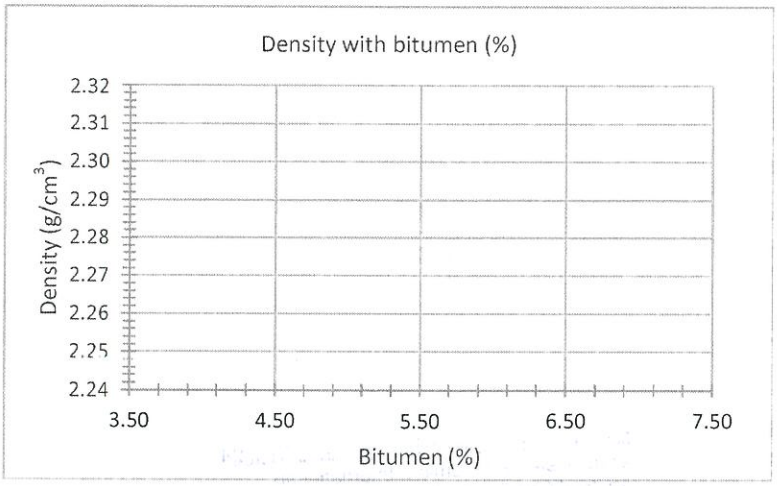


(a) Stability with bitumen (%)



(b) Density with bitumen (%)

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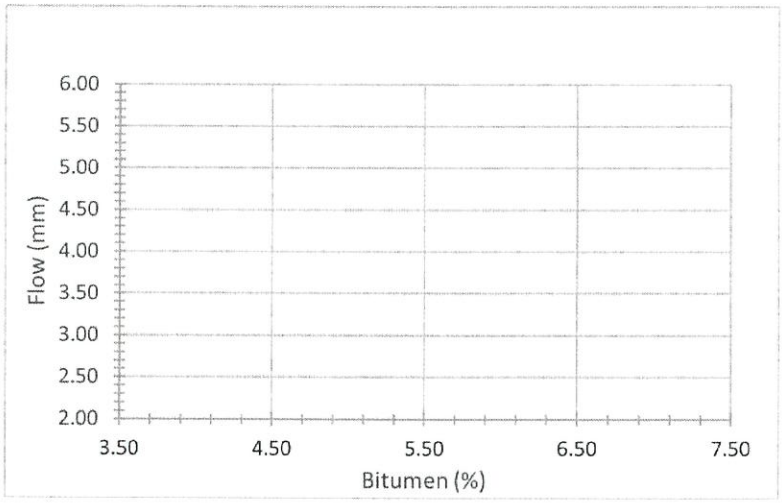
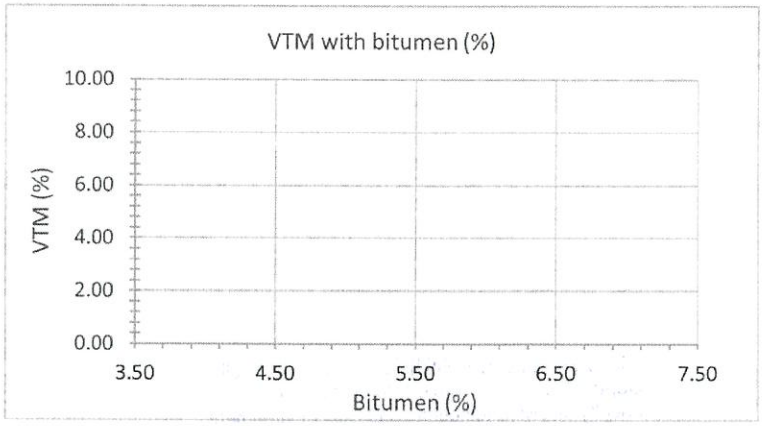


(c) Flow with bitumen (%)



(d) VTM with bitumen (%)

