SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN AWAM

PEPERIKSAAN AKHIR

SESI II : 2024/2025

DCC20312 : PAVEMENT ENGINEERING

TARIKH : 20 MEI 2025
MASA : 11.30 PAGI - 1.30 PETANG (2 JAM)

Kertas ini mengandungi **SEPULUH (10)** halaman bercetak.

Subjektif (4 soalan)

Dokumen sokongan yang disertakan : Formula

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

INSTRUCTION:

This section consists of **FOUR (4)** subjective questions. Answer **ALL** questions.

ARAHAN:

*Bahagian ini mengandungi **EMPAT (4)** soalan subjektif. Jawab semua soalan.*

QUESTION 1

SOALAN 1

CLO1 (a) Explain briefly pavement engineering.

Jelaskan secara ringkas mengenai kejuruteraan turapan.

[5 marks]

[*5 markah*]

CLO1 (b) Pavement classification refers to the system used to categorize different types of pavements based on their structural components and material properties. Identify **TWO (2)** classifications of road pavement with their functions related to the construction methods and materials used.

*Klasifikasi turapan merujuk kepada sistem yang digunakan untuk kategori jenis turapan jalan raya berdasarkan komponen struktur dan sifat bahannya. Kenal pasti **DUA (2)** klasifikasi turapan jalan berkaitan dengan fungsi kaedah pembinaan dan bahan yang digunakan.*

[8 marks]

[*8 markah*]

CLO1 (c) The use of recycled road materials is an alternative in road pavements where they are designed to reduce environmental impact and increase cost efficiency. Identify the applications and benefits of **FOUR (4)** types of recycled materials that have been used in the construction of new road pavement surfaces.

*Penggunaan bahan jalan kitar semula adalah alternatif dalam turapan jalan di mana ia direka bentuk untuk mengurangkan kesan alam sekitar dan meningkatkan kecekapan kos. Kenal pasti aplikasi dan faedah **EMPAT (4)** jenis bahan kitar semula yang telah digunakan dalam pembinaan permukaan turapan jalan baru.*

[12 marks]
[*12 markah*]

QUESTION 2

SOALAN 2

CLO1 (a) Explain **TWO (2)** objectives of pavement maintenance and emphasize their importance in ensuring an efficient and reliable road networks.

*Terangkan **DUA (2)** objektif untuk penyelenggaraan turapan dan menekankan kepentingannya dalam memastikan rangkaian jalan raya yang cekap dan boleh dipercayai.*

[5 marks]

[*5 markah*]

CLO1 (b) Pavement crack refers to a variety of pavement distresses that occur on the surface of pavements. Different types of pavements develop different cracks. The type of cracking is also correlated with the type of climate and traffic. By using a diagram, identify **TWO (2)** types of pavement cracks.

*Keretakan permukaan turapan merujuk kepada pelbagai kerosakan turapan yang berlaku pada permukaan turapan. Pelbagai jenis turapan menghasilkan rekahan yang berbeza. Jenis keretakan juga dikaitkan dengan jenis iklim dan lalu lintas. Dengan bantuan gambar rajah, kenalpasti **DUA (2)** jenis keretakan turapan.*

[8 marks]

[*8 markah*]

CLO1 (c) Non-Destructive Testing (NDT) in pavement assessment provides several advantages, making it a preferred method for evaluating road conditions without causing damage. Identify **SIX (6)** benefits of NDT.

*Ujian Tanpa Musnah (NDT) dalam penilaian turapan memberikan beberapa kelebihan, menjadikannya kaedah pilihan untuk menilai keadaan jalan tanpa menyebabkan kerosakan. Kenalpasti **ENAM (6)** faedah Ujian Tanpa Musnah (NDT).*

[12 marks]

[*12 markah*]

QUESTION 3

SOALAN 3

CLO2 (a) The aggregate used must have specific physical characteristics to withstand heavy vehicle loads and resist weather changes. Based on the situation above, identify **FIVE (5)** physical characteristics of aggregates that are suitable for road construction.

*Agregat yang digunakan mestilah mempunyai ciri-ciri fizikal tertentu agar dapat menampung beban kenderaan berat dan tahan terhadap perubahan cuaca. Berdasarkan situasi di atas, kenal pasti **LIMA (5)** ciri fizikal agregat yang sesuai digunakan dalam pembinaan jalan raya.*

[5 marks]

[*5 markah*]

CLO2 (b) A team of pavement engineers is conducting laboratory tests to evaluate the properties of bituminous binders used in road construction. To ensure the quality and durability of asphalt pavements, specific tests such as penetration and softening point tests are performed. Identify penetration and softening point tests for common bituminous binders, with reference to their purpose and procedures carried out in the laboratory.

