Mansoura University

Faculty of Engineering
Public Works Dept.

4th Year Civil

Highway and Airport Engineering
نظام قديم - الامتحان فى ورقتين(وجهين)

Time: 3 Hours
Date: 22-01-2011

Try all questions & Use neat sketches as possible & Assume reasonably Any missing data & Total Marks = 110 Marks.

First Question (20 Marks)

a **(5 Marks)** Define the following using sketches, if needed:
Plate bearing test – Group index – Relative Compaction – Optimum moisture content - Tri-axial repeated loading test -

b **(7 Marks)** Find the CBR ratio, the following results are obtained from a test:

0.5	0.4	0.3	0.2	0.15	0.10	0.05	**Penetration (in)**
600	525	450	300	195	90	30	**Load (Ib)**

c **(8 Marks)** Classify the following two soils according to the AASHTO classification system and then describe each soil.

Sieve No.		**4**	**10**	**40**	**60**	**100**	**200**	**L.L**	**P.L**
Soil	**A**	90	72	44	35	25	14	29	24
	B	100	100	100	84	62	26	50	42

Second Question (15Marks)

a) Answer the following (Use neat sketches if possible):

1. **(2 Marks)** What is the effect of aggregate particle shape on stability and workability of pavement courses?
2. **(2 Marks)** What are the factors affecting binder performance?
3. **(2 Marks)** What are the causes and types of binder ageing?

b) **(3 Marks)** A coarse aggregate has a bulk saturated surface dry specific gravity of 2.750. If the absorption of the aggregate is 3%, determine the bulk dry specific gravity of the aggregate.

c) **(6 Marks)** The following table shows a gradation of an aggregate material it is required to find:

a) The maximum aggregate size b) The nominal maximum aggregate size.

c) Determine the required percent passing a #4 sieve (4.75 mm) to achieve the maximum density.

d) If a HMA using these aggregates was planned to be used in a rural highway. The structure design showed that the required HMA thickness is 2.5 cm. Do you think that this thickness is appropriate? Why?

Sieve size (mm)	25	19	12.5	9.5	4.75	0.425	0.15	0.075
% Passing	100	99	98	83	63	44	28	18

Third Question (20 Marks)

1. **(5 Marks)** Write short notes about the following:

a) Passing sight distance **b)** Importance of shoulders for highways **c)** Importance of transition curves
d) Transverse skidding effect on horizontal curves **e)** Widening of pavement on horizontal curves

2. **(6 Marks)** A motorist traveling down a grade of 5% on a highway observes an accident at a distance of 635.5ft ahead of him involving an overturned truck that is completely blocking the road. He also read a warning sign at a distance of 500 ft from the truck. If the motorist was able to stop his vehicle 30 ft from the overturned truck, what was the travel speed when the driver first reacted with the accident? (Use t= 2.5 sec and f = 0.3).
3. A 2-lane rural highway is going to be widened **from one side** to join a 4-lane rural highway in the same direction. The running speeds on the 2-lane and 4-lane highways are 40 and 60 mph respectively. The highways have the following features:

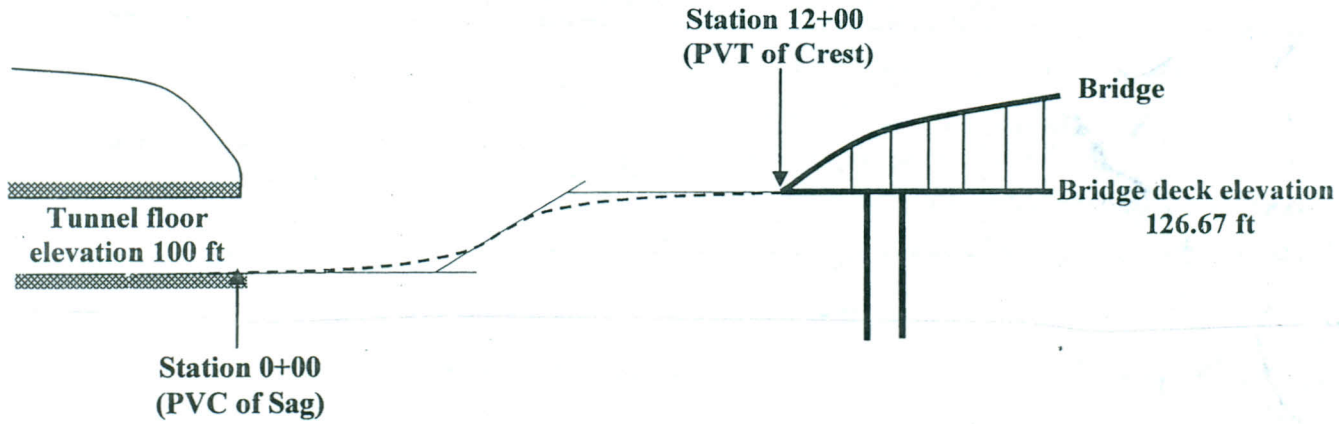
4-Lane Highway	2-Lane Highway	
12 ft	12 ft	Lane Width
12 ft	--	Median Width
10 ft	12 ft	Shoulder Width

is required to draw the following to a reasonable scale:

a) **(3 Marks)**A cross section in a cut area for the 2-lane highway.
b) **(3 Marks)**A cross section in a fill area for the 4-lane highway.
c) **(3 Marks)**Draw a plan for the widening area showing all the principal elements of both highways if the required length to achieve the necessary widening is 235 ft.