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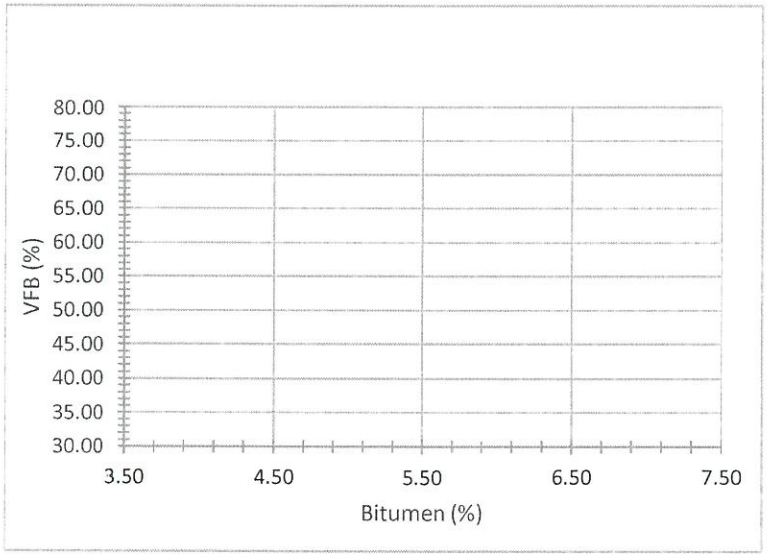
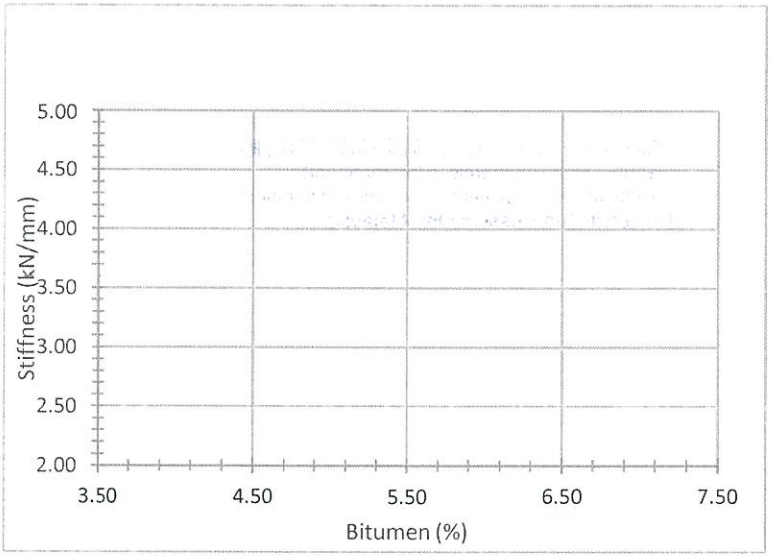


(e) VFB with bitumen (%)



(f) Stiffness with bitumen (%)

Figure Q1(c)(ii)(a) – (f): Graph of density, stability, flow, void in total mix (VTM), void filled with bitumen (VFB) and stiffness against bitumen content

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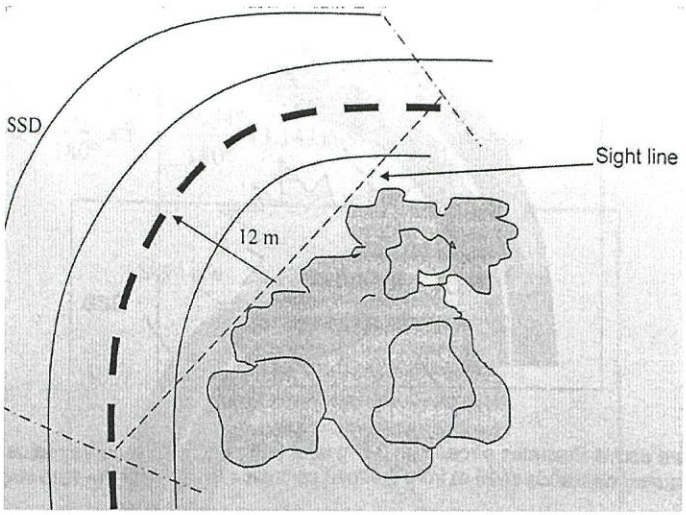

