Highway Engineering

1. Draw a detail sketch of the process of distillation of **paving asphaltic cement** showing all details.

2. Design a rigid pavement for combined *wheel load* & *temperature stresses* using **Bradbury's** stress coefficients for wheel load stresses, and using the following data:
   Modulus of elasticity of concrete= **$3*10^5$ kg/cm²**
   Poisons ratio= **0.2**
   Load intensity to produce unit deflection =**0.375kg/cm²**
   Allowable flexural strength = **75 kg/cm²**
   Factor of safety = **3**
   Thermal coefficient of concrete= **$8*10^{-6}$ per C°**
   Temperature difference during the day = **0.8C°/cm**
   Unit weight of concrete = **2500 kg/m³**
   Slab Length = **7m**
   Cx=**1.04** & CY=**0.3** (for any assumed thicknesses)

3. Basic requirements for **binder course** according to Iraqi specifications.

4. Explain the **surface defects** in flexible pavements, causes and their corresponding remedies.

5. Draw a diamond interchange with all details.

6.

Design the rigid pavement for combined ***wheel load & temperature stresses*** using the following data:
Modulus of elasticity of concrete= $3*10^5$ kg/cm^2
Poisons ratio= **0.2**
Load intensity=**0.375kg/cm^2**
Allowable flexural strength = **45 kg/cm^2**&Factor of safety = **1.5**
Thermal coefficient of concrete= $7*10^{-6}$ **per C°**
Temperature difference during the day = **0.6 C°/cm**
Unit weight of concrete = **2500 kg/m^3**
Slab length is **4** times of its width.
Cx= **1.03** & Cy= **0.3**

7.

Check the weighted speed of several trains below on a **6°** curved section of railway track.

Number of trains	Speed(kph)
8	100
6	90
12	80
18	60
24	50

8.

The following data refer to the test specimen of Marshall Test, determine the (%) aggregate used in the sample:
Weight of sample in air= 1225 gm
Weight of sample in water= 664gm
Weight of sample S.S.D.= 1240gm
(%)Voids in Mineral Aggregate= 27.84%
[Use: G_{Ac}= 1 & $G_{agg.}$= 2.8]

9.

Fix the **grade** of the asphalt according to Iraqi specifications, if the penetration index of the sample is equal to **15**.

10.

Shortcomings of **Marshall Test**.

11.

Differentiate by sketch between: **apparent &bulk** specific gravity of aggregate

12.

Design a rigid pavement for combined *wheel load* & *temperature stresses* using **Bradbury's** stress coefficients for wheel load stresses, and using the following data:

Modulus of elasticity of concrete= $3*10^5$ kg/cm²
Poisons ratio= **0.2**
Load intensity to produce unit deflection =**0.375kg/cm²**
Allowable flexural strength = **75 kg/cm²**
Factor of safety = **3**
Thermal coefficient of concrete= $8*10^{-6}$ **per C°**
Temperature difference during the day = **0.8C°/cm**
Unit weight of concrete = **2500 kg/m³**
Slab Length = **7m**
Cx=1.04 & **CY=0.3** (for any assumed thicknesses)

13.

Explain with sketches the engineering properties of soil lime mixture.

14.

What are the main chemical compositions of asphalt.

15.

Design the rigid pavement using Bradbury's stress coefficients for standard conditions and using the following data:

Modulus of elasticity of concrete = $3*10^5$ kg/cm²
Load to produce unit deflection = 0.375 kg/cm²
Modulus of rupture of concrete =45 kg/cm²
Factor of safety = 1.8