Sekumpulan jurutera turapan sedang menjalankan ujian makmal bagi menilai sifat pengikat bitumen yang digunakan dalam pembinaan jalan raya. Untuk memastikan kualiti dan ketahanan turapan asfalt, ujian khusus seperti ujian penusukan dan ujian titik lembut dijalankan. Ujian ini membantu menentukan prestasi bitumen dalam pelbagai keadaan suhu, memastikan jalan raya dapat menahan kesan perubahan cuaca dan beban trafik yang berterusan. Kenal pasti ujian penusukan dan ujian titik lembut bagi pengikat bitumen, dengan merujuk kepada tujuan dan prosedur yang dijalankan di makmal

[8 marks]

[*8 markah*]

CLO2 (c) The mix formulation for each type of asphalt concrete mixture must be prepared based on tests done by several laboratory mixtures within the appropriate bitumen content range according to the Marshall test procedures. Table 3(c) shows the Marshall Test Result for an Asphalt Concrete Binder Course (ACB 28) carried out in the laboratory. Based on the results according to the Standard Specification for Road Construction JKR/SPJ/2008-S4, calculate the optimum bitumen content by plotting the graph in Appendix 2 (Submit Appendix 2 together with answer script).

Formula campuran yang direka bentuk untuk setiap jenis campuran konkrit asfaltik hendaklah disediakan berdasarkan ujian beberapa penggredan campuran agregat reka bentuk makmal pada julat kandungan bitumen yang sesuai mengikut Prosedur Ujian Marshall. Jadual 3(c) menunjukkan Keputusan Ujian Marshall bagi Asphaltic Concrete Binder Course (ACB 28) yang telah dilakukan di makmal. Berdasarkan keputusan tersebut mengikut Standard *Specification for Road Works JKR/SPJ/2008-S4, kirakan kandungan bitumen optimum dengan memplot graf di dalam Lampiran 2 (Hantar Lampiran 2 bersama skrip jawapan).*

Table 3(c) / *Jadual 3(c)*

Bitumen Content/ *Kandungan Bitumen* (%)	Density/ *Ketumpatan* (Mg/cu.m^3)	Stability/ *Kestabilan* (kg)	Flow/*Aliran* (mm)	Air Voids in Mix (VIM) / *Lompang Udara dalam Campuran* (%)	Void in Aggregate Filled with Bitumen (VFB) / *Lompang terisi Bitumen* (%)
4.0	2.315	1160	2.80	8.0	54.0
4.5	2.320	1200	3.00	6.5	60.0
5.0	2.340	1350	3.20	5.5	67.0
5.5	2.327	1300	3.25	5.0	70.1
6.0	2.318	1240	3.50	4.5	75.0

[12 marks]

[*12 markah*]

QUESTION 4

SOALAN 4

CLO 2 (a) Flexible pavements are commonly used in the construction of road and has multiple layers. By using a diagram, identify **FIVE (5)** layers of flexible pavement.

*Turapan lentur biasanya digunakan dalam pembinaan jalan raya dan mempunyai pelbagai lapisan. Dengan menggunakan gambar rajah, kenalpasti **LIMA (5)** lapisan turapan lentur*

[5 marks]

[*5 markah*]

CLO 2 (b) Flexible pavements are designed to distribute loads to the underlying layer, relying on the resilience of the material to withstand traffic and environmental pressure. Explain the process of constructing layers for flexible pavements.

Turapan lentur direka bentuk untuk mengagihkan beban ke lapisan bawah, bergantung pada daya tahan bahan untuk menahan tekanan lalu lintas dan persekitaran. Terangkan proses membina lapisan untuk turapan lentur.

[8 marks]

[*8 markah*]

CLO 2 (c) Figure 4(c) shows the proposed highway construction design for the AAA Highway Project in Perak, which spans 100 km and passes through rolling terrain. The design assumptions including a design life for 20 years, an annual traffic growth rate of 4.0% and L are shown in Figure 4(c). The average daily traffic flow (16 hours) is 8000 pcu/hr and the details of commercial vehicle types are as follows:

- CV1 = 650 vehicles
- CV2 = 460 vehicles
- CV3 = 279 vehicles
- CV4 = 90 vehicles

Subgrade CBR data from tests :

- CBR mean = 213 MPa
- CBR Standard Deviation = 30 MPa
- Probability Normal Deviate = 1.643

Select a suitable pavement structure for the project based on the given design data.