FIGURE Q2(b): Horizontal curve section of a rural highway

Table Q2(c)(i): 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) Range	Design Input Value
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)(ii): 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%

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Table Q2(c)(iii): 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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Table Q2(c)(iv): Summary of material use in pavement structure in Malaysia

NEW PAVEMENT DESIGN AND CONSTRUCTION		
DESIGNATION	**DESCRIPTION**	**ABBREVIATION/ SYMBOL**
DRAINAGE LAYER	Primarily functional granular layer with load distribution capability similar to the Sub-Base	DL
SUB-BASE COURSE	Crushed or natural granular material with maximum 10% fines	GSB
ROAD BASE COURSE		
• Crushed Aggregate	Crushed granular material with maximum 10% fines	CAB
• Wet Mix	Crushed granular material with maximum 10% fines	WMB
• Bituminous	Coarse bituminous mix (AC 28)	BB
• STB 1	Stabilised base with at least 3% Portland cement	STB1
• STB2	Stabilised base with bituminous emulsion and maximum of 2% Portland cement	STB2
BINDER COURSE		
• Binder Course	Coarse bituminous mix (AC 28)	BC
WEARING COURSE		
• Asphaltic Concrete	Medium to fine bituminous mix (AC 10 or AC 14).	BSC
• Polymer Modified Asphalt (PMA)	Medium to fine bituminous mix (AC 10 or AC 14) incorporated with polymer modified bitumen.	PMA
• Stone Mastic Asphalt (SMA)	Stone mastic asphalt (SMA 14 or SMA 20)	SMA
• Porous Asphalt	Primarily functional porous asphalt (PA 10 or PA 14)	PA
• Gap-Graded Asphalt	Gap Graded Asphalt GPA I or GPA II	FC

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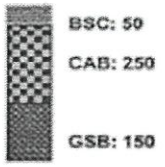
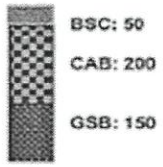
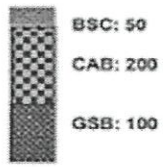
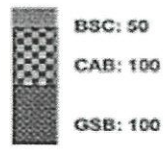
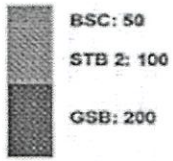
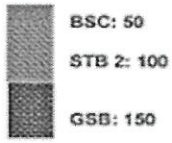
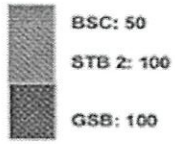
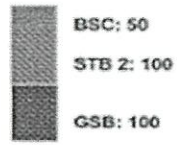
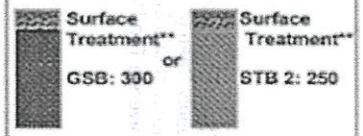
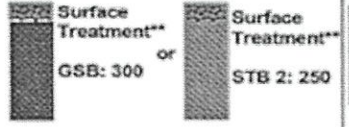
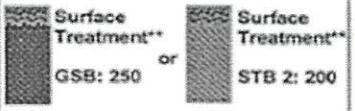
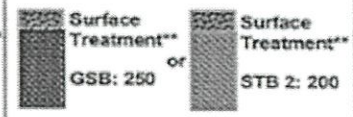
Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base				
Deep Strength: Stabilised Base				
Stabilised Base with Surface Treatment*				

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)