L/b	Qi	Qe	L/b	Qi	Qe
1.0	0.34	0.21	8.0	1.48	2.27
1.5	0.56	0.61	8.5	1.52	2.33
2.0	0.72	0.89	9.0	1.55	2.39
2.5	0.85	1.12	9.5	1.58	2.44
3.0	0.94	1.30	10.0	1.61	2.49
3.5	1.02	1.45	10.5	1.63	2.54
4.0	1.10	1.65	11.0	1.66	2.59
4.5	1.17	1.76	11.5	1.68	2.63
5.0	1.22	1.81	12.0	1.71	2.68
5.5	1.28	1.90	12.5	1.73	2.72
6.0	1.33	1.99	13.0	1.75	2.75
6.5	1.38	2.07	13.5	1.77	2.80
7.0	1.41	2.14	14.0	1.79	2.83
7.5	1.45	2.21	14.5	1.81	2.86
8.0	1.48	2.27	15.0	1.83	2.90

(a√2)/L	Qc	(a√2)/L	Qc	(a√2)/L	Qc
0.00	3.00	0.25	1.69	0.50	1.02
0.05	2.50	0.30	1.54	0.55	0.90
0.10	2.25	0.35	1.40	0.60	0.79
0.15	2.04	0.40	1.27		
0.20	1.86	0.45	1.14		

16. Criteria's regarded in designing of sag vertical curves.

17. The 30^{th} Hour volume and how it is expressed.

18. Draw the profile of attainment of super elevation by revolving about the inneredge.

19. Capital Recovery Factor.

20. Drawbacks of transportation.

21. Draw a sketch of the ***Clover Leaf Interchange*** and show all details and traffic movements on it.

22. Design the rigid pavement for combined *wheel load & temperature stresses* for the following data:

Wheel load & Tire pressure= **Standard**
Modulus of elasticity of concrete= **$3*10^5$ kg/cm²**
Poisons ratio= **0.2**
Load intensity=**0.375kg/cm²**
Allowable flexural strength = **45 kg/cm²**
Factor of safety = **1.5**
Thermal coefficient of concrete= **$8*10^{-6}$ per C°**
Temperature difference during the day = **0.6 C°/cm**
Unit weight of concrete = **2500 kg/m³**
Coefficient of subgrade restraint = **1.5**
Slab dimensions = **4.5m*3.8m**

23.

Determine the allowable safe speed on 4° curve (without transition) for B.G. railway.

24.

State Westergaards assumptions for stress analysis in rigid pavements due to wheel loads

25.

In Marshall Test on **Binder Course** the following data were obtained:

Asphalt %	Weight(gm)			Stability(KN)	Flow
	In air	In water	SSD	Corrected	mm
4	1195	706	1205	7.33	2.35
5	1175	691	1177	12.88	3.33
6	1212	715	1219	8.43	5.11

Determine Optimum Asphalt Content(***OAC***) based on Iraqi standards.[use:G_{Ac}=1& $G_{Agg.}$=2.8]

26.

The following Data refer to the test specimen of Marshall Test, determine ***the (%) asphalt used in the sample.***

Weight of sample in air=**1145gm.**
Weight of sample in water=**675gm.**
Weight of sample SSD=**1150gm.**
%voids in the mix=**6.19**
Use $G_{ac.}$=**1** & $G_{agg.}$=**2.8**]

27.

The following data refer to the test specimen of Marshall Test, determine the (%) aggregate used in the sample:
Weight of sample in air= 1225 gm
Weight of sample in water= 664gm
Weight of sample S.S.D.= 1240gm
(%)Voids in Mineral Aggregate= 27.84%
[Use: G_{Ac}= 1 & $G_{agg.}$= 2.8]

28. Fix the **grade** of the asphalt according to Iraqi specifications, if the penetration index of the sample is equal to **15**.

29. What are the precisions of Penetration Test.

30. For the 2lane-2way rural highway with inside a horizontal curve the following data are given:
Level of centerline at TS= **50m** (**50** station)
Spiral constant (A) = **200**
Required:
(i) Draw the *profile* of attainment of superelevation by revolving about the inner edge with finding different levels of the centerline, inner and outer edges of cross section of the pavement.
(ii) Derive a formula for computing the length of transition curve based on *the rate of change of centrifugal acceleration*.
(iii) Is the *capacity* of the highway is safe in compare with standards.