Rajah 4(c) menunjukkan cadangan reka bentuk pembinaan lebuh raya bagi Projek Lebuhraya AAA di Perak, yang menjangkau 100 km dan melalui kawasan cerun sederhana. Andaian reka bentuk termasuk hayat reka bentuk selama 20 tahun, kadar pertumbuhan trafik tahunan sebanyak 4.0% dan L seperti ditunjukkan dalam Rajah 1. Purata aliran trafik harian (16 jam) ialah 8000 pcu/jam dan butiran jenis kenderaan komersial adalah seperti berikut:

- *CV1 = 650 kenderaan*
- *CV2 = 460 kenderaan*
- *CV3 = 279 kenderaan*
- *CV4 =90 kenderaan*

Data CBR daripada ujian subgred:

- *Purata CBR=213Mpa*
- *Sisihan Piawai CBR= 30Mpa*
- *Kebarangkalian Sisihan Normal = 1.643*

Pilih struktur turapan yang sesuai untuk projek berdasarkan data reka bentuk yang diberikan.

Figure 4(c)/*Rajah 4(c)*

[12 marks]

[*12 markah*]

SOALAN TAMAT

Appendix 1

Table and Formula in Design Flexible Pavement ATJ 5/85 (Pindaan 2013)

$$ESAL_{Y1} = [ADT_{vc1} \times LEF_1 + ADT_{vc2} \times LEF_2 + \ldots + ADT_{vc9} \times LEF_9] \times 365 \times L \times T \quad \ldots(1)$$

where;

$ESAL_{Y1}$ = Number of ESALs for the Base Year (Design Lane)

ADT_{VC2}, etc = Average Daily Number of Vehicles in each Vehicle Class

LEF_2, etc = Load Equivalence Factors of applicable vehicle class

L = Lane Distribution Factor (refer to **Table 2.2**)

T = Terrain Factor (refer to **Table 2.3**)

$$\text{Design Traffic } ESAL_{DES} = ESAL_{Y1} \times \frac{[(1+r)^n - 1]}{r} \quad \ldots (3)$$

where;

$ESAL_{DES}$ = Design Traffic for the Design Lane in one Direction (determines the Traffic Category used as Basis for selecting a Pavement Structure from the Catalogue)

$ESAL_{Y1}$ = Number of ESALs for the Base Year (Equation 1 or 2)

r = Average Annual Traffic Growth Factor for Design Period

n = Number of Years in Design Period

$$\text{Design Traffic } ESAL_{DES} = ESAL_{Y1} \times TGF \quad \ldots (3a)$$

Design Input Value = Mean – (Normal Deviate x Standard Deviation)

Appendix 1

Amendment 2.

Section 2.2 Determination of Design Traffic (Table 2.1, page 8) shall be read as follows:

Amendment 2 **TABLE 2.1: Axle Configuration and Load Equivalence Factors (LEF)**

Vehicle		Load Equivalence Factor (LEF)
Class Designation	Class	
Cars and Taxis	C	0
Rigid Vehicle (1+1) incl. Buses (2 Axle)	CV1	3.9
Rigid Vehicle (1+2) incl. Buses (3 Axle)	CV2	2.8
Rigid Vehicle (2+2) (4 Axle)	CV3	2.6
Articulated Vehicle (1+1+1) (3 Axle)	CV4	7.1
Articulated Vehicle (1+1+2) (4 Axle)	CV5	6.1
Articulated Vehicle (1+1+3) (5 Axle)	CV6	4.7
Articulated Vehicle (1+2+2) (5 Axle)	CV7	4.2
Articulated Vehicle (1+2+3) (6 Axle)	CV8	3.5
Articulated Vehicle (1+2+4) (7 Axle)	CV9	3.6
Motorcycles	MC	0

TABLE 2.2: Lane Distribution Factors

Number of Lanes (in ONE direction)	Lane Distribution Factor, L
One	**1.0**
Two	**0.9**
Three or more	**0.7**

TABLE 2.3: Terrain Factors

Type of Terrain	Terrain Factor, T
Flat	**1.0**
Rolling	**1.1**
Mountainous/Steep	**1.3**

Appendix 1

TABLE 2.5: Traffic Categories used in this Manual (ESAL = 80 kN)

