UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2011/2012

COURSE NAME	:	HIGHWAY ENGINEERING
COURSE CODE	:	BFC 3042 / 31802
PROGRAMME	:	BFF
DATE	:	JANUARY 2012
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS PAPER CONSISTS OF **THIRTEEN (13)** PAGES

Q1 (a) List **TWO (2)** testing that should be done to the following flexible pavement's material and state the function for each testing.

(i) road base

(2 marks)

(ii) sub-base

(2 marks)

(iii) Bitumen

(2 marks)

(b) Describe good and bad sub-grades in term of their properties.

(7 marks)

(c) In general, asphaltic concrete mixtures are a uniformly mixed combination of **THREE (3)** basic materials. List each of the material and explain its function in the mixture.

(6 marks)

(d) The bituminous layer of a flexible pavement consists of wearing course and binder course. List **THREE (3)** comparisons of these two courses.

(6 marks)

Q2 (a) Briefly describe **TWO (2)** types of rigid pavement and give the condition for each type will be constructed.

(5 marks)

(b) A plain concrete rigid pavement, un-doweled joint is designed for a two-lane two-direction road. Accumulated number of axle load during the design period is shown in Figure **Q2(b)(i)** and Figure **Q2(b)(ii).**

Given:

Modulus of subgrade reaction (k)	= 40	MPa/m
Concrete Modulus of Rupture (M_R)	= 4.5	MPa
Safety factor LSF	= 1.0	
Slab thickness	= 240	mm

Using nomograph and tables (PCA method), complete the calculation form as shown in Figure **Q2(b)(i)** and Figure **Q2(b)(ii).**

(i) Determine percentage of fatigue.
(ii) Determine percentage of damage cause by erosion.
(iii) Justify the better condition, with or without concrete shoulder?

(20 marks)

Q3 (a) Site investigation is carried in most cases as a preliminary to new works. State the reasons why the site investigation is needed for the road construction.

(3 marks)

(b) The sub-grade, sub-base and road base layer were constructed based on the minimum strength value which fulfill the requirement. Generally, the strength of these layers was measured according to the California Bearing Ratio (CBR) value. Give the minimum CBR value of each layer.

(3 marks)

(c) Prior to the construction of binder and wearing course, a thin layer of bituminous coats will be sprayed.

(i) Name **TWO (2)** of this bituminous coats and its location.

(2 marks)

(ii) Explain the purposes of these each coats.

(4 marks)

(d) The Aggregate Crushing Value (ACV) for the sub-base and road base material for the road construction according to Specification of Roadworks by Jabatan Kerja Raya is 35 and 30 respectively. Explain why there is the different value of the ACV for both materials.

(3 marks)

(e) After the suitability of the materials fulfills the standard value, the most important part is to ensure the quality of works during the construction also fulfill the needs of the requirement. As an engineer, summarize the action that need to be conducted to ensure the quality of the following layers.

(i) Sub-grade, sub-base and road base layers.

(6 marks)

(ii) Binder and wearing coarse layers.

(4 marks)

Q4 (a) Chip seal is proposed for a new road with crushed stone road base. Current daily traffic volume is 750 vehicle per-day per-lane and no significant increment is expected in 5 years ahead. The existing surface is asphalt concrete. Sand patch test result and average surface day time temperature for last three days are presented in **Table 1**. The result of Average Least Dimension (ALD) test on aggregate is shown in **Table 2**.

(i) Propose type of bitumen and size of aggregate that suitable for the work.

(5 marks)

(ii) Calculate the rate of aggregate application.

(6 marks)

(iii) Calculate the rate of binder application if the binder will consists of 80 pen grade bitumen plus kerosene.

(6 marks)

(b) Pavement recycling techniques on site are CIPR and HIPR. Define CIPR.

(1 mark)

(c) Identify the difference between CIPR and HIPR.

(1 mark)

(d) Discuss **THREE (3)** types of stabilising agents (excluding water) for CIPR.

(6 marks)

Q5 (a) Explain the effect of highway drainage to the safety of road user and pavement structure.

(4 marks)

(b) Sub-surface drainage is used to remove water from the underlying strata of the pavement. Explain the sources of the sub-surface water which contribute to the existing of water for the road by using the suitable diagram.

(4 marks)

(c) The efficiency of drainage system is important for the safety of road user and pavement structure. Recommend the action that can be conducted to minimize the deterioration of the drainage system.

(4 marks)

(d) Different types of surface drainage system are provided based on the location of the highway. Sketch the common types of surface drainage and give explanation for each answer by using the suitable diagram.

(8 marks)

(e) The mountainous and hilly roads are prone to slips and landslides problem. This situation may happen due to the lack of maintenance works. Describe the maintenance work that can be conducted to avoid these problems to occur.

(5 marks)

S1 (a) Senaraikan **DUA (2)** pengujian yang sepatutnya dijalankan ke atas bahan turapan anjal yang berikut serta nyatakan fungsi setiap pengujian yang dinyatakan.

(i) tapak jalan

(2 markah)

(ii) sub-tapak

(2 markah)

(iii) Bitumen

(2 markah)

(b) Terangkan ciri-ciri subgred yang baik dan subgred yang tidak sesuai.