Fourth Question (20 Marks)

1. **(2 Marks)** List the factors usually considered in designing crest and sag vertical curves.
2. **(6 Marks)** Draw a superelevation diagram for a 2-lane highway in a horizontal curve with radius of 1400 ft and design speed of 65 mph, (Use a cross slope of 2% and a coefficient of side friction of 0.12).
3. **(12 Marks)**An engineering mistake has resulted in the need to connect an already constructed tunnel and a bridge with a sag vertical curve followed by a crest vertical curve. The profile view of the tunnel, bridge is given in the shown Figure. A design speed of 50 mph for desirable SSD is assumed for the sag and crest (equal tangent) vertical curves. This leads to K-values of 110 and 160 for the sag and crest curves respectively. Compute the stationing and elevations of PVC, PVI and PVT curve points of both curves.



Fifth Question (20 Marks)

a) **(3Marks)** Draw the 6 plots used to design the HMA using Marshall Method and explain how the optimum asphalt content is determined from these plots.
b) An asphalt mix specimen was removed from 6-lane free way pavement surface. The extraction test indicated that the percent of asphalt content was 5.63%, expressed as a percentage of weight of aggregate, the asphalt absorption of aggregate was 0.45% and its bulk specific gravity was 2.64. The specific gravity of asphalt cement was 1.025. the unit weight of the mix was 2.23 gm/cm^3. It is required:
   1. **(3Marks)** Draw the component diagram showing **all volumetric properties and mass quantities** of the tested specimen.
   2. **(3Marks)** Calculate: VMA, VFA, Maximum theoretical specific gravity of the mix and the effective specific gravity of the aggregate.
   3. **(2Marks)** Is the asphalt mix air voids percent within specification or not?
c) **(4 Marks)** A 4-lane major rural highway with an initial total truck count of 1000, 60% on the design lane, and zero annual growth rate. Estimate the 30-year cumulative ESAL in the design lane for the following data:

Truck Type	Percent Distribution	Truck Factor
2-axle	40	0.18
4-axle	25	0.73
5-axle	35	1.07

Use: $G = \frac{\left((1+r)^n - 1\right)}{r}$

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Faculty of Engineering — Highway and Airport Engineering — Time: 3 Hours

Public Works Dept. — نظام حديث – الامتحان فى ورقتين(وجهين) — Date: 22-01-2011

Try all questions & Use neat sketches as possible & Assume reasonably Any missing data & Total Marks = 100 Marks.

First Question: Airport Engineering (25 Marks)

1. (4 Marks) Explain in brief the surveys and factors required for airport site selection (show the effect of bad weather during winter 2010/2011).
2. (2 Marks) Explain the recent developments in Cairo airport (opened by president Mubark in 2010).
3. (3 Marks) Draw typical airport configurations and cross sections of runway and taxiway.
4. (2 Marks) Explain the importance of the aircraft characteristics to airport geometric and structural design.
5. (3 Marks) Determine the corrected length of a runway , the following data are giving :-

Basic runway length	= 3200 m	Maximum ground level	= 34 m
Minimum ground level	= 30 m	Average ground level	= 32 m
Mean of maximum daily temperature	= 38 ° C	Mean of average daily temperature	= 25° C

6. (3 Marks) Draw the imaginary surfaces. Determine the limiting heights of tower buildings for safe landing, take off and turning zoon . The towers is located at a distance of 4500 m from the middle of the runway (runway length is 4200 m)
7. (2 Marks) Explain the effect of wind on runway orientation .
8. (2 Marks) Explain the effect of sight distance and longitudinal gradient on runway design
9. (2 Marks) Where and why the use of concrete pavement is a must in airports?
10. (2 Marks) What are the main points in the report you prepared about airport engineering?

Second Question (25 Marks)

a) (5 Marks) Show five of the known distresses occurred in an asphalt pavement. For each one show shape, reason and the method of repair.

b) (5 Marks) Design a framework for quality control for an asphalt pavement project.

c) (4 Marks) Explain how can you inspect the following:
1) Hauling Trucks 2) Asphalt Mix

d) (4 Marks) What precaution must be followed in handling and storing the following materials:
1) Aggregate 2) Bitumen

e) (7 Marks) Explain the difference between rigid and flexible pavements. Show with neat sketches the joints must be provided in rigid pavements and the function of each.