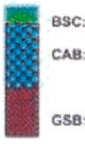
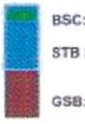
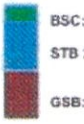
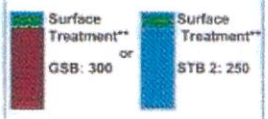
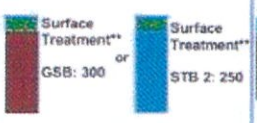
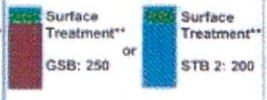
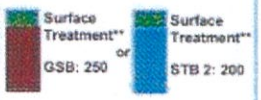
Traffic Category	Design Traffic (ESAL x 10^6)	Probability (Percentile) Applied to Properties of Sub-Grade Materials
▪ T 1	**≤ 1.0**	≥ 60%
▪ T 2	**1.1 to 2.0**	≥ 70%
▪ T 3	**2.1 to 10.0**	≥ 85%
▪ T 4	**10.1 to 30.0**	≥ 85%
▪ T 5	**> 30.0**	≥ 85%

TABLE 2.6: Classes of Sub-Grade Strength (based on CBR) used as Input in the Pavement Catalogue of this Manual

Sub-Grade Category	CBR (%)	Elastic Modulus (MPa)	
		Range	Design Input Value
▪ SG 1	**5 to 12**	50 to 120	**60**
▪ SG 2	**12.1 to 20**	80 to 140	**120**
▪ SG 3	**20.1 to 30.0**	100 to 160	**140**
▪ SG 4	**> 30.0**	120 to 180	**180**

Appendix 1

FIGURE 3.1: Pavement Structures for Traffic Category T 1: < 1.0 million ESALs (80 kN)

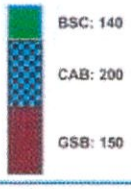
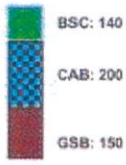
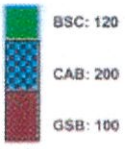
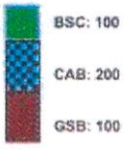
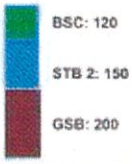
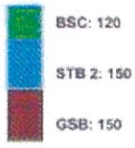
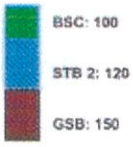
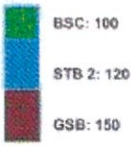
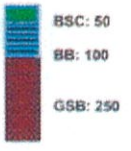
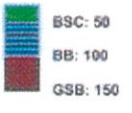
Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base				
Deep Strength: Stabilised Base				
Stabilised Base with Surface Treatment*				

Notes:

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

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

FIGURE 3.2: Pavement Structures for Traffic Category T 2: 1.0 to 2.0 million ESALs (80 kN)

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				
Full Depth: Asphalt Concrete Base				

Appendix 1

FIGURE 3.3: Pavement Structures for Traffic Category T 3: 2.0 to 10.0 million ESALs (80 kN)

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 3.4: Pavement Structures for Traffic Category T 4: 10.0 to 30.0 million ESALs (80 kN)

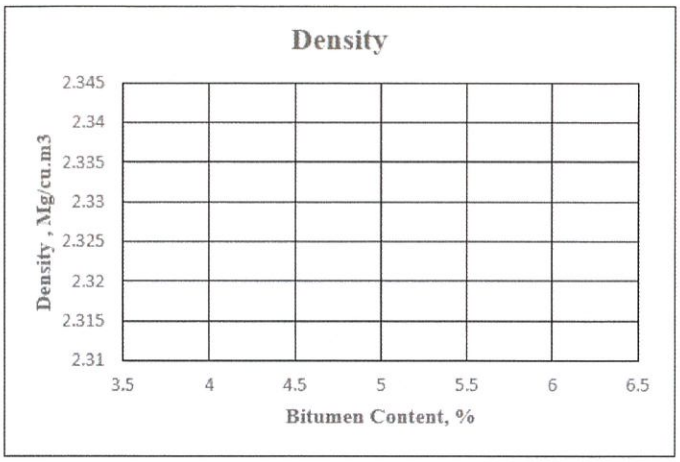
Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base	Sub-Grade Improvement is Recommended	BSC: 50 BC/BB: 150 CAB: 200 GSB: 200	BSC: 50 BC/BB: 150 CAB: 200 GSB: 150	BSC: 50 BC/BB: 150 CAB: 200 GSB: 100
Deep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