(7 markah)

(c) Secara umumnya, campuran konkrit asphalt adalah kombinasi campuran seragam **TIGA (3)** bahan asas. Senaraikan setiap bahan tersebut serta terangkan fungsinya dalam campuran.

(6 markah)

(d) Lapisan berbitumen suatu turapan anjal terdiri daripada lapiran penghausan dan lapisan pengikat. Senaraikan **TIGA (3)** perbezaan di antara kedua-dua jenis lapisan ini.

(6 markah)

S2 (a) Huraikan dengan ringkas **DUA (2)** jenis turapan tegar dan berikan keadaan setiap jenis pembinaannya.

(5 markah)

(b) Sebuah turapan tegar, tanpa sambungan tercemat direkabentuk untuk jalan dua lorong dan dua hala.

Diberi:

Modulus reaksi subgred (k)	= 40	MPa/m
Modulus kepecahan konkrit (M_R)	= 4.5	MPa
Faktor Keselamatan *LSF*	= 1.0	
Tebal papak	= 240	mm

Dengan menggunakan nomograf dan jadual (kaedah *PCA*), lengkapkan borang pengiraan seperti di dalam Rajah **Q2(b)(i)** dan Rajah **Q2(b)(ii)**.

(i) Tentukan peratusan kelesuan.
(ii) Tentukan peratusan kerosakan disebabkan oleh hakisan.
(iii) Justifikasikan keadaan yang lebih baik, samada, ada bahu atau tanpa bahu konkrit.

(20 markah)

S3 (a) Penyiasatan tapak dilakukan pada setiap kes sebagai kerja-kerja awal sesuatu projek. Nyatakan alasan mengapa penyiasatan tapak adalah diperlukan untuk pembinaan jalan.

(3 markah)

(b) Lapisan sub-gred, sub-tapak dan tapak dibina berdasarkan kepada kekuatan minimum yang memenuhi syarat. Amnya, kekuatan lapisan tersebut diukur berpandukan kepada nilai nisbah keupayaan galas California *(CBR)*. Berikan nilai minimum *CBR* untuk setiap lapisan tersebut.

(3 markah)

(c) Sebelum pembinaan lapisan pengikat dan penghausan dilaksanakan, satu lapisan nipis bitumen akan disemburkan.

(i) Namakan **DUA (2)** lapisan bitumen ini dan kedudukannya.

(2 markah)

(ii) Terangkan keperluan setiap lapisan bitumen ini.

(4 markah)

(d) Nilai Agregat Terhancur *(ACV)* untuk bahan sub-tapak dan tapak untuk pembinaan jalan berdasarkan Spesifikasi Pembinaaan Jalan oleh Jabatan Kerja Raya adalah 35 dan 30 masing-masing. Terangkan mengapa terdapat perbezaan nilai *ACV* untuk kedua-dua bahan ini.

(3 markah)

(e) Setelah kesesuaian bahan memenuhi kehendak nilai piawai, satu perkara yang penting adalah untuk memastikan kualiti kerja semasa pembinaan juga memenuhi kehendak paiwaian. Sebagai seorang jurutera, simpulkan tindakan yang boleh dilaksanakan untuk memastikan kualiti lapisan-lapisan berikut.

(i) Sub-gred, sub-tapak dan tapak.

(6 markah)

(ii) Lapisan pengikat dan penghausan.

(4 markah)

S4 (a) *Chip seal* dicadangkan untuk pembinaan jalan baru dengan batuan hancur sebagai lapisan tapak jalan. Isipadu lalu lintas harian terkini ialah 750 kenderaan per-hari per-lorong dan dijangka tiada pertumbuhan ketara dalam masa 5 tahun akan datang. Lapisan permukaan sedia ada adalah konkrit asfalt. Keputusan ujikaji *Sand patch* dan suhu purata permukaan untuk tiga hari terakhir ditunjukkan di **Jadual 1**. Keputusan ujikaji *Average Least Dimension (ALD)* ke atas agregat ditunjukkan di **Jadual 2**.

(i) Cadangkan jenis bitumen dan saiz agregat yang bersesuaian dengan kerja.

(5 markah)

(ii) Kirakan kadar penggunaan agregat.

(6 markah)

(iii) Kirakan kadar penggunaan lapisan pengikat jika lapisan pengikat akan menggunakan bitumen gred 80 pen ditambahkan dengan kerosen.

(6 markah)

(b) Teknik kitar semula turapan di lapangan adalah *CIPR* dan *HIPR*. Takrifkan *CIPR*.

(1 markah)

(c) Kenalpasti perbezaan di antara *CIPR* dan *HIPR*.

(1 markah)

(d) Bincangkan **TIGA (3)** jenis ejen penstabilan (tidak termasuk air) untuk *CIPR*.

(6 markah)

S5 (a) Terangkan kesan saliran jalan terhadap keselamatan pengguna jalanraya dan struktur turapan.