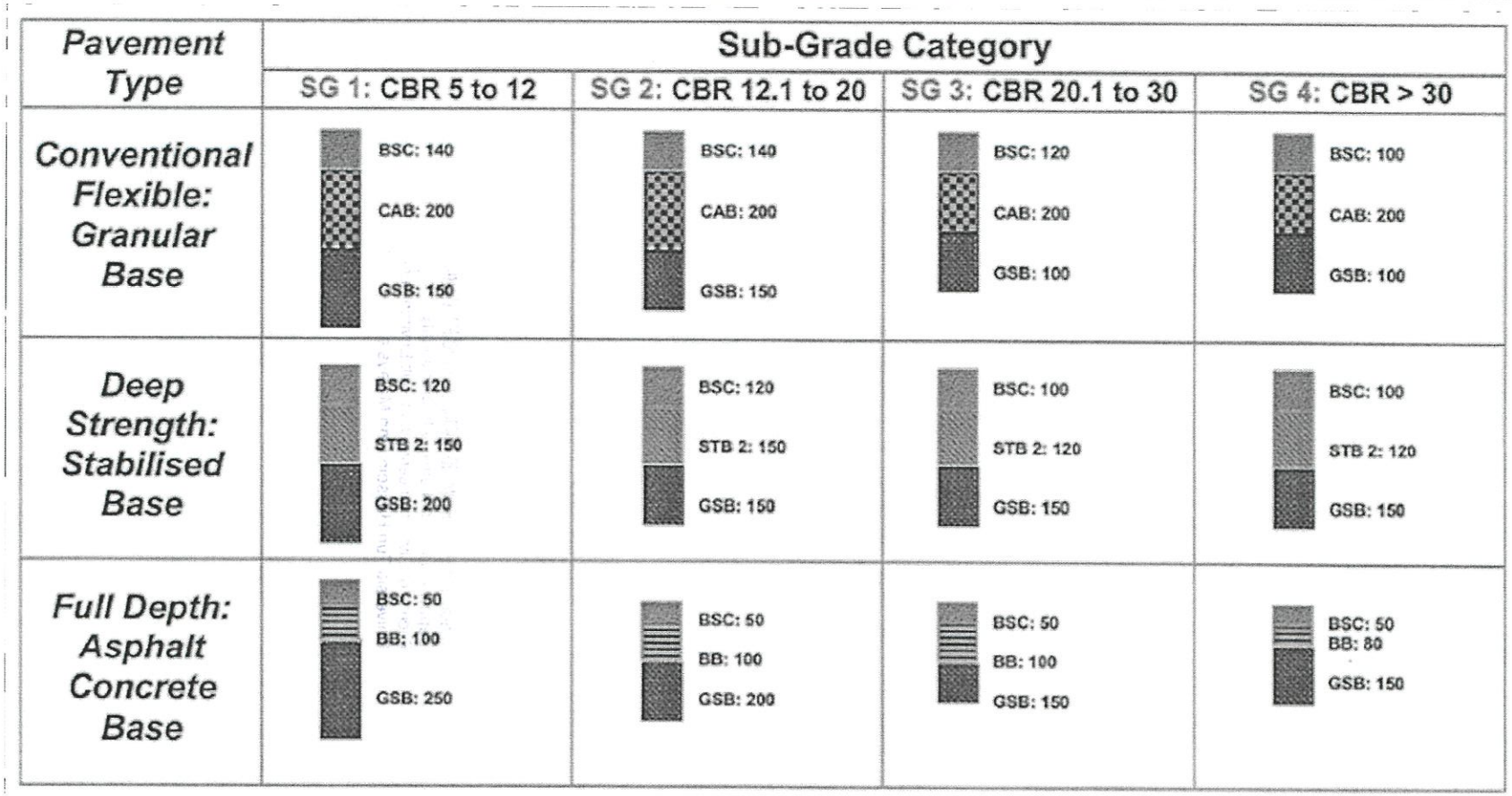


FIGURE Q1(c)(ii): Pavement structure for traffic category T2: 1.0 to 2.0 million ESALs