31. ***Determine the specific gravity of combined aggregate in a bituminous mix having maximum theoretical S.G 2.5, The bitumen content is 6% by weight of the mix and S.G is 1 ?***

32. ***The time in Saybolt-Furol Test on cutback was (265)sec. . Fix the grade of cutback.***

33. The Group Index of the subgrade soil consisting **55%** material passing No.200sieve is **5.1**% & the plastic limit of **41%**; Fined the **liquid limit** of the soil.

34.

Stripping in asphalt mix.

35.

What is alignment and what are the surveys required for good alignment.

36.

The economic study conducted for improving an existing road gave three alternative proposals A,B and C which are given in table below(use an average life30years&interest as7%):

Road	Total vehicle operation cost in(100$)	Annual cost of highway construction in (100$)
Existing Road	29221	2080
Proposal A	9980	3210
Proposal B	4980	7500
Proposal C	2670	9120

Find out the best proposal using:
(i) Annual Cost Method, and
(ii) Benefit Cost Method.

37.

Draw a diamond interchange with all details.

38.

Coverage.
Pot holes.
Performance of soil cement.
Cause ways.
Sand asphalt.

39.

Explain the **surface defects** in flexible pavements, causes and their corresponding remedies.

40.

Determine the Group Index of the subgrade soil consisting 55% material passing 75 micron sieve, liquid limit of 50% and plastic limit of 41%.

41.

What are the main chemical compositions of asphalt.

42.

Explain with sketches the engineering properties of soil lime mixture.

43.

There are five alternate proposals of road plans for a district. The details are given below. Justify with reasons which proposals is the best assuming suitable data:

Proposal	Total road length(km)	Number of towns & villages served with population ranges					Productivity with (1000)tones	
		<500	501-1000	1001-2000	2001-5000	>5000	Agricultural	Industrial
A	500	100	150	40	20	3	250	20
B	600	200	250	68	28	3	320	25
C	700	270	350	82	36	4	500	35
D	800	280	410	91	41	4	600	42
E	900	290	430	96	44	4	630	45

44.

A highway with 5% down gradient inside horizontal alignment of R=400m radius of th circular curve and the following data are given:
Design speed=100kph
Number of lanes=2(3.5m width each)
Normal crown=2%
Level of centerline at Ts=40m (0 Station)
Spiral constant (A)=160
Coefficient of friction=0.15 (40 %)

quired:

(i) Draw the profile of attainment of superelevation by revolving about the centerline with finding different levels of the centerline, inner and outer edges of cross section of the pavement.
(ii) Derive a formula for computing the length of transition curve based on the rate of change of centrifugal acceleration.
(iii) Calculate the total width for the curve, if the length of the longest wheel base of vehicle expected to use the highway is 6m.
(iv) Calculate the maximum permissible speed, if the pressures on inner and exterior wheels are equal and the superelevation is not to exceed 8% 0.08
(v) Find the basic capacity of a traffic lane, assuming average length of vehicles 5m.

45.

In **Arbil-Koya** rural highway, There is a horizontal curve of radius **R=500m** with a gradient **4%** upward located in low intensity rainfall region, using level of centerline at **Ts=60m**(1st station)& spiral constant **A=180**;
(i) Draw the profile of attainment of super elevation by revolving about the **inner edge** with finding different levels of the centerline, inner and outer edges of cross section of the pavement.
(ii) Calculate the **basic capacity** of a traffic lane, assuming average length of vehicles as **16m**.

46.

In Arbil-Makhmoor rural highway there is a horizontal curve at a grade of (**+6%**)and the following data are given:
Normal crown of the road= **1.5%**
Level of centerline at TS= **100m** (**0** station)
Spiral constant (A) = **180**
Coefficient of friction = **0.1**
Radius of a horizontal curve=**300m.**

Required:

(A) Draw the *profile* of attainment of super elevation by revolving about the centerline with finding different levels of the centerline, inner and outer edges of cross section of the pavement.
(B) Derive a formula for computing the length of transition curve based on ***the rate of change of centrifugal acceleration.***
(C) Calculate the ***total width*** of the highway at the curve, if the length of the longest wheel base of vehicles expected to use the highway is **10m.**
(D) Calculate the ***maximum permissible speed***, if the pressures on inner and exterior wheels are equal.
(E) Find the ***basic capacity*** of traffic lane, assuming average length of vehicles as **6m.**

47.