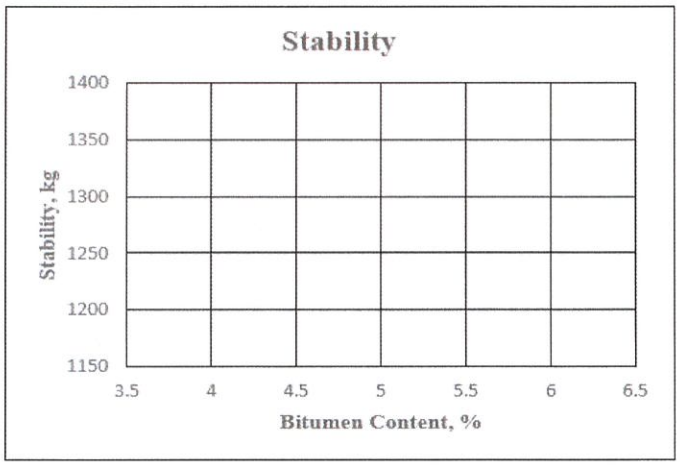
Appendix 1

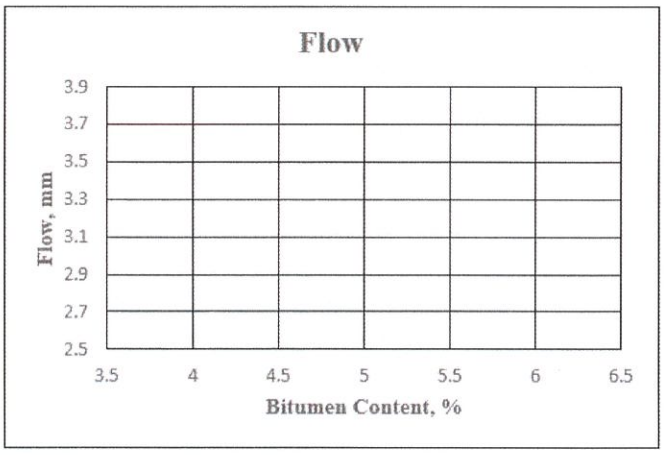
FIGURE 3.5: Pavement Structures for Traffic Category T 5: > 30.0 million ESALs (80 kN)

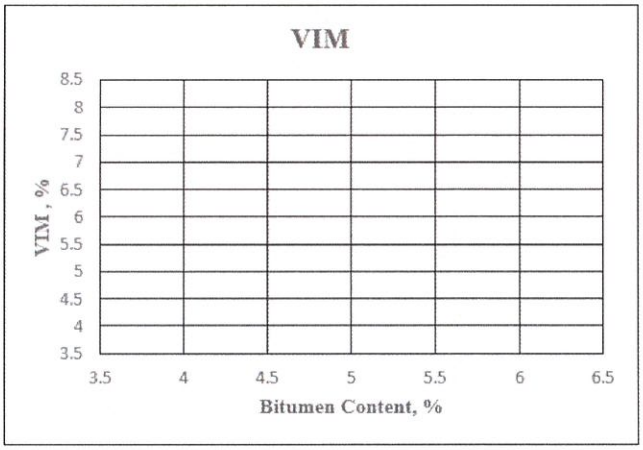
Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base	Sub-Grade Improvement is Recommended	BSC: 50 BC/BB: 190 CAB: 200 GSB: 200	BSC: 50 BC/BB: 190 CAB: 200 GSB: 150	BSC: 50 BC/BB: 190 CAB: 200 GSB: 100
Deep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

Appendix 2









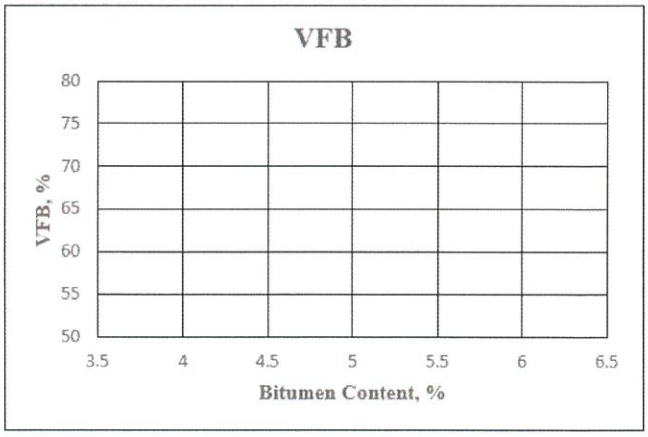


TABLE 4.3.5: TEST AND ANALYSIS PARAMETERS

Parameter	Wearing Course	Binder Course
Stability, S	> 8000 N	> 8000 N
Flow, F	2.0 - 4.0 mm	2.0 - 4.0 mm
Stiffness, S/F	> 2000 N/mm	> 2000 N/mm
Air voids in mix (VIM)	3.0 - 5.0%	3.0 - 7.0%
Voids in aggregate filled with bitumen (VFB)	70 - 80%	65 - 75%

Candidates are required to detach this sheet and attach it together with the answer script

Calon diminta untuk ceraikan helaian ini dan kepilkan bersama skrip jawapan