(4 markah)

(b) Saliran sub-permukaan digunakan untuk menyingkirkan air dari lapisan bawah turapan. Terangkan sumber air bawah tanah yang menyumbang kepada kehadiran air terhadap jalan dengan menggunakan gambarajah yang sesuai.

(4 markah)

(c) Keberkesanan sistem saliran adalah penting untuk keselamatan pengguna jalanraya dan struktur turapan. Cadangkan tindakan yang boleh dilakukan untuk memastikan kerosakan terhadap sistem saliran jalan raya adalah pada tahap yang minimum.

(4 markah)

(d) Sistem saliran permukaan yang berbeza disediakan bergantung kepada lokasi jalan. Lakarkan saliran permukaan jalan yang biasa digunakan dan berikan penerangan terhadap setiap jawapan yang diberikan dengan menggunakan gambarajah yang sesuai.

(8 markah)

(e) Jalanraya di kawasan gunung-ganang dan berbukit terdedah kepada masalah tanah runtuh. Situasi ini mungkin berlaku akibat kurang kerja-kerja penyelenggaraan. Huraikan kerja-kerja penyelenggaraan yang boleh dilaksanakan untuk menghalang daripada masalah ini berlaku.

(5 markah)

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Matric Card No.								

Calculation of Pavement Thickness

Project
Trial Thickness — Doweled joints : no
Modulus of Rupture, MR — Conrete shoulder : yes
Load Safety factor, LSF 1 — Design period : years

Axle load (kN)	Multiplied by LSF	Expected repetitions	Fatigue analysis		Erosion analysis	
			Allowable repetitions	Fatigue percent	Allowable repetitions	Damage, percent
1	2	3	4	5	6	7

8. Equivalent stress : 1.15 **10.** Erosion factor: 2.41
9. Stress ratio factor : 0.26

Single axle

115		15,000				
98		58,150				
89		128,150				
80		167,000				

11. Equivalent stress : 1.01 **13.** Erosion factor: 2.59
12. Stress ratio factor : 0.22

Tandem axle

231		12,000				
178		200,000				
160		450,000				
142		500,000				
125		900,000				
			Total		**Total**	

FIGURE Q2(b)(i) : Rigid Pavement analysis (with concrete shoulder and un-doweled joint)

***Note:** *Please separate and attach this attachment in your answer script book.*

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Calculation of Pavement Thickness

Project
Trial Thickness — Doweled joints : no
Modulus of Rupture, MR — Conrete shoulder : no
Load Safety factor, LSF 1 — Design period : years

Axle load (kN)	Multiplied by LSF	Expected repetitions	Fatigue analysis		Erosion analysis	
			Allowable repetitions	Fatigue percent	Allowable repetitions	Damage, percent
1	2	3	4	5	6	7

8. Equivalent stress : 1.39 **10.** Erosion factor: 2.83
9. Stress ratio factor : 0.31

Single axle

115		15,000				
98		58,150				
89		128,150				
80		167,000				

11. Equivalent stress : 1.28 **13.** Erosion factor: 3.05
12. Stress ratio factor : 0.29

Tandem axle

231		12,000				
178		200,000				
160		450,000				
142		500,000				
125		900,000				
			Total		**Total**	

FIGURE Q2(b)(ii) : Rigid Pavement analysis (without concrete shoulder and un-doweled joint)

***Note:** *Please separate and attach this attachment in your answer script book.*

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TABLE 1: Sand patch test and daily air temperature

No.	Sand patch diameter (mm)	Air temperature (^{0}C)
1	200	32
2	210	32.5
3	220	33

TABLE 2: ALD test result

Least Dimension	Thickness Range (mm)	Tally Stones in Class
	4 – 5	15
	5 – 6	18
	6 – 7	23
	7 – 8	24
	8 – 9	25
	9 – 10	21
	10 – 11	19
	11 – 12	18

TABLE 3: Kerosene proportion for chip seal with pen-grade 80/100

Shade Air Temperature (^{0}C)	Proportion of Kerosene to blended to 80/100 pen-grade (PPH)*	Spraying temperature (^{0}C)
17.5	13	151
20	11	157
22.5	9	162
25	7	167
27.5	5	172
30	3	171
32.5	1	182
> 34	0	185

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TABLE 4: Guide on the selection of aggregate size

Existing Surface and traffic	Nominal size (mm)
Soft surface, such as Penetration Macadam with < 1000 vehicle per day	20 mm
Soft surface with > 1000 vehicle per day per lane	14 mm
Medium surface, such as rolled asphalt with < 1000 vehicle per day	10 mm
Hard surface, such as Portland Cement Concrete or Asphalt Concrete with > 1000 vehicle per day per lane	6 mm

TABLE 5: Residual rate of binder application

Sand Circle Diameter (mm)	Bitumen needed to fill surface void (l/m^2), "e"
210	0.22
220	0.20
230	0.18
240	0.16
250	0.14

TABLE 6: Traffic factor

Traffic in lane (vpd/lane)	T_f
500	1.117
750	1.074
1,000	1.004
1,500	1.002

Formulae:

$$C = \frac{ALD}{666} \qquad (^{m^3}/_{m^2})$$

$$R = (0.138 \times ALD + e) \times T_f$$