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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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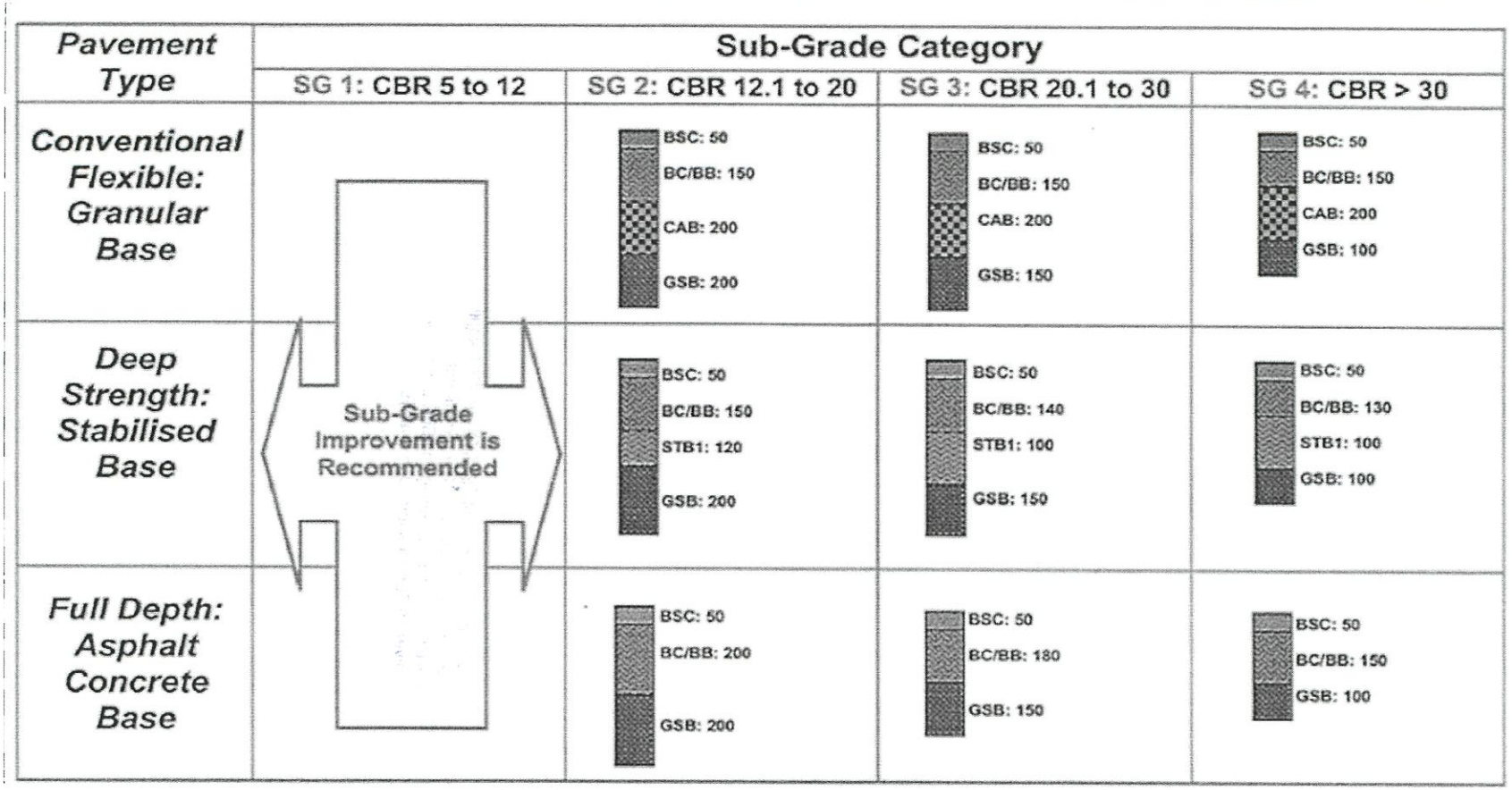

Figure Q1(c)(iv): Pavement structure for traffic category T4: 10.0 to 30.0 million ESALs (80 kN)