Third Question (20 Marks)

(5 Marks) Explain briefly the meaning of the following terms:
Soil classification systems - Plate bearing test - Relative Compaction – California bearing ratio (CBR) – Tri-axial repeated loading test.

, Marks) A coarse aggregate has a bulk saturated surface dry specific gravity of 2.750. If the osorption of the aggregate is 3%, determine the bulk dry specific gravity of the aggregate.

Answer the following (Use neat sketches if possible):

a) (2 Marks) What is the effect of aggregate particle shape on stability and workability of pavement courses?

b) (2 Marks) What are the factors affecting binder performance?

c) (2 Marks) What are the causes and types of binder ageing?

4) (6 Marks) The following table shows a gradation of an aggregate material it is required to find:

a) The maximum aggregate size

b) The nominal maximum aggregate size.

c) Determine the required percent passing a #4 sieve (4.75 mm) to achieve the maximum density.

d) If a HMA using these aggregates was planned to be used in a rural highway. The structure design showed that the required HMA thickness is 2.5 cm. Do you think that this thickness is appropriate? Why?

Sieve size (mm)	25	19	12.5	9.5	4.75	0.425	0.15	0.075
% Passing	100	99	98	83	63	44	28	18

Fourth Question (20 Marks)

1) (4 Marks) Illustrate the importance of the following:

a) Transition curves
b) Reduction of transverse skidding effect on horizontal curves
c) Widening of pavement on horizontal curves.
d) Coordination between vertical and horizontal alignments.

2) A 4-lane undivided highway is to be designed to connect two points A and B. One horizontal curve and two vertical curves are adopted to provide the safest and most economical design. Figures 1 and 2 show the plan and elevation of this highway section. The following are the relevant data for the design process:

- Design Speed = 70mph
- Lane width = 12ft
- Coefficient of friction (f) = 0.12
- Maximum superelevation = 4 %
- Shoulder width = 10ft
- Side slopes (3:2) in fill sections & (4:1) in cut sections

It is required to:

a. (4 Marks) Design a horizontal circular simple curve at station (280+00) for this facility.

b. (5 Marks) Draw a superelevation diagram for the attainment of super elevation necessary for movements along the horizontal curve at station (280+00).

c. (4 Marks) Determine the length of the crest vertical curve if this curve passes through two points X and Y having stations of (220+00) and (236+00) respectively. Their elevations are 340.38 and 339.3 ft respectively.

d. (3 Marks) Determine the lowest point of the sag vertical curve if its length is 1460 ft.

Fifth Question (22 Marks)

1) (3 Marks) Draw the 6 plots used to design the HMA using Marshall Method and explain how the optimum asphalt content is determined from these plots.

2) (2 Marks) Illustrate two of the flexible pavement design methods and compare between them.

d) **(5 Marks)** Determine the AC, Base and Subbase layer thicknesses for the pavement system shown in following figure for an ESAL of 40×10^6, R = 99%, So = 0.35, initial PSI =4.5 and terminal PSI =2.5

Surface, $E_1 = 450{,}000$ psi , $a_1 = 0.44$
Base, $E_2 = 38{,}000$ psi , $a_2 = 0.14$, $m_2 = 1.2$
Subbase, $E_3 = 12{,}000$ psi, $a_3 = 0.08$, $m_3 = 1.1$
Subgrade, CBR = 6%

Sixth Question: Airport Engineering (25 Marks)

1. **(4 Marks)** Explain in brief the surveys and factors required for airport site selection (show the effect of bad weather during winter 2010/2011).
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9. **(2 Marks)** Where and why the use of concrete pavement is a must in airports?
10. **(2 Marks)** What are the main points in the report you prepared about airport engineering?

Best Wishes

Examiners:

1- Prof. Dr. Mohammed El-Shabrawy
2- Dr. El-Metwally El-Sekelly
3- Dr. Moustafa Kamel
4- Dr. Sherief El-Badawy

AASHTO Soil Classification System

General Classification	***Granular Materials*** *(35% or less passing 0.075 mm)*							***Silty-Clay Material*** *(More than 35% passing 0.075 mm)*			
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5 A-7-6
Sieve Analysis Percent passing:											**
#10 sieve	50 max										
#40 sieve	30 max	50 max	51 min								
#200 sieve	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of Fraction passing 0.42 mm											
Liquid Limit				40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plastic Index	6 max	6 max	N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min
Usual types of significant constitutent materials	Stone Fragments - gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good							Fair to poor			

** A-7-5 – PI <= LL - 30
A-7-6 – PI > LL - 30

$$GI = (F - 35)[0.2 + 0.005(LL - 40)] + 0.01(F - 15)(PI - 10)$$

- **AASHTO Design Chart for Flexible Pavements**