(B) In an urban area at the intersection of road **A&B** a signal has been designed, for a thirty minutes traffic count of **300&200** vehicles for A&B respectively. Assuming average time headway (spacing) of **2.5** seconds per vehicle during the green phase & yellow time as **4.58**sec,& **3.05**sec for A&B respectively. Find out the **cycle length** required.

48.

A 4-lane rural divided highway AB intersects another similar highway CD at point F,
Design the overpass bridge and the approaches between A &B if:
G1=4% , **G2 = -4%** for crest curve
~~**R=60000m** for PSD for crest & sag curve~~
R=10000m for SSD for crest curve
R=5000m for SSD for sag curve
Clear height=**9m**
Neglect the straight between two reserve curves

Point	Station	Elevation(m)
A	1+00	40.00
F on CD		40.00
B		40.00

REQUIRED:

(A) Design the overpass bridge from the point A to B & draw the PROFILE showing stations & elevations.
(B) Find the allowed thickness (t) of the bridge, and
(C) If SSD required is**120m**, is the above design is safe.

49.

A 6-lane divided Kurdistan street intersects a 6-lane Peermam street at Shorsh intersection in Arbil city, at the elevation of **50m** in the centerline. Design an overpass bridge and approaches on Kurdistan street(**for 4-lanes only without division in between**),if: mean undivided.
Length of straight between two reverse vertical curves=**50m**
G1=**+6%** and G2=**-6%** for crest curve.
R=**1500m**. for PSD & R=**1000m**. for SSD.
Clear height required=**6m.**

50.

A 4-lane divided highway AB intersects another 4-lane highway CD at point F.
Design the overpass bridge and the approaches between A &B if:
Design speed for highway AB =100m.
G1=4% , G2 = -4% for crest curve
R=60000m for PSD for crest&sag curve
R=10000m for SSD for crest curve
R=5000m for SSD for sag curve
Clear height=9m
Neglect the straight between two reserve curves

Point	Station	Elevation(m)
A	1+00	40.00
F at CD		40.00
B		40.00

REQUIRED:

(A) Design of the overpass bridge from the point A to B and draw the PROFILE showing stations & elevations

(B) If SSD required =100m, is the above design is safe.

51.

What is the load in (Kgs) which produce the minimum value of %CBR of an aggregate sample according to SORB?

52.

The Original weight of aggregate was 570 gms , and after Five cycles in sodium Sulphate in soundness was 470 gms , is the satisfactory according to ASTM permissions.

53.

With sketches explain the difference bulk and apparent specific gravity of road aggregates.

54.

Give four basic requirements of binder course according to Iraqi specifications.

55.

Give four basic requirements of surface course according to Iraqi specifications.

56.

Laboratory maximum density of a soil is 1.9 gm/cm^2 , Specifications require 95% compaction & in the field density test the following results were recorded:

Mass of soil from test hole = 639.5 gm
Mass of sand filling the test hole = 452.9 gm
Volume of calibrating cylinder = 970 cm^3
Mass of sand in calibrating cylinder = 1387.1 gm
Moisture content sample of this soil: Original mass = 154.9 gm
Final mass = 132.7 gm

A visual check of the soil in the field indicates that it contains about 20% gravel sizes.

Check for Compaction? (use specific gravity of gravel = 2.65)

57.

Laboratory maximum density of a soil is 1.92 gm/cm^2 , Specifications require 95% compaction & in the field density test the following results were recorded:

Mass of soil from test hole = 638.5 gm
Mass of sand filling the test hole = 454.9 gm
Volume of calibrating cylinder = 972 cm^3
Mass of sand in calibrating cylinder = 1387.8 gm
Moisture content sample of this soil: Original mass = 155.9 gm
Final mass = 135.7 gm

A visual check of the soil in the field indicates that it contains about 18% gravel sizes.

