COURSE CODE : SAB2832
COURSE : HIGHWAY ENGINEERING
PROGRAMME : SAW
DURATION : 2 HOURS
DATE : JANUARY 2013

INSTRUCTION TO CANDIDATES:
1. ANSWER FOUR (4) QUESTIONS ONLY.
2. REFERENCES ARE NOT ALLOWED.

WARNING!
Students caught copying/cheating during the examination will be liable for disciplinary actions and the faculty may recommend the student to be expelled from the study.

This examination question consists of (8) printed pages only.
Semua Pelajar
Program Pengajian Sepanjang Masa
Universiti Teknologi Malaysia

Saudara/i,

PERINGATAN KHAS PEPERIKSAAN


2. Tindakan tatatertib boleh dikenakan ke atas mana-mana pelajar yang ditangkap kerana kesalahan seperti di atas dan jika disabit kesalahan boleh dihukum melalui Peruntukan Kaedah 48, Bahagian V, Tatacara Tatatertib, Kaedah-Kaedah Universiti Teknologi Malaysia (Tatatertib Pelajar-Pelajar) 1999, yang membawa hukuman maksima seperti "digantung daripada pengajian" atau "dipecat" dari Universiti Teknologi Malaysia. Hukuman juga boleh berdasarkan Peraturan Akademik, UTB Bahagian XIII yang membawa hukuman maksima "membatalkan keputusan keseluruhan peperiksaan dan diberhentikan daripada pengajian".

3. Pihak Universiti tidak teragak-agak untuk mengambil tindakan dan menjatuhkan hukuman maksima jika saudara/i didapati bersalah dalam melakukan penyelewengan akademik.

Sekian.

DEKAN
Sekolah Pendidikan Profesional dan Pendidikan Berterusan (UTMSpace)
Universiti Teknologi Malaysia

2 Januari 2013
Q1. (a) JKR/SPJ 2008 includes the following requirements for coarse aggregate to be used in SMA mix:
   Loss in Los Angeles Abrasion not more than 25%;
   Flakiness Index not more than 25%; and
   Water Absorption not more than 2%.

Results of tests on a sample of coarse aggregate are:

Los Angeles Abrasion value test
   Sample tested: 5000.4 g
   Mass passing sieve: 1352.4 g

Flakiness Index Test
   Sample tested: 9066.4 g
   Mass passing slot: 2448.8 g

Water Absorption test
   Dry mass: 1250.4 g
   Submerged under water mass: 788.2 g
   Saturated surface dry mass: 1280.6 g

i) Can this aggregate be used for the specified job? Why?
ii) How will it affect the pavement if this aggregate was used in the mix?

(15 marks)

(b) Durability and rheology are two of the important properties for bitumen (asphalt cement).

i) Explain what is durability and rheology, and why they are important.
ii) Name and explain one test for each property.

(10 marks)
Q2. (a) Field density test was then carried out on the compacted sub-base (using sand replacement method), and the following results were recorded:

- Mass of sand in the bottle (before test) 8740 g
- Mass of sand in the bottle (after test) 5075 g
- Mass of moist soil from test hole 4220 g

Knowing the density of sand is 1275 kg/m³, mass of sand in cone 1255g, determine the allowable maximum moisture content at site so that the layer can still be considered properly compacted. Explain. The relationship between dry density and moisture content for laboratory compaction is given in the Figure 2(b).

(10 marks)

(b) Asphalt concrete mixes need to be properly designed and fulfill the requirement specified by the relevant highway agencies.

i) Specifications of asphalt concrete often give a minimum and maximum value for allowable air voids. Why? What properties are affected and how?

ii) What tests need to be carried out on asphalt concrete cored sample and why each of them is important?

iii) Given below is data of an AC10 core sample. Determine whether the pavement has been properly compacted, knowing the laboratory Marshall density is 2.322 Mg/m³ at optimum bitumen content of 5.8%. Also check for the bitumen content adequacy.

- Mass of cored sample in air 982.8 g
- Mass submerged under water 554.5 g
- Mass of saturated surface dry 993.3 g

Bitumen extraction:

- Mass of sample before extraction 1185.8 g
- Mass of filter paper before extraction 14.1 g
- Mass of filter paper after extraction 16.7 g
- Mass of extracted aggregate 1110.6 g

(15 marks)
Figure Q2 (a) Dry Density vs. Moisture Content

Note: Please return this figure along with your answer book.
Q3. (a) Arahan Teknik (Jalan) 5/85 and Road Note 31 are two methods currently used to design the structural thickness of new bituminous pavement in Malaysia.

i) Clearly explain the differences in the design concept/approach for these two methods.

ii) Determine the equivalent single axle load (e) for a three axles truck with BG1 = 6000kg, BG2 = 10000kg, and BG3 = 10000kg using Road Note 31 approach. How can we reduce the damage factor exerted onto the pavement by this truck?