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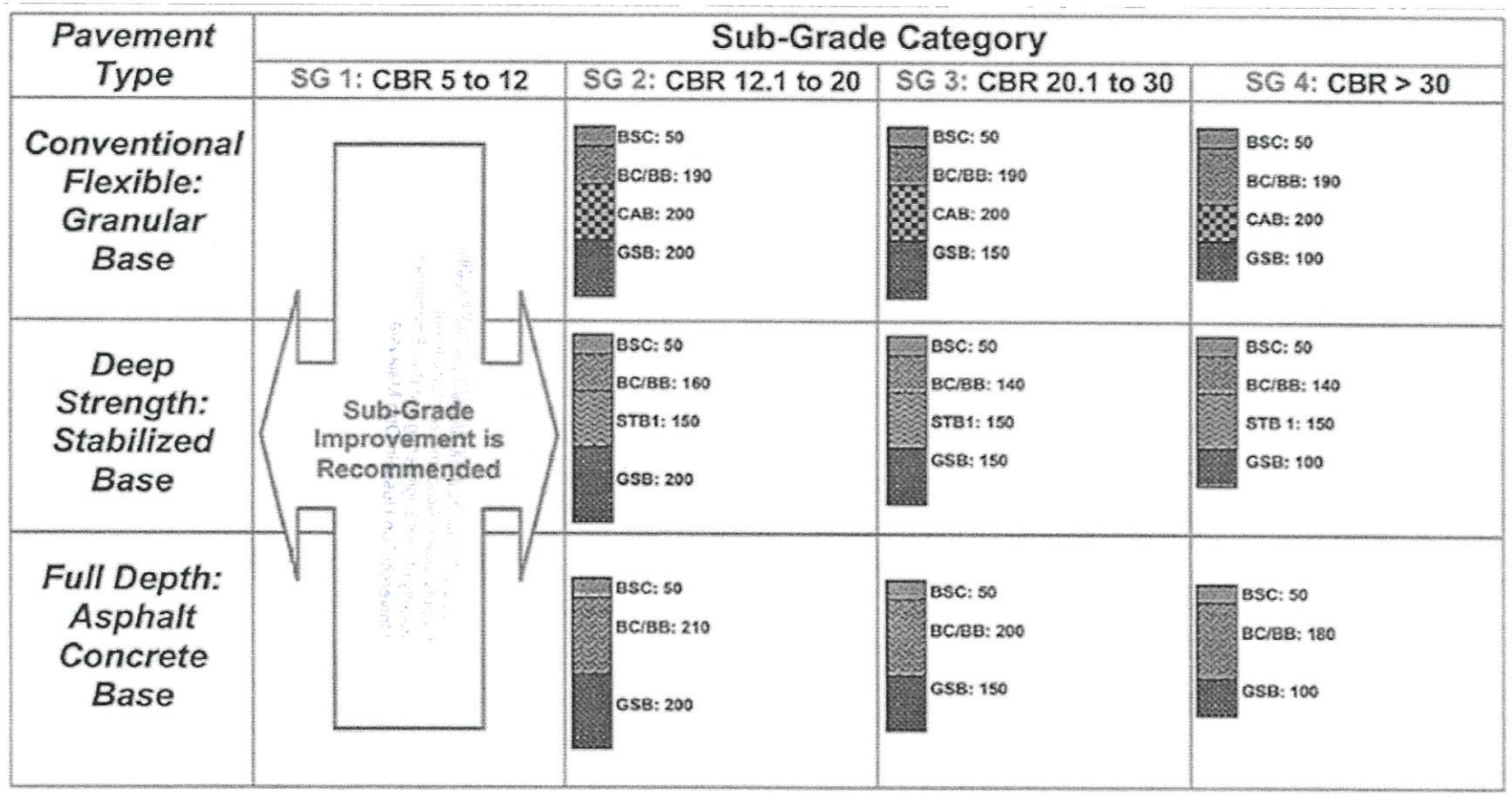

Figure Q2(c)(v): Pavement structure for traffic category T5: > 30.0 million ESALs (80 kN)

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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