Check for Compaction? (use specific gravity of gravel = 2.65)

58.

What is the necessity of planning a road system? Name the studies by which information is collected for planning of roads?

59.

The economic study conducted for improving an existing road gave three alternative proposals: A,B and C particularies of which are given in table below:

Road	Annual vehicle operation cost in($)	Annual cost of highway construction in ($)
Existing Road	95000	30500
Proposal A	85000	42000
Proposal B	70000	45000
Proposal C	65000	47000

Find out the best proposal using:
(i) Annual Cost Method, and
(ii) Benefit Cost Method.

60.

A section of an existing road follows a circuitous route, has inadequate width of roadway and poor surface condition. There are four alternatives for improvement namely **A**, **B**, **C** and **D**. Estimated useful life; length and the costs of the four alternatives are given below:

Element	Estimated useful life(Years)	Cost in ($)			
		A	B	C	D
Right of way	100	30000	35000	40000	45000
Grading	50	35000	50000	60000	65000
Structures	50	20000	25000	30000	31000
Markings	20	15000	18000	30000	40000
Maintenance cost$/km		50	60	70	80
Road user cost $/veh.		0.2	0.12	0.225	0.15
Length(km)		20	12	15	10

The traffic is expected to decrease by **25%** after the useful life of the road. The present average annual daily traffic is **1575** vehicles and assuming the rate of interest as **8%**. Choose the alternative which is economically a better proposition from the various proposals.

61.

A section of an existing road follows a circuitous route, has inadequate width of roadway and poor surface condition. There are four alternatives for improvement namely A, B, C and D. Estimated useful life; length and the costs of the four alternatives are given below:

Element	Estimated useful life(Years)	Cost in 100$			
		A	B	C	D
Right of way	100	300	350	400	450
Grading	50	350	500	600	650
Structures	50	200	250	300	310
Markings	20	150	180	300	400
Maintenance/km		50	60	70	80
Road user cost/km		0.01	0.01	0.015	0.015
Length(km)		20	12	15	10

The traffic is expected to increase by 75% in 20 years. The present average annual daily traffic is 900vehicles and assuming the rate of interest as 8%. Choose the alternative which is economically a better proposition from the various proposals.

62.

)After an improvement of a poor subgrade the thickness of flexible pavement required decreased by 50% under standard conditions and minimum value required for subgrade strength according to SORB. Find the original %CBR of the subgrade.

63.

Aging of asphalt.

64.

Orientation of runway

65.

Explain: Pot holes

66.

In Marshall Test on **Binder Course** the following data were obtained:

Asphalt %	Weight(gm)			Stability(KN)	Flow
	In air	In water	SSD	Corrected	mm
4	1195	706	1205	7.33	2.35
5	1175	691	1177	12.88	3.33
6	1212	715	1219	8.43	5.11

Determine Optimum Asphalt Content(***OAC***) based on Iraqi standards.[use:G_{Ac}=1& $G_{Agg.}$=2.8]

67.

Explain the procedure of **Soundness Test.**

68.

The % loss after five cycles in Sodium Sulphate of aggregate sample in Soundness Test was **18**.Is this satisfactory according to ASTM permissions.

69.

The time in Saybolt-Furol Test on cutback was **(260) sec**.Fix.the grade of cutback.

70.

Draw a sketch of **full** control of **seepage flow** showing all details

71.

Derive an expression for **breaking distance**.

72.

Explain the following:
(A) Effect of lime on **permeability** in lime stabilization (with sketch).
(B) **Draw backs** of transportation.
(C) Designing the **grade line**.
(D) **Submersible** Bridges.

73.

Explain:

The addition or removal of soil particles in mechanical stabilization.

74.

Explain: Sand asphalt.

75.

Explain: Cause ways.

76.

Explain: Coverage

77.

Explain: Effect of sulpher in bituminous stabilization

78.

Explain: Poor subgrade

79.

Explain: Catch Drain

80. Criteria’s in designing sag curve