(10 marks)

(b) Design a pavement based on the following data using ATJ 5/85 approach:

- Average daily traffic, ADT in 2011 = 6200
- Directional split = 58/42
- Percentage of commercial vehicle, Pc = 22%
- Growth rate = 6% per year

Road will be opened to traffic in 2013.

Thickness and CBR value for 1 meter of sub-grade soil are:
- 250 mm CBR 10%
- 400 mm CBR 7%
- 350 mm CBR 5%

Materials to be used are:

<table>
<thead>
<tr>
<th>Layer</th>
<th>Material</th>
<th>Coefficient, a</th>
<th>One layer lift, (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wearing</td>
<td>Asphaltic Concrete</td>
<td>1.00</td>
<td>4 – 5</td>
</tr>
<tr>
<td>Binder</td>
<td>Asphaltic Concrete</td>
<td>1.00</td>
<td>5 – 10</td>
</tr>
<tr>
<td>Road base</td>
<td>Crushed Aggregate</td>
<td>0.32</td>
<td>10 – 15</td>
</tr>
<tr>
<td>Sub base</td>
<td>Crushed Aggregate</td>
<td>0.25</td>
<td>10 – 20</td>
</tr>
</tbody>
</table>

\[ V_0 = ADT \times 365 \times \left( P_C / 100 \right) \times \text{Directional Split} \]
\[ V_e = V_0 \left( (1 + r)^a - 1 \right) / r \]
\[ ESA = V_e \times e \]
\[ V_s = V_e \left( 1 + r \right)^a \]
\[ TA' = a_1D_1 + a_2D_2 + \ldots + a_nD_n \]

Please state all the assumption used in the design.

(15 marks)
Figure Q3 (b) Design Nomograph

Note: Please return this figure along with your answer book
Q4. (a) Depletion of natural resources for construction has initiated the recycling of old pavement material. Lately, asphalt pavement recycling has gained more attention and become a preferred option in Malaysian’s pavement industry especially for pavement rehabilitation. Two main recycling methods in practice are hot recycling and cold recycling. Briefly explain the two recycling methods and discuss in detail one of them.

(10 marks)

(b) A stretch of highway has to pass through a cut section of a mountainous area. Using properly labeled sketch, discuss drainage systems (including but not limited to; types, functions and importance) that need to be installed on that particular stretch.

(10 marks)

(c) Surface deformation and surface defects are two of the pavement distresses that can be identified through visual assessment of the pavement surface. With the aids of properly labeled sketch, clearly discuss one of the distress in terms of their types, effect to road users, causes, and corrective actions.

(5 marks)
Q5. (a) i) Using a suitable example, explain the concept of “rate of return” in economic analysis.

ii) A construction company invested RM850,000 to buy a new excavator. If the net income from temporary leasing the excavator is expected to be RM150,000 per year, what is the approximate length of time (in years) required to recover the investment at the interest rate of 10% per year. Show your trial and error values.

(10 marks)

(b) A 15 km stretch of road needs to be upgraded with the cost of RM5 million per km. Annual road users, maintenance, and accident costs are tabulated below. Use study period (n) of 20 years with discount rate (r) of 4%, for the following analysis.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Road User</th>
<th>Accident</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td>147.2</td>
<td>4.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Upgrade</td>
<td>134.4</td>
<td>1.4</td>
<td>3.8</td>
</tr>
</tbody>
</table>

i) Draw the cash flow diagram for both alternatives; and

ii) Calculate the Net Present Worth (NPW) and the Benefit Cost Ratio (BCR) for the given project.

Is the upgrading worth undertaken?

\[
(P / F, i, n) = \frac{1}{(1 + i)^n}
\]

\[
(P / A, i, n) = \frac{(1 + i)^n - 1}{i(1 + i)^n}
\]

\[
(F / A, i, n) = \frac{(1 + i)^n - 1}{i}
\]

(15 marks)
KERTAS SOALAN PEPERIKSAAN TAMAT